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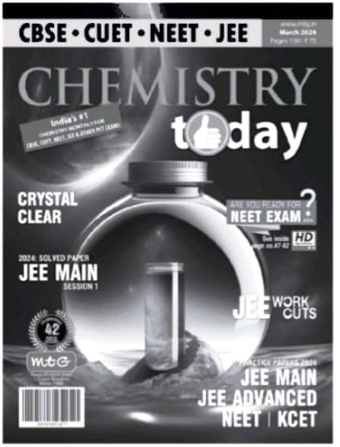

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Contents

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Editor : Anil Ahlawat

SOLVED PAPER

Held on 27th Jan, Morning Shift (Session - 1)

JEE MAIN 2024

SECTION-A (MULTIPLE CHOICE QUESTIONS)

1. Given below are two statements :

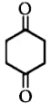
Statement (I) : Aqueous solution of ammonium carbonate is basic.

Statement (II) : Acidic/basic nature of salt solution of a salt of weak acid and weak base depends on K_a and K_b value of acid and the base forming it.

In the light of the above statements, choose the most appropriate answer from the options given below :

(a) Statement I is correct but Statement II is incorrect.
(b) Both Statement I and Statement II are correct.
(c) Both Statement I and Statement II are incorrect.
(d) Statement I is incorrect but Statement II is correct.

2. Highest enol content will be shown by

(a) 
(b) 
(c) 
(d) 

3. The correct statement regarding nucleophilic substitution reaction in a chiral alkyl halide is

(a) retention occurs in S_N1 reaction and inversion occurs in S_N2 reaction
(b) racemisation occurs in S_N1 reaction and retention occurs in S_N2 reaction
(c) racemisation occurs in both S_N1 and S_N2 reactions
(d) racemisation occurs in S_N1 reaction and inversion occurs in S_N2 reaction.

4. Choose the polar molecule from the following.

(a) $CH_2=CH_2$ (b) $CHCl_3$
(c) CCl_4 (d) CO_2

5. Consider the following complex ions

$P = [FeF_6]^{3-}$
$Q = [V(H_2O)_6]^{2+}$
$R = [Fe(H_2O)_6]^{2+}$

The correct order of the complex ions, according to their spin only magnetic moment values (in B.M.) is

(a) $R < P < Q$ (b) $R < Q < P$
(c) $Q < P < R$ (d) $Q < R < P$

6. Yellow compound of lead chromate gets dissolved on treatment with hot NaOH solution. The product of lead formed is a

(a) dianionic complex with coordination number six
(b) neutral complex with coordination number four
(c) dianionic complex with coordination number four
(d) tetraanionic complex with coordination number six.

7. Given below are two statements : one is labelled as Assertion (A) and the other is labelled as Reason (R).

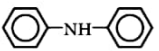
Assertion (A) : Melting point of boron (2453 K) is unusually high in group 13 elements.

Reason (R) : Solid boron has very strong crystalline lattice.

In the light of the above statements, choose the most appropriate answer from the options given below :

(a) Both (A) and (R) are correct but (R) is not the correct explanation of (A).
(b) (A) is true but (R) is false.
(c) (A) is false but (R) is true.
(d) Both (A) and (R) are correct and (R) is the correct explanation of (A).

8. Which of the following is strongest Bronsted base?

(a) 
(b) 
(c) 
(d) 

9. Two nucleotides are joined together by a linkage known as
(a) disulphide linkage
(b) glycosidic linkage
(c) phosphodiester linkage
(d) peptide linkage.

10. NaCl reacts with conc. H_2SO_4 and $K_2Cr_2O_7$ to give reddish fumes (*B*), which react with NaOH to give yellow solution (*C*). (*B*) and (*C*) respectively are
(a) CrO_2Cl_2, $KHSO_4$ (b) CrO_2Cl_2, Na_2CrO_4
(c) CrO_2Cl_2, $Na_2Cr_2O_7$ (d) Na_2CrO_4, CrO_2Cl_2

11. The electronic configuration for neodymium is [Atomic number for neodymium 60]
(a) [Xe] $5f^7\,7s^2$ (b) [Xe] $4f^6\,6s^2$
(c) [Xe] $4f^1\,5d^1\,6s^2$ (d) [Xe] $4f^4\,6s^2$

12. Which of the following electronic configuration would be associated with the highest magnetic moment?
(a) [Ar] $3d^8$ (b) [Ar] $3d^7$
(c) [Ar] $3d^6$ (d) [Ar] $3d^3$

13. Cyclohexene  is _____ type of an organic compound.
(a) acyclic
(b) benzenoid non-aromatic
(c) benzenoid aromatic
(d) alicyclic

14. IUPAC name of following compound (*P*) is

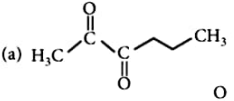
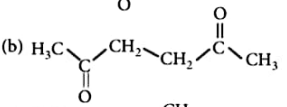
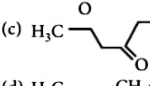
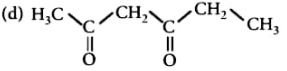

(*P*)

(a) 1-ethyl-3,3-dimethylcyclohexane
(b) 3-ethyl-1,1-dimethylcyclohexane
(c) 1,1-dimethyl-3-ethylcyclohexane
(d) 1-ethyl-5,5-dimethylcyclohexane.

15. Given below are two statements :
Statement (I) : The 4*f* and 5*f*-series of elements are placed separately in the periodic table to preserve the principle of classification.
Statement (II) : *s*-Block elements can be found in pure form in nature.
In the light of the above statements, choose the most appropriate answer from the options given below :
(a) Both Statement I and Statement II are false.
(b) Both Statement I and Statement II are true.
(c) Statement I is true but Statement II is false.
(d) Statement I is false but Statement II is true.

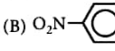
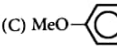
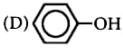
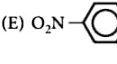
16. Element not showing variable oxidation state is
(a) bromine (b) chlorine
(c) iodine (d) fluorine.

17. Which of the following has highly acidic hydrogen?

(a) 
(b) 
(c) 
(d) 

18. Given below are two statements :
Statement (I) : *p*-Nitrophenol is more acidic than *m*-nitrophenol and *o*-nitrophenol.
Statement (II) : Ethanol will give immediate turbidity with Lucas reagent.
In the light of the above statements, choose the correct answer from the options given below :
(a) Both Statement I and Statement II are true.
(b) Statement I is false but Statement II is true.
(c) Both Statement I and Statement II are false.
(d) Statement I is true but Statement II is false.

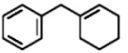
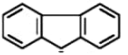
19. A solution of two miscible liquids showing negative deviation from Raoult's law will have
(a) decreased vapour pressure, decreased boiling point
(b) increased vapour pressure, decreased boiling point
(c) decreased vapour pressure, increased boiling point
(d) increased vapour pressure, increased boiling point.

20. The ascending order of acidity of –OH group in the following compounds is
(A) Bu–OH
(B) 
(C) 
(D) 
(E) 
Choose the correct answer from the options given below :
(a) (C) < (A) < (D) < (B) < (E)
(b) (C) < (D) < (B) < (A) < (E)
(c) (A) < (D) < (C) < (B) < (E)
(d) (A) < (C) < (D) < (B) < (E)

SECTION - B (NUMERICAL VALUE TYPE)

Attempt any 5 questions out of 10.

21. Among the following, total number of *meta* directing functional groups is _____.
(Integer based)
$-OCH_3$, $-NO_2$, $-CN$, $-CH_3$, $-NHCOCH_3$, $-COR$, $-OH$, $-COOH$, $-Cl$

22. Among the given organic compounds, the total number of aromatic compounds is _____.
(A) 
(B) 
(C) 
(D) 

23. The mass of silver (Molar mass of Ag : 108 g mol^{-1}) displaced by a quantity of electricity which displaces 5600 mL of O_2 at S.T.P. will be _____ g.

24. The number of electrons present in all the completely filled subshells having $n = 4$ and $s = +\frac{1}{2}$ is _____.
(Where n = principal quantum number and s = spin quantum number)

25. Sum of bond order of CO and NO^+ is _____.

26. Mass of methane required to produce 22 g of CO_2 after complete combustion is _____ g.
(Given : Molar mass in g mol^{-1} ; C = 12.0, H = 1.0, O = 16.0)

27. 3-Methylhex-2-ene on reaction with HBr in presence of peroxide forms an addition product (*A*). The number of possible stereoisomers for '*A*' is _____.

28. If three moles of an ideal gas at 300 K expand isothermally from 30 dm^3 to 45 dm^3 against a constant opposing pressure of 80 kPa, then the amount of heat transferred is _____ J.

29. From the given list, the number of compounds with +4 oxidation state of sulphur is _____.
SO_3, H_2SO_3, $SOCl_2$, SF_4, $BaSO_4$, $H_2S_2O_7$

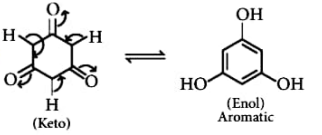
30. Consider the following data for the given reaction
$2HI_{(g)} \rightarrow H_{2(g)} + I_{2(g)}$

	1	2	3
HI (mol L^{-1})	0.005	0.01	0.02
Rate (mol L^{-1} s^{-1})	7.5×10^{-4}	3.0×10^{-3}	1.2×10^{-2}

The order of the reaction is _____.

SOLUTIONS

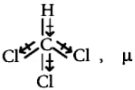
1. **(b):** Aqueous solution of ammonium carbonate contains ammonium hydroxide and carbonic acid. As ammonium hydroxide is a stronger base as compared to the acidic strength of carbonic acid, the solution has basic nature. The pH of salt of a weak acid and a weak base is calculated by the formula, $pH = 7 + \frac{1}{2}pK_a - \frac{1}{2}pK_b$

2. **(d):** 
(Keto) (Enol) Aromatic
As option (d) leads to the formation of an aromatic compound, its enol content will be highest.

3. **(d):** As S_N1 reaction proceeds *via* the formation of a planar carbocation intermediate, it allows attack by nucleophile from either direction leading to racemisation.

On the other hand, in S_N2 reaction attack by nucleophile occurs from the backside leading to inversion of configuration of the chiral alkyl halide.

4. (b): Among the given compounds, only $CHCl_3$ has uncancelled bond moments, so it is polar.



$\mu \neq 0$

5. (d): $P = [FeF_6]^{3-}$: Fe is in +3 oxidation state and forms outer orbital complex, so it has d^5 configuration, *i.e.*, 5 unpaired electrons.

$Q = [V(H_2O)_6]^{2+}$: V is in +2 oxidation state and forms inner orbital complex, so it has d^3 configuration, *i.e.*, 3 unpaired electrons.

$R = [Fe(H_2O)_6]^{2+}$: Fe is in +2 oxidation state and forms outer orbital complex, so it has 4 unpaired electrons.

Spin only magnetic moment $\propto$ No. of unpaired electrons

$\therefore$ The correct order is $Q < R < P$.

6. (c): $PbCrO_4 + 2NaOH \rightarrow Pb(OH)_2 + Na_2CrO_4$

Lead chromate (Yellow)

$\downarrow 2NaOH$

$Na_2[Pb(OH)_4]$

Soluble (Dianionic and has coordination number 4)

7. (d): Due to very strong crystalline lattice of boron, its melting point is extremely high.

8. (d): In  , the lone pair of electrons of nitrogen atom is easily available for donation and thus it behaves as the strongest Bronsted base. In all the other options, lone pairs of nitrogen are either involved in aromaticity such as in (a) or they are involved in resonance with rings such as in (b) and (c).

9. (c): Nucleotides are joined together by phosphodiester linkage between 5′ and 3′ carbon atoms of the pentose sugar.

10. (b): NaCl reacts with conc. H_2SO_4 and $K_2Cr_2O_7$ to give reddish fumes of chromyl chloride, CrO_2Cl_2 (*B*). Chromyl chloride reacts with NaOH to give yellow solution of sodium chromate, Na_2CrO_4(*C*).

$4NaCl + 6H_2SO_4 + K_2Cr_2O_7 \longrightarrow 2CrO_2Cl_2 + 2KHSO_4 + 4NaHSO_4 + 3H_2O$

$CrO_2Cl_2 + 4NaOH \rightarrow Na_2CrO_4 + 2NaCl + 2H_2O$

(Yellow)

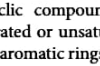
11. (d): The electronic configuration for neodymium is [Xe] $4f^4\,6s^2$.

12. (c): Higher the number of unpaired electrons, higher is the magnetic moment.

d^8 configuration has 2 unpaired electrons.
d^7 configuration has 3 unpaired electrons.
d^6 configuration has 4 unpaired electrons.
d^3 configuration has 3 unpaired electrons.

13. (d): Cyclohexene has six membered carbon ring with a double bond. Such compounds are called alicyclic compounds which are defined as the saturated or unsaturated hydrocarbons containing non-aromatic rings of carbon atoms or one or more heteroatoms.

14. (b):



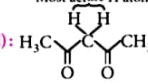
(*P*)

3-ethyl-1,1-dimethylcyclohexane

15. (c): *s*-Block elements are highly reactive, they are never found in pure form in nature.

16. (d): Fluorine is the most electronegative element and shows only −1 oxidation state, while other halogens show variable oxidation states.

17. (d): Most acidic H atoms



has $-CH_2$ group present in between two electron withdrawing carbonyl groups, hence it has most acidic 'H' atoms.

18. (d): *p*-Nitrophenol is more acidic than *meta* and *ortho*-isomers. The electron withdrawing group, $-NO_2$ stabilises the phenoxide ion through $-R$ effect at the *ortho* and *para* positions. The effective delocalisation of negative charge in phenoxide ion enhances the acidic strength of phenols. The $-NO_2$ group at *meta* position will show $-I$ effect only. The $-NO_2$ group at *ortho* position forms hydrogen bond with –OH group. Ethanol being primary alcohol does not react with Lucas reagent at room

MONTHLY TEST DRIVE CLASS XI — ANSWER KEY

1. (a)	**2.** (b)	**3.** (a)	**4.** (c)	**5.** (d)
6. (d)	**7.** (a)	**8.** (d)	**9.** (c)	**10.** (b)
11. (a)	**12.** (c)	**13.** (d)	**14.** (d)	**15.** (a)
16. (a)	**17.** (d)	**18.** (c)	**19.** (b)	**20.** (b,d)
21. (a,d)	**22.** (a,c)	**23.** (a,b)	**24.** (4)	**25.** (5)
26. (10)	**27.** (c)	**28.** (a)	**29.** (d)	**30.** (d)

temperature. Tertiary alcohol will give turbidity immediately.

19. (c) : Solutions with negative deviation show decrease in vapour pressure and increase in boiling point.

20. (d): Presence of electron withdrawing groups enhances the acidity of phenols, while the presence of electron donating groups decreases the acidity of phenol. So, the correct order is A < C < D < B < E.

21. (4):

Group	Directional nature
$-OCH_3$	*o*, *p*-director
$-NO_2$	*m*-director
$-CN$	*m*-director
$-CH_3$	*o*, *p*-director
$-NHCOCH_3$	*o*, *p*-director
$-COR$	*m*-director
$-OH$	*o*, *p*-director
$-COOH$	*m*-director
$-Cl$	*o*, *p*-director

22. (3)

23. (108) : 5600 mL of O_2 at S.T.P. $= \frac{5600}{22400}$

$= 0.25$ moles O_2

Anode : $\underset{(0.25\ \text{mole})}{2H_2O} \longrightarrow O_2 + \underset{1F}{4H^+ + 4e^-}$

Cathode : $\underset{1F}{Ag^+ + e^-} \longrightarrow \underset{\substack{1\ \text{mole}\\(108\ \text{g})}}{Ag_{(s)}}$

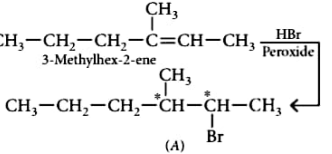
24. (16) : $n = 4$ has one '*s*', three '*p*', five '*d*' and seven '*f*' orbitals. In these 16 orbitals, 16 electrons have spin $(s) = +1/2$ while other 16 electrons have spin $(s) = -1/2$.

25. (6): Bond order of both CO and NO^+ is 3.
Sum = 3 + 3 = 6

26. (8): $\underset{\substack{1\ \text{mol}\\16\ \text{g}\\?}}{CH_4} + 2O_2 \longrightarrow \underset{\substack{1\ \text{mol}\\44\ \text{g}\\22\ \text{g}}}{CO_2} + 2H_2O$

44 g of CO_2 is produced by 16 g of methane.
$\therefore$ 22 g of CO_2 is produced by 8 g of methane.

27. (4):



There are '2' chiral centres which form 4 stereoisomers.

28. (1200) : $w = -P_{ext}\Delta V$

$= -80 \times 10^3\ \text{N m}^{-2} \times (45 - 30) \times 10^{-3}\ \text{m}^3$

$= -80 \times (15)\ \text{N m} = -1200\ \text{J}$

$q + w = \Delta U = 0 \Rightarrow q = -w$

$q = +1200\ \text{J}$

29. (3) : Let x be the oxidation state of S.

$\overset{x}{SO_3}$: $x - 6 = 0$ or, $x = +6$

$H_2\overset{x}{S}O_3$: $+2 + x - 6 = 0$ or, $x = +4$

$\overset{x}{S}OCl_2$: $x - 2 - 2 = 0$ or, $x = +4$

$\overset{x}{S}F_4$: $x - 4 = 0$ or, $x = +4$

$Ba\overset{x}{S}O_4$: $+2 + x - 8 = 0$ or, $x = +6$

$H_2\overset{x}{S}_2O_7$: $+2 + 2x - 14 = 0$ or, $x = +6$

30. (2) : Let the order of the reaction be '*n*'.

$\therefore \quad r = k\,[HI]^n$

$7.5 \times 10^{-4} = k\,(0.005)^n$ ....(i)

$3.0 \times 10^{-3} = k\,(0.01)^n$ ....(ii)

On dividing (ii) by (i), we get

$\frac{3.0\times10^{-3}}{7.5\times10^{-4}} = \left(\frac{0.01}{0.005}\right)^n ; 4 = 2^n$

$\Rightarrow \quad 2^n = 2^2 \Rightarrow n = 2$

So, the order of the reaction is 2.

JEE WORK OUTS

SINGLE OPTION CORRECT TYPE

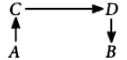
1. For the reaction : $4KClO_3 \rightarrow 3KClO_4 + KCl$
if $\frac{-d[KClO_3]}{dt} = k_1[KClO_3]^4$
$\frac{d[KClO_4]}{dt} = k_2[KClO_3]^4$
$\frac{d[KCl]}{dt} = k_3[KClO_3]^4$, the correct relation between k_1, k_2 and k_3 is
(a) $k_1 = k_2 = k_3$ (b) $4k_1 = 3k_2 = k_3$
(c) $3k_1 = 4k_2 = 12k_3$ (d) none of these.

2. Photoelectric emission is observed from a metal surface with incident frequencies ν_1 and ν_2, where $\nu_1 > \nu_2$. If the kinetic energies of the photoelectrons emitted in the two cases are in the ratio 2 : 1, then the threshold frequency ν_0 of the metal is
(a) $\nu_1 - \nu_2$ (b) $\frac{\nu_1 - \nu_2}{h}$
(c) $2\nu_1 - \nu_2$ (d) $2\nu_2 - \nu_1$

3. If the salts M_2X, QY_2 and PZ_3 have the same solubilities, their K_{sp} values are related as
(a) $K_{sp}(M_2X) = K_{sp}(QY_2) < K_{sp}(PZ_3)$
(b) $K_{sp}(M_2X) > K_{sp}(QY_2) = K_{sp}(PZ_3)$
(c) $K_{sp}(M_2X) < K_{sp}(QY_2) = K_{sp}(PZ_3)$
(d) $K_{sp}(M_2X) > K_{sp}(QY_2) > K_{sp}(PZ_3)$

4. An electric current is passed through silver nitrate solution using silver electrodes. 10.79 g of silver was found to be deposited on the cathode. If the same amount of electricity is passed through copper sulphate solution using copper electrodes, the weight of copper deposited on the cathode is
(a) 6.4 g (b) 2.3 g (c) 3.2 g (d) 1.6 g

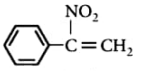
5. The direct conversion of A to B is difficult, hence it is carried out by the following shown path :

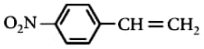


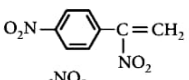
Given : $\Delta S_{(A \rightarrow C)} = 50$ e.u.; $\Delta S_{(C \rightarrow D)} = 30$ e.u.; $\Delta S_{(B \rightarrow D)} = 20$ e.u., where e.u. is the entropy unit, then $\Delta S_{(A \rightarrow B)}$ is
(a) + 60 e.u. (b) + 100 e.u.
(c) – 60 e.u. (d) – 100 e.u.

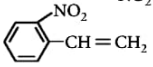
6. Consider the following pairs of electrons :
(A) (i) $n = 3, l = 1, m_l = 1, m_s = +\frac{1}{2}$
(ii) $n = 3, l = 2, m_l = 1, m_s = +\frac{1}{2}$
(B) (i) $n = 3, l = 2, m_l = -2, m_s = -\frac{1}{2}$
(ii) $n = 3, l = 2, m_l = -1, m_s = -\frac{1}{2}$
(C) (i) $n = 4, l = 2, m_l = 2, m_s = +\frac{1}{2}$
(ii) $n = 3, l = 2, m_l = 2, m_s = +\frac{1}{2}$
The pairs of electrons present in degenerate orbitals is/are
(a) only (A) (b) only (B)
(c) only (C) (d) (B) and (C).

7. In the given reaction sequence, the major product 'C' is
$C_8H_{10} \xrightarrow[H_2SO_4]{HNO_3} A \xrightarrow[\Delta]{Br_2} B \xrightarrow[KOH]{\text{alcoholic}} C$

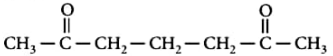
(a) 

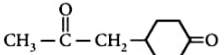
(b) 

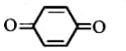
(c) 

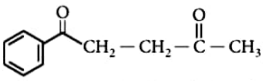
(d) 

8. Which of the following is an example of conjugated diketone?

(a) 

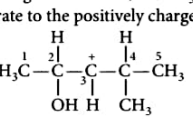
(b) 

(c) 

(d) 

9. If a rocket runs on a fuel ($C_{15}H_{30}$) and liquid oxygen, the weight of oxygen required and CO_2 released for every litre of fuel respectively are
(Given : density of the fuel is 0.756 g/mL)
(a) 1188 g and 1296 g (b) 2376 g and 2592 g
(c) 2592 g and 2376 g (d) 3429 g and 3142 g

10. In the following carbocation, H/CH_3, the most likely to migrate to the positively charged carbon is

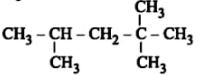


(a) CH_3 at C-4 (b) H at C-4
(c) CH_3 at C-2 (d) H at C-2.

11. In which of the following reactions, the underlined substance gets reduced?
(a) $Cl_2 + 2\underline{I}^- \rightarrow 2Cl^- + I_2$
(b) $\underline{Zn} + H_2SO_4 \rightarrow ZnSO_4 + H_2$
(c) $\underline{Fe}^{2+} + H_2O_2 \rightarrow Fe^{3+} + H_2O$
(d) $\underline{CuO} + H_2 \rightarrow Cu + H_2O$

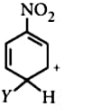
12. The positions of elements P to T in the periodic table are given as :
P : Element in the fourth period and group 14
Q : Element in the third period and group 16
R : Element in the sixth period and group 13
S : Element in the second period and group 18
T : Element in the fourth period and group 16
Arrange these elements in the expected order of increasing first ionisation energy.
(a) $P < Q < R < S < T$ (b) $T < S < R < Q < P$
(c) $R < P < T < Q < S$ (d) $S < Q < T < P < R$

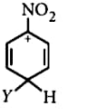
13. How many primary, secondary, tertiary and quaternary (if any) carbon atoms are present in the following compound?



(a) One primary, two secondary and one tertiary
(b) Five primary and three secondary
(c) Five primary, one secondary, one tertiary and one quaternary
(d) Four primary, two secondary and two quaternary.

14. Which of the following carbocations is expected to be most stable?

(a) 

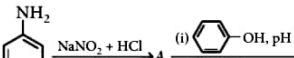
(b) 

(c) 

(d) 

15. The correct statement on the isomerism associated with the following complex ions,
(1) $[Ni(H_2O)_5(NH_3)]^{2+}$,
(2) $[Ni(H_2O)_4(NH_3)_2]^{2+}$ and
(3) $[Ni(H_2O)_3(NH_3)_3]^{2+}$ is
(a) (1) and (2) show only geometrical isomerism
(b) (1) and (2) show geometrical and optical isomerism
(c) (2) and (3) show geometrical and optical isomerism
(d) (2) and (3) show only geometrical isomerism.

NUMERICAL VALUE TYPE

16. 

If molar mass of compound B is x, then find the value of $x/2$.

17. A decapeptide (mol. wt. = 796) on complete hydrolysis gives glycine (mol. wt. = 75), alanine and phenylalanine. Glycine contributes 47.0% to the total weight of the hydrolysed products. The number of glycine units present in decapeptide is _____.

18. Calculate the amount of sodium chloride (in g) which must be added to 1000 mL of water so that its freezing point is depressed by 0.744 K. For water, $K_f = 1.86$ K/m. Assume density of water to be 1 g mL^{-1}.

19. A compound *X*, of boron (B) reacts with NH_3 on heating to give another compound *Y* which is called inorganic benzene. What is the sum of total B–atoms present in *X* and *Y*?

20. In how many of the following species, S-atom is sp^3 hybridised?
S_8, SO_4^{2-}, SO_3, H_2S, SCl_4

21. The oxidation number of Mn in the product of alkaline oxidative fusion of MnO_2 is _____.

22. The total number of monohalogenated organic products in the following (including stereoisomers) reaction is _____.

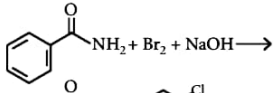
$$\underset{\text{(Simplest optically active alkene)}}{A} \xrightarrow[\text{(ii) } X_2/\Delta]{\text{(i) } H_2/Ni/\Delta}$$

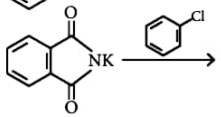
23. The number of species among the following which have fractional bond order is _____.
Li_2, He_2^+, N_2^+, N_2^{2-}, O_2^+, O_2^{2-}, O_2^-, CO_3^{2-}, C_6H_6, O_3

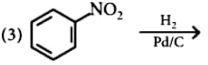
24. For the reactions, $A \longrightarrow B$; $k_1 = 10^8 e^{-\frac{6000}{8.34T}}$
and $P \longrightarrow Q$; $k_2 = 10^{10} e^{-\frac{8000}{8.34T}}$
The temperature (in K) at which $k_1 = k_2$ is _____. (Nearest integer)

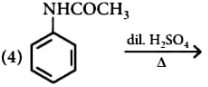
25. The number of $>C=O$ groups present in a tripeptide Asp – Glu – Lys is _____.

26. How many of the transformations given below would result in aromatic amines?

(1) 

(2) 

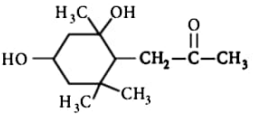
(3) 

(4) 

27. The kinetic energy of an electron in the second Bohr orbit of a hydrogen atom is equal to $\frac{h^2}{x\,m\,a_0^2}$. The value of $10x$ is _____.
(a_0 is radius of Bohr's orbit.) (Nearest integer)
[Given : $\pi = 3.14$]

28. Diborane reacts with ammonia to form an adduct which on heating at 473 K decomposes to give a volatile compound called borazine. The number of π-bonds in borazine is _____.

29. Total number of stereoisomers for the following compound is _____.



30. For the reaction, $C_2H_6 \rightarrow C_2H_4 + H_2$
the reaction enthalpy $\Delta_r H$ = _____ kJ mol^{-1}.
(Round off to the Nearest Integer)
[Given : Bond enthalpies in kJ mol^{-1} : C — C : 347, C = C : 611, C — H : 414, H — H : 436]

STATEMENT TYPE

Directions : Questions (31 to 45) contains two statements : Statement-I and Statement-II. Also these questions have four alternative choices, only one of them is the correct answer. You have to select the correct choice.

(a) Both statements-I and II are true.
(b) Both statements-I and II are false.
(c) Statement-I is true, statement-II is false.
(d) Statement-I is false, statement-II is true.

31. **Statement-I :** Acetic acid does not undergo haloform reaction.
Statement-II : Acetic acid has no alpha-hydrogen.

32. **Statement-I** : Ethyl pent-4-yn-oate on reaction with CH_3MgBr gives a 3°-alcohol.
Statement-II : In this reaction, one mole of ethyl pent-4-yn-oate utilises two moles of CH_3MgBr.

33. **Statement-I :** In the titration between strong acid and weak base, methyl orange is suitable as an indicator.
Statement-II : For titration of acetic acid with NaOH, phenolphthalein is not a suitable indicator.

34. **Statement-I :** Upon heating a borax bead dipped in cupric sulphate in a luminous flame, the colour of the bead becomes green.
Statement-II : Copper(I) metaborate is colourless.

35. **Statement-I :** Aniline on reaction with $NaNO_2$/HCl at 0°C followed by coupling with β-naphthol gives a dark blue coloured precipitate.
Statement-II : The colour of the compound formed in the reaction of aniline with $NaNO_2$/HCl at 0°C followed by coupling with β-naphthol is due to the extended conjugation.

36. **Statement-I :** Aniline is less basic than acetamide.
Statement-II : In aniline, the lone pair of electrons on nitrogen atom is delocalised over benzene ring due to resonance and hence less available to a proton.

37. **Statement-I :** The acidic strength of monosubstituted nitrophenol is higher than phenol because of electron withdrawing nitro group.
Statement-II : *o*-Nitrophenol, *m*-nitrophenol and *p*-nitrophenol will have same acidic strength as they have one nitro group attached to the phenolic ring.

38. **Statement-I :** In Lucas test, primary, secondary and tertiary alcohols are distinguished on the basis of their reactivity with conc. HCl + $ZnCl_2$, known as Lucas Reagent.
Statement-II : Primary alcohols are most reactive and immediately produce turbidity at room temperature on reaction with Lucas Reagent.

39. **Statement-I :** The chlorides of both Be and Al have Cl-bridged structure, soluble in organic solvents and act as Lewis bases.
Statement-II : Hydroxides of Be and Al dissolve in excess alkali to give beryllate and aluminate ions.

40. **Statement-I :** $Al(OH)_3$ is amphoteric in nature.
Statement-II : Al—O and O—H bonds can be broken with equal ease in $Al(OH)_3$.

41. **Statement-I :** Although PF_5, PCl_5 and PBr_5 are known, the pentahalides of nitrogen have not been observed.
Statement-II : Phosphorus has higher electronegativity than nitrogen.

42. **Statement-I :** Potassium permanganate, on heating at 573 K forms potassium manganate.
Statement-II : Both potassium permanganate and potassium manganate are tetrahedral and paramagnetic in nature.

43. **Statement-I :** Zn^{2+} is paramagnetic.
Statement-II : The electrons are lost from 3*d*-orbital to form Zn^{2+}.

44. **Statement-I :** Both SO_2 and H_2O possess V-shaped structures.
Statement-II : The bond angle of SO_2 is less than that of H_2O.

45. **Statement-I :** Both *trans*-pent-2-ene and *trans*-but-2-ene are non-polar.
Statement-II : The polarity of *cis*-isomer is more than *trans-isomer*, which is either non-polar or less polar.

ASSERTION AND REASON TYPE

Directions : In the following questions (46 to 60), a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as :
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) Both A and R are false.

46. **Assertion (A) :** Phenol forms 2, 4, 6-tribromophenol on treatment with Br_2- water at 273 K.
Reason (R) : Phenol is *o*, *p*-directing group.

47. **Assertion (A) :** Phenol is more acidic than ethanol.
Reason (R) : Phenoxide ion is resonance stabilised.

48. **Assertion (A) :** Chloroform is stored in dark coloured bottles.
Reason (R) : Chronic chloroform exposure may cause damage to liver and kidneys.

49. **Assertion (A) :** In Zeise's salt, the coordination number of Pt is five.
Reason (R) : Ethene is a bidentate ligand.

50. **Assertion (A) :** $Co[Hg(SCN)_6]$ and $Hg[Co(SCN)_6]$ are isomers.
Reason (R) : SCN^- is a stronger ligand as compared to NCS^-.

51. **Assertion (A) :** One atomic mass unit is defined as one-twelfth of the mass of one carbon-12 atom.

Reason (R) : Carbon-12 isotope is the most abundant isotope of carbon and has been chosen as standard.

52. **Assertion (A) :** Mixture of CH_3COOH and CH_3COONH_4 is an example of acidic buffer.
Reason (R) : Acidic buffer contains equimolar mixture of weak acid and its salt with weak base.

53. **Assertion (A) :** Both $\pi(2p_x)$ and $\pi^*(2p_x)$ MO's have one nodal plane each.
Reason (R) : All MO's formed by side way overlapping of $2p$-orbitals have one nodal plane.

54. **Assertion (A) :** Molecular nitrogen is less reactive than molecular oxygen.
Reason (R) : The bond length of N_2 is shorter than that of oxygen.

55. **Assertion (A) :** The electron gain enthalpy of N is positive while that of P is negative.
Reason (R) : This is due to the smaller atomic size of N in which there is a considerable electron-electron repulsion and hence the additional electron is not accepted easily.

56. **Assertion (A) :** Fine lines are observed in spectra if an atom is placed in a magnetic field.
Reason (R) : Degenerate orbitals split in the presence of magnetic field.

57. **Assertion (A) :** Phenol and benzoic acid can be distinguished by Na_2CO_3.
Reason (R) : Benzoic acid is a stronger acid than phenol, hence reacts with Na_2CO_3.

58. **Assertion (A) :** Direct attachment of groups such as phenyl or vinyl to the carboxylic acid, increases the acidity of the carboxylic acid.
Reason (R) : Resonance effect always increases the acidity of carboxylic acids.

59. **Assertion (A) :** Coordination number of Fe and Co in $[Fe(C_2O_4)_3]^{3-}$ and $[Co(en)_3]^{3+}$ is 6.
Reason (R) : $C_2O_4^{2-}$ and *en* (ethane-1,2-diamine) are didentate ligands.

60. **Assertion (A) :** According to crystal field theory, during complex formation, the *d*-orbitals split and form two sets of orbitals t_{2g} and e_g.
Reason (R) : Splitting of *d*-orbitals occurs only in case of strong field ligands.

SOLUTIONS

1. **(c) :** $\text{Rate} = -\frac{1}{4}\frac{d[KClO_3]}{dt} = \frac{1}{3}\frac{d[KClO_4]}{dt} = \frac{d[KCl]}{dt}$

$\therefore \quad \frac{k_1}{4}[KClO_3]^4 = \frac{k_2}{3}[KClO_3]^4 = k_3[KClO_3]^4$

$\therefore \quad 3k_1 = 4k_2 = 12k_3$

2. **(d) :** $hv_1 = hv_0 + K.E.$ ...(i)

$hv_2 = hv_0 + \frac{1}{2}K.E.$ or $2hv_2 = 2hv_0 + K.E.$ ...(ii)

Subtracting eqn. (ii) from eqn. (i) gives ;

$hv_1 - 2hv_2 = hv_0 - 2hv_0$

or $v_1 - 2v_2 = -v_0$ or $v_0 = 2v_2 - v_1$

3. **(a)**

4. **(c) :** Applying $\frac{W_{Cu}}{W_{Ag}} = \frac{E_{Cu}}{E_{Ag}}$

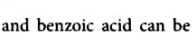
$W_{Cu} = \frac{31.75}{108} \times 10.79 \approx 3.2 \text{ g}$

5. **(a) :** $\Delta S_{(A \to B)} = \Delta S_{(A \to C)} + \Delta S_{(C \to D)} - \Delta S_{(B \to D)}$
$= 50 + 30 - 20 = 60$ e.u.

6. **(b) :** (A) has $3p$ and $3d$ electrons.
(B) has both $3d$ electrons.
(C) has $4d$ and $3d$ electrons.
As (B) has both electrons from $3d$-orbital so these are from degenerate orbitals.

7. **(b)**

8. **(c) :** Conjugated means alternate single and double bonds.



is a conjugated diketone as it has alternate double and single bonds.

9. **(c)**

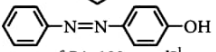
10. **(d) :** The H at C – 2 is most likely to migrate at C – 3 because the carbocation developed at C – 2 is the most stable due to $+M$ effect of oxygen atom.

11. **(d) :** In this reaction, Cu gets reduced as its oxidation state changes from +2 (in CuO) to 0 (in Cu).

12. **(c) :** The ionisation energy of elements decreases down the group because as one moves down a group, electrons are located in successively higher energy levels, farther away from the attraction of the nucleus. On the other hand, across a period, ionisation energy increases. As elements have successively more electrons across a period, atoms get closer and closer to their goal of achieving an octet. So removal of electrons becomes difficult as atoms approach an octet. Therefore, the correct increasing order of first ionisation energy of the given elements is $R < P < T < Q < S$.

13. (c) **14. (c)** **15. (d)**

16. (99) : (*A*) is  ;

(*B*) is 

Molar mass of *B* is 198 g mol^{-1}.

$\therefore \quad x = 198 ; \frac{x}{2} = \frac{198}{2} = 99$

17. (6) : Decapeptide + $9H_2O \longrightarrow$ Glycine + Alanine + Phenylalanine

Total weight of amino acids after addition of 9 moles of $H_2O = 796 + (9 \times 18) = 958$

For *n* units of glycine, $\frac{n \times 75}{958} \times 100 = 47 \Rightarrow n = 6$

18. (12)

19. (5) : $\underset{(X)}{3B_2H_6} + 6NH_3 \xrightarrow{\text{Heat}} \underset{(Y)}{2B_3N_3H_6} + 12H_2$

$X = B_2H_6$; $Y = B_3N_3H_6$ (Inorganic benzene)

Total no. of boron atoms = 2 + 3 = 5

20. (3) :

S_8	sp^3-hybridisation
SO_4^{2-}	sp^3-hybridisation
SO_3	sp^2-hybridisation
H_2S	sp^3-hybridisation
SCl_4	sp^3d-hybridisation

21. (6) **22. (8)**

23. (7) : Bond orders :

$Li_2 = 1$, $He_2^+ = 0.5$, $N_2^+ = 2.5$, $N_2^{2-} = 2$, $O_2^+ = 2.5$,

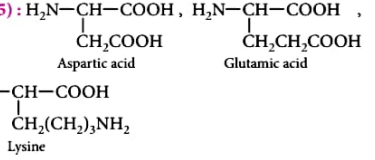
$O_2^{2-} = 1.0$, $O_2^- = 1.5$, $CO_3^{2-} = 1.33$, $C_6H_6 = 1.5$, $O_3 = 1.5$

24. (52) : $k_1 = k_2$

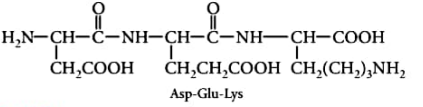
$10^8 \, e^{-\frac{6000}{8.34T}} = 10^{10} e^{-\frac{8000}{8.34T}}$

$\frac{10^{10}}{10^8} = e^{\frac{2000}{8.34T}} \Rightarrow 2.303 \log 100 = \frac{2000}{8.34\,T}$

$\Rightarrow \quad T = \frac{2000}{2.303 \times 2 \times 8.34} = 52 \text{ K}$

25. (5) : 

Aspartic acid, Glutamic acid, Lysine



Asp-Glu-Lys

26. (3)

27. (3155) : Kinetic energy in Bohr atom $= \frac{n^2h^2}{8m\pi^2r^2}$

For second Bohr orbit, $n = 2$, $r_2 = (2)^2 a_0 = 4a_0$

$$\text{K.E.} = \frac{(2)^2h^2}{8 \times m(4a_0)^2 \times \pi^2} = \frac{h^2}{32\pi^2 a_0^2 m} \quad \text{...(i)}$$

Given, $\text{K.E.} = \frac{h^2}{xma_0^2}$ ...(ii)

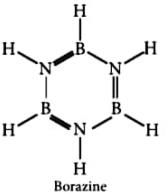
$x = 32\pi^2$

$10x = 32 \times 10 \times 3.14 \times 3.14 = 3155$

28. (3) : $3B_2H_6 + 6NH_3 \xrightarrow{\text{low temp.}} 3[B_2H_6 \cdot 2NH_3]$

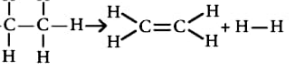
$2B_3N_3H_6 + 12H_2 \xleftarrow[473\text{ K}]{\Delta}$

Borazine



Borazine

29. (8) : It has three chiral carbon atoms, hence number of stereoisomers (2^3) will be 8.

30. (128) : 

$\Delta_r H$ = (total bond enthalpies of reactants) – (total bond enthalpies of products)

$= (1 \times \Delta_{C-C}H + 6 \times \Delta_{C-H}H) - (\Delta_{C=C}H + 4 \times \Delta_{C-H}H + 1 \times \Delta_{H-H}H)$

$= (347 + 6 \times 414) - (611 + 4 \times 414 + 436)$

$= (2831) - (2703) = 128 \text{ kJ mol}^{-1}$

31. (c) : In acetic acid ($C_\alpha H_3$—COOH), α-hydrogen atoms are present. So, acetic acid has α-hydrogen.

32. (c) **33. (c)**

34. (d) : The blue colour obtained is due to copper(II) metaborate while copper(I) metaborate is colourless.

35. (d)

36. (d): Aniline is more basic than acetamide because in acetamide, lone pair of nitrogen is delocalised on more electronegative element oxygen and lone pair of N-atom is delocalised over benzene ring.

37. (c): Electron withdrawing groups (*e.g.*, $-NO_2$) stabilise the phenoxide ion more by dispersing the negative charge relative to phenol (*i.e.*, release of proton becomes easy) and thus, increase the acidic strength of phenols. The particular effect is more when the substituent is present on *o*- and *p*-positions than in *m*-position with respect to the phenolic group. Thus, acidic strength of nitrophenols decreases in the order : *p*-nitrophenol > *o*-nitrophenol > *m*-nitrophenol > phenol.

38. (c): Tertiary alcohols are most reactive and immediately produce turbidity at room temperature while primary alcohols do not react with Lucas reagent at room temperature.

39. (d): The chlorides of both beryllium and aluminium have Cl-bridged structure in vapour phase. Both the chlorides are soluble in organic solvents and are strong Lewis acids. Beryllium hydroxide dissolves in excess of alkali to give beryllate $[Be(OH)_4]^{2-}$ while aluminium hydroxide gives aluminate, $[Al(OH)_4]^-$.

40. (a): The basic nature of the hydroxides of group 13 elements increases down the group. Small size of boron atom is responsible for high positive charge density on atom. This pulls off electrons from water molecules resulting in the weakening of O–H bond and, therefore facilitates the release of proton giving acidic solution. As the size of the ion increases, the tendency to rupture the O–H bond decreases and hence acidic nature decreases, *i.e.*, basic nature increases. Hence, $Al(OH)_3$ and $Ga(OH)_3$ are amphoteric in nature.

41. (c): Nitrogen cannot expand its octet because of absence of *d*-orbitals in its valence shell.

42. (c): $2KMnO_4 \xrightarrow[\Delta]{573\ K} K_2MnO_4 + MnO_2 + O_2$

Potassium permanganate — Potassium manganate

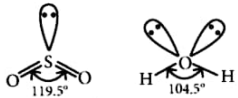
Potassium permanganate is diamagnetic while potassium manganate is paramagnetic. Both of these are tetrahedral.

43. (b): Zn : $\boxed{\uparrow\downarrow}\ \boxed{\uparrow\downarrow}\ \boxed{\uparrow\downarrow}\ \boxed{\uparrow\downarrow}\ \boxed{\uparrow\downarrow}$ (3*d*) $\boxed{\uparrow\downarrow}$ (4*s*)

Zn^{2+} : $\boxed{\uparrow\downarrow}\ \boxed{\uparrow\downarrow}\ \boxed{\uparrow\downarrow}\ \boxed{\uparrow\downarrow}\ \boxed{\uparrow\downarrow}$ $\square$

Since in Zn^{2+} there are no unpaired electrons, hence Zn^{2+} is diamagnetic.

44. (c):



Hybridisation sp^2 — Hybridisation sp^3

Both SO_2 and H_2O possess V-shaped structures, but the bond angle of H_2O < SO_2 because of the presence of two lone pairs in H_2O, due to which repulsion is greater (*lp-lp* repulsion), so bond angle decreases to a greater extent.

45. (d)

46. (b): Phenol forms 2, 4, 6-tribromophenol on treatment with Br_2-water. In phenols, the polarisation of bromine takes place even in the absence of Lewis acid.

47. (a)

48. (b): Chloroform is slowly oxidised by air in the presence of light to an extremely poisonous gas 'phosgene'. Therefore, it is stored in dark bottles, completely filled so that air is kept out.

49. (d): Zeise's salt : $\left[\begin{array}{l} \quad\quad Cl \\ H_2C \quad | \\ \quad\ \| \!-\! Pt \!-\! Cl \\ H_2C \quad | \\ \quad\quad Cl \end{array}\right]$

Coordination no. of Pt is four.
Ethylene is a monodentate ligand.

50. (c): $Co[Hg(SCN)_6]$ and $Hg[Co(SCN)_6]$ are ionisation isomers. NCS^- is a stronger ligand than SCN^-.

51. (b)

52. (d): CH_3COOH/CH_3COONH_4 is not an example of acidic buffer. Acidic buffer contains equimolar mixture of weak acid and its salt with strong base.
e.g., CH_3COOH/CH_3COONa

53. (d): $\pi(2p_x)$ has one nodal plane whereas $\pi^*(2p_x)$ has two nodal planes.

54. (a): Bond order of $N_2 = 3$, bond order of $O_2 = 2$.
Higher the bond order, shorter is the bond length and higher is the bond dissociation energy *i.e.*, higher stability or lesser reactivity. Thus, N_2 is less reactive than O_2.

55. (a) **56. (a)** **57. (a)**

58. (c): This is due to greater electronegativity of sp^2 hybridised carbon to which carboxyl carbon is attached.

59. (a)

60. (c): Splitting of orbitals takes place for both weak field and strong field ligands. Pairing of electrons in these orbitals depends on the strength of the field.

PRACTICE PAPER
NEET 2024

SECTION - A

1. What weight of HCl is present in 155 mL of a 0.54 M solution?
   (a) 3.06 g (b) 6.12 g
   (c) 1.53 g (d) 0.30 g

2. Which of the following has been arranged in the increasing order of freezing point?
   (a) 0.025 M KNO_3 < 0.1 M NH_2CSNH_2 < 0.05 M $BaCl_2$ < 0.1 M NaCl
   (b) 0.1 M NaCl < 0.05 M $BaCl_2$ < 0.1 M NH_2CSNH_2 < 0.025 M KNO_3
   (c) 0.1 M NH_2CSNH_2 < 0.1 M NaCl < 0.05 M $BaCl_2$ < 0.025 M KNO_3
   (d) 0.025 M KNO_3 < 0.05 M $BaCl_2$ < 0.1 M NaCl < 0.1 M NH_2CSNH_2

3. A hydrocarbon reacts with HI to give (*X*) which on reaction with aqueous KOH forms (*Y*). Oxidation of (*Y*) gives 3-methyl-2-butanone. The hydrocarbon is
   (a) $CH_3CH{=}\overset{\overset{CH_3}{|}}{C}{-}CH_3$
   (b) $CH_2{=}CH{-}\underset{\underset{CH_3}{|}}{CH}{-}CH_3$
   (c) $CH_3{-}CH_2{-}\underset{\underset{CH_3}{|}}{C}{=}CH_2$
   (d) $CH{\equiv}C{-}\underset{\underset{CH_3}{|}}{CH}{-}CH_3$

4. The equilibrium constant of the reaction :
   $A_{(s)} + 2B^+_{(aq)} \rightleftharpoons A^{2+}_{(aq)} + 2B_{(s)}; E^\circ_{cell} = 0.0295$ V is
   $\left[\text{Given, } \frac{2.303\,RT}{F} = 0.059\right]$
   (a) 10 (b) 2×10^2
   (c) 3×10^2 (d) 2×10^5

5. **Assertion :** Boron can only form $[BF_4]^-$, whereas aluminium forms $[AlF_6]^{3-}$.
   Reason : The first member of a group of elements in the *s*- and *p*-blocks shows anomalous behaviour.
   (a) If both assertion and reason are true and reason is the correct explanation of assertion.
   (b) If both assertion and reason are true but reason is not the correct explanation of assertion.
   (c) If assertion is true but reason is false.
   (d) If both assertion and reason are false.

6. Which of the following is not the correct order of stability of carbocations?
   (a) $Ph_3C^+ > Ph_2CH^+ > PhCH_2^+$
   (b) $(CH_3)_3C^+ > CH_3{-}\overset{+}{C}H_2 > (CH_3)_2\overset{+}{C}H$
   (c) $CH_2{=}CH{-}CH_2^+ > CH_3CH_2^+ > HC{\equiv}C^+$
   (d) $p\text{-}CH_3O{-}C_6H_4CH_2^+ > p\text{-}CH_3{-}C_6H_4CH_2^+ > p\text{-}NO_2{-}C_6H_4CH_2^+$

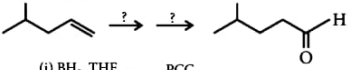
7. One mole of an ideal gas at 300 K is expanded isothermally from an initial volume of 1 litre to 10 litres. The ΔE (internal energy) for this process is (R = 2 cal mol^{-1} K^{-1})
   (a) 1381.1 cal (b) zero
   (c) 163.7 cal (d) 9 L atm

8. **Assertion :** $CH_3{-}\underset{\underset{Br}{|}}{CH}{-}CH_2CH_3$ on reaction with alcoholic KOH gives $CH_3CH{=}CHCH_3$ as a result of dehydrohalogenation.
   Reason : Elimination reaction takes place in accordance with Markownikoff's rule.
   (a) If both assertion and reason are true and reason is the correct explanation of assertion.
   (b) If both assertion and reason are true but reason is not the correct explanation of assertion.
   (c) If assertion is true but reason is false.
   (d) If both assertion and reason are false.

9. In $Fe(CO)_5$, the Fe—C bond possesses
(a) ionic character (b) σ-character only
(c) π-character only
(d) both σ and π-character.

10. The equilibrium constant of a reaction is 0.008 at 298 K. The standard free energy change of the reaction at the same temperature is
(a) +11.96 kJ (b) −11.96 kJ
(c) −5.43 kJ (d) −8.46 kJ

11. The suitable reaction steps to carry out the following transformation are



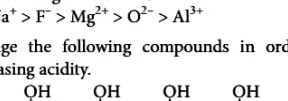
(a) $\xrightarrow[(ii)\ H_2O_2,\ NaOH]{(i)\ BH_3,\ THF} \xrightarrow[CH_2Cl_2]{PCC}$
(b) $\xrightarrow[(ii)\ H_2O_2,\ NaOH]{(i)\ BH_3,\ THF} \xrightarrow{HIO_4}$
(c) $\xrightarrow{H_2O,\ H_2SO_4} \xrightarrow[CH_2Cl_2]{PCC}$
(d) $\xrightarrow[(CH_3)_3CCOOH,\ OH^-]{OsO_4} \xrightarrow[H_2O]{K_2Cr_2O_7,\ H_2SO_4}$

12. The rate of the reaction, $N_{2(g)} + 3H_{2(g)} \longrightarrow 2NH_{3(g)}$, was measured as $\frac{d}{dt}[NH_3] = 2 \times 10^{-4}$ mol L^{-1} s^{-1}
The rate of the reaction expressed in terms of N_2 and H_2 are

	Rates in terms of N_2 ($mol\ L^{-1}\ s^{-1}$)	Rate in terms of H_2 ($mol\ L^{-1}\ s^{-1}$)
(a)	1×10^{-4}	3×10^{-4}
(b)	3×10^{-4}	1×10^{-4}
(c)	1×10^{-4}	1×10^{-4}
(d)	2×10^{-4}	2×10^{-4}

13. The correct sequence which shows decreasing order of the ionic radii of the element is
(a) $O^{2-} > F^- > Na^+ > Mg^{2+} > Al^{3+}$
(b) $Al^{3+} > Mg^{2+} > Na^+ > F^- > O^{2-}$
(c) $Na^+ > Mg^{2+} > Al^{3+} > O^{2-} > F^-$
(d) $Na^+ > F^- > Mg^{2+} > O^{2-} > Al^{3+}$

14. Arrange the following compounds in order of decreasing acidity.



(I) (II) (III) (IV)

(a) IV > III > I > II (b) II > IV > I > III
(c) I > II > III > IV (d) III > I > II > IV

15. Match each coordination compound in List-I with an appropriate pair of characteristics from List-II and select the correct option.
(*en* = $H_2NCH_2CH_2NH_2$; atomic numbers : Ti = 22; Cr = 24; Co = 27; Pt = 78)

List-I		List-II	
(P)	$[Cr(NH_3)_4Cl_2]Cl$	1.	Paramagnetic and exhibits ionisation isomerism
(Q)	$[Ti(H_2O)_5Cl](NO_3)_2$	2.	Diamagnetic and exhibits *cis-trans* isomerism
(R)	$[Pt(en)(NH_3)Cl]NO_3$	3.	Paramagnetic and exhibits *cis-trans*
(S)	$[Co(NH_3)_4(NO_3)_2]NO_3$	4.	Diamagnetic and exhibits ionisation isomerism

	P	Q	R	S
(a)	4	2	3	1
(b)	3	1	4	2
(c)	2	1	3	4
(d)	1	3	4	2

16. For the dissociation reaction $N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$, the degree of dissociation (α) in terms of K_p and total equilibrium pressure P is
(a) $\alpha = \sqrt{\frac{4P + K_p}{K_p}}$ (b) $\alpha = \sqrt{\frac{K_p}{4P + K_p}}$
(c) $\alpha = \sqrt{\frac{K_p}{4P}}$ (d) none of these.

17. Which of the following statements is not correct?
(a) Replacement of halogen by $—NH_2$ in alkyl halide is a nucleophilic substitution reaction.
(b) Aryl halides show more reactivity as compared to alkyl halides in the replacements of halogen by the $—NH_2$ group.
(c) During the replacement of halogen by $—NH_2$ group, ammonia is taken in large excess so as to avoid the formation of 2° and 3° amines.
(d) Tertiary alkyl halide generally produces alkene instead of the replacement of halogen by $—NH_2$ group.

18. Match column I with column II and select the correct option.

Column I (Species)		Column II (Bond order)	
(A)	O_2^{2+}	(p)	1.0
(B)	O_2	(q)	2.0
(C)	F_2	(r)	2.5
(D)	O_2^+	(s)	3.0

(a) (A) → (s); (B) → (p); (C) → (q); (D) → (r)
(b) (A) → (q); (B) → (r); (C) → (p); (D) → (s)
(c) (A) → (s); (B) → (q); (C) → (p); (D) → (r)
(d) (A) → (r); (B) → (s); (C) → (p); (D) → (q)

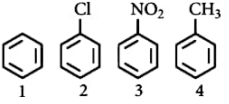
19. A 5.82 g silver coin is dissolved in nitric acid. When sodium chloride is added to the solution, all the silver is precipitated as AgCl. The AgCl precipitate weighs 7.20 g. The percentage of silver in the coin is
(a) 60.3% (b) 80.4% (c) 93.1% (d) 70%

20. What will be the $\Delta H°$ and $\Delta S°$ values for the given cell having $E°$ at 20°C and 30°C to be 0.18 V and 0.28 V respectively?
The cell : (Pt) $H_2|H^+ || KCl|Hg_2Cl_2|Hg$
(Given : 1 F = 96500 coulombs)
(a) $\Delta S° = 2017\ J\ K^{-1}$ and $\Delta H° = 630.54$ kJ
(b) $\Delta S° = -4532\ J\ K^{-1}$ and $\Delta H° = 768.73$ kJ
(c) $\Delta S° = 3425\ J\ K^{-1}$ and $\Delta H° = -530.75$ kJ
(d) $\Delta S° = 1930\ J\ K^{-1}$ and $\Delta H° = 530.75$ kJ

21. **Statement 1 :** If the uncertainty in position is same for two particles of different mass then uncertainty in momentum is also same.
Statement 2 : The product of the uncertainty in position and the uncertainty in momentum is same irrespective of the mass of the particles.
(a) Statement 1 is true but statement 2 is false.
(b) Both statement 1 and statement 2 are false.
(c) Both statement 1 and statement 2 are true.
(d) Statement 1 is false but statement 2 is true.

22. An aqueous solution of a substance gives a white precipitate on treatment with dilute hydrochloric acid, which dissolves on heating. When hydrogen sulphide is passed through the hot acidic solution, a black precipitate is obtained. The substance is a
(a) Hg_2^{2+} salt (b) Cu^{2+} salt
(c) Ag^+ salt (d) Pb^{2+} salt.

23. The decreasing order of reactivity towards electrophilic substitution of the following compounds is



(a) 1 > 3 > 4 > 2 (b) 4 > 1 > 3 > 2
(c) 4 > 1 > 2 > 3 (d) 1 > 4 > 3 > 2

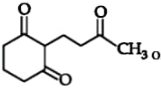
24. A buffer solution is made up of acetic acid [$pK_a = 5$] having conc. = 1.5 M and sodium acetate having conc. = 0.15 M. What is the number of OH^- ions present in 1 litre solution?
(a) $10^{-10} N_A$ (b) $10^{-4} N_A$
(c) $10^{-3} N_A$ (d) $10^{-6} N_A$

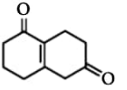
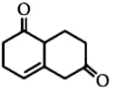
25. On passing C ampere of current for time t sec through 1 litre of 2 M $CuSO_4$ solution (atomic weight of Cu = 63.5), the amount m of Cu (in g) deposited on cathode will be

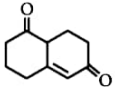
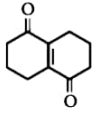
(a) $m = \frac{Ct}{(63.5 \times 96500)}$ (b) $m = \frac{Ct}{(31.25 \times 96500)}$

(c) $m = \frac{C \times 96500}{(31.75 \times t)}$ (d) $m = \frac{31.75 \times C \times t}{96500}$

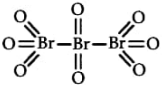
26. **Assertion :** The number of collisions per second per unit volume of the reaction mixture is known as collision frequency.
Reason : The rate of reaction having negative order with respect to a reactant decreases with the increase in concentration of the reactant.
(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

27.  on aldol condensation followed by heating gives

(a) 
(b) 

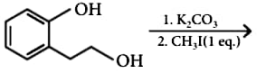
(c)  (d) 

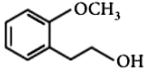
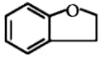
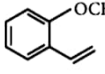
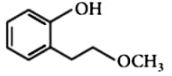
28. Oxidation number of bromine in sequence in Br_3O_8 is



(a) +8, +6, +8 (b) +6, +4, +6
(c) 0, 0, 0 (d) +8, +4, +3

29. The major product of the following reaction is



(a) 
(b) 
(c)  (d) 

30. The number of radial nodes of 3*p* and 2*s*-orbitals are respectively
(a) 2, 0 (b) 0, 2 (c) 1, 1 (d) 1, 2

31. Amongst $[NiCl_4]^{2-}$, $[Ni(H_2O)_6]^{2+}$, $[Ni(PPh_3)_2Cl_2]$, $[Ni(CO)_4]$ and $[Ni(CN)_4]^{2-}$, the paramagnetic species are
(a) $[NiCl_4]^{2-}$, $[Ni(H_2O)_6]^{2+}$, $[Ni(PPh_3)_2Cl_2]$
(b) $[Ni(CO)_4]$, $[Ni(PPh_3)_2Cl_2]$, $[NiCl_4]^{2-}$
(c) $[Ni(CN)_4]^{2-}$, $[Ni(H_2O)_6]^{2+}$, $[NiCl_4]^{2-}$
(d) $[Ni(PPh_3)_2Cl_2]$, $[Ni(CO)_4]$, $[Ni(CN)_4]^{2-}$

32. Heating an aqueous solution of aluminium chloride to dryness will give
(a) $AlCl_3$ (b) Al_2Cl_6
(c) Al_2O_3 (d) $Al(OH)Cl_2$

33. The correct increasing order of *s*-character (in percentage) in the hybrid orbitals in the given molecules/ions is
(assume all hybrid orbitals are exactly equivalent)

CO_3^{2-}	XeF_4	I_3^-	NCl_3	$BeCl_2$
I	II	III	IV	V

(a) II < III < IV < I < V
(b) II < IV < III < V < I
(c) III < II < I < V < IV
(d) II < IV < III < I < V

34. $C_7H_8 \xrightarrow{3Cl_2/\Delta} A \xrightarrow{Br_2/Fe} B \xrightarrow{Zn/HCl} C$
The compound *C* is
(a) *o*-bromotoluene
(b) *m*-bromotoluene
(c) *p*-bromotoluene
(d) 3-bromo-2, 2, 6-trichlorotoluene.

35. Glucose $\xrightarrow{HCN}$ $\xrightarrow{Hydrolysis}$ $\xrightarrow{HI/heat} A$
The final product *A* is
(a) heptanoic acid (b) 2-iodohexane
(c) heptane (d) heptanol.

SECTION - B

Attempt any 10 questions out of 15.

36. **Assertion :** $Na_2Cr_2O_7$ is not a primary standard in volumetric analysis.
Reason : $Na_2Cr_2O_7$ is hygroscopic.
(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

37. The osmotic pressure of a solution containing 300 mg of a non-volatile, non-ionising, and non-associating solute in 100 mL of water at 27°C was found to be 1.23 atmosphere. The molar mass of the solute in g mol^{-1} is ($R = 8.2 \times 10^{-2}$ L atm $K^{-1}mol^{-1}$)
(a) 40 (b) 120 (c) 60 (d) 180

38. The dark purple colour of $KMnO_4$ disappears in the titration with oxalic acid in acidic medium. The overall change in the oxidation number of manganese in the reaction is
(a) 5 (b) 1 (c) 7 (d) 2

39. **Statement I :** α and β forms of sulphur can change reversibly between themselves with slow heating or slow cooling.
Statement II : At room temperature, the stable crystalline form of sulphur is monoclinic sulphur.

(a) Statement I is false but statement II is true.
(b) Both statement I and statement II are true.
(c) Statement I is true but statement II is false.
(d) Both statement I and statement II are false.

40. When copper is treated with a certain concentration of nitric acid, nitric oxide and nitrogen dioxide are liberated in equal volumes according to the equation,

$x\text{Cu} + y\text{HNO}_3 \rightarrow x\text{Cu(NO}_3)_2 + \text{NO} + \text{NO}_2 + 3\text{H}_2\text{O}$

The coefficients x and y respectively are

(a) 2 and 3 (b) 2 and 6
(c) 1 and 3 (d) 3 and 8

41. The complex ion which has no d electrons in the central metal atom is

(a) $[MnO_4]^-$ (b) $[Co(NH_3)_6]^{3+}$
(c) $[Fe(CN)_6]^{3-}$ (d) $[Cr(H_2O)_6]^{3+}$

42. Which of the following arrangements does not represent the correct order of the property stated against it?

(a) Sc < Ti < Cr < Mn : number of oxidation states
(b) $V^{2+} < Cr^{2+} < Mn^{2+} < Fe^{2+}$: paramagnetic behaviour
(c) $Ni^{2+} < Co^{2+} < Fe^{2+} < Mn^{2+}$: ionic size
(d) $Co^{3+} < Fe^{3+} < Cr^{3+} < Sc^{3+}$: stability in aqueous solution

43. The azide ion N_3^- can be obtained from hydrazoic acid HN_3. Identify the correct statement about the structure of azide ion.

(a) Isoelectronic with I_3^-.
(b) Isostructural to O_3.
(c) Symmetrical and linear.
(d) Bent having bond angle of about 109°.

44. Consider the reaction, $2A + B \rightarrow$ products. When concentration of B alone was doubled, the half-life did not change. When the concentration of A alone was doubled, the rate increased by two times. The unit of rate constant for this reaction is

(a) s^{-1} (b) L mol^{-1} s^{-1}
(c) no unit (d) mol L^{-1} s^{-1}

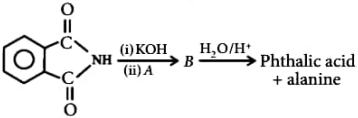
45. For the identification of β-naphthol using dye test, it is necessary to use

(a) dichloromethane solution of β-naphthol
(b) acidic solution of β-naphthol
(c) neutral solution of β-naphthol
(d) alkaline solution of β-naphthol.

46. The difference in ΔH and ΔU for the combustion of methane forming water in liquid state at 25°C would be

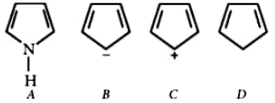
(a) zero (b) $2 \times 298 \times (-2)$ cal
(c) $2 \times 298 \times (-3)$ cal (d) $2 \times 25 \times (-3)$ cal

47. Identify A in the following reaction :



(a) $Cl-CH_2-COOC_2H_5$
(b) $Cl-\underset{\displaystyle CH_3}{\underset{|}{CH}}-COOH$
(c) $Cl-\underset{\displaystyle CH_3}{\underset{|}{CH}}-NH_2$ (d) $Cl-\underset{\displaystyle C_6H_5}{\underset{|}{CH}}-COOH$

48. Which of the following compounds are aromatic?



(a) A, B (b) A, B, C
(c) B, C (d) B, C, D

49. Which of the following is the major species in a solution of lysine at pH = 3.5?

(a) $H_3\overset{+}{N}-\underset{\displaystyle (CH_2)_4}{\underset{|}{\underset{\displaystyle {}^+NH_3}{\underset{|}{CH}}}}-COOH$
(b) $H_2N-\underset{\displaystyle (CH_2)_4}{\underset{|}{\underset{\displaystyle {}^+NH_3}{\underset{|}{CH}}}}-COOH$
(c) $H_2N-\underset{\displaystyle (CH_2)_4}{\underset{|}{\underset{\displaystyle {}^+NH_3}{\underset{|}{CH}}}}-COO^-$
(d) $H_2N-\underset{\displaystyle (CH_2)_4}{\underset{|}{\underset{\displaystyle NH_2}{\underset{|}{CH}}}}-COO^-$

50. Which of the following statements is not true?

(a) Halogens act as strong oxidising agents.
(b) Fluorine oxidises water to oxygen and ozone.
(c) Iodine has good solubility in water.
(d) Solubility of iodine in water increases by adding KI due to formation of I_3^- ions.

SOLUTIONS

1. (a): $\text{Molarity} = \dfrac{\text{No. of moles of solute}}{\text{Volume of solution (in litres)}}$

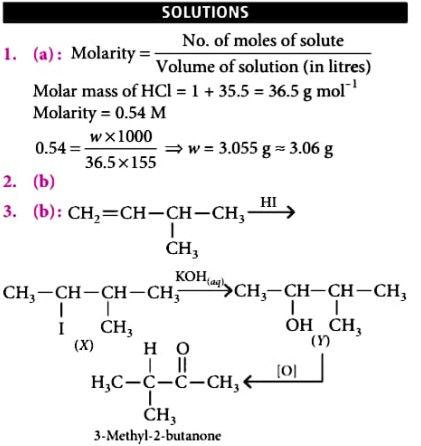
Molar mass of HCl = 1 + 35.5 = 36.5 g mol^{-1}

Molarity = 0.54 M

$$0.54 = \frac{w \times 1000}{36.5 \times 155} \Rightarrow w = 3.055 \text{ g} \approx 3.06 \text{ g}$$

2. (b)

3. (b):



3-Methyl-2-butanone

4. (a): $E^{\circ}_{cell} = \dfrac{0.0591}{n} \log_{10} K$

$n = 2$, $E^{\circ}_{cell} = 0.0295$ V ; $0.0295 = \dfrac{0.0591}{2} \log_{10} K$

K = antilog (0.998) = 9.96 ≈ 10

5. (b)

6. (b): Correct stability order is,

$(CH_3)_3\overset{+}{C} > (CH_3)_2\overset{+}{C}H > CH_3-\overset{+}{C}H_2$.

7. (b): Change in internal energy depends upon temperature. At constant temperature, the internal energy of the gas remains constant, so $\Delta E = 0$.

8. (c): Elimination reaction takes place in accordance with Saytzeff's rule.

9. (d): In metal carbonyls, the metal—carbon bond possesses both σ and π-character.

10. (a): $\Delta G^{\circ} = -2.303\, RT \log K$

$\Delta G^{\circ} = -2.303 \times 8.314 \times 298 \log (0.008)$

$\Delta G^{\circ} = -5705.84 \times -2.09$

$\Delta G^{\circ} = +11964.65$ J or +11.96 kJ

11. (a)

12. (a): $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$

$$\text{Rate} = -\frac{d[N_2]}{dt} = -\frac{1}{3}\frac{d[H_2]}{dt} = \frac{1}{2}\frac{d[NH_3]}{dt}$$

$$\frac{1}{2}\frac{d[NH_3]}{dt} = -\frac{d[N_2]}{dt} = \frac{2\times10^{-4}}{2} = 1 \times 10^{-4}$$

$$-\frac{d[H_2]}{dt} = \frac{3}{2}\frac{d[NH_3]}{dt} = \frac{3}{2}\times 2\times10^{-4} = 3 \times 10^{-4}$$

13. (a) **14. (d)**

15. (b): P : Cr^{3+} has $3d^3$ configuration, with 3 unpaired electrons. Hence, it shows paramagnetic behaviour. Complex of the type Ma_4b_2 shows *cis-trans* isomerism.

Q : Ti^{3+} has $3d^1$ configuration, hence shows paramagnetic behaviour. Ligands Cl^- and NO_3^- can be exchanged. Thus, it shows ionisation isomerism.

R : Pt^{2+} has $5d^8$ configuration but ligands are strong field ligands hence, it forms square planar complex. Thus, all electrons are paired and it also exhibits ionisation iosmerism.

S : Co^{3+} has $3d^6$ configuration. But ligands present are strong enough to cause electron pairing, hence, it shows diamagnetic behaviour and exhibits *cis-trans* isomerism as it is Ma_4b_2 type complex.

16. (b) **17. (b)** **18. (c)**

19. (c): Fraction of Ag in $AgCl = \dfrac{107.9}{143.3} = 0.753$

Wt. of Ag in AgCl = 0.753 × 7.20 = 5.42 g

Hence, 5.82 g coin contains 5.42 g of Ag

Now, fraction of Ag in coin = $\dfrac{5.42}{5.82} = 0.931$ g

% of Ag in the coin = 93.1%

20. (d): Cathode : $Hg_2Cl_{2(s)} + 2e^- \longrightarrow 2Hg_{(l)} + 2Cl^-_{(aq)}$

Anode : $2H^+ + 2e^- \longrightarrow H_2$; $n = 2$

$\Delta G^{\circ} = -nFE^{\circ} = -2 \times 96500 \times 0.18 = -34740$ J

$$\Delta S^{\circ} = nF\left(\frac{dE}{dT}\right)$$

We can take $\dfrac{dE}{dT} = \dfrac{\Delta E}{\Delta T} = \dfrac{0.28 - 0.18}{10} = 0.01$ V / K

(From temperature 293 K to 303 K)

$\Delta S^\circ = 2 \times 96500 \times 0.01 = 1930\ J\ K^{-1}$

$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$

$\Delta H^\circ = \Delta G^\circ + T\Delta S^\circ$

$= -34740 + 293 \times 1930 = 530750\ J = 530.75\ kJ$

21. (a)

22. (d): $Pb^{2+} + 2HCl \longrightarrow \underset{\text{(White ppt.)}}{PbCl_2} \xrightarrow[\text{Soluble in hot water}]{H_2S} \underset{\text{(Black ppt.)}}{PbS}$

23. (c) : Due to $+I$ effect of $-CH_3$ group, (4) has higher electron density than benzene (1). Due to strong $-I$ effect of $-Cl$ group and strong $-I$ and $-M$ effects of $-NO_2$ group, both (2) and (3) have lower electron density than benzene (1). As $-I$ effect of $-Cl$ group is weaker than that of $-NO_2$ group, (3) has much lower electron density than (2).

Thus, the overall reactivity order towards electrophilic substitution is 4 > 1 > 2 > 3.

24. (a)

25. (d): According to Faraday's law of electrolysis,

$m \propto Ct$ or $m = ZCt$

where C = current, t = time

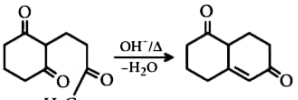
$$Z = \frac{\text{Equivalent weight of substance}}{96500}$$

Eq. wt. of Cu $= \frac{63.5}{2}$ ($\because$ $Cu^{2+} \rightarrow Cu$)

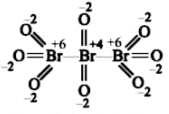
$$\therefore\ m = \frac{63.5 \times C \times t}{2 \times 96500} = \frac{31.75 \times C \times t}{96500}$$

26. (b)

27. (c) :

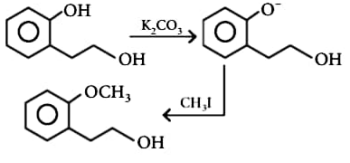


28. (b):



Oxidation states of the three bromine atoms are + 6, + 4, + 6.

29. (a) :



30. (c) : The number of radial nodes = $n - l - 1$.

For 3*p*, it is 3 − 1 − 1 = 1.

For 2*s*, it is 2 − 0 − 1 = 1.

31. (a) : $Ni^{2+} = 3d^8 4s^0$

(i) $[NiCl_4]^{2-} \rightarrow Cl^-$ is a weak field ligand, so no pairing is possible.

CFSE < Pairing energy.

(ii) $[Ni(H_2O)_6]^{2+} \rightarrow H_2O$ is a weak field ligand.

So, no pairing is possible.

CFSE < Pairing energy.

(iii) $[Ni(PPh_3)_2Cl_2] \rightarrow$ In square planar geometry, the ligands cause steric repulsion between one another, hence, the geometry will be tetrahedral.

32. (b)

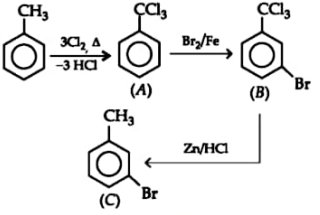
33. (a) :

Species	Hybridisation
CO_3^{2-}	sp^2
XeF_4	sp^3d^2
I_3^-	sp^3d
NCl_3	sp^3
$BeCl_2$	sp

Therefore, the correct increasing order of percentage of *s*-character is :

II < III < IV < I < V

34. (b) :



35. (a) **36. (a)**

37. (c) : $\pi = CRT$

$$1.23 = \frac{300 \times 10^{-3} \times 1000 \times 8.2 \times 10^{-2} \times 300}{M \times 100}$$

$$\Rightarrow\ M = \frac{300 \times 8.2 \times 10^{-2} \times 300}{1.23 \times 100} = 60$$

$\Rightarrow$ Molar mass = 60 g mol^{-1}

38. (a) : $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

Oxidation state of Mn changes from +7 to +2.

$\therefore$ Change in oxidation number of manganese = 5

39. (c) : α-sulphur $\underset{< 369\ K}{\overset{> 369\ K}{\rightleftharpoons}}$ β-sulphur

At room temperature, rhombic sulphur is most stable.

40. (b): Out of given options, only $x = 2$ and $y = 6$ makes the equation balanced.

$2Cu + 6HNO_3 \rightarrow 2Cu(NO_3)_2 + NO + NO_2 + 3H_2O$

41. (a)

42. (b): Number of unpaired electrons in Fe^{2+} is less than Mn^{2+}, so Fe^{2+} is less paramagnetic than Mn^{2+}.

43. (c)

44. (b): Rate $= k\,[A]^x\,[B]^y$

When $[B]$ is doubled, keeping $[A]$ constant, half-life of the reaction does not change.

Now, for a first order reaction $t_{1/2} = \dfrac{0.693}{k}$ *i.e.*, $t_{1/2}$ is independent of the concentration of the reactant. Hence, the reaction is first order with respect to B. Now when $[A]$ is doubled, keeping $[B]$ constant, the rate also doubles. Hence, the reaction is first order with respect to A.

$\therefore$ Rate $= [A]^1\,[B]^1$

Now for a n^{th} order reaction, unit of rate constant is $(L)^{n-1}\,(mol)^{1-n}\,s^{-1}$ when $n = 2$, unit of rate constant is $L\,mol^{-1}\,s^{-1}$.

45. (d)

46. (b): $\Delta H - \Delta U = \Delta n_g RT$

Also, $CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(l)}$

$\therefore \quad \Delta n_g = -2$

$\Delta H - \Delta U = -2 \times 298 \times 2$ cal

47. (b): Alanine is $H_2N-\underset{\displaystyle CH_3}{\underset{|}{CH}}-COOH$.

Hence, A is $Cl-\underset{\displaystyle CH_3}{\underset{|}{CH}}-COOH$.

The reaction is Gabriel phthalimide synthesis.

48. (a)

49. (a) : At low pH, cationic form dominates.

50. (c)

PRACTICE PAPER 2024

JEE MAIN

Exam Dates

Session-2

Between 4th April and 15th April 2024

SECTION-A (MULTIPLE CHOICE QUESTIONS)

1. For the decomposition of a compound AB at 600 K, the following data were obtained.

$[AB]$ mol dm^{-3}	Rate of decomposition of AB in mol dm^{-3} s^{-1}
0.2	2.75×10^{-8}
0.4	11.0×10^{-8}
0.6	24.75×10^{-8}

The order for the decomposition of AB is

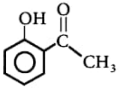
(a) 0 (b) 1 (c) 2 (d) 1.5

2. Match the Column I with Column II and select the correct option.

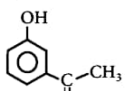
Column I (Element)		Column II (Position in periodic table)	
(A)	Tl	(i)	s-block
(B)	Ra	(ii)	p-block
(C)	Ru	(iii)	d-block
(D)	Es	(iv)	f- block

(a) (A) → (ii), (B) → (i), (C) → (iii), (D) → (iv)
(b) (A) → (ii), (B) → (i), (C) → (iv), (D) → (iii)
(c) (A) → (i), (B) → (ii), (C) → (iii), (D) → (iv)
(d) (A) → (i), (B) → (ii), (C) → (iv), (D) → (iii)

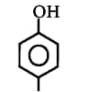
3. The correct acidic strength order is



(X)



(Y)



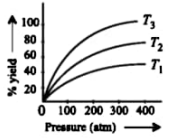
(Z)

(W)

(a) $X > Z > W > Y$ (b) $Z > X > Y > W$
(c) $W > Z > X > Y$ (d) $X > Z > Y > W$

4. The preparation of ammonia by Haber's process is an exothermic reaction. If the process follows the following temperature-pressure relationship for its % yield, then for temperatures T_1, T_2 and T_3 the correct option is

(a) $T_3 > T_2 > T_1$
(b) $T_1 > T_2 > T_3$
(c) $T_1 = T_2 = T_3$
(d) nothing could be predicted.



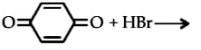
5. Number of Cl═O bonds in chlorous acid, chloric acid and perchloric acid respectively are

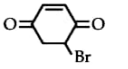
(a) 4, 1 and 0 (b) 3, 1 and 1
(c) 1, 1 and 3 (d) 1, 2 and 3

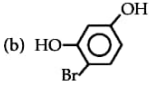
6. The octahedral complexes of a metal ion M^{3+} with four monodentate ligands L_1, L_2, L_3 and L_4 absorb wavelengths in the region of red, green, yellow and blue, respectively. The increasing order of ligand strength of the four ligands is

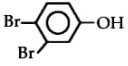
(a) $L_1 < L_2 < L_4 < L_3$ (b) $L_4 < L_3 < L_2 < L_1$
(c) $L_1 < L_3 < L_2 < L_4$ (d) $L_3 < L_2 < L_4 < L_1$

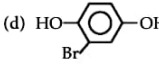
7. What will be the end product of the following reaction?



(a) 

(b) 

(c) 

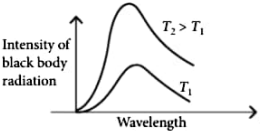
(d) 

8. Based upon VSEPR theory, match the shape of the molecules in Column I with the molecules in Column II and select the correct option.

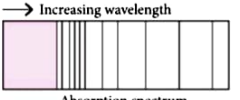
Column I (Shape)		Column II (Molecules)	
(A)	T-shaped	(i)	XeF_4
(B)	Trigonal planar	(ii)	SF_4
(C)	Square planar	(iii)	ClF_3
(D)	See-saw	(iv)	BF_3

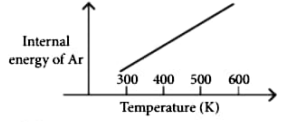
(a) (A) - (i), (B) - (ii), (C) - (iii), (D) - (iv)
(b) (A) - (iii), (B) - (iv), (C) - (i), (D) - (ii)
(c) (A) - (iii), (B) - (iv), (C) - (ii), (D) - (i)
(d) (A) - (iv), (B) - (iii), (C) - (i), (D) - (ii)

9. The figure that is not a direct manifestation of the quantum nature of atom is

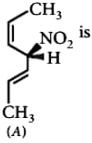
(a)


(b)

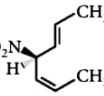

(c)


(d)


10. Given below are two statements.

Statement I : The compound  is optically active.

(A)

Statement II :  is mirror image of above compound *A*.

In the light of the above statements, select the most appropriate answer from the options given below :
(a) Both Statement I and Statement II are correct.
(b) Both Statement I and Statement II are incorrect.
(c) Statement I is correct but Statement II is incorrect.
(d) Statement I is incorrect but Statement II is correct.

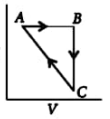
11. The major products obtained from the reactions in Column II are the reactants for the named reactions mentioned in Column I. Match Column I with Column II and choose the correct option.

Column I		Column II	
(P)	Etard reaction	1.	Acetophenone $\xrightarrow[HCl]{Zn\text{-}Hg,}$
(Q)	Gattermann reaction	2.	Toluene $\xrightarrow[(ii)\ SOCl_2]{(i)\ KMnO_4,\ KOH,\ \Delta}$
(R)	Gattermann–Koch reaction	3.	Benzene $\xrightarrow[anhyd.\ AlCl_3]{CH_3Cl}$
(S)	Rosenmund reduction	4.	Aniline $\xrightarrow[273\text{-}278\ K]{NaNO_2/HCl}$
		5.	Phenol $\xrightarrow{Zn,\ \Delta}$

(a) P → 2; Q → 4; R → 1; S → 3
(b) P → 1; Q → 3; R → 5; S → 2
(c) P → 3; Q → 2; R → 1; S → 4
(d) P → 3; Q → 4; R → 5; S → 2

12. **Statement-1 :** Although PF_5, PCl_5 and PBr_5 are known, the pentahalides of nitrogen have not been observed.
Statement-2 : Phosphorus has lower electronegativity than nitrogen.
(a) Statement-1 is true; statement-2 is true; statement-2 is a correct explanation for statement-1.
(b) Statement-1 is true; statement-2 is true; statement-2 is not a correct explanation for statement-1.
(c) Statement-1 is true, statement-2 is false.
(d) Statement-1 is false, statement-2 is true.

13. An ideal gas undergoes a cyclic process as shown in figure :
$\Delta U_{BC} = -5$ kJ mol^{-1},
$q_{AB} = 2$ kJ mol^{-1},
$W_{AB} = -5$ kJ mol^{-1},
$W_{CA} = 3$ kJ mol^{-1}



Heat absorbed by the system during process *CA* is

(a) 18 kJ mol^{-1} (b) +5 kJ mol^{-1}

(c) −5 kJ mol^{-1} (d) −18 kJ mol^{-1}

14. **Assertion** : A solution of sucrose in water is dextrorotatory. But on hydrolysis in the presence of a little hydrochloric acid, it becomes laevorotatory.
Reason : Sucrose on hydrolysis gives unequal amounts of glucose and fructose. As a result of this, change in sign of rotation is observed.

(a) If both assertion and reason are true and reason is the correct explanation of assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of assertion.

(c) If assertion is true but reason is false.

(d) If both assertion and reason are false.

15. A solution of methanol in water is 20% by volume. If the solution and pure methanol have densities of 0.964 kg L^{-1} and 0.793 kg L^{-1}, respectively, find the percent of methanol by weight.

(a) 15.83 (b) 16.45

(c) 20.42 (d) 14.85

16. Identify the correct statements from the following :

(A) $CO_{2(g)}$ is used as refrigerant for ice-cream and frozen food.

(B) The structure of C_{60} contains twelve six carbon rings and twenty five carbon rings.

(C) ZSM-5, a type of zeolite, is used to convert alcohols into gasoline.

(D) CO is colourless and odourless gas.

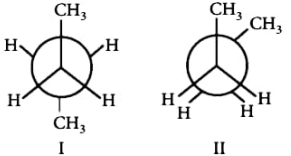
(a) (A), (B) and (C) only (b) (A) and (C) only

(c) (B) and (C) only (d) (C) and (D) only

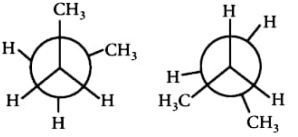
17. In Dumas' method of estimation of nitrogen 0.35 g of an organic compound gave 55 mL of nitrogen collected at 300 K temperature and 715 mm Hg pressure. The percentage composition of nitrogen in the compound would be (aqueous tension at 300 K = 15 mm Hg)

(a) 15.45 (b) 16.46 (c) 17.45 (d) 14.45

18. Arrange the following conformational isomers of *n*-butane in order of their increasing potential energy and select the correct option.



I II



III IV

(a) I < III < IV < II (b) I < IV < III < II

(c) II < IV < III < I (d) II < III < IV < I

19. Given : $Co^{3+} + e^- \rightarrow Co^{2+}$; $E^\circ = +1.81$ V

$Pb^{4+} + 2e^- \rightarrow Pb^{2+}$; $E^\circ = +1.67$ V

$Ce^{4+} + e^- \rightarrow Ce^{3+}$; $E^\circ = +1.61$ V

$Bi^{3+} + 3e^- \rightarrow Bi$; $E^\circ = +0.20$ V

Oxidising power of the species will increase in the order

(a) $Co^{3+} < Pb^{4+} < Ce^{4+} < Bi^{3+}$

(b) $Co^{3+} < Ce^{4+} < Bi^{3+} < Pb^{4+}$

(c) $Ce^{4+} < Pb^{4+} < Bi^{3+} < Co^{3+}$

(d) $Bi^{3+} < Ce^{4+} < Pb^{4+} < Co^{3+}$

20. Identify the incorrect statement among the following.

(a) Potassium permanganate forms dark purple crystals which are isostructural with those of $KClO_4$.

(b) *d*-Block elements show irregular and erratic chemical properties among themselves.

(c) Acidified permanganate solution is unable to oxidise oxalates to carbon dioxide.

(d) The chemistry of various lanthanoids is very similar.

SECTION-B (NUMERICAL TYPE QUESTIONS)

Attempt any 5 questions out of 10.

21. The standard reduction potentials of Cu^{2+}/Cu and Cu^{2+}/Cu^+ are 0.337 V and 0.153 V respectively. The standard electrode potential of Cu^+/Cu half cell is _____ V.

22. An optically active compound (*A*), $C_3H_7O_2N$ forms a hydrochloride but dissolves in water to give a neutral solution. On heating with sodalime, (*A*) yields C_2H_7N(*B*). Both (*A*) and (*B*) react with $NaNO_2$ and HCl, the former yielding a compound (*C*) $C_3H_6O_3$, which on heating is converted to (*D*), $C_6H_8O_4$ while the latter yields (*E*), C_2H_6O. The type of carbon to which N is attached to in (*A*) is _____.

23. Relative decrease in vapour pressure of an aqueous glucose dilute solution is found to be 0.018. The elevation in boiling point (in K) of this solution is _____.
(Given : 1 molal aqueous urea solution boils at 100.54°C at 1 atm pressure.)

24. 10.0 mL of Na_2CO_3 solution is titrated against 0.2 M HCl solution. The following titre values were obtained in 5 readings :
4.8 mL, 4.9 mL, 5.0 mL, 5.0 mL and 5.0 mL.
Based on these readings, and convention of titrimetric estimation, the concentration of Na_2CO_3 solution is _____ mM.

25. What is the molecular formula mass (in g mol^{-1}) of a nitrogeneous base, 0.295 g of which on treating with CH_3MgI liberates 112 mL of CH_4 at STP?

26. When 12 g of carbon reacted with oxygen to form CO and CO_2 at 25°C at constant pressure, 75.0 kcal of heat was liberated and no carbon remained. The mass of oxygen needed (in g) for it is _____.
$\Delta H_{f\,(CO_2)} = -94.05$ kcal mol^{-1} and
$\Delta H_{f\,(CO)} = -26.41$ kcal mol^{-1}.

27. Reaction of $[Co(H_2O)_6]^{2+}$ with excess ammonia and in the presence of oxygen results into a diamagnetic product. Number of electrons present in t_{2g} orbitals of the product is _____.

28. The heat of combustion of ethanol into carbon dioxide and water is –327 kcal at constant pressure. The heat evolved at constant volume and 27 °C (if all gases behave ideally) is – _____ cal.
(R = 2 cal mol^{-1} K^{-1})

29. In the following sequence of reactions the maximum number of atoms present in molecule 'C' in one plane is _____.

$$A \xrightarrow[\text{Cu tube}]{\text{Red hot}} B \xrightarrow[\text{Anhydrous } AlCl_3]{CH_3Cl(1\text{ eq.})} C$$

(A is the lowest molecular weight alkyne.)

30. Compound (P) on nitration with dil. HNO_3 yields two isomers (A) and (B). These isomers can be separated by steam distillation. Isomers (A) and (B) show the intramolecular and intermolecular hydrogen bonding respectively. Compound (P) on reaction with conc. HNO_3 yields a yellow compound (C), a strong acid. The number of oxygen atoms present in compound (C) is _____.

SOLUTIONS

1. (c) : Let rate equation be, rate = $k[AB]^n$
Case (i) $2.75 \times 10^{-8} = k[0.2]^n$
Case (ii) $11.0 \times 10^{-8} = k[0.4]^n$
Case (iii) $24.75 \times 10^{-8} = k[0.6]^n$
Divide (ii) by (i)

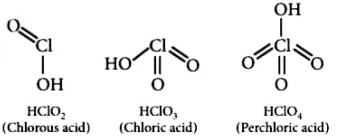
$$\frac{11.0\times10^{-8}}{2.75\times10^{-8}} = \frac{[0.4]^n}{[0.2]^n} \Rightarrow 2^n = 4 \Rightarrow n = 2$$

$\therefore$ Order of reaction = 2

2. (a) **3. (b)**

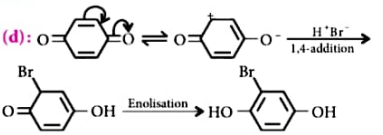
4. (b) : For exothermic reactions, as temperature increases, yield decreases. Thus, $T_1 > T_2 > T_3$.

5. (d) :



6. (c)

7. (d) :



8. (b)

9. (d) : The direct manifestations of the quantum nature of atom are (a) the emission of radiations from hot bodies (black-body radiation), (b) ejection of electrons from metal surface, when radiation strikes it (photoelectric effect) and (c) atomic absorption.

10. (b) **11. (d)**

12. (b) : Nitrogen cannot expand its octet because of absence of d-orbitals in valence shell.

13. (b) : From the first law of thermodynamics,
$\Delta U = q + w$
where, q = heat change, w = work done
Now, for state $A \rightarrow B$,
$\Delta U_{AB} = q_{AB} + w_{AB} = 2 - 5 = -3$ kJ mol^{-1}
For state $A \rightarrow B \rightarrow C$,
$\Delta U_{ABC} = \Delta U_{AB} + \Delta U_{BC} = -3 - 5 = -8$ kJ mol^{-1}
$\Delta U_{CBA} = -\Delta U_{ABC} = -(-8) = +8$ kJ mol^{-1}
As, internal energy is a state function, thus,
$\Delta U_{CBA} = \Delta U_{CA} = +8$ kJ mol^{-1} and, $\Delta U_{CA} = q_{CA} + w_{CA}$
$8 = q_{CA} + 3$
$q_{CA} = 8 - 3 = +5$ kJ mol^{-1}

14. (c)

15. (b): Volume of solution = 100 L

Then, volume of methanol = 20 L

Mass of solution = $V \times d = 100 \times 0.964 = 96.4$ kg

Mass of methanol = $20 \times 0.793 = 15.86$ kg

$$\text{Mass \% of methanol} = \frac{15.86}{96.4} \times 100 = 16.45\%$$

16. (d): (A) Solid CO_2 (dry ice) is used as refrigerant for ice-cream and frozen food.

(B) The structure of C_{60} contains twenty six-membered rings and twelve five-membered rings.

(C) and (D) are correct statements.

17. (b): Given : $V_1 = 55$ mL, $V_2 = ?$

$P_1 = 715 - 15 = 700$ mm Hg, $P_2 = 760$ mm Hg

$T_1 = 300$ K, $T_2 = 273$ K

General gas equation, $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Volume of nitrogen at STP,

$$V_2 = \frac{P_1V_1T_2}{P_2T_1} = \frac{700 \times 55 \times 273}{760 \times 300} = 46.099 \text{ mL}$$

$$\text{\% of nitrogen} = \frac{V_2}{8W}, \text{ where } W = \text{the mass of organic compound.}$$

$$\text{\% of N} = \frac{46.099}{8 \times 0.35} = 16.46$$

18. (a): Higher the stability, lower will be its potential energy.

Order of stability : I > III > IV > II

Order of potential energy : I < III < IV < II

19. (d): Oxidising power of the species will increase with increase in the positive value of E°. Hence, the correct order of the increasing oxidising power of the given species are as follows :

$Bi^{3+} < Ce^{4+} < Pb^{4+} < Co^{3+}$.

20. (c): Acidified permanganate solution oxidises oxalate ion at 333 K as shown :

$5C_2O_4^{2-} + 2MnO_4^- + 16H^+ \rightarrow 2Mn^{2+} + 8H_2O + 10CO_2$

21. (0.52): (i) $Cu^{2+} + 2e^- \rightarrow Cu$, $E_1^\circ = 0.337$ V,

$\Delta G_1^\circ = -n_1FE_1^\circ$ and $n_1 = 2$

(ii) $Cu^{2+} + e^- \rightarrow Cu^+$, $E_2^\circ = 0.153$ V,

$\Delta G_2^\circ = -n_2FE_2^\circ$ and $n_2 = 1$

Target reaction (iii) $Cu^+ + e^- \rightarrow Cu$, $E_3^\circ = ?$, $\Delta G_3^\circ = ?$

So, target equation = (i) – (ii)

$\Delta G_3^\circ = \Delta G_1^\circ - \Delta G_2^\circ$

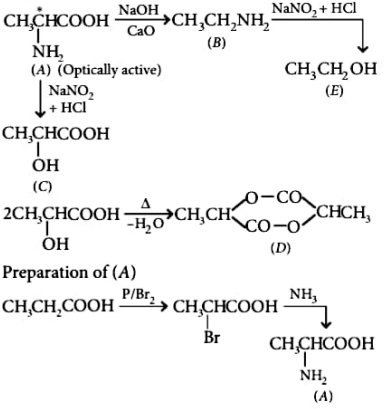
$\Rightarrow \quad -FE_3^\circ = -2FE_1^\circ - (-1FE_2^\circ) \Rightarrow -E_3^\circ = -2E_1^\circ + E_2^\circ$

$\Rightarrow \quad E_3^\circ = 2E_1^\circ - E_2^\circ = 2(0.337) - 0.153 = 0.521$ V

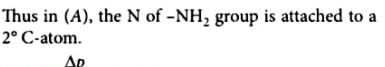
22. (2): Degree of unsaturation of $(A) = 1$

It contains both a basic and an acidic functional group. It is likely to be an amino acid as the molecular formula contains one N and 2 O-atoms. On decarboxylation, it forms an amine (B).

Degree of unsaturation of $(B) = 0$



Preparation of (A)



Thus in (A), the N of $-NH_2$ group is attached to a 2° C-atom.

23. (0.55): $\frac{\Delta p}{p^\circ} = 0.018 = x_{\text{glucose}}$

For aqueous urea solution,

$\Delta T_b = T_b - T_b^\circ = 100.54 - 100 = 0.54$ °C

$\Delta T_b = K_b m$

$0.54 = K_b \times 1 \Rightarrow K_b = 0.54$ °C kg mol^{-1}

To calculate elevation in boiling point of aqueous glucose solution,

$$\Delta T_b = K_b \cdot m = 0.54 \times m = 0.54 \times \frac{n_{\text{glucose}}}{w_{\text{water (in g)}}} \times 1000$$

$$= \frac{0.54 \times 0.018}{(0.982 \times 18)} \times 1000 = 0.54 \times 1.018 = 0.549 \text{ K}$$

24. (50): $Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2CO_3$

With one mole of Na_2CO_3, 2 mol of HCl is used.

Using precise volume of HCl = 5 mL,

Meq. of Na_2CO_3 = Meq. of HCl

Let the molarity of Na_2CO_3 solution = M then,

$M \times 10 \times 2 = 0.2 \times 5 \times 1$

$\Rightarrow \quad M = 0.05$ mol/L = 50 mM

25. (59): Nitrogeneous base which reacts with Grignard reagent is 1° or 2° amine having general formula $C_nH_{2n+3}N$.

Number of moles of CH_4 = number of moles of amine

$$\frac{112}{22400} = \frac{0.295}{\text{Molecular mass of amine}}$$

$$\text{Molecular mass of amine} = \frac{0.295 \times 22400}{112} = 59$$

$C_nH_{2n+3}N = 59$; $C_nH_{2n+3} = 59 - 14 = 45$;

$C_nH_{2n} = 45 - 3 = 42$; $n = 42/14 = 3$

Thus molecular formula is C_3H_9N and molecular formula mass = 59 g mol^{-1}.

26. (27.49) : $C + O_2 \longrightarrow CO_2$; $\Delta H_f = -94.05$ kcal

$C + \frac{1}{2}O_2 \longrightarrow CO$; $\Delta H_f = -26.41$ kcal

Let a moles of carbon react to form CO_2 and b moles of carbon react to form CO.

Since 12 g or 1 mole carbon is used up

$a + b = 12/12 = 1$ ...(i)

$a \times 94.05 + b \times 26.41 = 75$ ...(ii)

$a = 0.718$ *i.e.,* mole of CO_2 formed

$b = 0.282$ *i.e.,* mole of CO formed

Also moles of O_2 used for this change

$$= 0.718 + \frac{0.282}{2} = 0.859$$

Thus, weight of O_2 used = $0.859 \times 32 = 27.49$ g

27. (6): $[Co(H_2O)_6]^{2+} + NH_3 \xrightarrow[\text{(excess)}]{O_2}$

$[Co(NH_3)_6]^{3+}_{(aq)} + 6H_2O$

In $[Co(NH_3)_6]^{3+}$, Co^{3+} : $[Ar]\ 3d^6\ 4s^0$

According to CFT of octahedral complex, Co is in +3 O.S and NH_3 is present as a moderate field ligand which forces electrons to pair up in t_{2g} orbital and complex is diamagnetic. So, the number of electrons in t_{2g} orbitals is 6.

28. (326400) : Given : $\Delta H_{comb} = -327$ kcal

$C_2H_5OH_{(l)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(l)}$

$\Delta n_g = n_{g(\text{products})} - n_{g(\text{reactants})} = 2 - 3 = -1$

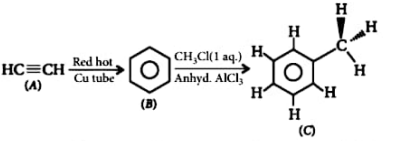
$\Delta H = \Delta U + \Delta n_g RT$

$-327 \times 1000 = \Delta U + (2)(-1)(300)$

$-327000 = \Delta U - 600$

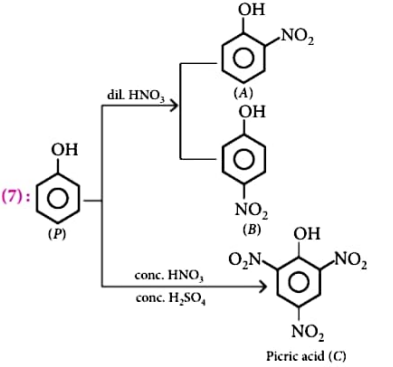
$\Delta U = -327000 + 600 = -326400$ cal

29. (13) : The lowest molecular weight alkyne is ethyne HC≡CH, which on passing through red hot Cu tube undergoes cyclic polymerisation.



Thus, maximum number of atoms in one plane is 13.

30. (7) :



Picric acid (C)

Picric acid contains seven oxygen atoms.

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For MTG Learning Media Pvt. Ltd.
Mahabir Singh
Director

JEE 2024 PRACTICE PAPER ADVANCED

Exam on 26th May

PAPER-I

SECTION 1 (MAXIMUM MARKS : 12)

- *This section contains THREE (03) questions.*
- *Each question has FOUR options (a), (b), (c) and (d). ONE OR MORE THAN ONE of these four option(s) is(are) correct answer(s).*
- *For each question, choose the option(s) corresponding to (all) the correct answer(s).*
- *Answer to each question will be evaluated according to the following marking scheme:*

Full Marks	*: +4*	*ONLY if (all) the correct option(s) is(are) chosen;*
Partial Marks	*: +3*	*If all the four options are correct but ONLY three options are chosen;*
Partial Marks	*: +2*	*If three or more options are correct but ONLY two options are chosen, both of which are correct;*
Partial Marks	*: +1*	*If two or more options are correct but ONLY one option is chosen and it is a correct option;*
Zero Marks	*: 0*	*If none of the options is chosen (i.e., the question is unanswered);*
Negative Marks	*: –2*	*In all other cases.*

- *For example, in a question, if (a), (b) and (d) are the ONLY three options corresponding to correct answers, then*
  choosing ONLY (a), (b) and (d) will get +4 marks;
  choosing ONLY (a) and (b) will get +2 marks;
  choosing ONLY (a) and (d) will get +2 marks;
  choosing ONLY (b) and (d) will get +2 marks;
  choosing ONLY (a) will get +1 mark;
  choosing ONLY (b) will get +1 mark;
  choosing ONLY (d) will get +1 mark;
  choosing no option (i.e., the question is unanswered) will get 0 marks; and choosing any other combination of options will get –2 marks.

1. Which of the following statement(s) is/are true?

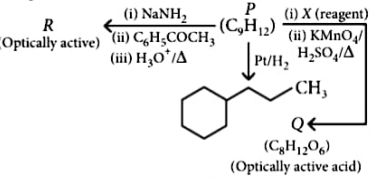
(a) The two six-membered cyclic hemiacetal forms of *D*-(+)-glucose are called anomers.

(b) Hydrolysis of sucrose gives dextrorotatory glucose and laevorotatory fructose.

(c) Monosaccharides cannot be hydrolysed to give polyhydroxy aldehydes and ketones.

(d) Oxidation of glucose with bromine water gives glutamic acid.

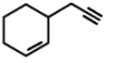
2. Consider the following transformations of a compound *P*.

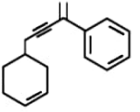


Choose the correct option(s).

(a) *P* is 

(b) *X* is Pd-C/quinoline/H_2.

(c) *P* is 

(d) *R* is 

3. In the depression of freezing point experiment, it is found that the

(a) vapour pressure of the solution is less than that of pure solvent

(b) vapour pressure of the solution is more than that of pure solution

(c) only solute molecules solidify at the freezing point

(d) only solvent molecules solidify at the freezing point.

SECTION 2 (MAXIMUM MARKS : 12)

- ***This section contains FOUR (04) questions.***
- ***Each question has FOUR options (a), (b), (c) and (d). Only one of these four option is the correct answer.***
- ***For each question, choose the option corresponding to the correct answer.***
- ***Answer to each question will be evaluated according to the following marking scheme:***

Full Marks : ***+3*** ***If ONLY the correct option is chosen;***

Zero Marks : ***0*** ***If none of the options is chosen (i.e., the question is unanswered);***

Negative Marks : ***–1*** ***In all other cases.***

4. In aqueous solution the ionisation constants for carbonic acid are $K_1 = 4.2 \times 10^{-7}$ and $K_2 = 4.8 \times 10^{-11}$. Select the correct statement for a saturated 0.034 M solution of the carbonic acid.

(a) The concentration of H^+ is double that of CO_3^{2-}.

(b) The concentration of CO_3^{2-} is 0.034 M.

(c) The concentration of CO_3^{2-} is greater than that of HCO_3^-.

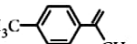
(d) The concentration of H^+ and HCO_3^- are approximately equal.

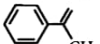
5. Compounds *P* and *R* upon ozonolysis produce *Q* and *S* respectively. The molecular formula of *Q* and *S* is C_8H_8O. *Q* undergoes Cannizzaro reaction but not haloform reaction, whereas *S* undergoes haloform reaction but not Cannizzaro reaction.

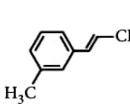
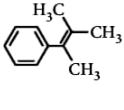
(i) $P \xrightarrow[\text{(ii) } Zn/H_2O]{\text{(i) } O_3/CH_2Cl_2} \underset{(C_8H_8O)}{Q}$

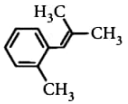
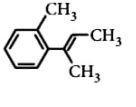
(ii) $R \xrightarrow[\text{(ii) } Zn/H_2O]{\text{(i) } O_3/CH_2Cl_2} \underset{(C_8H_8O)}{S}$

The correct option with suitable combination of *P* and *R*, respectively, is

I.  and 

II.  and 

III.  and 

IV.  and 

(a) II and IV only (b) II and III only

(c) I, II and III only (d) I, III and IV only

6. A solution of *m*-chloroaniline, *m*-chlorophenol and *m*-chlorobenzoic acid in ethyl acetate was extracted initially with a saturated solution of $NaHCO_3$ to give fraction *A*. The left over organic phase was extracted with dilute NaOH solution to give fraction *B*. The final organic layer was labelled as fraction *C*. Fractions *A*, *B* and *C*, contain respectively

(a) *m*-chlorobenzoic acid, *m*-chloroaniline and *m*-chlorophenol

(b) *m*-chlorobenzoic acid, *m*-chlorophenol and *m*-chloroaniline

(c) *m*-chlorophenol, *m*-chlorobenzoic acid and *m*-chloroaniline

(d) *m*-chloroaniline, *m*-chlorobenzoic acid and *m*-chlorophenol.

7. Select the correct statements about the following reaction sequence.

$$\text{Cumene } (C_9H_{12}) \xrightarrow[\text{(ii) } H_3O^+]{\text{(i) } O_2} P \xrightarrow[H_3O^+]{CHCl_3/NaOH} \underset{\text{(Major)}}{Q} + \underset{\text{(Minor)}}{R}$$

$$Q \xrightarrow[PhCH_2Br,\ \Delta]{NaOH} S$$

I. *R* is steam volatile.

II. *Q* gives dark violet colouration with 1% aqueous $FeCl_3$ solution.

III. *S* gives yellow precipitate with 2, 4-dinitrophenylhydrazine.

IV. *S* gives dark violet colouration with 1% aqueous $FeCl_3$ solution.

(a) I and IV only (b) II and III only

(c) III and IV only (d) I and II only

SECTION 3 (MAXIMUM MARKS : 24)

- ***This section contains SIX (06) questions.***
- ***The answer to each question is a NON-NEGATIVE INTEGER.***
- ***For each question, enter the correct integer corresponding to the answer using the mouse and the onscreen virtual numeric keypad in the place designated to enter the answer.***
- ***Answer to each question will be evaluated according to the following marking scheme:***

Full Marks : ***+4*** ***If ONLY the correct integer is entered;***

Zero Marks : ***0*** ***In all other cases.***

8. Gas *Q* is obtained on dissolving 1.24 g of white phosphorus in boiling NaOH solution in an inert atmosphere. The amount of $CuSO_4$ (in g) required to completely consume the gas *Q* is _____.

[Given : Atomic mass of H = 1, O = 16, Na = 23, P = 31, S = 32, Cu = 63]

9. Tin is obtained from cassiterite by reduction with coke. Use the data given below to determine the minimum temperature (in K) at which the reduction of cassiterite by coke would take place.

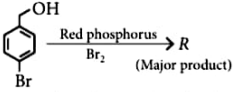
At 298 K : $\Delta_f H°(SnO_{2(s)}) = -581.0$ kJ mol^{-1},
$\Delta_f H°(CO_{2(g)}) = -394.0$ kJ mol^{-1},
$S°(SnO_{2(s)}) = 56.0$ J K^{-1}mol^{-1},
$S°(Sn_{(s)}) = 52.0$ J K^{-1}mol^{-1}, $S°(C_{(s)}) = 6.0$ J K^{-1}mol^{-1},
$S°(CO_{2(g)}) = 210.0$ J K^{-1}mol^{-1}.

Assume that the enthalpies and the entropies are temperature independent.

10. Two salts A_2X and MX have the same value of solubility product of 4.0×10^{-12}. The ratio of their molar solubilities *i.e.*, $\frac{S(A_2X)}{S(MX)} =$ _____.

11. The atomic masses of He and Ne are 4 and 20 a.m.u., respectively. The value of the de Broglie wavelength of He gas at –73 °C is M times that of the de Broglie wavelength of Ne at 727 °C. M is _____.

12. Consider the following reaction.



On estimation of bromine in 1.00 g of R using Carius method, the amount of AgBr formed (in g) is ____.

[Given : Atomic mass of H = 1, C = 12, O = 16, P = 31, Br = 80, Ag = 108]

13. For the octahedral complexes of Fe^{3+} in SCN^- (thiocyanato-S) and in CN^- ligand environments, the difference between the spin-only magnetic moments in Bohr magnetons (when approximated to the nearest integer) is _____.

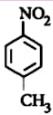
[Atomic number of Fe = 26]

SECTION 4 (MAXIMUM MARKS : 12)

- ***This section contains FOUR (04) Matching List Sets.***
- ***Each set has ONE Multiple Choice Question.***
- ***Eact set has TWO lists : List-I and List-II.***
- ***List-I has Four entries (P), (Q), (R) and (S) and List-II has Five entries (1), (2), (3), (4) and (5).***
- ***FOUR options are given in each Multiple Choice Question based on List-I and List-II and ONLY ONE of these four options satisfies the condition asked in the Multiple Choice Question.***
- ***Answer to each question will be evaluated according to the following marking scheme:***

Full Marks	:	***+3 ONLY if the option corresponding to the correct combination is chosen;***
Zero Marks	:	***0 If none of the options is chosen (i.e. the question is unanswered);***
Negative Marks	:	***–1 In all other cases.***

14. Match the four starting materials (P, Q, R, S) given in List-I with the corresponding reaction schemes (1, 2, 3, 4, 5) provided in List-II and select the correct option.

List-I		List-II	
(P)	CH ≡ CH	1.	**Scheme I** (i) $KMnO_4$, HO^-, heat (ii) H^+/H_2O (iii) $SOCl_2$ (iv) NH_3 ? ⟶ $C_7H_6N_2O_3$
(Q)		2.	**Scheme II** (i) Sn/HCl (ii) CH_3COCl (iii) conc. H_2SO_4 (iv) HNO_3 (v) dil. H_2SO_4, heat (vi) HO^- ? ⟶ $C_6H_6N_2O_2$
(R)		3.	**Scheme III** (i) red hot iron, 873 K (ii) fuming HNO_3, H_2SO_4, heat (iii) H_2S, NH_3 (iv) $NaNO_2$, H_2SO_4 (v) hydrolysis ? ⟶ $C_6H_5NO_3$
(S)		4.	**Scheme IV** (i) conc. H_2SO_4, 60 °C (ii) conc. HNO_3, conc. H_2SO_4 (iii) dil. H_2SO_4, heat ? ⟶ $C_6H_5NO_4$
		5.	**Scheme V** (i) H_2/Pd ethanol (ii) $(CH_3CO)_2O$ (iii) Br_2 (iv) H_2O/H^+ ? ⟶ $C_6H_4NBr_3$

	P	Q	R	S
(a)	5	4	2	3
(b)	3	1	5	2
(c)	3	4	2	1
(d)	4	1	3	2

15. Match List – I with List – II.

List - I (Name of oxo acid)		List - II (Oxidation state of 'P')	
(P)	Hypophosphorous acid	1.	+5
(Q)	Orthophosphoric acid	2.	+4
(R)	Hypophosphoric acid	3.	+3
(S)	Orthophosphorous acid	4.	+2
		5.	+1

Choose the correct answer from the options given below :

(a) (P) → 4, (Q) → 5, (R) → 2, (S) → 3
(b) (P) → 4, (Q) → 1, (R) → 2, (S) → 3
(c) (P) → 5, (Q) → 4, (R) → 2, (S) → 3
(d) (P) → 5, (Q) → 1, (R) → 2, (S) → 3

16. Match List-I with List-II.

List-I (Polymer)		List-II (Nature)	
(P)	Buna – S	1.	Thermo-setting polymer
(Q)	Nylon – 6, 6	2.	Fibres
(R)	Polystyrene	3.	Elastomer
(S)	Bakelite	4.	Thermo-plastic polymer
		5.	Semi-synthetic polymer

Choose the correct answer from the options given below :

(a) (P) → 2, (Q) → 3, (R) → 1, (S) → 5
(b) (P) → 3, (Q) → 2, (R) → 4, (S) → 1
(c) (P) → 3, (Q) → 1, (R) → 5, (S) → 4
(d) (P) → 5, (Q) → 4, (R) → 4, (S) → 2

17. Dilution processes of different aqueous solutions, with water, are given in List-I. The effects of dilution of the solutions on $[H^+]$ are given in List-II.

(Note: Degree of dissociation (α) of weak acid and weak base is $\ll 1$; degree of hydrolysis of salt $\ll 1$; $[H^+]$ represents the concentration of H^+ ions)

List-I		List-II	
P.	(10 mL of 0.1 M NaOH + 20 mL of 0.1 M acetic acid) diluted to 60 mL	1.	The value of $[H^+]$ does not change on dilution.
Q.	(20 mL of 0.1 M NaOH + 20 mL of 0.1 M acetic acid) diluted to 80 mL	2.	The value of $[H^+]$ will be 10^{-12} M.
R.	(20 mL of 0.1 M HCl + 20 mL of 0.1 M ammonia solution) diluted to 80 mL	3.	The value of $[H^+]$ changes to two times of its initial value on dilution.
S.	0.05 mole of sodium hydroxide is added to 5 litres of water.	4.	The value of $[H^+]$ changes to $\frac{1}{\sqrt{2}}$ times of its initial value on dilution.
		5.	The value of $[H^+]$ changes to $\sqrt{2}$ times of its initial value on dilution.

Match each process given in List-I with effects in List-II and select the correct option.

(a) P → 4; Q → 2; R → 3; S → 1
(b) P → 4; Q → 3; R → 2; S → 5
(c) P → 1; Q → 4; R → 5; S → 3
(d) P → 1; Q → 5; R → 4; S → 2

PAPER - II

SECTION 1 (MAXIMUM MARKS : 12)

- ***This section contains FOUR (04) questions.***
- ***Each question has FOUR options (a), (b), (c) and (d). Only one of these four options is the correct answer.***
- ***For each question, choose the option corresponding to the correct answer.***
- ***Answer to each question will be evaluated according to the following marking scheme:***

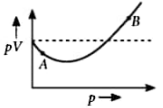
Full Marks : +3 ***If ONLY the correct option is chosen;***
Zero Marks : 0 ***If none of the options is chosen (i.e., the question is unanswered);***
Negative Marks : –1 ***In all other cases.***

1. Amount of oxalic acid present in a solution can be determined by its titration with $KMnO_4$ solution in the presence of H_2SO_4. The titration gives unsatisfactory result when carried out in the presence of HCl, because HCl
   (a) oxidises oxalic acid to carbon dioxide and water
   (b) gets oxidised by oxalic acid to chlorine
   (c) furnishes H^+ ions in addition to those from oxalic acid
   (d) reduces permanganate to Mn^{2+}.

2. In context with the transition elements, which of the following statements is incorrect?
   (a) In addition to the normal oxidation states, the zero oxidation state is also shown by these elements in complexes.
   (b) In the highest oxidation states, the transition metals show basic character and form cationic complexes.
   (c) In the highest oxidation states of the first five transition elements (Sc to Mn), all the 4*s* and 3*d* electrons are used for bonding.
   (d) Once the d^5 configuration is exceeded, the tendency to involve all the 3*d* electrons in bonding decreases.

3. 0.27 g of a long chain fatty acid was dissolved in 100 cm^3 of hexane. 10 mL of this solution was added dropwise to the surface of water in a round watch glass. Hexane evaporates and a monolayer is formed. The distance from edge to centre of the watch glass is 10 cm. What is the height of the monolayer?
   [Density of fatty acid = 0.9 g cm^{-3}; $\pi = 3$]
   (a) 10^{-4} m (b) 10^{-2} m (c) 10^{-8} m (d) 10^{-6} m

4. For 1 mole of a gas the plot of pV *vs.* p is shown below, p is the pressure and V is the volume of the gas.



   What is the value of compressibility factor at point *A*?

   (a) $1-\frac{b}{V}$ (b) $1-\frac{a}{RTV}$

   (c) $1+\frac{b}{V}$ (d) $1+\frac{a}{RTV}$

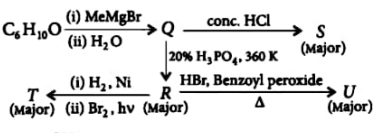
SECTION 2 (MAXIMUM MARKS : 12)

- ***This section contains THREE (03) questions.***
- ***Each question has FOUR options (a), (b), (c) and (d). ONE OR MORE THAN ONE of these four option(s) is(are) correct answer(s).***
- ***For each question, choose the option(s) corresponding to (all) the correct answer(s).***
- ***Answer to each question will be evaluated according to the following marking scheme:***

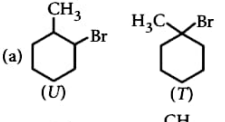
Full Marks	***: +4***	***ONLY if (all) the correct option(s) is(are) chosen;***
Partial Marks	***: +3***	***If all the four options are correct but ONLY three options are chosen;***
Partial Marks	***: +2***	***If three or more options are correct but ONLY two options are chosen, both of which are correct;***
Partial Marks	***: +1***	***If two or more options are correct but ONLY one option is chosen and it is a correct option;***
Zero Marks	***: 0***	***If unanswered;***
Negative Marks	***: –2***	***In all other cases.***

- ***For example, in a question, if (a), (b) and (c) are the ONLY three options corresponding to correct answers, then choosing ONLY (a), (b) and (d) will get +4 marks; choosing ONLY (a) and (b) will get +2 marks; choosing ONLY (a) and (d) will get +2 marks; choosing ONLY (b) and (d) will get +2 marks; choosing ONLY (a) will get +1 mark; choosing ONLY (b) will get +1 mark; choosing ONLY (d) will get +1 mark; choosing no option(s) (i.e., the question is unanswered) will get 0 marks; and choosing any other option(s) will get –2 marks.***

5. Choose the correct option(s) for the following set of reactions.

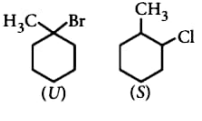


(a)

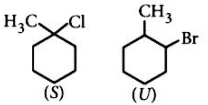


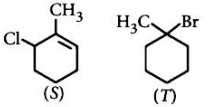
(*U*) (*T*)

(b)

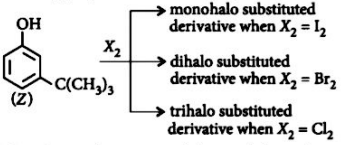


(*U*) (*S*)

(c) 

(d) 

6. The reactivity of compound *Z* with different halogens under appropriate conditions is given below :



The observed pattern of electrophilic substitution can be explained by

(a) the steric effect of the halogen
(b) the steric effect of the *tert*-butyl group
(c) the electronic effect of the phenolic group
(d) the electronic effect of the *tert*-butyl group.

7. Which series of reaction(s) correctly represents chemical relations related to iron and its compounds?

(a) $Fe \xrightarrow{O_2,\ heat} Fe_3O_4 \xrightarrow{CO,\ 600\ ^\circ C} FeO \xrightarrow{CO,700\ ^\circ C} Fe$

(b) $Fe \xrightarrow{dil.\ H_2SO_4} FeSO_4 \xrightarrow{H_2SO_4,\ O_2} Fe_2(SO_4)_3 \xrightarrow{heat} Fe$

(c) $Fe \xrightarrow{O_2,\ heat} FeO \xrightarrow{dil.\ H_2SO_4} FeSO_4 \xrightarrow{heat} Fe$

(d) $Fe \xrightarrow{Cl_2,\ heat} FeCl_3 \xrightarrow{heat,\ air} FeCl_2 \xrightarrow{Zn} Fe$

SECTION 3 (MAXIMUM MARKS : 24)

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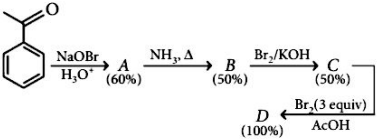
- ***The answer to each question is a NON-NEGATIVE INTEGER.***
- ***For each question, enter the correct integer corresponding to the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.***
- ***Answer to each question will be evaluated according to the following marking scheme:***
  Full Marks : +4 If ONLY the correct integer is entered;
  Zero Marks : 0 In all other cases.

8. Consider the following reaction sequence.



The yield (%) corresponding to the product in each step is given in the parenthesis. (Atomic weights in g mol^{-1}: H = 1, C = 12, N = 14, O = 16, Br = 80.)
The amount of *D* (in g) formed from 10 moles of acetophenone is _____.

9. All the energy released from the reaction $X \rightarrow Y$, $\Delta_r G^\circ = -193$ kJ mol^{-1} is used for oxidising M^+ as $M^+ \rightarrow M^{3+} + 2e^-$, $E^\circ = -0.25$ V.
Under standard conditions, the number of moles of M^+ oxidised when one mole of *X* is converted to *Y* is _____. [$F = 96500$ C mol^{-1}]

10. Sucrose hydrolyses in acid solution into glucose and fructose following first order rate law with a half-life of 3.33 hr at 25 °C. After 9 hr, the fraction of sucrose remaining is *f*. The value of $\log_{10}\left(\frac{1}{f}\right)$ is _____ $\times 10^{-2}$.
[Assume : ln 10 = 2.303, ln 2 = 0.693]

11. Consider the following compounds in the liquid form :
O_2, HF, H_2O, NH_3, H_2O_2, CCl_4, $CHCl_3$, C_6H_6, C_6H_5Cl.
When a charged comb is brought near their flowing stream, how many of them show deflection as per the following figure?

12. A solid has a structure in which *X* atoms are located at cubic corners of unit cell. O atoms are at the edge centers and *Y* atoms at cube center.
Then the formula of compound is $X_aY_bO_c$.
If two atoms of O are missing from any of two edge centers per unit cell, then the molecular formula is $X_xY_yZ_z$.
Then, find the value of $(x + y + z) - (a + b + c)$.

13. The total number of compounds having at least one bridging oxo group among the molecules given below is _____.
N_2O_5, P_4O_6, P_4O_7, $H_4P_2O_5$, $H_5P_3O_{10}$, $H_2S_2O_3$, $H_2S_2O_5$

SECTION 4 (MAXIMUM MARKS : 12)

- *This section contains TWO (02) paragraphs.*
- *Based on each paragraph, there are TWO (02) questions.*
- *The answer to each question is a NUMERICAL VALUE.*
- *For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.*
- *If the numerical value has more than two decimal places, truncate/round-off the value to TWO decimal places.*
- *Answer to each question will be evaluated according to the following marking scheme:*

Full Marks : +3 If ONLY the correct numerical value is entered in the designated place;
Zero Marks : 0 In all other cases.

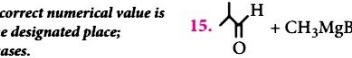
PARAGRAPH-I

Organic compounds in which a metal atom is directly linked to carbon or organic compounds which contain at least one carbon-metal bond are called organometallic compounds. The ionic character of carbon-metal bond increases with increase in electropositive character of metal. The reactivity of metal alkyls increases with increase in ionic character. The carbon atom constitutes the negative end of the metal-carbon polar covalent bond. Mostly organometallic compounds are prepared by reaction of alkyl halides with metals. 1, 4 or higher dihalides can form independent salts like Grignard reagent with Mg.

Organometallic compounds are mostly colourless, mobile liquids having low boiling points and are generally very unstable. The organometallic compounds give double decomposition reactions with compounds having acidic hydrogen, nucleophilic addition reactions with carbonyl or cyanide functional groups and nucleophilic substitution reactions with alkyl halides (or tosylates).

14. 

The sum of four membered rings, five membered rings and number of deuterium atoms in *C* is _____.

15. 

The number of carbon atoms in '*B*' is _____.

PARAGRAPH-II

Tollens' reagent is used for the detection of aldehyde. When a solution of $AgNO_3$ is added to glucose with NH_4OH then gluconic acid is formed.

$Ag^+ + e^- \longrightarrow Ag$; $E^\circ_{red} = 0.8$ V

$C_6H_{12}O_6 + H_2O \longrightarrow$ Gluconic acid $(C_6H_{12}O_7)$ $+ 2H^+ + 2e^-$; $E^\circ_{oxd} = -0.05$ V

16. $2Ag^+ + C_6H_{12}O_6 + H_2O \longrightarrow 2Ag_{(s)} + C_6H_{12}O_7 + 2H^+$

Find ln*K* of this reaction.

17. When ammonia is added to the solution, pH is raised to 11. The E_{red} increases by a factor *x* from E°_{red}. Determine the value of *x*.

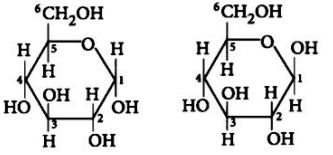
$$\left[\text{Use } 2.303 \times \frac{RT}{F} = 0.0591 \text{ and } \frac{F}{RT} = 38.92 \text{ at } 298 \text{ K}\right]$$

SOLUTIONS

PAPER-I

1. (a, b, c) :

(a)



α = 112° α-*D*-(+)-glucopyranose

α = 19° β-*D*-(+)-glucopyranose

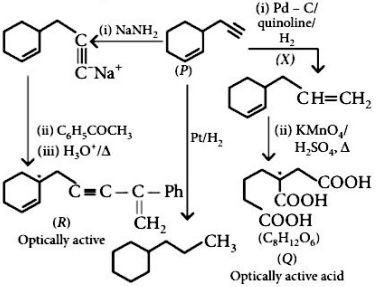
Pair of stereoisomers which differ in configuration only around C1 are called anomers.

(b) Sucrose $\xrightarrow[\text{hydrolysis}]{H^+/H_2O}$ *D*-(+)-Glucose + *D*-(−)-Fructose (Dextrorotatory) (Laevorotatory)

(c) Monosaccharides cannot be hydrolysed.

(d) Oxidation of glucose with bromine water gives gluconic acid.

2. (b, c) : The given reactions are summarised as :



3. (a, d)

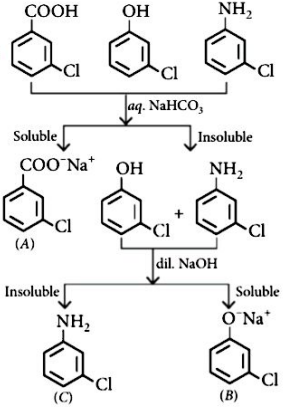
4. (d): $H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$; $K_1 = 4.2 \times 10^{-7}$

$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$; $K_2 = 4.8 \times 10^{-11}$

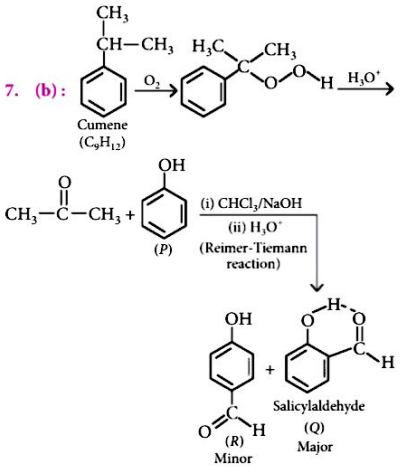
$\because$ $K_1 >> K_2$, so, H_2CO_3 ionises more than HCO_3^- and hence, contribution of H^+ is mostly due to ionisation of carbonic acid, thus the concentrations of H^+ and HCO_3^- are approximately equal.

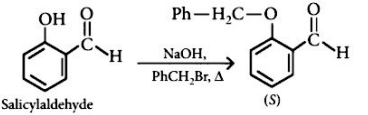
5. (c)

6. (b):



7. (b):





'*Q*' is steam volatile due to intramolecular hydrogen bonding while '*R*' undergoes intermolecular hydrogen bonding hence, has higher boiling point. '*Q*' gives dark

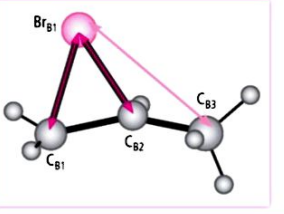
Chemistry bulletin

Watching molecular ions transform in real time

A new method that combines ultrafast electron diffraction with multiphoton ionisation has captured the dynamics of a cation in the gas phase for the first time

The formation and structural dynamics of molecular ions in the gas phase have been monitored for the first time using high-speed electron diffraction combined with resonance-enhanced multiphoton ionisation. The new method overcomes some of the difficulties associated with exploring these chemical species, unlocking exciting opportunities in ion chemistry.

'This remarkable achievement opens up a new frontier in imaging, offering a paramount contribution to our understanding of the fundamental mechanisms governing chemistry,' says Andrea Trabattoni at DESY Hamburg and Leibniz University Hannover in Germany, who wasn't involved in the study. He calls the approach groundbreaking and says that it holds promise for extension to other systems.



violet colouration with 1% aqueous $FeCl_3$ solution due to the presence of phenolic group while 'S' gives yellow precipitate with 2, 4-dinitrophenyl hydrazine due to the presence of aldehydic group (—CHO).

8. (2) : $\underset{\text{(White phosphorus)}}{P_4} + 3NaOH + 3H_2O \longrightarrow \underset{(Q)}{PH_3} + 3NaH_2PO_2$

124 g of white phosphorus gives 34 g of phosphine gas (PH_3).

1.24 g of white phosphorus gives $\left(\frac{34}{124}\times 1.24\right)$g of PH_3 *i.e.*, 0.34 g of PH_3

$3CuSO_4 + 2PH_3 \longrightarrow Cu_3P_2 + 3H_2SO_4$

68 g of PH_3 required 477 g of $CuSO_4$.

So, 0.34 g of PH_3 required $\left(\frac{477}{68}\times 0.34\right)$g of $CuSO_4$

i.e., 2.38 g of $CuSO_4 \approx 2$ g of $CuSO_4$

9. (935) : $SnO_{2(s)} + C_{(s)} \longrightarrow Sn_{(s)} + CO_{2(g)}$

From the given data,

$\Delta_r H° = \Sigma\Delta H°_{products} - \Sigma\Delta H°_{reactants}$

$\Delta_r H° = -394.0 + 581.0 = 187$ kJ/mol

$\Delta_r S° = \Sigma\Delta S°_{products} - \Sigma\Delta S°_{reactants}$

$\Delta_r S° = 52 + 210 - 56 - 6 = 200$ J/K mol

Minimum temperature at which reaction will take place, $T = \frac{\Delta_r H°}{\Delta_r S°} = \frac{187\times 1000\text{ J/mol}}{200\text{ J/mol}} = 935$ K

10. (50) : $A_2X \rightleftharpoons \underset{S_1}{2A^+} + \underset{S_1}{X^{2-}}$

$K_{sp} = 4S_1^3 \Rightarrow S_1 = 3\sqrt{\frac{K_{sp}}{4}} = \sqrt{\frac{4\times 10^{-12}}{4}}$

$S_1 = 10^{-4}$

$MX \rightleftharpoons \underset{S_2}{M^{2+}} + \underset{S_2}{X^{2-}}$

$K_{sp} = S_2^2 \Rightarrow S_2 = \sqrt{K_{sp}} = \sqrt{4\times 10^{-12}} = 2\times 10^{-6}$

$S_1 = S(A_2X)$; $S_2 = S(MX)$

$\frac{S_1}{S_2} = \frac{S(A_2X)}{S(MX)} = \frac{10^{-4}}{2\times 10^{-6}} = 50$

11. (5) : $\lambda = \frac{h}{\sqrt{2m\times K.E.}}$; $\frac{\lambda_{He}}{\lambda_{Ne}} = \sqrt{\frac{m_{Ne}\times K.E._{Ne}}{m_{He}\times K.E._{He}}}$

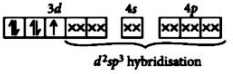
$\frac{\lambda_{He}}{\lambda_{Ne}} = \sqrt{\frac{m_{Ne}\times T_{Ne}}{m_{He}\times T_{He}}}$ $[\because K.E. \propto T]$

$= \sqrt{\frac{20\times 1000}{4\times 200}}$; $\frac{\lambda_{He}}{\lambda_{Ne}} = \sqrt{\frac{20000}{800}} = 5 \Rightarrow \lambda_{He} = 5\lambda_{Ne}$

12. (2)

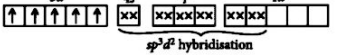
13. (4) : Fe (26) : $3d^6 4s^2$; Fe^{3+} : $3d^5$

In $[Fe(CN)_6]^{3-}$, CN^- is a strong field ligand which causes pairing of electrons.



$\mu = \sqrt{n(n+2)} = \sqrt{1(1+2)} = \sqrt{3} = 1.732$ B.M.

In $[Fe(SCN)_6]^{3-}$, SCN^- being a weak field ligand does not cause pairing of electrons.



$\mu = \sqrt{n(n+2)} = \sqrt{5(5+2)} = \sqrt{35} = 5.916$ B.M.

Difference = 5.916 – 1.732 = 4.184 ≈ 4 B.M.

14. (c)

15. (d) :

Acid	Formula	Oxidation state of P
Hypophosphorous acid	H_3PO_2	+1
Orthophosphoric acid	H_3PO_4	+5
Hypophosphoric acid	$H_4P_2O_6$	+4
Orthophosphorous acid	H_3PO_3	+3

16. (b) **17. (d)**

TRIO ANSWERS FEBRUARY 2024

The 3 sets of trio are **(OME, EMO, MOE), (AMI, IMA, MIA), (OTR, ROT, TOR)**

MONOMERIC

HAEMOGLOBIN

TETRABROMOETHANE

AMINOETHANOIC ACID

SUBLIMATION

ANAEMIA

AZEOTROPES

PROTIUM

REACTORS

Winners : *Kaushikkumar Kevadiya, Rohit Bisla, Sheena Dalal, Shital Kiran Sartale*

PAPER-II

1. (d) : Oxalic acid present in a solution can be determined by its titration with $KMnO_4$ solution in the presence of H_2SO_4.

$$2KMnO_4 + 3H_2SO_4 + 5\begin{vmatrix}COOH\\COOH\end{vmatrix} \longrightarrow K_2SO_4 + 2MnSO_4 + 10CO_2 + 8H_2O$$

Titration cannot be done in the presence of HCl because $KMnO_4$ being a strong oxidising agent oxidises HCl to Cl_2 and get itself reduced to Mn^{2+}. So actual amount of oxalic acid in solution cannot be determined.

2. (b)

3. (d) : Surface area of watch glass = πr^2

$= 3 \times (10)^2$ (Given : $\pi = 3$) = 300 cm^2

0.27 g of fatty acid was dissolved in 100 cm^3 of hexane

1 mL = 1 cm^3

$\therefore$ 10 mL = 10 cm^3

$\therefore$ Mass of fatty acid in 10 cm^3 of hexane

$$= \frac{10\ cm^3 \times 0.27\ g}{100\ cm^3} = 0.027\ g$$

Given that, density of fatty acid = 0.9 g cm^{-3}

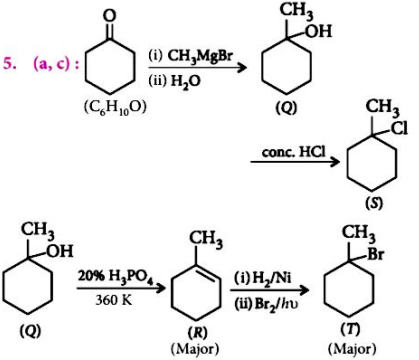
$$\text{Volume of fatty acid} = \frac{0.027\ g}{0.9\ g\ cm^{-3}} = 0.03\ cm^3$$

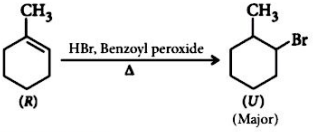
$$\text{Height of the monolayer} = \frac{\text{Volume of fatty acid}}{\text{Surface area of watch glass}}$$

$$= \frac{0.03\ cm^3}{300\ cm^2} = 10^{-4}\ cm \text{ or } 10^{-6}\ m$$

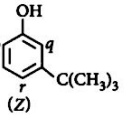
4. (b)

5. (a, c) :





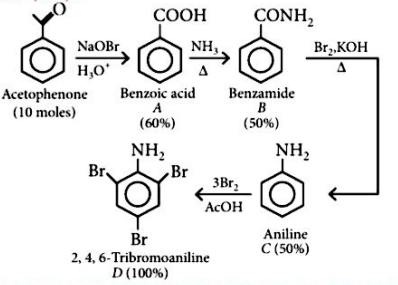
6. (a, b, c) : *p*, *q* and *r* are suitable positions as per electronic effect of –OH group. Due to steric effect of the *tert*-butyl group, the bulky electrophiles are less likely to attack positions *q* and *r*.



Hence, position *p* is suitable for I_2, positions *p* and *r* are suitable for Br_2 and Cl_2 being smaller can attack all *p*, *q* and *r* positions.

7. (a) : Formation of Fe_3O_4 through Fe, corresponds to the combustion of Fe and rest part of the reactions correspond to the production of Fe by reduction of Fe_3O_4 in blast furnace.

8. (495) :



SOLUTIONS TO FEBRUARY 2024 QUIZ CLUB

1. gauche
2. sp^2, trigonal planar
3. stoichiometric coefficient
4. oxide
5. hydrogen
6. catalyst
7. 5
8. temperature
9. volume
10. increases
11. Adiabatic process
12. oxidising
13. increased, decreased
14. six, ketonic
15. 9
16. –2, +6
17. 77
18. valence
19. one Einstein
20. trigonal pyramidal

Winners : *Kaushikkumar Kevadiya, Rahul Yadav, Neha Sharma, Rayala Prasad, Shital Kiran Sartale*

Yield of D in moles $= 10 \times \frac{60}{100} \times \frac{50}{100} \times \frac{50}{100} = 1.5$ moles

Amount of D = Number of moles × Molecular weight
$= 1.5 \text{ mol} \times 330 \text{ g/mol} = 495 \text{ g}$

9. (4) : Given : $X \rightarrow Y$; $\Delta_r G^\circ = -193 \text{ kJ mol}^{-1}$

$M^+ \rightarrow M^{3+} + 2e^-$; $E^\circ = -0.25$ V

$F = 96500 \text{ C mol}^{-1}$

Let 193 kJ be used for oxidising x moles of M^+.

For 1 mole of M^+,

$\Delta G^\circ = -nFE^\circ = -2 \text{ mol} \times 96500 \text{ C mol}^{-1} \times (-0.25) \text{ J/C}$
$= 48250 \text{ J mol}^{-1} = 48.25 \text{ kJ mol}^{-1}$

Thus, no. of moles of M^+ oxidised when one mole of X is converted to Y is equal to $\frac{193 \text{ kJ mol}^{-1}}{48.25 \text{ kJ mol}^{-1}} = 4$

10. (81)

11. (6) : Non-polar compounds which have zero dipole moment will not show any deflection, *i.e.*, O_2, CCl_4, C_6H_6 does not show any deflection.

Only polar compounds having net dipole moment will show deflection when a charged comb is brought near their flowing stream, *e.g.*, HF, H_2O, NH_3, H_2O_2, $CHCl_3$, C_6H_5Cl.

12. (4) : First case, Number of X-atoms

$= 8 \times \frac{1}{8} = 1$ per unit cell

Number of Y-atoms = 1 per unit cell

Number of O-atoms $= 12 \times \frac{1}{4} = 3$ per unit cell

Formula is $XYO_3 \Rightarrow X_aY_bO_c$; $a = 1, b = 1, c = 3$

Second case, Number of O atoms missing from two edge centers per unit cell $= 2 \times \frac{1}{4} = \frac{1}{2} = 0.5$ per unit cell

Number of O atoms left $= 3 - \frac{1}{2} = 2.5$ per unit cell

Formula is $XYO_{2.5} \Rightarrow X_2Y_2O_5 \Rightarrow X_xY_yO_z$;

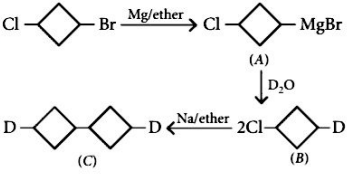
$x = 2, y = 2, z = 5$

$\therefore$ The value of

$(x + y + z) - (a + b + c) = (2 + 2 + 5) - (1 + 1 + 3) = 4$

13. (5)

14. (4) :



Number of four membered rings = 2

Number of five membered rings = 0

Number of deuterium atoms = 2

Sum = 2 + 2 + 0 = 4

15. (5) : The product B is 3-Methylbutan-2-ol. The number of carbon atoms in B is 5.

16. (58.45) : $E^\circ_{cell} = \frac{RT}{nF} \ln K$

$0.8 - 0.05 = \frac{0.0591}{2 \times 2.303} \ln K$

$\therefore \ln K = \frac{(0.8 - 0.05) \times 2 \times 2.303}{0.0591} = 58.45$

17. (0.65) : On increasing concentration of NH_3, the concentration of H^+ ion decreases.

$E_{red} = E^\circ_{red} - \frac{2.303RT}{nF} \log[H^+]$

$E_{red} = E^\circ_{red} - \frac{0.0591}{n} \log[H^+]$

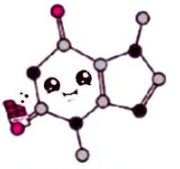
$E_{red} = E^\circ_{red} - \frac{0.0591}{1} \log 10^{-11}$

$= E^\circ_{red} - 0.0591 \times (-11) = E^\circ_{red} + 0.65$

◆◆

CHEM CAPSULE

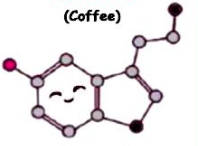
Chemistry is awesome



Theobromine
(Chocolate)

Caffeine
(Coffee)

Dopamine
(Catechol)

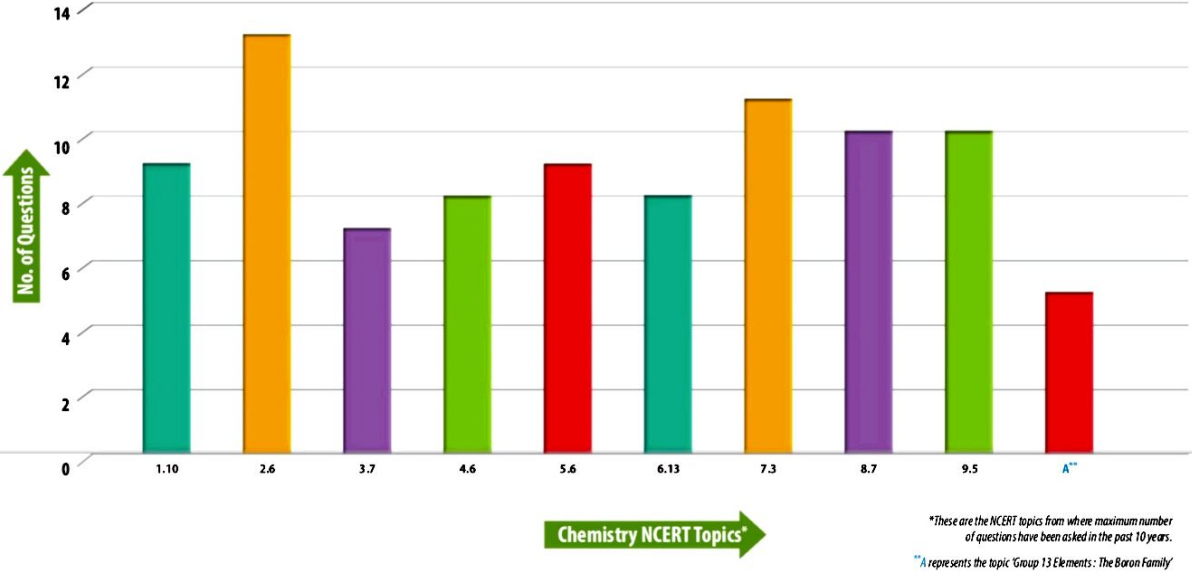


Serotonin
(5-Hydroxytryptamine)

Are You Ready for NEET Exam 2024?

Class 11

Past 10 Years (2014-2023) Chapterwise Trend Analysis of NEET Questions



*These are the NCERT topics from where maximum number of questions have been asked in the past 10 years.

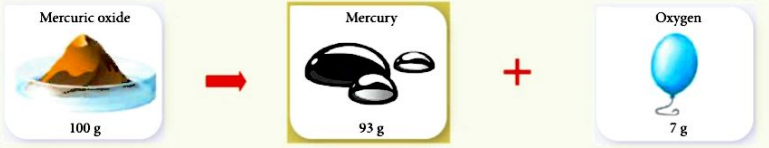
**A represents the topic 'Group 13 Elements : The Boron Family'

1 Some Basic Concepts of Chemistry

Laws of Chemical Combinations

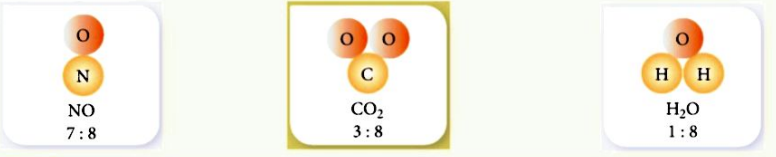
Law of Conservation of Mass (Lavoisier)

Matter can neither be created nor destroyed. In all physical and chemical changes, the total mass of the reactants is equal to that of the products.



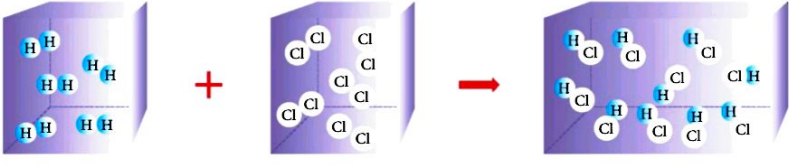
Law of Definite Proportions (Proust)

A given compound always contains exactly the same proportion of elements by weight.



Gay Lussac's Law of Gaseous Volumes

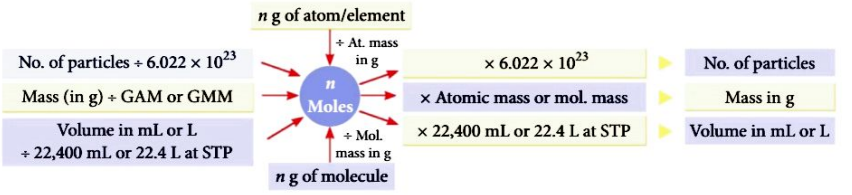
When gases combine or are produced in a chemical reaction, they do so in a simple ratio by volume, provided all gases are at same temperature and pressure.



Reaction of hydrogen with chlorine

It has been experimentally observed that one volume of hydrogen reacts with one volume of chlorine to form two volumes of hydrogen chloride.

Mole Concept



Determination of Empirical and Molecular Formulae

$$\text{Molar ratio} = \frac{\text{Percentage of element}}{\text{Atomic mass}} \rightarrow \text{Simplest molar ratio} = \frac{\text{Molar ratio}}{\text{Minimum molar ratio}}$$

Change to → Simplest whole number molar ratio = Simplest ratio × Integer

Write the numbers below the symbols of element → Empirical formula → Molecular formula = n × Empirical formula

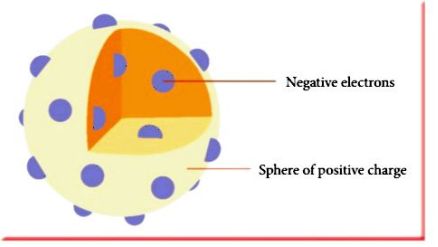
Stoichiometry of Chemical Reactions

The reactant that is completely used up in a reaction is known as the limiting reactant. It is called the limiting reactant because it determines or limits the amount of product(s) formed. The reactants that are not used up completely are called the excess reactants.

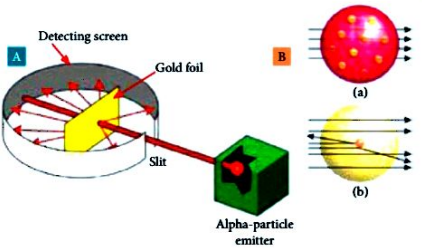
$$H_{2(g)} + Cl_{2(g)} \longrightarrow 2HCl_{(g)}$$

2 Structure of Atom

Thomson's Model of Atom



Rutherford's Nuclear Model of Atom

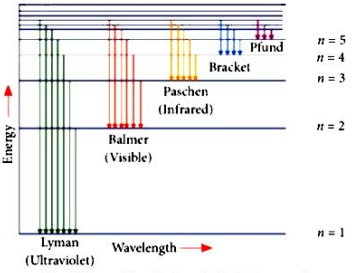


(A) The experimental setup for Rutherford's gold foil experiment : A radioactive element that emitted alpha-particles was directed toward a thin sheet of gold foil that was surrounded by a screen which would allow detection of the deflected particles. (B) (a) According to the plum-pudding model, all of the alpha-particles should have passed through the gold foil with little or no deflection. (b) Rutherford found that a small percentage of alpha-particles were deflected at large angles, which could be explained by an atom with a very small, dense, positively-charged nucleus at its centre.

Atomic Spectra of Hydrogen

- In discharge tube experiments, light spectrum emitted by hydrogen consists of a large number of lines of different wavelengths.
- **Rydberg formula :** $\bar{\nu} = \frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)Z^2$

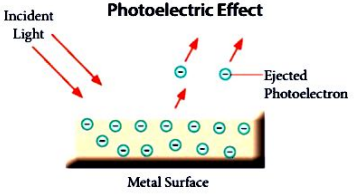
  where, $n_2 > n_1$; R_H is Rydberg constant and has a value equal to 109,677 cm^{-1}.
- The number of spectral lines possible for hydrogen or hydrogen like species when the electrons from n^{th} energy level return to ground state in different atoms = $\frac{1}{2}n(n-1)$



Transitions of the electron in the hydrogen atom

Planck's Quantum Theory

A body can emit or absorb energy not continuously but discontinuously in the form of small packets of energy called quanta. A quantum of light is called a photon. It explains photoelectric effect and black body radiations.



Each photon having energy equal to or greater than threshold energy can eject only one electron.

No. of electrons ejected ∝ Intensity of incident radiations

K.E. $= h(\nu - \nu_0) = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$

K.E. of electrons ∝ Frequency of incident radiations

Towards Quantum Mechanical Model of the Atom

- **de Broglie Equation :** $\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{2mE_k}} = \frac{h}{\sqrt{2mqV}}$

  where, E_k = kinetic energy, q = charge on particle, m = mass and V = accelerating potential.
- **Heisenberg's Uncertainty Principle :** $\Delta x \times \Delta p \geq \frac{h}{4\pi}$ or $\Delta x \times \Delta v \geq \frac{h}{4\pi m}$

  where, Δx is uncertainty in position and Δp and Δv are uncertainty in momentum and velocity respectively.
- **Schrödinger Wave Equation :** Based on the wave motion associated with the particles,

$$\frac{\partial^2\psi}{\partial x^2}+\frac{\partial^2\psi}{\partial y^2}+\frac{\partial^2\psi}{\partial z^2}+\frac{8\pi^2 m}{h^2}(E-V)\psi=0$$

  ψ has no physical significance but ψ^2 gives the intensity of the electron wave at that point.
- An atomic orbital may be defined as three-dimensional space around the nucleus where the probability of finding an electron is maximum (upto 90-95%).

3 Classification of Elements and Periodicity in Properties

Modern Periodic Law and Present Form of the Periodic Table

Moseley suggested that, the basis of classification of elements should be the atomic number of the elements rather than the atomic mass of the elements.

Modern periodic law states that "the physical and chemical properties of the elements are periodic functions of their atomic numbers". Thus, when the elements were arranged in the order of their increasing atomic numbers, the elements of similar properties appear at regular intervals.

Long form of periodic table consists of horizontal rows called as 'periods' and vertical columns called as 'groups'.

General Trends of Different Periodic Properties in the Periods and Groups

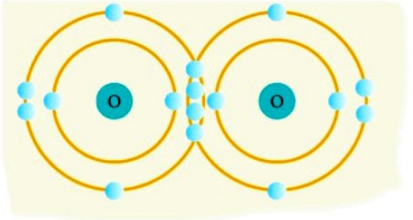
Down the Group	Across the Period: Atomic size	Across the Period
Increases	Atomic size	Decreases
Decreases	Ionisation enthalpy	Increases
Decreases	Electron gain enthalpy	Increases
Decreases	Electronegativity	Increases
Increases	Metallic character	Decreases

Down the Group	Across the Period: Oxidising nature	Across the Period
Decreases	Oxidising nature	Increases
Increases	Reducing nature	Decreases
Increases	Electropositivity	Decreases
Increases	Basic character of oxides	Decreases
Increases	Basic character of hydroxides	Decreases

4 Chemical Bonding and Molecular Structure

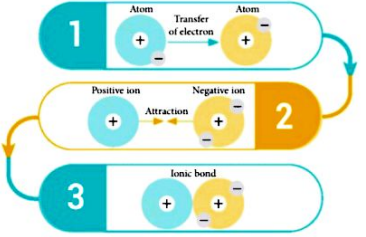
Covalent Bond

A covalent bond is a chemical bond in which pairs of electrons are shared between two atoms.



Ionic Bond

An ionic bond is the bond formed by the complete transfer of valence electron(s) from one atom to another to attain stability.



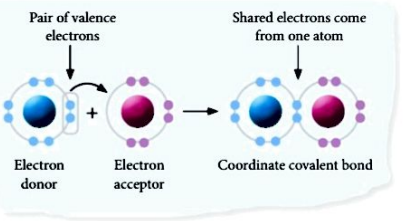
Lewis Representation of Simple Molecules

The Lewis dot structures provide a picture of bonding in molecules and ions in terms of the shared pairs of electrons and the octet rule.

Molecule		Lewis Representation
H_2	H : H	H—H
O_2	:Ö : : Ö:	:Ö=Ö:
O_3		

Coordinate Bond

A coordinate covalent or dative bond is a covalent bond that is formed when both electrons come from the same atom.



Some Important Bond Characteristics

- Bond length $\propto$ Size of atom $\propto \frac{1}{\%\ s\text{-character}}$ $\propto \frac{1}{\text{bond multiplicity}}$
- Bond energy $\propto \frac{1}{\text{Bond length}} \propto \%\ s\text{-character}$
- Bond angle $\propto \%\ s\text{-character} \propto$ Electronegativity of central atom $\propto \frac{1}{\text{Electronegativity of surrounding atom}}$

Valence Bond Theory (Heitler and London)

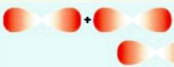
The basic assumptions of this theory are :

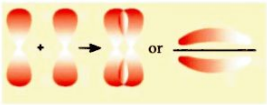
A covalent bond is formed by overlapping of atomic orbitals of valence shell of the two atoms.

Only half-filled atomic orbitals, *i.e.*, orbitals singly occupied take part in overlapping process.

As the orbital of one atom overlaps the orbital of another, the electrons in the orbitals begin to move around both atoms.

The strength of bonding depends on orbital overlap, orbitals other than *s*-orbitals form bonds only in given directions.

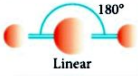
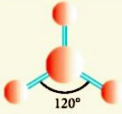
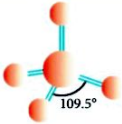
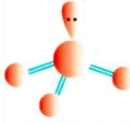
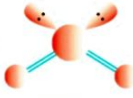
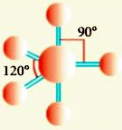
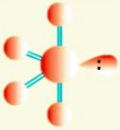
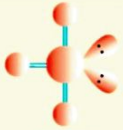
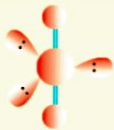
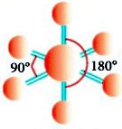
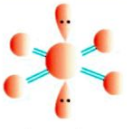
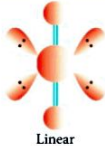
Orbitals used in bond formation	Diagram showing overlap
s-orbital – *s*-orbital	
s-orbital – *p*-orbital	
p-orbital – *p*-orbital (head-head overlap)	

p_y-orbital – p_y-orbital (sidewise overlap)	

VSEPR Theory (Nyholm and Gillespie)

The shape of a molecule depends upon the number of valence shell electron pairs (bonded or non-bonded) surrounding the central atom. The repulsive interactions of electron pairs decrease in the order : *lp–lp* > *lp–bp* > *bp–bp*.

Molecular Geometry of Molecules Containing Bond Pairs Only or Bond Pairs and Lone Pairs

Steric Number	Lone Pairs = 0	Lone Pairs = 1	Lone Pairs = 2	Lone Pairs = 3	Lone Pairs = 4
2	 Linear				
3	 Trigonal planar	 Angular or bent			
4	 Tetrahedral	 Trigonal pyramidal	 Angular or bent		
5	 Trigonal bipyramidal	 See-saw	 T-shaped	 Linear	
6	 Octahedral	 Square pyramidal	 Square planar	–	 Linear

Hybridisation

According to the concept of hybridisation, certain atomic orbitals of nearly the same energy undergo mixing to produce equal number of new orbitals. The new orbitals so obtained are called hybrid orbitals. The process of mixing of the atomic orbitals to form new hybrid orbitals is called hybridisation.

$$\text{Number of hybrid orbitals } (X) = \frac{1}{2}\left\{\begin{matrix}\text{No. of valence electrons}\\ \text{of the central atom}\end{matrix}\right\} + \left\{\begin{matrix}\text{No. of monovalent atoms/groups}\\ \text{surrounding the central atom}\end{matrix}\right\} - \left\{\begin{matrix}\text{Charge on the cation if the given}\\ \text{species is a polyatomic cation}\end{matrix}\right\} + \left\{\begin{matrix}\text{Charge on the anion if the given}\\ \text{species is a polyatomic anion}\end{matrix}\right\}$$

Value of X	2	3	4	5	6	7
Type of hybridisation	sp	sp^2	sp^3	sp^3d	sp^3d^2	sp^3d^3

Molecular Orbital Theory (MOT) or Linear Combination of Atomic Orbitals (LCAO)

- Energy order for molecular orbitals upto N_2 :
  $\sigma 1s < \sigma^*1s < \sigma 2s < \sigma^*2s < (\pi 2p_x = \pi 2p_y) < \sigma 2p_z < \pi^*2p_x = \pi^*2p_y < \sigma^*2p_z$
- Energy order for molecular orbitals beyond N_2 :
  $\sigma 1s < \sigma^*1s < \sigma 2s < \sigma^*2s < \sigma 2p_z < (\pi 2p_x = \pi 2p_y) < (\pi^*2p_x = \pi^*2p_y) < \sigma^*2p_z$

Bond Order

- The number of covalent bonds formed in a molecule is called its bond order. Mathematically, it is defined as half of the difference between the number of bonding and antibonding electrons.
- Bond order (B.O.) $= \frac{1}{2}\left(N_b - N_a\right)$
  where, N_b is number of electrons present in BMO and N_a is number of electrons present in ABMO.

5 Thermodynamics

First Law of Thermodynamics

It is a law of conservation of energy which states that energy can neither be created nor destroyed, although it can be converted from one form to another.
Mathematically : ΔE or $\Delta U = q + W$ or $q = \Delta U - W$

Enthalpy (H)

- Total heat content of the system at constant pressure is known as its enthalpy. Its absolute value cannot be determined. Mathematically, it is given as
  $$\Delta H = \Delta U + P\Delta V$$
- Enthalpy change at constant pressure $(q_p) = \Delta H$
  Enthalpy change at constant volume $(q_v) = \Delta U$
  $q_p = q_v + P\Delta V$ or $q_p = q_v + \Delta n_g RT$
  where, Δn_g is the difference in the number of moles of gaseous product and gaseous reactant.
- **Calorimetry** is the quantitative measurement of the heat required or evolved during a chemical process. The principle of measurement is that the heat given out is equal to the heat taken *i.e.*,
  $$q = (w + m) \times C \times (T_2 - T_1)$$
  where, q = heat of reaction
  w = water equivalent of calorimeter

m = mass of liquid in calorimeter

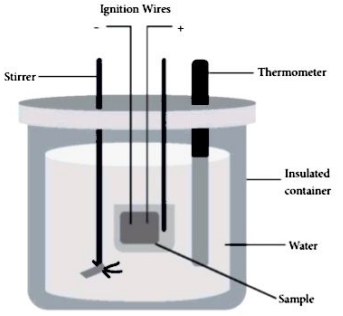
C = specific heat

T_1 and T_2 = initial and final temperatures of the system respectively.

- Internal energy change from bomb calorimeter :

$$\Delta U = \frac{\text{Heat capacity of calorimeter} \times \text{Rise in temperature} \times \text{Molecular mass of substance}}{\text{Mass of substance taken}}$$

$$= q \times \Delta T \times \frac{M}{m}$$



Bomb calorimeter

Second Law of Thermodynamics

- **Entropy (S)** is a measure of the degree of randomness or disorder of the system.
  - ΔS is related with q and T for a reversible reaction as : $\Delta S = \frac{q_{rev}}{T}$
  - The total entropy change for the system and surroundings of a spontaneous process is given by $\Delta S_{total} = \Delta S_{system} + \Delta S_{surrounding} > 0$
  - Entropy changes during phase transformations are :

$$\Delta_{fusion}S = \frac{\Delta_{fusion}H}{T_m}, \quad \Delta_{vap}S = \frac{\Delta_{vap}H}{T_b},$$

$$\Delta_{sub}S = \frac{\Delta_{sub}H}{T}$$

where, T_m is the melting point, T_b is the boiling point and T is the temperature at which sublimation occurs.

  - $\Delta_r S^\circ = \Sigma S^\circ_{products} - \Sigma S^\circ_{reactants}$
- **Gibbs free energy (G)** is the net energy available to do useful work and is a measure of the 'free energy'. $G = H - TS$
  - **Standard free energy of a reaction :** $\Delta_r G^\circ = \Sigma \Delta_f G^\circ_{products} - \Sigma \Delta_f G^\circ_{reactants}$
  - **Gibbs-Helmholtz equation :** $\Delta G = \Delta H - T\Delta S$

$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$

  - $\Delta G^\circ = -nFE^\circ$; where, E° is standard emf of cell.
- **Gibbs free energy change and equilibrium :** Gibbs free energy change, $\Delta_r G^\circ$ is related to the equilibrium constant of the reaction as $\Delta_r G^\circ = -2.303\, RT \log K$.

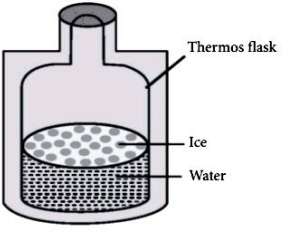
6 Equilibrium

Equilibrium is the state of a process in which the concentration of reactants and products becomes constant until the conditions of temperature and pressure are unchanged. If the opposing process involves only physical changes, the equilibrium is called physical equilibrium and if the process involves only chemical changes, the equilibrium is called chemical equilibrium.

Physical Equilibrium

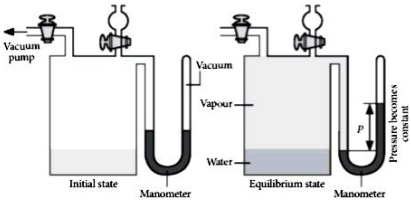
The equilibrium involving only physical changes is called physical equilibrium.

Solid-Liquid Equilibrium



Thermos flask containing ice in equilibrium with water

Liquid-Gas Equilibrium



Evaporation of water in a closed vessel

Law of Chemical Equilibrium

- Law of chemical equilibrium is a result obtained by applying the law of mass action to a reversible reaction in equilibrium.
- For example, consider a general reversible reaction, $aA + bB \rightleftharpoons cC + dD$

  $K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$; where, K_c is equilibrium constant.

  K_c is specific for a reaction and this equation is known as law of chemical equilibrium.

Equilibrium Constant of a Chemical Reaction

When the equation is	Equilibrium constant
reversed	$1/K$
divided by 2	$\sqrt{K}$
multiplied by 2	K^2
divided into 2 steps	$K = K_1 \times K_2$

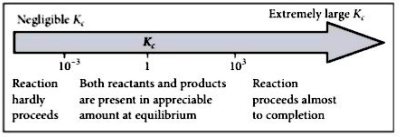
- For a gas phase reaction, $aA + bB \rightleftharpoons cC + dD$

  $K_p = \frac{(p_C)^c(p_D)^d}{(p_A)^a(p_B)^b}$ and $K_p = K_c(RT)^{\Delta n_g}$;

  where, $\Delta n_g = (n_{\text{gaseous products}} - n_{\text{gaseous reactants}})$

Applications of Equilibrium Constant

- **Predicting the extent of reaction :**
  - $K_c > 10^3$ [Forward reaction is favoured.]
  - $K_c < 10^{-3}$ [Reverse reaction is favoured.]
  - $10^{-3} < K_c < 10^3$ [Appreciable concentrations of both reactants and products are present in equilibrium.]



- **Predicting the direction of reaction :**
  - $Q_c > K_c$ [Reverse reaction is favoured.]
  - $Q_c < K_c$ [Forward reaction is favoured.]
  - $Q_c = K_c$ [Reaction is in equilibrium.]

Ionic Equilibrium

- Substances that conduct electricity in their aqueous solutions or in molten state are called electrolytes.
- Strong electrolytes are completely ionised in aqueous solutions and weak electrolytes are partially ionised in aqueous solutions.
- In weak electrolytes, an equilibrium is established between ions and unionised molecules, leading to an ionic equilibrium in the aqueous solution. All acids, bases and salts may be classified as weak or strong electrolytes.
- Degree of dissociation (α) $= \frac{\text{No. of moles dissociated}}{\text{Total no. of moles taken}}$

  For strong electrolytes, $\alpha = 1$ and for weak electrolytes, $\alpha < 1$.

Acids and Bases

Concept	Acid	Base
Arrhenius concept	Produces H^+ ions when dissolved in water.	Produces OH^- ions when dissolved in water.
Bronsted-Lowry concept	Proton donors	Proton acceptors
Lewis concept	Electron acceptors	Electron donors

Buffer Solutions

A buffer solution is defined as a solution which resists the change in its pH value when a small amount of acid or base is added to it or when the solution is diluted.

- **pH of an acidic buffer :**

$$pH = pK_a + \log\frac{[Salt]}{[Acid]} = pK_a + \log\frac{[Conjugate\ base]}{[Acid]}$$

- **pH of a basic buffer :**

$$pOH = pK_b + \log\frac{[Salt]}{[Base]}$$

$$= pK_b + \log\frac{[Conjugate\ acid]}{[Base]}$$

$$pH = 14 - pOH$$

Hydrolysis of Salts

It is a process in which a salt reacts with water to give an acid and a base.

- **Salt of strong base and strong acid :**
  Neutral solution ; pH = 7
- **Salt of weak base and strong acid :**

$$K_h = \frac{K_w}{K_b};\ pH = \frac{1}{2}[pK_w - pK_b - \log C]$$

- **Salt of strong base and weak acid :**

$$K_h = \frac{K_w}{K_a};\ pH = \frac{1}{2}[pK_w + pK_a + \log C]$$

- **Salt of weak acid and weak base :**

$$K_h = \frac{K_w}{K_a \times K_b};\ pH = \frac{1}{2}[pK_w + pK_a - pK_b]$$

Solubility Product

A solid salt of the general formula, A_xB_y with molar solubility 'S' in equilibrium with its saturated solution may be represented by the equation :

$$A_xB_y \rightleftharpoons xA^{y+} + yB^{x-}$$

$$K = \frac{[A^{y+}]^x[B^{x-}]^y}{[A_xB_y]};\ K[A_xB_y] = [A^{y+}]^x[B^{x-}]^y$$

$\because$ $[A_xB_y]$ in solid state remains constant,

$\therefore$ $[A^{y+}]^x[B^{x-}]^y = K_{sp}$

Salt type	Relation between K_{sp} and S
AB_2	$K_{sp} = (S)(2S)^2 = 4S^3$
A_2B	$K_{sp} = (2S)^2(S) = 4S^3$
AB_3	$K_{sp} = (S)(3S)^3 = 27S^4$

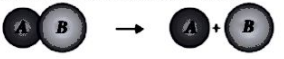
7 Redox Reactions

A reaction in which electrons are transferred from one reactant to another is called redox reaction. Thus, a redox reaction involves both oxidation and reduction. These reactions involve change in oxidation number of interacting species.

Types of Redox Reactions

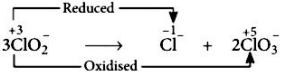
- **Combination reactions :** These are the reactions in which two atoms or molecules combine together to form a third molecule.

- **Decomposition reactions :** These are the reactions in which a molecule/compound breaks down to form two or more atoms or molecules.



- **Displacement reactions :** These are the reactions in which an atom or ion in a compound is replaced by another atom or ion.

  - **Metal displacement reaction :** If a metal atom/ion is displaced by another metal atom/ion in the reaction, it is called metal displacement reaction.
  - **Non-metal displacement reaction :** The non-metal displacement redox reactions include hydrogen displacement and a rarely occurring reaction involving oxygen displacement.
- **Disproportionation reactions :** These are the reactions in which a single species is oxidised as well as reduced simultaneously. In these reactions, the reacting species must have an element which can have at least three variable oxidation states.



8 Organic Chemistry – Some Basic Principles and Techniques

Organic chemistry is the chemistry of carbon compounds as all organic compounds contain carbon as their essential constituent. Organic compounds may be regarded as hydrocarbons *i.e.*, compounds of carbon and hydrogen only. A large number of organic compounds also contain elements like N, O, S, etc. which are derived from hydrocarbons by replacing one or more hydrogen atoms in their molecules with these atoms. Thus, the modern definition of the organic chemistry is "the chemistry of the hydrocarbons and their derivatives."

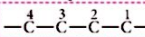
IUPAC Nomenclature

IUPAC name = **2° prefix** + **1° prefix** + **word root** + **1° suffix** + **2° suffix**

Some functional groups are always treated as substituents whether organic compound is monofunctional or polyfunctional *e.g.*, Fluoro (–F), Chloro (–Cl), Bromo (–Br), Iodo (–I), Nitro ($-NO_2$), Nitroso (–NO), Diazo ($-\overset{+}{N}\equiv N$), Alkoxy (–*OR*), Alkyl (–*R*), Phenyl ($-C_6H_5$), etc.

Cyclo is used for carbocyclic compounds. If cyclo is not used, it indicates acyclic or open chain compound.

Principal chain



If no. of C atoms is 1-meth, 2-eth, 3-prop(*a*), 4-but(*a*), 5-pent(*a*), 6-hex(*a*), 7-hept(*a*), 8-oct(*a*), 9-non(*a*), 10-dec(*a*), 11-undec(*a*), 12-dodec(*a*). Extra '*a*' is added to word root if 1° suffix begins with a consonant.

Single bond only – ane

1 (=)bond –ene	1 (≡)bond –yne
2 (=)bonds –diene	2 (≡)bonds –diyne
3 (=)bonds –triene	3 (≡)bonds –triyne

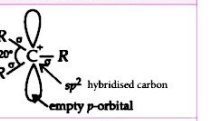
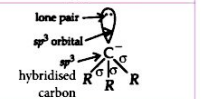
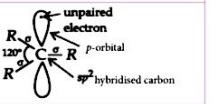
Indicates functional group,
—OH(-ol), —CHO(-al)
>CO(-one),
—COOH (-oic acid),
—$CONH_2$ (-amide),
—COCl (-oyl chloride),
—COO*R* (alkyl ..... -oate),
—CN (nitrile), —SH (thiol),
—NH_2 (-amine).
If 2° suffix begins with a vowel, the terminal '*e*' is dropped.

Isomerism

The phenomenon of existence of two or more compounds possessing the same molecular formula but different properties is known as isomerism. It is classified broadly into structural isomerism and stereoisomerism.

Fundamental Concepts in Reaction Mechanism

Reaction Intermediates

	Species	Orbital Structure
1.	**Carbocations** (Planar) – These are highly reactive chemical species since the carbon atom carrying the positive charge has only six electrons in its valence shell and thus a strong tendency to complete its octet.	
2.	**Carbanions** (Pyramidal) – Chemical species bearing a negative charge on carbon and possessing eight electrons in its valence shell are called carbanions.	
3.	**Free Radicals** (Planar) – A free radical can be defined as an atom or a group of atoms having an odd or unpaired electron.	

Attacking Reagents

Attacking Reagents

Electrophiles

Positively charged or neutral molecules, having electron deficient atom.

- **Charged**: H^+, NO_2^+, NH_4^+, R^+, etc.
- **Neutral**: BF_3, $AlCl_3$, SO_3, etc.

Nucleophiles

Negatively charged or neutral molecules, having electron rich atom with unshared electron pair.

- **Charged**: H^-, OH^-, R^-, $RCOO^-$, etc.
- **Neutral**: $\ddot{N}H_3$, $H_2\ddot{O}$:, $R\ddot{O}H$, $R\ddot{N}H_2$, etc.

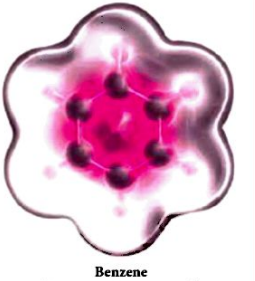
Electron Displacement Effects in Covalent Bond

Inductive effect : Displacement of σ-electrons along a saturated carbon chain when an electron donating (+*I* effect) or electron withdrawing (–*I* effect) group is attached at the end of the carbon chain.	↳ **–*I* effect :** $R_3\overset{+}{N}-$, $-NO_2$, $-SO_2R$, $-CN$, $-COOH$, $-F$, $-Cl$, $-Br$, $-I$, $-COR$, etc. ↳ **+*I* effect :** $(CH_3)_3C-$, $(CH_3)_2CH-$, CH_3CH_2- , CH_3-, etc.
Electromeric effect : It involves complete transfer of π-electrons of a multiple bond to one of the bonded atoms (usually more electronegative) in the presence of an attacking reagent.	↳ **+*E* effect :** If the electrons of the π-bond are transferred to that atom of the double bond to which the reagent gets finally attached. ↳ **–*E* effect :** If the electrons of the double bond are transferred to an atom of the double bond other than the one to which the reagent gets finally attached.
Resonance or mesomeric effect : It is defined as the polarity produced in the molecule by the interaction of two π-bonds or between a π-bond and a lone pair of electrons present on adjacent atom.	↳ **+*R* effect :** $-Cl$, $-Br$, $-I$, $-NH_2$, $-NHR$, $-NR_2$, $-OH$, $-OR$, $-SR$, $-SH$, etc. ↳ **–*R* effect :** $-NO_2$, $-CN$, $-CHO$, $-COOH$, etc.

10 Hydrocarbons

Classification of Organic Compounds

- **Organic compounds**
  - Acyclic or open chain or aliphatic compounds
    - Unsaturated
    - Saturated
  - Cyclic compounds
    - Homocyclic compounds
      - Alicyclic compounds
      - Aromatic compounds
        - Benzenoid
        - Non-Benzenoid
    - Heterocyclic compounds
      - Alicyclic compounds
      - Aromatic compounds



Benzene
(An aromatic compound)

Alkanes

Methods of Preparation

By hydrogenation of unsaturated hydrocarbons

$$CH_2{=}CH_2 + H_2 \xrightarrow[\text{or Pt or Pd}]{\text{Raney Ni}} CH_3{-}CH_3$$

Wurtz reaction

$$RX + 2Na + XR \xrightarrow{\text{Dry ether}} R{-}R + 2NaX$$

By hydroboration of alkenes

$$RCH{=}CH_2 \xrightarrow[\text{In diglyme}]{B_2H_6} (RCH_2CH_2)_3B \xrightarrow[NaOH]{AgNO_3} RCH_2CH_2CH_2CH_2R$$

Kolbe's electrolysis

$$2RCOONa + 2H_2O \xrightarrow{\text{Electrolysis}} R{-}R + 2CO_2 + 2NaOH + H_2$$

ALKANES

Chemical Properties

Halogenation

$$CH_4 + 4Cl_2 \xrightarrow[520\text{-}670\ K]{h\nu} CCl_4 + 4HCl$$

Complete combustion

$$C_nH_{2n+2} + \left(\frac{3n+1}{2}\right)O_2 \longrightarrow nCO_2 \quad (n+1)H_2O$$

Catalytic oxidation

$$2CH_4 + O_2 \xrightarrow[100\ atm/573\ K]{\text{Cu tube}} 2CH_3OH$$
(9 : 1)

Aromatisation

$$\underset{n\text{-Hexane}}{C_6H_{14}} \xrightarrow[773\ K/10\text{-}20\ atm]{Cr_2O_3/Al_2O_3} \underset{\text{Benzene}}{\bigcirc} + 4H_2$$

Alkenes

Methods of Preparation

Dehydration of alcohols

$$R{-}OH \xrightarrow[473\ K]{\text{conc. } H_2SO_4}$$

$$R{-}OH \xrightarrow[623\ K\text{-}673\ K]{Al_2O_3}$$

Dehydrohalogenation of alkyl halides

$$R{-}Br + KOH_{(alc.)} \xrightarrow{\Delta}$$

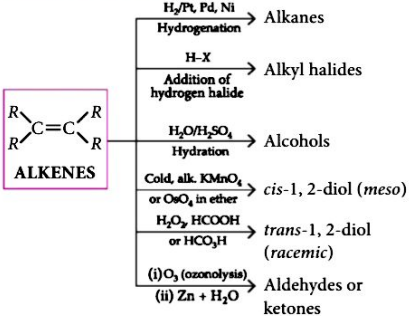
Partial hydrogenation of alkynes

$$R{-}C{\equiv}C{-}R \xrightarrow[\text{(Lindlar's catalyst)}]{H_2, Pd/CaCO_3} \textit{cis}\text{-alkene}$$

$$R{-}C{\equiv}C{-}R \xrightarrow[\text{Ethanol}]{\text{Na /196-200 K}} \textit{trans}\text{-alkene}$$

ALKENES

Chemical Properties



Alkynes

Methods of Preparation

Dehydrohalogenation of dihalides

$$CH_2Br{-}CH_2Br \xrightarrow[NaNH_2,\ liq.\ NH_3]{alc.\ KOH,\ \Delta}$$

Kolbe's electrolysis

$$\begin{matrix} CHCOO^- \\ \| \\ CHCOO^- \end{matrix} + 2H_2O \xrightarrow{-2e^-}$$

By heating tetrahalides with Zn dust

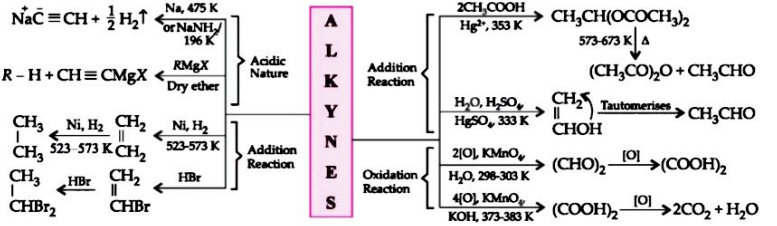
$$CHCl_2{-}CHCl_2 + 2Zn \xrightarrow[\Delta]{\text{Alcohol}}$$

Laboratory method

$$\underset{\text{Calcium carbide}}{CaC_2} + 2H_2O \longrightarrow$$

ALKYNES

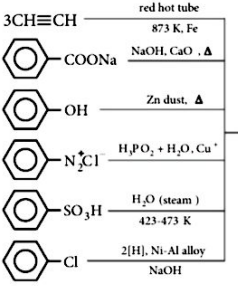
Chemical Properties



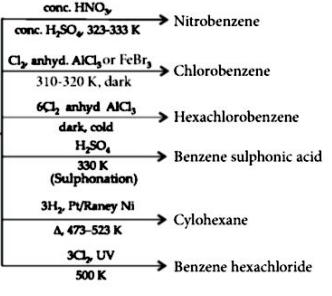
Aromatic Hydrocarbons

- Aromatic hydrocarbons are also known as arenes. Benzene is the simplest aromatic hydrocarbon.
- Arenes are the aromatic hydrocarbons which contain one or more benzene rings. Benzene ring is a six-membered ring containing carbon atoms linked to each other with alternate single and double bonds.

Methods of Preparation



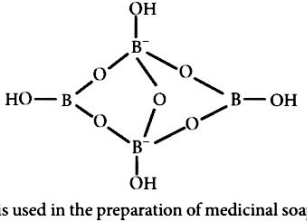
Chemical Properties



A *p*-Block Elements (Groups 13 and 14)

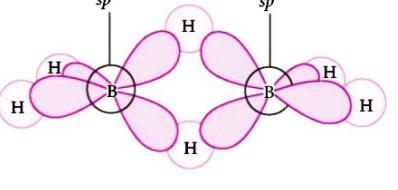
Some Important Compounds of Boron

Borax



Borax is used in the preparation of medicinal soaps due to its antiseptic properties.

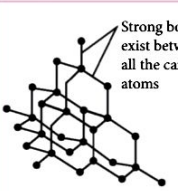
Diborane



Diborane is used for preparing a number of borohydrides such as $LiAlH_4$ and $NaBH_4$. It is also used as a reducing agent in many chemical reactions.

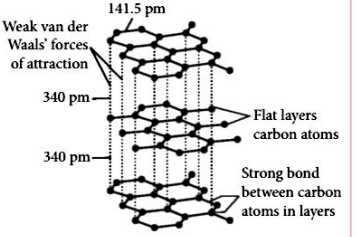
Allotropic Forms of Carbon

Diamond



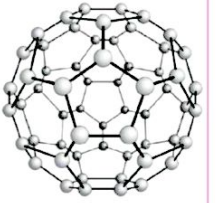
Structure of diamond (Black balls represent carbon atoms)

Graphite



Structure of graphite

Buckminsterfullerene



Structure of C_{60} fullerene

Silicates

Silicates can be considered as metal derivatives of silicic acid. Different silicates may have discrete SiO_4^{4-} tetrahedra or number of such units joined together by sharing of oxygen atoms.

Silicates are formed by heating metal oxides or metal carbonates with sand. *e.g.*,

$$n Na_2CO_3 \xrightarrow[SiO_2]{\text{Fused with sand}} Na_2(SiO_3)_n + nCO_2$$

Silicates are classified into different types on the basis of number of oxygen atoms of SiO_4^{4-} shared with other tetrahedra.

Type	No. of oxygen atoms shared	Basic unit	Example
Orthosilicates	No sharing	SiO_4^{4-}	Zircon–$ZrSiO_4$, Foresterite–Mg_2SiO_4
Pyrosilicates or islands	One oxygen atom shared	$Si_2O_7^{6-}$	Thortveitite–$Sc_2(Si_2O_7)$, Hemimorphite–$Zn_3(Si_2O_7)\cdot Zn(OH)_2\cdot H_2O$
Cyclic or ring silicates	Two oxygen atoms per tetrahedron shared	$\left(SiO_3^{2-}\right)_n$ or $\left(SiO_3\right)_n^{2n-}$	Wollastonite–$Ca_3Si_3O_9$, Beryl–$Be_3Al_2Si_6O_{18}$
Chain silicates	Two oxygen atoms per tetrahedron shared	$\left(SiO_3\right)_n^{2n-}$ or $\left(Si_4O_{11}\right)_n^{6n-}$	Spodumene–$LiAl(SiO_3)_2$, Diopside–$CaMg(SiO_3)_2$
Sheet silicates (two dimensional)	Three oxygen atoms per tetrahedron shared	$\left(Si_2O_5\right)_n^{2n-}$ or $\left(Si_2O_5^{2-}\right)_n$	Kaolin–$Al_2(OH)_4(Si_2O_5)$, Talc-$Mg_3(Si_2O_5)_2(OH)_2$
Three-dimensional silicates	All four oxygen atoms shared	$(SiO_3)_n$	Zeolites, Quartz, Feldspar, Ultramarines, etc.

PRACTICE PAPER 2024

Karnataka CET

1. Standard electrode potentials of iron species are given as follows :
Fe^{2+}/Fe; $E^\circ = -0.44$ V and Fe^{3+}/Fe^{2+}; $E^\circ = 0.77$ V. If Fe^{2+}, Fe^{3+} and Fe blocks are kept together, then the concentration of
(a) Fe^{3+} increases
(b) Fe^{3+} decreases
(c) Fe^{2+} remains unchanged
(d) Fe^{2+} decreases.

2. The basic character of MgO, SrO, K_2O and NiO increases in the order
(a) $K_2O < SrO < MgO < NiO$
(b) $NiO < MgO < SrO < K_2O$
(c) $MgO < NiO < SrO < K_2O$
(d) $K_2O < MgO < NiO < SrO$

3. From the colligative properties of solution, which one is the best method for the determination of molecular weight of proteins and polymers?
(a) Osmotic pressure
(b) Lowering in vapour pressure
(c) Lowering in freezing point
(d) Elevation in boiling point

4. In which of the following complex ions, there is outer orbital hybridisation?
(a) $[Zn(NH_3)_6]^{2+}$ (b) $[Co(NH_3)_6]^{3+}$
(c) $[Cr(NH_3)_6]^{3+}$ (d) $[V(NH_3)_6]^{3+}$

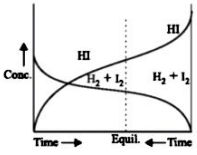
5. If Henry's law constant for oxygen is 1.1×10^{-3} mol dm^{-3} atm^{-1} and its partial pressure is 0.20 atm, the concentration of dissolved oxygen at NTP will be
(a) 2.2×10^{-3} mol dm^{-3}
(b) 2.2×10^{-4} mol dm^{-3}
(c) 1.1×10^{-4} mol dm^{-3}
(d) 0.22×10^{-4} mol dm^{-3}

6. Which of the following pairs will have different hybridisation but same shape?
(i) NO_3^- and CO_3^{2-} (ii) SO_2 and NH_2^-
(iii) XeF_2 and CO_2 (iv) H_2O and NH_3
(a) (i) and (iv) (b) (ii) and (iv)
(c) (ii) and (iii) (d) None of these

7. The slope of Arrhenius plot $\left(\ln k \, vs \frac{1}{T}\right)$ of first order reaction is -5×10^3 K. The value of E_a of the reaction is
[Given : $R = 8.314$ J K^{-1} mol^{-1})
(a) -83 kJ mol^{-1} (b) 41.5 kJ mol^{-1}
(c) 83.0 kJ mol^{-1} (d) 166 kJ mol^{-1}

8. The correct relationship between C_p and C_V for an ideal gas is
(a) $C_p = C_V - R$ (b) $C_p = C_V \times R$
(c) $C_V = C_p \times R$ (d) $C_p - C_V = R$

9. Consider the following graph and mark the correct statement.

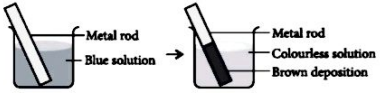


(a) Chemical equilibrium in the reaction, $H_2 + I_2 \rightleftharpoons 2HI$ can be attained from either directions.
(b) Equilibrium can be obtained when H_2 and I_2 are mixed in an open vessel.
(c) The concentrations of H_2 and I_2 keep decreasing while concentration of HI keeps increasing with time.
(d) We can find out equilibrium concentration of H_2 and I_2 from the given graph.

10. Which of the following contains the maximum number of atoms?

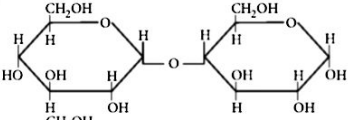
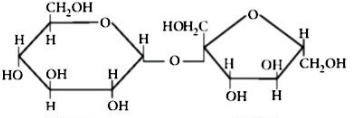
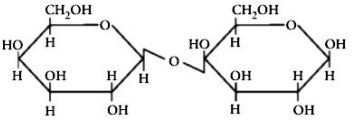
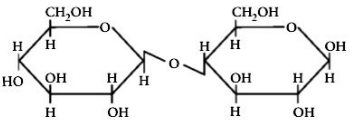
(a) 1.0 g of hydrogen (H_2)
(b) 1.0 g of nitrogen (N_2)
(c) 1.0 g of oxygen (O_2)
(d) 1.0 g of water (H_2O)

11. A redox reaction is shown in the following diagrams.

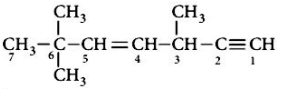


Identify the reaction taking place.
(a) $Zn_{(s)} + Cu^{2+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$
(b) $Cu_{(s)} + 2Ag^{+}_{(aq)} \rightarrow Cu^{2+}_{(aq)} + 2Ag_{(s)}$
(c) $2Ag_{(s)} + Cu^{2+}_{(aq)} \rightarrow 2Ag^{+}_{(aq)} + Cu_{(s)}$
(d) $Cu_{(s)} + Zn^{2+}_{(aq)} \rightarrow Cu^{2+}_{(aq)} + Zn_{(s)}$

12. In disaccharides, if the reducing groups of monosaccharides *i.e.*, aldehydic or ketonic groups are bonded, these are non-reducing sugars. Which of the following disaccharide is a non-reducing sugar?

(a) 
(b) 
(c) 
(d) 

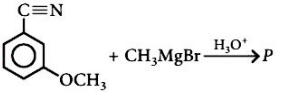
13. The states of hybridisation of C_1, C_2, C_4 and C_5 of the hydrocarbon,



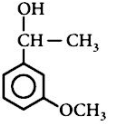
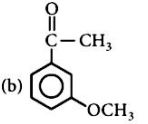
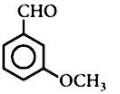
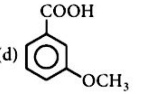
are in the sequence

(a) sp^3, sp^2, sp^2 and sp (b) sp, sp^2, sp^2 and sp^3
(c) sp, sp^2, sp^3 and sp^2 (d) sp, sp, sp^2 and sp^2

14. Dinucleotide is obtained by joining two nucleotides together by phosphodiester linkage. Between which carbon atoms of pentose sugars of nucleotides are these linkages present?
(a) 5′ and 3′ (b) 1′ and 5′
(c) 5′ and 5′ (d) 3′ and 3′

15. 

Product '*P*' in the above reaction is

(a) 
(b) 
(c) 
(d) 

16. 2,3-Dimethyl-2-butene can be prepared by heating which of the following compounds with a strong acid?
(a) $(CH_3)_3CCH{=}CH_2$
(b) $(CH_3)_2C{=}CHCH_2CH_3$
(c) $(CH_3)_2CHCH_2CH{=}CH_2$
(d) $(CH_3)_2CH-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH{=}CH_2$

17. Ethyl benzoate can be prepared from benzoic acid by using
(a) ethyl alcohol and dry ether
(b) ethyl alcohol and dry HCl
(c) ethyl chloride
(d) sodium ethoxide.

18. A microscope using suitable photons is employed to locate an electron in an atom within a distance of 0.1 Å. What is the uncertainty involved in the measurement of its velocity?
(a) 6.69×10^8 m/s (b) 5.79×10^6 m/s
(c) 7.32×10^8 m/s (d) 4.42×10^6 m/s

19. Isomerization of an alkane may be carried out by using

(a) Al_2O_3 (b) HI/P
(c) anhyd. $AlCl_3$ and HCl gas
(d) concentrated H_2SO_4.

20. Which of the following does not show positive deviation from Raoult's law?
(a) Benzene-Chloroform
(b) Carbon disulphide-Acetone
(c) Acetone-Ethanol
(d) Cyclohexanol-Cyclohexane

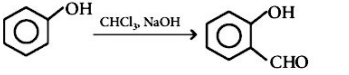
21. Mark the correct statement.
(a) Methylamine is a stronger acid than ammonia.
(b) Methylamine is a weaker base than ammonia.
(c) Methylamine is a stronger base than ammonia.
(d) Methylamine forms salts with alkalies.

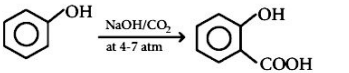
22. The reaction, $2A_{(g)} + B_{(g)} \rightleftharpoons 3C_{(g)} + D_{(g)}$ begins with the concentrations of A and B both at an initial value of 1.00 M. When equilibrium is reached, the concentration of D is measured and found to be 0.25 M. The value for the equilibrium constant for this reaction is given by the expression
(a) $[(0.75)^3(0.25)] \div [(1.00)^2(1.00)]$
(b) $[(0.75)^3(0.25)] \div [(0.50)^2(0.75)]$
(c) $[(0.75)^3(0.25)] \div [(0.50)^2(0.25)]$
(d) $[(0.75)^3(0.25)] \div [(0.75)^2(0.25)]$

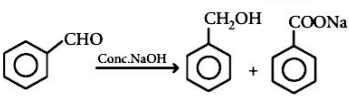
23. $CH_3CH_2Cl \xrightarrow{NaCN} X \xrightarrow{Ni/H_2} Y \xrightarrow{\text{acetic anhydride}} Z$

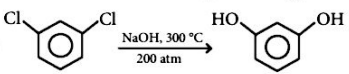
Z in the above reaction sequence is
(a) $CH_3CH_2CH_2NHCOCH_3$
(b) $CH_3CH_2CH_2NH_2$
(c) $CH_3CH_2CH_2CONHCH_3$
(d) $CH_3CH_2CH_2CONHCOCH_3$

24. Which of the following represents Reimer-Tiemann reaction?

(a) 

(b) 

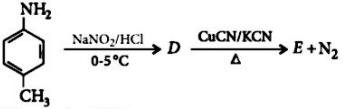
(c) 

(d) 

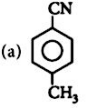
25. Which of the following will make a basic buffer?
(a) 100 mL of 0.1 M HCl + 100 mL of 0.1 M NaOH
(b) 50 mL of 0.1 M NaOH + 25 mL of 0.1 M CH_3COOH
(c) 100 mL of 0.1 M CH_3COOH + 100 mL of 0.1 M NaOH
(d) 100 mL of 0.1 M HCl + 200 mL of 0.1 M NH_4OH

26. 1 g of Mg is burnt in a closed vessel containing 0.5 g of O_2. Which reactant is limiting reagent and how much of the excess reactant will be left?
(a) O_2 is a limiting reagent and Mg is in excess by 0.25 g.
(b) Mg is a limiting reagent and is in excess by 0.5 g.
(c) O_2 is a limiting reagent and is in excess by 0.25 g.
(d) O_2 is a limiting reagent and Mg is in excess by 0.75 g.

27. In the reaction,

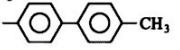


The product (E) is

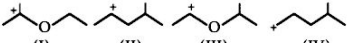
(a) 

(b) 

(c) 

(d) 

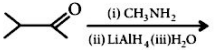
28. The correct stability order for the following species is

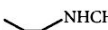


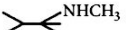
(a) (II) > (IV) > (I) > (III)
(b) (I) > (II) > (III) > (IV)
(c) (II) > (I) > (IV) > (III)
(d) (I) > (III) > (II) > (IV)

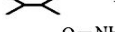
29. Which factor has no influence on the rate of reaction?
(a) Molecularity (b) Temperature
(c) Concentration of reactant
(d) Nature of reactant

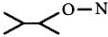
30. The major organic product formed from the following reaction :



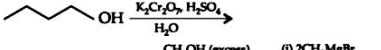
(a) 

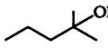
(b) 

(c) 

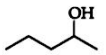
(d) 

31. The end product of the following sequence of reactions is



(a) 

(b) 

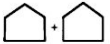
(c) 

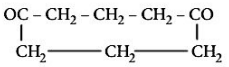
(d) 

32. 0.5 M solution of urea is isotonic with
(a) 0.5 M NaCl solution
(b) 0.5 M sugar solution
(c) 0.5 M $BaCl_2$ solution
(d) 0.5 M solution of benzoic acid in benzene.

33. The pair of compounds having metals in their highest oxidation state is
(a) MnO_2, $FeCl_3$
(b) $[MnO_4]^-$, CrO_2Cl_2
(c) $[Fe(CN)_6]^{4-}$, $[Co(CN)_6]^{3-}$
(d) $[NiCl_4]^{2-}$, $[Ni(CO)_4]$

34. Ozonolysis of  will give

(a) 

(b) 

(c) 

(d) none of these.

35. A coordination complex compound of cobalt has the molecular formula containing five ammonia molecules, one nitro group and two chlorine atoms for one cobalt atom. One mole of this compound produces three mole ions in an aqueous solution. On reacting this solution with excess of $AgNO_3$ solution, we get two moles of AgCl precipitate. The ionic formula for this complex would be
(a) $[Co(NH_3)_5(NO_2)]Cl_2$
(b) $[Co(NH_3)_5Cl][Cl(NO_2)]$
(c) $[Co(NH_3)_4(NO_2)Cl][(NH_3)Cl]$
(d) $(Co(NH_3)_5][(NO_2)_2Cl_2]$

36. In which of the following reactions, the product is an ether?
(a) $C_6H_6 + CH_3COCl$/anhydrous $AlCl_3$
(b) C_2H_5Cl + *aq.* KOH
(c) $C_6H_6 + C_6H_5COCl$/anhydrous $AlCl_3$
(d) $C_2H_5Cl + C_2H_5ONa$

37. Elements, *P*, *Q*, *R* and *S* have the following electronic configurations :
P : $[Ar]3d^{10}4s^1$
Q : $[Ar]3d^{10}4s^24p^65s^1$
R : $[Ar]3d^{10}4s^24p^64d^{10}5s^1$
S : $[Ar]3d^{10}4s^24p^64d^55s^1$
Which two elements fall into the same group?
(a) *Q* and *R* (b) *P* and *R*
(c) *Q* and *S* (d) *P* and *Q*

38. Match the amines given in column-I with their classification in the column-II and choose the correct option.

Column-I		Column-II	
A.		1.	Primary amine
B.		2.	Secondary amine
C.	$(C_2H_5)_2NH$	3.	Tertiary amine

	A	B	C
(a)	1	2	3
(b)	1	3	2
(c)	2	1	3
(d)	2	3	1

39. On the basis of the information available from the reaction, $4/3Al + O_2 \rightarrow 2/3Al_2O_3$, $\Delta G° = -827$ kJ mol^{-1} of O_2, the minimum e.m.f. required to carry out an electrolysis of Al_2O_3 is
($F = 96500$ C mol^{-1})
(a) 2.14 V (b) 4.28 V (c) 6.42 V (d) 8.56 V

40. Which overlap is involved in HCl molecule?
(a) *s-s* overlap (b) *p-p* overlap
(c) *s-d* overlap (d) *s-p* overlap

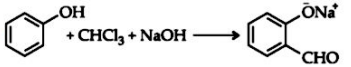
41. 3-Methyl-2-pentene on reaction with HOCl gives

(a) $CH_3-CH_2-\underset{CH_3}{\overset{Cl}{\underset{|}{\overset{|}{C}}}}-\overset{OH}{\overset{|}{CH}}-CH_3$

(b) $\underset{CH_3}{\overset{H_3C}{\underset{|}{\overset{|}{C}}}}-\overset{OH}{\overset{|}{CH}}-CH_3$

(c) $CH_3-CH_2-\underset{CH_3}{\overset{Cl}{\underset{|}{\overset{|}{C}}}}-\overset{Cl}{\overset{|}{CH}}-CH_3$

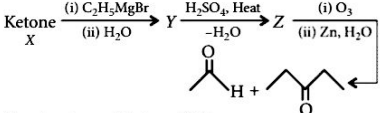
(d) $CH_3-CH_2-\underset{H_3C}{\overset{OH}{\underset{|}{\overset{|}{C}}}}-\overset{Cl}{\overset{|}{CHCH_3}}$

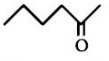
42. 

The electrophile involved in the above reaction is
(a) dichloromethyl cation ($\overset{+}{C}HCl_2$)
(b) dichlorocarbene ($:CCl_2$)
(c) trichloromethyl anion ($\overset{-}{C}Cl_3$)
(d) formyl cation ($\overset{+}{C}HO$)

43. The incorrect statement among the following is
(a) bonding molecular orbitals possess less energy than combining atomic orbitals
(b) bonding molecular orbitals are denoted by σ^*, π^*, etc.
(c) every electron in bonding molecular orbitals contributes to attraction between atoms
(d) bonding molecular orbital contributes towards the stability of molecule.

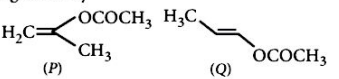
44. Consider the following sequence of reactions :



The structure of ketone (*X*) is
(a) 
(b) 
(c) 
(d) 

45. Which among the following statements is correct with respect to the optical isomers?
(a) Enantiomers are non-superimposable mirror images.
(b) Diastereomers are superimposable mirror images.
(c) Enantiomers are superimposable mirror images.
(d) Meso forms have no plane of symmetry.

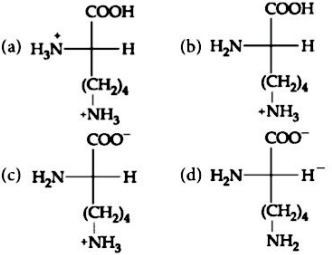
46. The product of acid hydrolysis of *P* and *Q* can be distinguished by



(a) Lucas reagent (b) 2,4-DNP
(c) Fehling's solution (d) $NaHSO_3$

47. The work done during the free expansion of one mole of an ideal gas at 27°C to twice its original volume is (Given : $RT = 2494\ J\ mol^{-1}$, ln 2 = 0.7, log 2 = 0.3)
(a) 1746 J mol^{-1} (b) −1746 J mol^{-1}
(c) zero (d) 748.2 J mol^{-1}

48. Which of the following is the major species in a solution of lysine at pH = 3.5?



49. The emission spectrum of hydrogen is found to satisfy the expression for the energy change ΔE (in Joules) such that

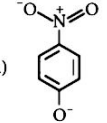
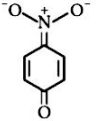
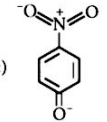
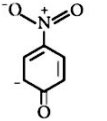
$$\Delta E = 2.18 \times 10^{-18}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) J$$

where n_1 = 1, 2, 3, ... and n_2 = 2, 3, 4, ...
The spectral lines will correspond to Paschen series if
(a) $n_1 = 1$ and $n_2 = 2, 3, 4$
(b) $n_1 = 3$ and $n_2 = 4, 5, 6$
(c) $n_1 = 1$ and $n_2 = 3, 4, 5$
(d) $n_1 = 2$ and $n_2 = 3, 4, 5$

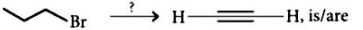
50. The equilibrium constant, K for the reaction, $2HI_{(g)} \rightleftharpoons H_{2(g)} + I_{2(g)}$ at room temperature is 2.85 and that at 698 K is 1.4×10^{-2}. This implies that

(a) HI is an acidic compound
(b) HI is very stable at room temperature
(c) the formation of H_2 and I_2 is less favourable at high temperature
(d) formation of H_2 and I_2 is more favourable at high temperature.

51. The most unlikely representation of resonance structures of *p*-nitrophenoxide ion is

(a) 
(b) 
(c) 
(d) 

52. The reagent(s) for the following conversion,



(a) alcoholic KOH
(b) alcoholic KOH followed by $NaNH_2$
(c) aqueous KOH followed by $NaNH_2$
(d) Zn/CH_3OH.

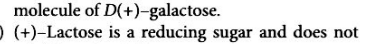
53. Which one of the following statements is not true regarding (+)–lactose?

(a) On hydrolysis (+)–lactose gives equal amount of *D*(+)–glucose and *D*(+)–galactose.
(b) (+)–Lactose is a β-glucoside formed by the union of a molecule of *D*(+)–glucose and a molecule of *D*(+)–galactose.
(c) (+)–Lactose is a reducing sugar and does not exhibit mutarotation.
(d) (+)–Lactose contains 8 —OH groups.

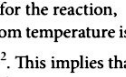
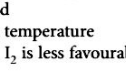
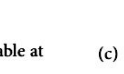
54. For the reaction, $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ + Heat

(a) $K_p = K_c$ (b) $K_p = K_c(RT)^{-1}$
(c) $K_p = K_c(RT)^{-2}$ (d) $K_p = K_c\,RT$

55. In a set of reactions acetic acid yielded a product *D*.



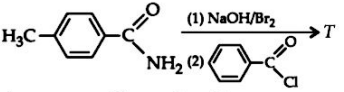
The structure of *D* would be

(a) 
(b) 
(c) 
(d) 

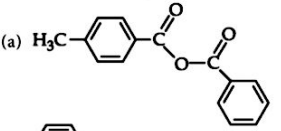
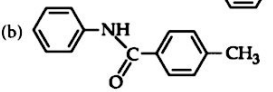
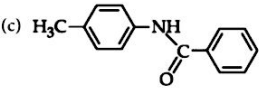
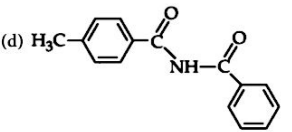
56. The densities of graphite and diamond at 298 K are 2.25 and 3.31 g cm^{-3}, respectively. If the standard free energy difference (ΔG°) is equal to 1895 J mol^{-1}, the pressure at which graphite will be transformed into diamond at 298 K is

(a) 11.08×10^8 Pa (b) 11.08×10^7 Pa
(c) 9.92×10^6 Pa (d) 10.03×10^5 Pa

57. In the reaction :



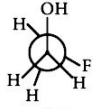
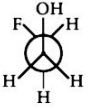
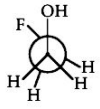
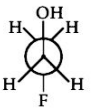
the structure of the product *T* is

(a) 
(b) 
(c) 
(d) 

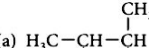
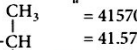
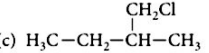
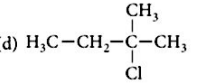
58. Which of the following is a decreasing order of oxidation state of the central atoms?

(a) PCl_5, HIO_4, $Cr_2O_7^{2-}$, CO_2
(b) $Cr_2O_7^{2-}$, CO_2, HIO_4, PCl_5
(c) HIO_4, $Cr_2O_7^{2-}$, PCl_5, CO_2
(d) $Cr_2O_7^{2-}$, HIO_4, CO_2, PCl_5

59. The most stable conformation of 2-fluoroethanol is

(a) 
(b) 
(c) 
(d) 

60. An alkene *A* on reaction with O_3 and Zn—H_2O gives propanone and ethanal in equimolar ratio. Addition of HCl to alkene *A* gives *B* as the major product. The structure of product *B* is

(a) 
(b) 
(c) 
(d) 

SOLUTIONS

1. (b): $E^{\circ}_{Fe^{2+}/Fe} = -0.44$ V and $E^{\circ}_{Fe^{3+}/Fe^{2+}} = +0.77$ V

If a cell is constructed combining these two electrodes, oxidation occurs at Fe^{2+}/Fe electrode.

At anode : $Fe \rightarrow Fe^{2+} + 2e^-$

At cathode : $[Fe^{3+} + e^- \rightarrow Fe^{2+}] \times 2$

Cell reaction : $Fe + 2Fe^{3+} \rightarrow 3Fe^{2+}$

If Fe^{2+}, Fe^{3+} and Fe blocks are kept together, then Fe^{3+} reacts with Fe to yield Fe^{2+} *i.e.*, concentration of Fe^{3+} is decreased and that of Fe^{2+} is increased.

2. (b): Basic character of oxides increases with increase in electropositive character. Also, the basic nature of oxides increases along the group and decreases across the period.

3. (a) **4. (a)**

5. (b): According to Henry's law, $S = K_H P$

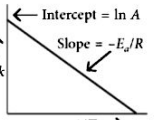
$\Rightarrow S = 1.1 \times 10^{-3}$ mol dm^{-3} atm$^{-1} \times 0.20$ atm
$= 2.2 \times 10^{-4}$ mol dm^{-3}

6. (c): (i) NO_3^- (sp^2, trigonal planar) CO_3^{2-} (sp^2, trigonal planar)
Same hybridisation and same shape.
(ii) SO_2 (sp^2, bent) NH_2^- (sp^3, bent)
Different hybridisation and same shape.
(iii) XeF_2 (sp^3d, linear) CO_2 (sp, linear)
Different hybridisation and same shape.
(iv) H_2O (sp^3, angular) NH_3 (sp^3, pyramidal)
Same hybridisation and different shapes.

7. (b): $\ln k = -\frac{E_a}{RT} + \ln A$

$-\frac{E_a}{R} = -5 \times 10^3$ K $= -5000$ K

$E_a = 5000$ K $\times$ 8.314 J K^{-1} mol^{-1}
$= 41570$ J mol^{-1}
$= 41.57$ kJ mol^{-1}



8. (d)

9. (a): It is a reversible reaction. Equilibrium can be attained by either side of the reactions of equilibrium.

10. (a): Number of atoms = Number of molecules × number of atoms in one molecule

One mole of a substance contains 6.022×10^{23} atoms / ions / molecules which is known as Avogadro's number (N_A).

$$\text{Number of moles} = \frac{\text{Given mass (g)}}{\text{Molar mass (g/mol)}}$$

The molar masses of H_2, N_2, O_2 and H_2O are 2 g/mol, 28 g/mol, 32 g/mol and 18 g/mol respectively.

Number of atoms in 1.0 g hydrogen (H_2)

$$= \frac{1}{2} \times N_A \times 2 = N_A$$

Number of atoms in 1.0 g nitrogen (N_2)

$$= \frac{1}{28} \times N_A \times 2 = \frac{N_A}{14}$$

Number of atoms in 1.0 g oxygen (O_2)

$$= \frac{1}{32} \times N_A \times 2 = \frac{N_A}{16}$$

Number of atoms in 1.0 g water (H_2O)

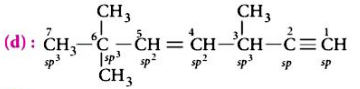
$$= \frac{1}{18} \times N_A \times 3 = \frac{N_A}{6}$$

Thus, 1 g of hydrogen has maximum number of atoms.

11. (a)

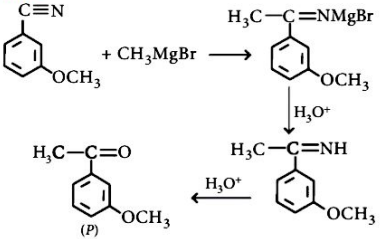
12. (b): In option (b), two monosaccharides are held together by a glycosidic linkage between C-1 of α-glucose and C-2 of β-fructose.

13. (d) :

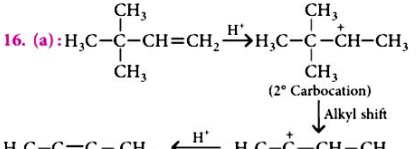


14. (a)

15. (b) :



16. (a) :



17. (b) : Ethyl benzoate can be prepared by heating benzoic acid with ethyl alcohol in presence of dry HCl or conc. H_2SO_4. The reaction is called as esterification reaction.

$$C_6H_5-COOH + C_2H_5-OH \xrightarrow[-H_2O]{\text{dry HCl}} \underset{\text{Ethyl benzoate}}{C_6H_5COOC_2H_5}$$

18. (b) : $\Delta p \cdot \Delta x = \dfrac{h}{4\pi} \Rightarrow m\Delta v \cdot \Delta x = \dfrac{h}{4\pi}$

$$\Rightarrow \Delta v \cdot \Delta x = \frac{h}{4\pi m}$$

$$\Delta v \times 0.1 \times 10^{-10} = \frac{6.6\times10^{-34}}{4\times3.14\times9.1\times10^{-31}}$$

$$\Delta v = \frac{6.6\times10^{-34}}{4\times3.14\times9.1\times10^{-31}\times10^{-11}} = 5.79 \times 10^6 \text{ m/s}$$

19. (c) **20. (a)**

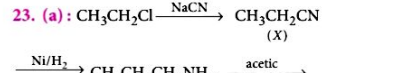
21. (c) : Methylamine is a stronger base than ammonia due to electron releasing inductive effect of methyl group.

22. (b) :

	$2A_{(g)}$	+ $B_{(g)}$	$\rightleftharpoons 3C_{(g)}$	+ $D_{(g)}$
Initial concentration :	1	1	0	0
Concentration at eq. :	1 – (2 × 0.25) = 0.50 M	1 – 0.25 = 0.75 M	3 × 0.25 = 0.75 M	0.25 = 0.25 M

Equilibrium constant, $K = \dfrac{[C]^3[D]}{[A]^2[B]} = \dfrac{(0.75)^3(0.25)}{(0.50)^2(0.75)}$

23. (a) :



24. (a) : Phenol reacts with chloroform in presence of base (KOH or NaOH) to yield salicylaldehyde. This reaction is known as Reimer-Tiemann reaction.

25. (d) : Acid-base titration :

$$\underset{10\text{ mmol}}{HCl} + \underset{20\text{ mmol}}{NH_4OH} \longrightarrow NH_4Cl + H_2O$$

$\therefore$ HCl is the limiting reagent.

Solution contains NH_4OH (weak base) and NH_4Cl (salt of strong acid and weak base). Therefore, a basic buffer will be formed.

26. (a) :

$$\underset{2\times24=48}{2Mg} + \underset{2\times16=32}{O_2} \longrightarrow \underset{2(24+16)=80}{2MgO}$$

48 g of Mg requires 32 g of O_2

1 g of Mg requires $\dfrac{32}{48} = 0.66$ g of O_2

The amount of oxygen available = 0.5 g

Hence, O_2 is the limiting reagent.

32 g of O_2 reacts with 48 g of Mg

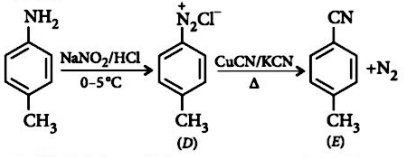
EXAM ALERT 2024

Exam	Date
JEE Main Session 2	Between 4th April and 15th April
KARNATAKA CET MATHS / BIOLOGY	18th April
KARNATAKA CET PHYSICS / CHEMISTRY	19th April
WB JEE	28th April
NEET	5th May
COMEDK (Engg.)	12th May
CUET	Between 15th May and 31st May
JEE Advanced	26th May
BITSAT Session 1	Between 21st May to 26th May
BITSAT Session 2	Between 22nd June to 26th June
CBSE Class 12th	
CBSE Physics	4th March
CBSE Mathematics	9th March
CBSE Biology	19th March

0.5 g of O_2 will react with $\frac{48}{32} \times 0.5 = 0.75$ g of Mg

Excess of Mg = (1.0 – 0.75) g = 0.25 g

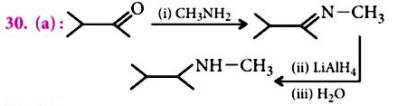
27. (a):



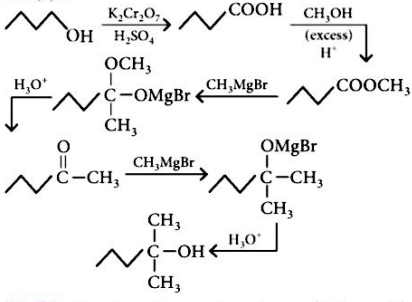
28. (d): Stability of the given species depends upon the hyperconjugation having higher number of α-hydrogens as well as resonance due to lone pair on the oxygen atom. Hence, the correct stability order will be (I) > (III) > (II) > (IV).

29. (a): The number of reacting species (atoms, ions or molecules) taking part in an elementary reaction is called molecularity and it has no influence on the rate of reaction.

30. (a):



31. (a):



32. (b): At a given temperature, two solutions with same osmotic pressure are isotonic. 0.5 M urea solution and 0.5 M sugar solution will exhibit same osmotic pressure due to same concentration. NaCl and $BaCl_2$ will undergo dissociation while benzoic acid will undergo association.

33. (b): MnO_4^- ; $x + 4(-2) = -1$ or $x = +7$

CrO_2Cl_2 ; $x + 2(-2) + 2(-1) = 0$ or $x = +6$

34. (b)

35. (a): As the complex gives two moles of AgCl ppt. with $AgNO_3$ solution, so the complex must have two ionisable Cl atoms. Hence, the probable complex, which gives three mole ions may be $[Co(NH_3)_5NO_2]Cl_2$.

$[Co(NH_3)_5NO_2]Cl_2 \rightarrow [Co(NH_3)_5NO_2]^{2+} + 2Cl^-$

36. (d): $C_2H_5Cl + C_2H_5ONa \longrightarrow \underset{\text{Diethyl ether}}{C_2H_5OC_2H_5} + NaCl$
(Williamson's synthesis)

37. (b): P : [Ar] $3d^{10}4s^1$ = Cu

R : [Ar] $3d^{10}4s^24p^64d^{10}5s^1$ or [Kr] $4d^{10}5s^1$ = Ag

38. (b)

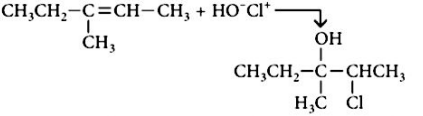
39. (a): $\Delta G^\circ = -nFE^\circ$

$\because$ $1\,Al \equiv 3e^-$, $\frac{4}{3}Al = \frac{4}{3} \times 3e^- = 4e^-$

$$E^\circ = \frac{\Delta G^\circ}{-nF} = \frac{-827000}{-4 \times 96500} = 2.14\ V$$

40. (d)

41. (d): Addition takes place according to Markownikoff's rule.

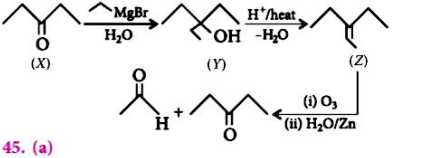


42. (b): The electrophile is dichlorocarbene, $:CCl_2$ generated from chloroform by the action of a base.

$OH^- + CHCl_3 \rightleftharpoons H_2O + {}^-:CCl_3 \longrightarrow Cl^- + :CCl_2$

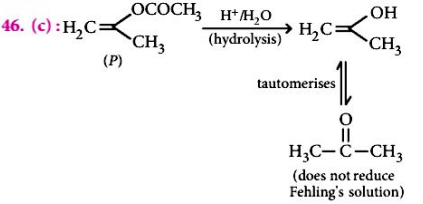
43. (b): Bonding molecular orbitals are denoted by σ, π.

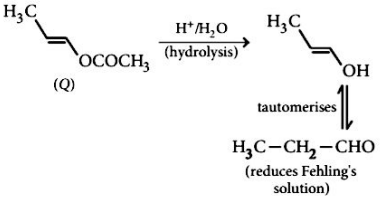
44. (b): Ketone (X) is 3-pentanone which undergoes given sequence of reactions.



45. (a)

46. (c):





47. (c) : The work done during reversible process is given by $\int Pdv$. Since, here no work is done against external pressure (as expansion is free), the work done is zero.

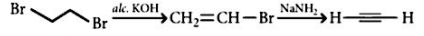
48. (a) : At low pH, cationic form dominates.

49. (b) : For Paschen series, $n_1 = 3$, $n_2 = 4, 5, 6$.

50. (c) : Equilibrium constant K is decreasing with increasing temperature. It shows that reaction is exothermic in forward direction. This means that at high temperature the formation of H_2 and I_2 is less favourable.

51. (c)

52. (b) : Simple alkyl halides are dehydrohalogenated by using strong base such as alcoholic KOH. Whereas vinyl halides require stronger base like NH_2^- for elimination.



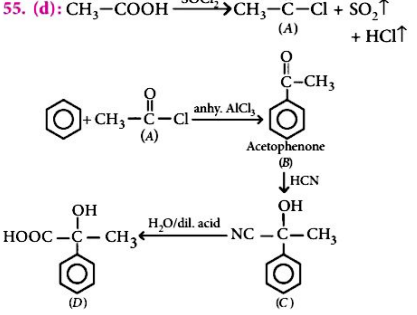
53. (c) : (+)-Lactose is a reducing sugar and all reducing sugars show mutarotation.

54. (c) : Applying, $K_p = K_c(RT)^{\Delta n_g}$

$\Delta n_g = 2 - (1 + 3) = -2$

$\therefore \quad K_p = K_c(RT)^{-2}$

55. (d):



56. (a) : $\Delta G^\circ = -P\Delta V$ = Work done

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

The atomic mass of carbon is 12 g/mol.

The transformation of graphite to diamond occurs as :

$C_{(s,\ graphite)} \longrightarrow C_{(s,\ diamond)}$

$$\Delta V = \left(\frac{12}{3.31} - \frac{12}{2.25}\right) \times 10^{-3}\ \text{L} = -1.71 \times 10^{-3}\ \text{L}$$

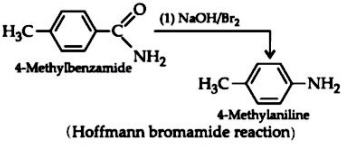
ΔG° = Work done = $-(-1.71 \times 10^{-3}) \times P \times 101.3$ J

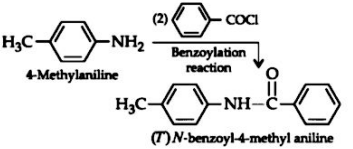
$$\left(\because\ 1\ \text{J} = \frac{1\ \text{L atm}}{101.3}\right)$$

$$P = \frac{1895}{1.71 \times 10^{-3} \times 101.3} = 10.93 \times 10^3\ \text{atm}$$

$= 11.08 \times 10^8$ Pa $\qquad (\because 1\ \text{atm} = 101325\ \text{Pa})$

57. (c) :





58. (c) : $CO_2 \rightarrow x + 2(-2) = 0 \Rightarrow x = +4$

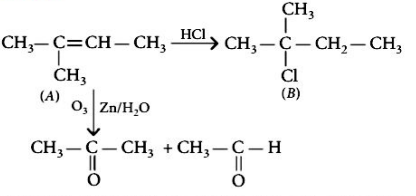
$Cr_2O_7^{2-} \rightarrow 2x + 7(-2) = -2 \Rightarrow x = +6$

$HIO_4 \rightarrow +1 + x + 4(-2) = 0 \Rightarrow x = +7$

$PCl_5 \rightarrow x + (-5) = 0 \Rightarrow x = +5$

59. (b) : Most stable due to intramolecular H-bonding.

60. (d):



Addition of HCl to an alkene (*A*) will take place according to Markovnikov's rule.

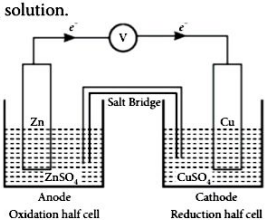
CRYSTAL CLEAR

Dr. Abdul Ashik Khan*

This article aims to provide NEET and JEE students with a concise and comprehensive introduction to the essential concepts in chemistry, empowering them with knowledge and understanding necessary to succeed in their examination.

ELECTROCHEMICAL CELL / GALVANIC CELL / VOLTAIC CELL

It is a device that converts free energy of the spontaneous redox chemical reaction into electrical energy. It is also known as a galvanic cell or voltaic cell. An electrochemical cell is typically made up of two electrodes immersed in one or more suitable electrolytes, which are connected externally. A chemical reaction happens within the cell. Oxidation occurs at one electrode, and the electrons released are used for reduction at the other electrode. The anode is the electrode where the oxidation takes place. The cathode is the electrode where the reduction takes place. The flow of electrons is from the anode to the cathode, hence the flow of electricity is from cathode to anode. The Daniell cell is an electrochemical cell. It consists of a Zn rod dipped in $ZnSO_4$ solution and a Cu rod dipped in $CuSO_4$ solution.



At anode : $Zn \rightarrow Zn^{2+} + 2e^-$ Oxidation

At cathode : $Cu^{2+} + 2e^- \rightarrow Cu$ Reduction

$Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$ Redox reaction

Zn metal is more likely to get oxidised than copper. Therefore, oxidation takes place at the zinc compartment.

$$Zn \rightleftharpoons Zn^{2+} + 2e^-$$

Zinc rod acts as an anode. Zn^{2+} dissolves in the fluid, leaving the $2e^-$ on the Zn rod. As a result, the zinc rod becomes negatively charged. Cu^{2+} has a stronger tendency for reduction than Zn^{2+}, thus it accepts electrons, get reduced, and deposits on copper rod.

$$Cu^{2+} + 2e^- \rightleftharpoons Cu$$

Cu rod acts as a cathode. The flow of electrons through an externally connected wire from zinc to copper is equivalent to the flow of electricity from Cu to Zn.

Functions of Salt Bridge

Consider the oxidation of zinc metal :

$$Zn \rightleftharpoons Zn^{2+} + 2e^-$$

Zn^{2+} ions are added to $ZnSO_4$, leaving the $2e^-$ on the Zn rod. As a result, an excess of positive charge arises in the oxidation half-cell. An excess negative charge accumulates in the reduction half-cell as a result of Cu^{2+} consumption from $CuSO_4$. This charge buildup process opposes the current flow. As a result, a way must be given to ensure that each compartment remains electrically neutral. A permeable partition or a salt bridge can be utilised for this. The salt bridge is an inverted U-shaped tube containing concentrated solution of an inert electrolyte like KCl, KNO_3, K_2SO_4 etc. or solidified solution of such an electrolyte in agar-agar and gelatine. The ions K^+ and Cl^- have identical mobility. The excess positive charge generated in $ZnSO_4$ solution is neutralised by negative ions from salt bridge. Similarly, excess charge in $CuSO_4$ is neutralised by positive ions from the salt bridge. Thus,

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the salt bridge completes the circuit. The salt bridge also inhibits the diffusion of interfering ions from one compartment to another. For example, in the Daniell cell, the passage of Cu^{2+} ions to the Zn compartment must be inhibited since they deposit on Zn metal.

Representation of Electrochemical Cell

Anode components are written on the left side. Cathode components are written on the right side. Each phase interface is separated by a single line. A salt bridge is represented by a double line. A galvanic cell is represented in a manner as illustrated below for the Daniell cell.

$$Zn \mid Zn^{2+} \parallel Cu^{2+} \mid Cu$$

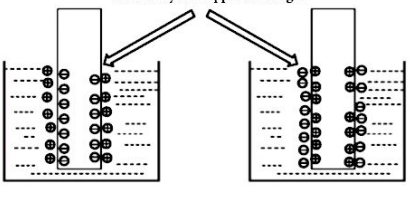
Single electrode potential: Origin of single electrode potential - Helmholtz double layer

A metal can be visualised as metal ions embedded in a pool of valence electrons. When a metal rod is dipped in its own salt solution, two alternatives exist:

- **Oxidation :** $M \rightleftharpoons M^{n+} + ne^-$.
  Metal atoms of the metal may lose electrons and change into M^{n+} ions, *i.e.*, metal atoms get oxidised. As oxidation continues, the electrons will accumulate on the metal surface which will, therefore develop a negative charge.
- **Reduction :** M^{n+} ions may gain electrons and change into metal atoms, *i.e.*, M^{n+} ions are reduced. As a result, metal will develop a positive charge with respect to the solution and ultimately the following equilibrium will be attained.

$$M^{n+} + ne^- \rightleftharpoons M$$

Oxidation or reduction generates a charge density at the electrode surface, attracting ions with opposing charges from the electrolyte. The charge on the electrode surface is balanced by the redistribution of ions near the electrode surface. A simplified model for visualising this scenario is the Helmholtz electrical double layer. A layer of positive and negative charges remains close together, one on the electrode surface and the other on the electrode-electrolyte interface.



As a result, the metal and solution have different potentials. This potential difference is known as single electrode potential. The electrode potential of a metal is the ability of a metallic electrode to lose or absorb electrons while in contact with its own salt. The magnitude is determined by the nature of the metal, concentration of ions and temperature.

If in the half cell, the metal rod is suspended in a solution of one molar concentration, and the temperature is kept at 298 K, the electrode potential is called standard electrode potential. The oxidation potential is the tendency of an electrode to get oxidise (lose electrons) and can be written as $E_{oxd.}$ The tendency for reduction (gain of electrons) is the reduction potential and is written as E_{red}.

$$E_{red} = -E_{oxd}$$

According to IUPAC convention, standard reduction potentials are now called standard electrode potentials. It is impossible to determine the absolute value of electrode potential since neither oxidation nor reduction occur separately (both occur simultaneously). Thus, just the cell potential may be measured. That is, only the relative value of emf with respect to a reference electrode can be determined.

Reference Electrodes

It should have a consistent and well-defined electrode potential at a given temperature. One application for a reference electrode is to determine the potential of other electrodes. Use of reference electrodes:

1. Potential of other electrodes can be assessed.
2. The pH of a solution can be determined.

Examples of reference electrodes :

- Standard hydrogen electrode : It is represented by $Pt_{(s)} \mid H_{2(g)} \mid H^+_{(aq)}$. It is a primary reference electrode. Its electrode potential value is arbitrarily assigned as zero.
- Calomel electrode : It is a secondary reference electrode.
- Glass electrode : It is an internal reference electrode used for pH measurements.

MONTHLY TEST DRIVE CLASS XII **ANSWER KEY**

1. (c)	**2.** (b)	**3.** (c)	**4.** (d)	**5.** (d)
6. (c)	**7.** (b)	**8.** (a)	**9.** (b)	**10.** (b)
11. (b)	**12.** (a)	**13.** (d)	**14.** (a)	**15.** (b)
16. (a)	**17.** (b)	**18.** (b)	**19.** (d)	**20.** (b,d)
21. (a,c)	**22.** (a,c,d)	**23.** (a,b)	**24.** (3)	**25.** (5)
26. (2)	**27.** (c)	**28.** (c)	**29.** (a)	**30.** (b)

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B.Sc. in Food Technology

Food Technology is the study of food science in manufacturing safe, wholesome and nutritious food products. Training in Food Technology gives adequate knowledge regarding the quality analysis of raw materials, packaging standards and methodology. The study of food science and technology aims to develop internationally minded people whose enhanced understanding of Food Science and Technology can facilitate the development of creative and appropriate solutions.

The objectives of the course are :

- To impart knowledge in areas related to Food Science and Technology.
- To enable the students to understand the food composition along with its physico-chemical, nutritional, microbiological and sensory aspects.
- To acquaint the students with the technologies of food processing and preservation of plant and animal foods; cereals, pulses, oilseeds, fruits, vegetables, spices, meat, fish, poultry, sea food, milk and dairy products.
- To stress on the importance of food safety and quality management, national and international food laws and regulations as well as importance of food engineering and packaging in food industry.

Eligibility

The candidate should have completed 10+2 education in the science stream, from a recognised educational board with Chemistry, Mathematics, Physics, Biology/Home Science as the main subjects.

Universities

- **University of Delhi, New Delhi**
- University of Calcutta, Kolkata, West Bengal
- University of Madras, Chennai, Tamil Nadu
- Andhra University, Visakhapatnam, Andhra Pradesh
- University of Bombay, Mumbai, Maharashtra
- Mahatma Gandhi University, Kottayam, Kerala
- Manipur University, Imphal, Manipur

Entrance Exams

- NPAT
- CUCET
- CUET
- SET

Job Prospects

Food Technology offers numerous attractive career options and you can choose according to your skills and areas of interest. There are a large number of job opportunities for those who want to pursue their career in the field of Food Technology.

Top recruiters : Food industries like Amul, Parle, FSSAI, Britannia, Mother Dairy, Nestle, Coca Cola, Dabur, Godrej, Hindustan Unilever, Cadbury, etc.

Top jobs : Food Research Laboratories, Lab Technician, Food Labs, Food Processing Operator, Machinery Inspection, Research Scientists, Organic Chemists, Food Inspector, Restaurants, etc.

University of Delhi, New Delhi

The University of Delhi is a premier university of the country with a venerable legacy and international acclaim for highest academic standards, diverse educational programmes, distinguished faculty, illustrious alumni, varied co-curricular activities and modern infrastructure. Established in 1922 as a unitary, teaching and residential University by the Act of the then Central Legislative Assembly, a strong commitment to excellence in teaching, research and social outreach has made the University a role-model and trend setter for other universities. The Food Technology course at the Bachelors level is being run in the University of Delhi since the last 25 years and was introduced by the Faculty of Science from the academic year 1989-1990.

UNSCRAMBLE ME

Unscramble the words given in column I and match them with their explanations in column II.

Column I		Column II
1. ANCHOYT	(a)	It is the molecular orbital having absence of centre of symmetry.
2. PAEMNASERHIN	(b)	It is a natural photosynthetic pigment found largely in fruits and dark green leafy vegetables.
3. SECFRNEUIOL	(c)	It is a hypothetical subatomic particle whose velocity always exceeds that of light.
4. ERUNEGDA	(d)	It is a protein that stores iron and makes it available for critical cellular processes while protecting lipids, DNA, and proteins from the potentially toxic effects of iron.
5. OHIYTRDHL	(e)	It is an orange dye with a yellowish-green fluorescence, used as an indicator and tracer.
6. IEFRTNIR	(f)	It is another name for ytterbium oxide, a colourless weakly basic hygroscopic substance used in certain alloys.
7. UCMSAEI	(g)	It is an antibiotic drug that is also known as Salvarsan.
8. EAOTRECN	(h)	It is the arrangement in which the monomers are linked by covalent/intermolecular strong or weak bonds.
9. TBAERTYI	(i)	It is an alkali metal which was discovered by Bunsen and Kirchhoff by flame spectroscopy.
10. MIRDECI	(j)	It is trade name of calcium hydride which is used for hydrogen production.

Readers can send their responses at editor@mtg.in or post us with complete address by 10th of every month. Winners' names and answers will be published in next issue.

GET SET GO for NEET

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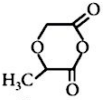
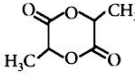
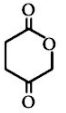
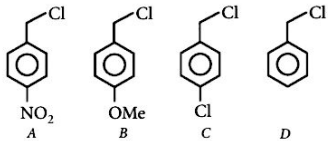
1. The end product (*C*) in the following reaction sequence is

$$CH_3CH_2COOH \xrightarrow[\Delta]{Br_2,\ red\ P} A \xrightarrow{OH^-_{(aq)}} B \xrightarrow{\Delta} C$$

(a) $CH_2{=}CH{-}COOH$ (b) 

(c)  (d) 

2. Decreasing order of reactivity towards S_N1 reaction for the following compounds is



(a) $D > B > C > A$ (b) $B > D > C > A$
(c) $A > C > D > B$ (d) $A > B > C > D$

3. The rate of a certain biochemical reaction at physiological temperature (T) occurs 10^6 times faster with enzyme than without. The change in the activation energy upon adding enzyme is

(a) $-6RT$ (b) $-6(2.303)RT$
(c) $+6RT$ (d) $+6(2.303)RT$

4. Which of the following has longest C—O bond length? (Free C — O bond length in CO is 1.128 Å.)

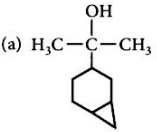
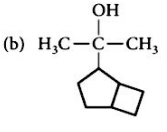
(a) $[Fe(CO)_4]^{2-}$ (b) $[Mn(CO)_6]^+$
(c) $[Ni(CO)_4]$ (d) $[Co(CO)_4]^-$

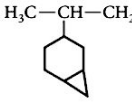
5. For 1 molal aqueous solution of the following compounds, which one will show the highest freezing point?

(a) $[Co(H_2O)_6]Cl_3$
(b) $[Co(H_2O)_5Cl]Cl_2.H_2O$
(c) $[Co(H_2O)_4Cl_2]Cl.2H_2O$
(d) $[Co(H_2O)_3Cl_3].3H_2O$

6. $A(C_{10}H_{18}O) \xrightarrow{HCl} H_3C{-}\underset{\displaystyle Cl}{\overset{\displaystyle Cl}{\underset{|}{\overset{|}{C}}}}{-}CH_3$ (with a cyclohexane ring)

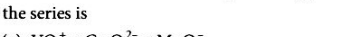
Degree of unsaturation of A = 2, it contains no double or triple bond. A is

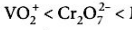
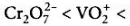
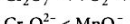
(a)  (b) 

(c)  (d) none of these.

7. The correct order of increasing oxidising power in the series is
   (a) $VO_2^+ < Cr_2O_7^{2-} < MnO_4^-$
   (b) $Cr_2O_7^{2-} < VO_2^+ < MnO_4^-$
   (c) $Cr_2O_7^{2-} < MnO_4^- < VO_2^+$
   (d) $MnO_4^- < Cr_2O_7^{2-} < VO_2^+$

8. What is the product of following reaction?



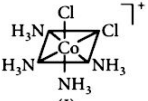
   (a) 
   (b) 
   (c) 
   (d)

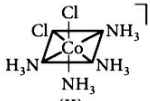
9. When 9.65 ampere current was passed for 1.0 hour into nitrobenzene in acidic medium, the amount of *p*-aminophenol produced is
   (a) 10.9 g (b) 98.1 g
   (c) 109.0 g (d) 9.81 g

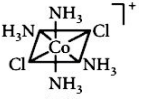
10. Consider the reaction,

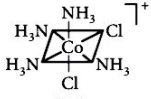
   A and *B* respectively are
   (a) $CH_3-\overset{O^{18}}{\overset{\|}{C}}-OC_2H_5 + H_2O$
   (b) $CH_3-\overset{O}{\overset{\|}{C}}-OC_2H_5 + H_2O^{18}$
   (c) $CH_3-\overset{O}{\overset{\|}{C}}-OC_2H_5 + H_2O$
   (d) both (a) and (b).

11. Consider the following arrangements of the octahedral complex ion $[Co(NH_3)_4Cl_2]^+$.

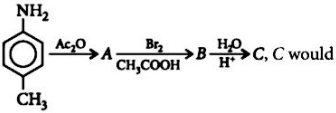

(I)

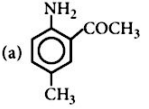
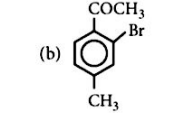
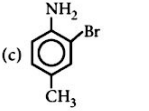
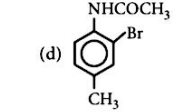

(II)


(III)


(IV)

Which of the following statements is incorrect?
   (a) I and II are enantiomers.
   (b) II and III are *cis* and *trans* isomers respectively.
   (c) III and IV are *trans* and *cis* isomers respectively.
   (d) None of these.

12. 

   (a) 
   (b) 
   (c) 
   (d) 

13. The compound that does not produce nitrogen gas by the thermal decomposition is
   (a) $Ba(N_3)_2$ (b) $(NH_4)_2Cr_2O_7$
   (c) NH_4NO_2 (d) $(NH_4)_2SO_4$

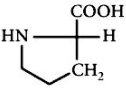
UNSCRAMBLED WORDS

FEBRUARY 2024

1-g-PEROVSKITE	2-h-ELECTRUM
3-i-COLLAGEN	4-a-DEHYDROGENATION
5-f-ELECTROCATALYSIS	6-c-AMALGAM
7-j-PROTONATION	8-e-TURBIDITY
9-d-BITUMEN	10-b-LACTOSE

Winners : *Kaushikkumar Kevadiya, Anusha Sharma, Vanya Tiwari, Shital Kiran Sartale*

14. Which of the following is the side chain of an essential amino acid?

(a) 

(b) $H_2N-\overset{\overset{O}{\|}}{C}-CH_2-CH_2-$

(c) $HOOC-CH_2-$ (d) 

15. The cation that will not be precipitated by H_2S in the presence of dil. HCl is

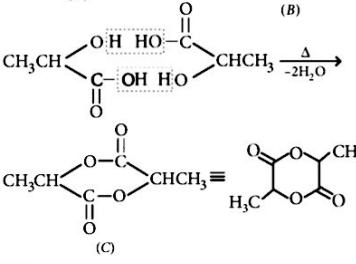
(a) Cu^{2+} (b) Pb^{2+} (c) As^{3+} (d) Co^{2+}

SOLUTIONS

1. **(c) :** $CH_3\overset{\alpha}{-}CH_2-COOH \xrightarrow[-HBr]{Br_2/red\ P,\ \Delta}$

$CH_3-\underset{Br}{\underset{|}{CH}}-COOH \xrightarrow{OH^-_{(aq)}} CH_3-\underset{OH}{\underset{|}{CH}}-COOH$

(*A*) Lactic acid (*B*)



(*C*)

2. **(b) :** Electron donating groups stabilise the carbocation formed during the S_N1 reaction while electron withdrawing groups destabilise it. Hence, the correct order of given organic compounds for S_N1 reaction is, $B > D > C > A$.

3. **(b) :** $k = Ae^{-E/RT}$ ...(i)

$10^6 k = Ae^{-E_{Enzyme}/RT}$ ...(ii)

Dividing equation (ii) by (i) we get

$10^6 = e^{(E - E_{Enzyme})/RT}$

Taking ln on both sides

$$\ln 10^6 = \frac{(E - E_{Enzyme})}{RT}$$

$6 \ln 10 = (E - E_{Enzyme})/RT$

$$\left(\frac{E - E_{Enzyme}}{RT}\right) = 2.303 \times 6$$

$E - E_{Enzyme} = 2.303 \times 6RT$

$\Delta E_a = E_{Enzyme} - E = -2.303 \times 6RT = -6(2.303)RT$

4. **(a) :** The greater the negative charge on the carbonyl complex, the easier it would be for the metal to permit its electrons to participate in the back-bonding, and the higher would be the $M-C$ bond order and simultaneously there would be larger reduction in the $C-O$ bond order. Thus, $[Fe(CO)_4]^{2-}$ has the lowest $C-O$ bond order which means it has the longest bond length.

5. **(d) :** $\Delta T_f = iK_f m$

m is same for all the solutions thus,

$\Delta T_f \propto i$ (number of ions or molecules)

where, $\Delta T_f = T_f - T_i$

$[Co(H_2O)_6]Cl_3 \Rightarrow 4$ ions ($i = 4$)

$[Co(H_2O)_5Cl]\,Cl_2 \cdot H_2O \Rightarrow 3$ ions ($i = 3$)

$[Co(H_2O)_4Cl_2]\,Cl \cdot 2H_2O \Rightarrow 2$ ions ($i = 2$)

$[Co(H_2O)_3Cl_3] \cdot 3H_2O \Rightarrow$ No ion ($i = 1$)

Winners : *Kaushikkumar Kevadiya, Praveen Gulati, Nitin Bhatia*

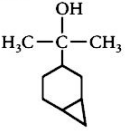
SOLUTIONS TO FEBRUARY 2024 WORD GRID

U	M	J	J	I	N	E	Y	G	O	L	P	N	M	I	L
R	R	E	T	I	N	O	I	D	S	T	H	F	H	P	E
X	E	X	T	E	E	F	F	U	T	I	Y	N	G	Y	R
C	S	O	S	A	N	X	X	J	E	X	T	T	T	R	R
O	O	G	L	N	R	C	L	E	R	Y	O	Q	V	O	Y
C	L	K	E	I	O	O	H	W	O	P	C	A	N	N	C
O	U	W	P	R	G	C	T	D	L	O	H	E	O	E	O
Y	T	B	I	H	L	O	I	A	S	R	E	H	I	S	T
E	I	U	W	X	E	Y	M	L	T	T	M	J	T	H	T
Q	O	E	O	V	C	E	N	E	I	I	I	I	A	X	L
O	N	L	P	W	T	Q	H	P	R	S	S	O	R	L	A
L	I	E	E	Y	O	O	W	H	D	I	T	N	B	I	N
E	V	B	N	I	T	R	I	F	I	C	R	T	I	O	N
B	L	T	E	L	S	W	C	L	T	A	Y	E	L	B	F
T	A	Z	I	L	A	R	E	N	I	M	R	D	A	X	Y
Q	U	I	N	I	D	I	N	E	I	C	W	L	C	I	N
F	L	O	C	C	U	L	A	T	I	O	R	L	T	M	K
M	Z	Y	M	N	I	L	U	S	N	I	D	W	O	L	B

1. Retinoids
2. Sterols
3. Quinidine
4. Pyrones
5. Phytochemistry
6. Resolution
7. Oligomer
8. Insulin

As the freezing point of solution increases, the value of *i* decreases. So, the highest freezing point will be of $[Co(H_2O)_3Cl_3].3H_2O$ solution.

6. **(a) :** Degree of unsaturation of $C_{10}H_{18}O$ = 2, but it contains no double or triple bond. Hence, there are two rings – one six membered as indicated by product and the other three membered which is cleaved by HCl due to strain. Hence, *A* has following structure :

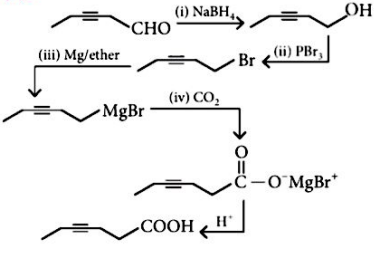


7. **(a) :** Greater the oxidation state of the central metal ion, higher is the oxidising power.

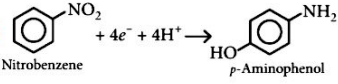
∴ Order of oxidising power is :

$\overset{+5}{VO_2^+} < \overset{+6}{Cr_2O_7^{2-}} < \overset{+7}{MnO_4^-}$

8. **(b) :**



9. **(d):**



Molar mass of *p*-aminophenol

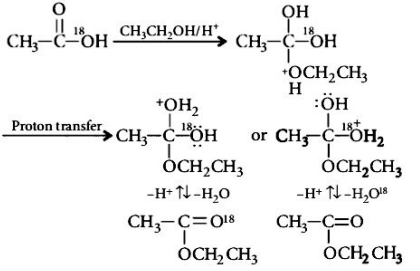
$= 6 \times 12 + 7 \times 1 + 14 + 16 = 109 \text{ g mol}^{-1}$

$$\text{Eq. wt.} = \frac{W}{Q} \times 96500 = \frac{W}{I \times t} \times 96500$$

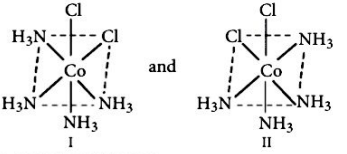
$$W = \frac{\text{Eq. wt.} \times I \times t}{96500}$$

$$= \frac{109}{4} \times \frac{9.65 \times 1 \times 60 \times 60}{96500} = 9.81 \text{ g}$$

10. **(d):** Consider the acid catalysed mechanism of esterification :

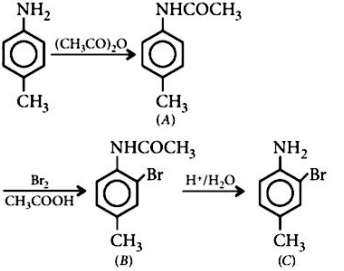


11. **(a) :**



These are not enantiomers.

12. **(c) :**



13. **(d):** $(NH_4)_2SO_4 \rightarrow 2NH_3 + H_2SO_4$

On thermal decomposition of $(NH_4)_2SO_4$, NH_3 is evolved. On thermal decompostion of the other given compounds, N_2 is evolved.

14. **(d):**

represents the side chain of histidine which is an essential amino acid.

15. **(d):** Co^{2+} ion present in group IV is precipitated by H_2S in presence of NH_4OH. Other ions are precipitated as sulphide in presence of dil. HCl in group II.

GK CORNER

Enhance Your General Knowledge with Current Updates!

SCIENCE AND TECHNOLOGY

1 India's **Raman Research Institute (RRI)** researchers have developed a new image-correction algorithm that significantly improves images used to study cold atoms or atoms at absolute zero temperature. The advanced imaging will provide a deeper understanding of the intriguing quantum mechanics governed properties of atoms.

2 India is planning for a manned space mission Gaganyaan in 2025. A space-bound robot friend named **"Vyommitra"** will fly to space, ahead of its ambitious **"Gaganyaan"** manned mission, later this year to test critical systems. This female humanoid robot is equipped to simulate human functions within the spacecraft's orbit.

3 American space agency **NASA** has discovered a **"Super Earth"** planet, dubbed TOI-715 b, that could potentially support life. It is located 137 light-years away and was founded by NASA's planet-hunting Transiting Exoplanet Survey Satellite (TESS) mission. This planet is approximately one and a half times as wide as Earth and orbits a smaller, cooler red dwarf star. It completes a full orbit in just 19 days.

4 Recently, the Russian astronaut or (cosmonaut) **Oleg Kononenko** has set a world record for the most cumulative time spent in space. He has spent over 878 days or nearly two-and-a-half years in orbit and is expected to complete 1000 days in space on 5th June, 2024. Further, he will have spent 1,110 days in space when his current expedition trip, which is planned to end in late September will be completed.

5 **INSAT-3DS** is an exclusive meteorological satellite realized by ISRO with the primary objective to provide continuity of services to the existing in-orbit INSAT-3D and 3DR satellites and significantly enhancing the capabilities of INSAT system is flagged off to SDSC-SHAR launch port on January 25th, 2024 for the launch onboard GSLV F14.

6 The **National Science Day** was celebrated on 28th February, and Union Minister of Science and Technology, Dr. Jitendra Singh released the theme for the National Science Day 2024, titled **"Indigenous Technologies for Viksit Bharat"** in New Delhi.

7 Recently, researchers at Stanford University discovered a new virus-like entity called **obelisks**. These obelisks have been found in large numbers within the human mouth and gut.

8 Israeli scientists have recently discovered new underwater canyon near Cyprus. This canyon is known as **Eratosthenes**, which is near the sea mountain, and its origin dates back to the Messinian event, which occurred about 5.5 million years ago. This canyon is about 10 km wide and 500 metres deep and was underwater at the beginning of the Messinian period, when the salt layer was equalised before deposition. It was formed when the level of the Mediterranean Sea decreased and at the same time the salinity of the water increased, causing draught currents or dense ploughs that destabilised the underwater slopes and caused the sinking of the sea floor.

9 Recently, the Indian Space Research Organisation (ISRO) has developed the second-generation **Distress Alert Transmitter (DAT-SG)**, an indigenous technological solution for fishermen at sea to send emergency messages from fishing boats.

10 Propelling Kerala's foray into exciting emergent technologies, Digital University Kerala has designed the State's first silicon-proven artificial intelligence (AI) chip – **Kairali AI Chip**. The chip leverages unique features to deliver capabilities such as speed, power efficiency and scalability.

Test Yourself!

1. What is the reason behind the celebration of National Science Day on 28th February every year?
   (a) To highlight the significance of science in society
   (b) On this day in 1952, the first Forensic Science Laboratory in India came into existence
   (c) On this day in 1928, Sir C.V. Raman announced the discovery of the 'Raman Effect'
   (d) To highlight the significance of ISRO
2. The scientists of which of the following countries recently unveiled underwater canyon?
   (a) Israel (b) Iran
   (c) Kuwait (d) Saudi Arabia
3. What "Super Earth" was recently discovered by NASA?
   (a) TOI-716 d (b) TOT-715 b
   (c) TOT-716 b (d) TOI-715 b
4. Which Satellite System was launched by ISRO to enhance the capability of existing INSAT system?
   (a) INSAT-3DS (b) INSAT-4F
   (c) INSAT-4B (d) INSAT-3DE
5. In which of the following cities is RRI located?
   (a) Gurugram (b) Mumbai
   (c) Delhi (d) Bengaluru
6. Which technological solution is recently developed by ISRO for the fishermen at sea to send emergency messages from fishing boats?
   (a) DAT-SG (b) DAT-TG
   (c) DAT-FG (d) DAT-EG
7. How many times has Oleg Kononenko visited the International Space Station since 2008?
   (a) Three times (b) Four times
   (c) Five times (d) Six times
8. Which University's researchers discovered a new virus-like entity called obelisks?
   (a) Saint Petersburg University
   (b) Stanford University
   (c) University of St. Andrews
   (d) Minami Kyushu University
9. What was the theme of National Science Day 2024?
   (a) Indigenous Technologies for Viksit Bharat
   (b) Science for Nation Building
   (c) Women in Science
   (d) Global Science for Global Wellbeing
10. The name of the AI chip designed by Digital University Kerala is
    (a) Kairali AI Chip (b) Sawai AI Chip
    (c) Kino AI Chip (d) Maitri AI Chip

Answer Key

1.	(c)	2.	(d)	3.	(b)	4.	(a)	5.	(d)
6.	(a)	7.	(c)	8.	(b)	9.	(a)	10.	(a)

TRIO

Here are the nine shuffled words containing 3 sets of trio. The three letters of trio can be arranged in any sequence. Complete these words by finding 3 sets of trio.

CYCLO — — — PENE
M — — — HINE
— — — ARISIBILITY
CA — — — NATE
CYC — — — ENTANONE
LA — — — ATORY
— — — MIDE
— — — PHYRIN
PHEN — — — HTHALEIN

Readers can send their responses at editor@mtg.in or post us with complete address by 10th of every month. Winners' names will be published in next issue.

WORD GRID

Readers are requested to send their responses of word grid. Be the Winner!

Find and encircle the words in the given grid, running in one of the possible directions; horizontal, vertical or diagonal by reading the clues given below.

A	E	F	E	T	I	N	I	N	A	R	U	C	K	Y
H	K	I	C	P	E	K	W	B	K	W	Q	H	J	H
L	P	O	L	O	N	I	U	M	O	C	U	E	G	T
M	R	E	A	F	R	I	C	D	C	M	I	S	M	R
N	C	A	S	D	N	K	S	X	E	S	M	R	I	T
O	C	I	E	F	T	E	G	C	L	E	N	T	W	J
K	R	R	B	H	Y	A	T	E	D	S	M	G	A	S
A	O	R	C	L	B	A	H	W	B	N	U	K	D	A
S	L	M	W	F	N	L	E	R	M	S	R	A	S	O
E	H	I	Z	T	O	E	T	A	L	A	X	O	D	S
S	C	G	I	N	I	N	D	H	Y	P	R	L	R	A
D	I	L	N	L	E	X	Y	B	B	R	A	I	O	W
I	T	N	C	L	I	V	K	O	O	O	G	N	L	G
N	N	U	R	F	O	P	E	J	A	C	E	D	I	R
W	A	D	E	A	H	G	A	P	H	S	A	S	T	N
T	U	E	A	V	E	C	U	S	A	E	H	L	G	K
C	Y	E	N	E	T	I	C	G	E	O	S	I	N	H
I	C	C	I	E	F	C	M	O	L	E	C	L	E	N

Clues

1. It is a soft white clay that is an essential ingredient in the manufacture of china and porcelain and is widely used in the making of paper, rubber, paint, and many other products.
2. It is a compound which bind together with calcium in the intestine but gets absorbed into the bloodstream in the absence of calcium and end up in the urine, where it will form stones.
3. It is the element symbolic of an Italian river.
4. It is the enzyme that catalyses the hydrolysis of fats.
5. It is a red fluorescent dye that is a bromine derivative of fluorescein, or one of its salts or other derivatives.
6. It is a hygroscopic substance which is used to keep things moist.
7. It is a substance used in removing the excess of chlorine or bleaching liquor left in paper pulp or textile fibres after bleaching.
8. It is a radioactive mineral and ore, also known as pitchblende.

Please send entries of solutions both with words and scanned copy of the grid by 10th of every month.

Quiz CLUB

Unlock Your Knowledge!

1. Removal of an amino group from an organic compound is called _____.
2. Cheilosis occurs due to the deficiency of _____.
3. The orbitals having same energy are called _____ .
4. Lithium nitride reacts with water to produce _____ gas.
5. In the equation, $PV = ZRT$ for real gas, Z is called the _____.
6. The O—O bond length in O_2 is _____ than that in O_2^{2+}.
7. _____ resonance involves delocalisation of sigma electrons of C—H bond of an alkyl group directly attached to an atom of unsaturated system or to an atom with an unshared *p*-orbital.
8. _____ reduction of an unsymmetrical alkyne produces *trans* alkene.
9. A non-ideal solution with positive deviation has _____ vapour pressure than an ideal solution.
10. Scuba divers use a mixture of oxygen and _____ for breathing underwater.
11. Substances having concentration lower than 10^{-8} have pH less than _____.
12. The _____ of ionisation of weak electrolyte by addition of a strong electrolyte having a common ion, is called common ion effect.
13. Work and heat are _____ functions.
14. Standard enthalpy of formation of graphite is _____ than that of diamond.
15. Leclanche cell is an example of _____ cell.
16. The oxidation number of S in $H_2S_2O_8$ is _____.
17. Acidic hydrolysis of _____ is an example of pseudo unimolecular reaction.
18. _____ formed by the reaction of ammonia and formaldehyde is used to treat urinary tract infection.
19. The molecular geometry of xenon difluoride is _____.
20. Zeise's salt includes _____ as the central metal.

Readers can send their responses at editor@mtg.in or post us with complete address by 10th of every month. Winners' names and answers will be published in next issue.

CHEM CAPSULE

MONTHLY TEST DRIVE

XII

This specially designed column enables students to self analyse their extent of understanding the specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Total Marks : 120 **Haloalkanes and Haloarenes | Alcohols, Phenols and Ethers** **Time Taken : 60 Min.**

NEET

Only One Option Correct Type

1. Consider the reaction,
$CH_3CH_2CH_2Br + NaCN \rightarrow CH_3CH_2CH_2CN + NaBr$
This reaction will be the fastest in
(a) ethanol
(b) methanol
(c) *N*, *N*′-dimethylformamide (DMF)
(d) water.

2. Two possible stereo-structures of $CH_3CHOHCOOH$, which are optically active, are called
(a) anomers (b) enantiomers
(c) mesomers (d) diastereomers.

3. *n*-Propyl alcohol and isopropyl alcohol can be chemically distinguished by
(a) PCl_5
(b) reduction
(c) oxidation with potassium dichromate
(d) ozonolysis.

4. Increasing order of reactivity of the following alkyl halides in the Williamson's synthesis is
I. $CH_2{=}CHCH_2Cl$ II. $CH_3CH_2CH_2Br$
III. $(CH_3)_3CCH_2Br$ IV. $CH_3CH_2CH_2Cl$
(a) II < III < IV < I (b) III < II < IV < I
(c) IV < III < I < II (d) III < IV < II < I

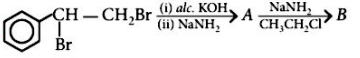
5. Dow's reaction involves
(a) electrophilic addition
(b) electrophilic substitution
(c) nucleophilic addition
(d) nucleophilic substitution.

6. *o*-Xylene $\xrightarrow[\Delta]{HNO_3} X \xrightarrow[H_2SO_4]{Phenol} Y$.
The product *Y* is
(a) phthalic acid
(b) isophthalic acid
(c) phenolphthalein
(d) *o*-hydroxysulphonic acid.

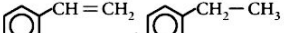
7. Which of the following reactions is not correctly matched?
(a) $2C_2H_5Br + 2Na \xrightarrow{\text{Dry ether}} C_4H_{10} + 2NaBr$: Wurtz reaction
(b) $CH_3Br + AgF \longrightarrow CH_3F + AgBr$: Etard reaction
(c) $C_6H_5Br + 2Na + BrC_2H_5 \xrightarrow{\text{Dry ether}} C_6H_5C_2H_5 + 2NaBr$: Wurtz–Fittig reaction
(d) $2C_6H_5Br + 2Na \xrightarrow{\text{Dry ether}} C_6H_5 - C_6H_5 + 2NaBr$: Fittig reaction

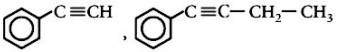
8. In the reaction, $CH_3-\underset{\displaystyle C_2H_5}{\underset{|}{CH}}-Br \xrightarrow{OH}$
(a) racemisation takes place by S_N1 and inversion by S_N2
(b) racemisation takes place by S_N2 and inversion by S_N1
(c) racemisation takes place in both S_N1 and S_N2 reactions
(d) inversion takes place in both S_N1 and S_N2 reactions.

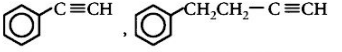
9. Chloropicrin which is used as an insecticide and a war gas is
(a) CH_2ClCCl_3 (b) CCl_3NO_2
(c) $CH_2(OH)CH_2Cl$ (d) CHI_3

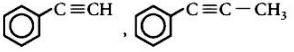
10. 

A and *B* respectively are

(a) 

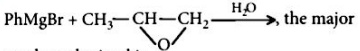
(b) 

(c) 

(d) 

11. The boiling point of glycerol is more than propanal because of
(a) hybridisation (b) H-bonding
(c) resonance (d) all of these.

12. In the reaction,



product obtained is
(a) $Ph-CH_2-CH(OH)CH_3$
(b) $Ph-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_2OH$
(c) $Ph-CH=CH_2$
(d) 

Assertion & Reason Type

Directions : In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :
(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

13. **Assertion :** Acid catalysed dehydration of *t*-butanol is slower than *n*-butanol.
Reason : Dehydration involves formation of the carbanion.

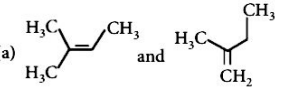
14. **Assertion :** Nucleophilic substitution reaction of an optically active halide gives a mixture of enantiomers.
Reason : The reaction should be in accordance with S_N1 mechanism.

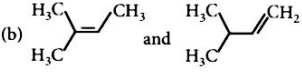
15. **Assertion :** Anisole undergoes electrophilic substitution at *ortho*- and *para*-positions.
Reason : Anisole is less reactive than phenol towards electrophilic substitution reactions.

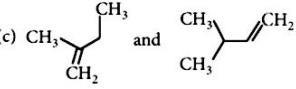
JEE (Main & Advanced)

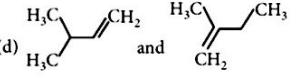
Only One Option Correct Type

16. When neopentyl alcohol is heated with an acid, it is slowly converted into an 85 : 15 mixture of alkenes *A* and *B*, respectively. What are these alkenes?

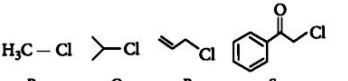
(a) 

(b) 

(c) 

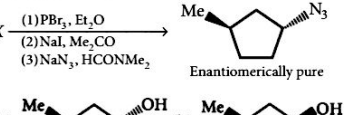
(d) 

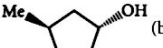
17. KI in acetone, undergoes S_N2 reaction with each of *P*, *Q*, *R* and *S*. The rates of the reaction vary as

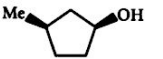


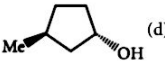
(a) $P > Q > R > S$ (b) $S > P > R > Q$
(c) $P > R > Q > S$ (d) $R > P > S > Q$

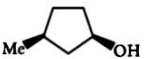
18. In the following reaction sequence, the correct structure of *X* is

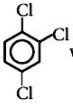


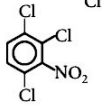
(a) 

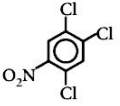
(b) 

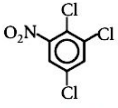
(c) 

(d) 

19. Nitration of  will give

(a) 

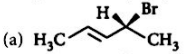
(b) 

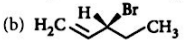
(c) 

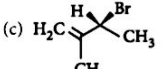
(d) all of these.

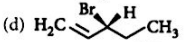
More than One Option Correct Type

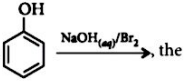
20. Compounds that produce optically inactive compounds on hydrogenation are

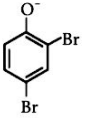
(a) 

(b) 

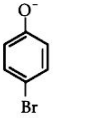
(c) 

(d) 

21. In the reaction,  the intermediates are

(a) 

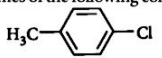
(b) 

(c) 

(d) 

22. The correct combination of names for isomeric alcohols with molecular formula $C_4H_{10}O$ are
(a) *tert*-butanol and 2-methylpropan-2-ol
(b) *tert*-butanol and 1,1-dimethylethan-1-ol
(c) *n*-butanol and butan-1-ol
(d) *iso*-butyl alcohol and 2-methylpropan-1-ol.

23. The IUPAC names of the following compound can be

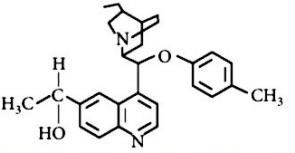


(a) 1-chloro-4-methylbenzene
(b) 4-chlorotoluene
(c) 1-methyl-4-chlorobenzene
(d) 4-methylchlorobenzene.

Integer / Numerical Value Type

24. An organic compound of formula, $C_3H_8O_3$ on acetylation with acetic anhydride yields a derivative of the formula $C_9H_{14}O_6$. The number of hydroxyl groups present in the compound is _____ .

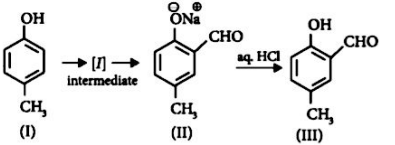
25. The number of chiral carbon atoms present in the molecule given below is _____.



26. The number of ethers in the given list which cannot be prepared by Williamson's synthesis is _____ .
$CH_3OCH_2CH_3$, $C_6H_5OCH_3$, $C_6H_5OCH_2CH_3$, $(C_6H_5)_2O$, $(CH_3)_3COCH_3$, $(CH_3)_3COCH_2CH_3$, $(CH_3)_3COC(CH_3)_3$, $(C_2H_5)_2O$, $C_6H_5CH_2OC_6H_5$

Comprehension Type

Reimer-Tiemann reaction introduces an aldehyde group on the aromatic ring of phenol and *ortho* to the hydroxyl group. This reaction involves electrophilic aromatic substitution. This is a general method for the synthesis of substituted salicylaldehydes as depicted below.

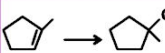
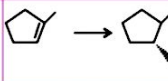


27. Which of the following reagents is used in the above reaction?
(a) aq. NaOH + CH_3Cl
(b) aq. NaOH + CH_2Cl_2
(c) aq. NaOH + $CHCl_3$
(d) aq. NaOH + CCl_4

28. The electrophile in this reaction is
(a) :CHCl (b) $+CHCl_2$
(c) $:CCl_2$ (d) $\cdot CCl_3$

Matching Type

29. Match the chemical conversions in column I with the appropriate reagents in column II and select the correct option.

Column I		Column II	
(A)		(i)	(i) $Hg(OAc)_2$; (ii) $NaBH_4$
(B)		(ii)	NaOEt
(C)		(iii)	Et-Br
(D)		(iv)	(i) BH_3; (ii) H_2O_2/ NaOH

(a) (A) → (ii), (B) → (iii), (C) → (i), (D) → (iv)
(b) (A) → (iii), (B) → (ii), (C) → (i), (D) → (iv)
(c) (A) → (ii), (B) → (iii), (C) → (iv), (D) → (i)
(d) (A) → (iii), (B) → (ii), (C) → (iv), (D) → (i)

30. Match the reactions given in column I with the type of reaction mentioned in column II and select the correct option.

Column I		Column II	
(A)	$CH_3-\underset{Br}{CH}-\underset{CH_3}{CH}-CH_3$ + C_2H_5ONa → $CH_3CH_2-\underset{CH_3}{\overset{OC_2H_5}{C}}-CH_3$	(i)	β-elimination
(B)	$CH_3CH_2Br \xrightarrow{AgOH} CH_3CH_2OH$	(ii)	S_N1 nucleophilic substitution
(C)	$CH_3CH=CH_2 + HBr \xrightarrow{Peroxide} CH_3CH_2CH_2Br$	(iii)	S_N2 nucleophilic substitution
(D)	CH_3-CH_2Br + *alc.* KOH → $CH_2=CH_2$	(iv)	Kharasch effect

(a) (A) → (iv), (B) → (i), (C) → (ii), (D) → (iii)
(b) (A) → (ii), (B) → (iii), (C) → (iv), (D) → (i)
(c) (A) → (i), (B) → (ii), (C) → (iv), (D) → (iii)
(d) (A) → (iii), (B) → (i), (C) → (ii), (D) → (iv)

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SELF CHECK

No. of questions attempted	.....
No. of questions correct	.....
Marks scored in percentage	.....

Check your score! If your score is

> 90%	EXCELLENT WORK !	You are well prepared to take the challenge of final exam.
90-75%	GOOD WORK !	You can score good in the final exam.
74-60%	SATISFACTORY !	You need to score more next time.
< 60%	NOT SATISFACTORY!	Revise thoroughly and strengthen your concepts.

MONTHLY TEST DRIVE

XI

This specially designed column enables students to self analyse their extent of understanding the specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Total Marks : 120

Redox Reactions

Time Taken : 60 Min.

NEET

Only One Option Correct Type

1. Select the correct sequence with the decreasing value of the oxidation states of N-atoms.
   (a) HNO_3, NO, N_2, NH_4Cl
   (b) HNO_3, NO, NH_4Cl, N_2
   (c) HNO_3, NH_4Cl, NO, N_2
   (d) NH_4Cl, N_2, NO, HNO_3

2. Phosphorus has the oxidation state of +5 in
   (a) H_3PO_2 (b) H_3PO_4
   (c) $H_4P_2O_6$ (d) H_3PO_3

3. Which of the following arrangements represent increasing oxidation number of the central atom?
   (a) CrO_2^-, ClO_3^-, CrO_4^{2-}, MnO_4^-
   (b) ClO_3^-, CrO_4^{2-}, MnO_4^-, CrO_2^-
   (c) CrO_2^-, ClO_3^-, MnO_4^-, CrO_4^{2-}
   (d) CrO_4^{2-}, MnO_4^-, CrO_2^-, ClO_3^-

4. Which of the following reactions is an example of a redox reaction?
   (a) $XeF_6 + H_2O \rightarrow XeOF_4 + 2HF$
   (b) $XeF_6 + 2H_2O \rightarrow XeO_2F_2 + 4HF$
   (c) $XeF_4 + O_2F_2 \rightarrow XeF_6 + O_2$
   (d) $XeF_2 + PF_5 \rightarrow [XeF]^+ PF_6^-$

5. Carbon has oxidation number of _____ and _____ respectively in diamond and graphite.
   (a) +2, +2 (b) +1, +1
   (c) +4, –4 (d) zero, zero

6. Consider the change in oxidation state of bromine corresponding to different EMF values as shown in the given diagram :

$$BrO_4^- \xrightarrow{1.82\ V} BrO_3^- \xrightarrow{1.5\ V} HBrO$$

$$Br^- \xleftarrow{1.0652\ V} Br_2 \xleftarrow{1.595\ V}$$

   Then the species undergoing disproportionation is
   (a) BrO_3^- (b) BrO_4^- (c) Br_2 (d) HBrO

7. Given $E^\circ_{Cr^{3+}/Cr} = -0.74$ V; $E^\circ_{MnO_4^-/Mn^{2+}} = 1.51$ V; $E^\circ_{Cr_2O_7^{2-}/Cr^{3+}} = 1.33$ V; $E^\circ_{Cl/Cl^-} = 1.36$ V
   Based on the data given above, strongest oxidising agent will be
   (a) MnO_4^- (b) Cl^-
   (c) Cr^{3+} (d) Mn^{2+}

8. Which of the following is a redox reaction?
   (a) $NaCl + KNO_3 \rightarrow NaNO_3 + KCl$
   (b) $CaC_2O_4 + 2HCl \rightarrow CaCl_2 + H_2C_2O_4$
   (c) $Mg(OH)_2 + 2NH_4Cl \rightarrow MgCl_2 + 2NH_4OH$
   (d) $Zn + 2AgCN \rightarrow 2Ag + Zn(CN)_2$

9. The oxidation number of carbon in CH_2O is
   (a) –2 (b) +2 (c) 0 (d) +4

10. Arrange the oxides of nitrogen in increasing order of oxidation state of N from +1 to +5.
    (a) $N_2O < N_2O_3 < NO_2 < N_2O_5 < NO$
    (b) $N_2O < NO < N_2O_3 < NO_2 < N_2O_5$
    (c) $N_2O_5 < NO_2 < N_2O_3 < NO < N_2O$
    (d) $NO < N_2O < NO_2 < N_2O_3 < N_2O_5$

11. In the balanced chemical reaction,
$IO_3^- + aI^- + bH^+ \rightarrow cH_2O + dI_2$
a, b, c and d respectively correspond to
(a) 5, 6, 3, 3 (b) 5, 3, 6, 3
(c) 3, 5, 3, 6 (d) 5, 6, 5, 5

12. Oxidation states of Cr in $K_2Cr_2O_7$ and CrO_5 are, respectively
(a) +6, +5 (b) +6, +10
(c) +6, +6 (d) none of these.

Assertion & Reason Type

Directions : In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :
(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

13. **Assertion :** F_2 undergoes disproportionation reactions.
Reason : Fluorine shows both positive and negative oxidation states.

14. **Assertion :** In the reaction,
$2Cu_2O_{(s)} + Cu_2S_{(s)} \rightarrow 6Cu_{(s)} + SO_{2(g)}$
copper acts as a reductant and sulphur acts as an oxidant.
Reason : The given reaction is not a redox reaction.

15. **Assertion :** In the reaction
$Zn_{(s)} + CuSO_{4(aq)} \longrightarrow ZnSO_{4(aq)} + Cu_{(s)}$
Zn is a reductant but itself gets oxidised.
Reason : In a redox reaction, oxidant is reduced by accepting electrons and reductant is oxidised by losing electrons.

JEE (Main & Advanced)

Only One Option Correct Type

16. The oxidation number of sulphur in S_8, S_2F_2, H_2S respectively, are
(a) 0, +1 and –2 (b) +2, +1 and –2
(c) 0, +1 and +2 (d) –2, +1 and +2

17. Which is not true about the variation of oxidation state of the following elements?
(a) Sulphur : +6 to –2
(b) Carbon : +4 to –4
(c) Chlorine : +7 to –1
(d) Nitrogen : +3 to –1

18. An example of a disproportionation reaction is
(a) $2KMnO_4 \rightarrow K_2MnO_4 + MnO_2 + O_2$
(b) $2NaBr + Cl_2 \rightarrow 2NaCl + Br_2$
(c) $2CuBr \rightarrow CuBr_2 + Cu$
(d) $2MnO_4^- + 10I^- + 16H^+ \rightarrow 2Mn^{2+} + 5I_2 + 8H_2O$

19. In the reaction,
$S_8 + 12OH^- \rightarrow 4S^{2-} + 2S_2O_3^{2-} + 6H_2O$
S has undergone oxidation and reduction. Which of the following statements is true?
(a) In S^{2-}, sulphur has been oxidised and in $S_2O_3^{2-}$, sulphur has been reduced.
(b) In S^{2-}, sulphur has been reduced and in $S_2O_3^{2}$, sulphur has been oxidised.
(c) In both S^{2-} and $S_2O_3^{2-}$, sulphur has been oxidised.
(d) In both S^{2-} and $S_2O_3^{2-}$, sulphur has been reduced.

More than One Option Correct Type

20. Which of the following will act as cathode when connected to standard hydrogen electrode which has $E°$ value given as zero?
(a) Zn^{2+}/Zn, $E° = -0.76$ V
(b) Cu^{2+}/Cu, $E° = +0.34$ V
(c) Al^{3+}/Al, $E° = -1.66$ V
(d) Hg^{2+}/Hg, $E° = +0.885$ V

21. Reduction is defined in terms of
(a) electronation and hydrogenation
(b) de-electronation and gain of oxygen
(c) increase in oxidation number
(d) decrease in oxidation number.

22. Select the correct statements from the following.
(a) In elements, in the free or the uncombined state, each atom bears an oxidation number of zero.
(b) For ions composed of only one atom, the oxidation number is not equal to the charge on the ion.
(c) In all its compounds, fluorine has an oxidation number of –1.
(d) The oxidation number of oxygen in most compounds is +2.

23. Which of the following reactions are disproportionation reactions?
(a) $2Cu^+ \longrightarrow Cu^{2+} + Cu^0$
(b) $3MnO_4^{2-} + 4H^+ \longrightarrow 2MnO_4^- + MnO_2 + 2H_2O$
(c) $2KMnO_4 \xrightarrow{\Delta} K_2MnO_4 + MnO_2 + O_2$
(d) $2MnO_4^- + 3Mn^{2+} + 2H_2O \longrightarrow 5MnO_2 + 4H^+$

Integer / Numerical Value Type

24. Among the following, the number of underlined elements having +6 oxidation state is _____ .

$\underline{P}O_4^{3-}$, $H_2\underline{S}_2O_8$, $H_2\underline{S}O_5$, $\underline{O}F_2$, $\underline{Cr}_2O_7^{2-}$, $\underline{Cr}O_5$

25. The difference in the oxidation numbers of the two types of sulphur atoms in $Na_2S_4O_6$ is _____.

26. What is the approximate mass of Fe_3O_4 (in g) if it reacts completely with 25 mL of 0.3 M $K_2Cr_2O_7$?

Comprehension Type

The term oxidation was first used for those chemical reactions in which oxygen is added to an element or a compound. The reverse of such a process can be defined as reduction.

According to the modern concept, loss of electrons (*i.e.*, increase in the oxidation number) is called oxidation while gain of electrons (*i.e.*, decrease in the oxidation number) is called reduction.

The following equation shows a simple redox reaction which can obviously be described in terms of oxygen transfer.

$CuO + Mg \longrightarrow Cu + MgO$

If we rewrite this as an ionic equation, it becomes :

$Cu^{2+} + Mg \longrightarrow Cu + Mg^{2+}$

A substance which undergoes oxidation acts as reducing agent and the other one which undergoes reduction acts as oxidising agent.

27. Which of the following is a redox reaction?

(a) Reaction of H_2SO_4 with NaOH

(b) In atmosphere, formation of O_3 from O_2 by lightning

(c) Formation of nitrogen oxide from nitrogen and oxygen by lightning

(d) Evaporation of H_2O

28. In the reaction, $SO_2 + 2H_2S \longrightarrow 3S + 2H_2O$, the substance that is oxidised is

(a) H_2S (b) SO_2

(c) S (d) H_2O

Matching Type

29. Match the column I with column II and select the correct option from the given codes.

	Column I		Column II
(A)	$3Mg_{(s)} + N_{2(g)} \xrightarrow{\Delta} Mg_3N_{2(s)}$	(i)	Displacement
(B)	$NaH_{(s)} + H_2O_{(l)} \rightarrow NaOH_{(aq)} + H_{2(g)}$	(ii)	Decomposition
(C)	$3ClO^-_{(aq)} \rightarrow 2Cl^-_{(aq)} + ClO^-_{3\,(aq)}$	(iii)	Combination
(D)	$2KClO_{3(s)} \xrightarrow{\Delta} 2KCl_{(s)} + 3O_{2(g)}$	(iv)	Disproportionation

(a) (A) → (i), (B) → (iii), (C) → (ii), (D) → (iv)

(b) (A) → (iv), (B) → (iii), (C) → (ii), (D) → (i)

(c) (A) → (ii), (B) → (i), (C) → (iii), (D) → (iv)

(d) (A) → (iii), (B) → (i), (C) → (iv), (D) → (ii)

30. Match the column I with column II and select the correct option from the given codes.

	Column I (Reaction)		Column II (Coefficients of x and y)
(A)	$xCu + yHNO_3 \longrightarrow Cu(NO_3)_2 + NO + NO_2 + H_2O$	(i)	2 and 6
(B)	$xSO_2 + O_2 \longrightarrow ySO_3$	(ii)	2 and 2
(C)	$P + OH^- + H_2O \longrightarrow xPH_3 + yH_2PO_2^-$	(iii)	1 and 3
(D)	$xKI + yH_2SO_4 \longrightarrow I_2 + H_2S + K_2SO_4$	(iv)	8 and 5

(a) (A) → (ii); (B) → (iii); (C) → (i); (D) → (iv)

(b) (A) → (iii); (B) → (i); (C) → (ii); (D) → (iv)

(c) (A) → (ii); (B) → (iv); (C) → (iii); (D) → (i)

(d) (A) → (i); (B) → (ii); (C) → (iii); (D) → (iv)

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