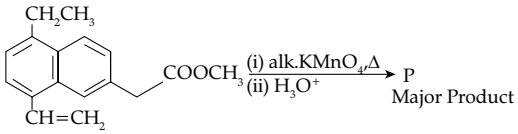
JEE (Main) CHEMISTRY SOLVED PAPER

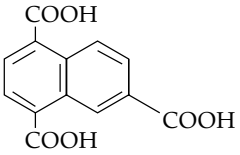
2023

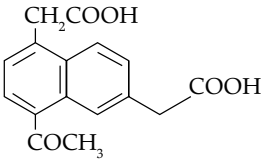
10th April Shift 1

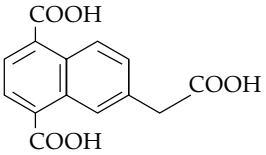
Section A

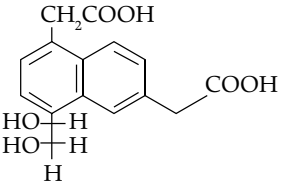
1. The major product 'P' formed in the given reaction is



(1) 

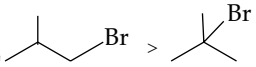
(2) 

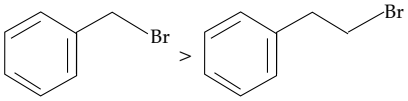
(3) 

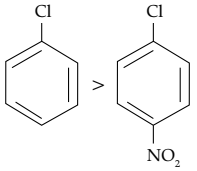
(4) 

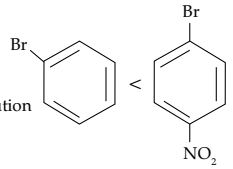
2. Prolonged heating is avoided during the preparation of ferrous ammonium sulphate to
(1) prevent hydrolysis **(2)** prevent reduction
(3) prevent breaking **(4)** prevent oxidation

3. Identify the correct order of reactivity for the following pairs towards the respective mechanism

(A) S_N2 

(B) S_N1 

(C) Electrophilic substitution 

(D) Nucleophilic substitution 

Choose the correct answer from the options given below:
(1) (A), (C) and (D) only **(2)** (A), (B) and (D) only
(3) (B), (C) and (D) only **(4)** (A), (B), (C) and (D)

4. Given
(A) $2CO(g)+O_2(g) \rightarrow 2CO_2(g)$ $\Delta H_1^0 = -x$ kJ mol^{-1}
(B) $C(graphite)+O_2(g) \rightarrow CO_2(g)$ $\Delta H_2^0 = -y$ kJ mol^{-1}
The ΔH^0 for the reaction

$$C(graphite)+\frac{1}{2}O_2(g) \rightarrow CO(g)$$ is

(1) $\frac{x-2y}{2}$ **(2)** $\frac{x+2y}{2}$ **(3)** $\frac{2x-y}{2}$ **(4)** $2y-x$

5. Using column chromatography mixture of two compounds 'A' and 'B' was separated. 'A' eluted first, this indicates 'B' has
(1) high R_f, weaker adsorption
(2) high R_f, stronger adsorption
(3) low R_f, stronger adsorption
(4) low R_f, weaker adsorption

6. Lime reacts exothermally with water to give 'A' which has low solubility in water. Aqueous solution of 'A' is often used for the test of CO_2. A test in which insoluble B is formed. If B is further reacted with CO_2 then soluble compound is formed. 'A' is
(1) Quick lime **(2)** Slaked lime
(3) White lime **(4)** Lime water

7. Match list I with list II

List I Industry	List II Waste Generated
(A) Steel plants	(I) Gypsum
(B) Thermal power plants	(II) Fly ash
(C) Fertilizer industries	(III) Slag
(D) Paper mills	(IV) Bio-degradable wastes

Choose the correct answer from the options given below
(1) (A)-(III), (B)-(IV), (C)-(I), (D)-(II)
(2) (A)-(IV), (B)-(I), (C)-(II), (D)-(III)
(3) (A)-(II), (B)-(III), (C)-(IV), (D)-(I)
(4) (A)-(III), (B)-(II), (C)-(I), (D)-(IV)

8. Suitable reaction condition for preparation of Methyl phenyl ether is
(1) Benzene, MeBr **(2)** PHO^-Na^+,MeOH
(3) Ph-Br,MeO^-Na^+ **(4)** PhO^-Na^+,MeBr

9. The one that does not stabilize 2^0 and 3^o structures of proteins is
(1) H-bonding **(2)** –S–S–linkage
(3) van der waals forces **(4)** –O–O–linkage

10. The compound which does not exist is
(1) $PbEt_4$ **(2)** BeH_2
(3) NaO_2 **(4)** $(NH_4)_2BeF_4$

11. Given below are two reactions, involved in the commercial production of dihydrogen (H_2). The two reactions are carried out at temperature "T_1" and "T_2", respectively

$$C(s)+H_2O(g)\xrightarrow{T_1}CO(g)+H_2(g)$$
$$CO(g)+H_2O(g)\xrightarrow[\text{catalyst}]{T_2}CO_2(g)+H_2(g)$$

The temperatures T_1 and T_2 are correctly related as
(1) $T_1 = T_2$
(2) $T_1 < T_2$
(3) $T_1 > T_2$
(4) $T_1 = 100$ K, $T_2 = 1270$ K

12. The enthalpy change for the adsorption process and micelle formation respectively are
(1) $\Delta H_{ads} < 0$ and $\Delta H_{mic} < 0$
(2) $\Delta H_{ads} > 0$ and $\Delta H_{mic} < 0$
(3) $\Delta H_{ads} < 0$ and $\Delta H_{mic} > 0$
(4) $\Delta H_{ads} > 0$ and $\Delta H_{mic} > 0$

13. The pair from the following pairs having both compounds with net non-zero dipole moment is
(1) cis-butene, trans-butene
(2) Benzene, anisidine
(3) CH_2Cl_2, $CHCl_3$
(4) 1,4-Dichlorohenzene, 1,3-Dichlorobenzene

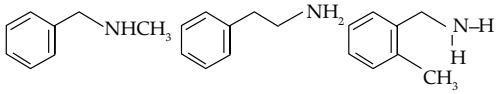
14. Which of the following is used as a stabilizer during the concentration of sulphide ores?
(1) Xanthates **(2)** Fatty acids
(3) Pine oils **(4)** Cresols

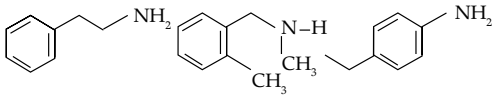
15. Which of the following statements are correct?
(A) The M^{3+}/M^{2+} reduction potential for iron is greater than manganese
(B) The higher oxidation states of first row d-block elements get stabilized by oxide ion.
(C) Aqueous solution of Cr^{2+} can liberate hydrogen from dilute acid.
(D) Magnetic moment of V^{2+} is observed between 4.4-5.2 BM.
Choose the correct answer from the options given below:
(1) (C), (D) only **(2)** (B), (C) only
(3) (A), (B), (D) only **(4)** (A), (B) only

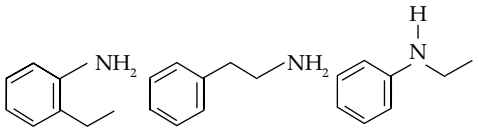
16. Given below are two statements:
Statement I : Aqueous solution of $K_2Cr_2O_7$ is preferred as a primary standard in volumetric analysis over $Na_2Cr_2O_7$ aqueous solution.
Statement II : $K_2Cr_2O_7$ has a higher solubility in water than $Na_2Cr_2O_7$
In the light of the above statements, choose the correct answer from the options given below:
(1) Statement I is false but Statement II is true
(2) Statement I is true but Statement II is false
(3) Both Statement I and Statement II are true
(4) Both Statement I and Statement II are false

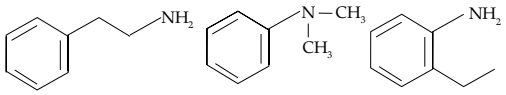
17. The octahedral diamagnetic low spin complex among the following is
(1) $[CoF_6]^{3-}$ (2) $[CoCl_6]^{3-}$
(3) $[Co(NH_3)_6]^{3+}$ (4) $[NiCl_4]^{2-}$

18. Isomeric amines with molecular formula $C_8H_{11}N$ given the following tests
Isomer (P) ⇒ Can be prepared by Gabriel phthalimide synthesis
Isomer (Q) ⇒ Reacts with Hinsberg's reagent to give solid insoluble in NaOH
Isomer (R) ⇒ Reacts with HONO followed by β-naphthol in NaOH to given red dye.
Isomer (P), (Q) and (R) respectively are

(1) 

(2) 

(3) 

(4) 

19. The number of molecules and moles in 2.8375 litres of O_2 at STP are respectively
(1) 7.527×10^{22} and 0.125 mol
(2) 1.505×10^{23} and 0.250 mol
(3) 7.527×10^{23} and 0.125 mol
(4) 7.527×10^{22} and 0.250 mol

20. Match list I with List II

List I Polymer	List II Type/Class
(A) Nylon-2-Nylon-6	(I) Thermosetting polymer
(B) Buna-N	(II) Biodegradable polymer
(C) Urea-Formaldehyde resin	(III) Synthetic rubber
(D) Dacron	(IV) Polyester

Choose the correct answer from the options given below:
(1) (A)-(IV), (B)-(III), (C)-(I), (D)-(II)
(2) (A)-(II), (B)-(I), (C)-(IV), (D)-(III)
(3) (A)-(IV), (B)-(I), (C)-(III), (D)-(II)
(4) (A)-(II), (B)-(III), (C)-(I), (D)-(IV)

Section B

21. If the degree of dissociation of aqueous solution of weak monobasic acid is determined to be 0.3, then the observed freezing point will be_____ % higher than the expected/theoretical freezing point. (Nearest integer)

22. In the following reactions, the total number of oxygen atoms in X and Y is_____

$Na_2O + H_2O \rightarrow 2X$, $Cl_2O_7 + H_2O \rightarrow 2Y$

23. The sum of lone pairs present on the central atom of the interhalogen IF_5 and IF_7 is_____

24. The number of bent-shaped molecule/s from the following is_____

N_3^-, NO_2^-, I_3^-, O_3, SO_2

25. The number of correct statement/s involving equilibria in physical from the following is_____

(1) Equilibrium is possible only in a closed system at a given temperature.

(2) Both the opposing processes occur at the same rate.

(3) When equilibrium is attained at a given temperature, the value of all its parameters

(4) For dissolution of solids in liquids, the solubility is constant at a given temperature.

26. At constant temperature, a gas is at pressure of 940.3 mm Hg. The pressure at which its volume decreases by 40% is_____ mm Hg. (Nearest integer)

27. $FeO_4^{2-} \xrightarrow{+2.2V} Fe^{3+} \xrightarrow{+0.70V} Fe^{2+} \xrightarrow{-0.45V} Fe^0$

$E^0_{FeO_4^{2-}/Fe^{2+}}$ is $x \times 10^{-3}$V. The value of x is_____

28. A molecule undergoes two independent first order reactions whose respective half lifes are 12 min and 3 min. If both the reactions are occurring then the time taken for the 50% consumption of the reactant is_____ min. (Nearest integer)

29. The number of incorrect statement/s about the black body from the following is_____

(1) Emit or absorb energy in the form of electromagnetic radiation.

(2) Frequency distribution of the emitted radiation depends on temperature.

(3) At a given temperature, intensity vs frequency curve passes through a maximum value.

(4) The maximum of the intensity vs frequency curve is at a higher frequency at higher temperature compared to that at lower temperature.

30. In potassium ferrocyanide, there are_____ pairs of electrons in the t_{2g} set of orbitals.

Answer Key

Q. No.	Answer	Topic name	Chapter name
1	(1)	Reactions of Carboxylic Acid	Aldehyde, Ketones & Carboxylic Acids
2	(4)	Some Important Compounds of Transition Elements	d & f Block Elements
3	(4)	Fundamental Concepts in Organic Reaction Mechanism	Organic Chemistry - Some Basic Principles and Techniques
4	(1)	Enthalpies for Different Types of Reactions	Thermodynamics
5	(3)	Methods of Purification of Organic Compounds	Organic Chemistry - Some Basic Principles and Techniques
6	(2)	Some Important Compounds of Calcium	The s-Block Elements
7	(4)	Strategies to Control Pollution	Environmental Chemistry
8	(4)	Ethers	Alcohols, Phenols and Ethers
9	(4)	Proteins	Biomolecules
10	(3)	Characteristics of the Compounds of Alkali Metals	The s-Block Elements
11	(3)	Preparation and Properties of Dihydrogen	Hydrogen
12	(3)	Classification of Colloids	Surface Chemistry
13	(3)	Bond Parameters	Chemical Bonding and Molecular Structure
14	(4)	Concentration of Ores	General Principles and Processes of Isolation of Elements
15	(2)	General Properties of the Transition Elements (d-Block)	d & f Block Elements
16	(2)	Some Important Compounds of Transition Elements	d & f Block Elements
17	(3)	Valency Bond Theory	Coordination Compounds
18	(2)	Preparation of Amines	Amines
19	(1)	Mole Concept and Molar Masses	Some Basic Concepts Of Chemistry

20	**(4)**	Types of Polymerisation Reactions	Polymers
21	**[30]**	Colligative Properties and Determination of Molar Mass	Solutions
22	**[5]**	Properties of elements	s block elements
23	**[1]**	Hybridization	Chemical Bonding and Molecular Structure
24	**[3]**	Hybridization	Chemical Bonding and Molecular Structure
25	**[3]**	Chemical Equilibrium	Equilibrium
26	**[1567]**	Boyle's Law	State of Matter
27	**[1825]**	Nernst Equation	Electrochemistry
28	**[2]**	Integrated Rate Equations	Chemical Kinetics
29	**[3]**	Development Leading to Bohr's Model of Atom	Structure of Atom
30	**[3]**	Crystal Field Theory	Coordination Compounds

Solutions

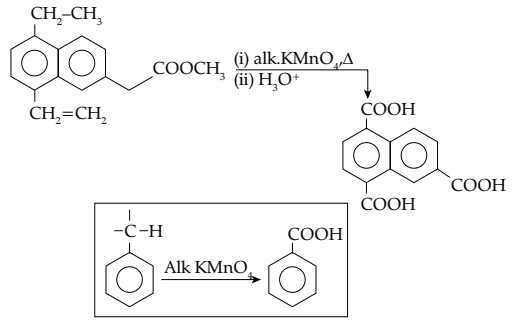
Section A

1. Option (1) is correct.

Treatment of an alkylbenzene with potassium permanganate results in oxidation to give the benzoic acid. An alkylbenzene is simply a benzene ring with an alkyl group attached to it.

Alkyl groups are usually fairly resistant to oxidation. However, when they are attached to a benzene ring, they are easily oxidized by an alkaline solution of potassium permanganate.

An alkyl group is oxidized back to a -COOH group on the ring under these conditions. Here, Alkaline $KMnO_4$ converts hydrogen into benzoic acid.



2. Option (4) is correct.

Prolonged heating of ferrous ammonium sulfate is avoided to prevent oxidation. Ferrous ammonium sulfate is a green crystalline solid that is used as a reducing agent in various chemical reactions. When heated, it can undergo oxidation to form ferric ammonium sulfate. This is because heating provides energy that can be used to overcome the activation energy required for the oxidation reaction to occur. The oxidation of ferrous ammonium sulfate can be represented by the following chemical equation:

$$NH_4FeSO_4(NH_4)_2SO_4.6H_2O + O_2 \rightarrow 2Fe_2(SO_4)_3.(NH_4)_2SO_4 + 12H_2O$$

This reaction is exothermic and releases a large amount of heat. Therefore, prolonged heating can provide the energy required to drive the reaction forward, leading to the formation of ferric ammonium sulfate. To prevent this oxidation reaction from occurring, prolonged heating of ferrous ammonium sulfate is avoided.

3. Option (4) is correct.

(A) Steric hindrance (crowding) is the basis of S_N2 reaction.

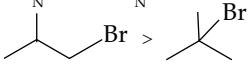
$$\text{Rate of } S_N2 \propto \frac{1}{\text{Steric crowding at 'C' bearing leaving group}}$$

As steric hinderance (crowding) increases, rate of S_N2 reaction decreases.

Note: The order of reactivity towards S_N2 reaction for alkyl halides is:

Methyl > Primary halides (1°) > (2°) > Tertiary halides (3°)

$S_N2 \rightarrow$ for S_N2 Reaction 1°>2°>3°

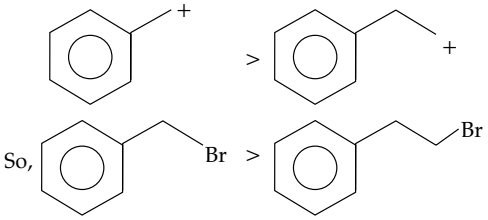


(B) Reactivity of S_N1 reaction depends on the stability of the carbocation formed. Higher the stability of carbocation, higher will be its reactivity.

Stability of carbocation follows the order,

Tertiary > Secondary > Primary

(B) $S_N1 \rightarrow$ reactivity × Stability of Carbocation formed



The rate of electrophilic substitution depends on the nature of the substituent already present in the benzene ring.

(C) If the substituent is o/p directing (activating groups) then the rate of substitution increases. If it is meta directing (deactivating groups) then the rate of substitution decreases. Electron-withdrawing groups destabilize the carbocation intermediate of electrophilic aromatic substitution. All activating substituents increase the rate of electrophilic aromatic substitution and are ortho-para directors.

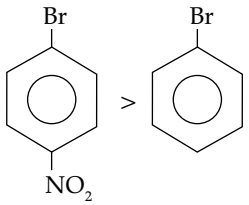
Electrophilic Substitution reaction

$$\text{rate} \propto \frac{1}{\text{EWG}}$$

The presence of nitro group ($-NO_2$) at ortho/para positions increase the reactivity of haloarenes towards nucleophilic substitution reaction.

This is because nitro group ($-NO_2$) at o/p positions withdraw the electrons from the benzene ring which facilitates the attack of the nucleophile. The negative charge in the carbanion formed at o/p positions with respects to halogen atom is stabilized by the presence of nitro groups ($-NO_2$) and resonance respectively.

(D) Nueleophilic substitution: rate × no. of EWG attached at benzene.



4. Option (1) is correct.

Hess's law of constant heat summation:

The law states that the change in enthalpy for a reaction is the same whether the reaction takes place in one or a series of steps. The Hess's law can also be stated as the enthalpy change for a chemical reaction is the same regardless of the path by which the reaction occurs.

$2CO(g) + O_2(g) \rightarrow 2CO_2(g)\ \Delta H_1^\circ = -x\ KJmol^{-1}$ ...(i)

$C(graphite) + O_2(g) \rightarrow CO_2(g)\ \Delta H_2^\circ = -y\ KJmol^{-1}$ (ii)

Multiply eq (i) by ½ and subtract from eq (ii)

$C(graphite) + \frac{1}{2} O_2(g) \rightarrow CO(g)$

$$\Delta H_3^\circ = \Delta H_2^\circ - \frac{\Delta H_1^\circ}{2} = -y + \frac{x}{2} = \frac{x-2y}{2}$$

5. Option (3) is correct.

Chromatography is a term used to describe a separation technique in which a mobile phase carrying a mixture is caused to move in contact with a selectively adsorbent stationary phase. This is a solid-liquid technique in which the stationary phase is a solid and the mobile phase is liquid. The solvent used as the mobile phase is called eluent. Compounds attracted more strongly by the mobile phase will move fast through the column and elute from the column dissolved in the eluent.

The compound which is more strongly attracted to the stationary phase will move slowly through the column.

More Polar the compound, the more it will adhere to the adsorbent and the smaller the distance it will travel from baseline, and Lower its R_f value. B has Low Rf value and strong Adsorption.

$$R_f = \frac{\text{distance covered by substance from base line}}{\text{total distance covered by solvent from base line}}$$

6. Option (2) is correct.

When water is added to calcium oxide, it forms calcium hydroxide. During this process, hissing sound is observed and also a large amount of heat is evolved which converts water into steam. This process is termed as slaking of lime and fine powder obtained is called 'slaked lime'. The reaction is:

$$CaO + H_2O \rightarrow Ca(OH)_2$$

When slaked lime is added in water it turns into a suspension which is called "milk of lime". After some time the solution becomes clear and is known as "lime water". So, on above arguments we can say that reaction of water with slaked lime is an 'exothermic' reaction. Also, from above it is cleared that calcium oxide and water react to form 'calcium hydroxide or slaked lime'.

Note: It should be remembered that when carbon dioxide is passed through lime water, it turns milky due to formation of calcium carbonate. This reaction is used as a test to identify carbon dioxide gas. The reaction is:

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3\downarrow + H_2O$$

When excess of CO_2 is passed in above reaction, the milkiness disappears due to the formation of soluble calcium bicarbonate. The reaction is:

$$CaCO_3 + CO_2 + H_2O \rightarrow \underset{\text{(soluble)}}{Ca(HCO_3)_2}$$

7. Option (4) is correct.

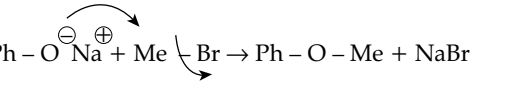
Non-biodegradable waste is a type of waste that can not be broken down into its base compounds by micro-organisms, air, moisture or soil in a reasonable amount of time. Non-biodegradable waste is an environmental concern, as it threatens to overwhelm landfills and create disposal problems. Almost all industries generate some amount of non biodegradable waste for eg fly ash, slag, mud which are major concern for the environment. Steel plant produces slag from blast furnace. Thermal power plant produces fly ash, Fertilizer industries produces gypsum. Paper mills produces bio degradable waste

8. Option (4) is correct.

Explanation: Williamson synthesis: It is used for the preparation of simple as well as mixed ethers. Alkyl halide is heated with alcoholic sodium or potassium alkoxide to form corresponding ethers.

Methyl phenyl ether is also known as anisole.

Williamson's synthesis:-



9. Option (4) is correct.

Secondary structure: Long polypeptide chains fold or coil to form secondary structure. These secondary structures are produced and maintained by hydrogen bonding, Two types of secondary structures are:

(i) **α-helix:** In this, the chain is coiled spirally, generally in the right handed manner. The helix is stabilised by Hydrogen bond between carboxylic acid of one amino acid and amino group of next fourth amino acid.

(ii) **β-pleated sheets:** In this, two or more chains are joined together by intermolecular bond, Hydrogen bond.

Tertiary structure: The polypeptide chain may undergo coiling and folding to produce the tertiary structure. These structures are stabilised by the several types of bonds namely hydrogen bond, ionic bond, van der waal's interaction, covalent bond (disulphide bridges) and hydrophobic bond.

10. Option (3) is correct.

Explanation: The stability of the lattice of a ionic compound depends on the size difference of the cation and anion. Less the difference of the cation and anion results higher stability in the lattice of a ionic compound.

Metallic sodium reacts with oxygen at 200–350°C to produce sodium oxide Na_2O;-

$4\ Na + O_2 \rightarrow 2\ Na_2O$

If enough excess oxygen is present, sodium oxide reacts with oxygen to produce sodium peroxide at temperatures of 350–450°C ;-

$2\ Na_2O + O_2 \longleftrightarrow 2\ Na_2O_2$

If sodium peroxide is reacted with an even larger excess of oxygen at high pressure, the result is sodium superoxide (NaO_2);-

$Na_2O_2 + O_2 \rightarrow 2\ NaO_2$. There cannot be any why for this case.

11. Option (3) is correct.

The commercial preparation of hydrogen is a huge industry because there is a huge demand for hydrogen in the production of fertilizers and oil-refining process.

$$C(s)+H_2O(g)\xrightarrow{1273K}CO(g)+H_2(g)$$

$$CO(g)+H_2O(g)\xrightarrow[(FeO,Cr_2O_3)]{673K}CO_2(g)+H_2(g)$$

$T_1 = 1270$ K, $T_2 = 673$ K , $T_1 > T_2$

12. Option (3) is correct.

Adsorption Enthalpy: Adsorption enthalpy is the heat released or absorbed during the adsorption process as defined by thermodynamics.

1. Adsorption is the process of attracting molecules of adsorbate to the adsorbent's surface.
2. As a result, energy is released, and the heat of adsorption is negative, implying that adsorption is always exothermic.
3. As per Gibb's energy equation: $\Delta G = \Delta H - T\Delta S$
4. For a process to be spontaneous $\Delta G < 0$.
5. As it is an exothermic reaction, so the entropy of the system decreases because the atoms are more ordered at lower temperatures. So, $\Delta S < 0$.
6. From the above equation, we can say that if $\Delta G < 0$ and $\Delta S < 0$ then $\Delta H < 0$.

Micelle formation is an endothermic process with positive entropy change. For micelle formation, $\Delta S > 0$ (hydrophobic effect). This is possible because, the decrease in entropy due to clustering is offset by increase in entropy due to desolvation of the surfactant. Also $\Delta H > 0$

13. Option (3) is correct.

A dipole moment is the product of the magnitude of the charge and the distance between the centers of the positive and negative charges. It is denoted by the Greek letter 'μ'.

Mathematically,

Dipole Moment (μ) = Charge (Q) × distance of separation (r)

It is measured in Debye units denoted by 'D'. 1 D = 3.33564×10^{-30} C.m, where C is Coulomb and m denotes a metre.

The bond dipole moment that arises in a chemical bond between two atoms of different electronegativities can be expressed as follows:

$\mu = \delta.d$

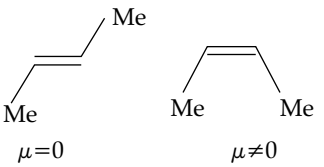
Where: μ is the bond dipole moment,

δ is the magnitude of the partial charges δ^+ and δ^-,

And d is the distance between δ^+ and δ^-.

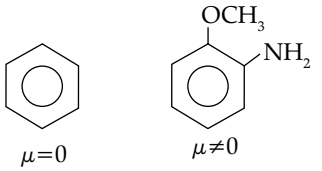
The bond dipole moment (μ) is also a vector quantity, whose direction is parallel to the bond axis. In chemistry, the arrows that are drawn in order to represent dipole moments begin at the positive charge and end at the negative charge.

(1)



$\mu = 0$ $\mu \neq 0$

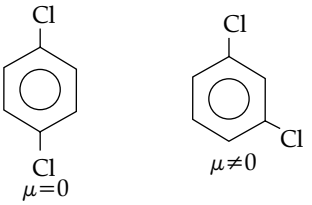
(2)



$\mu = 0$ $\mu \neq 0$

(3) CH_2Cl_2 $\mu = 0$ $CHCl_3$ $\mu \neq 0$

(4)



$\mu = 0$ $\mu \neq 0$

14. Option (4) is correct.

Froth stabilizer: Froth stabilizers are the substances that help stabilize the froth formed during the froth flotation process.

In order to get the froth to be stable, we use froth stabilizers so that the froth can be skimmed off easily.

Common examples of froth stabilizers are cresol and aniline.

Froth Flotation: Froth flotation is the process for separating minerals from gangue by taking advantage of differences in their hydrophobicity.
Froth flotation is one of the most popular operational processes for mineral beneficiation.
The minerals that do not float into the froth are called the flotation tailings or flotation tails.
Cresol are added to stabilize the froth and enhance the non- wettability of the mineral particles.
Pine oil: Pine oil is added in the froth flotation method to create froth or bubble so that metal can be purified easily because pine oil prevents the ore from gangue for further mixing.
Pine oil also acts as the best substance for forming froth for the minerals.
It also increases the non- wettability of mineral particles.
Xanthate: The function of xanthate in the froth flotation process is to make the ore water repellant.

15. Option (2) is correct.

(A) Since we know, as the reduction potential increases oxidizing power increases and reducing power decreases. According to the IUPAC convention, standard reduction potential is taken as the electrode potential. The given value of electrode potential can be considered as the standard reduction potential unless it is mentioned that it is oxidation potential. Standard reduction potential means that reduction is taking place at the electrode. Standard oxidation potential means that oxidation is taking place at the electrode. An electrolytic cell consists of cathode and anode. Now the standard electrode potential of any element can be measured by preparing a cell having half-cell of that element and the other half cell is the standard hydrogen electrode. The potential of SHE is arbitrarily taken as zero. So it can be used to find out the electrode potential . The standard electrode potentials are very important and we can extract a lot of information from them. Suppose if standard electrode potential of an electrode is greater than zero then its reduced form is more stable as compared to hydrogen gas. (Since the electrode of SHE is zero). Similarly if the electrode potential of an electrode is negative then hydrogen gas is more stable than the reduced form of the electrode.
Mn^{3+}/Mn^{2+} has large positive value and Mn(III) is least stable as it can be easily reduced to Mn(II).
Fe^{3+}/Fe^{2+} has small positive value and Fe(III) is more stable than Mn(III).

(B) The highest oxidation state of a metal exhibited in its oxide or fluoride only since fluorine and oxygen are the most electronegative elements. The highest oxidation state shown by any transition element is +8.

$E^0_{Fe^{+3}/Fe^{+2}} = +0.77,\ E^0_{Mn^{+3}/Mn^{+2}} = +1.57$

(C) The comparison of electronegativities of the first-row transition metals will provide us the correct answer as we go from left to right the electronegativity increases.

$E^0_{Cr^{+3}/Cr^{+2}} = -0.26,\ Cr^{2\oplus} + H^{\oplus} \rightarrow Cr^{3\oplus} + \frac{1}{2}H_2$

(D) V^{2+} has outer electronic configuration of $3d^3$ with 3 unpaired electrons.
The magnetic moment $\mu_{eff} = \sqrt{n(n+2)}$ B.M.
$\mu_{eff} = \sqrt{3(3+2)}$ B.M.
$\mu_{eff} = \sqrt{15}$ B.M., $\mu_{eff} = 3.87$ B.M.

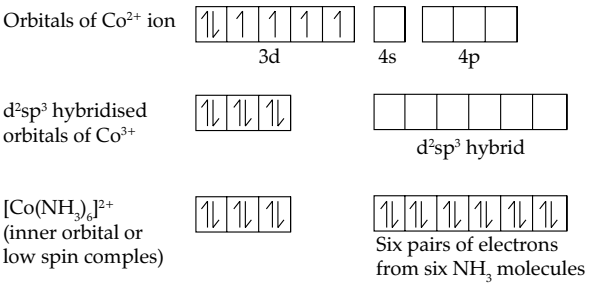
16. Option (2) is correct.

$K_2Cr_2O_7$ is generally preferred than $Na_2Cr_2O_7$ in volumetric analysis as $Na_2Cr_2O_7$ is hygroscopic in nature, therefore it is difficult to prepare its standard solution for volumetric analysis as accurate weighing is not possible in normal atmospheric conditions. A hygroscopic substance can absorb moisture from the atmosphere due to which there will be inaccuracy in weight.

17. Option (3) is correct.

(1) Paramagnetic, High Spin & Tetrahedral
(2) Paramagnetic, High Spin & Octahedral
(3) Diamagnetic, Low Spin & Octahedral
(4) Paramagnetic, High Spin & Octahedral

In $[Co(NH_3)_6]^{3+}$ the oxidation state of cobalt is +3. Ammonia is a strong field ligand so it pair up 4 unpaired electron and free up 2 3d orbitals. These 3d orbitals are involved in hybridisation with one 4s and three 4p orbitals forming an inner orbital complex, so hybridisation of $[Co(NH_3)_6]^{3+}$ is d^2sp^3
Since it has no unpaired electrons, $[Co(NH_3)_6]^{3+}$ is diamagnetic.



18. Option (2) is correct.

(P) Gabriel phthalimide reaction is used to prepare primary unhindered amine only. Because in Gabriel phthalimide reaction no other place for nitrogen, therefore it attack at terminal position only and after hydrolysis it give primary amine

(Q) Hinsberg test is a chemical reaction used to distinguish between primary, secondary, and tertiary amines. In the Hinsberg Test, the amines act as nucleophiles and attack the electrophile (sulfonyl chloride). This leads to the displacement of the chloride and the generation of the sulfonamides. When primary and secondary amines form sulfonamides, this sulfonamide product is not soluble and precipitates from the solution as a solid.

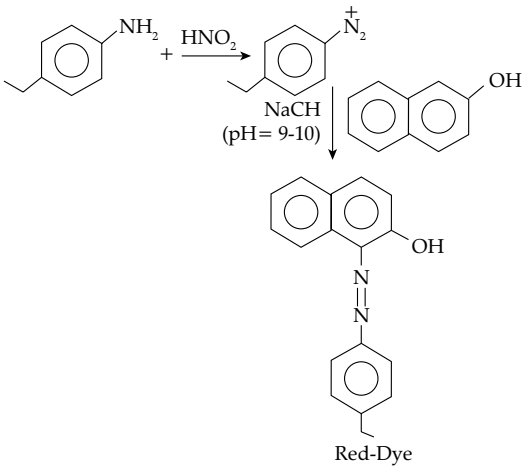
(R) The aromatic primary amine can be confirmed by azo dye test. In this test, primary aromatic amine like aniline reacts with nitrous acid

(produced by reaction of sodium nitrite with hydrochloric acid) at zero to five degree Celsius to form diazonium salt or benzene diazonium chloride. The reaction of formed benzene diazonium chloride with β-naphthol gives a scarlet red dye and this die is sparingly soluble in water.

P = Can be prepased by Gabriel phthalimide synthesis it should be 1° -amine

Q = React with Hinsberg's reagent and insoluble in NaOH it should be 2°–amine

R = React with HNO_2 followed by β-Napthol in NaOH it give red dye it must be Aromatic Amine.



Red-Dye

19. Option (1) is correct.

The temperature of 273 K and pressure of 1 atmosphere are known as standard temperature and pressure. At STP, one mole of any gas will have a volume of 22.4 L. This volume is known as molar volume of a gas at STP. The formula to find out the number of moles at STP is

$$\text{Number of moles} = \frac{\text{Volume at STP(litres)}}{\text{Molar volume at STP(litres)}}$$

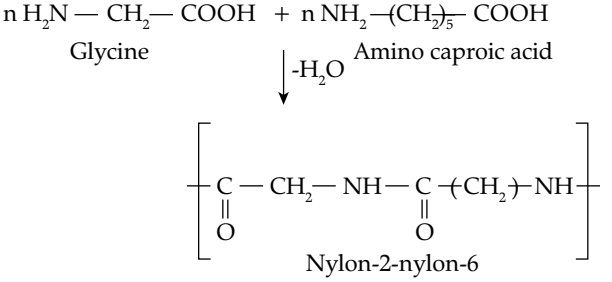
$$\text{Moles of } O_2(n_{O2}) = \frac{\text{Volume of } O_2}{22.4} = 0.125 \text{ moles}$$

$$\text{Molecules of } O_2 = \text{moles} \times N_A$$
$$= 0.125 \times 6.022 \times 10^{23}$$
$$= 7.525 \times 10^{22} \text{ molecules}$$

20. Option (4) is correct.

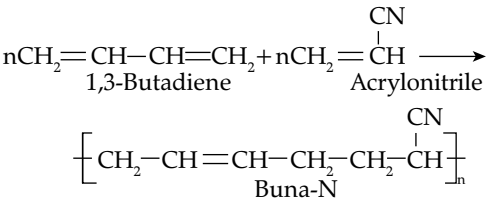
(A) A large number of polymers are responsible for the accumulation of polymeric solid waste materials because these are quite resistant to the environmental degradation process. These polymers have remained undegraded for a long time and cause acute environmental problems. Biodegradable synthetic polymers are designed and developed to overcome the problems created by the polymers created by the polymeric solid waste. Similar to functional groups in biopolymers, these biodegradable polymers contain functional groups. One of the important classifications of biodegradable polymers are aliphatic polyesters and some examples are, poly- β -hydroxybutyrate – co- β -hydroxy valerate (PHBV) and Nylon 2-nylon-6.

Nylon–2–Nylon–6 → It is α Biodegradable polymer. Nylon 2-nylon 6 is an alternating polyamide copolymer of glycine ($H_2N–CH_2–COOH$) and aminocaproic acid [$H_2N(CH_2)_5COOH$].



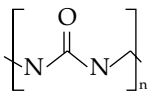
(B) Buna−N is a synthetic rubber copolymer made up of 1,3−Butadiene ($H_2C=CH–CH=CH_2$) and acrylonitrile ($H_2C=CH–CN$).

The synthesis is as follows:



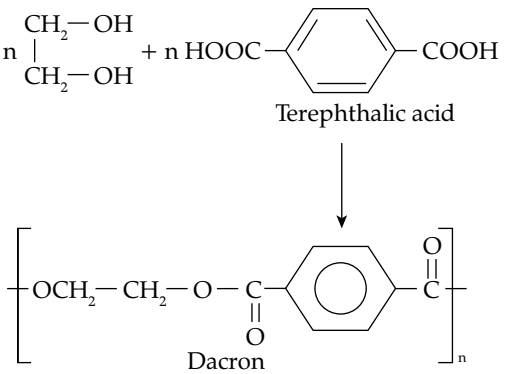
(C) Urea–formaldehyde (UF) resins are among the oldest thermoset resins based on formaldehyde [1], [2]. They are generally amorphous polymers and almost insoluble when cured [1], [2], and commonly used as adhesives in the production of wood-based panels such as particleboard, medium density fiberboard, and plywood [3].

Urea– formaldehyde resin



It is a thermos setting polymer

(D) Dacron or Terylene is a condensation polymer formed by condensation reaction of ethylene glycol & terephthalic acid, with the removal water molecules. It is a polyester as in the polymeric chain an ester linkage is present joining the monomers.



Section B

21. Correct answer is [30].

The relationship between the depression in the freezing point and the molality of the solution is as given below.

$\Delta T_f = iK_f m$ (1)

Let α be the degree of dissociation of the weak acid.

The dissociation equilibrium of the weak acid is as represented below

$HA \rightarrow H^+ + A^-$

$1-\alpha \quad \alpha \quad \alpha$

For mono basic acid $\rightarrow n = 2$

The Van't Hoff factor i is the total number of ions/ molecules given by the dissociation of 1 molecule of solute.

$i = 1 + (n-1)\alpha = 1 + (2-1)0.3$

$i = 1.3$

$$\% \text{ increase} = \frac{(\Delta Tf)obs - (\Delta Tf)cal}{(\Delta Tf)cal} \times 100$$

$$= \frac{Kf \times i \times m - Kf \times m}{Kf \times m}$$

$$= \frac{i-1}{1} \times 100 = 30\%$$

22. Correct answer is [5].

$Na_2O + H_2O \rightarrow 2NaOH$

that's why Na_2O is basic oxide as it form basic oxide.

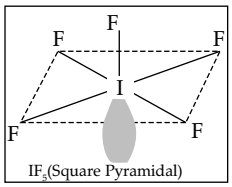
$Cl_2O_7 + H_2O \rightarrow 2HClO_4$

The Cl_2O_7 forms acid on reaction with water. Thus, it is acidic oxide.

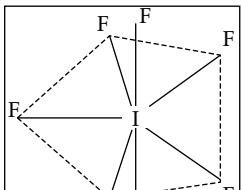
Total no. of oxygen atoms 1 + 4 = 5

23. Correct answer is [1].

In IF_5 (iodine pentafluoride), the central atom is iodine (I). Iodine has 7 valence electrons (group 7 or 17), and each fluorine (F) atom has 7 valence electrons. Therefore, the total number of valence electrons in IF_5 is: 1(I) x 7 valence electrons + 5(F) x 7 valence electrons = 42 valence electrons To determine the number of lone pairs on the central atom, we need to subtract the number of electrons involved in bonding from the total number of valence electrons. In IF_5, each fluorine atom contributes 1 electron to form a single bond with the iodine atom. Therefore, there are 5 bonding pairs (I-F) in the molecule, accounting for a total of 10 electrons. The remaining 32 valence electrons are used to complete the octet of each fluorine atom, leaving 2 electrons on iodine. Since each lone pair has 2 electrons, there is 1 lone pair on the central atom in IF_5. In IF_7 (iodine heptafluoride), the central atom is also iodine (I). Iodine has 7 valence electrons, and each fluorine atom has 7 valence electrons. Therefore, the total number of valence electrons in IF_7 is: 1(I) x 7 valence electrons + 7(F) x 7 valence electrons = 56 valence electrons. In IF_7, each fluorine atom contributes 1 electron to form a single bond with the iodine atom. Therefore, there are 7 bonding pairs (I-F) in the molecule, accounting for a total of 14 electrons. The remaining 42 valence electrons are used to complete the octet of each fluorine atom, leaving no electrons on iodine. Since there are no lone pairs on the central atom in IF_7, the sum of the number of lone pairs in IF_5 and IF_7 is 1 + 0 = 1.



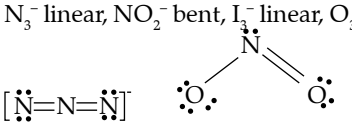
IF_5(Square Pyramidal)

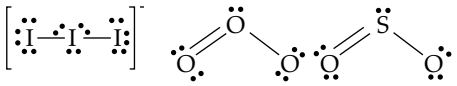


IF_7(Pentagonal bipyramidal)

24. Correct answer is [3].

N_3^- linear, NO_2^- bent, I_3^- linear, O_3^- bent, SO_2^- bent





25. Correct answer is [3].

(1) Equilibrium is possible only in a closed system at a particular temperature. Equilibrium is dynamic in nature. Rate of forward reaction is equal to rate of reverse reaction. At equilibrium, all measurable properties of system remain constant. There cannot be chemical equilibrium in an open system as mass and heat escapes from open system can not be used reversibly and there is no fixed mass in an open system.

(2) At equilibrium both forward & backward reactions occur at same rate. So, the equilibrium is dynamic in nature and all physical processes do not stop at equilibrium. However, the conditions becomes stable at equilibrium.

(3) When equilibrium is attained for physical process, it is characterized by constant value of one of its parameters at a given temperature. The magnitude of such quantities at any stage indicates the extent to which the physical process has proceeded before reaching equilibrium.

(4) When a solid solute is added to a liquid, the solute particles dissolve in the solvent and this process is known as dissolution. Some solute particles in the solution collide with each other and get separated from the solution, this process is called crystallization. A state of dynamic equilibrium exists between these two processes. It means that the number of solute molecules entering the solution is equal to that leaving the solution. As a result,

the concentration of the solute in the solution remains constant at a constant temperature and pressure condition but varies with the temperature change.

26. Correct answer is [1567].

Boyle's law: At constant temperature, for a given mass of a gas, Volume (V) is inversely proportional to Pressure (P).

$$V \propto \frac{1}{P}$$

Therefore, for a gas at two different conditions of temperature and pressure follow the relationship given below:

$P_1 V_1 = P_2 V_2$

P_1 = 940.3 mm of Hg (given)

P_2 = Pressure at which volume is reduced by 40%

V_2 = Volume decreased by 40%

$$V_2 = V_1 - \frac{40}{100}V_1 = \frac{60}{100}V_1$$

V_1 = Volume at pressure P_1

$$940.3 \times V_1 = P_2 \times \frac{60}{100}V_1$$

$$P_2 = \frac{940.3 \times 100}{60} = 1566.5 \approx 1567 \text{ mm of Hg}$$

27. Correct answer is [1825].

$$3e^- + FeO_4^{2-} \rightarrow Fe^{3+} - (I) \quad \Delta G_1^0 = -3F \times 2.20$$

$$e^- + Fe^{3+} \rightarrow Fe^{2+} (III) \quad \Delta G_2^0 = -1F \times 0.77$$

$$2e^- + Fe^{2+} \rightarrow Fe - (II) \quad \Delta G_3^0 = -2F(-0.445)$$

Adding equation (1) and (II)

$$4e^- + FeO_4^{2-} \rightarrow Fe^{2+}$$

$$\Delta G_1^0 + \Delta G_2^0 = \Delta G_3^0$$

$$\Rightarrow -3F \times 2.2 + (-1 \times F \times 0.77) = -4 \times F \times E_3^0$$

$$\Rightarrow \frac{3 \times 2.2 + 1 \times 0.77}{4} = E_3^0 = 1.84 \text{ V}$$

28. Correct answer is [2].

The half-life of a reaction is the time required during which amount of reactant has reacted becomes half of its initial amount.

The rate law expression for the first order reaction is $= K \times [A]$.

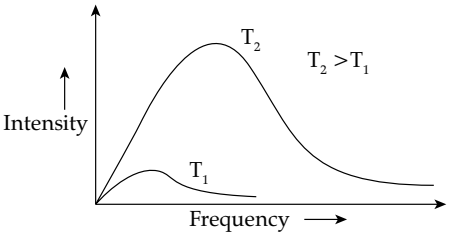
$$k_{eff} = k_1 + k_2$$

$$\frac{\ell n^2}{t_{eff}} = \frac{\ell n^2}{t_1} + \frac{\ell n^2}{t_2}$$

$$\frac{1}{t_{eff}} = \frac{1}{12} + \frac{1}{3} = \frac{1+4}{12} = \frac{5}{12}, \; t_{eff} = \frac{12}{5} = 2.4 = 2$$

29. Correct answer is [3].

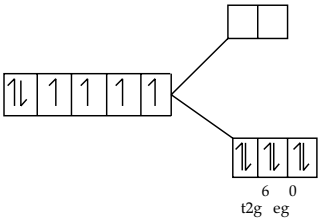
The ideal body, which emits and absorbs radiation of all frequencies, is called a black body and the radiation emitted by such is called black body radiation. The exact frequency distribution of the emitted radiation from a black body depends only on its temperature. At a given temperature, Intensity of radiation emitted increases with decreases of wavelength, reaches a maximum value at a given wavelength and then starts decreasing with further decrease of wavelength.



30. Correct answer is [3].

According to crystal field theory, the five degenerate d orbitals getting splitted into two sets, t_{2g} (d_{xy}, d_{yz} & d_{zx} of lower energy) and eg ($d_{x^2-y^2}$ & d_{z^2} of higher energy) orbitals in the octahedral environment. Since CN- is strong ligand, the six d electrons will occupy low energy t_{2g} level.

Potassium ferrocyanide is $K_4[Fe(CN)_6]$. It contains Fe^{2+} ions with $3d^6$ outer electronic configuration. Since cyanide is strong field ligand, all 3d electrons will be paired. Hence, potassium ferrocyanide will be diamagnetic.



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