

# MHT-CET Chemistry Sample Paper-20

Duration: 45 Minutes

Maximum Marks: 50

## Instructions

- This paper contains a total of **50** Multiple Choice Questions.
- Each correct answer carries **+1 marks**.
- No negative marking for incorrect questions.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.
- No marks will be deducted for questions that are left unattempted.

**Q1.** The correct order of acid strength for the following compounds is: I. Phenol, II. p-Nitrophenol, III. m-Nitrophenol, IV. p-Methylphenol.

- (A) II > III > I > IV  
(B) IV > I > III > II  
(C) II > I > III > IV  
(D) I > II > III > IV

**Q2.** In the extraction of Chlorine from brine, the value of  $\Delta G^\circ$  for the reaction  $2Cl^-(aq) + 2H_2O(l) \rightarrow H_2(g) + Cl_2(g) + 2OH^-(aq)$  is:

- (A) Positive  
(B) Negative  
(C) Zero  
(D) Infinite

**Q3.** Which of the following polymers is a heteropolymer?

- (A) Polyethylene  
(B) PVC  
(C) Nylon-6,6



(D) Buna-S

**Q4.** Identify the major product 'X' in the reaction: Benzene +  $CH_3CH_2CH_2Cl$  in the presence of anhydrous  $AlCl_3 \rightarrow X$ .

(A) n-propyl benzene

(B) Isopropyl benzene

(C) Ethyl benzene

(D) Chlorobenzene

**Q5.** The number of possible optical isomers for a compound with the formula  $[Co(en)_2Cl_2]^+$  is:

(A) 2

(B) 3

(C) 4

(D) 6

**Q6.** Which of the following p-block elements does not show an oxidation state higher than +2?

(A) Oxygen

(B) Nitrogen

(C) Fluorine

(D) Carbon

**Q7.** The work done during the expansion of an ideal gas from 2 L to 10 L against a constant external pressure of 2 atm is:

(A) -16 L-atm

(B) 16 L-atm

(C) -8 L-atm

(D) 8 L-atm



- Q8.** The rate constant of a first-order reaction is  $1.15 \times 10^{-3} \text{ s}^{-1}$ . How much time will it take for 5 g of this reactant to reduce to 3 g?
- (A) 444 s  
(B) 400 s  
(C) 500 s  
(D) 350 s
- Q9.** Which of the following molecules has the highest dipole moment?
- (A)  $\text{NF}_3$   
(B)  $\text{NH}_3$   
(C)  $\text{BF}_3$   
(D)  $\text{CHCl}_3$
- Q10.** The spin-only magnetic moment of  $\text{Sc}^{3+}$  ( $Z = 21$ ) is:
- (A) 0 BM  
(B) 1.73 BM  
(C) 2.84 BM  
(D) 3.87 BM
- Q11.** In a face-centered cubic lattice, atom A occupies the corners and atom B occupies the face centers. If one atom of B is missing from one of the face-centered points, the formula of the compound is:
- (A)  $\text{A}_2\text{B}_5$   
(B)  $\text{AB}_2$   
(C)  $\text{A}_2\text{B}_3$   
(D)  $\text{AB}_3$
- Q12.** For the reaction  $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$ , the degree of dissociation is  $\alpha$  at equilibrium pressure P. The equilibrium constant  $K_p$  is:



- (A)  $\frac{\alpha^2 P}{1-\alpha^2}$
- (B)  $\frac{\alpha^2 P^2}{1-\alpha}$
- (C)  $\frac{\alpha P}{1-\alpha}$
- (D)  $\frac{\alpha^2}{1-\alpha^2}$

**Q13.** Which of the following amines will not give the carbylamine test?

- (A) Ethylamine
- (B) Aniline
- (C) Dimethylamine
- (D) Methylamine

**Q14.** The relationship between the solubility ( $s$ ) and solubility product ( $K_{sp}$ ) for  $As_2S_3$  is:

- (A)  $K_{sp} = 108s^5$
- (B)  $K_{sp} = 27s^4$
- (C)  $K_{sp} = 4s^3$
- (D)  $K_{sp} = 6s^4$

**Q15.** What is the hybridization of the central atom in  $XeF_2$ ?

- (A)  $sp^3$
- (B)  $sp^3d$
- (C)  $sp^3d^2$
- (D)  $sp^2$

**Q16.** The most stable carbocation among the following is:

- (A)  $(CH_3)_3C^+$
- (B)  $(CH_3)_2CH^+$
- (C)  $CH_3CH_2^+$
- (D)  $CH_3^+$



- Q17.** Identify the product of the reaction:  $CH_3 - Mg - Br + CO_2 \xrightarrow{H_3O^+} ?$
- (A)  $CH_3COOH$   
(B)  $CH_3CHO$   
(C)  $CH_3OH$   
(D)  $CH_4$
- Q18.** The number of moles of  $AgCl$  precipitated when excess  $AgNO_3$  is added to one mole of  $[Cr(H_2O)_4Cl_2]Cl$  is:
- (A) 1  
(B) 2  
(C) 3  
(D) 0
- Q19.** Which of the following is a non-reducing sugar?
- (A) Glucose  
(B) Fructose  
(C) Sucrose  
(D) Lactose
- Q20.** In the Daniel cell, if the concentration of  $Zn^{2+}$  is increased, the E-cell value:
- (A) Increases  
(B) Decreases  
(C) Remains same  
(D) Becomes zero
- Q21.** The IUPAC name of the complex  $[Pt(NH_3)_2Cl(NH_2CH_3)]Cl$  is:
- (A) Diamminechloromethylamineplatinum(II) chloride  
(B) Diamminechloromethylamineplatinum(IV) chloride



- (C) Diamminechloromethylamineplatinum(I) chloride
- (D) Chlorodiamminemethylamineplatinum(II) chloride

**Q22.** The boiling point of  $0.2 \text{ mol kg}^{-1}$  solution of glucose in water ( $K_b = 0.52 \text{ K kg mol}^{-1}$ ) is:

- (A) 373.104 K
- (B) 373.208 K
- (C) 100.104 K
- (D) 373 K

**Q23.** Which of the following acts as a chain transfer agent in vinyl polymerization?

- (A) Benzoyl peroxide
- (B) Carbon tetrachloride
- (C) Hydroquinone
- (D) Tertiary butyl peroxide

**Q24.** The element with the highest second ionization enthalpy is:

- (A) Li
- (B) Be
- (C) B
- (D) C

**Q25.** What is the value of the gas constant R in  $\text{L} \cdot \text{atm} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$ ?

- (A) 0.0821
- (B) 8.314
- (C) 1.987
- (D) 0.08314

**Q26.** The major product of the nitration of Benzoic acid is:



- (A) o-nitrobenzoic acid
- (B) p-nitrobenzoic acid
- (C) m-nitrobenzoic acid
- (D) 2,4-dinitrobenzoic acid

**Q27.** Which of the following d-block elements shows the maximum number of oxidation states?

- (A) Cr
- (B) Fe
- (C) Mn
- (D) V

**Q28.** The coordination number of a body-centered cubic (BCC) structure is:

- (A) 4
- (B) 6
- (C) 8
- (D) 12

**Q29.** Which of the following is a neutral amino acid?

- (A) Lysine
- (B) Glycine
- (C) Aspartic acid
- (D) Arginine

**Q30.** The molar conductivity of  $0.025 \text{ mol L}^{-1}$  methanoic acid is  $46.1 \text{ S cm}^2 \text{ mol}^{-1}$ . Its degree of dissociation is: (Given  $\lambda_{H^+}^\circ = 349.6$  and  $\lambda_{HCOO^-}^\circ = 54.6$ )

- (A) 0.114
- (B) 0.228
- (C) 0.057



(D) 0.50

**Q31.** The bond order of  $O_2^{2-}$  is:

(A) 1

(B) 2

(C) 1.5

(D) 2.5

**Q32.** Which of the following is an example of an elastomer?

(A) Neoprene

(B) Nylon-6,6

(C) Terylene

(D) Bakelite

**Q33.** The reaction  $C_6H_5N_2Cl + CuCN \rightarrow C_6H_5CN + N_2 + CuCl$  is known as:

(A) Gattermann reaction

(B) Sandmeyer reaction

(C) Wurtz reaction

(D) Finkelstein reaction

**Q34.** The shape of  $IF_7$  molecule is:

(A) Pentagonal bipyramidal

(B) Octahedral

(C) Trigonal bipyramidal

(D) Square pyramidal

**Q35.** What is the oxidation number of Cr in  $K_2Cr_2O_7$ ?

(A) +6

(B) +3



(C) +7

(D) +4

**Q36.** The monomers of Nylon-6,6 are:

(A) Adipic acid and Hexamethylene diamine

(B) Caprolactam

(C) Ethylene glycol and Phthalic acid

(D) Styrene and 1,3-Butadiene

**Q37.** Which of the following is used as an antiseptic?

(A) Bithional

(B) Chloroamphenicol

(C) Penicillin

(D) Morphine

**Q38.** The unit of the rate constant for a zero-order reaction is:

(A)  $\text{mol L}^{-1} \text{s}^{-1}$

(B)  $\text{L mol}^{-1} \text{s}^{-1}$

(C)  $\text{s}^{-1}$

(D)  $\text{mol}^2 \text{L}^{-2} \text{s}^{-1}$

**Q39.** Which of the following has the smallest atomic radius?

(A) F

(B) Cl

(C) Br

(D) I

**Q40.** The process of converting ore into oxide by heating it strongly in the presence of excess air is:



- (A) Roasting
- (B) Calcination
- (C) Smelting
- (D) Reduction

**Q41.** Which alcohol is most reactive towards Lucas reagent?

- (A) 2-methylpropan-2-ol
- (B) Butan-1-ol
- (C) Butan-2-ol
- (D) Ethanol

**Q42.** The number of atoms per unit cell in a simple cubic lattice is:

- (A) 1
- (B) 2
- (C) 4
- (D) 8

**Q43.** Which of the following is a greenhouse gas?

- (A)  $CO_2$
- (B)  $N_2$
- (C)  $O_2$
- (D)  $Ar$

**Q44.** The pH of a 0.01 M  $NaOH$  solution is:

- (A) 12
- (B) 2
- (C) 10
- (D) 7



- Q45.** The geometry of  $[Ni(CN)_4]^{2-}$  is:
- (A) Square planar
  - (B) Tetrahedral
  - (C) Octahedral
  - (D) Pyramidal
- Q46.** Which of the following is a fat-soluble vitamin?
- (A) Vitamin A
  - (B) Vitamin B12
  - (C) Vitamin C
  - (D) Vitamin B6
- Q47.** The catalyst used in the Haber process is:
- (A) Fe + Mo
  - (B)  $V_2O_5$
  - (C) Pt
  - (D) Ni
- Q48.** Which of the following is an intensive property?
- (A) Temperature
  - (B) Mass
  - (C) Volume
  - (D) Enthalpy
- Q49.** The product of the reaction of Phenol with  $CHCl_3$  and  $NaOH$  is:
- (A) Salicylaldehyde
  - (B) Salicylic acid
  - (C) Benzene



(D) Chlorobenzene

**Q50.** The value of Henry's constant  $K_H$ :

- (A) increases with increase in temperature
- (B) decreases with increase in temperature
- (C) remains constant
- (D) first increases then decreases



## Detailed Solutions

Q1.

## Solution

**Concept:** The acidity of substituted phenols is governed by the stability of the phenoxide ion formed after the release of a proton.

- **Stability Increase:** Electron-withdrawing groups (EWG) via  $-I$  and  $-M$  effects disperse the negative charge.
- **Stability Decrease:** Electron-donating groups (EDG) intensify the negative charge through  $+I$  or  $+M$  effects.

The nitro group ( $-NO_2$ ) is a strong EWG, while the methyl group ( $-CH_3$ ) is a weak EDG.

**Solution:**

- p-Nitrophenol (II):** The nitro group at the para position exerts strong  $-I$  and  $-M$  effects, significantly stabilizing the phenoxide ion. (Most Acidic)
- m-Nitrophenol (III):** At the meta position, only the  $-I$  effect operates. It is more acidic than phenol but less than the para isomer.
- Phenol (I):** The reference compound with no substituents.
- p-Methylphenol (IV):** The methyl group exerts  $+I$  and hyperconjugation, destabilizing the phenoxide ion. (Least Acidic)

**Final Answer:** The correct order of decreasing acidity is  $II > III > I > IV$ .

Answer: (A)



Q2.

**Solution**

**Concept:** The Gibbs free energy change ( $\Delta G^\circ$ ) determines the spontaneity of a reaction at constant temperature and pressure.

- **Non-spontaneous:** Energy must be supplied, and  $\Delta G^\circ > 0$ .
- **Electrolysis:** The process of using electrical energy to drive a non-spontaneous chemical change.

**Solution:**

- (a) The reaction is:  $2Cl^-(aq) + 2H_2O(l) \rightarrow H_2(g) + Cl_2(g) + 2OH^-(aq)$ .
- (b) This represents the **electrolysis of brine**, which requires an external electrical source.
- (c) Using the relationship:  $\Delta G^\circ = -nFE^\circ$ .
- (d) For electrolysis, the standard cell potential ( $E^\circ_{cell}$ ) is negative.
- (e) Since  $E^\circ$  is negative, the term  $-nFE^\circ$  results in a positive value.
- (f) Thus,  $\Delta G^\circ$  must be positive for this process to occur.

**Final Answer:** The value of  $\Delta G^\circ$  is positive.

**Answer: (A)**



Q3.

**Solution**

**Concept:** Polymers are classified by their monomer variety:

- **Homopolymer:** Formed from a single type of monomer species.
- **Heteropolymer (Copolymer):** Formed from two or more different types of monomers.

**Solution:**

- (a) **Polyethylene:** Formed only from ethylene ( $CH_2 = CH_2$ ). (Homopolymer)
- (b) **PVC:** Formed only from vinyl chloride ( $CH_2 = CHCl$ ). (Homopolymer)
- (c) **Nylon-6,6:** Synthesized from two distinct monomers: hexamethylenediamine and adipic acid. (Heteropolymer)
- (d) **Buna-S:** A copolymer of Styrene and Butadiene.
- (e) In standard condensation polymer contexts, Nylon-6,6 is the primary example of a heteropolymer produced by alternating monomers.

**Final Answer:** Nylon-6,6 is a heteropolymer.

Answer: (C)

Q4.

**Solution**

**Concept:** Friedel-Crafts alkylation involves a Lewis acid catalyst (anhydrous  $AlCl_3$ ) and generates a **carbocation intermediate**. Carbocations frequently undergo rearrangements (1,2-hydride or 1,2-methyl shifts) to form more stable species before attacking the benzene ring.

**Solution:**

- (a) The reactant is n-propyl chloride ( $CH_3CH_2CH_2Cl$ ).
- (b)  $AlCl_3$  abstracts the  $Cl$ , forming a primary n-propyl carbocation:  $CH_3 - CH_2 - CH_2^+$ .
- (c) A **1,2-hydride shift** occurs to stabilize the ion.
- (d) This results in a secondary carbocation:  $CH_3 - CH^+ - CH_3$  (isopropyl carbocation).
- (e) The benzene ring is attacked by this isopropyl carbocation.
- (f) The major product is isopropyl benzene (cumene).

**Final Answer:** The major product is Isopropyl benzene.

Answer: (B)



Q5.

### Solution

#### Concept:

Stereoisomerism in octahedral complexes ( $[M(aa)_2b_2]$  type).

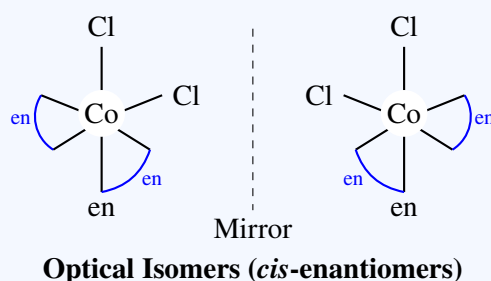
#### Solution:

1: Determine the geometric isomers. The complex  $[Co(en)_2Cl_2]^+$  exists in two geometric forms: *cis* and *trans*.

2: Analyze the *trans* isomer. The  $Cl^-$  ligands are opposite ( $180^\circ$ ). It possesses a plane of symmetry, making it achiral and optically inactive.

3: Analyze the *cis* isomer. The  $Cl^-$  ligands are adjacent ( $90^\circ$ ). It lacks a plane of symmetry and is therefore chiral.

4: A chiral molecule exists as a pair of non-superimposable mirror images (enantiomers). Thus, there are 2 optical isomers (the *d* and *l* forms of the *cis* isomer).



**Final Answer:**

2

Answer: (A)



Q6.

**Solution****Concept:**

The oxidation state of an element in a compound is determined by its electronic configuration and its ability to expand its octet.

- **Second Period Limitation:** For p-block elements in the second period (like Oxygen, Nitrogen, and Fluorine), the absence of vacant d-orbitals in their valence shell limits their ability to exhibit higher oxidation states.
- **Electronegativity:** Fluorine, being the most electronegative element in the periodic table, always exhibits an oxidation state of -1 in its compounds (except in  $F_2$ , where it is 0).

**Solution:**

- (a) **Oxygen:** Generally shows -2, but in  $OF_2$  it shows +2. It cannot exhibit higher states due to its high electronegativity and the lack of d-orbitals.
- (b) **Nitrogen:** Can exhibit a wide range of oxidation states from -3 to +5 (e.g., in  $HNO_3$ ).
- (c) **Fluorine:** As the most electronegative element, it never loses electrons to show a positive oxidation state. Its only stable oxidation state is -1. Consequently, it never shows an oxidation state higher than +2 (it never even reaches positive values).
- (d) **Carbon:** Commonly exhibits oxidation states ranging from -4 to +4 (e.g., in  $CO_2$  or  $CH_4$ ).

**Conclusion:** While Oxygen is limited to +2, Fluorine is the most restricted as it is confined to -1. In typical competitive exam contexts, Fluorine is the definitive answer because it cannot exhibit any positive oxidation state whatsoever.

**Final Answer:** Fluorine does not show an oxidation state higher than +2.

**Answer: (C)**



Q7.

**Solution****Concept:**

Pressure-volume ( $PV$ ) work is defined as the work done by or on a gas during expansion or compression against an external pressure. For an irreversible expansion against a constant external pressure ( $P_{ext}$ ), the formula for work done ( $W$ ) is:

$$W = -P_{ext} \times \Delta V$$

where  $\Delta V = V_{final} - V_{initial}$ . In thermodynamics, the sign convention typically used (IUPAC) dictates that work done by the system (expansion) is negative.

**Solution:**

1. Identify the given values: - Initial volume ( $V_1$ ) = 2 L - Final volume ( $V_2$ ) = 10 L - External pressure ( $P_{ext}$ ) = 2 atm  
2. Calculate the change in volume ( $\Delta V$ ):

$$\Delta V = V_2 - V_1 = 10 \text{ L} - 2 \text{ L} = 8 \text{ L}$$

3. Calculate the work done using the formula:

$$W = -P_{ext} \times \Delta V$$

$$W = -(2 \text{ atm}) \times (8 \text{ L}) = -16 \text{ L-atm}$$

4. The negative sign indicates that the work is done by the gas on the surroundings during expansion. 5. If the question requires the answer in Joules, we would multiply by 101.325, but since the options are in L-atm, -16 is the required magnitude with the correct sign.

**Final Answer:** The work done is -16 L-atm.

**Answer: (A)**



Q8.

**Solution****Concept:**

For a first-order reaction, the rate of reaction is proportional to the concentration of one reactant. The integrated rate equation for a first-order reaction is:

$$k = \frac{2.303}{t} \log \left( \frac{[A]_0}{[A]_t} \right)$$

where  $k$  is the rate constant,  $t$  is the time,  $[A]_0$  is the initial concentration (or mass), and  $[A]_t$  is the concentration (or mass) at time  $t$ .

**Solution:**

1. Identify the given parameters: - Rate constant ( $k$ ) =  $1.15 \times 10^{-3} \text{ s}^{-1}$  - Initial mass ( $[A]_0$ ) = 5 g - Final mass ( $[A]_t$ ) = 3 g  
2. Rearrange the formula to solve for  $t$ :

$$t = \frac{2.303}{k} \log \left( \frac{[A]_0}{[A]_t} \right)$$

3. Substitute the values into the equation:

$$t = \frac{2.303}{1.15 \times 10^{-3}} \log \left( \frac{5}{3} \right)$$

4. Calculate the log value:  $\log(5/3) = \log(1.666) \approx 0.2218$ . 5. Perform the final calculation:

$$t = \frac{2.303 \times 0.2218}{1.15 \times 10^{-3}}$$

$$t = \frac{0.5108}{1.15 \times 10^{-3}} \approx 444.17 \text{ s}$$

6. Rounding to the nearest whole number as per the options, we get 444 s.

**Final Answer:** The time taken is 444 s.

**Answer:** (A)



Q9.

**Solution****Concept:**

The dipole moment ( $\mu$ ) of a molecule depends on the bond polarity and the molecular geometry (vector sum of individual bond moments). Electronegativity differences create bond dipoles. In molecules with lone pairs, the lone pair contribution to the dipole moment is significant. For  $NH_3$  and  $NF_3$ , both have pyramidal geometry with one lone pair, but the direction of bond moments relative to the lone pair moment differs.

**Solution:**

1.  $BF_3$ : It has a trigonal planar geometry ( $sp^2$ ). The three  $B - F$  bond moments are at  $120^\circ$  and cancel each other out exactly.  $\mu = 0$ . 2.  $CHCl_3$ : While polar, the tetrahedral symmetry reduces the net vector sum compared to simpler pyramidal molecules with lone pairs. 3.  $NH_3$  vs  $NF_3$ : - In  $NH_3$ , Nitrogen is more electronegative than Hydrogen. The bond moments are directed towards Nitrogen, which is the same direction as the lone pair moment. They reinforce each other. - In  $NF_3$ , Fluorine is more electronegative than Nitrogen. The bond moments are directed away from Nitrogen, opposing the lone pair moment. This significantly reduces the net dipole. 4. Therefore,  $NH_3$  has a much higher dipole moment than  $NF_3$ . 5. Comparing  $NH_3$  and  $CHCl_3$ , the reinforcement of the lone pair in  $NH_3$  typically results in a very high localized dipole.

**Final Answer:**  $NH_3$  has the highest dipole moment.

**Answer: (B)**



Q10.

**Solution****Concept:**

The "spin-only" magnetic moment ( $\mu_s$ ) is calculated based on the number of unpaired electrons ( $n$ ) in the d-subshell of a transition metal ion. The formula is:

$$\mu_s = \sqrt{n(n+2)} \text{ BM}$$

where BM stands for Bohr Magnetons. To find  $n$ , we must first determine the electronic configuration of the neutral atom and then the specific ion.

**Solution:**

1. Scandium ( $Sc$ ) has an atomic number of 21. 2. The ground state electronic configuration of  $Sc$  is:  $[Ar]3d^14s^2$ . 3. When Scandium forms the  $Sc^{3+}$  ion, it loses three electrons (two from the  $4s$  orbital and one from the  $3d$  orbital). 4. The electronic configuration of  $Sc^{3+}$  is:  $[Ar]3d^04s^0$ . 5. In the  $3d^0$  configuration, there are no electrons in the d-orbitals. 6. Number of unpaired electrons ( $n$ ) = 0. 7. Substitute  $n = 0$  into the formula:

$$\mu_s = \sqrt{0(0+2)} = 0 \text{ BM}$$

8. Since there are no unpaired electrons, the ion is diamagnetic and its magnetic moment is zero.

**Final Answer:** The spin-only magnetic moment of  $Sc^{3+}$  is 0 BM.

**Answer: (A)**



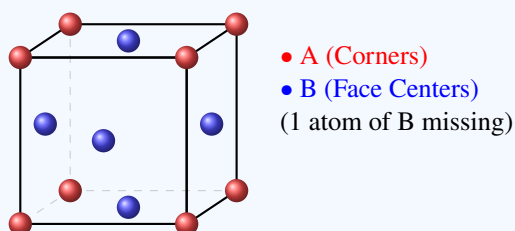
Q11.

**Solution****Concept:**

Unit Cell Stoichiometry in a Defective Face-Centered Cubic (FCC) Lattice.

**Solution:**

- 1: Calculate the effective number of atoms of A at the corners. There are 8 corners, each shared by 8 unit cells. Number of atoms of A =  $8 \times \frac{1}{8} = 1$ .
- 2: Calculate the effective number of atoms of B at the face centers. A standard FCC has 6 faces, but since one atom is missing, only 5 faces are occupied. Number of atoms of B =  $5 \times \frac{1}{2} = \frac{5}{2}$ .
- 3: Determine the simplest whole-number ratio of A to B. Ratio A : B =  $1 : \frac{5}{2} = 2 : 5$ .
- 4: Based on the ratio, the empirical formula of the compound is  $A_2B_5$ .

**Final Answer:****Answer: (A)**

Q12.

**Solution****Concept:**

$K_p$  is the equilibrium constant expressed in terms of partial pressures. For the gas-phase dissociation of phosphorus pentachloride ( $PCl_5$ ), the relationship between the degree of dissociation ( $\alpha$ ), total pressure ( $P$ ), and  $K_p$  can be derived using the stoichiometry of the reaction. The total number of moles at equilibrium must be calculated to find the mole fraction of each species.

**Solution:**

1. Write the reaction and the moles at equilibrium: - Reaction:  $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$   
- Initial moles: 1, 0, 0 - Moles at equilibrium:  $(1 - \alpha), \alpha, \alpha$  - Total moles at equilibrium =  $(1 - \alpha) + \alpha + \alpha = 1 + \alpha$ .
2. Calculate the mole fractions: -  $X_{PCl_5} = (1 - \alpha)/(1 + \alpha)$  -  $X_{PCl_3} = \alpha/(1 + \alpha)$  -  $X_{Cl_2} = \alpha/(1 + \alpha)$
3. Calculate the partial pressures: -  $p_{PCl_5} = \frac{1 - \alpha}{1 + \alpha}P$  -  $p_{PCl_3} = \frac{\alpha}{1 + \alpha}P$  -  $p_{Cl_2} = \frac{\alpha}{1 + \alpha}P$
4. Substitute into the  $K_p$  expression:

$$K_p = \frac{p_{PCl_3} \cdot p_{Cl_2}}{p_{PCl_5}} = \frac{\left[\frac{\alpha}{1 + \alpha}P\right] \cdot \left[\frac{\alpha}{1 + \alpha}P\right]}{\left[\frac{1 - \alpha}{1 + \alpha}P\right]}$$

$$K_p = \frac{\alpha^2 P}{(1 + \alpha)(1 - \alpha)} = \frac{\alpha^2 P}{1 - \alpha^2}$$

**Final Answer:** The equilibrium constant  $K_p$  is  $\frac{\alpha^2 P}{1 - \alpha^2}$ .

**Answer: (A)**



Q13.

**Solution****Concept:**

The carbylamine reaction (also known as the Hoffmann isocyanide test) is a highly specific chemical test used for the detection of primary amines. When a primary amine is heated with chloroform ( $CHCl_3$ ) and alcoholic potassium hydroxide ( $KOH$ ), it produces an isocyanide (carbylamine), which is characterized by an extremely foul or unpleasant smell. This test is not given by secondary or tertiary amines.

**Solution:**

1. Primary Amines: Both aliphatic and aromatic primary amines ( $R - NH_2$ ) undergo this reaction.
2. Analyze the options: - Ethylamine:  $CH_3CH_2NH_2$  is a primary aliphatic amine. It will give a positive test. - Aniline:  $C_6H_5NH_2$  is a primary aromatic amine. It will give a positive test. - Dimethylamine:  $(CH_3)_2NH$  is a secondary amine. Because the nitrogen atom is bonded to two carbon groups, it cannot form the isocyanide intermediate required for the foul smell. - Methylamine:  $CH_3NH_2$  is a primary aliphatic amine. It will give a positive test.
3. Since the question asks which will "not" give the test, the secondary amine is the correct choice.
4. Reasoning: The reaction requires two hydrogen atoms on the nitrogen to be replaced during the formation of the  $-NC$  group. Secondary amines have only one hydrogen, and tertiary amines have none.

**Final Answer:** Dimethylamine will not give the carbylamine test.

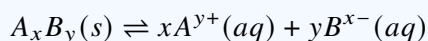
**Answer:** (C)



Q14.

**Solution****Concept:**

The solubility product constant ( $K_{sp}$ ) is the equilibrium constant for a solid substance dissolving in an aqueous solution. For a generic salt  $A_xB_y$ , the dissociation is:

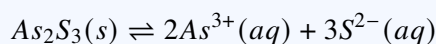


If the molar solubility is  $s$ , then the concentrations are  $[A^{y+}] = xs$  and  $[B^{x-}] = ys$ . The  $K_{sp}$  expression is then:

$$K_{sp} = (xs)^x \cdot (ys)^y$$

**Solution:**

1. Identify the dissociation of Arsenic sulphide ( $As_2S_3$ ):



2. Let the molar solubility be  $s$ . 3. At equilibrium: - Concentration of Arsenic ions  $[As^{3+}] = 2s$  - Concentration of Sulphide ions  $[S^{2-}] = 3s$  4. Write the  $K_{sp}$  expression:

$$K_{sp} = [As^{3+}]^2 \cdot [S^{2-}]^3$$

5. Substitute the solubility terms:

$$K_{sp} = (2s)^2 \cdot (3s)^3$$

$$K_{sp} = (4s^2) \cdot (27s^3)$$

$$K_{sp} = 108s^5$$

6. This numerical relationship is characteristic of  $A_2B_3$  type salts.

**Final Answer:** The relationship is  $K_{sp} = 108s^5$ .

**Answer: (A)**



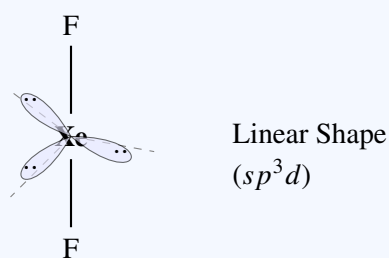
Q15.

**Solution****Concept:**

VSEPR Theory and Steric Number for Hybridization.

**Solution:**

- 1: Find the valence electrons of the central atom Xenon ( $Xe$ ), which is 8.
- 2: Calculate the Steric Number ( $S$ ):  $S = \frac{1}{2}[V + M - C + A]$  Where  $V = 8$  (valence  $e^-$ ),  $M = 2$  (monovalent atoms like  $F$ ),  $C = 0$ ,  $A = 0$ .  $S = \frac{1}{2}[8 + 2] = 5$ .
- 3: For  $S = 5$ , the hybridization is  $sp^3d$ .
- 4: The 5 orbitals are arranged in a trigonal bipyramidal geometry. With 2 bond pairs and 3 lone pairs, the molecular shape is linear.

**Final Answer:** $sp^3d$ **Answer: (B)**

Q16.

**Solution****Concept:**

The stability of carbocations is primarily determined by the dispersal of the positive charge through inductive effects (+I) and hyperconjugation. Alkyl groups are electron-donating. A tertiary ( $3^\circ$ ) carbocation has three alkyl groups donating electron density toward the positively charged carbon, a secondary ( $2^\circ$ ) has two, and a primary ( $1^\circ$ ) has one. More alkyl groups lead to greater stabilization.

**Solution:**

1. Identify the types of carbocations provided: -  $(CH_3)_3C^+$ : This is a tertiary ( $3^\circ$ ) carbocation. -  $(CH_3)_2CH^+$ : This is a secondary ( $2^\circ$ ) carbocation. -  $CH_3CH_2^+$ : This is a primary ( $1^\circ$ ) carbocation. -  $CH_3^+$ : This is a methyl carbocation.
2. Analyzing Hyperconjugation: The stability is directly proportional to the number of alpha-hydrogens ( $\alpha$ -H). - Tertiary butyl carbocation has 9  $\alpha$ -H atoms. - Isopropyl carbocation has 6  $\alpha$ -H atoms. - Ethyl carbocation has 3  $\alpha$ -H atoms. - Methyl carbocation has 0  $\alpha$ -H atoms.
3. Analyzing Inductive Effect: Three methyl groups in the tertiary cation provide the maximum +I effect, reducing the electron deficiency on the central carbon most effectively.
4. Conclusion: The order of stability is  $3^\circ > 2^\circ > 1^\circ > \text{methyl}$ . Thus, the tertiary butyl carbocation is the most stable.

**Final Answer:** The most stable carbocation is  $(CH_3)_3C^+$ .

**Answer: (A)**



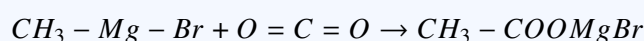
Q17.

**Solution****Concept:**

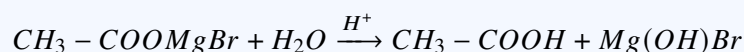
Grignard reagents ( $R - Mg - X$ ) act as powerful nucleophiles because the  $C - Mg$  bond is highly polarized, giving the carbon a partial negative charge. When a Grignard reagent reacts with Carbon Dioxide ( $CO_2$ ), the nucleophilic carbon attacks the electrophilic carbon of  $CO_2$ . This forms a carboxylate salt, which upon subsequent acid hydrolysis, yields a carboxylic acid. This is a standard method for increasing the carbon chain length by one unit.

**Solution:**

1. Nucleophilic Attack: The methyl group from  $CH_3 - Mg - Br$  (acting as  $CH_3^-$ ) attacks the carbon atom of  $O = C = O$ .



2. Intermediate Formation: The resulting species is a magnesium salt of ethanoic acid (magnesium bromomethane carboxylate). 3. Hydrolysis: Treatment with hydronium ions ( $H_3O^+$ ) or dilute acid breaks the  $O - MgBr$  bond.



4. Product Identification: The organic product formed is Ethanoic acid (Acetic acid). 5. The reaction results in the addition of a  $-COOH$  group to the original alkyl group of the Grignard reagent.

**Final Answer:** The product of the reaction is  $CH_3COOH$ .

**Answer:** (A)



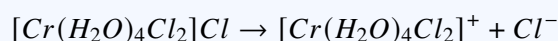
Q18.

**Solution****Concept:**

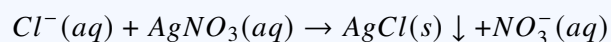
In coordination compounds, ligands located inside the coordination sphere (within the square brackets) are ionically bonded to the metal and do not dissociate in water. Only the ions located outside the coordination sphere (counter-ions) ionize when the complex is dissolved in a solvent. When silver nitrate ( $AgNO_3$ ) is added to a solution of a chloro-complex, it reacts specifically with the free chloride ions ( $Cl^-$ ) in the solution to form a white precipitate of Silver Chloride ( $AgCl$ ).

**Solution:**

1. Analyze the complex formula:  $[Cr(H_2O)_4Cl_2]Cl$ . 2. Dissociation in water:



3. Identify ionizable species: There is only one  $Cl^-$  ion outside the square brackets. The two chlorine atoms inside the brackets are ligands and remain attached to the Chromium center. 4. Reaction with  $AgNO_3$ :



5. Stoichiometry: Since 1 mole of the complex releases 1 mole of  $Cl^-$  ions, it will react with  $AgNO_3$  to produce exactly 1 mole of  $AgCl$  precipitate.

**Final Answer:** The number of moles of  $AgCl$  precipitated is 1.

**Answer: (A)**



Q19.

**Solution****Concept:**

Sugars are classified as **reducing** or **non-reducing** based on their ability to reduce Tollen's reagent or Fehling's solution.

- **Reducing Sugar:** Contains a free (or potentially free) aldehydic or ketonic group, typically indicated by a free hemiacetal or hemiketal hydroxyl group at the anomeric carbon.
- **Non-reducing Sugar:** In disaccharides, if the glycosidic linkage involves the anomeric carbons of both monosaccharide units, the sugar cannot open into its chain form.

**Solution:**

- (a) **Glucose and Fructose:** These are monosaccharides that exist in equilibrium with open-chain forms containing free carbonyl groups. They are reducing sugars.
- (b) **Lactose:** A disaccharide ( $\beta(1 \rightarrow 4)$  linkage) where the anomeric carbon of the glucose unit remains free. It is a reducing sugar.
- (c) **Sucrose:** A disaccharide of  $\alpha$ -D-glucose and  $\beta$ -D-fructose. The glycosidic linkage is between **C1 of glucose** and **C2 of fructose**.
- (d) **Anomeric Carbons:** Since both anomeric carbons are involved in the glycosidic bond, there is no free hemiacetal group available.
- (e) **Result:** Sucrose cannot form a free aldehyde or ketone group; therefore, it cannot reduce Fehling's or Tollen's reagents.

**Final Answer:** Sucrose is a non-reducing sugar.

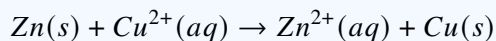
**Answer:** (C)



Q20.

**Solution****Concept:**

The cell potential of a Daniel cell is calculated using the **Nernst equation**. A Daniel cell consists of a Zinc anode and a Copper cathode with the net reaction:



The Nernst equation at 298 K is:

$$E_{cell} = E_{cell}^{\circ} - \frac{0.0591}{2} \log \frac{[\text{Zn}^{2+}]}{[\text{Cu}^{2+}]}$$

**Solution:**

- (a) **Logarithmic Term:** The term represents the ratio of (Concentration of Products / Concentration of Reactants).
- (b) **Effect of increasing  $[\text{Zn}^{2+}]$ :** If the concentration of zinc ions in the anode compartment increases, the ratio  $[\text{Zn}^{2+}]/[\text{Cu}^{2+}]$  increases.
- (c) **Mathematical Logic:** As the value of the log term increases, the subtracted value  $(\frac{0.0591}{2} \log Q)$  becomes larger, causing  $E_{cell}$  to decrease.
- (d) **Le Chatelier's Principle:** Increasing the concentration of a product ( $\text{Zn}^{2+}$ ) shifts the equilibrium to the left, opposing the forward reaction and reducing the driving force of the cell.

**Final Answer:** The  $E_{cell}$  value decreases.

**Answer: (B)**



Q21.

**Solution****Concept:**

The nomenclature of coordination compounds follows specific **IUPAC rules**:

- Ligands are named in alphabetical order before the central metal.
- Anionic ligands end in '-o' (e.g., chlorido).
- Oxidation states are indicated by Roman numerals in parentheses.
- The counter-ion is named separately at the end.

**Solution:****(a) Identify Ligands:**

- Two  $NH_3$  groups: "diammine"
- One  $Cl^-$  group: "chlorido"
- One  $NH_2CH_3$  group: "methylamine"

**(b) Alphabetical Order:** Ammine (A) > Chlorido (C) > Methylamine (M).

**(c) Oxidation State of Platinum (Pt):** Let  $x$  be the oxidation state.

$$x + 2(0) + (-1) + 0 = +1 \text{ (Charge of the coordination sphere)}$$

$$x - 1 = +1 \Rightarrow x = +2$$

**(d) Full Name:** Diamminechloridomethylamineplatinum(II) chloride.

**Final Answer:** The IUPAC name is Diamminechloridomethylamineplatinum(II) chloride.

**Answer: (A)**



Q22.

**Solution****Concept:**

The boiling point of a solution containing a non-volatile solute is higher than the boiling point of the pure solvent. This phenomenon is known as elevation in boiling point ( $\Delta T_b$ ). The formula is:

$$\Delta T_b = i \cdot K_b \cdot m$$

where  $i$  is the van't Hoff factor (for glucose,  $i = 1$ ),  $K_b$  is the ebullioscopic constant, and  $m$  is the molality of the solution. The boiling point of the solution ( $T_b$ ) is:

$$T_b = T_b^\circ + \Delta T_b$$

The boiling point of pure water ( $T_b^\circ$ ) is  $100^\circ\text{C}$  or  $373.15\text{ K}$ .

**Solution:**

1. Identify the given values: - Molality ( $m$ ) =  $0.2\text{ mol kg}^{-1}$  -  $K_b$  of water =  $0.52\text{ K kg mol}^{-1}$  - For glucose (non-electrolyte),  $i = 1$ . 2. Calculate the elevation in boiling point ( $\Delta T_b$ ):

$$\Delta T_b = 1 \times 0.52 \times 0.2 = 0.104\text{ K}$$

3. Calculate the boiling point of the solution: - Using  $T_b^\circ = 373\text{ K}$  (as per standard MHT-CET approximation): -  $T_b = 373 + 0.104 = 373.104\text{ K}$ . 4. Note: If using the more precise  $373.15\text{ K}$ , the value would be  $373.254\text{ K}$ , but in CET exams,  $373\text{ K}$  is the standard base for water's boiling point.

**Final Answer:** The boiling point of the solution is  $373.104\text{ K}$ .

**Answer: (A)**



Q23.

**Solution****Concept:**

In free radical polymerization, a **chain transfer agent** is a substance that reacts with the growing polymer chain to terminate its growth while simultaneously generating a new radical that can initiate another chain. This process effectively limits the molecular weight of the polymer. Common agents include halogenated compounds or thiols.

**Solution:**

- (a) **Mechanism:** Chain transfer involves the abstraction of an atom (usually  $H$  or  $Cl$ ) from the transfer agent ( $S - X$ ) by the growing radical  $R\cdot$ .
- (b) **Carbon Tetrachloride ( $CCl_4$ ):** This is a classic example. The radical  $R\cdot$  attacks  $CCl_4$  to form  $R - Cl$  and a  $\cdot CCl_3$  radical.
- (c) **Initiation:** The new  $\cdot CCl_3$  radical initiates a separate polymer chain, keeping the polymerization going but at a lower molecular weight.
- (d) **Other Options:** Benzoyl peroxide and Tertiary butyl peroxide are *initiators*. Hydroquinone is a polymerization *inhibitor*.

**Final Answer:** Carbon tetrachloride acts as a chain transfer agent.

**Answer: (B)**



Q24.

**Solution****Concept:**

The **second ionization enthalpy** ( $IE_2$ ) is the energy required to remove an electron from a unipositive cation ( $M^+$ ). This value is exceptionally high when the first ionization ( $IE_1$ ) results in a stable, noble gas electronic configuration ( $ns^2np^6$ ).

**Solution:**

- (a) **Lithium ( $Li$ ,  $Z=3$ ):** Configuration is  $1s^22s^1$ .
- (b) **Ion Analysis ( $M^+$ ):**
- $Li^+$ :  $1s^2$  (Helium configuration – **Very Stable**)
  - $Be^+$ :  $1s^22s^1$
  - $B^+$ :  $1s^22s^2$
  - $C^+$ :  $1s^22s^22p^1$
- (c) **IE2 Comparison:** Removing an electron from  $Li^+$  requires breaking into a stable, fully-filled  $K$ -shell ( $1s^2$ ). This demands significantly more energy than removing electrons from  $2s$  or  $2p$  orbitals in the other ions.

**Final Answer:** Lithium ( $Li$ ) has the highest second ionization enthalpy.

**Answer: (A)**

Q25.

**Solution****Concept:**

The **universal gas constant** ( $R$ ) numerical value depends entirely on the units used for pressure ( $P$ ) and volume ( $V$ ) in the Ideal Gas Law ( $PV = nRT$ ).

**Solution:**

- (a) **SI Units:**  $R \approx 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$  (using  $Pa$  and  $m^3$ ).
- (b) **Atm-Litre Units:** When pressure is in atmospheres (atm) and volume is in liters (L), we use conversion factors ( $1 \text{ atm} = 101325 \text{ Pa}$ ).
- (c) **Calculation:** The derived value is approximately  $0.082057 \text{ L} \cdot \text{atm} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$ .
- (d) **Standard Value:** In standard chemistry contexts (like MHT-CET), this is rounded to **0.0821**.

**Final Answer:** The value of  $R$  is  $0.0821 \text{ L} \cdot \text{atm} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$ .

**Answer: (A)**



Q26.

**Solution****Concept:**

The nitration of benzoic acid is an **electrophilic aromatic substitution**. The carboxyl group ( $-COOH$ ) is a strong **electron-withdrawing group (EWG)** due to  $-M$  and  $-I$  effects.

**Solution:**

- (a) **Deactivation:** The  $-COOH$  group reduces electron density on the ring.
- (b) **Directing Effect:** Resonance structures show that positive charges develop at the *ortho* and *para* positions.
- (c) **Meta-Attack:** The electrophile ( $NO_2^+$ ) attacks the **meta** position as it is relatively more electron-rich than the *ortho/para* positions.
- (d) **Product:** Reaction with conc.  $HNO_3$  and conc.  $H_2SO_4$  yields *m*-nitrobenzoic acid.

**Final Answer:** The major product is *m*-nitrobenzoic acid.

Answer: (C)

Q27.

**Solution****Concept:**

The variety of oxidation states in d-block elements arises from the small energy gap between  $(n-1)d$  and  $ns$  orbitals. The number of states peaks in the middle of the series where the number of unpaired electrons is highest.

**Solution:**

- (a) **Configurations:**
- $V (3d^3 4s^2)$ : Max OS +5
  - $Cr (3d^5 4s^1)$ : Max OS +6
  - $Mn (3d^5 4s^2)$ : Max OS +7
  - $Fe (3d^6 4s^2)$ : Max OS +6
- (b) **Manganese (Mn):** With 7 valence electrons (5 in  $3d$  + 2 in  $4s$ ), it shows the widest range (+2 to +7).
- (c) **Post-Mn Trend:** After Manganese,  $d$ -electrons begin to pair up, reducing the number of electrons available for bonding and thus the number of oxidation states.

**Final Answer:** Manganese (Mn) shows the maximum number of oxidation states.

Answer: (C)



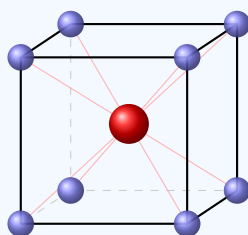
Q28.

**Solution****Concept:**

Coordination Number in Body-Centered Cubic (BCC) Lattices.

**Solution:**

- 1: In a Body-Centered Cubic (BCC) arrangement, atoms are located at all eight corners of the cube and one single atom is positioned at the center of the cube body.
- 2: The coordination number represents the number of nearest neighbors that are in direct contact with a specific central atom.
- 3: By observing the body-centered atom (shown in red), we can see it is equidistant from all 8 corner atoms (shown in blue).
- 4: Since these 8 corner atoms are the closest to the center, the coordination number is 8.



**Figure:** BCC Unit Cell showing 8-fold coordination

**Final Answer:**

8
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Answer: (C)
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Q29.

**Solution****Concept:**

Amino acids are organic compounds containing both an amino group ( $-NH_2$ ) and a carboxyl group ( $-COOH$ ). They are classified as acidic, basic, or neutral depending on the relative number of amino and carboxyl groups in their side chain (R-group). - Acidic: Extra  $-COOH$  group. - Basic: Extra  $-NH_2$  (or nitrogenous) group. - Neutral: Equal number of amino and carboxyl groups with no additional acidic/basic groups in the side chain.

**Solution:**

1. Lysine: Contains an additional amino group in its side chain, making it a basic amino acid.  
2. Arginine: Contains a guanidino group in its side chain, making it strongly basic. 3. Aspartic acid: Contains an additional carboxyl group in its side chain, making it an acidic amino acid. 4. Glycine: The simplest amino acid where the side chain is just a Hydrogen atom ( $H$ ). It has exactly one  $-NH_2$  group and one  $-COOH$  group. 5. Because the counts of acidic and basic groups are balanced and the side chain is non-functional, Glycine is a neutral amino acid.

**Final Answer:** Glycine is a neutral amino acid.

**Answer: (B)**



Q30.

**Solution****Concept:**

The degree of dissociation ( $\alpha$ ) of a weak electrolyte is the ratio of its molar conductivity ( $\lambda_m$ ) at a given concentration to its limiting molar conductivity ( $\lambda_m^\circ$ ) at infinite dilution.

$$\alpha = \frac{\lambda_m}{\lambda_m^\circ}$$

According to Kohlrausch's law, the limiting molar conductivity of an electrolyte is the sum of the limiting ionic conductivities of its individual ions.

**Solution:**

1. Calculate the limiting molar conductivity ( $\lambda_m^\circ$ ) for methanoic acid ( $HCOOH$ ):

$$\lambda_m^\circ(HCOOH) = \lambda_{H^+}^\circ + \lambda_{HCOO^-}^\circ$$

$$\lambda_m^\circ = 349.6 + 54.6 = 404.2 \text{ S cm}^2 \text{ mol}^{-1}$$

2. Identify the given molar conductivity at concentration  $C$ :

$$\lambda_m = 46.1 \text{ S cm}^2 \text{ mol}^{-1}$$

3. Calculate the degree of dissociation ( $\alpha$ ):

$$\alpha = \frac{\lambda_m}{\lambda_m^\circ} = \frac{46.1}{404.2}$$

4. Perform the division:

$$\alpha \approx 0.114$$

5. This value indicates that at the given concentration, roughly 11.4% of the methanoic acid molecules are dissociated into ions.

**Final Answer:** The degree of dissociation is 0.114.

**Answer: (A)**



Q31.

**Solution****Concept:**

The bond order of a molecule or ion can be determined using **Molecular Orbital (MO) Theory**. Bond order is defined as half the difference between the number of electrons in bonding molecular orbitals ( $N_b$ ) and antibonding molecular orbitals ( $N_a$ ):

$$\text{Bond Order} = \frac{N_b - N_a}{2}$$

The electronic configuration for the peroxide ion ( $O_2^{2-}$ ) is derived from the neutral  $O_2$  molecule by adding two extra electrons to the highest occupied molecular orbitals.

**Solution:**

- (a) **Total Electrons in  $O_2^{2-}$ :** Each Oxygen atom has 8 electrons, so  $8 + 8 + 2$  (extra) = 18 electrons.
- (b) **Molecular Orbital Configuration:**  $\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^2, (\pi 2p_x^2 = \pi 2p_y^2), (\pi^* 2p_x^2 = \pi^* 2p_y^2)$ .
- (c) **Count Bonding Electrons ( $N_b$ ):**  $N_b = 2(\sigma 1s) + 2(\sigma 2s) + 2(\sigma 2p_z) + 4(\pi 2p_{x,y}) = 10$ .
- (d) **Count Antibonding Electrons ( $N_a$ ):**  $N_a = 2(\sigma^* 1s) + 2(\sigma^* 2s) + 4(\pi^* 2p_{x,y}) = 8$ .
- (e) **Calculate Bond Order:**

$$\text{Bond Order} = \frac{10 - 8}{2} = \frac{2}{2} = 1$$

**Conclusion:** A bond order of 1 indicates a single covalent bond, consistent with the structure of the peroxide ion  $[O - O]^{2-}$ .

**Final Answer:** The bond order of  $O_2^{2-}$  is 1.

**Answer: (A)**



Q32.

**Solution****Concept:**

Polymers are classified into four categories based on their intermolecular forces:

- **Elastomers:** Weakest intermolecular forces; return to original shape after stretching.
- **Fibers:** Strongest forces (e.g., H-bonding); high tensile strength.
- **Thermoplastics:** Intermediate forces; soften on heating.
- **Thermosetting:** Highly cross-linked; infusible and brittle.

**Solution:**

- (a) **Nylon-6,6 and Terylene:** Classified as **fibers** due to strong hydrogen bonding or dipole-dipole interactions.
- (b) **Bakelite:** A **thermosetting polymer** with a high degree of 3D cross-linking.
- (c) **Neoprene:** A synthetic rubber (polychloroprene).
- (d) **Characterization:** Because Neoprene exhibits high elasticity and returns to its original form after stretching, it belongs to the **elastomer** category.

**Final Answer:** Neoprene is an example of an elastomer.

**Answer:** (A)



Q33.

**Solution****Concept:**

The conversion of benzene diazonium salts into aryl derivatives is typically achieved via two main named reactions:

- **Sandmeyer Reaction:** Uses **Copper(I) salts** (e.g.,  $CuCl$ ,  $CuBr$ ,  $CuCN$ ).
- **Gattermann Reaction:** Uses finely divided **Copper powder** in halogen acid.

**Solution:**

- (a) **Reactants:**  $C_6H_5N_2Cl$  (Benzene diazonium chloride) and  $CuCN$  (Copper(I) cyanide).
- (b) **Mechanism:** The diazonium group ( $-N_2Cl$ ) is replaced by the cyanide ion ( $CN^-$ ).
- (c) **Reaction:**  $C_6H_5N_2Cl + CuCN \rightarrow C_6H_5CN + N_2 + CuCl$ .
- (d) **Classification:** Since a **copper(I) salt** is utilized as the reagent, this is a classic **Sandmeyer reaction**.

**Final Answer:** The reaction is known as the Sandmeyer reaction.

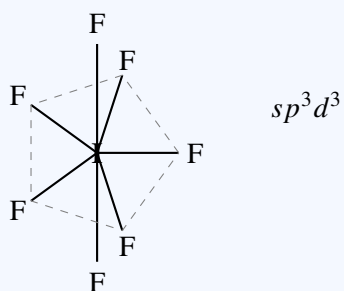
**Answer: (B)**



Q34.

**Solution****Concept:**VSEPR Theory and  $sp^3d^3$  Hybridization.**Solution:**

- 1: Determine the valence electrons of Iodine (I), which is 7.
- 2: Calculate the Steric Number (S):  $S = (\text{Bond Pairs}) + (\text{Lone Pairs}) = 7 + 0 = 7$ .
- 3: For  $S = 7$ , the central atom undergoes  $sp^3d^3$  hybridization.
- 4: The geometry for 7 bond pairs and 0 lone pairs is Pentagonal Bipyramidal.

**Final Answer:**

Pentagonal bipyramidal

Answer: (A)



Q35.

**Solution****Concept:**

The oxidation number (O.N.) of an element in a compound is the formal charge an atom would carry if all bonds were considered ionic. The algebraic sum of the oxidation numbers of all atoms in a neutral compound must equal zero. For Potassium Dichromate ( $K_2Cr_2O_7$ ), we use the known oxidation states of Potassium (+1) and Oxygen (-2) to solve for Chromium (Cr).

**Solution:**

1. Let the oxidation number of Chromium be  $x$ . 2. Write the formula:  $K_2Cr_2O_7$ . 3. Set up the equation based on the sum of oxidation numbers:

$$2 \times (\text{O.N. of } K) + 2 \times (\text{O.N. of } Cr) + 7 \times (\text{O.N. of } O) = 0$$

4. Substitute the known values ( $K = +1, O = -2$ ):

$$2(+1) + 2(x) + 7(-2) = 0$$

5. Solve for  $x$ :

$$2 + 2x - 14 = 0$$

$$2x - 12 = 0$$

$$2x = 12 \Rightarrow x = +6$$

6. Thus, in the dichromate ion ( $Cr_2O_7^{2-}$ ), each Chromium atom is in the +6 oxidation state.

**Final Answer:** The oxidation number of Cr is +6.

**Answer:** (A)



Q36.

**Solution**

**Concept:** Nylon-6,6 is a synthetic **polyamide** formed via **condensation polymerization**. The "6,6" indicates that both the diamine and the dicarboxylic acid monomers contain 6 carbon atoms each.

**Solution:**

- **Monomer 1:** Hexamethylenediamine [ $H_2N(CH_2)_6NH_2$ ] (6 Carbons).
- **Monomer 2:** Adipic acid [ $HOOC(CH_2)_4COOH$ ] (6 Carbons).
- **Reaction:** The  $-NH_2$  and  $-COOH$  groups react to form amide linkages ( $-NH-CO-$ ) with the elimination of water ( $H_2O$ ).



**Final Answer:** The monomers are Adipic acid and Hexamethylene diamine.

**Answer: (A)**

Q37.

**Solution**

**Concept:** **Antiseptics** kill or prevent the growth of microbes on **living tissues**. They are commonly added to soaps to reduce odor caused by bacterial decomposition.

**Solution:**

- (a) **Bithional:** Added to soaps to impart antiseptic properties and reduce skin bacterial action.
- (b) **Chloramphenicol/Penicillin:** Antibiotics for internal infections.
- (c) **Morphine:** A narcotic analgesic (painkiller).

Since Bithional is the only substance applied topically in soaps among the options, it is the correct antiseptic.

**Final Answer:** Bithional is used as an antiseptic.

**Answer: (A)**



Q38.

**Solution****Concept:**

The rate law for a chemical reaction expresses the rate as a function of the concentration of reactants. For a zero-order reaction, the rate is independent of the concentration of the reactants.

The rate equation is:

$$\text{Rate} = k[A]^0 = k$$

By analyzing the units of 'Rate' and 'Concentration', we can derive the units for the rate constant  $k$  for any order of reaction.

**Solution:**

1. The unit of Rate is always "Change in concentration per unit time":

$$\text{Unit of Rate} = \text{mol L}^{-1} \text{ s}^{-1}$$

2. For a zero-order reaction:

$$\text{Rate} = k$$

3. Since the rate is equal to the rate constant  $k$ , the units of  $k$  must be identical to the units of the rate itself. 4. Therefore:

$$\text{Unit of } k = \text{mol L}^{-1} \text{ s}^{-1}$$

5. General formula for units of  $k$ :  $(\text{mol L}^{-1})^{1-n} \text{ s}^{-1}$ , where  $n$  is the order. For  $n = 0$ :

$$(\text{mol L}^{-1})^{1-0} \text{ s}^{-1} = \text{mol L}^{-1} \text{ s}^{-1}$$

**Final Answer:** The unit of the rate constant for a zero-order reaction is  $\text{mol L}^{-1} \text{ s}^{-1}$ .

**Answer: (A)**



Q39.

**Solution**

**Concept:** Atomic radius increases **down a group** due to the addition of new electronic shells and decreases **across a period** as increasing nuclear charge pulls electrons closer.

**Solution:**

- (a) The elements belong to Group 17 (Halogens): *F*, *Cl*, *Br*, and *I*.
- (b) Arrangement from top to bottom: *F* (Period 2) < *Cl* (Period 3) < *Br* (Period 4) < *I* (Period 5).
- (c) **Fluorine** is at the top; it has only two shells ( $n = 2$ ).
- (d) Moving down to Iodine, shells increase to  $n = 5$ , significantly enlarging the atom.

[Image of periodic trend of atomic radius]

**Final Answer:** Fluorine has the smallest atomic radius.

**Answer:** (A)

Q40.

**Solution**

**Concept:** Metal oxides are obtained from concentrated ores via:

- **Calcination:** Heating in limited air (for carbonates/hydroxides).
- **Roasting:** Heating strongly in a **regular supply of air** (for sulfides).

**Solution:**

- (a) Roasting is specifically used for **sulfide ores** (e.g., *ZnS*, *PbS*).
- (b) The sulfide reacts with oxygen to form an oxide and *SO*<sub>2</sub> gas:  $2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$ .
- (c) This process is carried out below the metal's melting point in a furnace with free air circulation.

**Final Answer:** The process is called Roasting.

**Answer:** (A)



Q41.

**Solution**

**Concept:** Reactivity toward **Lucas reagent** (anhyd.  $ZnCl_2$  + conc.  $HCl$ ) follows the stability of the carbocation intermediate: **Tertiary** ( $3^\circ$ ) > **Secondary** ( $2^\circ$ ) > **Primary** ( $1^\circ$ ).

**Solution:**

- **2-methylpropan-2-ol:** Tertiary ( $3^\circ$ ); forms a stable  $3^\circ$  carbocation. Reacts **immediately** (instant turbidity).
- **Butan-2-ol:** Secondary ( $2^\circ$ ); reacts within 5–10 minutes.
- **Butan-1-ol / Ethanol:** Primary ( $1^\circ$ ); do not show turbidity at room temperature.

**Final Answer:** 2-methylpropan-2-ol is most reactive towards Lucas reagent.

Answer: (A)

Q42.

**Solution**

**Concept:** The number of atoms per unit cell ( $Z$ ) is the sum of the contributions of all atoms located in the cell.

**Solution:**

- Location:** In a simple cubic (SC) lattice, atoms are only at the **8 corners**.
- Contribution:** Each corner atom is shared by 8 unit cells; thus, each contributes  $1/8$  to one cell.
- Calculation:**  $Z = 8 \text{ corners} \times \frac{1}{8} \text{ per corner} = 1$ .

**Final Answer:** The number of atoms per unit cell in a simple cubic lattice is 1.

Answer: (A)



Q43.

**Solution**

**Concept:** Greenhouse gases ( $CO_2$ ,  $CH_4$ ,  $N_2O$ ) absorb and emit infrared radiation, trapping heat in the atmosphere. Diatomic homonuclear molecules like  $N_2$  and  $O_2$  do not.

**Solution:**

- $CO_2$  (**Carbon Dioxide**): A primary greenhouse gas that effectively absorbs thermal infrared energy.
- $N_2/O_2$ : Major atmospheric components that do not contribute to the greenhouse effect.
- $Ar$ : An inert noble gas; does not trap heat.

**Final Answer:**  $CO_2$  is a greenhouse gas.

**Answer:** (A)

Q44.

**Solution**

**Concept:**

The pH scale measures the acidity or basicity of a solution. For a strong base like Sodium Hydroxide ( $NaOH$ ), which dissociates completely in water, we first calculate the pOH and then use the relationship between pH and pOH at 298 K:

$$pH + pOH = 14$$

The pOH is defined as the negative logarithm of the hydroxide ion concentration:

$$pOH = -\log[OH^-]$$

**Solution:**

1. Identify the concentration:  $[NaOH] = 0.01 \text{ M} = 10^{-2} \text{ M}$ . 2. Since  $NaOH$  is a strong base:

$$[OH^-] = [NaOH] = 10^{-2} \text{ M}$$

3. Calculate the pOH:

$$pOH = -\log(10^{-2}) = 2$$

4. Calculate the pH:

$$pH = 14 - pOH$$

$$pH = 14 - 2 = 12$$

5. A pH of 12 indicates a strongly basic solution, which is consistent with the nature of  $NaOH$ .

**Final Answer:** The pH of the solution is 12.

**Answer:** (A)



Q45.

### Solution

#### Concept:

Valence Bond Theory (VBT) and Crystal Field Theory (CFT) for  $d^8$  complexes.

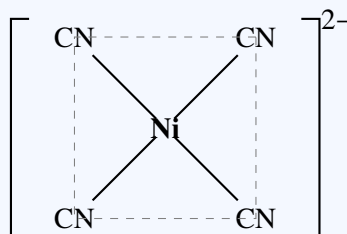
#### Solution:

1: Determine the oxidation state of Ni in  $[Ni(CN)_4]^{2-}$ .  $x + 4(-1) = -2 \Rightarrow x = +2$ . Electronic configuration of  $Ni^{2+}$  is  $[Ar]3d^8$ .

2: Identify ligand strength.  $CN^-$  is a strong field ligand, which causes electrons in the  $3d$  orbitals to pair up.

3: After pairing, the  $3d$  configuration becomes  $(3d_{xy})^2(3d_{yz})^2(3d_{xz})^2(3d_{x^2-y^2})^0$ . One  $3d$  orbital ( $d_{x^2-y^2}$ ) is available for hybridization.

4: The hybridization involves one  $3d$ , one  $4s$ , and two  $4p$  orbitals, resulting in  $dsp^2$  hybridization. This corresponds to a square planar geometry.



Square Planar ( $dsp^2$ )

#### Final Answer:

Square planar

Answer: (A)



Q46.

**Solution**

**Concept:** Vitamins are essential micronutrients classified by their solubility:

- **Water-soluble:** Vitamin C and B-complex group (not stored in the body).
- **Fat-soluble:** Vitamins A, D, E, and K (stored in liver and adipose tissues).

**Solution:**

- Vitamin A (Retinol):** Essential for vision and immune function. It is a **fat-soluble** vitamin.
- Vitamin B12, B6, and C:** These are all **water-soluble** and excreted in urine if consumed in excess.
- Storage:** Unlike water-soluble vitamins, fat-soluble vitamins like A are stored for long periods, which can lead to toxicity if taken in extreme excess.

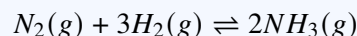
**Final Answer:** Vitamin A is a fat-soluble vitamin.

**Answer: (A)**

Q47.

**Solution**

**Concept:** The **Haber process** synthesizes Ammonia ( $NH_3$ ) via the reversible exothermic reaction:



A catalyst is used to lower the activation energy and increase the reaction rate.

**Solution:**

- Primary Catalyst:** Finely divided **Iron (Fe)** is used to facilitate the reaction.
- Promoter: Molybdenum (Mo)** (or  $K_2O/Al_2O_3$ ) is added to enhance the activity of the Iron catalyst.
- Other catalysts:**  $V_2O_5$  is for the Contact Process ( $H_2SO_4$ ); Pt is for the Ostwald Process ( $HNO_3$ ); Ni is for hydrogenation of oils.

**Final Answer:** The catalyst used is Fe + Mo.

**Answer: (A)**



Q48.

**Solution**

**Concept:** Thermodynamic properties are categorized based on their dependence on system size:

- **Extensive:** Depend on the amount of matter (e.g., Mass, Volume, Enthalpy).
- **Intensive:** Independent of the amount of matter (e.g., Temperature, Pressure).

**Solution:**

- **Mass, Volume, Enthalpy ( $H$ ):** These values double if the quantity of the substance is doubled; they are extensive.
- **Temperature ( $T$ ):** If a system in equilibrium is divided, the temperature of each part remains identical to the whole. It is an **intensive** property.

**Final Answer:** Temperature is an intensive property.

Answer: (A)

Q49.

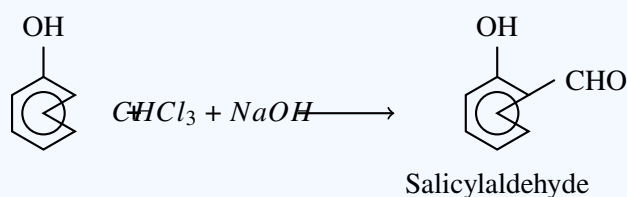
**Solution**

**Concept:**

Reimer-Tiemann Reaction.

**Solution:**

- 1: Identify the reagents. Phenol reacting with  $CHCl_3$  and  $NaOH$  is the Reimer-Tiemann reaction.
- 2: The reaction involves the formation of a reactive intermediate, dichlorocarbene ( $:CCl_2$ ).
- 3: The electrophile attacks the ortho position of the phenoxide ion.
- 4: Hydrolysis of the resulting intermediate yields Salicylaldehyde as the major product.



**Final Answer:**

Salicylaldehyde

Answer: (A)



Q50.

**Solution****Concept:**

Henry's Law states that the solubility of a gas in a liquid is directly proportional to the partial pressure of the gas above the liquid. The formula is:

$$P = K_H \cdot x$$

where  $P$  is the partial pressure,  $x$  is the mole fraction of the gas in the solution (solubility), and  $K_H$  is the Henry's Law constant.  $K_H$  is a function of the nature of the gas, the solvent, and the temperature.

**Solution:**

1. Solubility Trend: Generally, the solubility of gases in liquids decreases as the temperature increases (because the dissolution of a gas is usually an exothermic process). 2. Relationship with  $K_H$ : From the formula  $x = P/K_H$ , it is evident that for a constant pressure  $P$ , solubility ( $x$ ) is inversely proportional to  $K_H$ . 3. Conclusion: Since solubility decreases with an increase in temperature, the value of  $K_H$  must increase with an increase in temperature to maintain the mathematical equality. 4. This explains why aquatic life is more comfortable in cold water (higher dissolved oxygen) than in warm water.

**Final Answer:** The value of  $K_H$  increases with increase in temperature.

**Answer:** (A)



## Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	A	3	C	4	B	5	A
6	C	7	A	8	A	9	B	10	A
11	A	12	A	13	C	14	A	15	B
16	A	17	A	18	A	19	C	20	B
21	A	22	A	23	B	24	A	25	A
26	C	27	C	28	C	29	B	30	A
31	A	32	A	33	B	34	A	35	A
36	A	37	A	38	A	39	A	40	A
41	A	42	A	43	A	44	A	45	A
46	A	47	A	48	A	49	A	50	A

