JEE Main 2023 8 April Shift 1 Chemistry Question Paper with Solutions

Time Allowed :180 minutes	**Maximum Marks :**300	**Total questions :**90

General Instructions

Read the following instructions very carefully and strictly follow them:

(A) The test is of 3 hours duration. (B) The question paper consists of 90 questions. The maximum marks are 300. (C) There are three parts in the question paper consisting of Physics, Chemistry and Mathematics having 30 questions in each part of equal weightage. (D) Each part (subject) has two sections.

(i) Section-A: This section contains 20 multiple choice questions which have only one correct answer. Each question carries 4 marks for correct answer and –1 mark for wrong answer.

(ii) Section-B: This section contains 10 questions. In Section-B, attempt any five questions out of 10. The answer to each of the questions is a numerical value. Each question carries 4 marks for correct answer and –1 mark for wrong answer. For Section-B, the answer should be rounded off to the nearest integer.

1: The reaction

$$\frac{1}{2}\mathbf{H}_2(g) + \mathbf{AgCl}(s) \rightleftharpoons \mathbf{H}^+(aq) + \mathbf{Cl}^-(aq) + \mathbf{Ag}(s)$$

occurs in which of the given galvanic cells?

(A) Pt | H_2(g) | HCl(sol^n) | $AgNO_3$(sol^n) | Ag

(B) Pt | H_2(g) | HCl(sol^n) | AgCl(s) | Ag

(C) Pt | H_2(g) | KCl(sol^n) | AgCl(s) | Ag

(D) Ag | AgCl(s) | KCl(sol^n) | $AgNO_3$ | Ag

Correct Answer: (2)

Solution: The given reaction involves the oxidation of hydrogen gas to H^+ ions and the reduction of AgCl to Ag. This is consistent with the following electrode reactions:

- **Anode (oxidation):** $H_2 \rightarrow 2H^+ + 2e^-$
- **Cathode (reduction):** AgCl + $e^- \rightarrow$ Ag + Cl^-

The correct galvanic cell setup corresponding to this reaction is:

$$\text{Pt}|\text{H}_2(\text{g})|\text{HCl}(\text{sol}^n)|\text{AgCl(s)}|\text{Ag}$$

Here, the HCl provides the H^+ ions required for the anode reaction, and AgCl serves as the source of Ag^+ for the cathode reaction.

Quick Tip

In a galvanic cell, always identify the species undergoing oxidation and reduction to match the reaction with the cell setup.

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2. Sulphur (S)-containing amino acids from the following are: [label = ()] (A) Isoleucine

(B) Cysteine

(C) Lysine

(D) Methionine

(E) Glutamic acid

Choose the correct answer from the following:

(A) b, c, e

(B) a, d

(C) a, b, c

(D) b, d

Correct Answer: (4)

Solution: Sulphur-containing amino acids are those that have a sulphur atom in their side chain. From the given list:

- **Cysteine:** Contains a thiol group (-SH) in its side chain.
- **Methionine:** Contains a thioether (-S-) group in its side chain.

The remaining amino acids (Isoleucine, Lysine, and Glutamic acid) do not contain sulphur in their structures.

Thus, the sulphur-containing amino acids are **b (Cysteine)** and **d (Methionine)**.

Quick Tip

To identify sulphur-containing amino acids, look for functional groups like -SH (thiol) or -S- (thioether) in the side chains.

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3. Which of the following complex is octahedral, diamagnetic and the most stable?

(1) $K_3[Co(CN)_6]$

(2) $[Ni(NH_3)_6]Cl_2$

(3) $[Co(H_2O)_6]Cl_2$

(4) $Na_3[CoCl_6]$

Correct Answer: (1)

Solution:

To analyze the properties of $K_3[Co(CN)_6]$, let's break it down:

- **Oxidation state of cobalt:** The overall charge on the complex is 0. Let x represent the oxidation state of cobalt:

$$3 + x - 6 = 0 \implies x = +3$$

  So, Co is in the +3 oxidation state.

- **Electronic configuration of Co^{3+}:** Cobalt's ground state is [Ar] $3d^7\ 4s^2$. After losing 3 electrons, the configuration becomes $3d^6$.

- **Ligand strength:** CN^- is a strong field ligand (SFL) as per the spectrochemical series. Strong field ligands cause significant splitting of the d-orbitals, leading to pairing of electrons in the lower energy orbitals.
- **Electron pairing:** In the presence of CN^-, the 3d electrons pair as follows:

  Before pairing: $\uparrow\uparrow\uparrow\uparrow\uparrow\uparrow$

  After pairing: $\uparrow\downarrow\uparrow\downarrow\uparrow\downarrow$

  As all electrons are paired, the complex is **diamagnetic**.
- **Geometry:** The coordination number is 6, and with CN^- being a strong ligand, the geometry is octahedral.
- **Stability:** CN^- forms strong bonds with the metal center due to its strong field nature, making $K_3[Co(CN)_6]$ the most stable complex among the options.

Thus, $K_3[Co(CN)_6]$ is octahedral, diamagnetic, and the most stable.

Quick Tip

To determine the magnetic and geometric properties of a coordination complex, analyze the oxidation state, ligand field strength, and resulting electron configuration.

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4. Which of the following metals can be extracted through alkali leaching technique?

(1) Cu

(2) Au

(3) Pb

(4) Sn

Correct Answer: (4)

Solution:

- **Alkali leaching technique:** This technique is used to extract metals that are amphoteric in nature. Amphoteric metals can react with both acids and bases.

- **Amphoteric nature of Sn:** Tin (Sn) is amphoteric, meaning it reacts with alkali solutions (such as NaOH) to form soluble complexes. For example:

$$\text{SnO} + 2\text{NaOH} \rightarrow \text{Na}_2\text{SnO}_2 + \text{H}_2\text{O}$$

- **Comparison with other metals:**
  - **Copper (Cu):** Copper is not amphoteric; it does not react with alkalis.
  - **Gold (Au):** Gold is a noble metal and does not exhibit amphoteric behavior.
  - **Lead (Pb):** While lead exhibits slight amphoteric behavior, it is not commonly extracted through alkali leaching.

Thus, Sn is the only metal from the options that can be extracted via alkali leaching due to its amphoteric nature.

Quick Tip

Amphoteric metals like Sn and Al can react with both acids and bases, making them suitable for alkali leaching processes.

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5. The correct order of spin-only magnetic moments for the following complex ions is:

(1) $[CoF_6]^{3-} < [MnBr_4]^{2-} < [Fe(CN)_6]^{3-} < [Mn(CN)_6]^{3-}$

(2) $[Fe(CN)_6]^{3-} < [CoF_6]^{3-} < [MnBr_4]^{2-} < [Mn(CN)_6]^{3-}$

(3) $[MnBr_4]^{2-} < [CoF_6]^{3-} < [Fe(CN)_6]^{3-} < [Mn(CN)_6]^{3-}$

(4) $[Fe(CN)_6]^{3-} < [Mn(CN)_6]^{3-} < [CoF_6]^{3-} < [MnBr_4]^{2-}$

Correct Answer: (4)

Solution:

- **$[CoF_6]^{3-}$:** Co^{3+} (d^6) with weak field ligand F^-. Weak field ligands do not cause electron pairing, so:

$$\uparrow\uparrow\uparrow\uparrow\uparrow\uparrow \quad (\text{u.e.} = 4)$$

- **$[MnBr_4]^{2-}$:** Mn^{2+} (d^5) with weak field ligand Br^-. No pairing occurs:

$$\uparrow\uparrow\uparrow\uparrow\uparrow \quad (\text{u.e.} = 5)$$

- **$[Fe(CN)_6]^{3-}$:** Fe^{3+} (d^5) with strong field ligand CN^-. Strong field ligands cause electron pairing:

$$\uparrow\downarrow\uparrow\downarrow\uparrow \quad (\text{u.e.} = 1)$$

- **$[Mn(CN)_6]^{3-}$:** Mn^{3+} (d^4) with strong field ligand CN^-. Pairing occurs:

$$\uparrow\downarrow\uparrow\downarrow \quad (\text{u.e.} = 2)$$

Order of magnetic moments: The spin-only magnetic moment is proportional to the number of unpaired electrons (u.e.): $[Fe(CN)_6]^{3-} < [Mn(CN)_6]^{3-} < [CoF_6]^{3-} < [MnBr_4]^{2-}$

Quick Tip

The strength of the ligand (weak or strong field) affects the pairing of d-electrons, which in turn determines the magnetic moment.

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6. The water gas on reacting with cobalt as a catalyst forms:

(1) Methanoic acid

(2) Methanal

(3) Ethanol

(4) Methanol

Correct Answer: (4)

Solution:

The reaction between water gas (a mixture of CO and H_2) and a catalyst produces methanol (CH_3OH). The reaction is as follows:

$$CO + 2H_2 \xrightarrow{ZnO,\ Cr_2O_3,\ 700K} CH_3OH$$

- **Reactants:** CO and H_2 are essential components of water gas.
- **Catalyst:** ZnO and Cr_2O_3 act as catalysts at a temperature of 700 K to speed up the reaction.
- **Product:** Methanol is formed as the primary product due to the reaction of CO with H_2.

Quick Tip

Water gas reactions involve catalysts like ZnO or Cr_2O_3 for selective synthesis of methanol at high temperatures.

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7. The reaction:

$$2IO_3^- + xI^- + 12H^+ \rightarrow 6I_2 + 6H_2O$$

What is the value of x?

(1) 12

(2) 10

(3) 2

(4) 6

Correct Answer: (2)

Solution:

To balance the given redox reaction:

- The oxidation number of I in IO_3^- is +5, while in I_2, it is 0.
- The n-factor for IO_3^- is 5 because each IO_3^- gains 5 electrons to become I_2.
- I^- is oxidized to I_2, so its n-factor is 1.

To determine the value of x, we use the molar ratio of IO_3^- to I^-, which is 1:5:

$$IO_3^- + 6H^+ + 5I^- \rightarrow 3I_2 + 3H_2O$$

To obtain 6 moles of I_2, the equation is multiplied by 2:

$$2IO_3^- + 12H^+ + 10I^- \rightarrow 6I_2 + 6H_2O$$

Thus, $x = 10$.

Quick Tip

In redox reactions, balance the number of electrons gained and lost using the n-factor of the reacting species.

8. What is the purpose of adding gypsum to cement?

(1) To give a hard mass

(2) To speed up the process of setting

(3) To facilitate the hydration of cement

(4) To slow down the process of setting

Correct Answer: (4)

Solution:

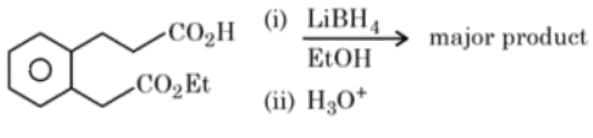
Gypsum ($CaSO_4 \cdot 2H_2O$) is added to cement to regulate the setting time. Without gypsum, cement would set immediately upon mixing with water, leaving no time for concrete placement.

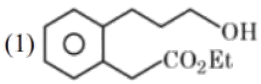
- Gypsum reacts with tricalcium aluminate (C_3A) in cement to form insoluble calcium sulfoaluminates, which slows down the hydration reaction.
- This delay ensures sufficient time for the mixing, transportation, and placement of concrete before it hardens.

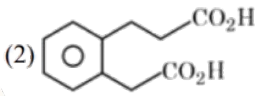
Quick Tip

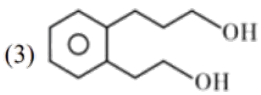
Gypsum in cement acts as a retarder, controlling the hydration rate and allowing time for proper application.

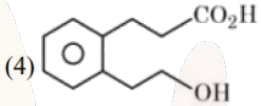
9. The major product formed in the following reaction is:



(1) 

(2) 

(3) 

(4) 

Correct Answer: (4)

Solution:

- **Reaction mechanism:** Lithium borohydride ($LiBH_4$) is a selective reducing agent that reduces esters (CO_2Et) to alcohols while leaving carboxylic acids (CO_2H) unchanged.
- **Step-by-step process:**

  (A) The ester group (CO_2Et) is reduced by $LiBH_4$ in ethanol (EtOH) to form a primary alcohol ($-CH_2CH_2OH$). (B) The carboxylic acid group (CO_2H) remains unchanged during the reaction. (C) Protonation with H_3O^+ ensures the stability of the final product.

The final product contains an unchanged carboxylic acid group and a newly formed primary alcohol group, corresponding to option (4).

Quick Tip

$LiBH_4$ is commonly used for the selective reduction of esters and lactones to alcohols, leaving carboxylic acids intact.

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10. Match List I with List II:

List I (Species)	**List II (Maximum Allowed Concentration in ppm in Drinking Water)**
A. F^-	I. < 50 ppm
B. SO_4^{2-}	II. < 5 ppm
C. NO_3	III. < 2 ppm
D. Zn	IV. < 500 ppm

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

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

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

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

Correct Answer: (4)

Solution:

- A. F^- (Fluoride): The allowed concentration is less than 1.5 ppm, but for safe drinking water, it is set at < 50 ppm.
- B. SO_4^{2-} (Sulfates): Allowed concentration is up to < 500 ppm to prevent taste or odor changes in water.
- C. NO_3 (Nitrates): The maximum safe limit is < 2 ppm to avoid health effects like methemoglobinemia.
- D. Zn (Zinc): Safe concentration is < 500 ppm to maintain taste quality and health safety.

Thus, the correct matching is A-I, B-II, C-III, D-IV.

Quick Tip

Understanding water safety limits for ions is crucial for environmental chemistry. Review WHO guidelines for more details.

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11. In chromyl chloride, the number of d-electrons present on chromium is the same as in:

(Given atomic numbers: Ti = 22, V = 23, Cr = 24, Mn = 25, Fe = 26)

(1) Fe (III)

(2) V (IV)

(3) Ti (III)

(4) Mn (VII)

Correct Answer: (4)

Solution:

Chromium in chromyl chloride (CrO_2Cl_2):

- Oxidation state of Cr is +6.
- Electronic configuration: Cr^{6+} = [Ar] $3d^0$ $4s^0$, meaning there are zero d-electrons.

Manganese in Mn (VII):

- Oxidation state of Mn is +7.

- Electronic configuration: Mn^{7+} = [Ar] $3d^0$ $4s^0$, also zero d-electrons.

Thus, the number of d-electrons is the same for Cr in CrO_2Cl_2 and Mn in Mn (VII).

Quick Tip

When comparing d-electrons, always determine the oxidation state and subtract the appropriate number of electrons from the neutral configuration.

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12. Assertion-Reason:

Assertion (A): Butan-1-ol has a higher boiling point than ethoxyethane.

Reason (R): Extensive hydrogen bonding leads to stronger association of molecules.

(A) Both A and R are true, but R is not the correct explanation of A.

(B) Both A and R are true, and R is the correct explanation of A.

(C) A is false, but R is true.

(D) A is true, but R is false.

Correct Answer: (2)

Solution:

- Butan-1-ol contains an -OH group, allowing it to form hydrogen bonds, which increase intermolecular forces and raise the boiling point.
- Ethoxyethane (ether) cannot form hydrogen bonds due to the lack of an -OH group, resulting in weaker intermolecular forces and a lower boiling point.
- Hydrogen bonding is the primary reason for the stronger association of molecules in butan-1-ol compared to ethoxyethane.

Thus, both A and R are true, and R is the correct explanation of A.

Quick Tip

Hydrogen bonding significantly increases boiling points. Alcohols with -OH groups boil higher than ethers with similar molecular weights.

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13. Match List I with List II:

List I (Reagents Used)	List II (Compound with Functional Group Detected)
A. Alkaline solution of copper sulphate and sodium citrate	I. 
B. Neutral $FeCl_3$ solution	II. 
C. Alkaline chloroform solution	III. 
D. Potassium iodide and sodium hypochlorite	IV. 

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

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

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

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

Correct Answer: (1)

Solution:

- **A: Alkaline solution of copper sulphate and sodium citrate** detects aldehydes. The aldehyde reacts to form a reddish-brown precipitate of Cu_2O.
- **B: Neutral $FeCl_3$ solution** is used for detecting phenolic groups. Phenols give a characteristic color (violet or blue).
- **C: Alkaline chloroform solution** (Haloform test) detects the presence of a methyl ketone or a methyl group adjacent to a hydroxyl group.
- **D: Potassium iodide and sodium hypochlorite** (Iodoform test) confirms alcohol groups ($-CH_3OH$).

Quick Tip

Matching reagents with functional groups is crucial for organic chemistry reactions. Memorize standard tests like $FeCl_3$ for phenols or Iodoform for alcohols.

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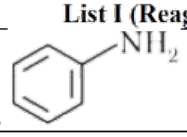
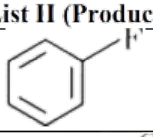
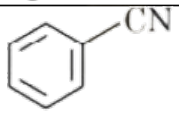
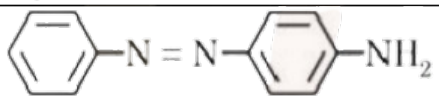
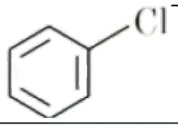
14. Match List I with List II:

List I (Reagent)	List II (Product)
A. 	I. 
B. HBF_4, Δ	II. 
C. Cu, HCl	III. 
D. CuCN/KCN	IV. 

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

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

(C) A-III, B-IV, C-II, D-II

(D) A-I, B-IV, C-III, D-I

Correct Answer: (3)

Solution:

- **A: NH_2-benzene (Aniline):** Aniline reacts with nitrous acid ($NaNO_2$/HCl) to form benzene-diazonium chloride.

$$C_6H_5NH_2 + NaNO_2 + HCl \rightarrow C_6H_5N_2Cl$$

  Hence, A matches with III.

- **B: HBF_4, Δ:** Benzene-diazonium chloride reacts with HBF_4 and heat to form fluorobenzene.

$$C_6H_5N_2Cl + HBF_4 \rightarrow C_6H_5F + N_2 + HCl$$

  Hence, B matches with IV.

- **C: Cu, HCl:** Benzene-diazonium chloride reacts with Cu and HCl to produce chlorobenzene.

$$C_6H_5N_2Cl + Cu + HCl \rightarrow C_6H_5Cl + N_2$$

  Hence, C matches with II.

- **D: CuCN/KCN:** Benzene-diazonium chloride reacts with CuCN/KCN to produce benzonitrile.

$$C_6H_5N_2Cl + CuCN \rightarrow C_6H_5CN + N_2$$

Hence, D matches with I.

Quick Tip

Diazonium salts are highly versatile intermediates in organic synthesis, forming halides, nitriles, and fluorides with specific reagents.

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15. Match List I with List II:

List I	List II
A. Saccharin	I. High potency sweetener
B. Aspartame	II. First artificial sweetening agent
C. Alitame	III. Stable at cooking temperature
D. Sucralose	IV. Unstable at cooking temperature

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

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

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

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

Correct Answer: (2)

Solution:

- **A: Saccharin** was the first artificial sweetening agent developed and is widely used.
- **B: Aspartame** is unstable at high temperatures, making it unsuitable for cooking.
- **C: Alitame** is a high-potency sweetener, approximately 2,000 times sweeter than cane sugar.
- **D: Sucralose** is stable at cooking temperatures and does not provide calories, making it ideal for baking.

Quick Tip

Different artificial sweeteners have varying stability and sweetness levels. Choose based on intended use (e.g., cooking or beverages).

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16. The correct order of electronegativity for given elements is:

(A) P > Br > C > At

(B) C > P > At > Br

(C) Br > P > At > C

(D) Br > C > At > P

Correct Answer: (4)

Solution:

Electronegativity is the ability of an atom to attract electrons in a chemical bond. Based on Pauling's scale:

- Br (2.8)
- C (2.5)
- At (2.2)
- P (2.1)

Thus, the order is:

$$\text{Br} > \text{C} > \text{At} > \text{P}$$

Quick Tip

Use Pauling's electronegativity scale to determine relative electronegativities of elements. Halogens generally have high electronegativity.

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17. Given below are two statements:

Statement I: Lithium and Magnesium do not form superoxide.

Statement II: The ionic radius of Li^+ is larger than the ionic radius of Mg^{2+}.

(A) Statement I is correct, but Statement II is incorrect.

(B) Statement I is incorrect, but Statement II is correct.

(C) Both Statement I and Statement II are correct.

(D) Both Statement I and Statement II are incorrect.

Correct Answer: (3)

Solution:

- **Statement I:** Lithium and Magnesium do not form superoxides due to their small ionic size and high ionization energy.
- **Statement II:** The ionic radius of Li^+ (76 pm) is larger than that of Mg^{2+} (72 pm). This is because Mg^{2+} loses two electrons, resulting in a greater effective nuclear charge.

Thus, both statements are correct.

Quick Tip

Diagonal relationships explain similar chemical properties of Li and Mg. Their small ionic size and high ionization energies prevent superoxide formation.

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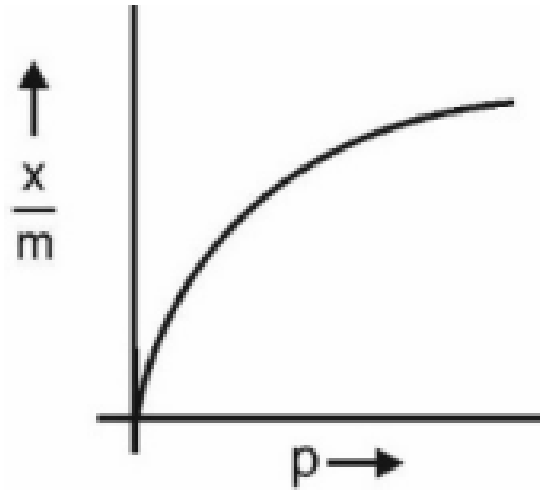
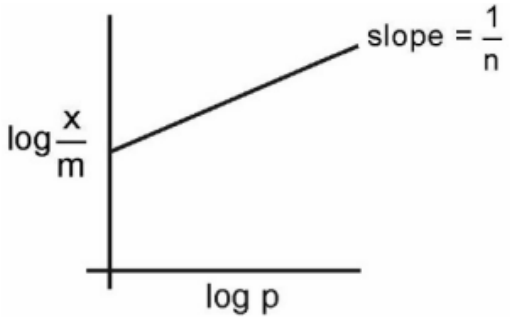
18. Which of the following represent the Freundlich adsorption isotherms?

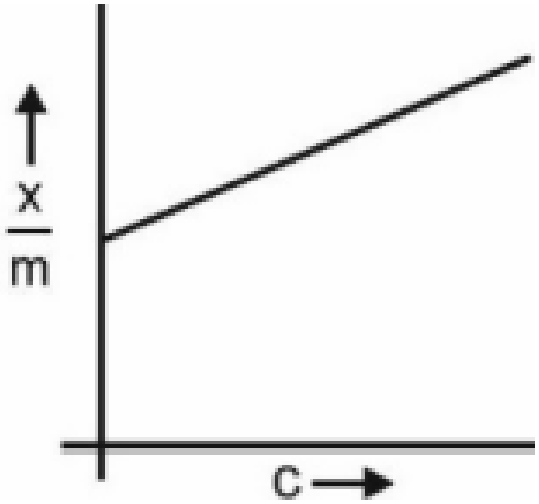
(A)



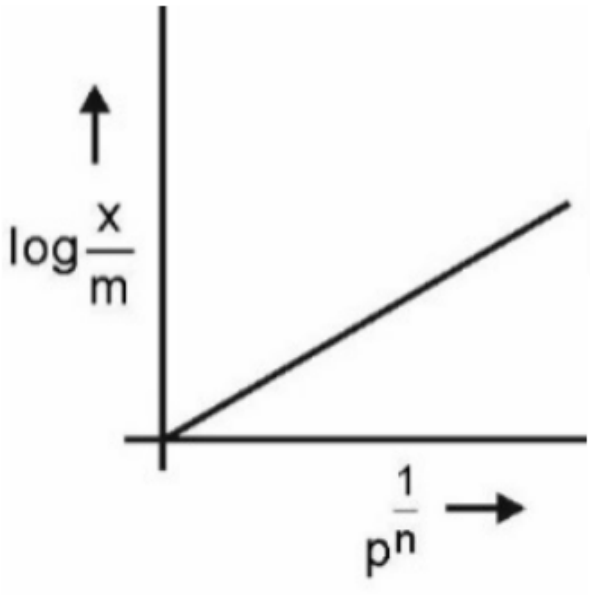
(B)



(C)



(D)



(A) A, C, D only

(B) A, B only

(C) A, B, D only

(D) B, C, D only

Correct Answer: (3)

Solution:

The Freundlich adsorption isotherm is an empirical relationship that describes the adsorption of gases or solutes onto a surface. It is represented by:

$$\frac{x}{m} = kp^{1/n}$$

where x is the mass of the adsorbate, m is the mass of the adsorbent, p is the pressure, and k and n are constants.

The graphical representations are:

- **A:** Correct, shows $\frac{x}{m}$ vs p with a logarithmic relationship.
- **B:** Correct, shows $\log \frac{x}{m}$ vs $\log p$ as a straight line.
- **D:** Correct, shows a logarithmic relationship $\frac{x}{m}$ vs $p^{1/n}$.
- **C:** Incorrect, as it shows a constant $\frac{x}{m}$, not related to Freundlich's isotherm.

Thus, the correct representations are A, B, and D.

Quick Tip

Freundlich isotherm applies to heterogeneous surfaces and is empirical. Look for curves or straight lines involving $\frac{x}{m}$ and p.

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19. Which halogen is known to cause the reaction given below:

$$2\text{Cu}^{2+} + 4X^- \rightarrow \text{Cu}_2X_2(s) + X_2$$

(A) All halogens

(B) Only chlorine

(C) Only bromine

(D) Only iodine

Correct Answer: (4)

Solution:

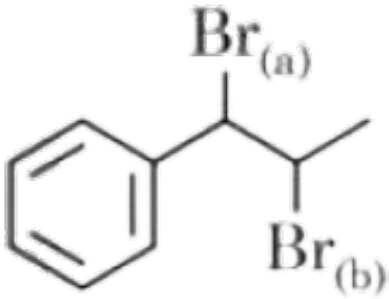
The reaction given involves the reduction of Cu^{2+} ions to Cu^{+}, forming Cu_2I_2 as a precipitate and iodine gas (I_2). Among the halogens, only iodine has the required reducing strength to cause this reaction:

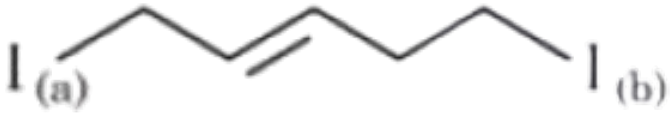
$$2\text{Cu}^{2+} + 4\text{I}^- \rightarrow \text{Cu}_2\text{I}_2 + \text{I}_2$$

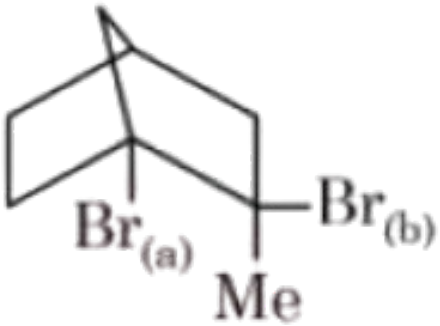
Quick Tip

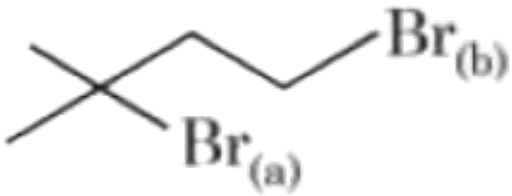
Iodide ions are strong enough to reduce Cu^{2+} to Cu^{+}, forming Cu_2I_2 as a solid precipitate.

20. Choose the halogen which is most reactive towards S_N1 reaction in the given compounds (A, B, C, & D):

A. 

B. 

C. 

D. 

(A) A-Br(a); B-I(a); C-Br(b); D-Br(a)

(B) A-Br(a); B-I(a); C-Br(a); D-Br(a)

(C) A-Br(b); B-I(b); C-Br(b); D-Br(b)

(D) A-Br(a); B-Br(a); C-Br(a); D-I(a)

Correct Answer: (1)

Solution:

The reactivity of halides towards the S_N1 mechanism depends on the stability of the carbocation intermediate formed during the reaction:

- Compound A forms a benzyl carbocation, which is highly stable due to resonance.
- Compound B forms a primary carbocation, which is less stable but reacts due to iodine's leaving group strength.
- Compound C forms a tertiary carbocation, which is very stable and reactive.
- Compound D forms a primary carbocation, less stable but reacts due to bromine's moderate leaving group strength.

Thus, the halogens are ordered as per the leaving group stability in S_N1.

Quick Tip

The stability of the carbocation intermediate determines the reactivity in the S_N1 mechanism.

---

21. Molar mass of the hydrocarbon (X) which on ozonolysis consumes one mole of O_3 per mole of (X) and gives one mole each of ethanol and propanone is:

Correct Answer: 70

Solution:

The reaction is:

$$CH_3 - C \equiv CH - CH_3 + O_3 \rightarrow CH_3CHO + CH_3COCH_3$$

- The hydrocarbon (X) is pent-2-yne (C_5H_8).
- Its molecular mass is calculated as:

$$5 \times 12 + 8 \times 1 = 70\,\text{g mol}^{-1}$$

Quick Tip

In ozonolysis, the cleavage of C=C or C≡C bonds produces aldehydes or ketones. Use product identification to backtrack the reactant.

---

22. XeF_4 reacts with SbF_5 to form:

$$[XeF_m]^{n+}[SbF_y]^{z-}$$

What is $m + n + y + z$?

(A) 10

(B) 11

(C) 12

(D) 13

Correct Answer: (2)

Solution:

The reaction is:

$$XeF_4 + SbF_5 \rightarrow [XeF_3]^+ + (SbF_6)^-$$

From the reaction:

$$m + n + y + z = 3 + 1 + 6 + 1 = 11$$

Quick Tip

In xenon-fluoride reactions, xenon acts as a donor/acceptor with fluoride ions, forming ionic complexes.

---

23. The number of following statements which is/are incorrect is:

(A) Line emission spectra are used to study the electronic structure.

(B) The emission spectra of atoms in the gas phase show a continuous spread of wavelength from red to violet.

(C) An absorption spectrum is like the photographic negative of an emission spectrum.

(D) The element helium was discovered in the sun by spectroscopic method.

Correct Answer: (1)

Solution:

The incorrect statement is:

- **Statement 2:** Emission spectra of atoms in the gas phase do not show a continuous spectrum. They display discrete lines corresponding to specific energy levels.

Quick Tip

Emission spectra show discrete wavelengths corresponding to electronic transitions, while absorption spectra are complementary.

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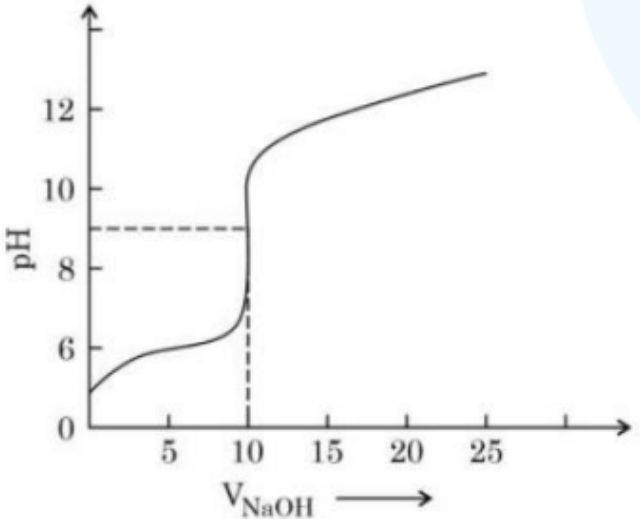
24. The titration curve of weak acid vs. strong base with phenolphthalein as indicator is shown below:



The $K_{\text{phenolphthalein}} = 4 \times 10^{-10}$ and log 2 = 0.3. The number of correct statements about phenolphthalein is:

(A) It can be used as an indicator for the titration of weak acid with weak base.

(B) It begins to change color at pH = 8.4.

(C) It is a weak organic base.

(D) It is colorless in acidic medium.

Correct Answer: (2)

Solution:

The pK_n for phenolphthalein is calculated as:

$$\text{p}K_n = -\log(4 \times 10^{-10}) = 9.4$$

The indicator range is given by:

$$\text{p}K_n \pm 1 \implies 8.4 \text{ to } 10.4$$

- Statement (B) is correct since phenolphthalein changes color around pH = 8.4.

- Statement (D) is correct as phenolphthalein is colorless in acidic medium due to its unionized form.

Quick Tip

Phenolphthalein is effective in titrations involving strong bases due to its color change range (pH 8.4 to 10.4).

---

25. When a 60 W electric heater is immersed in a gas for 100 s in a constant volume container with adiabatic walls, the temperature of the gas rises by 5°C. The heat capacity of the given gas is:

Correct Answer: 1200

Solution:

Under adiabatic conditions, the heat capacity (C_V) is calculated using:

$$C_V \times \Delta T = P \times t$$

Substituting the values:

$$C_V \times 5 = 60 \times 100$$

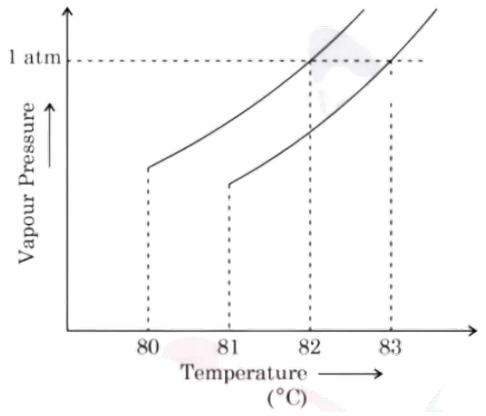
$$C_V = \frac{60 \times 100}{5} = 1200\,\text{J K}^{-1}$$

Quick Tip

In adiabatic systems, no heat is exchanged with the surroundings. Use $C_V \times \Delta T = P \times t$ for heat capacity.

---

26. The vapor pressure vs. temperature curve for a solution-solvent system is shown below. The boiling point of the solvent is:



(A) 81°C

(B) 82°C

(C) 83°C

(D) 84°C

Correct Answer: (2)

Solution:

The boiling point is defined as the temperature at which the vapor pressure equals 1 atm. From the graph, the solvent's boiling point corresponds to the temperature at which the vapor pressure reaches 1 atm, which is clearly 82°C.

Quick Tip

The boiling point is determined at the temperature where the vapor pressure curve intersects the 1 atm line.

---

27. 0.5 g of an organic compound (X) with 60% carbon will produce ____ $\times 10^{-1}$ g of CO_2 on complete combustion.

Correct Answer: 11

Solution:

- Moles of carbon in the compound are given by:

$$\text{Moles of carbon} = \frac{0.5 \times 0.6}{12} = 0.025\,\text{mol}$$

- On combustion, each mole of carbon produces 1 mole of CO_2:

$$\text{Moles of } CO_2 = 0.025\,\text{mol}$$

- The mass of CO_2 produced is:

$$\text{Mass of } CO_2 = 0.025 \times 44 = 1.1\,\text{g}$$

- Expressed as 11×10^{-1} g.

Quick Tip

In combustion problems, always use the stoichiometric ratio between carbon and CO_2 and their molar masses to calculate the mass of CO_2 formed.

---

28. The number of following factors which affect the percent covalent character of the ionic bond is ____.

(A) Polarising power of cation

(B) Extent of distortion of anion

(C) Polarisability of the anion

(D) Polarising power of anion

Correct Answer: 3

Solution:

- The percent covalent character in an ionic bond is influenced by:

  (A) **Polarising power of the cation:** A small, highly charged cation can polarise the anion's electron cloud, increasing covalent character.

  (B) **Extent of distortion of the anion:** A larger, more easily distortable anion increases covalent character. (C) **Polarisability of the anion:** A more polarisable anion (e.g., I^-) results in a higher covalent character.

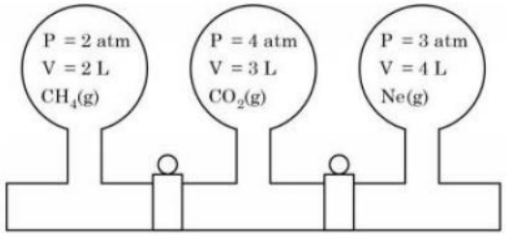
- The **polarising power of the anion** does not contribute to covalent character.

Quick Tip

Fajans' rule explains the percent covalent character of ionic bonds: small, highly charged cations and large, polarisable anions increase covalent character.

---

29. Three bulbs are filled with CH_4, CO_2, and Ne as shown in the picture. The bulbs are connected through pipes of zero volume. When the stopcocks are opened and the temperature is kept constant throughout, the pressure of the system is found to be _____ atm. (Nearest integer)



Correct Answer: 3

Solution:

The final pressure of the system, P_f, is calculated using Dalton's law:

$$P_f V_f = P_1 V_1 + P_2 V_2 + P_3 V_3$$

Given:

$$P_1 = 2\,\text{atm},\ V_1 = 2\,\text{L},\ P_2 = 4\,\text{atm},\ V_2 = 3\,\text{L},\ P_3 = 3\,\text{atm},\ V_3 = 4\,\text{L}$$

Total volume:

$$V_f = V_1 + V_2 + V_3 = 2 + 3 + 4 = 9\,\text{L}$$

Total pressure contribution:

$$P_f V_f = (2 \times 2) + (4 \times 3) + (3 \times 4) = 4 + 12 + 12 = 28\,\text{atm.L}$$

Final pressure:

$$P_f = \frac{28}{9} \approx 3.11\,\text{atm}$$

Thus, $P_f \approx 3$ atm.

Quick Tip

To calculate final pressure in a connected system, use Dalton's law of partial pressures and the total volume.

---

30. The number of given statements/s which is/are correct is _____:

(A) The stronger the temperature dependence of the rate constant, the higher is the activation energy.

(B) If a reaction has zero activation energy, its rate is independent of temperature.

(C) The stronger the temperature dependence of the rate constant, the smaller is the activation energy.

(D) If there is no correlation between the temperature and the rate constant, then it means that the reaction has negative activation energy.

Correct Answer: 2

Solution:

Let us analyze each statement:

(A) **Correct:** A higher activation energy implies a stronger dependence of the rate constant on temperature, as seen in the Arrhenius equation:

$$k = Ae^{-E_a/RT}$$

(B) **Correct:** If $E_a = 0$, the rate constant k is temperature independent.

(C) **Incorrect:** A smaller activation energy results in weaker temperature dependence of the rate constant.

(D) **Incorrect:** No correlation between temperature and rate constant does not imply negative activation energy.

Quick Tip

The Arrhenius equation relates the rate constant to activation energy and temperature. High activation energy indicates strong temperature dependence.
