JEE Main 2023 29 Jan Shift 2 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. Given below are two statements:

Statement I: The decrease in first ionization enthalpy from B to Al is much larger than that from Al to Ga.

Statement II: The *d* orbitals in Ga are completely filled.

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

(1) Statement I is incorrect but statement II is correct.

(2) Both the statements I and II are correct

(3) Statement I is correct but statement II is incorrect

(4) Both the statements I and II are incorrect

Correct Answer: (2) Both the statements I and II are correct.

Solution:

Statement I is correct because the decrease in ionization enthalpy from B to Al is influenced by the addition of a new electron shell, which increases shielding, causing a significant drop in ionization energy. However, from Al to Ga, the decrease is smaller due to the poor shielding effect of *d*-electrons, leading to only a slight decrease in ionization enthalpy.

Statement II is also correct because in Ga, the *d* orbitals (3d) are completely filled, contributing to the slight decrease in ionization energy.

Quick Tip

Ionization energy generally decreases down a group, but anomalies may arise due to poor shielding by *d* and *f*-orbitals.

---

2. Correct order of spin-only magnetic moment of the following complex ions is:

(Given At. No. Fe: 26, Co: 27)

(1) $[FeF_6]^{3-} > [CoF_6]^{3-} > [Co(C_2O_4)_3]^{3-}$

(2) $[Co(C_2O_4)_3]^{3-} > [CoF_6]^{3-} > [FeF_6]^{3-}$

(3) $[FeF_6]^{3-} > [Co(C_2O_4)_3]^{3-} > [CoF_6]^{3-}$

(4) $[CoF_6]^{3-} > [FeF_6]^{3-} > [Co(C_2O_4)_3]^{3-}$

Correct Answer: (1) $[FeF_6]^{3-} > [CoF_6]^{3-} > [Co(C_2O_4)_3]^{3-}$

Solution:

The spin-only magnetic moment depends on the number of unpaired electrons. For $[FeF_6]^{3-}$, Fe^{3+} has 5 unpaired electrons, resulting in the highest magnetic moment. For $[CoF_6]^{3-}$, Co^{3+} in a weak field ligand (fluoride) has 4 unpaired electrons. For $[Co(C_2O_4)_3]^{3-}$, Co^{3+} in a strong field ligand (oxalate) has 0 unpaired electrons. Thus, the order of magnetic moment is $[FeF_6]^{3-} > [CoF_6]^{3-} > [Co(C_2O_4)_3]^{3-}$.

Quick Tip

Magnetic moment (μ) is calculated using the formula $\mu = \sqrt{n(n+2)}$, where n is the number of unpaired electrons.

---

3. Match List-I and List-II:

List-I	List-II
A. Osmosis	I. Solvent molecules pass through semi-permeable membrane towards solvent side.
B. Reverse osmosis	II. Movement of charged colloidal particles under the influence of applied electric potential towards oppositely charged electrodes.
C. Electro osmosis	III. Solvent molecules pass through semi-permeable membrane towards solution side.
D. Electrophoresis	IV. Dispersion medium moves in an electric field.

Choose the correct answer from the options given below:

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

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

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

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

Correct Answer: (2) A-III, B-I, C-IV, D-II

Solution:

- Osmosis: The movement of solvent molecules through a semi-permeable membrane towards a solution side (III).

- Reverse Osmosis: Solvent molecules are forced in the reverse direction, from the solution side to the solvent side, under applied pressure (I).

- Electro osmosis: The dispersion medium moves under the effect of an electric field (IV)

- Electrophoresis: Charged colloidal particles move under the influence of an electric potential to oppositely charged electrodes (II).

Hence, the correct match is A-III, B-I, C-IV, D-II.

Quick Tip

In electrochemical processes, remember that particle movement depends on the charge and the electric potential applied.

4. The set of correct statements is:

(i) Manganese exhibits +7 oxidation state in its oxide.

(ii) Ruthenium and Osmium exhibit +8 oxidation states in their oxides.

(iii) Sc shows +4 oxidation state which is oxidizing in nature.

(iv) Cr shows oxidizing nature in +6 oxidation state.

(1) (i) and (iii)

(2) (i), (ii) and (iv)

(3) (i) and (iii)

(4) (ii), (iii) and (iv)

Correct Answer: (2) (i), (ii) and (iv)

Solution:

- (i) Manganese exhibits a +7 oxidation state in its oxide (Mn_2O_7), which is correct.

- (ii) Ruthenium (Ru) and Osmium (Os) exhibit a +8 oxidation state in their respective oxides (RuO_4, OsO_4), making this statement correct.

- (iii) Scandium (Sc) does not show a +4 oxidation state; it only shows a +3 oxidation state in most of its compounds. Hence, this is incorrect.

- (iv) Chromium (Cr) in the +6 oxidation state, such as in CrO_3, exhibits strong oxidizing

behavior. This makes the statement correct.

Thus, the correct set of statements is (i), (ii), and (iv).

Quick Tip

Transition elements often exhibit multiple oxidation states. Pay attention to group trends and stability of oxidation states.

---

5. Match List-I and List-II:

List-I	List-II
A. Elastomeric polymer	I. Urea formaldehyde resin
B. Fibre polymer	II. Polystyrene
C. Thermosetting polymer	III. Polyester
D. Thermoplastic polymer	IV. Neoprene

Options:

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

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

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

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

Correct Answer: (3) A-IV, B-III, C-I, D-II

Solution:

- Neoprene is a synthetic rubber, making it an elastomeric polymer. (A-IV)
- Polyester is a strong and durable material often used as a fibre polymer. (B-III)
- Urea formaldehyde resin is a thermosetting polymer that hardens irreversibly. (C-I)
- Polystyrene is a thermoplastic polymer, which can be reshaped with heat. (D-II)

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

Quick Tip

Understand the properties and applications of polymer types to differentiate between elastomers, fibres, thermoplastics, and thermosetting polymers.

---

6. An indicator 'X' is used for studying the effect of variation in concentration of iodide on the rate of reaction of iodide ion with H_2O_2 at room temperature. The indicator 'X' forms blue colored complex with compound 'A' present in the solution. The indicator 'X' and compound 'A' respectively are:

(1) Starch and iodine

(2) Methyl orange and H_2O_2

(3) Starch and H_2O_2

(4) Methyl orange and iodine

Correct Answer: (1) Starch and iodine

Solution:

In this reaction, iodine (I_2) is produced as a product when I^- reacts with H_2O_2. Starch is commonly used as an indicator because it forms a blue-colored complex with iodine. The reaction steps are as follows:

$$I^- + H_2O_2 \rightarrow I_2 + H_2O$$

$$I_2 + \text{Starch} \rightarrow \text{Blue complex}$$

Thus, the indicator is starch, and the compound forming the blue complex is iodine.

Quick Tip

Starch is a specific indicator for iodine, producing a characteristic blue-black complex.

---

7. A doctor prescribed the drug Equanil to a patient. The patient was likely to have symptoms of which disease?

(1) Stomach ulcers

(2) Hyperacidity

(3) Anxiety and stress

(4) Depression and hypertension

Correct Answer: (4) Depression and hypertension

Solution:

Equanil is a drug that is used as a tranquilizer. It helps in the treatment of anxiety,

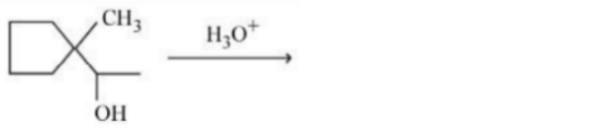
depression, and related disorders such as hypertension caused by stress. It acts by calming the central nervous system and stabilizing mood swings.

Quick Tip

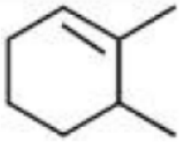
Remember that tranquilizers like Equanil are prescribed for mental health conditions involving anxiety, stress, or depression.

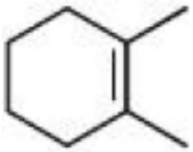
---

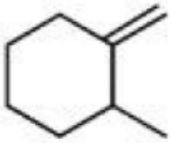
8. Find out the major product for the following reaction:



→ Major Product

(1) 

(2) 

(3) 

(4) 

Correct Answer: (2)

Solution:

The reaction involves the dehydration of a secondary alcohol to form an alkene. Under acidic conditions (H_2O^+), the $-OH$ group is protonated and leaves as water, forming a carbocation intermediate. The major product is determined by the stability of the alkene. In this case, the more substituted alkene (Zaitsev's rule) is the major product. The reaction mechanism is as follows:

1. Protonation of the alcohol group.
2. Loss of water to form a carbocation.
3. Elimination of a proton to form the alkene.

Thus, the major product is the one with the double bond in the more substituted position.

Quick Tip

Follow Zaitsev's rule: the major product of elimination is the more substituted, stable alkene.

---

9. The one giving maximum number of isomeric alkenes on dehydrohalogenation reaction is (excluding rearrangement):

(1) 1-Bromo-2-methylbutane

(2) 2-Bromopropane

(3) 2-Bromopentane

(4) 2-Bromo-3,3-dimethylpentane

Correct Answer: (3) 2-Bromopentane

Solution:

Dehydrohalogenation involves the elimination of HBr to form alkenes. The number of isomeric alkenes depends on the number of different β-hydrogens that can be removed.

For 2-Bromopentane, two different β-carbons are available, leading to the formation of multiple alkenes (e.g., pent-1-ene and pent-2-ene). Additionally, pent-2-ene can exist as cis and trans isomers, giving a total of three isomeric alkenes.

For the other options:

- 1-Bromo-2-methylbutane and 2-Bromo-3,3-dimethylpentane have only one possible elimination product.

- 2-Bromopropane gives only one product (propene).

Quick Tip

Identify β-hydrogens in the molecule to determine the number of possible elimination products.

---

10. When a hydrocarbon A undergoes combustion in the presence of air, it requires 9.5 equivalents of oxygen and produces 3 equivalents of water. What is the molecular

formula of A?

(1) C_8H_6

(2) C_9H_9

(3) C_6H_6

(4) C_9H_6

Correct Answer: (1) C_8H_6

Solution:

The combustion reaction can be represented as:

$$C_xH_y + O_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$$

Given that 9.5 moles of O_2 are required and 3 moles of water are produced, we can set up the following equations:

- $\frac{y}{2} = 3 \implies y = 6$

- $x + \frac{y}{4} = 9.5 \implies x + \frac{6}{4} = 9.5 \implies x = 8$

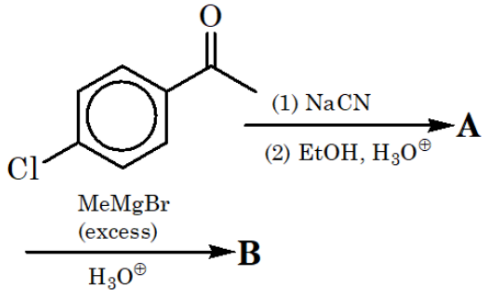
Thus, the molecular formula of the hydrocarbon is C_8H_6. This corresponds to an alkyne or aromatic compound.

Quick Tip

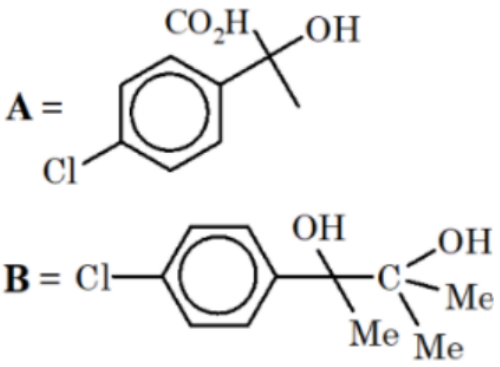
Balance the combustion reaction by relating oxygen consumption and water/CO_2 production to deduce the molecular formula.

---

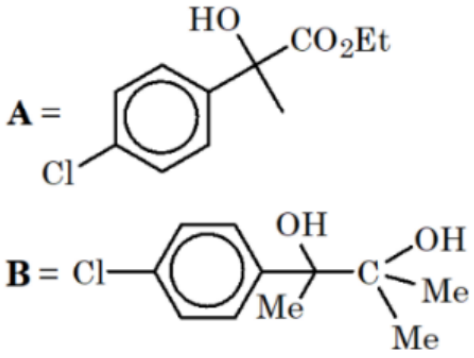
11. Find out the major products from the following reaction sequence:



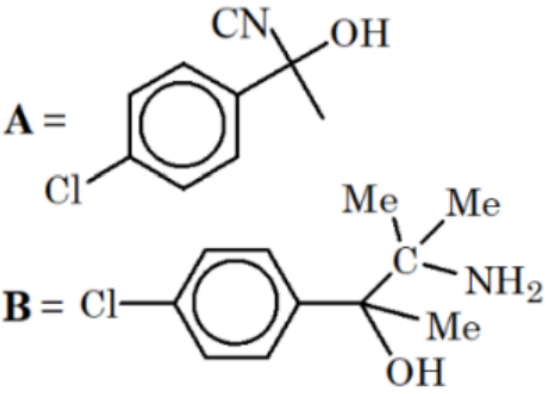
(A)


A =
CO2H
OH
Cl
B = Cl
OH
OH
C
Me
Me
Me

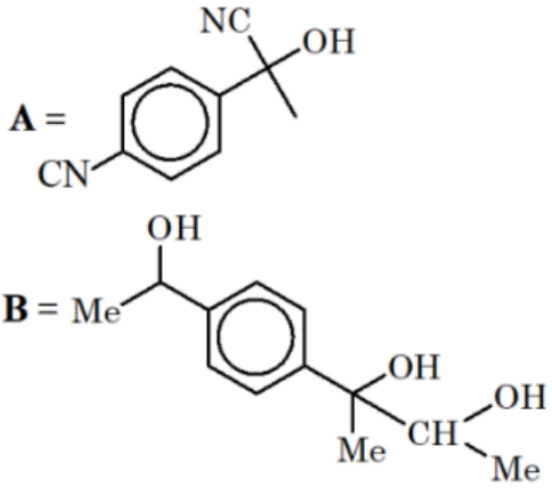
(B)


A =
HO
CO2Et
Cl
B = Cl
OH
OH
C
Me
Me
Me

(C)


A =
CN
OH
Cl
B = Cl
Me
Me
C
NH2
Me
OH

(D)


A =
NC
OH
CN
B = Me
OH
OH
OH
CH
Me
Me

Correct Answer: (2)

Solution:

The reaction proceeds as follows:

1. NaCN reacts with the carbonyl group to form a cyanohydrin (-CN and -OH groups on the same carbon).

2. Ethanol in the presence of H_2O^+ hydrolyzes the cyanohydrin to form a carboxylic acid group (-COOH) and retains the hydroxyl group.

Thus, the major products are as shown in option (2), where the carboxylic acid (-COOH) and hydroxyl (-OH) groups are appropriately positioned.

Quick Tip

Understand the reactivity of cyanohydrins and their hydrolysis products to predict major reaction outcomes.

---

12. According to MO theory, the bond orders for O_2^-, CO, and NO^+, respectively, are:

(1) 1, 3, and 3

(2) 1, 3, and 2

(3) 1, 2, and 3

(4) 2, 3, and 3

Correct Answer: (1) 1, 3, and 3

Solution:

The bond order (BO) is calculated using the molecular orbital (MO) theory formula:

$$\text{BO} = \frac{\text{(Number of bonding electrons - Number of antibonding electrons)}}{2}$$

- For O_2^-: Adding one electron to O_2 decreases the bond order from 2 to 1.

- For CO: The bond order remains 3 because of strong triple bonding.

- For NO^+: Removal of one electron from NO increases the bond order from 2.5 to 3.

Thus, the bond orders are 1, 3, and 3, respectively.

Quick Tip

For molecular ions, the addition of electrons decreases the bond order, while electron removal increases it.

---

13. A solution of CrO_3 in amyl alcohol has a ... colour:

(1) Green

(2) Orange-Red

(3) Yellow

(4) Blue

Correct Answer: (4) Blue

Solution:

CrO_3 (chromium trioxide) in amyl alcohol forms a blue complex. This is characteristic of certain chromium compounds when dissolved in organic solvents. The blue colour indicates the formation of a coordination compound involving chromium.

Quick Tip

The colour of chromium compounds is an important qualitative test for its oxidation states and complex formation.

---

14. The concentration of dissolved oxygen in water for growth of fish should be more than X ppm, and biochemical oxygen demand in clean water should be less than Y ppm. X and Y in ppm are respectively:

(1) X Y
6 5

(2) X Y
4 8

(3) X Y
4 15

(4) X Y
6 12

Correct Answer: (1) X Y

6 5

Solution:

The dissolved oxygen (DO) in water is an essential parameter for the survival of aquatic organisms. Fish and other aquatic species depend on adequate oxygen levels to carry out cellular respiration and maintain metabolic processes. In general:

- For healthy growth and reproduction of fish, the dissolved oxygen concentration must be above 6 ppm.
- Levels below 4 ppm can cause stress, and prolonged exposure to such conditions may be lethal to most fish species.

On the other hand, biochemical oxygen demand (BOD) measures the oxygen consumed by microorganisms while decomposing organic matter in the water. It serves as an indirect indicator of the level of organic pollution:

- For clean water, BOD values should remain below 5 ppm.
- Higher BOD levels indicate the presence of excess organic matter, leading to oxygen depletion, which adversely affects aquatic life.

Why X = 6 ppm and Y = 5 ppm?

1. Dissolved oxygen levels above 6 ppm ensure a favorable environment for fish, supporting their growth, activity, and reproduction.
2. A BOD below 5 ppm reflects clean water, indicating minimal pollution and sufficient oxygen for aquatic organisms.

Thus, the correct values for X and Y are 6 ppm and 5 ppm, respectively.

Quick Tip

Dissolved oxygen levels above 4 ppm and low BOD values are critical for maintaining healthy aquatic ecosystems.

---

15. Reaction of propanamide with Br_2/KOH (aq) produces:

(1) Ethyl nitrile

(2) Propylamine

(3) Propanenitrile

(4) Ethylamine

Correct Answer: (4) Ethylamine

Solution:

This reaction is the Hofmann bromamide reaction, where amides are converted to primary amines with one fewer carbon atom. For propanamide ($CH_3CH_2CONH_2$):

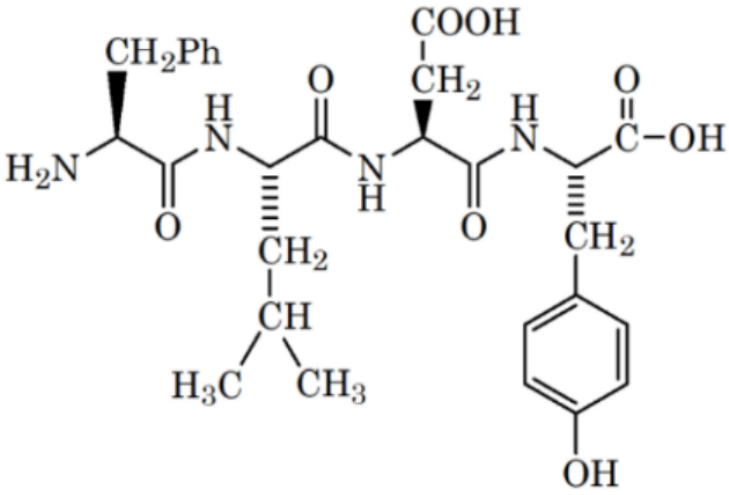
$$CH_3CH_2CONH_2 \xrightarrow{Br_2/KOH} CH_3CH_2NH_2(\text{Ethylamine})$$

Quick Tip

In the Hofmann bromamide reaction, the product has one less carbon than the starting amide.

---

16. Following tetrapeptide can be represented as:



(F, L, D, Y, I, Q, P are one-letter codes for amino acids)

(1) FIQY

(2) FLDY

(3) YQLF

(4) PLDY

Correct Answer: (2) FLDY

Solution:

The given tetrapeptide contains the following amino acid residues:

- Phenylalanine (F)

- Leucine (L)

- Aspartic acid (D)

- Tyrosine (Y)

Thus, the sequence of amino acids is FLDY.

Quick Tip

Learn the one-letter codes for amino acids to identify peptide sequences quickly.

---

17. Which of the following relations are correct?

(A) $\Delta U = q + p\Delta V$

(B) $G = H - TS$

(C) $\Delta S = \frac{q_{\text{rev}}}{T}$

(D) $\Delta H = \Delta U - nRT$

Choose the most appropriate answer from the options given below:

(1) C and D only

(2) B and C only

(3) A and B only

(4) B and D only

Correct Answer: (2) B and C only

Solution:

- (A) $\Delta U = q + p\Delta V$ is incorrect because the first law of thermodynamics states $\Delta U = q + w$, where $w = -p\Delta V$. Hence, the correct relation is $\Delta U = q - p\Delta V$.

- (B) $G = H - TS$ is correct, as it is the definition of Gibbs free energy (G).

- (C) $\Delta S = \frac{q_{\text{rev}}}{T}$ is correct, as it represents the change in entropy (S) under reversible conditions.

- (D) $\Delta H = \Delta U - nRT$ is incorrect because for an ideal gas, $\Delta H = \Delta U + nRT$.

Quick Tip

Remember that $\Delta U = q + w$, where $w = -p\Delta V$, and $\Delta H = \Delta U + nRT$ for ideal gases.

18. The major component of which of the following ore is sulphide based mineral?

(1) Calamine

(2) Siderite

(3) Sphalerite

(4) Malachite

Correct Answer: (3) Sphalerite

Solution:

- Calamine ($ZnCO_3$) is a carbonate-based mineral.

- Siderite ($FeCO_3$) is an iron carbonate mineral.

- Sphalerite (ZnS) is a sulphide-based mineral, making it the correct answer.

- Malachite ($Cu_2CO_3(OH)_2$) is a copper carbonate hydroxide mineral.

Quick Tip

Sphalerite (ZnS) is a sulphide ore commonly associated with zinc extraction.

---

19. Given below are two statements:

Statement I: Nickel is being used as the catalyst for producing syn gas and edible fats.

Statement II: Silicon forms both electron-rich and electron-deficient hydrides.

Choose the most appropriate answer from the options given below:

(1) Both the statements I and II are correct

(2) Statement I is incorrect but statement II is correct

(3) Both the statements I and II are incorrect

(4) Statement I is correct but statement II is incorrect

Correct Answer: (4) Statement I is correct but statement II is incorrect

Solution:

- Statement I is correct because nickel is widely used as a catalyst in hydrogenation reactions for producing edible fats (like margarine) and in the production of synthesis gas (syn gas).

- Statement II is incorrect as hydrides of silicon (SiH_4) are electron-precise and neither electron-rich nor electron-deficient.

Quick Tip

Silicon hydrides are electron-precise, unlike boron hydrides, which can be electron-deficient.

---

20. Match List I with List II:

List I	List II
A. van't Hoff factor, i	I. Cryoscopic constant
B. k_f	II. Isotonic solutions
C. Solutions with same osmotic pressure	III. Normal molar mass / Abnormal Mass
D. Azeotropes	IV. Solutions with same composition of vapour above it

Choose the correct answer from the options given below:

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

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

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

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

Correct Answer: (1) A-III, B-I, C-II, D-IV

Solution:

- i (van't Hoff factor) is associated with the abnormal molar mass (M_{ab}), making A-III correct.

- k_f (cryoscopic constant) relates to the depression of freezing point, making B-I correct.

- Solutions with the same osmotic pressure are isotonic solutions, making C-II correct.

- Azeotropes are solutions with the same composition in both the liquid and vapour phases, making D-IV correct.

Quick Tip

Understand colligative properties and their relation to the van't Hoff factor and isotonic solutions for better accuracy.

---

21. On heating, $LiNO_3$ gives how many compounds among the following? Li_2O, N_2, O_2, $LiNO_2$, NO_2

Correct Answer: (3)

Solution:

The decomposition of lithium nitrate ($LiNO_3$) is as follows:

$$2LiNO_3 \rightarrow 2Li_2O + 2NO_2 + \frac{1}{2}O_2$$

The reaction produces three compounds: Li_2O, NO_2, and O_2.

Quick Tip

Thermal decomposition of nitrates often produces oxides, nitrogen oxides, and oxygen depending on the metal.

---

22. At 298 K:

$$N_2 + 3H_2 \rightleftharpoons 2NH_3,\ K_1 = 4 \times 10^5$$

$$N_2 + O_2 \rightleftharpoons 2NO,\ K_2 = 1.6 \times 10^{12}$$

$$H_2 + \frac{1}{2}O_2 \rightleftharpoons H_2O,\ K_3 = 1.0 \times 10^{13}$$

Based on the above equilibria, the equilibrium constant of the reaction:

$$2NH_3 + \frac{5}{2}O_2 \rightleftharpoons 2NO + 3H_2O$$

is $\ldots \times 10^{-33}$ (nearest integer).

Correct Answer: (4)

Solution:

The equilibrium constant for the given reaction is calculated by combining the given equilibria:

$$K_{eq} = \frac{K_2 \times K_3^3}{K_1}$$

Substituting the values:

$$K_{eq} = \frac{(1.6 \times 10^{12}) \times (1.0 \times 10^{13})^3}{4 \times 10^5}$$

$$K_{eq} = \frac{1.6 \times 10^{12} \times 10^{39}}{4 \times 10^5} = 4 \times 10^{33}$$

Quick Tip

For combined equilibria, multiply or divide the equilibrium constants based on how the reactions are combined.

---

23. For conversion of compound A $\rightarrow$ B, the rate constant of the reaction was found to be 4.6×10^{-5} L mol^{-1} s^{-1}. The order of the reaction is ...

Correct Answer: (2)

Solution:

The unit of the rate constant is given as $L\,\text{mol}^{-1}\,\text{s}^{-1}$, which corresponds to a second-order reaction. The general formula for the unit of a rate constant is:

$$\text{Unit of } k = (\text{concentration})^{1-n} \times \text{time}^{-1}$$

where n is the order of the reaction. For $n = 2$, the unit becomes $L\,\text{mol}^{-1}\,\text{s}^{-1}$.

Quick Tip

The units of the rate constant can be used to quickly determine the order of the reaction.

---

24. Total number of acidic oxides among N_2O_3, NO, N_2O, Cl_2O_7, SO_2, CO, CaO, Na_2O and NO_2 is ...

Correct Answer: (4)

Solution:

Acidic oxides react with water to form acids. Among the given oxides: - Acidic oxides: N_2O_3, Cl_2O_7, SO_2, NO_2 - Neutral oxides: NO, N_2O, CO - Basic oxides: CaO, Na_2O

Thus, there are 4 acidic oxides.

Quick Tip

Classify oxides as acidic, basic, or neutral based on their reaction with water and acids/bases.

---

25. When 0.01 mol of an organic compound containing 60% carbon was burnt

completely, 4.4 g of CO_2 was produced. The molar mass of the compound is ... g mol^{-1} (nearest integer).

Correct Answer: (200)

Solution:

- Mass of carbon in the compound:

$$0.01 \times \frac{60}{100} = 0.006\,\text{g}$$

- Moles of CO_2 produced:

$$\frac{4.4}{44} = 0.1\,\text{mol}$$

- Mass of carbon in CO_2:

$$0.1 \times 12 = 1.2\,\text{g}$$

- The molar mass M of the compound:

$$M = \frac{\text{mass of compound}}{\text{moles of compound}} = \frac{0.01}{0.006} \times 12 = 200\,\text{g/mol}$$

Quick Tip

Relate the mass and moles of carbon to deduce the molar mass using the percentage composition.

---

26. The denticity of the ligand present in Fehling's reagent is ...

Correct Answer: (4)

Solution:

Fehling's reagent contains Cu^{2+} ions complexed with tartrate ions. Tartrate is a bidentate ligand as it binds to the metal through two donor atoms.

Quick Tip

The denticity of a ligand refers to the number of donor atoms through which it binds to a metal ion.

---

27. A metal M forms hexagonal close-packed structure. The total number of voids in 0.02 mol of it is $\ldots \times 10^{21}$ **(Nearest integer). (Given** $N_A = 6.02 \times 10^{23}$**)**

Correct Answer: (36)

Solution:

- One unit cell of hcp contains 18 voids.

- Total number of voids in 0.02 mol of hcp:

$$\text{No. of voids} = 18 \times 6.02 \times 10^{23} \times 0.02$$

$$= 3.6 \times 10^{21}$$

Quick Tip

In a hexagonal close-packed structure (hcp), the voids are always proportional to the number of atoms.

---

28. Assume that the radius of the first Bohr orbit of hydrogen atom is 0.6 Å. The radius of the third Bohr orbit of He^+ is ... picometer (Nearest integer).

Correct Answer: (270)

Solution:

The radius of the n-th Bohr orbit is given by:

$$r_n = r_1 \frac{n^2}{Z}$$

For $n = 3$ and $Z = 2$:

$$r_{He^+} = 0.6 \times \frac{3^2}{2} = 2.7\,\text{Å}$$

Converting to picometers:

$$2.7\,\text{Å} = 270\,\text{pm}$$

Quick Tip

For hydrogen-like atoms, the radius is inversely proportional to the nuclear charge (Z).

---

29. The equilibrium constant for the reaction:

$Zn(s) + Sn^{2+}(aq) \rightleftharpoons Zn^{2+}(aq) + Sn(s)$

is 1×10^{20} at 298 K. The magnitude of standard electrode potential of Sn^{2+}/Sn if $E^\circ_{Zn^{2+}/Zn} = -0.76\,\text{V}$ is ... $\times 10^{-2}$ V (Nearest integer).

Correct Answer: (17)

Solution:

The equilibrium constant is related to the electrode potentials:

$$\Delta G^\circ = -nFE^\circ = -2.303RT \log K$$

$$E^\circ_{\text{cell}} = \frac{0.059}{2} \log K$$

Substituting $K = 1 \times 10^{20}$:

$$E^\circ_{\text{cell}} = \frac{0.059}{2} \log(1 \times 10^{20}) = 0.059 \times 10 = 0.59\,\text{V}$$

Using $E^\circ_{\text{cell}} = E^\circ_{\text{Sn}^{2+}/\text{Sn}} - E^\circ_{\text{Zn}^{2+}/\text{Zn}}$:

$$0.59 = E^\circ_{\text{Sn}^{2+}/\text{Sn}} - (-0.76)$$

$$E^\circ_{\text{Sn}^{2+}/\text{Sn}} = 0.59 - 0.76 = 0.17\,\text{V} = 17 \times 10^{-2}\,\text{V}$$

Quick Tip

For electrochemical cells, use ΔG° or K_{eq} to find electrode potentials.

---

30. The volume of HCl containing 73 g L^{-1}, required to completely neutralize NaOH obtained by reacting 0.69 g of metallic sodium with water, is ... mL (Nearest integer).

Correct Answer: (15)

Solution:

Moles of Na:

$$\text{Moles of Na} = \frac{0.69}{23} = 3 \times 10^{-2}$$

$$\text{Na} + \text{H}_2\text{O} \rightarrow \text{NaOH} + \frac{1}{2}\text{H}_2$$

Moles of NaOH produced = 3×10^{-2}.

No. of equivalents of NaOH = No. of equivalents of HCl.

Mass of HCl = 73 g/L. Normality:

$$\text{Normality} = \frac{73}{36.5} = 2\,\text{N}$$

Using $\text{N}_1V_1 = \text{N}_2V_2$:

$$2 \times V = 3 \times 10^{-2} \quad \Rightarrow \quad V = 15\,\text{mL}$$

Quick Tip

Relate the moles of reactants to equivalents and use the concept of normality for neutralization reactions.
