BITSAT Chemistry Sample Paper-17

Duration: 40 Minutes **Maximum Marks: 90**

Instructions

- This paper contains **30** Multiple Choice Questions (Single Correct).
- Each correct answer carries **+3 marks**. Each incorrect answer carries **-1 mark**. Unattempted question carries **0 marks**.
- Only **one** option is correct for each question.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Q1. A hydrocarbon A on complete combustion produced carbon dioxide and water in the molar ratio 2:3. The vapour density of A was experimentally found to be 14 relative to hydrogen.

Further, when A was subjected to controlled catalytic hydrogenation, it absorbed exactly one mole of hydrogen per mole of A.

The molecular formula of hydrocarbon A is:

(A) C_2H_2

(B) C_2H_4

(C) C_3H_6

(D) C_4H_8

Q2. A photon of ultraviolet radiation ejects an electron from the surface of a metal. The kinetic energy of the emitted electron is observed to be exactly three times the work function of the metal.

If the threshold wavelength of the metal is λ_0, then the wavelength of incident radiation is:

(A) $\frac{\lambda_0}{2}$

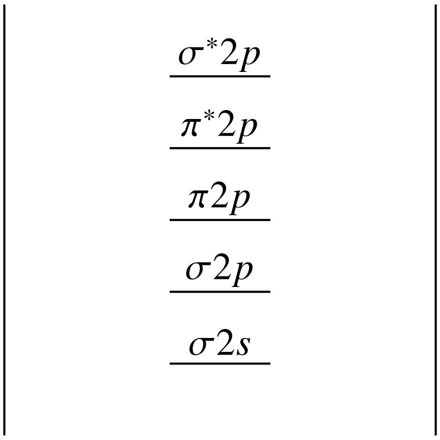
(B) $\frac{\lambda_0}{3}$

(C) $\dfrac{\lambda_0}{4}$

(D) $\dfrac{3\lambda_0}{4}$

Q3. The following schematic representation corresponds to the relative energies of molecular orbitals formed by overlap of 2p atomic orbitals.

The species having the maximum bond order among the following is:



(A) O_2

(B) O_2^-

(C) N_2

(D) B_2

Q4. A hypothetical atom has four electrons occupying degenerate p-orbitals according to Hund's rule.

The total number of unpaired electrons and the number of orbitals containing paired electrons respectively are:

(A) 2 and 1

(B) 4 and 0

(C) 3 and 0

(D) 2 and 0

Q5. The following species are arranged in order of increasing bond angle:

$$NH_3, \quad H_2O, \quad BF_3, \quad CH_4$$

The correct order is:

(A) $H_2O < NH_3 < CH_4 < BF_3$

(B) $NH_3 < H_2O < CH_4 < BF_3$

(C) $BF_3 < CH_4 < NH_3 < H_2O$

(D) $CH_4 < H_2O < NH_3 < BF_3$

Q6. A gaseous equilibrium was established inside a sealed container according to:

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

Initially, only PCl_5 was present at pressure P_0. At equilibrium, the total pressure was found to be $1.5P_0$.

The degree of dissociation of PCl_5 is:

(A) 25%

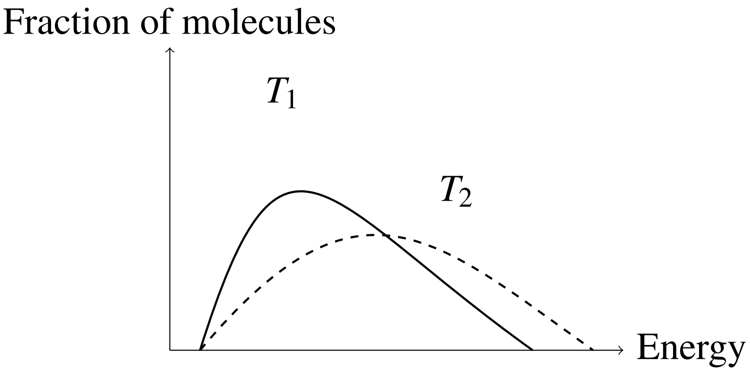
(B) 33.3%

(C) 50%

(D) 66.7%

Q7. The graph shown below represents the Maxwell-Boltzmann distribution of molecular energies at two different temperatures T_1 and T_2.

Identify the correct statement.



(A) $T_1 > T_2$

(B) Activation energy decreases at higher temperature

(C) Average kinetic energy is greater at T_2

(D) Fraction of molecules with high energy decreases at T_2

Q8. For the electrochemical cell:

$$Zn(s)|Zn^{2+}(0.01M)||Cu^{2+}(1M)|Cu(s)$$

Given:

$$E^\circ_{cell} = 1.10V$$

The cell potential at 298 K is closest to:

(A) 1.04 V

(B) 1.10 V

(C) 1.16 V

(D) 1.22 V

Q9. A first-order radioactive decay process has a half-life of 10 days.

Starting with a pure sample of 80 g, the amount remaining after 40 days will be:

(A) 40 g

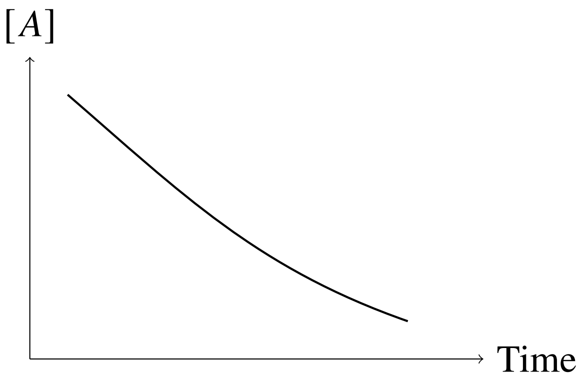
(B) 20 g

(C) 10 g

(D) 5 g

Q10. The variation of concentration of reactant A with time for a certain reaction is shown below.

The order of the reaction is:



(A) Zero order

(B) First order

(C) Second order

(D) Cannot be determined from graph

Q11. A solution was prepared by dissolving 0.5 mol of a non-volatile solute in exactly 1 kg of water.

If the observed elevation in boiling point was twice the expected value, the van't Hoff factor of the solute is:

(A) 0.5

(B) 1

(C) 2

(D) 4

Q12. The complex ion:

$$[Co(NH_3)_6]^{3+}$$

is diamagnetic in nature.

The oxidation state of cobalt and the number of unpaired electrons respectively are:

(A) +2 and 3

(B) +3 and 0

(C) +3 and 2

(D) +2 and 1

Q13. The major product formed during ozonolysis of the compound shown below followed by reductive workup is:

$$(CH_3)_2C = CHCH_3$$

(A) Acetone + Methanal

(B) Acetone + Ethanal

(C) Ethanal + Methanal

(D) Acetaldehyde only

Q14. A compound A with molecular formula C_3H_6O gives positive Tollens' test and undergoes aldol condensation.

The compound A is:

(A) Propanone

(B) Propanal

(C) Propanol

(D) Propanoic acid

Q15. The major product obtained when anisole reacts with concentrated HI under reflux conditions is:

(A) Phenol + Iodomethane

(B) Benzene + Methanol

(C) Iodobenzene + Methanol

(D) Phenol + Methanol

Q16. Which among the following compounds will exhibit optical isomerism?

(A) 2-Chloropropane

(B) 2-Butanol

(C) 2-Methylpropane

(D) Ethanol

Q17. The major product formed in the following reaction sequence is:

$$CH_3CH_2Br \xrightarrow{alc.KOH} A \xrightarrow{Br_2/CCl_4} B$$

(A) 1,2-dibromoethane

(B) Bromoethane

(C) Ethyne

(D) Ethanol

Q18. A face-centered cubic crystal structure contains atoms only at corners and face centers.

The total number of nearest neighbours surrounding each atom is:

(A) 4

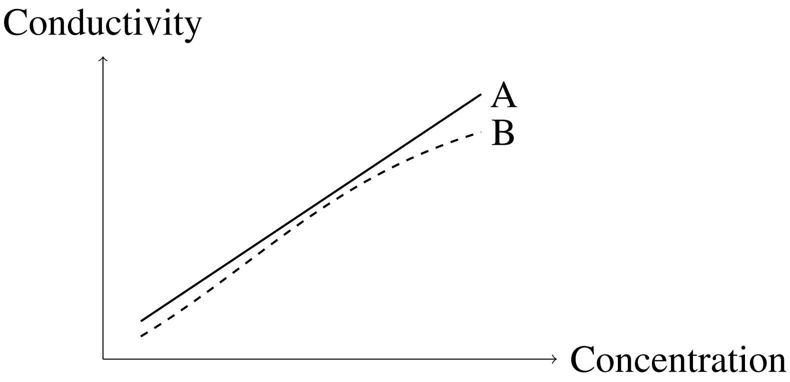
(B) 6

(C) 8

(D) 12

Q19. The graph below represents variation of electrical conductivity with concentration for two electrolytes A and B.

Identify A and B respectively.



(A) Strong electrolyte, Weak electrolyte

(B) Weak electrolyte, Strong electrolyte

(C) Both strong electrolytes

(D) Both weak electrolytes

Q20. The spin-only magnetic moment of a transition metal ion was experimentally found to be 4.90 BM.

The number of unpaired electrons present in the ion is:

(A) 2

(B) 3

(C) 4

(D) 5

Q21. The correct decreasing order of first ionization enthalpy among the following elements is:

$$N, \quad O, \quad F, \quad Ne$$

(A) Ne > F > N > O

(B) F > Ne > O > N

(C) Ne > O > F > N

(D) N > O > F > Ne

Q22. The major product formed during nitration of benzoic acid is:

(A) ortho-nitrobenzoic acid

(B) meta-nitrobenzoic acid

(C) para-nitrobenzoic acid

(D) 2,4-dinitrobenzoic acid

Q23. A primary amine when treated with nitrous acid at low temperature produces alcohol with evolution of nitrogen gas.

The amine is most likely:

(A) Aromatic primary amine

(B) Secondary amine

(C) Tertiary amine

(D) Aliphatic primary amine

Q24. The major product formed when glucose reacts with excess HI in presence of red phosphorus is:

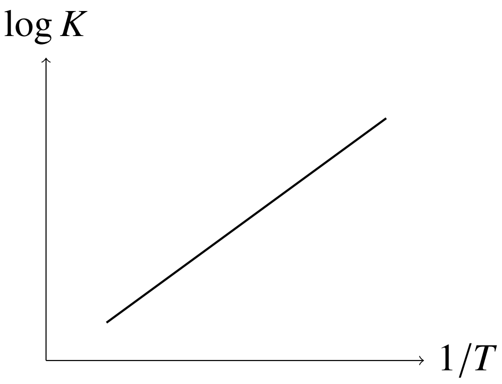
(A) Hexane

(B) Cyclohexane

(C) Hexanoic acid

(D) n-Hexanol

Q25. The following graphical variation corresponds to:



(A) Exothermic reaction

(B) Endothermic reaction

(C) Zero order reaction

(D) Adsorption isotherm

Q26. A polymer used extensively in making non-stick cookware has repeating unit:

$$(-CF_2 - CF_2-)_n$$

The monomer used in its preparation is:

(A) Vinyl fluoride

(B) Tetrafluoroethene

(C) Chloroethene

(D) Ethene

Q27. The percentage ionic character of a bond increases with:

(A) decrease in electronegativity difference

(B) increase in covalent character

(C) increase in electronegativity difference

(D) decrease in dipole moment

Q28. The number of stereoisomers possible for a compound having two asymmetric carbon atoms without any plane of symmetry is:

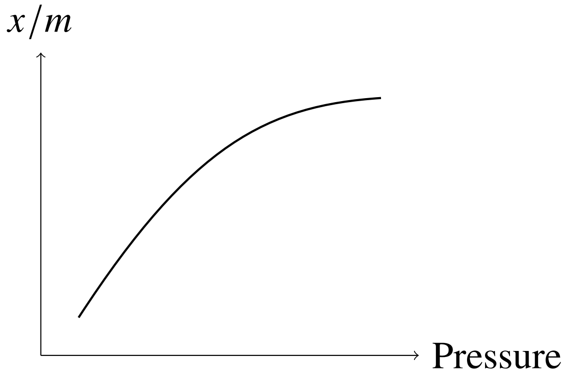
(A) 2

(B) 3

(C) 4

(D) 6

Q29. The following adsorption isotherm approaches saturation at high pressure. This behaviour is best explained by:



(A) Formation of multilayer adsorption

(B) Surface saturation by monolayer adsorption

(C) Increase in activation energy

(D) Chemical decomposition of adsorbate

Q30. The osmotic pressure of a solution was experimentally found to be lower than the theoretically expected value.

This observation can best be explained if the solute undergoes:

(A) dissociation

(B) ionization

(C) association

(D) hydration only

Detailed Solutions

Q1.

Solution

Concept: The molecular weight of a gaseous compound is twice its vapour density relative to hydrogen. Together with analysis of its addition reactions, such as catalytic hydrogenation, this determines the molecular formula of a hydrocarbon.

Solution:

Step 1:

$$\text{Molecular weight} = 2 \times \text{Vapour Density}$$

$$= 2 \times 14 = 28$$

Step 2: Let the hydrocarbon be C_xH_y.

$$12x + y = 28$$

For $x = 2$:

$$12(2) + y = 28 \Rightarrow y = 4$$

Hence, the hydrocarbon is:

$$C_2H_4$$

Step 3: Ethene undergoes catalytic hydrogenation:

$$C_2H_4 + H_2 \longrightarrow C_2H_6$$

Thus, the compound is **ethene**.

$$\boxed{C_2H_4}$$

Final Answer: $\boxed{C_2H_4}$

Answer: (B)

Go Back to Question 1

Q2.

Solution

Concept: The photoelectric effect is described by Einstein's photoelectric equation:

$$E = \Phi + \text{K.E.}$$

where E is the energy of the incident photon, Φ is the work function of the metal, and K.E. is the kinetic energy of the emitted electron.

Solution: Step 1: Relate the kinetic energy to the work function. The problem states that the kinetic energy of the emitted electron is exactly three times the work function of the metal:

$$\text{K.E.} = 3\Phi$$

Step 2: Express the incident photon energy in terms of the work function. Substitute this relation into Einstein's photoelectric equation:

$$E = \Phi + 3\Phi = 4\Phi$$

Step 3: Relate energy to wavelength. The energy of a photon of wavelength λ is:

$$E = \frac{hc}{\lambda}$$

The work function in terms of the threshold wavelength λ_0 is:

$$\Phi = \frac{hc}{\lambda_0}$$

Step 4: Solve for the incident wavelength λ. Substitute the energy expressions into the relation $E = 4\Phi$:

$$\frac{hc}{\lambda} = 4\left(\frac{hc}{\lambda_0}\right)$$

Dividing both sides by hc:

$$\frac{1}{\lambda} = \frac{4}{\lambda_0} \implies \lambda = \frac{\lambda_0}{4}$$

Thus, the wavelength of the incident radiation is $\frac{\lambda_0}{4}$.

Final Answer: $\boxed{\frac{\lambda_0}{4}}$

Answer: (C)

Go Back to Question 2

Q3.

Solution

Concept: According to Molecular Orbital (MO) Theory, the bond order of a homonuclear diatomic species is calculated as:

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

where N_b is the number of bonding electrons and N_a is the number of anti-bonding electrons.

Solution:

- **N_2**:

$$\text{Bond Order} = \frac{10-4}{2} = 3$$

- **O_2**:

$$\text{Bond Order} = \frac{10-6}{2} = 2$$

- **O_2^-**:

$$\text{Bond Order} = \frac{10-7}{2} = 1.5$$

- **B_2**:

$$\text{Bond Order} = \frac{6-4}{2} = 1$$

$$\text{Bond order: } N_2 > O_2 > O_2^- > B_2$$

Step 2: Compare the bond orders.

$$\text{Bond Order}(N_2) = 3 > \text{Bond Order}(O_2) = 2 > \text{Bond Order}(O_2^-) = 1.5 > \text{Bond Order}(B_2) = 1$$

Thus, N_2 has the maximum bond order.

Final Answer: $\boxed{N_2}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 3

Q4.

Solution

Concept: Hund's Rule of Maximum Multiplicity states that in degenerate orbitals, electrons singly occupy each orbital with parallel spins before any pairing occurs.

Solution: Step 1: Understand the degenerate p-orbitals. There are three degenerate p-orbitals: p_x, p_y, and p_z.
Step 2: Distribute the 4 electrons in these orbitals according to Hund's rule.

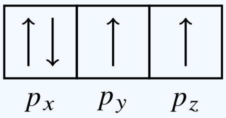
- First, 3 electrons occupy each of the three orbitals singly with parallel spins:

$$\text{Orbital occupancy: } p_x^1\, p_y^1\, p_z^1 \implies (\uparrow)\,(\uparrow)\,(\uparrow)$$

- The 4th electron must pair with one of the existing electrons in one of the orbitals (for example, p_x):

$$\text{Orbital occupancy: } p_x^2\, p_y^1\, p_z^1 \implies (\uparrow\downarrow)\,(\uparrow)\,(\uparrow)$$

Step 3: Count the paired and unpaired electrons. We can visualize this distribution using the diagram below:



From this arrangement:

- The total number of unpaired electrons is **2** (one each in p_y and p_z).
- The number of orbitals containing paired electrons is **1** (the p_x orbital).

Thus, the total number of unpaired electrons and the number of orbitals containing paired electrons respectively are 2 and 1.

Final Answer: $\boxed{\text{2 and 1}}$

Answer: (A)

Go Back to Question 4

Q5.

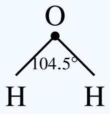
Solution

Concept: According to Valence Shell Electron Pair Repulsion (VSEPR) theory, molecular geometries and bond angles are determined by the repulsion between electron pairs around the central atom. The repulsive strength decreases in the order:

lone pair - lone pair (lp-lp) > lone pair - bond pair (lp-bp) > bond pair - bond pair (bp-bp)

Solution:

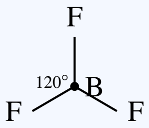
(a) **H_2O**: sp^3 hybridized with 2 lone pairs. Bond angle = 104.5°



(b) **NH_3**: sp^3 hybridized with 1 lone pair. Bond angle = 107°

(c) **CH_4**: Tetrahedral geometry. Bond angle = 109.5°

(d) **BF_3**: Trigonal planar geometry. Bond angle = 120°



Final Answer: $\boxed{H_2O < NH_3 < CH_4 < BF_3}$

Answer: (A)

Go Back to Question 5

Q6.

Solution

Concept: The degree of dissociation (α) is the fraction of a reactant that dissociates under equilibrium conditions. For a gaseous reaction, the equilibrium partial pressures can be expressed in terms of α and the initial pressure.

Solution: Step 1: Set up the equilibrium table in terms of partial pressures. Consider the dissociation of $PCl_5(g)$:

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

Let P_0 be the initial pressure of PCl_5. Let α be its degree of dissociation.

	$PCl_5(g)$	$\rightleftharpoons$	$PCl_3(g)$	$+$	$Cl_2(g)$
Initial Pressure:	P_0		0		0
Change:	$-P_0\alpha$		$+P_0\alpha$		$+P_0\alpha$
Equilibrium Pressure:	$P_0(1-\alpha)$		$P_0\alpha$		$P_0\alpha$

Step 2: Express the total pressure at equilibrium. The total pressure at equilibrium (P_{total}) is the sum of the partial pressures of all gaseous species:

$$P_{\text{total}} = P_{PCl_5} + P_{PCl_3} + P_{Cl_2}$$

$$P_{\text{total}} = P_0(1-\alpha) + P_0\alpha + P_0\alpha$$

$$P_{\text{total}} = P_0(1+\alpha)$$

Step 3: Solve for the degree of dissociation (α). We are given that the total equilibrium pressure is $1.5P_0$:

$$P_0(1+\alpha) = 1.5P_0$$

Dividing both sides by P_0:

$$1 + \alpha = 1.5 \implies \alpha = 0.5$$

Step 4: Express the degree of dissociation as a percentage.

$$\text{Percentage dissociation} = \alpha \times 100\% = 0.5 \times 100\% = 50\%$$

Thus, the degree of dissociation of PCl_5 is 50%.

Final Answer: $\boxed{50\%}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 6

Q7.

Solution

Concept: The Maxwell-Boltzmann distribution shows the distribution of molecular speeds or kinetic energies in a gas at a given temperature. Temperature is a direct measure of the average kinetic energy of the molecules.

Solution: Step 1: Determine the relative temperatures T_1 and T_2 from the graph. As temperature increases, the average kinetic energy of the molecules increases. This shifts the peak of the Maxwell-Boltzmann distribution curve to the right (higher energy) and makes the curve flatter (lower peak height) because the total area under the curve must remain constant (representing a total probability fraction of 1). Comparing the curves:

- The curve for T_2 is shifted to the right and is flatter than the curve for T_1.
- This directly implies that $T_2 > T_1$. Thus, option A is incorrect.

Step 2: Evaluate the statement about activation energy (E_a).
The activation energy (E_a) is the minimum energy required for a chemical reaction to occur. It is an intrinsic characteristic of a given reaction and does not change with temperature. Thus, option B is incorrect.

Step 3: Compare average kinetic energy.
The average kinetic energy of gas molecules is directly proportional to absolute temperature (T):

$$\text{Average K.E.} = \frac{3}{2}RT$$

Since $T_2 > T_1$, the average kinetic energy at temperature T_2 is greater than at T_1. Thus, option C is a correct statement.

Step 4: Evaluate the statement about the high-energy fraction.
At higher temperatures (T_2), the curve shifts to the right, which increases the area under the curve at higher energy values. This means the fraction of molecules with high energy increases at T_2. Thus, option D is incorrect.

Therefore, the only correct statement is that the average kinetic energy is greater at T_2.

Final Answer: $\boxed{\text{Average kinetic energy is greater at } T_2}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 7

Q8.

Solution

Concept: The cell potential under non-standard conditions is determined using the Nernst equation:

$$E_{\text{cell}} = E^{\circ}_{\text{cell}} - \frac{0.0591}{n} \log Q$$

where E°_{cell} is the standard cell potential, n is the number of moles of electrons transferred, and Q is the reaction quotient.

Solution: Step 1: Write the balanced overall cell reaction. The half-reactions are:

$$\begin{aligned} \text{Anode (Oxidation):} \quad & \text{Zn(s)} \rightarrow \text{Zn}^{2+}(aq) + 2e^{-} \\ \text{Cathode (Reduction):} \quad & \text{Cu}^{2+}(aq) + 2e^{-} \rightarrow \text{Cu(s)} \end{aligned}$$

The balanced overall cell reaction is:

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

The number of electrons transferred is $n = 2$.
Step 2: Define the reaction quotient Q. Since the activity of pure solids is taken as unity:

$$Q = \frac{[\text{Zn}^{2+}]}{[\text{Cu}^{2+}]}$$

Step 3: Substitute the concentration values. Given:

- $[\text{Zn}^{2+}] = 0.01 \text{ M} = 10^{-2} \text{ M}$
- $[\text{Cu}^{2+}] = 1 \text{ M}$

$$Q = \frac{10^{-2}}{1} = 10^{-2}$$

Step 4: Solve for E_{cell} at 298 K. Given $E^{\circ}_{\text{cell}} = 1.10$ V:

$$E_{\text{cell}} = 1.10 - \frac{0.0591}{2} \log \left(10^{-2}\right)$$

Using the property of logarithms ($\log 10^{-2} = -2$):

$$E_{\text{cell}} = 1.10 - \frac{0.0591}{2}(-2)$$

$$E_{\text{cell}} = 1.10 + 0.0591 = 1.1591 \text{ V}$$

This is closest to 1.16 V.

Final Answer: $\boxed{1.16 \text{ V}}$

Answer: (C)

Go Back to Question 8

Q9.

Solution

Concept: Radioactive decay processes follow first-order kinetics. The remaining amount of a sample (N) after a total time t can be calculated using:

$$N = N_0 \left(\frac{1}{2}\right)^n$$

where N_0 is the initial amount and n is the number of half-lives elapsed.

Solution: Step 1: Calculate the number of half-lives elapsed (n). The relationship between total time t, half-life $t_{1/2}$, and the number of half-lives n is:

$$n = \frac{t}{t_{1/2}}$$

Given:

- Total time, $t = 40$ days
- Half-life, $t_{1/2} = 10$ days

$$n = \frac{40 \text{ days}}{10 \text{ days}} = 4 \text{ half-lives}$$

Step 2: Calculate the remaining mass (N). Given initial mass $N_0 = 80$ g:

$$N = 80 \times \left(\frac{1}{2}\right)^4$$

$$N = 80 \times \frac{1}{16} = 5 \text{ g}$$

Thus, the remaining mass of the sample after 40 days is 5 g.

Final Answer: $\boxed{5 \text{ g}}$

Answer: (D)

Go Back to Question 9

Q10.

Solution

Concept: The integrated rate laws describe the variation of reactant concentration with time for different reaction orders:

- **Zero-order:** $[\mathrm{A}]_t = [\mathrm{A}]_0 - kt$ (linear decay).
- **First-order:** $[\mathrm{A}]_t = [\mathrm{A}]_0 e^{-kt}$ (exponential decay).
- **Second-order:** $[\mathrm{A}]_t = \dfrac{[\mathrm{A}]_0}{1 + k[\mathrm{A}]_0 t}$ (hyperbolic decay).

Solution: Step 1: Analyze the shape of the graph. The given graph represents the concentration of reactant [A] versus time.

- For a **zero-order reaction**, the plot of concentration vs. time is a straight line with a negative slope. Since the plot shown is non-linear (it is a curve), we can rule out a zero-order reaction. Thus, option A is incorrect.

Step 2: Distinguish between higher reaction orders. Both **first-order** and **second-order** (as well as other higher-order) reactions produce downward-sloping curves when concentration [A] is plotted directly against time:

- **First-order:** $[\mathrm{A}] = [\mathrm{A}]_0 e^{-kt}$
- **Second-order:** $[\mathrm{A}] = \dfrac{[\mathrm{A}]_0}{1 + k[\mathrm{A}]_0 t}$

Without specific numerical values on the axes or grid lines to evaluate the half-life behavior (which remains constant for first-order but depends on initial concentration for second-order), a qualitative downward curve of concentration versus time is visually identical for both cases and does not allow us to uniquely identify the reaction order.
Step 3: State the graphical requirements for determination. To distinguish between these orders graphically, we would require:

- A plot of $\ln[\mathrm{A}]$ vs. time, which yields a straight line with a negative slope only for first-order reactions.
- A plot of $1/[\mathrm{A}]$ vs. time, which yields a straight line with a positive slope only for second-order reactions.

Since only a raw qualitative curve of [A] vs. time is provided without labels, data points, or scaling, the order of the reaction cannot be determined from this graph alone.

Final Answer: $\boxed{\text{Cannot be determined from graph}}$

$\boxed{\textbf{Answer: (D)}}$

Go Back to Question 10

Q11.

Solution

Concept: Elevation in boiling point is a colligative property and depends on the number of solute particles present in the solution.

$$\Delta T_b = iK_b m$$

where:

- ΔT_b = elevation in boiling point
- i = van't Hoff factor
- K_b = molal elevation constant
- m = molality of the solution

Solution: Step 1: Express the expected elevation in boiling point. The expected elevation in boiling point ($\Delta T_{b,\text{expected}}$) is calculated assuming no dissociation or association of the solute, which corresponds to a van't Hoff factor $i = 1$:

$$\Delta T_{b,\text{expected}} = 1 \cdot K_b \cdot m$$

Step 2: Compare with the observed elevation. The observed elevation in boiling point ($\Delta T_{b,\text{observed}}$) is given by:

$$\Delta T_{b,\text{observed}} = i \cdot K_b \cdot m$$

According to the problem, the observed value is twice the expected value:

$$\Delta T_{b,\text{observed}} = 2 \cdot \Delta T_{b,\text{expected}}$$

Step 3: Solve for the van't Hoff factor (i). Substitute the expressions into the comparison:

$$i \cdot K_b \cdot m = 2 \cdot K_b \cdot m$$

Dividing both sides by $K_b \cdot m$:

$$i = 2$$

Thus, the van't Hoff factor of the solute is 2.

Final Answer: $\boxed{2}$

Answer: (C)

Go Back to Question 11

Q12.

Solution

Concept: The oxidation state of a transition metal in a coordination complex is calculated from the overall charge and the charges of the ligands. The magnetic behavior (paramagnetic or diamagnetic) depends on the presence or absence of unpaired d-electrons in the metal ion under the influence of the ligand field.

Solution: Step 1: Determine the oxidation state of Cobalt.
In the complex ion $[\mathrm{Co(NH_3)_6}]^{3+}$, ammonia ($\mathrm{NH_3}$) is a neutral ligand, so its charge is 0. Let x be the oxidation state of cobalt:

$$x + 6(0) = +3 \implies x = +3$$

Thus, the oxidation state of cobalt is +3, written as Co^{3+}.

Step 2: Determine the electronic configuration of Co^{3+}.
The atomic number of cobalt (Co) is 27. Its ground-state electronic configuration is:

$$\mathrm{Co} : [\mathrm{Ar}]\, 3d^7\, 4s^2$$

To form the Co^{3+} ion, three electrons are removed (two from $4s$ and one from $3d$):

$$\mathrm{Co}^{3+} : [\mathrm{Ar}]\, 3d^6\, 4s^0$$

Step 3: Determine the number of unpaired electrons.
The ligand ammonia ($\mathrm{NH_3}$) acts as a strong-field ligand towards Co^{3+}. It causes pairing of the six $3d$-electrons. The six d-electrons occupy the lower-energy t_{2g} orbitals in pairs:

$$\text{Orbital occupancy: } t_{2g}^6\, e_g^0 \implies (\uparrow\downarrow)(\uparrow\downarrow)(\uparrow\downarrow)\ (\ )\ (\ )$$

Since all electrons are fully paired, the number of unpaired electrons is **0**. This explains why the complex ion is diamagnetic.

Thus, the oxidation state of cobalt is +3 and the number of unpaired electrons is 0.

Final Answer: $\boxed{+3 \text{ and } 0}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 12

Q13.

Solution

Concept: Ozonolysis of alkenes involves the cleavage of the carbon-carbon double bond ($C = C$). Reductive workup (typically using Zn/H_2O or dimethyl sulfide, Me_2S) prevents further oxidation, converting the double-bonded carbons into carbonyl groups ($C = O$), yielding ketones and aldehydes.

Solution: Step 1: Identify the structure of the reactant compound. The given compound is:

$$(CH_3)_2C = CHCH_3$$

This is 2-methylbut-2-ene.
Step 2: Apply the double-bond cleavage. During ozonolysis, the $C = C$ double bond is cleaved and oxygen atoms are attached to both ends of the split bond:

$$R_1R_2C = CHR_3 \xrightarrow[(2)\ Zn/H_2O]{(1)\ O_3} R_1R_2C = O + O = CHR_3$$

Step 3: Identify the products.

- The left part $(CH_3)_2C =$ becomes propan-2-one (acetone):

$$(CH_3)_2C = O$$

- The right part $= CHCH_3$ becomes ethanal (acetaldehyde):

$$O = CHCH_3$$

Thus, the major products formed are Acetone and Ethanal.

Final Answer: $\boxed{\text{Acetone + Ethanal}}$

Answer: (B)

Go Back to Question 13

Q14.

Solution

Concept: The chemical behavior of carbonyl compounds (aldehydes and ketones) can be used to distinguish between them:

- **Tollens' test:** Positive for aldehydes (which are easily oxidized to carboxylic acids), but negative for ketones.
- **Aldol condensation:** Occurs in aldehydes or ketones containing at least one α-hydrogen.

Solution: Step 1: Analyze the molecular formula. The compound has the molecular formula C_3H_6O. Let's consider the possible carbonyl isomers:

(a) **Propanal** (CH_3CH_2CHO): an aldehyde.

(b) **Propanone** (CH_3COCH_3): a ketone.

Step 2: Apply the Tollens' test criterion. Since compound A gives a positive Tollens' test (forming a silver mirror), it must be an aldehyde. This rules out propanone.
Step 3: Verify the aldol condensation criterion. The structure of propanal is:

$$CH_3–\overset{\alpha}{C}H_2–CHO$$

The carbon atom adjacent to the carbonyl carbon (the α-carbon) has 2 hydrogen atoms (namely α-hydrogens). Since it possesses α-hydrogens, propanal undergoes aldol condensation in the presence of a dilute base.
Step 4: Analyze other options.

- **Propanol** has the formula C_3H_8O and is an alcohol, which does not undergo aldol condensation or give a positive Tollens' test.
- **Propanoic acid** has the formula $C_3H_6O_2$ and is a carboxylic acid, which does not undergo aldol condensation or give a positive Tollens' test.

Thus, the compound A is Propanal.

Final Answer: $\boxed{\text{Propanal}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 14

Q15.

Solution

Concept: Cleavage of alkyl aryl ethers with concentrated hydrohalic acids (such as HI) under reflux conditions proceeds via protonation of the ether oxygen, followed by nucleophilic attack by the halide ion (I^-).

Solution: Step 1: Analyze the structure of anisole. Anisole is methoxybenzene ($C_6H_5OCH_3$).
Step 2: Trace the reaction mechanism.

(a) **Protonation:** Anisole is protonated by the strong acid HI to form a methylphenyl oxonium ion:

$$C_6H_5–O–CH_3 + H^+ \rightleftharpoons C_6H_5–\overset{+}{O}(H)–CH_3$$

(b) **Nucleophilic attack:** The iodide ion (I^-) acts as a nucleophile. There are two bonds that could potentially be cleaved:

- The O–CH_3 bond (alkyl-oxygen bond).
- The C_6H_5–O bond (aryl-oxygen bond).

The phenyl-oxygen (C_{sp^2}–O) bond has partial double-bond character due to resonance stabilization involving the lone pairs of oxygen and the aromatic π-system. This makes it significantly stronger and more resistant to cleavage than the aliphatic O–CH_3 bond. Therefore, the nucleophile I^- attacks the less sterically hindered methyl group via an S_N2 pathway, cleaving the alkyl-oxygen bond:

$$I^- + C_6H_5–\overset{+}{O}(H)–CH_3 \rightarrow C_6H_5OH + CH_3I$$

Step 3: Identify the products. The reaction yields phenol (C_6H_5OH) and iodomethane (CH_3I).
Thus, the major products obtained are Phenol and Iodomethane.

Final Answer: $\boxed{\text{Phenol + Iodomethane}}$

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 15

Q16.

Solution

Concept: A compound exhibits optical isomerism if it contains an asymmetric carbon atom (also known as a chiral center), which is a carbon atom bonded to four different atoms or groups of atoms.

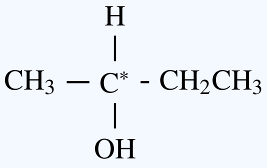
Solution:

(a) **2-Chloropropane:** Has two identical $-CH_3$ groups $\Rightarrow$ achiral.

(b) **2-Butanol:**

$$CH_3\text{–}CH(OH)\text{–}CH_2CH_3$$

The second carbon is attached to four different groups: $-CH_3$, $-H$, $-OH$, and $-CH_2CH_3$.



$$\begin{array}{c} H \\ | \\ CH_3 - C^* - CH_2CH_3 \\ | \\ OH \end{array}$$

Hence, it is chiral and optically active.

(c) **2-Methylpropane:** Has three identical $-CH_3$ groups $\Rightarrow$ achiral.

(d) **Ethanol:** No chiral carbon atom $\Rightarrow$ achiral.

Final Answer: $\boxed{\text{2-Butanol}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 16

Q17.

Solution

Concept: The synthesis sequence involves two sequential organic transformations:

(a) **Dehydrohalogenation:** Elimination of hydrogen halide from a haloalkane using a strong base like alcoholic KOH to form an alkene.

(b) **Halogenation:** Electrophilic addition of halogens across the carbon-carbon double bond of an alkene to form a vicinal dihalide.

Solution: Step 1: Analyze the first reaction step to find compound A. The starting material is bromoethane (CH_3CH_2Br). Reacting it with hot alcoholic potassium hydroxide (alc. KOH) initiates a β-elimination (E2 mechanism):

$$CH_3CH_2Br + KOH(alc) \rightarrow CH_2 = CH_2 + KBr + H_2O$$

Thus, compound A is ethene ($CH_2 = CH_2$).
Step 2: Analyze the second reaction step to find compound B. Ethene (compound A) is then reacted with bromine in carbon tetrachloride (Br_2/CCl_4). This is an electrophilic addition reaction where bromine adds across the double bond:

$$CH_2 = CH_2 + Br_2 \xrightarrow{CCl_4} CH_2Br\text{–}CH_2Br$$

The product B is 1,2-dibromoethane.
Thus, the major product formed is 1,2-dibromoethane.

Final Answer: $\boxed{\text{1,2-dibromoethane}}$

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 17

Q18.

Solution

Concept: The coordination number of a crystal structure is the number of nearest-neighbour atoms in direct contact with any given atom. In a face-centered cubic (fcc) lattice, also known as cubic close packing (ccp), the packing efficiency is 74%.

Solution: Step 1: Define the positions of atoms in the fcc unit cell. In a face-centered cubic crystal, atoms are located at the 8 corners and at the centers of the 6 faces of the cube.
Step 2: Determine the nearest neighbours for a reference atom. Let us choose a corner atom as our reference.

- The nearest neighbours to any corner atom are the face-centered atoms of the faces that meet at that corner.
- In any single unit cell, 3 faces meet at a given corner. The distance from the corner to each of these face centers is:

  $$d = \frac{a}{\sqrt{2}} \approx 0.707a$$

  where a is the edge length of the cubic unit cell. This is the shortest distance between any two atoms in the lattice.

Step 3: Count the total number of such nearest neighbours. A corner atom is shared by 8 adjacent unit cells in a three-dimensional lattice.

- In the horizontal plane passing through the corner atom, there are **4** nearest face-centered atoms.
- In the plane directly above it, there are **4** nearest face-centered atoms.
- In the plane directly below it, there are **4** nearest face-centered atoms.

Adding these together:

$$\text{Total nearest neighbours} = 4\text{ (same plane)} + 4\text{ (above plane)} + 4\text{ (below plane)} = 12$$

Thus, the total number of nearest neighbours (coordination number) surrounding each atom in an fcc structure is 12.

Final Answer: $\boxed{12}$

Answer: (D)

Go Back to Question 18

Q19.

Solution

Concept: The electrical conductivity (κ), also called specific conductance, of an electrolytic solution is defined as the conductance of a solution contained between two electrodes of unit area separated by unit distance. It depends on the number of ions present per unit volume of the solution and their mobility. Greater the number of current-carrying ions in the solution, higher is the electrical conductivity.

Solution: Step 1: Understand the variation of conductivity with concentration.
The electrical conductivity (κ) of an electrolytic solution increases with increase in concentration for both strong and weak electrolytes. This happens because increasing the concentration increases the number of ions present per unit volume, and hence more charge carriers are available to conduct electricity.

Step 2: Compare strong and weak electrolytes.

- **Strong Electrolyte (Curve A):** Strong electrolytes dissociate almost completely into ions even at low concentrations. Therefore, as concentration increases, the number of ions also increases proportionally, causing conductivity to increase rapidly and nearly linearly. Hence, the steep straight-line curve **A** represents a strong electrolyte.
- **Weak Electrolyte (Curve B):** Weak electrolytes ionize only partially in solution. At lower concentrations, ionization is relatively higher, but as concentration increases, the degree of ionization decreases. Therefore, the increase in conductivity is slower and non-linear compared to strong electrolytes. Hence, the curved line **B** represents a weak electrolyte.

Step 3: Identify A and B. From the graph:

- Electrolyte **A** is a **Strong electrolyte**.
- Electrolyte **B** is a **Weak electrolyte**.

Final Answer: $\boxed{\text{Strong electrolyte, Weak electrolyte}}$

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 19

Q20.

Solution

Concept: The magnetic moment of a transition metal ion can be calculated from its spin-only contribution using the formula:

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

where n is the number of unpaired electrons and BM stands for Bohr Magneton.

Solution: Step 1: Set up the equation using the given magnetic moment. We are given that the spin-only magnetic moment (μ) is 4.90 BM.

$$\sqrt{n(n+2)} = 4.90$$

Step 2: Solve for n by squaring both sides.

$$n(n+2) = (4.90)^2$$

$$n^2 + 2n = 24.01 \approx 24$$

Step 3: Rearrange into a quadratic equation.

$$n^2 + 2n - 24 = 0$$

Step 4: Factor the quadratic equation.

$$(n+6)(n-4) = 0$$

Since the number of unpaired electrons (n) must be a positive integer:

$$n = 4 \quad (\text{as } n \neq -6)$$

Thus, the number of unpaired electrons present in the transition metal ion is 4.

Final Answer: $\boxed{4}$

Answer: (C)

Go Back to Question 20

Q21.

Solution

Concept: Ionization enthalpy generally increases across a period from left to right due to an increase in effective nuclear charge. However, exceptions occur due to the extra stability of half-filled and fully-filled electronic configurations.

Solution: Step 1: Write down the electronic configurations of the given second-period elements.

- **Nitrogen (N, $Z = 7$):** $1s^2\ 2s^2\ 2p^3$ (has a stable half-filled $2p$-subshell).
- **Oxygen (O, $Z = 8$):** $1s^2\ 2s^2\ 2p^4$ (has a partially filled $2p$-subshell).
- **Fluorine (F, $Z = 9$):** $1s^2\ 2s^2\ 2p^5$.
- **Neon (Ne, $Z = 10$):** $1s^2\ 2s^2\ 2p^6$ (stable noble gas with a fully-filled valence shell).

Step 2: Compare ionization enthalpies.

- **Neon (Ne)** has the highest ionization enthalpy because removing an electron from a completely filled shell requires an exceptionally large amount of energy: $\text{Ne} > \text{F}$.
- Between **Nitrogen (N)** and **Oxygen (O)**, the stable half-filled configuration of Nitrogen makes it more difficult to remove an electron compared to Oxygen, where removal of one electron from $2p^4$ yields a more stable half-filled $2p^3$ state. Hence, Nitrogen has a higher first ionization enthalpy than Oxygen: $\text{N} > \text{O}$.
- **Fluorine (F)** has a higher ionization enthalpy than Nitrogen (N) because the increase in effective nuclear charge from N to F outweighs the half-filled shell effect.

Step 3: Arrange in decreasing order. Combining these effects yields the overall trend:

$$\text{Ne} > \text{F} > \text{N} > \text{O}$$

Final Answer: $\boxed{\text{Ne} > \text{F} > \text{N} > \text{O}}$

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 21

Q22.

Solution

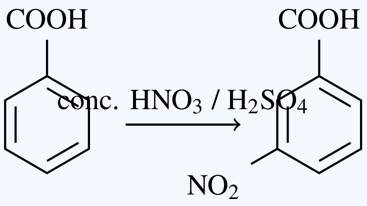
Concept: The orientation of an incoming electrophile during electrophilic aromatic substitution is governed by the substituent already present on the benzene ring. Substituents can be either activating (ortho/para-directing) or deactivating (meta-directing).

Solution: Step 1: Analyze the directing nature of the substituent in benzoic acid. Benzoic acid contains a carboxylic acid group ($-$COOH) attached directly to the benzene ring.

- The carbon atom of the $-$COOH group is highly electron-deficient because it is bonded to two electronegative oxygen atoms.
- It withdraws electron density from the benzene ring via resonance ($-M$ effect) and induction ($-I$ effect).
- This electron withdrawal deactivates the ortho and para positions more than the meta position, leaving the meta position relatively more electron-dense.

Thus, the $-$COOH group is a strongly deactivating, **meta-directing** group.

Step 2: Determine the nitration product. When benzoic acid is subjected to nitration using concentrated nitric acid (HNO_3) in the presence of concentrated sulfuric acid (H_2SO_4), the electrophile NO_2^+ attacks the meta position:



Therefore, the major product of the nitration of benzoic acid is meta-nitrobenzoic acid.

Final Answer: $\boxed{\text{meta-nitrobenzoic acid}}$

Answer: (B)

Go Back to Question 22

Q23.

Solution

Concept: Primary amines react with nitrous acid (HNO_2) at low temperatures (273–278 K) to form highly unstable diazonium salts, whose subsequent behavior differs significantly depending on whether an alkyl or aryl group is attached to the nitrogen atom.

Solution: Step 1: Analyze the reaction of aliphatic primary amines. Aliphatic primary amines ($R\text{–}NH_2$) react with freshly prepared nitrous acid (HNO_2, generated from $NaNO_2$ and HCl) at low temperature to form highly unstable aliphatic diazonium salts ($R\text{–}N_2^+Cl^-$). These salts immediately decompose even at 0°C to form a carbocation, releasing nitrogen gas quantitatively:

$$R\text{–}NH_2 + HNO_2 \xrightarrow{\text{273-278 K}} \left[R\text{–}N_2^+Cl^-\right] \xrightarrow{\text{decomposition}} R^+ + N_2(g)\uparrow$$

The carbocation (R^+) then reacts with water from the aqueous medium to produce an alcohol:

$$R^+ + H_2O \rightarrow R\text{–}OH + H^+$$

Step 2: Compare with other amines.

- **Aromatic primary amines** ($Ar\text{–}NH_2$) react with nitrous acid to form arenediazonium salts ($Ar\text{–}N_2^+Cl^-$), which are relatively stable at low temperatures (273–278 K) due to resonance stabilization. They do not decompose immediately to form phenols or evolve nitrogen gas unless heated.
- **Secondary amines** react with nitrous acid to yield insoluble, yellow oily *N*-nitrosamines.
- **Tertiary amines** dissolve in nitrous acid to form soluble trialkylammonium nitrite salts.

Thus, the amine in question is most likely an aliphatic primary amine.

Final Answer: $\boxed{\text{Aliphatic primary amine}}$

$\boxed{\textbf{Answer: (D)}}$

Go Back to Question 23

Q24.

Solution

Concept: The chemical structure of glucose can be investigated through various reduction reactions. Strong reducing agents like concentrated hydrogen iodide (HI) in the presence of red phosphorus (red P) are capable of completely reducing all hydroxyl (−OH) and carbonyl (−CHO) groups in carbohydrates to hydrocarbons.

Solution: Step 1: Write down the reaction of glucose. Glucose is an aldohexose with six carbon atoms. When glucose ($C_6H_{12}O_6$) is heated with concentrated hydrogen iodide (HI) in the presence of red phosphorus (red P) for a prolonged period, complete reduction occurs:

$$C_6H_{12}O_6 + 14HI \xrightarrow{\text{red P, }\Delta} CH_3CH_2CH_2CH_2CH_2CH_3 + 6H_2O + 7I_2$$

Step 2: Identify the major product. The resulting product is a six-carbon straight-chain alkane, namely **hexane** (or n-hexane).

Step 3: State the structural significance. Historically, this reduction reaction was crucial in establishing the structure of glucose, proving that all six carbon atoms are linked together in a continuous, straight chain.

Final Answer: $\boxed{\text{Hexane}}$

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 24

Q25.

Solution

Concept: The temperature dependence of equilibrium constant is given by the van 't Hoff equation:

$$\log K = -\frac{\Delta H^\circ}{2.303R}\left(\frac{1}{T}\right) + C$$

Hence, a plot of $\log K$ versus $\frac{1}{T}$ is a straight line with slope:

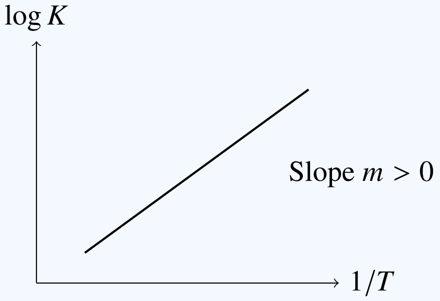
$$-\frac{\Delta H^\circ}{2.303R}$$

Solution: Step 1: Relate the equation to a straight line. Comparing the integrated van 't Hoff equation with the equation of a straight line, $y = mx + c$:

- $y = \log K$
- $x = \frac{1}{T}$
- Slope, $m = -\frac{\Delta H^\circ}{2.303R}$

Step 2: Determine the sign of the slope from the graph. In the provided graph:

- As $1/T$ increases, $\log K$ increases.
- This represents a straight line with a **positive slope** ($m > 0$).



Step 3: Relate the positive slope to the reaction thermodynamics. Since the slope is positive:

$$-\frac{\Delta H^\circ}{2.303R} > 0 \implies \Delta H^\circ < 0$$

A negative enthalpy change ($\Delta H^\circ < 0$) signifies that heat is released during the reaction. Therefore, the reaction is **exothermic**.

Thus, the graphical variation corresponds to an exothermic reaction.

Final Answer: $\boxed{\text{Exothermic reaction}}$

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 25

Q26.

Solution

Concept: Polytetrafluoroethylene (PTFE), commonly known as Teflon, is a synthetic fluoropolymer of tetrafluoroethene. It is highly resistant to heat and chemicals, making it ideal for non-stick coatings on cookware.

Solution: Step 1: Identify the polymer. The given polymer has the repeating unit:

$$(\text{–CF}_2\text{–CF}_2\text{–})_n$$

This polymer is polytetrafluoroethylene (Teflon).
Step 2: Determine the monomer. To prepare a polymer with the repeating unit $(\text{–CF}_2\text{–CF}_2\text{–})_n$, the double bond of the monomer undergoes addition polymerization. Reversing this process reveals the monomer:

$$CF_2 = CF_2$$

The IUPAC name of this molecule is **tetrafluoroethene**.
Step 3: Write down the polymerization reaction.

$$n\,CF_2 = CF_2 \xrightarrow{\text{initiator, pressure}} (\text{–CF}_2\text{–CF}_2\text{–})_n$$

Final Answer: $\boxed{\text{Tetrafluoroethene}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 26

Q27.

Solution

Concept: The bonding in a diatomic molecule ranges from purely covalent to highly ionic. The degree of ionic character of a chemical bond depends on the sharing of electron density between the two bonded atoms, which is determined by their relative electronegativities.

Solution: Step 1: Understand electronegativity. Electronegativity is the ability of an atom in a molecule to attract shared electrons toward itself.
Step 2: Relate electronegativity difference to ionic character.

- When two bonded atoms have identical electronegativities (difference $\Delta\chi = 0$), the bonding electrons are shared equally, and the bond is purely covalent.
- As the difference in electronegativity ($\Delta\chi$) between the two atoms increases, the more electronegative atom pulls the electron density more strongly towards itself.
- This uneven sharing creates a partial negative charge (δ^-) on the more electronegative atom and a partial positive charge (δ^+) on the less electronegative atom, giving the bond polar and ionic characteristics.

Step 3: Analyze using quantitative models. According to the Hannay-Smith equation, the percentage of ionic character of a bond is:

$$\%\ \text{Ionic Character} = 16|\chi_A - \chi_B| + 3.5|\chi_A - \chi_B|^2$$

where χ_A and χ_B are the electronegativities of the two atoms. This equation shows that the percentage ionic character is directly proportional to the electronegativity difference.
Therefore, the percentage ionic character of a bond increases with an increase in electronegativity difference.

Final Answer: $\boxed{\text{increase in electronegativity difference}}$

Answer: (C)

Go Back to Question 27

Q28.

Solution

Concept: For an unsymmetrical compound (a compound without any plane of symmetry or center of symmetry) containing n chiral (asymmetric) carbon atoms, the number of stereoisomers can be calculated using standard stereochemical formulas.

Solution: Step 1: Identify the number of chiral centers. The compound contains $n = 2$ asymmetric carbon atoms.
Step 2: Check for molecular symmetry. We are given that the compound has **no plane of symmetry**. This means the molecule is completely unsymmetrical and cannot exist in an optically inactive, achiral meso form.
Step 3: Apply the formula for the number of stereoisomers. For an unsymmetrical molecule with n chiral carbon atoms, the total number of stereoisomers (N) is given by:

$$N = 2^n$$

Substitute $n = 2$ into the equation:

$$N = 2^2 = 4$$

Step 4: Describe the nature of the stereoisomers. The 4 stereoisomers consist of two pairs of enantiomers (mirror images):

- Pair 1: $(1R, 2R)$ and $(1S, 2S)$
- Pair 2: $(1R, 2S)$ and $(1S, 2R)$

Since there is no symmetry, all four configurations are distinct and optically active.

Final Answer: $\boxed{4}$

Answer: (C)

Go Back to Question 28

Q29.

Solution

Concept: The Langmuir adsorption isotherm describes the relationship between the mass of gas adsorbed per unit mass of adsorbent (x/m) and the equilibrium gas pressure (P) at a constant temperature. It is based on the assumption that adsorption takes place on specific localized sites, forming a monolayer.

Solution: Step 1: Write down the Langmuir adsorption equation. The Langmuir isotherm is expressed as:

$$\frac{x}{m} = \frac{aP}{1 + bP}$$

where a and b are constants.

Step 2: Analyze the behavior at low pressure. At very low pressures, the term $bP \ll 1$, so the equation simplifies to:

$$\frac{x}{m} \approx aP$$

Thus, adsorption is directly proportional to pressure (first-order kinetics).

Step 3: Analyze the behavior at high pressure (saturation). At very high pressures, the term $bP \gg 1$, so the equation simplifies to:

$$\frac{x}{m} \approx \frac{aP}{bP} = \frac{a}{b} = \text{constant}$$

This explains why the isotherm curve flattens out and becomes independent of pressure (zero-order kinetics).

Step 4: Relate to physical behavior.

This leveling off (saturation) occurs because all the available active sites on the solid surface become completely occupied by gas molecules, forming a complete monolayer. Once the surface is fully saturated, further increases in pressure cannot lead to additional adsorption.

Therefore, this behavior is best explained by surface saturation by monolayer adsorption.

Final Answer: $\boxed{\text{Surface saturation by monolayer adsorption}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 29

Q30.

Solution

Concept: Colligative properties, such as osmotic pressure (Π), depend solely on the total concentration of solute particles in the solution. The relation incorporating the van't Hoff factor (i) is:

$$\Pi = i \cdot C \cdot R \cdot T$$

where C is the concentration of the solute and i represents the ratio of the observed colligative property to the theoretically expected value.

Solution: Step 1: Compare the observed and expected osmotic pressures. The problem states that the observed osmotic pressure (Π_{observed}) is lower than the theoretically expected value (Π_{expected}):

$$\Pi_{\text{observed}} < \Pi_{\text{expected}}$$

Since $\Pi_{\text{observed}} = i \cdot \Pi_{\text{expected}}$, this inequality directly implies:

$$i < 1$$

Step 2: Understand the physical meaning of $i < 1$. The van't Hoff factor i represents the actual number of particles in solution divided by the number of formula units dissolved:

$$i = \frac{\text{Total number of particles after association/dissociation}}{\text{Number of formula units dissolved}}$$

- **Dissociation / Ionization ($i > 1$):** The solute molecules split into two or more particles, increasing the total particle count. This would lead to a higher colligative property (osmotic pressure) than expected.
- **Association ($i < 1$):** Multiple solute molecules combine to form a single larger entity (such as dimer or trimer formation). This decreases the total concentration of independent particles in the solution, thereby lowering the osmotic pressure.

Step 3: Select the correct option. Since the osmotic pressure is lower than expected ($i < 1$), the solute must undergo association in the solution.

Final Answer: $\boxed{\text{association}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 30

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	C	3	C	4	A	5	A
6	C	7	C	8	C	9	D	10	D
11	C	12	B	13	B	14	B	15	A
16	B	17	A	18	D	19	A	20	C
21	A	22	B	23	D	24	A	25	A
26	B	27	C	28	C	29	B	30	C