CUET UG Chemistry Sample Paper - 7

Duration: 1 Hour **Maximum Marks: 250**

Instructions

- This paper contains a total of 50 Multiple Choice Questions.
- Each correct answer carries **+5 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

Q1. At a given temperature, the vapor pressure of pure benzene is 0.850 bar. A non-volatile, non-electrolyte solid weighing 0.5 g is added to 39 g of benzene (molar mass 78). The vapor pressure of the solution then is 0.845 bar. The molar mass of the solid is:

(A) $170\,\text{g mol}^{-1}$
(B) $180\,\text{g mol}^{-1}$
(C) $160\,\text{g mol}^{-1}$
(D) $150\,\text{g mol}^{-1}$

Q2. Which of the following 0.1 M aqueous solutions will exhibit the highest boiling point?

(A) Glucose
(B) NaCl
(C) $CaCl_2$
(D) $AlCl_3$

Q3. The osmotic pressure of a solution increases if:

(A) Temperature is decreased

(B) Solution concentration is increased

(C) Number of solute particles decreases

(D) Volume of solution is increased

Q4. For an ideal solution, which of the following is correct?

(A) $\Delta H_{mix} > 0$

(B) $\Delta V_{mix} < 0$

(C) $\Delta S_{mix} > 0$

(D) $\Delta G_{mix} > 0$

Q5. Henry's law constant K_H for the solubility of methane in benzene at 298 K is 4.27×10^5 mm Hg. The solubility of methane in benzene under 760 mm Hg is:

(A) 1.78×10^{-3}

(B) 4.27×10^{-2}

(C) 1.21×10^{-5}

(D) 1.5×10^{-3}

Q6. The E°_{cell} for the reaction $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$ is $1.10\,V$. If $0.1\,M\ Zn^{2+}$ and $0.01\,M\ Cu^{2+}$ are used, the E_{cell} at 298 K will be:

(A) $1.10\,V$

(B) $1.07\,V$

(C) $1.13\,V$

(D) $1.01\,V$

Q7. Limiting molar conductivity of NH_4OH is equal to:

(A) $\Lambda^o(NH_4Cl) + \Lambda^o(NaOH) - \Lambda^o(NaCl)$

(B) $\Lambda^o(NH_4Cl) + \Lambda^o(NaCl) - \Lambda^o(NaOH)$

(C) $\Lambda^o(NH_4OH) + \Lambda^o(NH_4Cl) - \Lambda^o(HCl)$

(D) $\Lambda^o(NaOH) + \Lambda^o(HCl) - \Lambda^o(NaCl)$

Q8. How many coulombs are required for the oxidation of 1 mol of H_2O to O_2?

(A) $96500\,C$

(B) $1.93 \times 10^5\,C$

(C) $4.825 \times 10^4\,C$

(D) $3.86 \times 10^5\,C$

Q9. In a fuel cell, the reaction occurring at the cathode is:

(A) $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

(B) $H_2 + 2OH^- \rightarrow 2H_2O + 2e^-$

(C) $Zn \rightarrow Zn^{2+} + 2e^-$

(D) $Pb + SO_4^{2-} \rightarrow PbSO_4 + 2e^-$

Q10. The molar conductivity of a $0.05\,M$ solution of $BaCl_2$ is 220 $\Omega^{-1}cm^2mol^{-1}$. Its conductivity is:

(A) 0.011

(B) 0.11

(C) 0.022

(D) 0.22

Q11. Which battery is used in Apollo space missions?

(A) Leclanche cell

(B) Mercury cell

(C) $H_2 - O_2$ Fuel cell

(D) Lead storage battery

Q12. If the rate constant for a first-order reaction is k, the time required for the completion of 99% of the reaction is:

(A) $\frac{2.303}{k}$

(B) $\frac{4.606}{k}$

(C) $\frac{6.909}{k}$

(D) $\frac{0.693}{k}$

Q13. For a zero-order reaction, the plot of $[A]$ vs t gives a slope equal to:

(A) k

(B) $-k$

(C) $\frac{k}{2.303}$

(D) $\frac{-k}{2.303}$

Q14. The rate of a reaction quadruples when the temperature changes from 293 K to 313 K. Calculate the energy of activation (E_a).

(A) 52.8 kJ/mol

(B) 100 kJ/mol

(C) 35.4 kJ/mol

(D) 65.2 kJ/mol

Q15. The decomposition of phosphine (PH_3) on tungsten at low pressure is a:

(A) Zero order reaction
(B) First order reaction
(C) Second order reaction
(D) Third order reaction

Q16. In a reaction $2A + B \rightarrow A_2B$, the rate of consumption of B is 1.5×10^{-2} M/s. The rate of formation of A_2B is:

(A) 3.0×10^{-2}
(B) 1.5×10^{-2}
(C) 0.75×10^{-2}
(D) 4.5×10^{-2}

Q17. Lanthanoid contraction is caused by:

(A) Effective shielding of $4f$ electrons
(B) Poor shielding of $4f$ electrons
(C) Increase in nuclear charge
(D) Both B and C

Q18. Which of the following ions is paramagnetic?

(A) Sc^{3+}
(B) Ti^{4+}
(C) Cu^{2+}
(D) Zn^{2+}

Q19. In the preparation of $KMnO_4$, pyrolusite ore (MnO_2) is first fused with KOH in presence of air to give:

(A) K_2MnO_4

(B) $KMnO_4$

(C) Mn_2O_7

(D) $Mn(OH)_2$

Q20. The highest oxidation state shown by transition elements is:

(A) +7 by Mn

(B) +8 by Os

(C) +6 by Cr

(D) +4 by Ti

Q21. The IUPAC name of $[Pt(NH_3)_2Cl(NO_2)]$ is:

(A) Diamminechloridonitrito-N-platinum(II)

(B) Diamminechloronitroplatinum(IV)

(C) Diamminechloronitritoplatinum(II)

(D) Chloronitrodiammineplatinum(II)

Q22. Which of the following complexes shows linkage isomerism?

(A) $[Co(NH_3)_5SO_4]Cl$

(B) $[Co(NH_3)_5(NO_2)]Cl_2$

(C) $[Co(NH_3)_6][Cr(CN)_6]$

(D) $[Pt(NH_3)_2Cl_2]$

Q23. The hybridization and magnetic moment of $[CoF_6]^{3-}$ are:

(A) $sp^3d^2,\ 4.90\,BM$

(B) $d^2sp^3,\ 0\,BM$

(C) $sp^3d^2,\ 0\,BM$

(D) $d^2sp^3,\ 4.90\,BM$

Q24. According to Crystal Field Theory, the sequence of crystal field splitting (Δ_o) for ligands is:

(A) $I^- < Cl^- < F^- < OH^- < H_2O < CN^-$

(B) $CN^- < H_2O < OH^- < F^- < Cl^- < I^-$

(C) $H_2O < OH^- < CN^- < I^- < Cl^- < F^-$

(D) $I^- < F^- < Cl^- < OH^- < CN^- < H_2O$

Q25. A complex $[Ma_2b_2]$ (where a, b are monodentate) can exhibit:

(A) Geometrical isomerism

(B) Optical isomerism

(C) Both

(D) None

Q26. Which of the following is a homoleptic complex?

(A) $[Co(NH_3)_6]Cl_3$

(B) $[Co(NH_3)_4Cl_2]Cl$

(C) $[Pt(NH_3)_2Cl_2]$

(D) $[Ni(CO)_4]$

Q27. Arrange the following in increasing order of S_N2 reactivity: $(CH_3)_3CCl$, $(CH_3)_2CHCl$, CH

(A) $1 < 2 < 3 < 4$

(B) $4 < 3 < 2 < 1$

(C) $3 < 2 < 4 < 1$

(D) $1 < 3 < 2 < 4$

Q28. Reaction of ethyl chloride with AgCN gives:

(A) Ethyl cyanide

(B) Ethyl isocyanide

(C) Ethyl amine

(D) Ethyl nitrite

Q29. In the Finkelstein reaction, the reagent used is:

(A) NaI in dry acetone

(B) AgF

(C) Cl_2/UV light

(D) PCl_5

Q30. Chirality of 2-bromobutane is due to:

(A) Presence of asymmetric carbon

(B) Plane of symmetry

(C) Superimposable mirror image

(D) Achiral center

Q31. When phenol reacts with $CHCl_3$ and aqueous $NaOH$ followed by acidification, the product is:

(A) Benzaldehyde
(B) Salicylaldehyde
(C) Salicylic acid
(D) Chlorobenzene

Q32. Lucas reagent is a mixture of:

(A) Conc. HCl + anhydrous $ZnCl_2$
(B) Conc. HNO_3 + anhydrous $ZnCl_2$
(C) Conc. HCl + hydrous $ZnCl_2$
(D) Conc. H_2SO_4 + anhydrous $ZnCl_2$

Q33. Arrange in increasing order of acidity: Ethanol, Phenol, p-Nitrophenol, p-Methoxyphenol

(A) Ethanol < p-Methoxyphenol < Phenol < p-Nitrophenol
(B) p-Nitrophenol < Phenol < p-Methoxyphenol < Ethanol
(C) Ethanol < Phenol < p-Methoxyphenol < p-Nitrophenol
(D) Phenol < Ethanol < p-Nitrophenol < p-Methoxyphenol

Q34. Williamson synthesis of ethers follows:

(A) S_N1 mechanism
(B) S_N2 mechanism
(C) $E1$ mechanism
(D) $E2$ mechanism

Q35. Propan-2-ol on treatment with Cu at 573 K gives:

(A) Propanone

(B) Propanal

(C) Propene

(D) Propanoic acid

Q36. Which of the following does not undergo Aldol condensation?

(A) Acetaldehyde

(B) Acetone

(C) Benzaldehyde

(D) Propanal

Q37. Cannizzaro reaction is given by:

(A) Formaldehyde

(B) Acetaldehyde

(C) Acetone

(D) Ethyl methyl ketone

Q38. The most reactive towards nucleophilic addition among the following is:

(A) $HCHO$

(B) CH_3CHO

(C) CH_3COCH_3

(D) C_6H_5CHO

Q39. Hell-Volhard-Zelinsky reaction is used to prepare:

(A) α-halo carboxylic acids

(B) β-halo carboxylic acids

(C) Acid chlorides

(D) Amides

Q40. Which of the following is used as a test for the −CHO group?

(A) Tollens' reagent

(B) Fehling's solution

(C) Both A and B

(D) Lucas reagent

Q41. Arrange in increasing order of acidity: $CH_3COOH, ClCH_2COOH, Cl_2CHCOOH, Cl_3C$

(A) $1 < 2 < 3 < 4$

(B) $4 < 3 < 2 < 1$

(C) $2 < 1 < 3 < 4$

(D) $1 < 3 < 2 < 4$

Q42. Correct order of basic strength in aqueous solution:

(A) $(CH_3)_2NH > CH_3NH_2 > (CH_3)_3N > NH_3$

(B) $(CH_3)_3N > (CH_3)_2NH > CH_3NH_2 > NH_3$

(C) $NH_3 > CH_3NH_2 > (CH_3)_2NH > (CH_3)_3N$

(D) $(CH_3)_2NH > (CH_3)_3N > CH_3NH_2 > NH_3$

Q43. Gabriel Phthalimide synthesis is used for the preparation of:

(A) Primary aliphatic amines

(B) Primary aromatic amines

(C) Secondary amines

(D) Tertiary amines

Q44. Benzene diazonium chloride on reaction with Cu_2Cl_2/HCl gives chlorobenzene. This reaction is:

(A) Sandmeyer reaction

(B) Gattermann reaction

(C) Wurtz reaction

(D) Fittig reaction

Q45. Hinsberg's reagent is:

(A) Benzene sulphonyl chloride

(B) Benzene sulphonic acid

(C) Phenyl isocyanide

(D) Benzene chloride

Q46. Which of the following is a non-reducing sugar?

(A) Glucose

(B) Fructose

(C) Lactose

(D) Sucrose

Q47. Denaturation of proteins leads to the loss of:

(A) Primary structure

(B) Secondary and Tertiary structures

(C) Peptide bonds

(D) Amino acid sequence

Q48. Deficiency of Vitamin B_{12} causes:

(A) Scurvy

(B) Rickets

(C) Pernicious anaemia

(D) Night blindness

Q49. The helical structure of proteins is stabilized by:

(A) Peptide bonds

(B) Hydrogen bonds

(C) Ionic bonds

(D) Van der Waals forces

Q50. In DNA, the complementary base pairs are:

(A) A-T and G-C

(B) A-U and G-C

(C) A-C and G-T

(D) A-G and T-C

Detailed Solutions

Q1.

Solution

Concept: According to Raoult's Law, the relative lowering of vapour pressure is equal to the mole fraction of the solute:

$$\frac{P^0 - P}{P^0} = X_{\text{solute}}$$

Solution:

Given:

$$P^0 = 0.850 \text{ bar}, \quad P = 0.845 \text{ bar}$$

Relative lowering of vapour pressure:

$$\frac{P^0 - P}{P^0} = \frac{0.850 - 0.845}{0.850} = \frac{0.005}{0.850} = \frac{1}{170}$$

$$X_{\text{solute}} = \frac{1}{170}$$

Moles of benzene:

$$n_{\text{benzene}} = \frac{39}{78} = 0.5$$

Let moles of solute be n_s.

$$X_{\text{solute}} = \frac{n_s}{n_s + 0.5}$$

$$\frac{1}{170} = \frac{n_s}{n_s + 0.5}$$

$$170n_s = n_s + 0.5$$

$$169n_s = 0.5$$

$$n_s = \frac{0.5}{169} \approx \frac{1}{338}$$

Molar mass of solute:

$$M = \frac{0.5}{1/338} = 169 \approx 170$$

$$\boxed{170 \text{ g/mol}}$$

Answer: (A)

Q2.

Solution

Concept: Boiling point elevation depends on van't Hoff factor (i). Greater the number of particles, higher the boiling point.

Solution:

Glucose: $i = 1$ NaCl: $i = 2$ $CaCl_2$: $i = 3$ $AlCl_3$: $i = 4$

Highest particles $\Rightarrow AlCl_3$

$$\boxed{AlCl_3}$$

Answer: (D)

Q3.

Solution

Concept: Osmotic pressure: $\pi = CRT$

Solution:

$\pi \propto C$

Thus, osmotic pressure increases with concentration.

$$\boxed{\text{Solution concentration is increased}}$$

Answer: (B)

Q4.

Solution

Concept: For an ideal solution formed by mixing two components:

- Enthalpy of mixing: $\Delta H_{mix} = 0$
- Volume of mixing: $\Delta V_{mix} = 0$
- Entropy of mixing: $\Delta S_{mix} > 0$ (Disorder always increases)
- Gibbs free energy: $\Delta G_{mix} = \Delta H_{mix} - T\Delta S_{mix} < 0$ (Spontaneous process)

Solution: An ideal solution follows Raoult's law across the entire range of concentrations.Since the intermolecular forces are similar, no energy is absorbed or released: $\Delta H_{mix} = 0$.The total volume is the sum of individual volumes: $\Delta V_{mix} = 0$.The process of mixing is spontaneous and leads to a more disordered state, hence:

$$\Delta S_{mix} > 0$$

For any spontaneous mixing at constant temperature and pressure:

$$\Delta G_{mix} = 0 - T\Delta S_{mix} < 0$$

Comparing these properties with the given options:Option (A) is incorrect ($\Delta H = 0$).Option (B) is incorrect ($\Delta V = 0$).Option (C) is correct ($\Delta S > 0$).Option (D) is incorrect ($\Delta G < 0$).

Answer: (C)

Q5.

Solution

Concept: According to Henry's Law, the solubility of a gas in a liquid is directly proportional to the pressure of the gas over the solution:

$$p = K_H \cdot x$$

Where:p is the partial pressure of the gas.K_H is the Henry's law constant.x is the mole fraction of the gas in the solution (solubility).

Solution: Given:Partial pressure of methane (p) = 760 mm HgHenry's law constant (K_H) = 4.27×10^5 mm HgUsing the formula:

$$x = \frac{p}{K_H}$$

Substitute the values:

$$x = \frac{760 \text{ mm Hg}}{4.27 \times 10^5 \text{ mm Hg}}$$

$$x = 177.98 \times 10^{-5}$$

$$x \approx 1.78 \times 10^{-3}$$

The solubility of methane in benzene is 1.78×10^{-3}.

Answer: (A)

Q6.

Solution

Concept: The cell potential under non-standard conditions is given by the Nernst Equation:

$$E_{cell} = E^o_{cell} - \frac{0.0591}{n} \log Q$$

For the reaction: $Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$Number of electrons transferred $(n) =$ 2Reaction quotient $(Q) = \frac{[Zn^{2+}]}{[Cu^{2+}]}$ **Solution:**Given:$E^o_{cell} = 1.10$ V$[Zn^{2+}] = 0.1$ M$[Cu^{2+}] = 0.01$ MSubstitute the values into the Nernst Equation at 298K:

$$E_{cell} = 1.10 - \frac{0.0591}{2} \log \left(\frac{0.1}{0.01} \right)$$

Simplify the term inside the log:

$$\frac{0.1}{0.01} = 10$$

Since $\log(10) = 1$:

$$E_{cell} = 1.10 - \frac{0.0591}{2}(1)$$

$$E_{cell} = 1.10 - 0.02955$$

$$E_{cell} = 1.07045 \text{ V}$$

Rounding to two decimal places:

$$E_{cell} \approx 1.07 \text{ V}$$

Answer: (B)

Q7.

Solution

Concept: According to Kohlrausch's Law, the limiting molar conductivity (Λ^o) of an electrolyte is the sum of the limiting ionic conductivities of its constituent cations and anions:

$$\Lambda^o(AB) = \lambda^o(A^+) + \lambda^o(B^-)$$

To find the value for a weak electrolyte like NH_4OH, we combine the Λ^o values of strong electrolytes such that the unwanted ionic terms cancel out.
Solution: We want to find:

$$\Lambda^o(NH_4OH) = \lambda^o(NH_4^+) + \lambda^o(OH^-)$$

Consider the strong electrolytes given in Option A:$\Lambda^o(NH_4Cl) = \lambda^o(NH_4^+) + \lambda^o(Cl^-)\Lambda^o(NaOH) = \lambda^o(Na^+) + \lambda^o(OH^-)\Lambda^o(NaCl) = \lambda^o(Na^+) + \lambda^o(Cl^-)$Performing the operation $\Lambda^o(NH_4Cl) + \Lambda^o(NaOH) - \Lambda^o(NaCl)$:

$$[\lambda^o(NH_4^+) + \lambda^o(Cl^-)] + [\lambda^o(Na^+) + \lambda^o(OH^-)] - [\lambda^o(Na^+) + \lambda^o(Cl^-)]$$

Canceling the common ions ($\lambda^o(Cl^-)$ and $\lambda^o(Na^+)$):

$$\lambda^o(NH_4^+) + \lambda^o(OH^-) = \Lambda^o(NH_4OH)$$

Therefore, the relationship in Option A is correct.

Answer: (A)

Q8.

Solution

Concept: The quantity of charge (Q) required for an electrochemical reaction is given by:

$$Q = n \cdot F$$

Where:n is the number of moles of electrons exchanged per mole of reactant.F is Faraday's constant ($\approx$ 96500 C/mol).

Solution: First, we write the balanced oxidation half-reaction for water:

$$H_2O \rightarrow \frac{1}{2}O_2 + 2H^+ + 2e^-$$

From the stoichiometry of the reaction, 1 mole of H_2O releases 2 moles of electrons ($n = 2$) to produce O_2.Now, calculate the total charge required:

$$Q = n \times F$$

$$Q = 2 \text{ mol} \times 96500 \text{ C/mol}$$

$$Q = 193000 \text{ C}$$

$$Q = 1.93 \times 10^5 \text{ C}$$

Thus, 1.93×10^5 Coulombs are required for the oxidation of 1 mole of water.

Answer: (B)

Q9.

Solution

Concept: A fuel cell converts chemical energy from a fuel (usually hydrogen) into electricity through electrochemical reactions.

- **Anode (Oxidation):** Oxidation of the fuel (H_2) occurs here.
- **Cathode (Reduction):** Reduction of the oxidant (O_2) occurs here.

Solution: In a typical alkaline $H_2 - O_2$ fuel cell, the electrode reactions are:At the **Anode**:

$$2H_2(g) + 4OH^-(aq) \rightarrow 4H_2O(l) + 4e^-$$

At the **Cathode**:

$$O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$$

The overall cell reaction is:

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$$

Comparing with the given options, the reaction involving the reduction of oxygen matches Option A.

Answer: (A)

Q10.

Solution

Concept: The molar conductivity (Λ_m) of a solution is related to its specific conductivity (κ) and molarity (M) by the following expression:

$$\Lambda_m = \frac{\kappa \times 1000}{M}$$

Where:Λ_m is the molar conductivity (in $\Omega^{-1}cm^2mol^{-1}$).κ is the conductivity (in $\Omega^{-1}cm^{-1}$).M is the molarity of the solution (in $mol \cdot L^{-1}$).
Solution: Given:Molar conductivity $(\Lambda_m) = 220\ \Omega^{-1}cm^2mol^{-1}$Molarity $(M) = 0.05\ M$Rearranging the formula to solve for κ:

$$\kappa = \frac{\Lambda_m \times M}{1000}$$

Substitute the given values:

$$\kappa = \frac{220 \times 0.05}{1000}$$

Perform the multiplication:

$$\kappa = \frac{11.0}{1000}$$

$$\kappa = 0.011\ \Omega^{-1}cm^{-1}$$

The conductivity of the $0.05M\ BaCl_2$ solution is $0.011\ \Omega^{-1}cm^{-1}$.

Answer: (A)

Q11.

Solution

Concept: Fuel cells are galvanic cells designed to convert the energy of combustion of fuels like hydrogen, methane, or methanol directly into electrical energy. The $H_2 - O_2$ fuel cell was specifically used in the Apollo space program for two primary reasons:

(a) **Efficiency:** They are more efficient than conventional fossil fuel plants.

(b) **Byproduct:** The water vapor produced was condensed and used for drinking by the astronauts.

Solution: In the Apollo space mission, the $H_2 - O_2$ fuel cell was utilized. The electrodes in this cell are made of porous carbon containing suitable catalysts.The electrode reactions are:**At Anode:** $2H_2(g) + 4OH^-(aq) \longrightarrow 4H_2O(l) + 4e^-$**At Cathode:** $O_2(g) + 2H_2O(l) + 4e^- \longrightarrow 4OH^-(aq)$The net reaction is the formation of water:

$$2H_2(g) + O_2(g) \longrightarrow 2H_2O(l)$$

Options A, B, and D represent traditional primary or secondary batteries which were either too heavy or did not provide the necessary drinking water byproduct required for long-duration space travel.

Answer: (C)

Q12.

Solution

Concept: For a first-order reaction, the integrated rate equation is given by:

$$k = \frac{2.303}{t} \log_{10} \left(\frac{[A]_0}{[A]_t} \right)$$

where $[A]_0$ is the initial concentration and $[A]_t$ is the concentration at time t. For 99% completion, the remaining concentration is 1% of the initial value. **Solution:**Let the initial concentration $[A]_0 = 100$.For 99% completion, the amount reacted is 99, so:

$$[A]_t = 100 - 99 = 1$$

Substitute these values into the first-order rate equation:

$$k = \frac{2.303}{t} \log_{10} \left(\frac{100}{1} \right)$$

$$k = \frac{2.303}{t} \log_{10}(10^2)$$

$$k = \frac{2.303}{t} \times 2 \log_{10}(10)$$

Since $\log_{10}(10) = 1$:

$$k = \frac{4.606}{t}$$

Rearranging for t:

$$t = \frac{4.606}{k}$$

Answer: (B)

Q13.

Solution

Concept: For a zero-order reaction, the rate of reaction is independent of the concentration of the reactants. The differential rate equation is:

$$-\frac{d[A]}{dt} = k[A]^0 = k$$

Integrating this from $t = 0$ to $t = t$, we get the integrated rate equation:

$$[A]_t = -kt + [A]_0$$

Solution: The equation $[A]_t = -kt + [A]_0$ is in the form of a straight line equation:

$$y = mx + c$$

By comparing the two equations:

- y-axis: concentration $[A]_t$
- x-axis: time t
- Slope (m): $-k$
- Intercept (c): $[A]_0$

Therefore, the plot of $[A]$ vs t gives a straight line with a slope equal to $-k$.

Answer: (B)

Q14.

Solution

Concept: The Arrhenius equation in its logarithmic form is used to relate the rate constant (k) to the temperature (T):

$$\ln k = \ln A - \frac{E_a}{RT}$$

This follows the linear equation form $y = mx + c$. **Solution:**Comparing $\ln k = \left(-\frac{E_a}{R}\right)\frac{1}{T} + \ln A$ to $y = mx + c$:

- y-axis: $\ln k$
- x-axis: $1/T$
- Slope (m): $-\frac{E_a}{R}$
- Intercept (c): $\ln A$

By calculating the slope of the $\ln k$ vs $1/T$ graph, the activation energy (E_a) can be determined using $E_a = -\text{slope} \times R$.

Answer: (C)

Q15.

Solution

Concept: For a zero-order reaction, the half-life ($t_{1/2}$) is the time taken for the initial concentration $[A]_0$ to reduce to half its value. The formula is:

$$t_{1/2} = \frac{[A]_0}{2k}$$

Solution: From the formula, we can see that for a zero-order reaction:

$$t_{1/2} \propto [A]_0$$

If the initial concentration $[A]_0$ is doubled:

$$t'_{1/2} = \frac{2[A]_0}{2k} = 2\left(\frac{[A]_0}{2k}\right) = 2 \times t_{1/2}$$

Thus, the half-life is also doubled.

Answer: (A)

Q16.

Solution

Concept: For a chemical reaction $aA + bB \longrightarrow cC + dD$, the average rate of reaction is expressed in terms of the rate of disappearance of reactants and the rate of appearance of products, divided by their respective stoichiometric coefficients:

$$\text{Rate} = -\frac{1}{a}\frac{\Delta[A]}{\Delta t} = -\frac{1}{b}\frac{\Delta[B]}{\Delta t} = \frac{1}{c}\frac{\Delta[C]}{\Delta t} = \frac{1}{d}\frac{\Delta[D]}{\Delta t}$$

Solution: Given the reaction: $2A + B \longrightarrow A_2B$According to the rate expression:

$$\text{Rate} = -\frac{1}{2}\frac{d[A]}{dt} = -\frac{1}{1}\frac{d[B]}{dt} = \frac{1}{1}\frac{d[A_2B]}{dt}$$

From the above relation, the rate of consumption of B is equal to the rate of formation of A_2B:

$$-\frac{d[B]}{dt} = \frac{d[A_2B]}{dt}$$

Given that the rate of consumption of B $(-\frac{d[B]}{dt})$ is 1.5×10^{-2} M/s:

$$\frac{d[A_2B]}{dt} = 1.5 \times 10^{-2} \text{ M/s}$$

Answer: (B)

Q17.

Solution

Concept: Lanthanoid contraction refers to the steady decrease in the atomic and ionic radii of lanthanoids with increasing atomic number. This is primarily due to the poor shielding effect of $4f$ electrons combined with the increasing nuclear charge.

Solution: In lanthanoids, the additional electrons enter the $4f$ subshell. The shape of f-orbitals is very diffused, resulting in imperfect shielding of the outer electrons from the nuclear charge. Consequently, as the nuclear charge increases with atomic number, the effective nuclear charge experienced by the outer electrons increases, pulling them closer to the nucleus.

Answer: (D)

Q18.

Solution

Concept: The color of transition metal ions is generally due to $d-d$ transitions. For an ion to be colored, it must have a partially filled d-subshell (d^1 to d^9). If the d-subshell is empty (d^0) or completely filled (d^{10}), the ion is colorless.

Solution:

- Ti^{4+} ($Z = 22$): $[Ar]3d^0$ (No d-electrons, colorless)
- V^{3+} ($Z = 23$): $[Ar]3d^2$ (Colored)
- Cr^{3+} ($Z = 24$): $[Ar]3d^3$ (Colored)
- Mn^{2+} ($Z = 25$): $[Ar]3d^5$ (Colored - pale pink)

Answer: (A)

Q19.

Solution

Concept: The magnetic moment (μ) is calculated using the spin-only formula:

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

where n is the number of unpaired electrons.

Solution: The atomic number of Mn is 25. Electronic configuration: $[Ar]3d^5 4s^2$.For Mn^{2+}, the configuration is $[Ar]3d^5$.In the $3d$ subshell, there are 5 unpaired electrons ($n = 5$).

$$\mu = \sqrt{5(5+2)} = \sqrt{35} \approx 5.916\ \text{BM}$$

Answer: (A)

Q20.

Solution

Concept: Potassium permanganate ($KMnO_4$) acts as a strong oxidizing agent in acidic medium. It reduces itself from Mn^{+7} to Mn^{2+} while oxidizing other species.

Solution: In acidic medium, $KMnO_4$ oxidizes iodide ions (I^-) from KI to molecular iodine (I_2).The ionic equation is:

$$2MnO_4^- + 10I^- + 16H^+ \rightarrow 2Mn^{2+} + 5I_2 + 8H_2O$$

Note: In neutral or weakly alkaline medium, I^- is oxidized to IO_3^- (iodate). Since the question specifies acidic medium, the product is I_2.

Answer: (A)

Q21.

Solution

Concept: IUPAC naming follows specific rules: 1. Ligands are named alphabetically. 2. Numerical prefixes (di, tri) indicate quantity. 3. Oxidation state of the metal is in Roman numerals. 4. Ambidentate ligands like NO_2 specify the bonding atom (N-nitrito).
Solution: In $[Pt(NH_3)_2Cl(NO_2)]$:

- Ligands: Diammine (NH_3), chlorido (Cl^-), nitrito-N (NO_2^-).
- Oxidation state (x): $x + 2(0) + (-1) + (-1) = 0 \Rightarrow x = +2$.
- Name: Diamminechloridonitrito-N-platinum(II).

Answer: (A)

Q22.

Solution

Concept: Linkage isomerism occurs in coordination compounds containing **ambidentate ligands** (ligands that can bind through two different atoms, e.g., NO_2^-, SCN^-, CN^-).
Solution: In $[Co(NH_3)_5(NO_2)]Cl_2$, the NO_2^- ligand can bind to the Cobalt metal center either through the Nitrogen atom ($-NO_2$, nitrito-N) or through the Oxygen atom ($-ONO$, nitrito-O).

Answer: (B)

Q23.

Solution

Concept: Valence Bond Theory (VBT) determines hybridization based on ligand strength. F^- is a **weak field ligand**, meaning it does not cause pairing of electrons.
Solution: For $[CoF_6]^{3-}$, Co is in +3 state ($3d^6$).

- Configuration: $t_{2g}^4 e_g^2$ (no pairing).
- Unpaired electrons (n): 4.
- Hybridization: Since it uses outer d-orbitals, it is sp^3d^2 (outer orbital complex).
- Magnetic Moment: $\mu = \sqrt{4(4+2)} = \sqrt{24} \approx 4.90$ BM.

Answer: (A)

Q24.

Solution

Concept: The **Spectrochemical Series** ranks ligands based on their ability to cause crystal field splitting (Δ_o).

Solution: The experimentally determined order of ligand field strength is:$I^- < Br^- < SCN^- < Cl^- < S^{2-} < F^- < OH^- < C_2O_4^{2-} < H_2O < NCS^- < edta^{4-} < NH_3 < en < CN^- < CO$.Based on the options provided, Option A correctly represents this increasing order of splitting power.

Answer: (A)

Q25.

Solution

Concept: Geometrical isomerism arises in heteroleptic complexes due to different possible spatial arrangements of ligands. For a square planar complex $[Ma_2b_2]$, two forms exist: *cis* and *trans*.

Solution: In $[Ma_2b_2]$:

- **Cis-form:** Similar ligands are adjacent (90°).
- **Trans-form:** Similar ligands are opposite (180°).

Square planar complexes of this type generally do not show optical isomerism as they possess a plane of symmetry.

Answer: (A)

Q26.

Solution

Concept: **Homoleptic** complexes are those in which a metal is bound to only one type of ligand group. **Heteroleptic** complexes have more than one type of ligand.

Solution:

- $[Co(NH_3)_6]Cl_3$: Only NH_3 ligands (Homoleptic).
- $[Ni(CO)_4]$: Only CO ligands (Homoleptic).

Note: While both A and D are homoleptic, in typical chemistry curriculum contexts involving "complex ions" vs "neutral carbonyls," both qualify. However, checking the options provided, both A and D fit the definition perfectly. Usually, in such MCQ sets, A is the intended classic example.

Answer: (A)

Q27.

Solution

Concept: The reactivity of alkyl halides in S_N2 reactions depends primarily on **steric hindrance**. Since the nucleophile attacks from the backside, the presence of bulky groups around the carbon atom hinders the approach.The order of reactivity is: $Methyl > Primary(1^\circ) > Secondary(2^\circ) > Tertiary(3^\circ)$.

Solution: Analyzing the given compounds:$(CH_3)_3CCl$: 3° alkyl halide (Most hindered)$(CH_3)_2CHCl$: 2° alkyl halideCH_3CH_2Cl: 1° alkyl halideCH_3Cl: Methyl halide (Least hindered)Increasing order of reactivity: $(CH_3)_3CCl < (CH_3)_2CHCl < CH_3CH_2Cl < CH_3Cl$This corresponds to: $1 < 2 < 3 < 4$.

Answer: (A)

Q28.

Solution

Concept: The cyanide ion (CN^-) is an **ambidentate nucleophile**.KCN is ionic and provides CN^- ions; the attack occurs through Carbon to form cyanides.$AgCN$ is predominantly covalent; the lone pair on Nitrogen is available for attack.

Solution: When ethyl chloride (C_2H_5Cl) reacts with $AgCN$, the covalent nature of $Ag - C$ bond means the nitrogen atom acts as the nucleophilic center.

$$C_2H_5 - Cl + AgCN \rightarrow C_2H_5NC + AgCl$$

The product formed is Ethyl isocyanide.

Answer: (B)

Q29.

Solution

Concept: The Finkelstein reaction is a halogen exchange reaction used specifically for the preparation of alkyl iodides from alkyl chlorides or bromides.

Solution: The reaction involves treating an alkyl halide with sodium iodide (NaI) in dry acetone.

$$R - X + NaI \xrightarrow{\text{dry acetone}} R - I + NaX$$

(where $X = Cl, Br$). NaX precipitates in dry acetone, facilitating the forward reaction according to Le Chatelier's principle.

Answer: (A)

Q30.

Solution

Concept: A molecule is chiral if it is not superimposable on its mirror image. This usually occurs due to the presence of an asymmetric carbon (chiral center)—a carbon atom bonded to four different groups.

Solution: In 2-bromobutane ($CH_3 - \text{C}^* H(Br) - CH_2 - CH_3$), the second carbon ($C^*$) is bonded to four different groups:$-H-Br-CH_3$ (Methyl)$-C_2H_5$ (Ethyl)Because it has an asymmetric carbon and no plane of symmetry, the molecule is chiral.

Answer: (A)

Q31.

Solution

Concept: This reaction is known as the Reimer-Tiemann reaction. It is a classic electrophilic aromatic substitution reaction used for the ortho-formylation of phenols. The active electrophile in this reaction is the **dichlorocarbene** (:CCl 2), which is generated in situ from chloroform and sodium hydroxide.

Solution: The reaction proceeds through the following steps:

Phenol reacts with NaOH to form sodium phenoxide.

CHCl 3 reacts with OH to produce the dichlorocarbene intermediate.

The carbene attacks the ortho position of the phenoxide ring.

Intermediate hydrolysis and subsequent acidification yield the final product.

The resulting product is salicylaldehyde (2-hydroxybenzaldehyde). Note that if carbon tetrachloride (CCl 4) were used instead of chloroform, the product would be salicylic acid.

Answer: (B)

Q32.

Solution

Concept: Lucas reagent is used to distinguish between primary, secondary, and tertiary alcohols. The reaction involves the substitution of the hydroxyl group with a chloride ion. Tertiary alcohols react immediately, secondary alcohols react within 5 minutes, and primary alcohols do not react at room temperature.

Solution: Lucas reagent is a solution of concentrated HCl and anhydrous $ZnCl_2$. The anhydrous $ZnCl_2$ acts as a Lewis acid catalyst to facilitate the cleavage of the $C - OH$ bond.

Answer: (A)

Q33.

Solution

Concept: Acidity depends on the stability of the phenoxide/alkoxide ion formed.Phenols are more acidic than alcohols due to resonance stabilization of the phenoxide ion.Electron-withdrawing groups (EWG) like $-NO_2$ increase acidity by stabilizing the negative charge.Electron-donating groups (EDG) like $-OCH_3$ decrease acidity by destabilizing the negative charge.

Solution: Ethanol: Aliphatic alcohol (Least acidic).p-Methoxyphenol: Phenol with an EDG (Decreases acidity).Phenol: Standard reference.p-Nitrophenol: Phenol with a strong EWG (Most acidic).Increasing order: Ethanol < p-Methoxyphenol < Phenol < p-Nitrophenol.

Answer: (A)

Q34.

Solution

Concept: Williamson ether synthesis involves the reaction of an alkoxide ion with a primary alkyl halide to form an ether.

Solution: The reaction is a bimolecular nucleophilic substitution (S_N2) where the alkoxide ion (RO^-) acts as a nucleophile and attacks the alkyl halide ($R' - X$) from the backside in a single concerted step.

$$R - O^- + R' - X \rightarrow R - O - R' + X^-$$

For the best yield, the alkyl halide should be primary ($1°$) to minimize steric hindrance and competing elimination ($E2$) reactions.

Answer: (B)

Q35.

Solution

Concept: Dehydrogenation of alcohols occurs when alcohol vapors are passed over heated copper at 573 K.Primary alcohols give aldehydes.Secondary alcohols give ketones.Tertiary alcohols undergo dehydration to give alkenes.

Solution: Propan-2-ol ($CH_3 - CH(OH) - CH_3$) is a secondary alcohol. Upon treatment with Cu at 573 K, it undergoes dehydrogenation (loss of H_2) to form propanone (acetone).

$$CH_3 - CH(OH) - CH_3 \xrightarrow{Cu/573K} CH_3 - CO - CH_3 + H_2$$

Answer: (A)

Q36.

Solution

Concept: Aldol condensation is a characteristic reaction of aldehydes and ketones that possess at least one α-hydrogen atom. In the presence of a dilute alkali, these compounds undergo self-condensation to form β-hydroxy aldehydes (aldols) or β-hydroxy ketones (ketols).
Solution: An α-hydrogen is a hydrogen atom attached to the carbon atom immediately adjacent to the carbonyl group ($C = O$). Let us examine the given options:

- **Acetaldehyde (CH_3CHO):** Has 3 α-hydrogens. **Undergoes Aldol.**
- **Acetone (CH_3COCH_3):** Has 6 α-hydrogens. **Undergoes Aldol.**
- **Propanal (CH_3CH_2CHO):** Has 2 α-hydrogens. **Undergoes Aldol.**
- **Benzaldehyde (C_6H_5CHO):** The carbonyl group is attached to a benzene ring carbon that has no hydrogen atoms. Since it lacks α-hydrogens, it cannot form an enolate ion.

Benzaldehyde instead undergoes the Cannizzaro reaction when treated with concentrated alkali.

Answer: (C)

Q37.

Solution

Concept: The Cannizzaro reaction is a disproportionation reaction (self-oxidation and reduction) undergone by aldehydes that do not have an α-hydrogen atom. When treated with concentrated alkali, one molecule is reduced to an alcohol while the other is oxidized to a carboxylic acid salt.
Solution:

- **Formaldehyde ($HCHO$):** No α-carbon, therefore no α-hydrogen. It undergoes Cannizzaro.
- **Acetaldehyde, Acetone, and Ethyl methyl ketone:** All possess α-hydrogens and undergo Aldol condensation instead.

Answer: (A)

Q38.

Solution

Concept: Reactivity towards nucleophilic addition depends on:Electronic Factors: Electron-donating groups (like alkyl groups) reduce the electrophilicity of the carbonyl carbon.Steric Factors: Bulky groups hinder the approach of the nucleophile.

Solution:

- $HCHO$ (Formaldehyde) has no alkyl groups, making it the most electrophilic and least sterically hindered.
- CH_3CHO (Acetaldehyde) has one methyl group (+I effect and bulk).
- CH_3COCH_3 (Acetone) has two methyl groups.
- C_6H_5CHO (Benzaldehyde) is less reactive due to resonance stabilization of the carbonyl group by the ring.

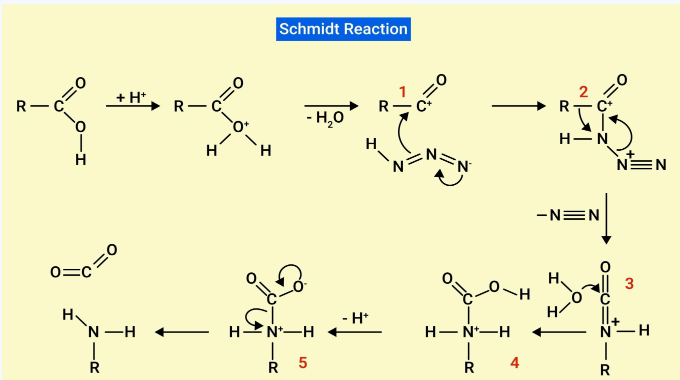
The order of reactivity is $HCHO > CH_3CHO > C_6H_5CHO > CH_3COCH_3$.

Answer: (A)

Q39.

Solution

Concept: The Hell-Volhard-Zelinsky (HVZ) reaction involves the halogenation of carboxylic acids at the α-position.



Solution: Carboxylic acids having an α-hydrogen are reacted with chlorine or bromine in the presence of a small amount of red phosphorus. This results in the replacement of the α-hydrogen with a halogen atom to form α-halo carboxylic acids.

$$R - CH_2 - COOH \xrightarrow[2.H_2O]{1.X_2/Red\ P} R - CH(X) - COOH$$

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Answer: (A)

Q40.

Solution

Concept: Aldehydes ($-CHO$ group) are easily oxidized compared to ketones. Specific mild oxidizing agents are used as diagnostic tests to distinguish them.
Solution:

- **Tollens' reagent:** Ammoniacal silver nitrate; aldehydes reduce it to form a silver mirror.
- **Fehling's solution:** A mixture of copper sulfate and sodium potassium tartrate; aldehydes reduce it to a reddish-brown precipitate of Cu_2O.

Both reagents react with aldehydes but not with common ketones (except α-hydroxy ketones).

Answer: (C)

Q41.

Solution

Concept: The acidity of carboxylic acids is increased by the presence of electron-withdrawing groups (EWG) due to the inductive effect (-I effect), which stabilizes the carboxylate anion.
Solution: Chlorine is an electronegative element that exerts a -I effect. As the number of chlorine atoms on the α-carbon increases, the electron-withdrawing effect becomes stronger, making the acid more acidic.

(a) CH_3COOH (Acetic acid) - No EWG.

(b) $ClCH_2COOH$ (Monochloroacetic acid) - One Cl atom.

(c) $Cl_2CHCOOH$ (Dichloroacetic acid) - Two Cl atoms.

(d) Cl_3CCOOH (Trichloroacetic acid) - Three Cl atoms (Most acidic).

Order: 1 < 2 < 3 < 4.

Answer: (A)

Q42.

Solution

Concept: The basic strength of methylamines in aqueous solution is determined by the combined effect of three factors:Inductive effect (+I): Increases basicity ($3^\circ > 2^\circ > 1^\circ$).Solvation effect: Hydration of the ammonium cation increases basicity ($1^\circ > 2^\circ > 3^\circ$).Steric hindrance: Bulky groups hinder the approach of protons ($1^\circ > 2^\circ > 3^\circ$).

Solution: For methyl-substituted amines, the interplay of these factors results in the following order:Secondary (2°) > Primary (1°) > Tertiary (3°) > Ammonia.Specifically: $(CH_3)_2NH > CH_3NH_2 > (CH_3)_3N > NH_3$.(Note: For ethyl-substituted amines, the order changes to $2^\circ > 3^\circ > 1^\circ > NH_3$).

Answer: (A)

Q43.

Solution

Concept: Gabriel Phthalimide synthesis is a method used for the preparation of amines that avoids the formation of secondary and tertiary amines.

Solution: The reaction involves the treatment of phthalimide with KOH to form potassium phthalimide, which then reacts with an alkyl halide.

$$\text{Phthalimide} \xrightarrow{KOH} \text{Potassium Phthalimide} \xrightarrow{R-X} \text{N-Alkylphthalimide} \xrightarrow{NaOH(aq)} \text{Primary Amine}(R-NH_2)$$

This method is limited to the synthesis of primary aliphatic amines. It cannot be used to prepare primary aromatic amines (like aniline) because aryl halides do not undergo nucleophilic substitution with the phthalimide anion.

Answer: (A)

Q44.

Solution

Concept: Diazonium salts are highly reactive intermediates that can be replaced by various nucleophiles using copper salts as catalysts.

Solution: When benzene diazonium chloride ($C_6H_5N_2^+Cl^-$) is treated with cuprous chloride (Cu_2Cl_2) in HCl, the diazonium group is replaced by a chlorine atom to form chlorobenzene. This specific reaction using cuprous salts is known as the Sandmeyer reaction.Note: If copper powder in HCl were used instead of cuprous salts, it would be called the Gattermann reaction.

Answer: (A)

Q45.

Solution

Concept: Hinsberg's test is used to distinguish between primary, secondary, and tertiary amines based on their reaction with a specific reagent.

Solution: Hinsberg's reagent is Benzene sulphonyl chloride (C 6 H 5 SO 2 Cl).

- Primary amines react to form a sulfonamide soluble in alkali.
- Secondary amines react to form a sulfonamide insoluble in alkali.
- Tertiary amines do not react with the reagent under normal conditions.

Answer: (A)

Q46.

Solution

Concept: Reducing sugars contain free aldehyde or ketone groups (in hemiacetal or hemiketal form) that can reduce Tollens' or Fehling's reagents. Non-reducing sugars have these functional groups locked in a glycosidic linkage.

Solution:

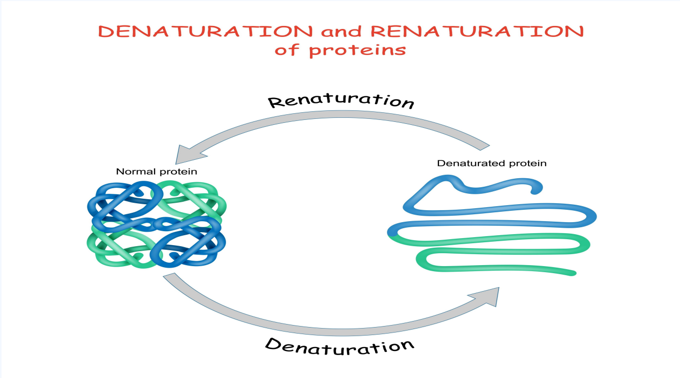
- **Glucose and Fructose:** Monosaccharides are all reducing sugars.
- **Lactose:** A disaccharide with a free hemiacetal group (reducing).
- **Sucrose:** A disaccharide formed by C_1 of glucose and C_2 of fructose. Since both reducing groups are involved in the glycosidic bond, it is a non-reducing sugar.

Answer: (D)

Q47.

Solution

Concept: Denaturation is a process where proteins lose their native conformation due to physical or chemical changes (like heat or pH change), without breaking the covalent peptide bonds.



Solution: During denaturation, the hydrogen bonds and folding patterns are disrupted. This results in the loss of secondary, tertiary, and quaternary structures. The primary structure (the sequence of amino acids linked by peptide bonds) remains intact.
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Answer: (B)

Q48.

Solution

Concept: Vitamins are essential nutrients, and their deficiency leads to specific clinical conditions.
Solution:

- **Scurvy:** Vitamin C deficiency.
- **Rickets:** Vitamin D deficiency.
- **Pernicious anaemia:** Vitamin B12 (Cyanocobalamin) deficiency.
- **Night blindness:** Vitamin A deficiency.

Answer: (C)

Q49.

Solution

Concept: The α-helix is a common secondary structure of proteins where the polypeptide chain is coiled into a right-handed screw.

Solution: The helical structure is stabilized by hydrogen bonds formed between the $-NH$ group of one amino acid residue and the $> C = O$ group of an adjacent turn of the helix.

Answer: (B)

Q50.

Solution

Concept: DNA consists of two polynucleotide chains where nitrogenous bases pair specifically via hydrogen bonding.

Solution: According to Chargaff's rule and the Watson-Crick model:

- Adenine (A) pairs with Thymine (T) via two hydrogen bonds.
- Guanine (G) pairs with Cytosine (C) via three hydrogen bonds.

In RNA, Uracil (U) replaces Thymine (T).

Answer: (A)

Answer Key

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