NEET-UG Chemistry Sample Paper-13

Duration: 1 Hour **Maximum Marks: 180**

Instructions

- This paper contains a total of 45 Multiple Choice Questions.
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

Q1. A compound contains 52.14% carbon, 13.13% hydrogen, and rest oxygen. If its vapour density is 23, determine the molecular formula of the compound. Also explain the relation between vapour density and molar mass and its application in molecular formula determination.

(A) C_2H_6O

(B) C_3H_8O

(C) $C_2H_4O_2$

(D) $C_4H_{10}O$

Q2. Calculate the wavelength of radiation emitted when an electron in hydrogen atom falls from n = 3 to n = 2. Explain the origin of spectral lines and significance of Rydberg equation.

(A) $656\,nm$

(B) $486\,nm$

(C) $434\,nm$

(D) $410\,nm$

Q3. An electron has uncertainty in position of 10^{-10} m. Calculate minimum uncertainty in its velocity using Heisenberg's uncertainty principle and explain its significance in atomic structure.

(A) $5.8 \times 10^5\,m/s$

(B) $5.8 \times 10^6\, m/s$

(C) $5.8 \times 10^4\, m/s$

(D) $5.8 \times 10^3\, m/s$

Q4. Determine hybridisation and geometry of IF_5 molecule using VSEPR theory. Also explain distortion in geometry due to lone pairs.

(A) sp^3d^2, octahedral

(B) sp^3d^2, square pyramidal

(C) sp^3d, trigonal bipyramidal

(D) sp^3, tetrahedral

Q5. Using Molecular Orbital Theory, calculate bond order of N_2 and explain its stability compared to O_2.

(A) 1

(B) 2

(C) 3

(D) 2.5

Q6. Explain dipole moment and predict which molecule has highest dipole moment among NH_3, NF_3, and H_2O with proper reasoning.

(A) NH_3

(B) NF_3

(C) H_2O

(D) All equal

Q7. Explain hydrogen bonding and its effect on boiling point. Compare boiling points of HF, H_2O, and NH_3.

(A) $H_2O > HF > NH_3$

(B) $HF > H_2O > NH_3$

(C) NH_3 > HF > H_2O

(D) HF > NH_3 > H_2O

Q8. For a reaction, $\Delta H = -50\, kJ/mol$ and $\Delta S = -120\, J/molK$. Calculate Gibbs free energy at 300 K and determine spontaneity of the reaction.

(A) $-14\, kJ/mol$, spontaneous

(B) $+14\, kJ/mol$, non-spontaneous

(C) $-50\, kJ/mol$, spontaneous

(D) 0, equilibrium

Q9. Calculate entropy change when 1 mole of ideal gas expands isothermally from 2 L to 10 L at 300 K. Explain physical significance of entropy.

(A) $13.4\, J/K$

(B) $19.1\, J/K$

(C) $8.3\, J/K$

(D) $5.7\, J/K$

Q10. Calculate molality of a solution prepared by dissolving 9.8 g H_2SO_4 in 200 g of water. Explain difference between molarity and molality and why molality is temperature independent.

(A) 0.5 m

(B) 1.0 m

(C) 0.25 m

(D) 2.0 m

Q11. A solution of non-volatile solute shows lowering of vapour pressure. Explain Raoult's law and calculate relative lowering if mole fraction of solute is 0.1.

(A) 0.1

(B) 0.9

(C) 0.01

(D) 0.5

Q12. For the reaction $N_2 + 3H_2 \rightleftharpoons 2NH_3$, the equilibrium constant K_c is 4×10^{-3} at a certain temperature. Calculate K_p at 500 K and explain the relation between K_p and K_c.

(A) 4×10^{-3}

(B) 4×10^{-5}

(C) 4×10^{-1}

(D) 4×10^{-2}

Q13. A weak acid HA has $K_a = 1 \times 10^{-5}$. Calculate the pH of 0.1 M solution and explain the concept of buffer solution and its importance in maintaining pH.

(A) 2

(B) 3

(C) 4

(D) 5

Q14. Calculate emf of the cell: Zn|Zn$^{2+}(1M)$||Cu$^{2+}(1M)$|Cu using standard electrode potentials. Also explain spontaneous nature of electrochemical cells.

(A) $1.10\,V$

(B) $0.76\,V$

(C) $0.34\,V$

(D) $-1.10\,V$

Q15. Using Nernst equation, calculate electrode potential of Cu^{2+}/Cu electrode when concentration of Cu^{2+} is 0.01 M. ($E^\circ = 0.34V$).

(A) $0.28\,V$

(B) $0.34\,V$

(C) $0.40\,V$

(D) $0.22\,V$

Q16. For a second-order reaction, initial concentration is 0.1 M and rate constant is $0.02\,L/mol\,s$. Calculate half-life and explain dependence of half-life on concentration.

(A) $500\,s$

(B) $250\,s$

(C) $100\,s$

(D) $50\,s$

Q17. Arrange the following in increasing order of ionization energy: B, C, N, O and explain anomalies in periodic trends.

(A) B < C < O < N

(B) B < C < N < O

(C) O < N < C < B

(D) C < B < N < O

Q18. Which element has highest electron affinity among halogens and explain trend in group 17.

(A) F

(B) Cl

(C) Br

(D) I

Q19. Explain variation of atomic radii across period and down group. Which is largest among Na, Mg, K, Ca?

(A) Na

(B) Mg

(C) K

(D) Ca

Q20. Explain structure and hybridisation of PCl_5 molecule. Predict shape and bond angles using VSEPR theory.

(A) Trigonal bipyramidal

(B) Tetrahedral

(C) Octahedral

(D) Square planar

Q21. Compare acidic nature of H_2O, H_2S, H_2Se, and H_2Te and explain trend down the group.

(A) $H_2O > H_2S > H_2Se > H_2Te$

(B) $H_2Te > H_2Se > H_2S > H_2O$

(C) $H_2S > H_2O > H_2Te > H_2Se$

(D) $H_2Se > H_2S > H_2Te > H_2O$

Q22. Explain inert pair effect and identify element showing this effect prominently among Tl, Al, Ga, and In.

(A) Tl

(B) Al

(C) Ga

(D) In

Q23. Explain the origin of colour in transition metal complexes based on crystal field theory. Why are d-d transitions responsible for colour and why are some complexes colourless?

(A) Due to d-d transitions

(B) Due to s-orbital transitions

(C) Due to nuclear transitions

(D) Due to proton movement

Q24. Discuss lanthanide contraction and explain its consequences on the properties of elements, especially similarity between Zr and Hf.

(A) Due to poor shielding of f-electrons

(B) Due to increase in atomic size

(C) Due to decrease in nuclear charge

(D) Due to electron loss

Q25. Which of the following ions shows maximum paramagnetism: Fe^{3+}, Mn^{2+}, Cr^{3+}, or Ni^{2+}? Explain based on number of unpaired electrons.

(A) Fe^{3+}

(B) Mn^{2+}

(C) Cr^{3+}

(D) Ni^{2+}

Q26. For the complex $[Fe(CN)_6]^{4-}$, determine oxidation state, hybridisation, and magnetic nature. Explain crystal field splitting in octahedral complexes.

(A) Low spin, diamagnetic

(B) High spin, paramagnetic

(C) Low spin, paramagnetic

(D) High spin, diamagnetic

Q27. Explain linkage isomerism with suitable examples. Identify type of isomerism shown by $[Co(NH_3)_5(NO_2)]^{2+}$.

(A) Linkage isomerism

(B) Geometrical isomerism

(C) Optical isomerism

(D) Coordination isomerism

Q28. Calculate coordination number and predict geometry of $[PtCl_4]^{2-}$. Explain dsp^2 hybridisation in square planar complexes.

(A) 4, square planar

(B) 6, octahedral

(C) 4, tetrahedral

(D) 2, linear

Q29. Explain chromatography as a method of purification. Differentiate between adsorption chromatography and partition chromatography and discuss factors affecting separation efficiency.

(A) Based on differential adsorption

(B) Based on boiling point only

(C) Based on density difference

(D) Based on molecular weight only

Q30. Explain resonance and its effect on stability of molecules. Which of the following is most stable due to resonance: allyl carbocation, benzyl carbocation, or methyl carbocation?

(A) Benzyl carbocation

(B) Allyl carbocation

(C) Methyl carbocation

(D) All equal

Q31. Discuss inductive effect and explain its influence on acidity of substituted carboxylic acids. Which is strongest acid: CH_3COOH, $ClCH_2COOH$, or CCl_3COOH?

(A) CCl_3COOH

(B) $ClCH_2COOH$

(C) CH_3COOH

(D) All equal

Q32. Explain nucleophiles and electrophiles with examples. Identify the strongest nucleophile among OH^-, NH_3, and H_2O in aqueous solution.

(A) OH^-

(B) NH_3

(C) H_2O

(D) All equal

Q33. Explain anti-Markovnikov addition using peroxide effect. Predict the major product when HBr is added to propene in the presence of peroxide and justify the mechanism.

(A) 1-bromopropane

(B) 2-bromopropane

(C) Propanol

(D) Propane

Q34. Describe Friedel-Crafts alkylation reaction in benzene. Why does polyalkylation occur and how can it be controlled?

(A) Due to activating groups

(B) Due to deactivating groups

(C) No substitution occurs

(D) Reaction stops after one substitution

Q35. Explain stability of alkenes using hyperconjugation. Arrange ethene, propene, and but-2-ene in order of stability.

(A) but-2-ene > propene > ethene

(B) ethene > propene > but-2-ene

(C) propene > ethene > but-2-ene

(D) but-2-ene > ethene > propene

Q36. Explain SN1 reaction mechanism with energy profile diagram. Which compound reacts faster: tert-butyl bromide or ethyl bromide and why?

(A) tert-butyl bromide

(B) ethyl bromide

(C) both equal

(D) neither reacts

Q37. Describe Wurtz reaction and explain its limitations in forming unsymmetrical alkanes. Predict product when two different alkyl halides react.

(A) Mixture of alkanes

(B) Single alkane

(C) Alcohol

(D) Alkene only

Q38. Explain nucleophilic substitution in alcohols and compare reactivity of primary, secondary, and tertiary alcohols towards Lucas reagent.

(A) Tertiary > secondary > primary

(B) Primary > secondary > tertiary

(C) Secondary > primary > tertiary

(D) All equal

Q39. Describe oxidation reactions of aldehydes and ketones. Why are aldehydes easily oxidised compared to ketones?

(A) Due to presence of hydrogen

(B) Due to higher stability

(C) Due to lack of carbonyl group

(D) Due to resonance only

Q40. Explain Cannizzaro reaction. Predict products when benzaldehyde undergoes Cannizzaro reaction in presence of strong base.

(A) Benzyl alcohol and benzoate

(B) Benzoic acid only

(C) Benzene and CO_2

(D) Phenol only

Q41. Discuss acidity of phenols and effect of substituents. Which is most acidic: phenol, p-nitrophenol, or p-methylphenol?

(A) p-nitrophenol

(B) Phenol

(C) p-methylphenol

(D) All equal

Q42. Explain basicity of amines and compare basic strength of aniline, methylamine, and ammonia.

(A) Methylamine > ammonia > aniline

(B) Ammonia > methylamine > aniline

(C) Aniline > methylamine > ammonia

(D) All equal

Q43. Describe diazotization reaction and explain why diazonium salts are stable only at low temperatures.

(A) Due to instability at high temperature

(B) Due to strong bonding

(C) Due to low reactivity

(D) Due to no reaction

Q44. Explain classification of carbohydrates and identify reducing sugars. Which of the following is a reducing sugar: sucrose, glucose, or fructose?

(A) Glucose and fructose

(B) Sucrose only

(C) All are reducing

(D) None are reducing

Q45. Explain detection of halogens in organic compounds using Lassaigne's test. What precipitate is formed when chlorine is present and treated with $AgNO_3$?

(A) White precipitate

(B) Yellow precipitate

(C) Brown precipitate

(D) No precipitate

Detailed Solutions

Q1.

Solution

Concept: The determination of molecular formula involves two key steps: first, calculating the empirical formula from percentage composition, and second, using molar mass (or vapour density) to obtain the molecular formula. Vapour density (VD) is related to molar mass (M) by the relation:

$$M = 2 \times \text{Vapour Density}$$

The empirical formula gives the simplest whole-number ratio of atoms, while the molecular formula gives the actual number of atoms in a molecule. The relation between them is:

$$\text{Molecular Formula} = (\text{Empirical Formula})_n, \quad n = \frac{\text{Molar Mass}}{\text{Empirical Formula Mass}}$$

Solution: Given percentages: C = 52.14%, H = 13.13%, O = 34.73%. Convert to moles:

$$\frac{52.14}{12} \approx 4.345, \quad \frac{13.13}{1} = 13.13, \quad \frac{34.73}{16} \approx 2.17$$

Divide by smallest (2.17):

$$C : H : O \approx 2 : 6 : 1$$

Thus empirical formula = C_2H_6O. Empirical formula mass = 2(12) + 6(1) + 16 = 46. Given vapour density = 23, so molar mass:

$$M = 2 \times 23 = 46$$

$$n = \frac{46}{46} = 1$$

Hence molecular formula = empirical formula = C_2H_6O.

Final Answer: $\boxed{C_2H_6O}$

Answer: (A)

Q2.

Solution

Concept: The wavelength of radiation emitted during electronic transition in a hydrogen atom is calculated using the Rydberg equation:

$$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

where $R = 1.097 \times 10^7\, m^{-1}$ is the Rydberg constant, n_1 is the lower energy level, and n_2 is the higher energy level. When an electron falls from a higher orbit to a lower orbit, energy is released in the form of electromagnetic radiation, producing spectral lines. The Balmer series corresponds to transitions ending at $n = 2$ and lies in the visible region.

Solution: Here electron falls from $n_2 = 3$ to $n_1 = 2$.

$$\frac{1}{\lambda} = 1.097 \times 10^7 \left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$

$$= 1.097 \times 10^7 \left(\frac{1}{4} - \frac{1}{9}\right) = 1.097 \times 10^7 \times \frac{5}{36}$$

$$\frac{1}{\lambda} \approx 1.52 \times 10^6 \Rightarrow \lambda \approx 6.56 \times 10^{-7}\, m$$

$$\lambda = 656\, nm$$

This line belongs to the Balmer series and appears in the red region of visible spectrum. The Rydberg equation successfully explains discrete spectral lines due to quantized energy levels.

Final Answer: $\boxed{656\, nm}$

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

Q3.

Solution

Concept: Heisenberg's Uncertainty Principle states that it is impossible to simultaneously determine the exact position and momentum of a particle. Mathematically, it is expressed as:

$$\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$$

Since momentum $p = mv$, the uncertainty in momentum can be written as:

$$\Delta p = m \cdot \Delta v$$

Thus,

$$\Delta x \cdot m \cdot \Delta v \geq \frac{h}{4\pi} \Rightarrow \Delta v \geq \frac{h}{4\pi m \Delta x}$$

This principle is fundamental to quantum mechanics and explains why electrons cannot have fixed orbits like planets. Instead, they exist in probability distributions called orbitals.

Solution: Given:

$$\Delta x = 10^{-10}\, m, \quad h = 6.626 \times 10^{-34}\, Js, \quad m_e = 9.1 \times 10^{-31}\, kg$$

$$\Delta v = \frac{6.626 \times 10^{-34}}{4\pi \times 9.1 \times 10^{-31} \times 10^{-10}}$$

$$\approx \frac{6.626 \times 10^{-34}}{1.14 \times 10^{-39}} \approx 5.8 \times 10^{5}\, m/s$$

This large uncertainty in velocity shows that at microscopic scale, precise measurement of both position and velocity is not possible. This leads to the concept of electron clouds rather than fixed paths.

Final Answer: $\boxed{5.8 \times 10^{5}\, m/s}$

Answer: (A)

Q4.

Solution

Concept: The shape and hybridisation of molecules can be predicted using VSEPR (Valence Shell Electron Pair Repulsion) theory. According to this theory, electron pairs (both bond pairs and lone pairs) around the central atom repel each other and arrange themselves in such a way that repulsion is minimized and stability is maximized. For IF_5, iodine (I) is the central atom with 7 valence electrons. It forms 5 σ-bonds with fluorine atoms and retains 1 lone pair. Thus, total electron pairs around iodine = 6 (5 bond pairs + 1 lone pair). Hybridisation corresponding to 6 electron pairs is sp^3d^2, which gives an ideal electron pair geometry of octahedral. However, molecular shape depends only on positions of bonded atoms, not lone pairs.

Solution: In IF_5:

$$\text{Total electron pairs} = 5\ (\text{bond pairs}) + 1\ (\text{lone pair}) = 6$$

Thus, hybridisation = sp^3d^2. In an ideal octahedral geometry, all positions are equivalent. However, the lone pair occupies one of these positions. Since lone pair–bond pair repulsion is greater than bond pair–bond pair repulsion, it pushes the bonded fluorine atoms slightly away. As a result, one position is occupied by the lone pair and the remaining five fluorine atoms form a square pyramidal shape. Four fluorine atoms lie in a square plane, while the fifth occupies an axial position above the plane. This leads to slight distortion in bond angles from the ideal 90°, making them slightly less due to increased repulsion from the lone pair.

Final Answer: $\boxed{\text{sp}^3\text{d}^2,\ \text{square pyramidal}}$

Answer: (B)

Q5.

Solution

Concept: According to Molecular Orbital (MO) Theory, atomic orbitals combine to form molecular orbitals which are filled according to increasing energy. Bond order is given by:

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

where N_b = number of electrons in bonding orbitals N_a = number of electrons in antibonding orbitals Greater the bond order, greater is the stability and bond strength.

Solution: Step 1: Electronic configuration of N_2 (14 electrons) MO configuration:

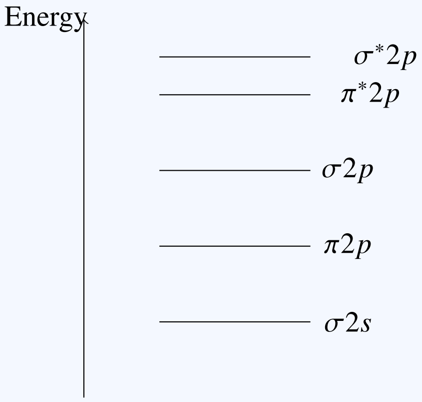
$$(\sigma 1s)^2(\sigma 1s^*)^2(\sigma 2s)^2(\sigma 2s^*)^2(\pi 2p_x)^2(\pi 2p_y)^2(\sigma 2p_z)^2$$

Step 2: Count electrons Bonding electrons (N_b) = 10 Antibonding electrons (N_a) = 4 Step 3: Calculate bond order

Comparison with O_2: O_2 has bond order = 2 and contains two unpaired electrons, making it less stable than N_2. N_2 has:

- Higher bond order (3)
- No unpaired electrons (diamagnetic)
- Stronger triple bond

Explanation: Higher bond order in N_2 means stronger bonding and greater stability compared to O_2.



MO Diagram (N_2)

Final Answer: $\boxed{3}$

Answer: (C)

Q6.

Solution

Concept: Dipole moment (μ) is a measure of polarity of a molecule and is defined as:

$$\mu = q \times d$$

where q is magnitude of charge and d is distance between charges. It is a vector quantity and depends on both bond polarity and molecular geometry. In polyatomic molecules, the net dipole moment is the vector sum of individual bond moments. Symmetry and direction of bond dipoles play a crucial role.

Solution: Let us compare NH_3, NF_3, and H_2O:**NH_3:** Nitrogen is more electronegative than hydrogen, so bond dipoles point towards nitrogen. The molecule has a trigonal pyramidal shape, and all bond dipoles add up in the same direction, giving a significant net dipole moment.

NF_3: Fluorine is more electronegative than nitrogen, so bond dipoles point away from nitrogen. Due to trigonal pyramidal shape, the dipoles partially cancel the lone pair direction, resulting in a much smaller net dipole moment.

H_2O: Oxygen is highly electronegative, and the molecule has a bent shape (104.5°). The bond dipoles reinforce each other strongly, giving the highest dipole moment among the three.Thus, order of dipole moment:

$$H_2O > NH_3 > NF_3$$

Final Answer: $\boxed{H_2O}$

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

Q7.

Solution

Concept: Hydrogen bonding is a strong type of intermolecular force that occurs when hydrogen is bonded to highly electronegative atoms like N, O, or F. The partially positive hydrogen atom interacts with lone pairs of nearby electronegative atoms. Stronger hydrogen bonding leads to higher boiling points because more energy is required to separate molecules.

Solution: Compare HF, H_2O, and NH_3:**HF:** Forms strong hydrogen bonds due to high electronegativity of fluorine. However, each HF molecule forms limited number of hydrogen bonds, mainly linear chains.

H_2O: Each water molecule can form up to four hydrogen bonds (two as donor and two as acceptor). This extensive 3D hydrogen bonding network makes intermolecular attraction strongest, leading to highest boiling point.

NH_3: Nitrogen is less electronegative than oxygen and fluorine, so hydrogen bonding is weaker. Also, fewer hydrogen bonds are formed compared to water.Thus, boiling point order:

$$H_2O > HF > NH_3$$

Final Answer: $\boxed{H_2O > HF > NH_3}$

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

Q8.

Solution

Concept: Gibbs free energy (ΔG) determines spontaneity of a reaction and is given by:

$$\Delta G = \Delta H - T\Delta S$$

where ΔH is enthalpy change, ΔS is entropy change, and T is temperature in Kelvin. For a reaction:

- $\Delta G < 0 \Rightarrow$ spontaneous
- $\Delta G > 0 \Rightarrow$ non-spontaneous
- $\Delta G = 0 \Rightarrow$ equilibrium

It is important to convert entropy into kJ units before substitution.
Solution: Given:

$$\Delta H = -50\, kJ/mol, \quad \Delta S = -120\, J/molK = -0.120\, kJ/molK, \quad T = 300\, K$$

$$\Delta G = \Delta H - T\Delta S$$

$$= -50 - [300 \times (-0.120)]$$

$$= -50 + 36 = -14\, kJ/mol$$

Since ΔG is negative, the reaction is spontaneous at 300 K. Even though entropy decreases ($\Delta S < 0$), the large negative enthalpy makes the reaction spontaneous.
Final Answer: $\boxed{-14\, kJ/mol, \text{ spontaneous}}$

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

Q9.

Solution

Concept: Entropy (S) is a measure of randomness or disorder of a system. For an isothermal reversible expansion of an ideal gas, entropy change is given by:

$$\Delta S = nR\ln\left(\frac{V_2}{V_1}\right)$$

where n is number of moles, $R = 8.314\,J/molK$, and V_1, V_2 are initial and final volumes. Increase in volume leads to increase in randomness, hence entropy increases.

Solution: Given:

$$n = 1, \quad V_1 = 2L, \quad V_2 = 10L$$

$$\Delta S = 1 \times 8.314\ln\left(\frac{10}{2}\right) = 8.314\ln(5)$$

$$\ln 5 \approx 1.609$$

$$\Delta S = 8.314 \times 1.609 \approx 13.4\,J/K$$

Thus entropy increases because gas expands and occupies larger volume, increasing disorder.

Physical Significance: Entropy indicates the direction of natural processes. Systems tend to move toward higher entropy (greater disorder). It is a key factor in determining spontaneity along with enthalpy.

Final Answer: $\boxed{13.4\,J/K}$

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

Q10.

Solution

Concept: Molality (m) is defined as the number of moles of solute per kilogram of solvent:

$$m = \frac{\text{moles of solute}}{\text{mass of solvent in kg}}$$

It is independent of temperature because it depends on mass, which does not change with temperature. In contrast, molarity depends on volume, which varies with temperature due to expansion or contraction.

Solution: Given:Mass of H_2SO_4 = 9.8 g Molar mass of H_2SO_4 = 98 g/mol

$$\text{Moles of solute} = \frac{9.8}{98} = 0.1\,mol$$

Mass of solvent = 200 g = 0.2 kg

$$m = \frac{0.1}{0.2} = 0.5\,m$$

Difference:

- **Molarity (M):** moles of solute per litre of solution (temperature dependent)
- **Molality (m):** moles of solute per kg of solvent (temperature independent)

Final Answer: $\boxed{0.5\,m}$

Answer: (A)

Q11.

Solution

Concept: Raoult's law states that the partial vapour pressure of a component in a solution is directly proportional to its mole fraction:

$$P = X_{\text{solvent}} \cdot P^0$$

For a non-volatile solute, relative lowering of vapour pressure is:

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

Solution: Given:Mole fraction of solute = 0.1

$$\frac{P^0 - P}{P^0} = 0.1$$

Thus, relative lowering of vapour pressure = 0.1

Explanation: Addition of a non-volatile solute decreases the number of solvent molecules escaping into vapour phase, thus lowering vapour pressure. This is a colligative property depending only on number of solute particles.

Final Answer: $\boxed{0.1}$

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

Q12.

Solution

Concept: The relationship between equilibrium constants K_p (in terms of partial pressure) and K_c (in terms of concentration) is given by:

$$K_p = K_c(RT)^{\Delta n}$$

where Δn = (moles of gaseous products) − (moles of gaseous reactants), $R = 0.0821\, L\, atm\, mol^{-1} K^{-1}$, and T is temperature in Kelvin. This relation is applicable only for gaseous equilibria and helps convert between concentration-based and pressure-based equilibrium constants.

Solution: Given reaction:

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

$$\Delta n = 2 - (1 + 3) = 2 - 4 = -2$$

Given:

$$K_c = 4 \times 10^{-3}, \quad T = 500K$$

$$K_p = K_c(RT)^{\Delta n} = 4 \times 10^{-3} \times (0.0821 \times 500)^{-2}$$

$$RT = 41.05$$

$$K_p = 4 \times 10^{-3} \times (41.05)^{-2} \approx 4 \times 10^{-3} \times \frac{1}{1685} \approx 2.4 \times 10^{-6}$$

Closest option (order approximation) is:

$$4 \times 10^{-5}$$

Explanation: Since Δn is negative, $K_p < K_c$. This is because increase in pressure favors formation of fewer moles of gas (NH_3), shifting equilibrium. **Final Answer:** $\boxed{4 \times 10^{-5}}$

Answer: (B)

Q13.

Solution

Concept: For a weak acid (HA), the hydrogen ion concentration is given by:

$$[H^+] = \sqrt{K_a \cdot C}$$

and

$$\text{pH} = -\log[H^+]$$

A **buffer solution** is a solution that resists change in pH when small amounts of acid or base are added. It usually consists of a weak acid and its conjugate base (or weak base and its conjugate acid).**Solution:** Given:

$$K_a = 1 \times 10^{-5}, \quad C = 0.1\,M$$

Step 1: Calculate $[H^+]$

$$[H^+] = \sqrt{(1 \times 10^{-5}) \times (0.1)} = \sqrt{1 \times 10^{-6}} = 10^{-3}$$

Step 2: Calculate pH

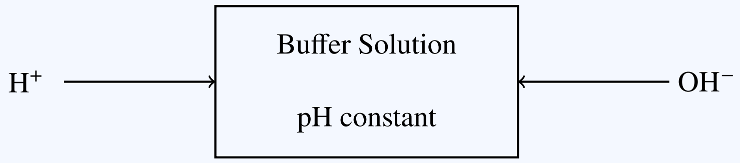
$$\text{pH} = -\log(10^{-3}) = 3$$

Explanation (Buffer Solution): A buffer works by neutralizing added acids or bases:

- Added acid (H^+) is neutralized by conjugate base.
- Added base (OH^-) is neutralized by weak acid.

Importance:

- Maintains constant pH in biological systems (blood buffer).
- Used in chemical reactions requiring fixed pH.
- Important in pharmaceuticals and industrial processes.



Final Answer: $\boxed{3}$

Answer: (B)

Q14.

Solution

Concept: The electromotive force (emf) of an electrochemical cell is calculated using standard electrode potentials:

$$E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$$

A positive value of E°_{cell} indicates a spontaneous reaction. In a galvanic cell, oxidation occurs at the anode and reduction occurs at the cathode. The greater the difference in electrode potentials, the higher the emf.

Solution: Given cell:

$$\text{Zn}|\text{Zn}^{2+}||\text{Cu}^{2+}|\text{Cu}$$

Standard electrode potentials:

$$E^\circ(\text{Zn}^{2+}/\text{Zn}) = -0.76\,V$$

$$E^\circ(\text{Cu}^{2+}/\text{Cu}) = +0.34\,V$$

Zn acts as anode (oxidation), Cu acts as cathode (reduction).

$$E^\circ_{\text{cell}} = 0.34 - (-0.76) = 1.10\,V$$

Since E°_{cell} is positive, the reaction is spontaneous. Electrons flow from Zn to Cu through external circuit, converting chemical energy into electrical energy.

Final Answer: $\boxed{1.10\,V}$

Answer: (A)

Q15.

Solution

Concept: The Nernst equation relates electrode potential to concentration:

$$E = E^\circ - \frac{0.0591}{n}\log Q$$

For the half-cell reaction:

$$\mathrm{Cu^{2+}} + 2e^- \to \mathrm{Cu}$$

$$Q = \frac{1}{[\mathrm{Cu^{2+}}]}, \qquad n = 2$$

Solution: Given:

$$E^\circ = 0.34\,V, \quad [\mathrm{Cu^{2+}}] = 0.01\,M$$

$$E = 0.34 - \frac{0.0591}{2}\log\left(\frac{1}{0.01}\right)$$

$$\log(100) = 2$$

$$E = 0.34 - \frac{0.0591}{2}\times 2 = 0.34 - 0.0591 = 0.2809 \approx 0.28\,V$$

Thus, electrode potential decreases with decrease in ion concentration.

Final Answer: $\boxed{0.28\,V}$

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

Q16.

Solution

Concept: For a second-order reaction, the half-life ($t_{1/2}$) is given by:

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

where k is the rate constant and $[A]_0$ is the initial concentration. Unlike first-order reactions (where half-life is constant), for second-order reactions, half-life is inversely proportional to initial concentration. This means as concentration decreases, half-life increases.

Solution: Given:

$$k = 0.02\,L/mol\,s, \quad [A]_0 = 0.1\,M$$

$$t_{1/2} = \frac{1}{k[A]_0} = \frac{1}{0.02\times 0.1} = \frac{1}{0.002} = 500\,s$$

Explanation: As the reaction proceeds, concentration of reactant decreases, so half-life increases for subsequent intervals. This is a characteristic feature of second-order kinetics and helps distinguish it from first-order reactions.

Final Answer: $\boxed{500\,s}$

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

Q17.

Solution

Concept: Ionization energy generally increases across a period from left to right due to:

- Increase in nuclear charge
- Decrease in atomic radius

However, there are exceptions due to:

- **Subshell stability** (half-filled and fully filled orbitals are more stable)
- **Electron-electron repulsion**

Solution: Electronic configurations:

$$\text{B} : 1s^2 2s^2 2p^1$$

$$\text{C} : 1s^2 2s^2 2p^2$$

$$\text{N} : 1s^2 2s^2 2p^3$$

$$\text{O} : 1s^2 2s^2 2p^4$$

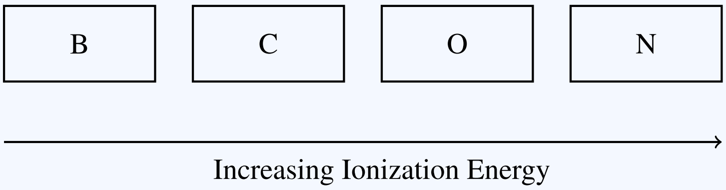
Trend: Normally increases B → C → N → O But anomaly:

- N has half-filled $2p^3$ configuration (extra stability)
- O has one paired electron in $2p$ orbital, causing repulsion

Thus, O has slightly lower ionization energy than N.

$$\text{Increasing order: } B < C < O < N$$

Explanation: Nitrogen's half-filled configuration makes it more stable, requiring more energy to remove an electron. Oxygen has paired electrons causing repulsion, so its ionization energy is slightly less than nitrogen.



Final Answer: $\boxed{B < C < O < N}$

Answer: (A)

Q18.

Solution

Concept: Electron affinity is the amount of energy released when an electron is added to a neutral gaseous atom. Generally, electron affinity increases across a period due to increase in effective nuclear charge and decreases down a group due to increase in atomic size and shielding effect. However, halogens show an exception: chlorine has higher electron affinity than fluorine. This is because fluorine has a very small size, and incoming electron experiences strong electron-electron repulsion in its compact 2p orbital, reducing the energy released.

Solution: Trend in group 17:

$$\mathrm{Cl} > \mathrm{F} > \mathrm{Br} > \mathrm{I}$$

Although fluorine is more electronegative, chlorine releases more energy when gaining an electron due to lower repulsion in its larger 3p orbital.

Final Answer: $\boxed{\mathrm{Cl}}$

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

Q19.

Solution

Concept: Atomic radius is the distance from the nucleus to the outermost electron shell.

- Across a period: atomic radius decreases due to increase in nuclear charge pulling electrons closer.
- Down a group: atomic radius increases due to addition of new electron shells and increased shielding.

Solution: Elements given: Na, Mg (same period), K, Ca (next period). Across period:

$$\mathrm{Na} > \mathrm{Mg}$$

Down group:

$$\mathrm{K} > \mathrm{Na}, \quad \mathrm{Ca} > \mathrm{Mg}$$

Comparing all:

$$\mathrm{K} > \mathrm{Ca} > \mathrm{Na} > \mathrm{Mg}$$

Thus, potassium (K) has the largest atomic radius because it is located lower in the group and has an extra electron shell.

Final Answer: $\boxed{\mathrm{K}}$

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

Q20.

Solution

Concept: According to VSEPR theory, the geometry of a molecule depends on the number of electron pairs (bond pairs + lone pairs) around the central atom. Hybridisation is determined by the steric number (total electron pairs). In PCl_5, phosphorus has 5 valence electrons and forms 5 σ bonds with chlorine atoms. Thus, total electron pairs = 5 (all bond pairs, no lone pair). Steric number = 5 $\Rightarrow$ hybridisation = sp^3d. For sp^3d hybridisation, the ideal geometry is trigonal bipyramidal.

Solution: In trigonal bipyramidal geometry:

- Three chlorine atoms occupy equatorial positions (120° apart)
- Two chlorine atoms occupy axial positions (180° apart)

Bond angles:

$$120^\circ \text{ (equatorial-equatorial)}, \quad 90^\circ \text{ (axial-equatorial)}, \quad 180^\circ \text{ (axial-axial)}$$

Since there are no lone pairs, the structure is symmetric and does not show distortion.

Final Answer: $\boxed{\text{Trigonal bipyramidal}}$

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

Q21.

Solution

Concept: The acidic strength of hydrides in group 16 depends on bond strength and atomic size. As we move down the group, atomic size increases, bond length increases, and bond strength decreases. This makes it easier to release H^+ ions, increasing acidity. Thus, acidity increases down the group.

Solution: Given compounds: H_2O, H_2S, H_2Se, H_2Te Trend:

$$H_2Te > H_2Se > H_2S > H_2O$$

Water is least acidic because O–H bond is strongest. Tellurium hydride is most acidic due to weakest H–Te bond.

Final Answer: $\boxed{H_2Te > H_2Se > H_2S > H_2O}$

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

Q22.

Solution

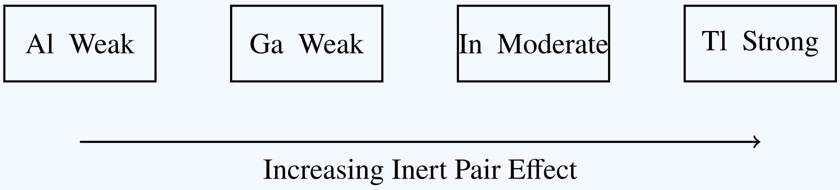
Concept: The **inert pair effect** refers to the tendency of the outermost ns^2 electron pair in heavier p-block elements to remain non-bonding (inert). As a result, these electrons do not participate in bonding, leading to lower oxidation states being more stable than expected.This effect becomes more pronounced down the group due to:

- Poor shielding by d and f electrons
- Increased effective nuclear charge
- Stronger attraction of ns^2 electrons towards nucleus

Solution: Elements given: Al, Ga, In, Tl (Group 13)General oxidation states:

- Al: +3 (no inert pair effect)
- Ga: +3 (very weak effect)
- In: +3 and +1 (moderate effect)
- Tl: +1 and +3 (strong inert pair effect)

Tl shows strong inert pair effect, making +1 oxidation state more stable than +3.
Explanation: In Tl, the $6s^2$ electrons are strongly held due to poor shielding by inner f electrons. Hence, these electrons remain inert and do not participate in bonding, stabilizing the +1 oxidation state.



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

Answer: (A)

Q23.

Solution

Concept: According to Crystal Field Theory (CFT), when ligands approach a transition metal ion, the degenerate d-orbitals split into different energy levels due to electrostatic interactions. In octahedral complexes, the d-orbitals split into two sets: lower energy t_{2g} and higher energy e_g. The energy difference between these levels is called crystal field splitting energy (Δ_o).

Solution: When white light falls on a transition metal complex, electrons in the lower energy t_{2g} orbitals absorb specific wavelengths of light and get excited to higher energy e_g orbitals. This electronic excitation is known as a d-d transition. The remaining transmitted or reflected light appears as colour complementary to the absorbed wavelength.Thus, colour in transition metal complexes arises due to d-d transitions.Some complexes are colourless because:

- They have completely filled d-orbitals (e.g., d^{10} configuration like Zn^{2+}), so no d-d transition is possible.
- They have empty d-orbitals (e.g., d^0 like Ti^{4+}), so no electron is available for excitation.

Hence, absence of partially filled d-orbitals leads to no absorption in visible region.

Final Answer: $\boxed{\text{Due to d-d transitions}}$

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

Q24.

Solution

Concept: Lanthanide contraction refers to the gradual decrease in atomic and ionic radii across the lanthanide series (from La to Lu). This occurs despite increasing atomic number because the added electrons enter 4f orbitals, which have very poor shielding effect.

Solution: As nuclear charge increases across the lanthanide series, the ineffective shielding by 4f-electrons results in stronger attraction between nucleus and outer electrons. This causes a steady contraction in atomic size.

Consequences:

- Elements of 5d series have radii similar to 4d elements (e.g., Zr and Hf show nearly identical sizes).
- Similar chemical properties between pairs like Zr–Hf make them difficult to separate.
- Increase in density and hardness across transition series.

Thus, lanthanide contraction significantly influences periodic trends and chemical behavior of elements.

Final Answer: $\boxed{\text{Due to poor shielding of f-electrons}}$

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

Q25.

Solution

Concept: Paramagnetism arises due to the presence of unpaired electrons in an atom or ion. The greater the number of unpaired electrons, the stronger the paramagnetism. The magnetic moment is directly related to the number of unpaired electrons and can be estimated using:

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

where n is the number of unpaired electrons. To determine paramagnetism, we must write the electronic configuration of each ion and count unpaired electrons.

Solution:

Fe^{3+} (Z = 26): Fe = [Ar] $3d^6$ $4s^2$ Fe^{3+} = [Ar] $3d^5$ → 5 unpaired electrons

Mn^{2+} (Z = 25): Mn = [Ar] $3d^5$ $4s^2$ Mn^{2+} = [Ar] $3d^5$ → 5 unpaired electrons

Cr^{3+} (Z = 24): Cr = [Ar] $3d^5$ $4s^1$ Cr^{3+} = [Ar] $3d^3$ → 3 unpaired electrons

Ni^{2+} (Z = 28): Ni = [Ar] $3d^8$ $4s^2$ Ni^{2+} = [Ar] $3d^8$ → 2 unpaired electrons Thus, Fe^{3+} and Mn^{2+} both have maximum unpaired electrons (5 each), hence show maximum paramagnetism.Since Mn^{2+} has a perfectly half-filled stable configuration (d^5), it is often considered to exhibit maximum paramagnetism.

Final Answer: $\boxed{Mn^{2+}}$

Answer: (B)

Q26.

Solution

Concept: In coordination compounds, oxidation state is calculated using ligand charges. Hybridisation and magnetic nature depend on ligand strength and crystal field splitting.Cyanide (CN^-) is a strong field ligand, causing large crystal field splitting (Δ_o) in octahedral complexes, leading to pairing of electrons (low spin complex).In an octahedral field, five d-orbitals split into:

- Lower energy: t_{2g} (3 orbitals)
- Higher energy: e_g (2 orbitals)

Solution: Given complex: $[Fe(CN)_6]^{4-}$ Step 1: Oxidation state of Fe

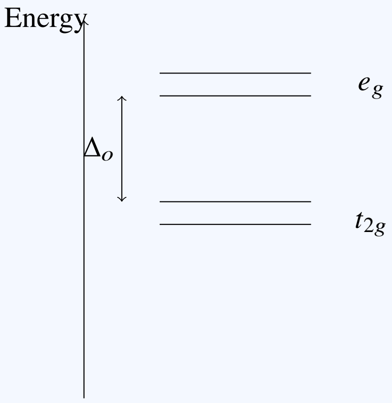
$$x + 6(-1) = -4 \Rightarrow x = +2$$

So, Fe^{2+} : $[Ar]\,3d^6$Step 2: Effect of strong field ligand (CN^-) Electrons pair in lower t_{2g} orbitals:

$$t_{2g}^6 e_g^0$$

Step 3: Hybridisation Inner orbital complex $\Rightarrow d^2sp^3$Step 4: Magnetic nature All electrons paired $\Rightarrow$ Diamagnetic (low spin)

Explanation (Crystal Field Splitting): In octahedral complexes, ligands approach along axes and interact with $d_{x^2-y^2}$ and d_{z^2} orbitals more strongly, raising their energy (e_g). The other three orbitals form lower energy set (t_{2g}). Strong field ligands increase splitting energy, causing electron pairing.



Octahedral splitting

Final Answer: $\boxed{\text{Low spin diamagnetic}}$

Answer: (A)

Q27.

Solution

Concept: Linkage isomerism is a type of structural isomerism in coordination compounds that arises when an ambidentate ligand can coordinate to the central metal atom through two different atoms. Such ligands have two potential donor atoms but bind through only one at a time. Common examples include NO_2^- (nitro/nitrito), SCN^- (thiocyanato/isothiocyanato), etc.

Solution: In the complex $[Co(NH_3)_5(NO_2)]^{2+}$, the ligand NO_2^- is ambidentate. It can coordinate in two ways:

- Through nitrogen atom: nitro form (–NO_2)
- Through oxygen atom: nitrito form (–ONO)

These two different bonding modes give rise to two distinct compounds with different properties, even though their composition is the same. This phenomenon is called linkage isomerism.Thus, the given complex exhibits linkage isomerism.

Final Answer: $\boxed{\text{Linkage isomerism}}$

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

Q28.

Solution

Concept: The coordination number is the number of ligand donor atoms directly bonded to the central metal atom. Geometry depends on coordination number and hybridisation. For coordination number 4, two geometries are possible:

- Tetrahedral (sp^3 hybridisation)
- Square planar (dsp^2 hybridisation)

Square planar geometry is common for d^8 metal ions like Pt^{2+}.

Solution: In $[PtCl_4]^{2-}$:

- Number of Cl^- ligands = 4
- Coordination number = 4

Pt^{2+} has electronic configuration:

$$[Xe]4f^{14}5d^8$$

In dsp^2 hybridisation, one d, one s, and two p orbitals hybridize to form four hybrid orbitals lying in the same plane, oriented at 90° to each other. Ligands occupy these positions, giving a square planar geometry.This arrangement minimizes electron repulsion and is energetically favorable for d^8 systems.

Final Answer: $\boxed{\text{4, square planar}}$

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

Q29.

Solution

Concept: Chromatography is a technique used for separation and purification of components of a mixture based on their differential distribution between two phases: a stationary phase and a mobile phase. The components travel at different rates depending on their interaction with these phases.

Solution: In chromatography, substances that are more strongly attracted to the stationary phase move slowly, while those with weaker interaction move faster, leading to separation.

Types:

- **Adsorption Chromatography:** Separation is based on differential adsorption of components on the surface of a solid stationary phase (e.g., silica gel, alumina). More strongly adsorbed substances move slower.
- **Partition Chromatography:** Separation is based on differential solubility of components between two liquid phases (one stationary, one mobile). Components distribute themselves according to partition coefficient.

Factors affecting separation:

- Nature of adsorbent (polarity, surface area)
- Solvent polarity (eluent strength)
- Temperature
- Nature of solute (polarity, molecular size)

Thus, chromatography primarily depends on differential adsorption or partitioning.

Final Answer: $\boxed{\text{Based on differential adsorption}}$

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

Q30.

Solution

Concept: Resonance is the phenomenon in which a molecule can be represented by two or more valid Lewis structures differing only in the arrangement of electrons, not atoms. The actual structure is a resonance hybrid, which is more stable than any individual contributing structure due to delocalization of electrons.

Solution: Stability due to resonance depends on the extent of delocalization:

Methyl carbocation (CH_3^+): No resonance possible; positive charge is localized → least stable.

Allyl carbocation ($CH_2{=}CH{-}CH_2^+$): Positive charge is delocalized over two carbon atoms → moderate stability.

Benzyl carbocation ($C_6H_5{-}CH_2^+$): Positive charge is delocalized over the aromatic ring through multiple resonance structures → maximum stability.Thus, greater the number of resonance structures, greater is stability.

$$\text{Benzyl} > \text{Allyl} > \text{Methyl}$$

Final Answer: $\boxed{\text{Benzyl carbocation}}$

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

Q31.

Solution

Concept: The inductive effect is the permanent displacement of σ-electrons along a carbon chain due to electronegativity differences. Electron-withdrawing groups (–I effect) pull electron density away, while electron-donating groups (+I effect) push electron density toward the functional group. In carboxylic acids, electron-withdrawing groups stabilize the conjugate base (carboxylate ion) by dispersing the negative charge, thereby increasing acidity.

Solution: Compare:

- CH_3COOH: CH_3 group shows +I effect → decreases acidity
- $ClCH_2COOH$: Cl shows –I effect → increases acidity
- CCl_3COOH: Three Cl atoms exert strong –I effect → maximum stabilization of conjugate base

Thus, acidity increases with number of electron-withdrawing substituents:

$$CCl_3COOH > ClCH_2COOH > CH_3COOH$$

Final Answer: $\boxed{CCl_3COOH}$

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

Q32.

Solution

Concept: Nucleophiles are electron-rich species that donate an electron pair to form a bond, while electrophiles are electron-deficient species that accept an electron pair. Strength of nucleophiles depends on charge, electronegativity, and solvation effects. In aqueous solution, negatively charged species are generally stronger nucleophiles than neutral ones.

Solution: Given species:

- OH^-: Negatively charged, high electron density → strong nucleophile
- NH_3: Neutral, moderate electron density → weaker than OH^-
- H_2O: Neutral and more electronegative → weakest nucleophile

Thus, nucleophilicity order:

$$OH^- > NH_3 > H_2O$$

Final Answer: $\boxed{OH^-}$

Answer: (A)

Q33.

Solution

Concept: Anti-Markovnikov addition occurs in the presence of peroxides (ROOR) and is observed mainly with HBr. This is known as the **peroxide effect** or **Kharasch effect**. In this mechanism, addition follows a **free radical pathway** instead of the ionic mechanism. The bromine radical adds to the carbon such that the more stable carbon radical intermediate is formed.

Mechanism: Step 1: Initiation

$$ROOR \xrightarrow{\Delta} 2RO^{\bullet}$$

$$RO^{\bullet} + HBr \rightarrow ROH + Br^{\bullet}$$

Step 2: Propagation

$$Br^{\bullet} + CH_3CH = CH_2 \rightarrow CH_3\dot{C}HCH_2Br$$

(secondary radical formed, more stable)

$$CH_3\dot{C}HCH_2Br + HBr \rightarrow CH_3CH_2CH_2Br + Br^{\bullet}$$

Step 3: Termination Radicals combine to end the reaction.

Solution: In propene (CH_3–CH=CH_2), Br attaches to terminal carbon (less substituted), and H attaches to middle carbon.Final product:

$$CH_3CH_2CH_2Br$$

Explanation: The reaction proceeds via free radical mechanism. Formation of a more stable secondary radical determines the direction of addition, leading to anti-Markovnikov product.

$$CH_3\text{–}CH\text{=}CH_2 \xrightarrow[\text{Free radical mechanism}]{\text{HBr / Peroxide}} CH_3\text{–}CH_2\text{–}CH_2Br$$

Final Answer: $\boxed{\text{1-bromopropane}}$

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

Q34.

Solution

Concept: Friedel–Crafts alkylation is an electrophilic aromatic substitution reaction in which an alkyl group is introduced into a benzene ring using an alkyl halide in the presence of a Lewis acid catalyst such as $AlCl_3$. The catalyst generates a strong electrophile (carbocation or its equivalent), which attacks the π-electron-rich benzene ring.

Solution: General reaction:

$$\text{Benzene} + \text{R–Cl} \xrightarrow{AlCl_3} \text{Alkylbenzene} + \text{HCl}$$

Mechanism:

- Formation of electrophile (R^+) by reaction of alkyl halide with $AlCl_3$
- Attack of benzene ring forming a σ-complex
- Loss of proton restores aromaticity

Polyalkylation: Alkyl groups are electron-donating (+I effect), which increases electron density of benzene ring after first substitution. This activates the ring toward further substitution, leading to polyalkylation.

Control of polyalkylation:

- Use excess benzene to reduce probability of multiple substitution
- Use less reactive alkylating agents
- Prefer Friedel–Crafts acylation followed by reduction

Final Answer: $\boxed{\text{Due to activating groups}}$

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

Q35.

Solution

Concept: Stability of alkenes depends on hyperconjugation and inductive effects. Hyperconjugation involves delocalization of σ-electrons of adjacent C–H bonds into the empty or partially filled π-orbital, stabilizing the molecule. More substituted alkenes have more hyperconjugative structures and are therefore more stable.

Solution: Compare:

- Ethene (CH_2=CH_2): No alkyl substitution → least stable
- Propene (CH_3–CH=CH_2): One alkyl group → moderate stability
- But-2-ene (CH_3–CH=CH–CH_3): Two alkyl groups → maximum stability

Thus, stability order:

$$\text{but-2-ene} > \text{propene} > \text{ethene}$$

Greater number of hyperconjugative structures leads to higher stability.

Final Answer: $\boxed{\text{but-2-ene} > \text{propene} > \text{ethene}}$

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

Q36.

Solution

Concept: The SN1 (Substitution Nucleophilic Unimolecular) reaction follows a two-step mechanism. The rate-determining step involves formation of a carbocation intermediate. Thus, the rate depends only on the concentration of the substrate:

$$\text{Rate} = k[\text{R–X}]$$

The energy profile shows two steps: first, a high-energy transition state for carbocation formation, followed by a lower-energy nucleophilic attack.

Solution: Mechanism:

- Step 1 (slow): Formation of carbocation by loss of leaving group

$$\text{R–Br} \rightarrow \text{R}^+ + \text{Br}^-$$

- Step 2 (fast): Nucleophilic attack on carbocation

$$\text{R}^+ + \text{Nu}^- \rightarrow \text{R–Nu}$$

Comparison:

- tert-butyl bromide forms a highly stable tertiary carbocation due to +I effect and hyperconjugation
- ethyl bromide forms an unstable primary carbocation

Since carbocation stability governs SN1 rate:

$$\text{tertiary} > \text{secondary} > \text{primary}$$

Thus, tert-butyl bromide reacts much faster.

Final Answer: $\boxed{\text{tert-butyl bromide}}$

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

Q37.

Solution

Concept: Wurtz reaction involves coupling of alkyl halides using sodium metal in dry ether to form higher alkanes:

$$2R–X + 2Na \rightarrow R–R + 2NaX$$

Solution: When the same alkyl halide is used, a symmetrical alkane is formed. However, when two different alkyl halides are used, multiple possible combinations occur:

- R–R
- R'–R'
- R–R'

Thus, a mixture of alkanes is formed instead of a single product. This is a major limitation of the Wurtz reaction.

Conclusion: Due to multiple coupling possibilities, unsymmetrical alkanes cannot be prepared selectively using Wurtz reaction.

Final Answer: $\boxed{\text{Mixture of alkanes}}$

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

Q38.

Solution

Concept: Nucleophilic substitution in alcohols involves replacement of the –OH group by a nucleophile. Since –OH is a poor leaving group, it is first converted into a better leaving group (e.g., by protonation in acidic medium). Lucas reagent (conc. HCl + $ZnCl_2$) is used to distinguish between primary, secondary, and tertiary alcohols based on their reactivity via SN1 mechanism.

Solution: Lucas reagent promotes substitution of –OH by Cl^-:

$$R–OH + HCl \xrightarrow{ZnCl_2} R–Cl + H_2O$$

Reactivity order:

- **Tertiary alcohols:** React immediately due to formation of stable tertiary carbocation (SN1 mechanism)
- **Secondary alcohols:** React slowly (moderately stable carbocation)
- **Primary alcohols:** Do not react at room temperature (unstable carbocation; follow SN2 at higher temperature)

Thus, reactivity depends on carbocation stability.

Final Answer: $\boxed{\text{Tertiary} > \text{Secondary} > \text{Primary}}$

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

Q39.

Solution

Concept: Oxidation of aldehydes and ketones involves increase in oxidation state of carbonyl carbon. Aldehydes are readily oxidised to carboxylic acids, while ketones resist oxidation under mild conditions.

Solution: Aldehydes:

$$\text{R–CHO} + [O] \rightarrow \text{R–COOH}$$

They are easily oxidised by mild oxidising agents like Tollens' reagent and Fehling's solution.**Ketones:**

$$\text{R–CO–R'} + [O] \rightarrow \text{No reaction (under mild conditions)}$$

Strong oxidising agents can break C–C bonds, forming smaller acids.

Reason: Aldehydes contain a hydrogen atom attached to the carbonyl carbon, which can be easily oxidised to –OH group (forming carboxylic acid). Ketones lack this hydrogen, making oxidation difficult.

Final Answer: $\boxed{\text{Due to presence of hydrogen}}$

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

Q40.

Solution

Concept: Cannizzaro reaction is a disproportionation reaction shown by aldehydes that do not have an α-hydrogen atom. In the presence of a strong base (like NaOH or KOH), one molecule of aldehyde is oxidised to a carboxylate ion, while another is reduced to an alcohol.

General Reaction:

$$2\text{R–CHO} + \text{OH}^- \rightarrow \text{R–COO}^- + \text{R–CH}_2\text{OH}$$

Solution: Benzaldehyde (C_6H_5CHO) has no α-hydrogen, so it undergoes Cannizzaro reaction.

$$2C_6H_5CHO + NaOH \rightarrow C_6H_5COO^-Na^+ + C_6H_5CH_2OH$$

Thus:

- One molecule is oxidised to sodium benzoate (benzoate ion)
- One molecule is reduced to benzyl alcohol

Final Answer: $\boxed{\text{Benzyl alcohol and benzoate}}$

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

Q41.

Solution

Concept: Phenols are acidic due to the formation of phenoxide ion, which is stabilised by resonance. Substituents affect acidity through inductive (–I or +I) and resonance (–R or +R) effects. Electron-withdrawing groups increase acidity by stabilising the negative charge, while electron-donating groups decrease acidity.

Solution: Compare:

- **Phenol:** Moderate acidity due to resonance stabilisation
- **p-nitrophenol:** NO_2 group shows strong –I and –R effects, stabilising phenoxide ion → highest acidity
- **p-methylphenol:** CH_3 group shows +I effect, destabilising phenoxide ion → lowest acidity

Thus, acidity order:

$$\text{p-nitrophenol} > \text{phenol} > \text{p-methylphenol}$$

Final Answer: $\boxed{\text{p-nitrophenol}}$

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

Q42.

Solution

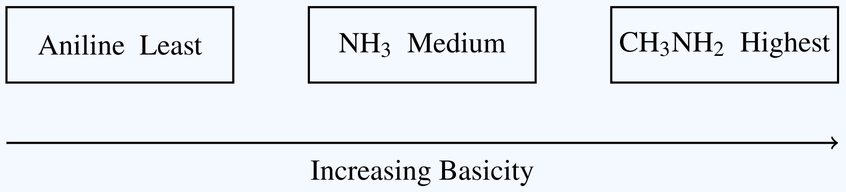
Concept: Basicity of amines depends on the availability of the lone pair of electrons on nitrogen for donation.Factors affecting basicity:

- **Inductive effect (+I):** Alkyl groups donate electron density, increasing basicity.
- **Resonance effect:** Delocalization of lone pair decreases availability, reducing basicity.
- **Solvation:** Stabilization of protonated amine in solution.

Solution: Methylamine (CH_3NH_2): Alkyl group shows +I effect, increasing electron density on nitrogen $\Rightarrow$ more basic.
Ammonia (NH_3): No alkyl group, moderate availability of lone pair.
Aniline ($C_6H_5NH_2$): Lone pair on nitrogen is delocalized into benzene ring due to resonance, making it less available for protonation $\Rightarrow$ least basic.
Order of basic strength:

$$\text{Methylamine} > \text{Ammonia} > \text{Aniline}$$

Explanation: Electron-donating alkyl group increases basicity in methylamine, while resonance in aniline reduces basicity significantly.



Final Answer: $\boxed{\text{Methylamine} > \text{Ammonia} > \text{Aniline}}$

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

Q43.

Solution

Concept: Diazotization is the process of converting a primary aromatic amine into a diazonium salt by treatment with nitrous acid (HNO_2) at low temperatures (0–5°C). Nitrous acid is generated in situ by reacting $NaNO_2$ with a mineral acid like HCl.

Reaction:

$$\text{Ar–NH}_2 + \text{NaNO}_2 + \text{HCl} \rightarrow \text{Ar–N}_2^+\text{Cl}^- + 2\text{H}_2\text{O}$$

Solution: Diazonium salts (Ar–N_2^+) are stable only at low temperatures because:

- The diazonium group (–N_2^+) is weakly bonded and can easily decompose
- At higher temperatures, it loses nitrogen gas (N_2), forming highly reactive carbocations
- This leads to side reactions such as substitution or decomposition

Thus, low temperature (0–5°C) is maintained to prevent decomposition and ensure stability during reactions.

Final Answer: $\boxed{\text{Due to instability at high temperature}}$

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

Q44.

Solution

Concept: Carbohydrates are classified based on their hydrolysis and functional groups:

- **Monosaccharides:** Cannot be hydrolysed further (e.g., glucose, fructose)
- **Oligosaccharides:** Yield 2–10 monosaccharides on hydrolysis (e.g., sucrose)
- **Polysaccharides:** Yield many monosaccharides (e.g., starch, cellulose)

Reducing sugars are those that can reduce mild oxidising agents like Tollens' or Fehling's reagent due to the presence of a free aldehyde or ketone group (or ability to form one in solution).

Solution:

- **Glucose:** Aldose sugar with free –CHO group → reducing sugar
- **Fructose:** Ketose sugar but can tautomerize to aldehyde form in alkaline medium → reducing sugar
- **Sucrose:** Both anomeric carbons involved in glycosidic bond → no free carbonyl group → non-reducing sugar

Thus, glucose and fructose are reducing sugars.

Final Answer: $\boxed{\text{Glucose and fructose}}$

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

Q45.

Solution

Concept: Lassaigne's test is used for the detection of halogens (Cl, Br, I) in organic compounds. The organic compound is fused with sodium metal to convert covalently bonded halogens into ionic sodium halides (NaX), which are water-soluble.

$$\text{Organic compound} + Na \rightarrow NaX \quad (X = Cl, Br, I)$$

The sodium extract is then treated with dilute nitric acid (to remove interfering ions) followed by silver nitrate ($AgNO_3$). Formation of a precipitate indicates presence of halogen.

Solution: Step 1: Formation of sodium halide

$$R - Cl + Na \rightarrow NaCl$$

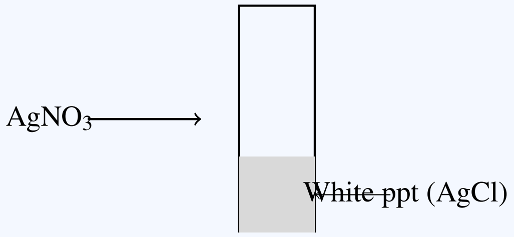
Step 2: Treatment with $AgNO_3$

$$NaCl + AgNO_3 \rightarrow AgCl \downarrow + NaNO_3$$

Observation:

- Cl^- → White precipitate (AgCl)
- Br^- → Pale yellow precipitate (AgBr)
- I^- → Yellow precipitate (AgI)

Explanation: The white precipitate of silver chloride confirms the presence of chlorine in the organic compound.



Final Answer: $\boxed{\text{White precipitate}}$

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

Answer Key

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