BITSAT Chemistry Sample Paper – 6

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

Instructions

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

Q1. A mixture of $\mathrm{Na_2CO_3}$ and $\mathrm{NaHCO_3}$ is heated. Only $\mathrm{NaHCO_3}$ decomposes: $\mathrm{2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2}$. If 2.1 g of $\mathrm{NaHCO_3}$ ($M = 84$) is present, the volume of $\mathrm{CO_2}$ produced at STP is:

(A) $0.28\,\mathrm{L}$

(B) $1.12\,\mathrm{L}$

(C) $2.24\,\mathrm{L}$

(D) $0.56\,\mathrm{L}$

Q2. The percentage of nitrogen by mass in urea $\mathrm{CO(NH_2)_2}$ ($M = 60\,\mathrm{g\,mol^{-1}}$) is:

(A) 23.3%

(B) 33.3%

(C) 16.7%

(D) 46.7%

Q3. The number of orbitals in the M shell ($n = 3$) of an atom is:

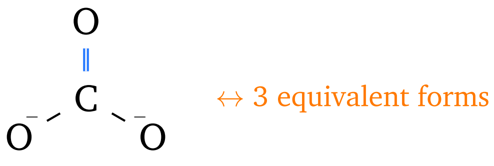
(A) 4

(B) 16

(C) 6

(D) 9

Q4. Resonance structures of CO_3^{2-} (carbonate ion): three equivalent structures contribute equally. The bond order of each C–O bond and the formal charge on each oxygen in the actual (resonance hybrid) structure are:



one resonance structure

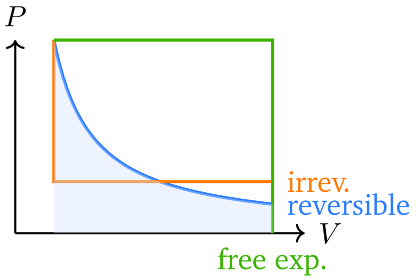
(A) Bond order $= 1$; each O has formal charge $-2/3$

(B) Bond order $= 4/3$; each O has formal charge $-2/3$

(C) Bond order $= 2$; each O has formal charge 0

(D) Bond order $= 3/2$; each O has formal charge -1

Q5. A gas expands reversibly and isothermally against an external pressure. For the indicator diagram (P vs V) shown, the work done by the gas is largest for:



(A) Free expansion against zero external pressure ($w = 0$)

(B) Irreversible expansion against constant external pressure

(C) Reversible isothermal expansion (area under curve is maximum)

(D) All three give equal work

Q6. The standard free energy change ΔG° is related to the equilibrium constant by $\Delta G^\circ = -RT\ln K$. For a reaction at $298\,\mathrm{K}$ with $K = 10^5$, the value of ΔG° ($R = 8.314\,\mathrm{J\,mol^{-1}K^{-1}}$) is:

(A) $\Delta G^\circ = -28.5\,\mathrm{kJ\,mol^{-1}}$

(B) $\Delta G^\circ = +28.5\,\mathrm{kJ\,mol^{-1}}$

(C) $\Delta G^\circ = -57.0\,\mathrm{kJ\,mol^{-1}}$

(D) $\Delta G^\circ = -285\,\mathrm{kJ\,mol^{-1}}$

Q7. For the reaction $\mathrm{H_2(g) + I_2(g) \rightleftharpoons 2HI(g)}$, $K_c = 64$ at $520°\mathrm{C}$. At equilibrium, if $[\mathrm{H_2}] = [\mathrm{I_2}] = 0.5\,\mathrm{M}$, the equilibrium concentration of HI is:

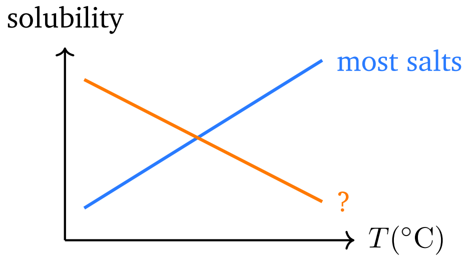
(A) $[\mathrm{HI}] = 4\,\mathrm{M}$

(B) $[\mathrm{HI}] = 2\,\mathrm{M}$

(C) $[\mathrm{HI}] = 8\,\mathrm{M}$

(D) $[\mathrm{HI}] = 1\,\mathrm{M}$

Q8. The solubility curve of a salt is shown. The salt whose solubility *decreases* with increasing temperature is most likely:



(A) NaCl

(B) $\mathrm{KNO_3}$

(C) $\mathrm{Ce_2(SO_4)_3}$ (cerium sulfate)

(D) $\mathrm{NH_4Cl}$

Q9. The standard electrode potential of the hydrogen electrode (SHE) is defined as exactly $0\,\mathrm{V}$ at all temperatures. The cell $\mathrm{Pt}|\mathrm{H_2}(1\,\mathrm{atm})|\mathrm{H^+}(1\,\mathrm{M})||\mathrm{Ag^+}(1\,\mathrm{M})|$ has $E^\circ_{\text{cell}} = 0.80\,\mathrm{V}$. This means:

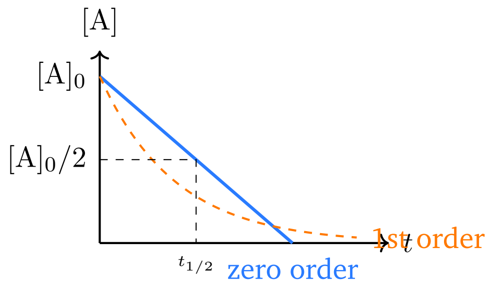
(A) Ag is the anode; H_2 is oxidised at the cathode

(B) $E^\circ(\mathrm{Ag^+/Ag}) = +0.80\,\mathrm{V}$; Ag is the cathode; H_2 is oxidised at the anode

(C) $E^\circ(\mathrm{H^+/H_2}) = +0.80\,\mathrm{V}$

(D) The cell is non-spontaneous; $\Delta G^\circ > 0$

Q10. The concentration-time profile for a zero-order reaction $\mathrm{A} \to \mathrm{B}$ is:



(A) Exponential decay; $[\mathrm{A}]$ never reaches zero

(B) Linear decrease; $[\mathrm{A}]$ reaches zero at $t = [\mathrm{A}]_0/k$

(C) $[\mathrm{A}]$ remains constant (zero rate)

(D) Parabolic decrease; $t_{1/2}$ increases with time

Q11. White phosphorus (P_4) ignites spontaneously in air, while red phosphorus does not. The reason is:

(A) White P has a higher molar mass than red P

(B) Red P reacts faster because it has more surface area

(C) White P is a gas at room temperature; red P is a solid

(D) White P is an allotrope with highly strained 60° P–P–P bond angles in the P_4 tetrahedron, making it highly reactive; red P is a polymeric solid with less strain

Q12. The reaction of SO_2 with Cl_2 in the presence of activated charcoal gives:

$$\boxed{SO_2 + Cl_2} \xrightarrow{\text{activated C}} ?$$

(A) $SO_3 + HCl$

(B) $SOCl_2 + O_2$ (thionyl chloride)

(C) SO_2Cl_2 (sulfuryl chloride)

(D) $S_2Cl_2 + 2O_2$

Q13. The IUPAC name of $K_3[Fe(CN)_6]$ is:

(A) Potassium hexacyanoferrate(II)

(B) Potassium hexacyanoferrate(III)

(C) Tripotassium ferricyanide (non-IUPAC)

(D) Iron(III) hexacyanopotassiate

Q14. In the zinc blende (ZnS) structure, S^{2-} ions form an FCC lattice and Zn^{2+} ions occupy half the tetrahedral holes. The formula of the compound and the coordination numbers of Zn and S are:

(A) ZnS; CN(Zn) = 6; CN(S) = 6

(B) ZnS; CN(Zn) = 4; CN(S) = 4

(C) Zn_2S; CN(Zn) = 4; CN(S) = 8

(D) ZnS; CN(Zn) = 8; CN(S) = 8

Q15. Reverse osmosis is used to purify sea water. It involves applying pressure **greater** than the osmotic pressure to push water through a semi-permeable membrane from:

(A) Pure water to the saline solution (normal osmosis direction)

(B) The saline solution to pure water (opposite to normal osmosis)

(C) Equal osmotic pressure on both sides (no net flow)

(D) The membrane dissolves the salt

Q16. Dehydrohalogenation of 2-bromopentane with KOH/ethanol (E2 mechanism) gives predominantly:

$$\boxed{CH_3CHBrCH_2CH_2CH_3}$$

$$\Big\downarrow \text{KOH/ethanol, heat}$$

$$? + KBr + H_2O$$

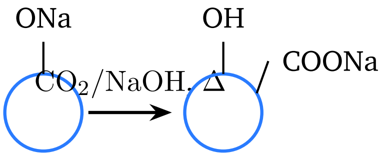
(A) Pent-1-ene ($CH_2 = CHCH_2CH_2CH_3$) — less substituted

(B) Cyclopentane (ring closure)

(C) 1,2-dibromopentane (addition of Br_2)

(D) Pent-2-ene ($CH_3CH = CHCH_2CH_3$) — more substituted (Zaitsev)

Q17. Phenol undergoes the Kolbe-Schmitt reaction with CO_2 under pressure and heat in the presence of NaOH:



(A) Salicylaldehyde (ortho-hydroxybenzaldehyde)

(B) Sodium salicylate (sodium 2-hydroxybenzoate) — used in aspirin synthesis

(C) Phenyl carbonate

(D) Benzoic acid and phenol mixture

Q18. The reaction of acetone with hydroxylamine (NH_2OH) gives:

$$(CH_3)_2C{=}O + NH_2OH$$

$$\Big\downarrow H^+ \text{ cat.}$$

$$(CH_3)_2C{=}NOH + H_2O$$

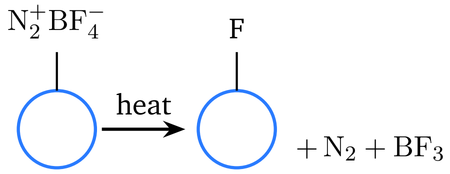
(A) Acetoxime ($(CH_3)_2C = NOH$); this is an oxime

(B) Acetohydroxamic acid ($CH_3CONHOH$)

(C) Dimethylamine ($(CH_3)_2NH$) and CO_2

(D) Acetaldoxime ($CH_3CH = NOH$)

Q19. The Sandmeyer reaction replaces the diazonium group with a halide using a cuprous salt. For $C_6H_5N_2^+BF_4^-$ heated (Balz-Schiemann):



(A) Fluorobenzene + N_2 + BF_3 (Balz-Schiemann reaction)

(B) Chlorobenzene + N_2 + BF_3

(C) Aniline + BF_3

(D) Benzene + NF_3

Q20. Which of the following is a **lipid** (fat)?

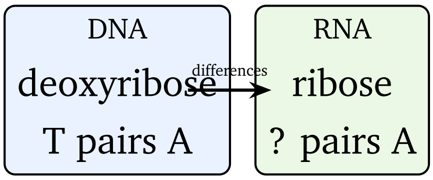
(A) Cellulose

(B) Glycine (amino acid)

(C) Tripalmitin (glycerol + three palmitic acid chains)

(D) Adenine (purine base)

Q21. The base-pairing and backbone of RNA differ from DNA. Which of the following correctly states a difference?



(A) RNA contains thymine; DNA contains uracil

(B) RNA is double-stranded; DNA is single-stranded

(C) RNA contains ribose and uracil; DNA contains deoxyribose and thymine

(D) RNA and DNA are identical in composition

Q22. Neoprene (polychloroprene) is a synthetic rubber made from chloroprene ($CH_2 = CCl - CH = CH_2$). Its polymerisation type is:

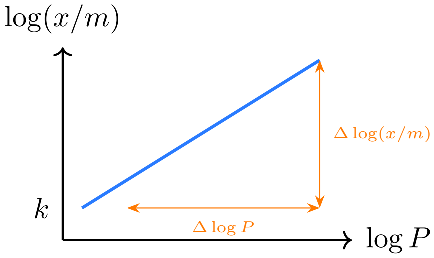
(A) Condensation polymerisation with loss of HCl

(B) Addition polymerisation of the diene unit ($1, 4$-addition)

(C) Cationic polymerisation with $AlCl_3$ as catalyst

(D) Ring-opening polymerisation

Q23. An adsorption isotherm (Freundlich) plots $\log(x/m)$ vs $\log P$ at constant T. The slope of the straight line is:



(A) slope $= k$ (Freundlich constant)

(B) slope $= n$ (always > 1)

(C) slope $= 1/n$ (where $0 < 1/n < 1$)

(D) slope $= -1/n$ (negative, since adsorption decreases with pressure)

Q24. When sodium metal is dissolved in liquid ammonia, a deep blue solution is obtained. On evaporation, the coloured compound obtained is:

(A) $Na(NH_3)_6$ (sodium hexaammine)

(B) Na_2O (sodium oxide)

(C) NaN_3 (sodium azide)

(D) $NaNH_2$ (sodium amide) + $\frac{1}{2}H_2$ (after slow decomposition)

Q25. Among the alkaline earth metals, which element shows anomalous behaviour (diagonal relationship with Al)?

(A) Calcium (Ca)

(B) Barium (Ba)

(C) Beryllium (Be)

(D) Magnesium (Mg)

Q26. The reaction of ethylene with H_2SO_4 (cold conc.) followed by hydrolysis gives:

(A) Ethane

(B) Ethanol (indirect hydration via ethyl sulphuric acid)

(C) Acetic acid

(D) Diethyl ether

Q27. Decarboxylation of sodium salt of carboxylic acid by soda lime (NaOH + CaO) gives an alkane with one less carbon (Duma's method):

$$\boxed{\mathrm{RCOONa}} \xrightarrow{\text{NaOH+CaO, heat}} \mathrm{RH} + \mathrm{Na_2CO_3}$$

(A) $\mathrm{RH} + \mathrm{Na_2CO_3}$; the alkane formed has one fewer carbon than the acid

(B) $\mathrm{ROH} + \mathrm{NaCO_3}$; a primary alcohol is formed

(C) $\mathrm{RNa} + \mathrm{CO_2} + \mathrm{H_2O}$; an organosodium compound

(D) $\mathrm{RH} + \mathrm{CO_2} + \mathrm{NaO^-}$ (only with acids, not salts)

Q28. Which of the following is **isoelectronic** with CO_2?

(A) SO_2

(B) NO_2

(C) H_2O

(D) N_3^- (azide ion)

Q29. Le Chatelier's principle: the equilibrium $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $(\Delta H = -92\,\mathrm{kJ\,mol^{-1}})$ is affected by changes in conditions. Increasing the temperature at constant pressure will:

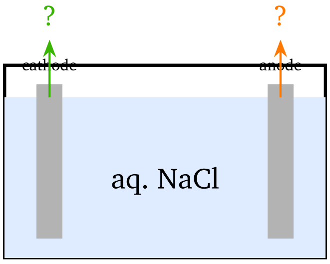
(A) Shift equilibrium to the right (more NH_3)

(B) Shift equilibrium to the left (less NH_3), decreasing K_c

(C) Shift equilibrium to the left (less NH_3) but increase K_c

(D) Have no effect on equilibrium

Q30. During electrolysis of aqueous $NaCl$ (chlor-alkali process), the products at the cathode and anode are:



(A) Cathode: Cl_2; Anode: H_2

(B) Cathode: Na; Anode: Cl_2

(C) Cathode: H_2 + $NaOH$; Anode: Cl_2

(D) Cathode: O_2; Anode: Na

Detailed Solutions

Q1.

Solution

Concept — Percentage composition and verification of law of definite proportions: The law of definite proportions (Proust): a pure chemical compound always contains the same elements in the same definite proportions by mass.

Step 1 — Percentage of Fe in Fe_2O_3: $M(\mathrm{Fe_2O_3}) = 2(56) + 3(16) = 112 + 48 = 160\,\mathrm{g\,mol^{-1}}$

$\%\,\mathrm{Fe} = \frac{2\times56}{160} \times 100 = \frac{112}{160} \times 100 = \mathbf{70\%}$

$\%\,\mathrm{O} = \frac{48}{160} \times 100 = 30\%$

Step 2 — Verify using given data: Sample A: $7.0\,\mathrm{g}$ Fe in $10\,\mathrm{g}$ ore; sample B: $3.5\,\mathrm{g}$ Fe in $5\,\mathrm{g}$ ore. Both give 70% Fe ⇒ same compound.

Step 3 — Law of multiple proportions (Dalton): If two elements form more than one compound, the masses of one element combining with a fixed mass of the other are in a simple whole-number ratio. Example: Fe_2O_3 (70% Fe) vs FeO (77.8% Fe) are different compounds.

Common error: Using $M(\mathrm{Fe}) = 55$ (rounded) gives 70.5%, a slight discrepancy. Always use $M(\mathrm{Fe}) = 56\,\mathrm{g\,mol^{-1}}$ unless otherwise specified.

Final Answer: $\%\,\mathrm{Fe} = 70\%;\ \ \%\,\mathrm{O} = 30\% \Rightarrow \boxed{\mathrm{C}}$

Answer: (C) Go Back to Q1

Q2.

Solution

Concept — Dual nature of matter: de Broglie wavelength: All matter exhibits wave properties. The de Broglie wavelength is:

$$\lambda = \frac{h}{mv} = \frac{h}{p}$$

Step 1 — Calculate wavelength: $h = 6.626 \times 10^{-34}\,\mathrm{J\,s}$; $m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$; $v = 2.0 \times 10^{6}\,\mathrm{m\,s^{-1}}$.

$$\lambda = \frac{6.626 \times 10^{-34}}{9.11 \times 10^{-31} \times 2.0 \times 10^{6}} = \frac{6.626 \times 10^{-34}}{1.822 \times 10^{-24}} = 3.637 \times 10^{-10}\,\mathrm{m} = 3.64\,\mathrm{\mathring{A}}$$

Step 2 — Physical significance: $3.64\,\mathrm{\mathring{A}}$ is in the X-ray/soft X-ray range, similar to the spacing of atoms in crystals ($\sim$ 2–4 $\mathrm{\mathring{A}}$). This is why electrons at this speed can be diffracted by crystal lattices, demonstrating their wave nature (Davisson-Germer experiment, 1927).

Step 3 — Why macroscopic objects show no wave behaviour: For a 1 g bullet at 300 m/s: $\lambda = 6.626 \times 10^{-34}/(10^{-3} \times 300) = 2.2 \times 10^{-33}\,\mathrm{m}$ — unmeasurably small. Wave properties only matter for sub-atomic particles.

Final Answer: $\lambda = 3.64\,\mathrm{\mathring{A}} \Rightarrow \boxed{\mathrm{B}}$

Answer: (B)

Go Back to Q2

Q3.

Solution

Concept — Electronegativity trends and bond polarity: Electronegativity increases left→right across a period and bottom→top up a group (Pauling scale). Fluorine has the highest electronegativity ($\chi = 4.0$).

Step 1 — Electronegativity values (Pauling): F: 4.0; O: 3.5; N: 3.0; Cl: 3.2; C: 2.5; H: 2.1; P: 2.1; S: 2.5.

Step 2 — Bond dipole moments: Bond polarity $\propto$ electronegativity difference ($\Delta\chi$).

Bond	$\Delta\chi$	Direction (δ^- on)
H–F	$4.0 - 2.1 = 1.9$	F
H–Cl	$3.2 - 2.1 = 1.1$	Cl
H–Br	$2.9 - 2.1 = 0.8$	Br
C–O	$3.5 - 2.5 = 1.0$	O
N–H	$3.0 - 2.1 = 0.9$	N

Step 3 — Most polar bond: H–F has the largest $\Delta\chi = 1.9 \Rightarrow$ most polar. Experimentally, HF dipole moment = 1.83 D.

Note on H–F anomaly: Despite being the most polar bond among HX, HF has the highest boiling point of the hydrogen halides due to strong F–H$\cdots$F intermolecular hydrogen bonding (not just bond polarity within the molecule).

Final Answer: H–F bond is most polar ($\Delta\chi = 1.9$) $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q3

Q4.

Solution

Concept — Born-Haber cycle for NaCl: The Born-Haber cycle applies Hess's Law to relate lattice energy to other thermodynamic quantities:

$$\Delta H_f = \Delta H_{sub} + \Delta H_{IE} + \frac{1}{2}D_{Cl_2} + \Delta H_{EA} + U$$

Step 1 — Energy terms for forming Na^+Cl^-:

- $\Delta H_{\text{sub}}(\text{Na}) = +108\,\text{kJ mol}^{-1}$ (Na solid → Na gas)
- $IE_1(\text{Na}) = +496$ ($Na \to Na^+ + e^-$)
- $\frac{1}{2}D(\text{Cl}_2) = +121$ (break $\frac{1}{2}$ Cl–Cl bond)
- $EA(\text{Cl}) = -349$ ($Cl + e^- \to Cl^-$)
- Lattice energy $U = -788$ ($Na^+(g) + Cl^-(g) \to NaCl(s)$)

Step 2 — Calculate ΔH_f:

$$\Delta H_f = 108 + 496 + 121 - 349 - 788 = -412\,\text{kJ mol}^{-1}$$

(Experimental: $-411\,\text{kJ mol}^{-1}$ — excellent agreement.)

Step 3 — Physical significance: The large lattice energy ($-788\,\text{kJ mol}^{-1}$) drives NaCl formation despite the substantial cost of ionisation (+496 kJ). The high lattice energy comes from the strong Coulombic attraction between Na^+ and Cl^- ions in the crystal.

Final Answer: $\Delta H_f(\text{NaCl}) = -412\,\text{kJ mol}^{-1} \Rightarrow \boxed{\text{D}}$

Answer: (D)

Go Back to Q4

Q5.

Solution

Concept — Spontaneity conditions: ΔH, ΔS, and temperature: $\Delta G = \Delta H - T\Delta S$; spontaneous when $\Delta G < 0$.

Summary of four cases:

ΔH	ΔS	ΔG	Spontaneity
$-$	$+$	always $-$	always spontaneous
$+$	$-$	always $+$	never spontaneous
$-$	$-$	$-$ at low T	spontaneous at low T
$+$	$+$	$-$ at high T	spontaneous at high T

Step 1 — Evaluate the question: If $\Delta H > 0$ (endothermic) and $\Delta S > 0$ (increasing disorder), then: $\Delta G = +(\text{positive}) - T(\text{positive})$. At high T, the $T\Delta S$ term dominates $\Rightarrow \Delta G < 0 \Rightarrow$ spontaneous.

Step 2 — Crossover temperature: $T^* = \Delta H/\Delta S$. Above T^*: spontaneous; below: non-spontaneous.

Real example: Dissolution of NH_4NO_3 in water ($\Delta H > 0$, $\Delta S > 0$) is spontaneous at room temperature (above T^*). This is why cold packs work: absorbs heat from surroundings.

Final Answer: $\Delta H > 0$, $\Delta S > 0 \Rightarrow$ spontaneous only at high $T \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q5

Q6.

Solution

Concept — Le Chatelier's principle applied to $N_2 + 3H_2 \rightleftharpoons 2NH_3$**:** $\Delta n_g = 2-4 = -2$ (fewer gas moles in products).

Step 1 — Effect of pressure: Increasing pressure shifts equilibrium to the side with fewer gas moles $\Rightarrow$ to the *right* (more NH_3). High pressure increases NH_3 yield.

Step 2 — Effect of temperature: Forward reaction is exothermic ($\Delta H = -92.4\,\text{kJ mol}^{-1}$). Increasing T shifts equilibrium to the left $\Rightarrow$ less NH_3. However, higher T increases reaction rate (Arrhenius).

Step 3 — Industrial compromise (Haber process):

- Temperature: 400–500°C (compromise: equilibrium yield ~ 15–25%, but fast rate)
- Pressure: 150–$300\,\text{atm}$ (high yield but expensive equipment)
- Catalyst: Fe with K_2O (promoter) and Al_2O_3 (structural promoter)
- N_2/H_2 ratio: 1:3 (stoichiometric)
- NH_3 is continuously removed to shift equilibrium right

Step 4 — Effect of catalyst: Catalyst lowers activation energy equally for forward and reverse reactions. K_{eq} is unchanged; equilibrium position is unchanged. Only the rate of reaching equilibrium increases.

Final Answer: High P increases yield; high T decreases yield; catalyst unchanged $K_{eq} \Rightarrow \boxed{\text{C}}$

$\boxed{\textbf{Answer: (C)}}$ **Go Back to Q6**

Q7.

Solution

Concept — Ostwald's dilution law for weak electrolytes: For weak acid HA with degree of dissociation α at concentration c:

$$K_a = \frac{c\alpha^2}{1-\alpha} \approx c\alpha^2 \quad (\alpha \ll 1)$$

Step 1 — Effect of dilution on α: As c decreases (dilution): α increases. At infinite dilution, $\alpha \to 1$ (complete dissociation).

Step 2 — Effect of dilution on $[\mathrm{H^+}]$: $[\mathrm{H^+}] = c\alpha = \sqrt{K_a c}$. As c decreases, $[\mathrm{H^+}]$ also decreases (though α increases). Both c and α affect $[\mathrm{H^+}]$.

Step 3 — Effect on pH: $\mathrm{pH} = \frac{1}{2}(\mathrm{p}K_a - \log c)$. Increasing dilution (decreasing c) $\Rightarrow -\log c$ increases $\Rightarrow$ pH increases (solution becomes less acidic, moves toward neutral). But pH never reaches 7 for a weak acid in water; it approaches 7 from below.

Step 4 — Conductivity on dilution: Molar conductivity Λ_m increases on dilution (more dissociation per mole). At infinite dilution: $\Lambda_m = \Lambda_m^\circ$ (Kohlrausch's law). This is unlike specific conductivity κ, which decreases on dilution.

Final Answer: On dilution: α increases, $[\mathrm{H^+}]$ decreases, pH increases, Λ_m increases $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q7

Q8.

Solution

Concept — Faraday's laws of electrolysis: First law: Mass deposited $\propto$ quantity of electricity (charge): $m = ZQ$ where $Z = M/(nF)$. **Second law:** For the same charge, masses of different substances deposited are proportional to their chemical equivalent weights (M/n).

Step 1 — Electrochemical equivalent and moles: $Q = I \times t = 2\,\text{A} \times 30 \times 60\,\text{s} = 3600\,\text{C}$ $n_e = Q/F = 3600/96500 = 0.03731\,\text{mol}$ electrons

Step 2 — Mass of Cu deposited: $\text{Cu}^{2+} + 2e^- \to \text{Cu}$; $n = 2$. $n(\text{Cu}) = 0.03731/2 = 0.01866\,\text{mol}$ $m(\text{Cu}) = 0.01866 \times 63.5 = \mathbf{1.185}\,\text{g}$

Step 3 — Electroplating: This calculation is fundamental to electroplating. The mass of metal deposited per ampere-second (coulomb) is the electrochemical equivalent: $Z = M/(nF)$. $Z(\text{Cu}) = 63.5/(2 \times 96500) = 3.29 \times 10^{-4}\,\text{g}\,\text{C}^{-1}$. $m = ZQ = 3.29 \times 10^{-4} \times 3600 = 1.184\,\text{g}$ (same answer).

Final Answer: $m(\text{Cu}) \approx 1.18\,\text{g} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q8

Q9.

Solution

Concept — Integrated rate law for second-order reactions: For $A \rightarrow$ products with rate $= k[A]^2$:

$$\frac{1}{[\mathrm{A}]_t} = \frac{1}{[\mathrm{A}]_0} + kt$$

Half-life: $t_{1/2} = \dfrac{1}{k[\mathrm{A}]_0}$ (depends on initial concentration, unlike first-order).

Step 1 — Calculate k from initial data: Using $[\mathrm{A}]_0 = 0.5\,\mathrm{M}$ and $t_{1/2} = 100\,\mathrm{s}$: $t_{1/2} = 1/(k \times 0.5) \Rightarrow k = 1/(0.5 \times 100) = 0.02\,\mathrm{L\,mol^{-1}s^{-1}}$

Step 2 — Concentration at $t = 200\,\mathrm{s}$: $\frac{1}{[\mathrm{A}]_{200}} = \frac{1}{0.5} + 0.02 \times 200 = 2 + 4 = 6$ $[\mathrm{A}]_{200} = 1/6 = \mathbf{0.167}\,\mathrm{M}$

Step 3 — Key distinction from first-order: For second-order, each successive half-life is *twice as long* as the previous one (because $t_{1/2} \propto 1/[\mathrm{A}]_0$, and $[\mathrm{A}]_0$ halves each half-life). After 1 half-life (100 s): $[\mathrm{A}] = 0.25\,\mathrm{M}$; second $t_{1/2} = 1/(0.02 \times 0.25) = 200\,\mathrm{s}$.

Final Answer: $[\mathrm{A}]_{200\,\mathrm{s}} = 0.167\,\mathrm{M} \Rightarrow \boxed{\mathrm{C}}$

Answer: (C) Go Back to Q9

Q10.

Solution

Concept — General characteristics of transition metals: Transition metals (Groups 3–11) have partially filled d orbitals in their atomic or commonly found ionic states.

Step 1 — Characteristic properties:

- **Variable oxidation states**: multiple stable OS due to small energy gap between $(n-1)d$ and ns electrons (e.g. Fe: $+2$, $+3$; Mn: $+2$ to $+7$; Cr: $+2$ to $+6$)
- **Coloured ions**: d-d transitions absorb visible light (e.g. $\mathrm{Cu^{2+}}$ blue, $\mathrm{Cr^{3+}}$ green)
- **Catalytic activity**: variable OS allows participation in redox cycles; large surface area for heterogeneous catalysis
- **Complex formation**: empty d orbitals accept lone pairs from ligands
- **Magnetic properties**: unpaired d electrons cause paramagnetism

Step 2 — Exceptions (not all are coloured): $\mathrm{Sc^{3+}}$ (d^0): colourless. $\mathrm{Zn^{2+}}$ (d^{10}): colourless (no d-d transition possible). $\mathrm{Cu^{+}}$ (d^{10}): colourless. $\mathrm{Ti^{4+}}$ (d^0): colourless.

Step 3 — Why Zn is sometimes debated as a transition metal: Zn ($3d^{10}4s^2$) has a full d shell in both neutral and ionic ($\mathrm{Zn^{2+}}$, $3d^{10}$) forms. IUPAC considers Zn a post-transition metal or "zinc group" element.

Final Answer: Variable OS, coloured ions (with exceptions), catalytic, paramagnetic, complex-forming $\Rightarrow \boxed{\text{D}}$

Answer: (D)

Go Back to Q10

Q11.

Solution

Concept — Osmoticpressure and molar mass determination: $\pi = MRT$ (van't Hoff): osmotic pressure is one of the most sensitive colligative properties, useful for determining molar masses of large molecules (polymers, proteins).

Step 1 — Find molarity from π:

$$M = \frac{\pi}{RT} = \frac{5\,\text{atm}}{0.0821\,\text{L atm mol}^{-1}\text{K}^{-1} \times 298\,\text{K}} = \frac{5}{24.47} = 0.2044\,\text{mol L}^{-1}$$

Step 2 — Moles of solute in 1 L: $n = 0.2044\,\text{mol}$; mass of solute $= 10\,\text{g}$ (given in 1 L solution).

Step 3 — Molar mass: $M_r = m/n = 10/0.2044 = \mathbf{48.9} \approx \mathbf{49}\,\text{g mol}^{-1}$

Step 4 — Why osmometry for large molecules: For a $10\,\text{g L}^{-1}$ protein solution with $M_r = 50000\,\text{g mol}^{-1}$: $\pi = 0.0002 \times 0.0821 \times 298 \approx 0.005\,\text{atm} \approx 4\,\text{mmHg}$ — measurable. Boiling point elevation would be $< 0.0001\,\text{K}$ (too small to measure). Hence osmometry is preferred for macromolecules.

Final Answer: $M_r \approx 49\,\text{g mol}^{-1} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q11

Q12.

Solution

Concept — Halogen oxyacids: acid strength trends: The strength of oxyacids of the same halogen increases with the number of oxygen atoms (oxidation state of the halogen): $HOCl < HClO_2 < HClO_3 < HClO_4$

Each additional electronegative O atom withdraws electron density from the O–H bond, making it easier to release H^+ (stronger acid).

Step 1 — Oxidation states and pKa values:

Acid	Cl OS	pK_a
HOCl (hypochlorous)	$+1$	7.5 (weakest)
$HClO_2$ (chlorous)	$+3$	2.0
$HClO_3$ (chloric)	$+5$	< -1 (strong)
$HClO_4$ (perchloric)	$+7$	< -10 (strongest acid known)

Step 2 — Compare across halogens (same OS): For HXO_4: $HClO_4 > HBrO_4 > HIO_4$ (stronger acid down the group decreases, because O–H bond is easier to break when central atom is more electronegative).

Step 3 — Why $HClO_4$ is strongest: Cl is the most electronegative of the central atoms (among Cl, Br, I); 4 oxygen atoms strongly withdraw electron density from the Cl–OH bond; O–H bond polarity is maximised ⇒ strongest acid.

Final Answer: $HClO_4 > HClO_3 > HClO_2 > HClO \Rightarrow \boxed{A}$

Answer: (A) Go Back to Q12

Q13.

Solution

Concept — Magnetic moment and spin-only formula:

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

where n = number of unpaired electrons and BM = Bohr magneton.

Step 1 — Electronic configuration of Mn^{2+}: Mn: $[\text{Ar}]\,3d^5\,4s^2$. Mn^{2+}: lose 2 electrons from $4s$ first ⇒ $[\text{Ar}]\,3d^5$.

d^5: by Hund's rule, 5 unpaired electrons (↑↑↑↑↑ in each of the five $3d$ orbitals).

Step 2 — Magnetic moment:

$$\mu = \sqrt{5(5+2)} = \sqrt{35} = 5.92\,\text{BM}$$

Step 3 — Significance: Mn^{2+} (d^5 high-spin) has the maximum number of unpaired electrons for a d^n ion ($n \le 5$). It shows the highest magnetic moment among the $+2$ ions of the first-row transition metals (in high-spin complexes). Fe^{3+} also has d^5 and $\mu = 5.92\,\text{BM}$.

Step 4 — If Mn^{2+} were low-spin: In a very strong field complex (e.g. $[\text{Mn(CN)}_6]^{4-}$), d^5 could become $t_{2g}^5 e_g^0$ with only 1 unpaired electron ⇒ $\mu = \sqrt{3} = 1.73\,\text{BM}$. This would indicate a strong-field (low-spin) complex.

Final Answer: $n = 5$ unpaired e^-; $\mu = 5.92\,\text{BM} \Rightarrow \boxed{\text{C}}$

Answer: (C) **Go Back to Q13**

Q14.

Solution

Concept — Ozonolysis of alkenes: Ozone (O_3) cleaves the C=C double bond completely. The products depend on the substitution at the two double bond carbons and the workup conditions.

Step 1 — Reductive workup (Zn/H_2O or Me_2S): Each carbon of the double bond becomes a carbonyl group:

- $= CH_2 \rightarrow$ formaldehyde $(HCHO)$
- $= CHR \rightarrow$ aldehyde $(RCHO)$
- $= CR_2 \rightarrow$ ketone $(R_2C = O)$

Oxidative workup (H_2O_2): Aldehydes are further oxidised to carboxylic acids; ketones are unchanged.

Step 2 — For 2-methylbut-2-ene: $CH_3 - C(CH_3) = CH - CH_3$

Carbon 1 of the double bond: $= C(CH_3)_2 \rightarrow$ acetone (CH_3COCH_3)

Carbon 2 of the double bond: $= CHCH_3 \rightarrow$ acetaldehyde (CH_3CHO)

Step 3 — Reverse: identifying an alkene from ozonolysis products: If two carbonyls A and B are produced, the original alkene had the fragment $A(=)B$ (join the two carbonyls at their C=O carbon with a double bond).

Synthetic utility: Ozonolysis can degrade an alkene to map its structure (useful in natural product structure determination).

Final Answer: Acetone + acetaldehyde (reductive workup) $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q14

Q15.

Solution

Concept — Nucleophilic addition to carbonyl: reaction with Grignard reagent: Grignard reagents (RMgX) are strong nucleophiles/bases. They add to carbonyl compounds to give alcohols after hydrolysis.

Step 1 — Reaction of formaldehyde (HCHO) **with RMgX:** HCHO has two H atoms on the carbonyl carbon. $RMgX + HCHO \xrightarrow{Et_2O} R-CH_2-OMgX \xrightarrow{H_3O^+} R-CH_2-OH$ (primary alcohol)

Step 2 — Reaction with aldehyde (RCHO)**:** $R'MgX + RCHO \to R-CH(R')-OMgX \to R-CHOH-R'$ (secondary alcohol)

Step 3 — Reaction with ketone (R_2CO)**:** $R'MgX + R_2CO \to R_2C(R')(OMgX) \to R_2C(R')(OH)$ (tertiary alcohol)

Step 4 — Reaction with CO_2: $RMgX + CO_2 \to RCOOMgX \xrightarrow{H^+} RCOOH$ (carboxylic acid)

For this question — $CH_3MgBr + (CH_3)_2CO$ (acetone): Product: $(CH_3)_3COH$ (tert-butanol, tertiary alcohol).

Final Answer: Tertiary alcohol (2-methylpropan-2-ol) $\Rightarrow \boxed{C}$

$\boxed{\text{Answer: (C)}}$ **Go Back to Q15**

Q16.

Solution

Concept — Hydrolysis of amides under acid and base: Amides ($\mathrm{RCONH_2}$) are the least reactive carboxylic acid derivative, requiring harsh conditions for hydrolysis.

Acid hydrolysis: $\mathrm{RCONH_2 + H_2O + H^+ \xrightarrow{\Delta} RCOOH + NH_4^+}$ Products: carboxylic acid + ammonium ion.

Alkaline hydrolysis (saponification-type): $\mathrm{RCONH_2 + NaOH \xrightarrow{\Delta} RCOONa + NH_3}$ Products: sodium carboxylate + ammonia gas.

Step 1 — Mechanism (alkaline):

(a) OH^- attacks electrophilic C of the amide C=O → tetrahedral intermediate.
(b) Collapse of intermediate → expulsion of NH_2^- (as NH_3 after proton transfer from water).
(c) Carboxylate ion formed.

Step 2 — Why amides are least reactive: The lone pair on N is delocalised into the C=O (resonance: $-\overset{+}{\mathrm{N}}\mathrm{H_2} = \overset{-}{\mathrm{C}} - \mathrm{O}^-$), reducing the electrophilicity of the carbonyl carbon. This resonance also makes the C–N bond shorter and stronger than a typical C–N single bond.

Final Answer: Acid hydrolysis → RCOOH + NH_4^+; alkaline hydrolysis → RCOONa + NH_3 ⇒ $\boxed{\mathrm{B}}$

Answer: (B) **Go Back to Q16**

Q17.

Solution

Concept — Fehling's vs Tollens' test in distinguishing aldehydes: Both Fehling's and Tollens' reagents are mild oxidising agents that test for the aldehyde group:

Tollens' reagent: $[Ag(NH_3)_2]^+$ in alkaline solution. $RCHO + 2[Ag(NH_3)_2]^+ + 2OH^- \rightarrow RCOO^- + 2Ag(s) + 4NH_3 + H_2O$ Silver mirror on clean glass tube = positive.

Fehling's solution: Deep blue Cu^{2+} (as tartrate complex). $RCHO + 2Cu^{2+} + 5OH^- \rightarrow RCOO^- + Cu_2O(s) + 3H_2O$ Brick-red Cu_2O precipitate = positive.

Step 1 — Key distinction:

- Both reagents test positive for *aliphatic* aldehydes (formaldehyde, acetaldehyde, etc.)
- **Aromatic aldehydes** (benzaldehyde): Tollens' positive but Fehling's *negative* (benzaldehyde does not reduce Fehling's solution)
- Ketones: both negative (except α-hydroxy ketones with Fehling's)

Step 2 — Application: If a compound gives a silver mirror with Tollens' but no brick-red precipitate with Fehling's $\Rightarrow$ aromatic aldehyde (benzaldehyde).

Final Answer: Aliphatic aldehydes: both positive. Benzaldehyde: Tollens' positive, Fehling's negative $\Rightarrow \boxed{D}$

Answer: (D)

Go Back to Q17

Q18.

Solution

Concept — Biodegradable vs non-biodegradable polymers: Biodegradable polymers can be broken down by microorganisms (bacteria, fungi) in the environment. They contain bonds (ester, amide, glycosidic) that enzymes can hydrolyse.

Step 1 — Biodegradable examples:

- PHA (polyhydroxyalkanoates): produced by bacteria; fully biodegradable
- PLA (polylactic acid): from lactic acid; degrades in composting conditions
- PHBV (poly-3-hydroxybutyrate-co-3-hydroxyvalerate): biodegradable plastic for packaging
- Nylon-2-nylon-6 (alternating copolymer of glycine and ε-aminocaproic acid): amide bonds hydrolysable $\Rightarrow$ biodegradable

Step 2 — Non-biodegradable (persistent) polymers:

- Polythene (polyethylene): pure C–C backbone; no hydrolysable bonds; persists for hundreds of years
- PVC: contains C–C and C–Cl bonds; non-biodegradable
- Bakelite: thermoset, crosslinked; non-biodegradable
- Polystyrene: C–C backbone; non-biodegradable

Step 3 — Why biodegradability matters: Plastic pollution in oceans and soil is a major environmental concern. Replacing non-biodegradable polymers with biodegradable alternatives (bioplastics) is a key sustainability goal.

Final Answer: PHBV and PLA are biodegradable; polyethylene and PVC are not $\Rightarrow \boxed{\text{C}}$

$\boxed{\text{Answer: (C)}}$ Go Back to Q18

Q19.

Solution

Concept — Relative reactivity of carboxylic acid derivatives: Order of reactivity toward nucleophilic substitution:

$$RCOCl > (RCO)_2O > RCOOC_2H_5 > RCONH_2$$

(Acid chloride > Anhydride > Ester > Amide)

Reason for the trend:

- Reactivity decreases as the leaving group becomes a weaker base (poorer leaving group means less reactive): Cl^- ($pK_a(HCl) = -7$) > $RCOO^-$ (from anhydride) > EtO^- ($pK_a \approx 16$) > NH_2^- (very poor leaving group, $pK_a \approx 38$)
- OR: as the lone pair on the heteroatom is more donated into the carbonyl (increasing resonance stabilisation), the carbonyl carbon becomes less electrophilic

Step 1 — Acid chloride with NH_3: $CH_3COCl + 2NH_3 \rightarrow CH_3CONH_2 + NH_4Cl$ (2 mol NH_3: 1 reacts, 1 neutralises HCl)

Step 2 — Ester with NaOH (saponification): $RCOOR' + NaOH \rightarrow RCOONa + R'OH$ (irreversible)

Final Answer: Acid chloride most reactive; amide least reactive $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q19

Q20.

Solution

Concept — Pinacol rearrangement (1,2-diol to carbonyl): When a 1,2-diol (pinacol) is treated with a protic acid, one $-$OH is protonated and leaves as water, generating a carbocation. A 1,2-shift of an alkyl or aryl group to the adjacent carbocation occurs, giving a more stable tertiary carbocation (or oxocarbenium), followed by deprotonation to give the carbonyl compound (pinacolone).

Step 1 — Classic example (pinacol → pinacolone): $(CH_3)_2C(OH)-C(OH)(CH_3)_2 \xrightarrow{H^+} (CH_3)_3C-CO-CH_3$ (2,3-dimethyl-2,3-butanediol → 3,3-dimethylbutan-2-one/pinacolone)

Mechanism:

(a) Protonation of one OH and loss of H_2O → tertiary carbocation at one C
(b) 1,2-methyl shift (migrates from adjacent C to the carbocation centre)
(c) Oxocarbenium ion formed; proton loss gives the ketone (pinacolone)

Step 2 — Why 1,2-shift occurs: The 1,2-shift converts a tertiary carbocation into an oxocarbenium ion ($C{=}O^+$), which is stabilised by resonance. This provides the thermodynamic driving force.

Step 3 — Preference for 1,2-aryl over 1,2-alkyl: Aryl groups migrate more easily than methyl groups due to better electron-donation in the bridged (phenonium ion) transition state.

Final Answer: Pinacolone via 1,2-methyl shift; tertiary carbocation → oxocarbenium $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q20

Q21.

Solution

Concept — Hydroboration-oxidation (anti-Markovnikov addition of water): This is a two-step procedure that adds water across a double bond in an anti-Markovnikov fashion with *syn* stereochemistry.

Step 1 — Hydroboration (BH_3·THF): BH_3 adds as $B-H$ across the double bond in a *concerted, syn* fashion: B adds to the less substituted C (anti-Markovnikov) and H to the more substituted C.

For 1-methylcyclohexene: B adds to C1 (less hindered), H to C2; both from the same face (syn addition).

Step 2 — Oxidation (H_2O_2/NaOH): The C–B bond is converted to C–OH with *retention* of configuration: $C-B+H_2O_2/NaOH \to C-OH$ (with retention).

Overall: the OH ends up on the less substituted carbon (anti-Markovnikov), and if a stereocenter is created, the overall process is **syn addition** of H and OH.

Contrast with acid-catalysed hydration: Acid hydration (H_3O^+) gives Markovnikov product (OH on more substituted C) via carbocation (no stereoselectivity). Hydroboration gives anti-Markovnikov product (OH on less substituted C) with syn addition (stereoselectivity).

Final Answer: Anti-Markovnikov; syn addition; OH on less substituted C $\Rightarrow \boxed{C}$

$\boxed{\text{Answer: (C)}}$ Go Back to Q21

Q22.

Solution

Concept — Beckmann rearrangement (oxime to amide): Ketoximes undergo Beckmann rearrangement with acid catalysts (H_2SO_4, PCl_5) to give amides. The group *anti* (trans) to the leaving OH migrates.

Step 1 — Mechanism:

(a) Protonation of oxime OH and departure as H_2O → nitrilium ion intermediate
(b) 1,2-alkyl/aryl shift (migration anti to the leaving group) → rearranged nitrilium
(c) Water attacks the electrophilic carbon → amide

Step 2 — Application to cyclohexanone oxime: Cyclohexanone oxime $\xrightarrow{H_2SO_4}$ ε-caprolactam (a 7-membered ring lactam). ε-Caprolactam is the monomer for **Nylon-6**: ring-opening polymerisation gives $[-\mathrm{NH}-(\mathrm{CH_2})_5-\mathrm{CO}-]_n$.

Industrial significance: The Beckmann rearrangement is used industrially to convert cyclohexanone (from cyclohexane oxidation) to caprolactam (for Nylon-6), one of the most important polymer monomers.

Final Answer: Beckmann rearrangement; oxime → amide; cyclohexanone oxime → caprolactam $\Rightarrow \boxed{\text{B}}$

$\boxed{\textbf{Answer: (B)}}$ **Go Back to Q22**

Q23.

Solution

Concept — Primary, secondary, and tertiary amines: distinction by reactions:

Hinsberg test (with benzenesulfonyl chloride, $C_6H_5SO_2Cl$):

- 1° amine: reacts to give sulfonamide soluble in NaOH (has an acidic N–H)
- 2° amine: reacts to give sulfonamide insoluble in NaOH (no acidic N–H)
- 3° amine: does not react (no N–H to substitute)

Nitrous acid test ($NaNO_2/HCl$ at 0–5°C):

- 1° amine: diazonium salt ($ArN_2^+Cl^-$, stable for $ArNH_2$; aliphatic decomposes to alcohol + N_2)
- 2° amine: N-nitrosoamine (R_2N-NO, yellow oil)
- 3° amine: forms a salt; no reaction with backbone

Step 1 — The question: Distinguishing a secondary amine from primary and tertiary using Hinsberg test:

- Primary: sulfonamide dissolves in NaOH
- Secondary: sulfonamide precipitates (insoluble in NaOH)
- Tertiary: no reaction, amine layer remains

Final Answer: Hinsberg test distinguishes 1°, 2°, 3° amines unambiguously $\Rightarrow \boxed{A}$

$\boxed{\text{Answer: (A)}}$ Go Back to Q23

Q24.

Solution

Concept — Amphoteric behaviour of amino acids: Amino acids contain both an acidic group ($-\mathrm{COOH}$, p$K_a \approx 2$) and a basic group ($-\mathrm{NH_2}$, p$K_b \approx 4.5$, or p$K_a(\mathrm{NH_3^+}) \approx 9.5$). They exist as zwitterions in solution.

Step 1 — At acidic pH (< pI): Both groups protonated: $\mathrm{H_3N^+ - CHR - COOH}$ (cationic form). Amino acid migrates toward cathode in electrophoresis.

Step 2 — At the isoelectric point (pI): $\mathrm{H_3N^+ - CHR - COO^-}$ (zwitterion, zero net charge). No migration in electrophoresis. $\mathrm{pI} = \frac{pK_{a1}+pK_{a2}}{2} = \frac{2.0+9.5}{2} = 5.75$ for most neutral amino acids.

Step 3 — At basic pH (> pI): $\mathrm{H_2N - CHR - COO^-}$ (anionic form). Migrates toward anode. This is the basis of gel electrophoresis for protein separation.

Amphoteric nature: With HCl: acts as a base ($-\mathrm{NH_2}$ accepts $\mathrm{H^+}$). With NaOH: acts as an acid ($-\mathrm{COOH}$ donates $\mathrm{H^+}$). This is the definition of an amphoteric compound.

Final Answer: Zwitterion at pI; cation at low pH; anion at high pH $\Rightarrow \boxed{\mathrm{D}}$

$\boxed{\textbf{Answer: (D)}}$ Go Back to Q24

Q25.

Solution

Concept — Nucleic acid structure: nucleosides and nucleotides:

Step 1 — Components:

- **Nucleoside** = nitrogenous base + sugar (N-glycosidic bond: base connected to C1′ of ribose/deoxyribose)
- **Nucleotide** = nucleoside + phosphate group(s) (ester bond at C3′ or C5′ of sugar)

Step 2 — Bases: DNA: adenine, guanine, cytosine, thymine (T, contains methyl group) RNA: adenine, guanine, cytosine, uracil (U, like thymine but without the methyl group)

Step 3 — Sugar: DNA: 2′-deoxyribose (missing OH at C2′) RNA: ribose (has OH at C2′)

Step 4 — DNA vs RNA stability: The 2′-OH in RNA makes it susceptible to intramolecular cleavage under alkaline conditions (OH^- abstracts the 2′-OH proton, which then attacks the phosphate $\rightarrow$ 2′,3′-cyclic phosphate, and cleavage). DNA lacks the 2′-OH and is therefore more chemically stable — this is why DNA is the long-term storage molecule.

Final Answer: Nucleotide = base + sugar + phosphate; DNA has T (not U); DNA more stable $\Rightarrow \boxed{\text{C}}$

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

Go Back to Q25

Q26.

Solution

Concept — Analgesics: classification and examples: Analgesics are drugs that relieve pain without causing loss of consciousness. Two main types:

Non-narcotic (mild) analgesics:

- Aspirin (acetylsalicylic acid): inhibits COX enzymes, reduces prostaglandin synthesis; anti-inflammatory, antipyretic
- Paracetamol (acetaminophen): fever-reducing, mild pain relief; no anti-inflammatory action
- Ibuprofen: NSAID (non-steroidal anti-inflammatory drug); COX inhibitor

Narcotic analgesics:

- Morphine, codeine, heroin: opioids; act on central nervous system; addictive; used for severe pain

Step 1 — Aspirin's mechanism: Irreversibly acetylates and inhibits cyclooxygenase (COX-1 and COX-2) enzymes, preventing the synthesis of prostaglandins, which are responsible for pain, inflammation, and fever. Low-dose aspirin (75–325 mg/day) also inhibits platelet aggregation (antiplatelet effect), preventing blood clots.

Step 2 — Side effects: Aspirin can irritate the stomach lining (avoid on empty stomach), and can cause Reye's syndrome in children with viral infections (avoid in under-16s during flu/chickenpox).

Final Answer: Aspirin (COX inhibitor); paracetamol; ibuprofen are non-narcotic analgesics $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q26

Q27.

Solution

Concept — Protective colloids and Gold number: When a lyophilic colloid is added to a lyophobic colloid, it adsorbs onto the surface of the lyophobic particles and forms a protective layer, stabilising the lyophobic sol against coagulation. The lyophilic colloid acts as a **protective colloid**.

Gold number (Zsigmondy): The gold number is the minimum mass (in mg) of a protective colloid needed to just prevent the coagulation of 10 mL of a standard gold sol by 1 mL of 10% NaCl solution.

Step 1 — Interpreting the gold number: Lower gold number = better protective colloid (less mass needed to protect).

Protective colloid	Gold number
Gelatin	0.005–0.01 (best)
Haemoglobin	0.03–0.07
Gum arabic	0.15–0.25
Potato starch	25

Step 2 — Why gelatin is most effective: Gelatin molecules (protein) adsorb strongly to the gold nanoparticle surfaces (hydrophilic coating) and sterically/electrostatically prevent the particles from approaching close enough to coagulate.

Application: Protective colloids are used in paints (prevent pigment settling), medicines (drug suspensions), and photographic films (gelatin stabilises AgBr particles).

Final Answer: Gold number is inversely related to protective power; gelatin has lowest gold number $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q27

Q28.

Solution

Concept — Schottky and Frenkel defects in ionic crystals:

Schottky defect:

- Equal number of cation and anion vacancies
- Crystal remains electrically neutral
- Density *decreases* (fewer ions per unit cell volume)
- Occurs in crystals where both ions are similar in size (e.g. NaCl, KCl, KBr, AgBr)

Frenkel defect:

- Smaller ion (usually cation) displaced from its normal site to an interstitial site
- No vacancies at anion sites; no change in number of ions
- Density essentially *unchanged* (same number of ions, same volume)
- Occurs when cation is much smaller than anion (e.g. AgCl, AgI, ZnS)

Step 1 — Evaluate statements: Option A: Schottky decreases density — **correct**. Option B: Frenkel decreases density — **incorrect**. Density is essentially unchanged (no ions are removed, just displaced to interstitial sites; though very slight increase possible). Option C: Frenkel occurs in large cation–small anion – **incorrect**. It requires *small* cation (to fit in interstitial site). Option D: Schottky occurs in small cation–large anion — **incorrect**. Schottky occurs when both ions are similar in size.

Final Answer: Schottky defect decreases density; Frenkel does not $\Rightarrow \boxed{\text{A}}$

$\boxed{\text{Answer: (A)}}$ Go Back to Q28

Q29.

Solution

Concept — Peptide bonds and protein primary structure: The peptide bond is formed between the α-carboxyl group ($-$COOH) of one amino acid and the α-amino group ($-\mathrm{NH_2}$) of the next, with loss of water:

$$\mathrm{H_2N-CHR-COOH+H_2N-CHR'-COOH \rightarrow H_2N-CHR-CO-NH-CHR'-COOH+}$$

Step 1 — Properties of the peptide bond:

- Partial double-bond character due to resonance: $-\mathrm{C}(=\mathrm{O})-\mathrm{NH}- \leftrightarrow -\overset{+}{\mathrm{C}}(-\mathrm{O}^-)=\overset{+}{\mathrm{N}}\mathrm{H}-$
- Bond is **planar** (all 4 atoms C, O, N, H are in one plane)
- Bond is **trans** (usually, to minimise steric clash of adjacent R groups)
- C–N bond length $\approx 1.32\ \text{Å}$ (shorter than C–N single bond 1.47 Å, longer than C=N double bond 1.27 Å)
- **Not freely rotatable** (unlike normal C–N single bonds)

Step 2 — Peptide bond test (ninhydrin): Ninhydrin reacts with α-amino acids to give a purple/violet colour (Ruhemann's purple). Proline gives a yellow colour. This is used for detection on TLC plates.

Final Answer: Planar, partial double-bond character, trans configuration, C–N length 1.32 Å $\Rightarrow \boxed{\mathrm{B}}$

Answer: (B)

Go Back to Q29

Q30.

Solution

Concept — Antacids: chemistry of acid neutralisation: Antacids are weak bases that neutralise excess stomach acid (HCl). Ideal antacid: fast-acting, no systemic absorption, no rebound acidity, non-toxic.

Step 1 — Common antacids and their reactions:

- $Mg(OH)_2$ (milk of magnesia): $\mathrm{Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O}$; mild laxative effect
- $Al(OH)_3$: $\mathrm{Al(OH)_3 + 3HCl \rightarrow AlCl_3 + 3H_2O}$; constipating effect; often combined with $Mg(OH)_2$
- $NaHCO_3$ (sodium bicarbonate): $\mathrm{NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2}$; fast-acting; produces CO_2 gas (burping); systemic absorption of Na^+ (not ideal for hypertensive patients)
- $CaCO_3$: $\mathrm{CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2}$; may cause rebound acidity; $\mathrm{Ca^{2+}}$ constipating

Step 2 — Why $Mg(OH)_2$ + $Al(OH)_3$ combination: $Mg(OH)_2$'s laxative effect and $Al(OH)_3$'s constipating effect cancel out. This is the rationale for combined antacid tablets (e.g. Maalox, Mylanta).

Step 3 — Proton pump inhibitors vs antacids: Antacids neutralise existing acid. PPIs (e.g. omeprazole) block H^+/K^+-ATPase (the proton pump in stomach parietal cells), preventing acid production at the source. Much more effective for chronic conditions like GERD.

Final Answer: Antacids neutralise HCl by proton transfer; $NaHCO_3$ releases CO_2 $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q30

Answer Key

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