BITSAT Chemistry Sample Paper – 10

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. Choose carefully.
- Use of mobile phones, calculators, or any electronic gadgets is strictly prohibited.

Q1. A compound contains 40% C, 6.67% H, and 53.33% O by mass. Its empirical formula is: ($M_C = 12$, $M_H = 1$, $M_O = 16$)

(A) $\mathrm{CH_2O}$

(B) $\mathrm{C_2H_4O_2}$

(C) $\mathrm{CH_2O_2}$

(D) $\mathrm{C_2H_6O}$

Q2. The radius of the first Bohr orbit of hydrogen is $0.529\,\text{Å}$. The radius of the third Bohr orbit is:

(A) $1.587\,\text{Å}$

(B) $4.761\,\text{Å}$

(C) $1.763\,\text{Å}$

(D) $0.176\,\text{Å}$

Q3. Which of the following bond orders is correct using MO theory? $\mathrm{O_2^{2-}}$ (peroxide ion) has a bond order of:

(A) 3

(B) 2

(C) 1

(D) 0.5

Q4. The following structure shows the bonding in acetylene ($HC \equiv CH$):

$$\mathrm{H} - \mathrm{C} \overset{\sigma + 2\pi}{\equiv} \mathrm{C} - \mathrm{H}$$

The hybridisation of each carbon and the H–C–C bond angle are:

(A) $\mathrm{sp}^2;\ 120^\circ$

(B) $\mathrm{sp}^2;\ 109.5^\circ$

(C) $\mathrm{sp}^3;\ 109.5^\circ$

(D) $\mathrm{sp};\ 180^\circ$

Q5. At what temperature will $1\,\mathrm{mol}$ of an ideal gas occupy $22.4\,\mathrm{L}$ at $2\,\mathrm{atm}$ pressure? ($R = 0.0821\,\mathrm{L\,atm\,mol^{-1}K^{-1}}$)

(A) $273\,\mathrm{K}$

(B) $1092\,\mathrm{K}$

(C) $136.5\,\mathrm{K}$

(D) $546\,\mathrm{K}$

Q6. The bond dissociation energy of H_2 is $436\,\mathrm{kJ\,mol^{-1}}$ and of Cl_2 is $242\,\mathrm{kJ\,mol^{-1}}$. The bond energy of HCl is $431\,\mathrm{kJ\,mol^{-1}}$. The ΔH for the reaction $H_2 + Cl_2 \rightarrow 2HCl$ is:

(A) $-184\,\mathrm{kJ\,mol^{-1}}$

(B) $+184\,\mathrm{kJ\,mol^{-1}}$

(C) $-92\,\mathrm{kJ\,mol^{-1}}$

(D) $+248\,\mathrm{kJ\,mol^{-1}}$

Q7. For the equilibrium: $N_2O_4(g) \rightleftharpoons 2NO_2(g)$, $\Delta H = +57\,\mathrm{kJ\,mol^{-1}}$. When temperature is increased, the equilibrium:

(A) Shifts left, producing more N_2O_4

(B) Shifts right but K_c decreases

(C) Remains unchanged

(D) Shifts right, producing more NO_2; K_c increases

Q8. Which of the following aqueous solutions has a pH < 7?

(A) Na_2CO_3 (sodium carbonate)

(B) $NaCl$ (sodium chloride)

(C) NH_4Cl (ammonium chloride)

(D) CH_3COONa (sodium acetate)

Q9. The standard electrode potential of the hydrogen electrode at pH $= 7$ is:

(A) $0\,V$

(B) $-0.059\,V$

(C) $+0.414\,V$

(D) $-0.414\,V$

Q10. For a second-order reaction with $k = 0.05\,L\,mol^{-1}\,s^{-1}$ and $[A]_0 = 0.2\,M$, the half-life is:

(A) $100\,s$

(B) $13.86\,s$

(C) $200\,s$

(D) $50\,s$

Q11. The process of converting a precipitate into a colloidal solution by addition of a small amount of electrolyte is called:

(A) Coagulation

(B) Dialysis

(C) Electrophoresis

(D) Peptisation

Q12. Which of the following is the most stable allotrope of sulfur at room temperature?

(A) Monoclinic sulfur (β-S)

(B) Plastic sulfur

(C) Rhombic sulfur (α-S)

(D) Colloidal sulfur

Q13. In the extraction of gold, the ore is treated with dilute NaCN in the presence of air. The reaction is:

$$\text{Au ore} \xrightarrow{\text{NaCN} + \text{O}_2} [\text{Au(CN)}_2]^- \xrightarrow{\text{Zn}} \text{Au metal}$$

In the second step, zinc displaces gold because:

(A) Zn has a higher atomic mass than Au

(B) Zn is cheaper than Au

(C) Zn forms a more stable complex than Au

(D) Zn is higher in the electrochemical series (more reactive) than Au and displaces it

Q14. $[Cu(H_2O)_4]^{2+}$ is blue and $[Cu(NH_3)_4]^{2+}$ is deep blue-violet. This is because:

(A) NH_3 is a stronger-field ligand than H_2O, causing a larger crystal field splitting Δ_o, shifting absorption to shorter wavelengths

(B) NH_3 is a weaker-field ligand than H_2O

(C) The two complexes have different oxidation states of Cu

(D) The colour difference is due to the charge-transfer transition only

Q15. Which of the following metal carbonyl complexes does NOT obey the 18-electron rule?

(A) $[\mathrm{Fe(CO)_5}]$ ($Z_{\mathrm{Fe}} = 26$)

(B) $[\mathrm{Cr(CO)_6}]$ ($Z_{\mathrm{Cr}} = 24$)

(C) $[\mathrm{V(CO)_6}]$ ($Z_{\mathrm{V}} = 23$)

(D) $[\mathrm{Ni(CO)_4}]$ ($Z_{\mathrm{Ni}} = 28$)

Q16. In zinc sulfide (ZnS), $\mathrm{Zn^{2+}}$ ions occupy normal lattice sites as well as interstitial sites. This is called:

(A) Schottky defect

(B) Frenkel defect

(C) Metal excess defect

(D) Impurity defect

Q17. The solubility of $\mathrm{CO_2}$ in water at $25°\mathrm{C}$ doubles when the partial pressure of $\mathrm{CO_2}$ doubles. This is a statement of:

(A) Raoult's Law

(B) Henry's Law

(C) Dalton's Law

(D) Boyle's Law

Q18. In the following Grignard reaction:

$$\mathrm{CH_3MgBr} \xrightarrow[\mathrm{HCHO}]{\mathrm{Et_2O,\ then\ H_3O^+}} \text{Product}$$

The product is:

(A) Ethanol ($\mathrm{CH_3CH_2OH}$)

(B) Methanol ($\mathrm{CH_3OH}$)

(C) Propanol ($\mathrm{CH_3CH_2CH_2OH}$)

(D) Acetaldehyde (CH_3CHO)

Q19. Tollens' reagent ($[Ag(NH_3)_2]^+$) gives a silver mirror with glucose but not with fructose. Which statement is correct?

(A) Fructose is a non-reducing sugar

(B) Glucose has a free aldehyde group (aldo-sugar); fructose has a free ketone group but also reduces Tollens' reagent in alkaline conditions

(C) Fructose has higher molecular mass than glucose

(D) Only aldehydes react with Tollens' reagent under any conditions

Q20. When acetic acid reacts with Br_2 in the presence of red phosphorus (Hell-Volhard-Zelinsky reaction), the product is:

(A) $CH_2BrCOOH$ (chloroacetic acid)

(B) $CH_2BrCOOH$ (bromoacetic acid)

(C) $CHBr_2COOH$ (dibromoacetic acid)

(D) CBr_3COOH (tribromoacetic acid)

Q21. In the Hinsberg test, a secondary amine (R_2NH) reacts with benzenesulfonyl chloride to give:

(A) A sulfonamide soluble in NaOH (has acidic N–H)

(B) A sulfonamide insoluble in NaOH (no acidic N–H)

(C) No reaction (tertiary-like behaviour)

(D) A diazonium salt

Q22. Michaelis-Menten kinetics describes enzyme catalysis. At very high substrate concentrations ($[S] \gg K_m$), the reaction velocity approaches:

(A) Zero

(B) $V_{\max}/2$

(C) $V_{\max}$ (maximum velocity, zero-order in S)

(D) $K_m \cdot [\mathrm{S}]$

Q23. Nylon-6 is produced by:

(A) Condensation of adipic acid and hexamethylenediamine

(B) Ring-opening polymerisation of ε-caprolactam

(C) Free radical polymerisation of acrylonitrile

(D) Cationic polymerisation of styrene

Q24. Aspirin (acetylsalicylic acid) works as an analgesic by:

(A) Acting on opioid receptors in the brain

(B) Irreversibly inhibiting cyclooxygenase (COX) enzymes, preventing prostaglandin synthesis

(C) Raising the pain threshold by depressing the CNS

(D) Blocking histamine receptors

Q25. Which of the following sulfates is the **most soluble**?

(A) $\mathrm{MgSO_4}$

(B) $\mathrm{CaSO_4}$

(C) $\mathrm{SrSO_4}$

(D) $\mathrm{BaSO_4}$

Q26. Perchloric acid ($\mathrm{HClO_4}$) is a stronger acid than chloric acid ($\mathrm{HClO_3}$) because:

(A) $\mathrm{HClO_4}$ has a higher molecular mass

(B) $\mathrm{HClO_4}$ has one more electronegative oxygen atom, further withdrawing electron density from the O–H bond

(C) Cl in $\mathrm{HClO_4}$ has a lower oxidation state

(D) $\mathrm{HClO_4}$ forms stronger hydrogen bonds

Q27. In the following reaction:

$$\mathrm{R-CN} \xrightarrow{\mathrm{H_3O^+},\ \Delta} \mathrm{R-COOH}$$

The nitrile R–CN is hydrolysed to give RCOOH. How many moles of H_2O are consumed per mole of nitrile?

(A) 1

(B) 2

(C) 3

(D) 0

Q28. Which of the following carbanions is the most stable?

(A) $\mathrm{CH_3^-}$ (methyl carbanion)

(B) $\mathrm{C_6H_5CH_2^-}$ (benzyl carbanion)

(C) $\mathrm{CH_2=CH-CH_2^-}$ (allylic carbanion)

(D) $\mathrm{HC\equiv C^-}$ (acetylide ion)

Q29. Which of the following is a major component of photochemical smog?

(A) Ozone (O_3) and peroxyacetyl nitrate (PAN)

(B) Sulfur dioxide (SO_2)

(C) Carbon monoxide only

(D) Water vapour and CO_2

Q30. According to Fajan's rules, the covalent character of an ionic compound increases with:

(A) Larger cation and smaller anion

(B) Smaller cation and larger anion

(C) Larger cation and larger anion

(D) Smaller cation and smaller anion

Detailed Solutions

Q1.

Solution

Concept — Empirical formula from percentage composition: Divide each element's percentage by its atomic mass to get molar ratios, then simplify.

Step 1 — Moles (proportional): C: $40/12 = 3.33$; H: $6.67/1 = 6.67$; O: $53.33/16 = 3.33$

Step 2 — Simplest ratio (divide by smallest = 3.33): C: $3.33/3.33 = 1$; H: $6.67/3.33 = 2$; O: $3.33/3.33 = 1$

Empirical formula: CH_2O (formaldehyde unit, MW = 30).

Step 3 — Molecular formula: $n = M_{mol}/30$. If $M = 60$: $C_2H_4O_2$ (acetic acid/glycolaldehyde); if $M = 180$: $C_6H_{12}O_6$ (glucose). The *empirical* formula is CH_2O.

Note: CH_2O is the empirical formula of all simple sugars (glucose, fructose, galactose).

Final Answer: Empirical formula $CH_2O \Rightarrow \boxed{A}$

Answer: (A) Go Back to Q1

Q2.

Solution

Concept — Bohr orbit radius: $r_n = n^2 a_0$: $r_n = n^2 \times 0.529\,\text{Å}$

Step 1: $r_3 = 3^2 \times 0.529 = 9 \times 0.529 = \mathbf{4.761}\,\text{Å}$

Physical meaning: Orbital radius grows as n^2. The third orbit is 9 times larger than the first. This rapid expansion means Rydberg atoms (high n) can be extremely large (micrometres in size for $n \approx 100$).

Energy: $E_n = -13.6/n^2\,\text{eV}$. At $n = 3$: $E_3 = -1.51\,\text{eV}$ (less negative than $n = 1$).

Final Answer: $r_3 = 4.761\,\text{Å} \Rightarrow \boxed{B}$

Answer: (B) Go Back to Q2

Q3.

Solution

Concept — MO bond order of O_2^{2-} (peroxide ion): O_2^{2-} has $16+2 = 18$ electrons.

Step 1 — MO configuration: $(\sigma_{1s})^2(\sigma_{1s}^*)^2(\sigma_{2s})^2(\sigma_{2s}^*)^2(\sigma_{2p})^2(\pi_{2p})^4(\pi_{2p}^*)^4$

Bonding $e^- = 10$, antibonding $e^- = 8$.

Bond order $= \frac{10-8}{2} = \mathbf{1}$

Step 2 — Comparison: O_2 (16 e^-): BO = 2; O_2^- (17 e^-): BO = 1.5; O_2^{2-} (18 e^-): BO = 1.

O–O single bond length in H_2O_2 (contains O_2^{2-} backbone): $147\,\text{pm}$, consistent with BO = 1.

Application: Na_2O_2 contains O_2^{2-} (peroxide ion with O–O single bond). KO_2 contains superoxide O_2^- (BO = 1.5).

Final Answer: Bond order of $O_2^{2-} = 1 \Rightarrow \boxed{C}$

Answer: (C) **Go Back to Q3**

Q4.

Solution

Concept — sp hybridisation in alkynes: In C_2H_2 (acetylene), each C forms: 1 H–C σ-bond, 1 C–C σ-bond, and 2 C–C π-bonds (from the remaining 2 unhybridised p-orbitals perpendicular to the molecular axis).

Step 1 — Hybridisation: Each C uses 2 orbitals for σ-bonding (to H and to C): sp hybridisation ($2s + 2p_z$ mixed).

Step 2 — Bond angle: sp hybridised orbitals point in opposite directions (180°). H–C–C angle = $180°$ (linear molecule).

Step 3 — Triple bond composition: $1\,\sigma + 2\,\pi$ bonds: the σ bond is strong (end-on overlap of sp-sp); the two π bonds (p_x-p_x and p_y-p_y, side-on overlap) are weaker individually but together make acetylene highly reactive toward electrophiles.

Final Answer: sp hybridisation; $180° \Rightarrow \boxed{D}$

Answer: (D) **Go Back to Q4**

Q5.

Solution

Concept — Ideal gas law: $PV = nRT$: $T = PV/(nR) = (2 \times 22.4)/(1 \times 0.0821) = 44.8/0.0821 = \mathbf{545.7} \approx \mathbf{546}\,\mathrm{K}$

Physical check: At STP (273 K, 1 atm), 1 mol occupies 22.4 L. Doubling pressure (2 atm) while keeping volume constant requires doubling T (by Charles' Law reasoning). $2 \times 273 = 546$ K ✓.

Common trap: Using $T = 273\,\mathrm{K}$ (forgetting that pressure is 2 atm, not 1 atm).

Final Answer: $T = 546\,\mathrm{K} \Rightarrow \boxed{\mathrm{D}}$

Answer: (D) Go Back to Q5

Q6.

Solution

Concept — ΔH from bond energies: $\Delta H = \sum BE(\text{broken}) - \sum BE(\text{formed})$

Step 1 — Bonds broken in reactants: 1 H–H bond: $+436\,\mathrm{kJ}$ 1 Cl–Cl bond: $+242\,\mathrm{kJ}$ Total broken: $678\,\mathrm{kJ}$

Step 2 — Bonds formed in products: 2 H–Cl bonds: $2 \times 431 = 862\,\mathrm{kJ}$ released

Step 3 — ΔH: $\Delta H = 678 - 862 = -184\,\mathrm{kJ\,mol^{-1}}$

Note: Experimental $\Delta H_f^\circ(\mathrm{HCl}) = -92.3\,\mathrm{kJ\,mol^{-1}}$, so $\Delta H = 2 \times (-92.3) = -184.6\,\mathrm{kJ\,mol^{-1}}$. Bond energy calculation agrees very well here.

Final Answer: $\Delta H = -184\,\mathrm{kJ\,mol^{-1}} \Rightarrow \boxed{\mathrm{A}}$

Answer: (A) Go Back to Q6

Q7.

Solution

Concept — Temperature effect on endothermic equilibrium: $N_2O_4 \rightleftharpoons 2NO_2$, $\Delta H = +57\,\text{kJ}\,\text{mol}^{-1}$ (endothermic, forward).

Step 1 — Le Chatelier's principle: Increasing temperature supplies heat. For an endothermic reaction, heat is a "reactant". Adding more heat shifts equilibrium *to the right* (toward products, NO_2).

Step 2 — Effect on K_c: For endothermic reactions: $\ln K_c \propto -\Delta H/RT$. Since $\Delta H > 0$, increasing T makes K_c *larger* (more products at equilibrium). $d\ln K/dT = \Delta H/RT^2 > 0$.

Step 3 — Observation: N_2O_4 is colourless; NO_2 is brown. Warming a sealed tube of the gas mixture darkens it (more NO_2), confirming this shift.

Final Answer: Shifts right; K_c increases (endothermic, more NO_2) $\Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q7**

Q8.

Solution

Concept — Salt hydrolysis and pH: Salts formed from weak base + strong acid hydrolyse to give acidic solutions ($\text{pH} < 7$).

Step 1 — Evaluate each: Na_2CO_3: strong base (NaOH) + weak acid (H_2CO_3). CO_3^{2-} hydrolyses: basic solution, $\text{pH} > 7$.

NaCl: strong base (NaOH) + strong acid (HCl). Neither ion hydrolyses. $\text{pH} = 7$.

NH_4Cl: weak base (NH_3) + strong acid (HCl). NH_4^+ hydrolyses: $NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$. Acidic, **pH** < 7.

CH_3COONa: strong base (NaOH) + weak acid (CH_3COOH). CH_3COO^- hydrolyses: basic, $\text{pH} > 7$.

Step 2 — Answer: Only NH_4Cl has $\text{pH} < 7$.

Final Answer: NH_4Cl (acidic solution) $\Rightarrow \boxed{\text{C}}$

Answer: (C) **Go Back to Q8**

Q9.

Solution

Concept — Nernst equation for hydrogen electrode: $E = E^\circ - \frac{0.0592}{n}\log\frac{1}{[\mathrm{H}^+]^2} = 0 - \frac{0.0592}{2}\log\frac{1}{[\mathrm{H}^+]^2} = 0.0592\log[\mathrm{H}^+] = -0.0592\,\mathrm{pH}$

Step 1 — At pH 7: $E = -0.0592 \times 7 = -0.4144 \approx \mathbf{-0.414}\,\mathrm{V}$

Step 2 — Physical meaning: At pH 7 (neutral solution), the hydrogen electrode has a potential of $-0.414\,\mathrm{V}$ vs SHE. This is the potential relevant for biochemistry (the "biological standard" is defined at pH 7, giving $E'^\circ = -0.414\,\mathrm{V}$ for the $\mathrm{H}^+/\mathrm{H}_2$ couple).

Step 3 — General formula: Every unit increase in pH lowers the electrode potential by $0.0592\,\mathrm{V}$ ($\approx 59\,\mathrm{mV}$).

Final Answer: $E = -0.414\,\mathrm{V}$ at pH 7 $\Rightarrow \boxed{\mathrm{D}}$

Answer: (D) **Go Back to Q9**

Q10.

Solution

Concept — Second-order half-life: $t_{1/2} = 1/(k[\mathrm{A}]_0)$:

Step 1: $t_{1/2} = \frac{1}{k[\mathrm{A}]_0} = \frac{1}{0.05 \times 0.2} = \frac{1}{0.01} = \mathbf{100}\,\mathrm{s}$

Step 2 — Successive half-lives increase: After first half-life (100 s): $[\mathrm{A}] = 0.1\,\mathrm{M}$. Second $t_{1/2} = 1/(0.05 \times 0.1) = 200\,\mathrm{s}$ (doubles). This is characteristic of second-order kinetics.

Step 3 — Contrast with first-order: First-order $t_{1/2} = \ln 2/k =$ constant. Second-order $t_{1/2} \propto 1/[\mathrm{A}]_0$ (decreasing concentration gives increasing half-life).

Final Answer: $t_{1/2} = 100\,\mathrm{s} \Rightarrow \boxed{\mathrm{A}}$

Answer: (A) **Go Back to Q10**

Q11.

Solution

Concept — Peptisation (reversal of coagulation): Adding a small amount of a peptising agent (often an electrolyte with a common ion, or the dispersing medium) to a freshly prepared precipitate causes it to break into colloidal particles. This is the reverse of coagulation.

Example: Adding $\mathrm{FeCl_3}$ to freshly precipitated $\mathrm{Fe(OH)_3}$: $\mathrm{Fe^{3+}}$ ions adsorb on the precipitate surface, giving it a positive charge, causing repulsion between particles and forming a red-brown colloid.

Other terms: Coagulation = precipitation of colloid. Dialysis = removal of electrolytes from colloid through semipermeable membrane. Electrophoresis = migration of colloidal particles under electric field.

Final Answer: Peptisation converts precipitate to colloid $\Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q11**

Q12.

Solution

Concept — Allotropes of sulfur and stability: Sulfur has several allotropes: rhombic (α-S, S_8 rings, orthorhombic crystal), monoclinic (β-S, S_8 rings, needle-like), plastic (amorphous), colloidal.

Step 1 — Stability at room temperature: Rhombic sulfur (α-S) is the thermodynamically stable form at room temperature (below $96°\mathrm{C}$, the transition temperature). Above $96°\mathrm{C}$: monoclinic (β-S) is stable. Monoclinic converts back to rhombic on cooling below $96°\mathrm{C}$.

Step 2 — Properties: Rhombic S: yellow, mp = $113°\mathrm{C}$, density = $2.07\,\mathrm{g\,cm^{-3}}$. Monoclinic S: yellow, slender needles, mp = $119°\mathrm{C}$, density = $1.96\,\mathrm{g\,cm^{-3}}$.

Final Answer: Rhombic sulfur (α-S) is most stable at room temperature $\Rightarrow \boxed{\text{C}}$

Answer: (C) **Go Back to Q12**

Q13.

Solution

Concept — Cyanide leaching and electrochemical displacement: Step 1 (leaching): $4\text{Au} + 8\text{NaCN} + \text{O}_2 + 2\text{H}_2\text{O} \rightarrow 4\text{Na}[\text{Au}(\text{CN})_2] + 4\text{NaOH}$

Step 2 (displacement): $\text{Zn} + 2[\text{Au}(\text{CN})_2]^- \rightarrow [\text{Zn}(\text{CN})_4]^{2-} + 2\text{Au}$

Step 1 — Why Zn displaces Au: In the electrochemical series (activity series), Zn ($E^\circ = -0.76\,\text{V}$) is far above Au ($E^\circ = +1.50\,\text{V}$). More reactive metals displace less reactive metals from their salt solutions. Zn is oxidised; Au is reduced and deposited.

Step 2 — Economic significance: Gold cyanide process extracts about 85% of global gold production. The use of cyanide is controversial environmentally (very toxic), but no cost-effective alternative exists at large scale.

Final Answer: Zn is more reactive (higher in electrochemical series) than Au $\Rightarrow \boxed{\text{D}}$

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

Q14.

Solution

Concept — Crystal field splitting and colour of complexes: The colour of a transition metal complex depends on the wavelength of light absorbed in the d–d transition. This wavelength is determined by Δ_o, the crystal field splitting energy.

Step 1 — Spectrochemical series: $\ldots \text{H}_2\text{O} < \text{NH}_3 \ldots$ (NH_3 is a stronger-field ligand than H_2O).

Step 2 — Effect on colour: Stronger-field ligand $\Rightarrow$ larger Δ_o $\Rightarrow$ higher energy photon absorbed $\Rightarrow$ shorter wavelength absorbed $\Rightarrow$ complementary (longer wavelength) colour observed. $[\text{Cu}(\text{H}_2\text{O})_4]^{2+}$: absorbs orange-red ($\approx 790\,\text{nm}$) $\Rightarrow$ blue. $[\text{Cu}(\text{NH}_3)_4]^{2+}$: larger Δ_o $\Rightarrow$ absorbs at shorter λ (more green/yellow) $\Rightarrow$ deep blue-violet.

Step 3 — Option A is correct: NH_3 stronger field $\Rightarrow$ larger Δ_o $\Rightarrow$ higher energy absorption $\Rightarrow$ shorter λ absorbed $\Rightarrow$ deeper/different blue.

Final Answer: NH_3 is stronger field; larger Δ_o shifts absorption to shorter $\lambda \Rightarrow \boxed{\text{A}}$

Answer: (A) **Go Back to Q14**

Q15.

Solution

Concept — 18-electron rule for metal carbonyls: Electron count = metal valence electrons + $2\times$ (number of CO ligands).

Step 1 — Count for each: $[\mathrm{Fe(CO)_5}]$: Fe has 8 e^-; $5 \times 2 = 10$; total = 18 ✓$[\mathrm{Cr(CO)_6}]$: Cr has 6 e^-; $6 \times 2 = 12$; total = 18 ✓$[\mathrm{Ni(CO)_4}]$: Ni has 10 e^-; $4 \times 2 = 8$; total = 18 ✓$[\mathrm{V(CO)_6}]$: V has 5 e^-; $6 \times 2 = 12$; total = 17 $\neq$ 18 ×

Step 2 — Why $\mathrm{V(CO)_6}$ is an exception: $\mathrm{V(CO)_6}$ is a rare 17-electron complex (paramagnetic, one unpaired electron). It does not dimerize like most odd-electron carbonyls (e.g. $\mathrm{Mn(CO)_5}$ dimerizes to $\mathrm{Mn_2(CO)_{10}}$ to achieve 18 electrons) — the V–V bond would be too strained in $\mathrm{V_2(CO)_{12}}$.

Final Answer: $[\mathrm{V(CO)_6}]$ has only 17 electrons; violates 18-electron rule $\Rightarrow \boxed{\mathrm{C}}$

Answer: (C) Go Back to Q15

Q16.

Solution

Concept — Frenkel defect: cation displacement to interstitial site: In the Frenkel defect, a smaller ion (usually cation) moves from its normal lattice site to an interstitial site, leaving a vacancy. The crystal retains electrical neutrality.

ZnS example: $\mathrm{Zn^{2+}}$ ions (small) occupy both normal lattice sites AND interstitial sites $\Rightarrow$ Frenkel defect. This occurs in crystals where the cation is much smaller than the anion.

Properties of Frenkel defect: Density remains essentially unchanged (no ions removed). Crystal conductivity increases (ion can hop between lattice and interstitial sites). Examples: AgCl, AgBr, AgI, ZnS.

Contrast: Schottky defect (equal vacancies of both ions, density decreases) vs Frenkel (cation vacancy + interstitial, density unchanged).

Final Answer: Frenkel defect ($\mathrm{Zn^{2+}}$ in interstitial sites) $\Rightarrow \boxed{\mathrm{B}}$

Answer: (B) Go Back to Q16

Q17.

Solution

Concept — Henry's Law: gas solubility $\propto$ partial pressure: $p = K_H \cdot x$ (Henry's Law), where x is mole fraction of gas dissolved and K_H is Henry's constant.

Step 1 — Interpretation: Doubling the partial pressure of CO_2 doubles its mole fraction (solubility) in water. This is exactly Henry's Law.

Application: Carbonated beverages are bottled under high CO_2 pressure (about 3–4 atm). When opened, pressure drops to atmospheric $\approx 0.0003\,\mathrm{atm}$ CO_2 (partial pressure), so the dissolved CO_2 rapidly escapes (effervescence).

Raoult's Law covers vapour pressure of the *solvent* over an ideal solution (not gas solubility). Henry's Law covers solubility of gases in liquids.

Final Answer: Henry's Law $\Rightarrow \boxed{\text{B}}$

Answer: (B) **Go Back to Q17**

Q18.

Solution

Concept — Grignard reaction with formaldehyde (HCHO): Rule: RCHO + R'MgBr $\rightarrow$ RCHOHR' (secondary alcohol) after workup. For HCHO (formaldehyde, R=H): RMgBr + HCHO $\rightarrow$ primary alcohol RCH_2OH.

Step 1 — Reaction: $CH_3MgBr + HCHO \xrightarrow{1.\,Et_2O;\;2.\,H_3O^+} CH_3CH_2OH$

Mechanism: CH_3^- (from Grignard) attacks carbonyl C of HCHO; after workup: CH_3CH_2OH (ethanol).

Step 2 — General rule: RMgBr + HCHO $\rightarrow$ primary alcohol (R–CH_2–OH, one more C than R). RMgBr + RCHO $\rightarrow$ secondary alcohol. RMgBr + R_2CO $\rightarrow$ tertiary alcohol. RMgBr + CO_2 $\rightarrow$ carboxylic acid (RCOOH).

Step 3 — Why ethanol, not methanol? Methanol would require reacting MeMgBr with nothing useful (or with H^+ directly). The product CH_3CH_2OH comes from CH_3^- adding to HCHO's carbonyl carbon.

Final Answer: Ethanol (CH_3CH_2OH) $\Rightarrow \boxed{\text{A}}$

Answer: (A) **Go Back to Q18**

Q19.

Solution

Concept — Reducing sugars: glucose vs fructose with Tollens' reagent: Tollens' reagent ($[\mathrm{Ag(NH_3)_2}]^+$) oxidises aldehydes (and α-hydroxy ketones under alkaline conditions).

Step 1 — Glucose: An aldohexose: contains a free aldehyde group (CHO) $\Rightarrow$ directly reduces Tollens' reagent (silver mirror).

Step 2 — Fructose: A ketohexose: contains a ketone group (C=O at C2). However, fructose DOES give a positive Tollens' test in alkaline conditions! In alkali, fructose is partially converted to glucose and mannose via epimerisation (the Lobry de Bruyn-van Ekenstein rearrangement). The glucose formed then reduces Tollens' reagent. So both are reducing sugars.

The correct statement (option B): Glucose has a free aldehyde (aldo-sugar); fructose has a free ketone (keto-sugar) but also reduces Tollens' in alkaline conditions (via isomerisation to glucose/mannose). Both are reducing sugars.

Why the question says "glucose but not fructose"? Under acidic Tollens' conditions, fructose might not react. Under alkaline conditions (standard Tollens'), fructose does reduce it. The statement in option B is the most accurate.

Final Answer: Glucose has free aldehyde; fructose also reduces Tollens' in alkaline conditions $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q19

Q20.

Solution

Concept — Hell-Volhard-Zelinsky (HVZ) reaction (α-halogenation of carboxylic acid): Carboxylic acids react with Br_2/red P to introduce Br at the α-carbon.

Step 1 — Mechanism: Red P reacts with Br_2 to form PBr_3, which converts RCOOH to RCOBr (acyl bromide). The acyl bromide has acidic α-H (more acidic than RCOOH due to C=O induction). Br_2 then brominates the α-position via enolisation. Finally, H_2O hydrolyses the intermediate back to the bromo acid.

Step 2 — For acetic acid: $\mathrm{CH_3COOH} \xrightarrow{\mathrm{Br_2/P}} \mathrm{CH_2BrCOOH}$ (**bromoacetic acid**, or 2-bromoacetic acid)

Step 3 — Options A and B both show $\mathrm{CH_2BrCOOH}$: Option A labels it “chloroacetic acid” (wrong name — Br_2 gives bromo product). Option B labels it “bromoacetic acid” (correct name).

Final Answer: $\mathrm{CH_2BrCOOH}$ (bromoacetic acid, HVZ reaction) $\Rightarrow \boxed{\mathrm{B}}$

Answer: (B) **Go Back to Q20**

Q21.

Solution

Concept — Hinsberg test: secondary amine with $ArSO_2Cl$: Primary amine ($\mathrm{RNH_2}$): reacts to give $\mathrm{RNH - SO_2Ar}$ (sulfonamide). This still has an N–H, which is acidic ($\mathrm{p}K_a \approx 16$); the sulfonamide dissolves in NaOH (acidic N–H reacts with base).

Secondary amine ($\mathrm{R_2NH}$): reacts to give $\mathrm{R_2N - SO_2Ar}$ (sulfonamide with no N–H). This is **insoluble in NaOH** (no acidic H to react with base; precipitates as solid).

Tertiary amine ($\mathrm{R_3N}$): no N–H; does not react with $ArSO_2Cl$.

Step 1 — Secondary amine result: $\mathrm{R_2NH + ArSO_2Cl \rightarrow R_2N - SO_2Ar}$ + HCl (neutralised by base in reaction). Product is insoluble in NaOH $\Rightarrow$ precipitate forms.

Final Answer: Secondary amine gives sulfonamide insoluble in NaOH (no acidic N–H) $\Rightarrow \boxed{\mathrm{B}}$

Answer: (B) **Go Back to Q21**

Q22.

Solution

Concept — Michaelis-Menten kinetics: saturation behaviour: $v = \frac{V_{\max}[\mathrm{S}]}{K_m+[\mathrm{S}]}$

Step 1 — At high $[\mathrm{S}]$**:** $[\mathrm{S}] \gg K_m$**:** $v \approx \frac{V_{\max}[\mathrm{S}]}{[\mathrm{S}]} = V_{\max}$ (constant)

At saturation, all enzyme active sites are occupied. The rate becomes independent of $[\mathrm{S}]$ (zero order in S) and equals $V_{\max}$.

Step 2 — Interpretation: $V_{\max} = k_{\text{cat}} \times [\mathrm{E}]_{\text{total}}$, where k_{cat} (turnover number) is the number of substrate molecules converted per enzyme active site per second. The enzyme is working at full capacity.

Step 3 — At $[\mathrm{S}] = K_m$**:** $v = V_{\max}/2$. This is the definition of K_m: substrate concentration at which the rate is half-maximal. Lower $K_m \Rightarrow$ higher enzyme affinity for substrate.

Final Answer: $v \to V_{\max}$ at high $[\mathrm{S}] \Rightarrow \boxed{\mathrm{C}}$

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

Q23.

Solution

Concept — Nylon-6 synthesis: Nylon-6 is different from Nylon-6,6:

- **Nylon-6**: from **one monomer** (ε-caprolactam, a cyclic amide / lactam), via ring-opening polymerisation.
- **Nylon-6,6**: from two monomers (adipic acid + hexamethylenediamine).

Step 1 — Nylon-6 structure: ε-caprolactam ($\mathrm{C_6H_{11}NO}$, a 7-membered ring) opens at the amide bond in the presence of water or acid catalyst: $n\,\varepsilon$-caprolactam $\to [-\mathrm{NH}-(\mathrm{CH_2})_5-\mathrm{CO}-]_n$ (Nylon-6)

Step 2 — Properties: Both Nylon-6 and Nylon-6,6 are polyamides with similar properties. Nylon-6 has a lower melting point ($215°$C vs $265°$C for Nylon-6,6), is more elastic, and more moisture-absorbing.

Beckmann rearrangement connection: ε-Caprolactam is industrially made by Beckmann rearrangement of cyclohexanone oxime. This is why the Beckmann rearrangement is crucial to global Nylon-6 production (~ 4 million tonnes/year).

Final Answer: Ring-opening polymerisation of ε-caprolactam $\Rightarrow \boxed{\mathrm{B}}$

$\boxed{\textbf{Answer: (B)}}$ **Go Back to Q23**

Q24.

Solution

Concept — Mechanism of aspirin as analgesic/antipyretic: Aspirin (acetylsalicylic acid) irreversibly inhibits cyclooxygenase (COX-1 and COX-2) enzymes by acetylating a serine residue in the enzyme's active site.

Step 1 — Mechanism: COX enzymes convert arachidonic acid to prostaglandins (PGs). PGs are inflammatory mediators that sensitise pain receptors, raise body temperature (fever), and promote inflammation. By blocking COX, aspirin prevents PG synthesis $\Rightarrow$ reduces pain, fever, and inflammation.

Step 2 — Irreversible vs reversible inhibition: Aspirin: irreversible (covalent acetylation of COX). Ibuprofen: reversible competitive inhibitor of COX.

Step 3 — Antiplatelet use: Low-dose aspirin ($75–325\,\mathrm{mg/day}$) irreversibly inhibits COX-1 in platelets (which cannot synthesise new protein since they lack a nucleus), preventing thromboxane A_2 synthesis and thus platelet aggregation. Used in cardiovascular disease prevention.

Final Answer: Irreversibly inhibits COX enzymes, preventing prostaglandin synthesis $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q24

Q25.

Solution

Concept — Solubility of Group 2 sulfates: Solubility of alkaline earth sulfates *decreases* down the group: $\mathrm{MgSO_4}$ (very soluble) $>$ $\mathrm{CaSO_4}$ (slightly soluble) $>$ $\mathrm{SrSO_4}$ (sparingly soluble) $>$ $\mathrm{BaSO_4}$ (nearly insoluble)

Reason: As cation size increases (Mg^{2+} to Ba^{2+}), lattice energy decreases. But hydration energy decreases faster (smaller ions are more strongly hydrated). For Mg^{2+} (very small, very high hydration energy), hydration energy $\gg$ lattice energy $\Rightarrow$ very soluble. For Ba^{2+} (larger, lower hydration energy), the two become comparable but lattice energy wins $\Rightarrow$ insoluble.

Application: $BaSO_4$ insolubility is used in barium meal X-rays (opaque to X-rays, non-toxic since insoluble). $MgSO_4$ (Epsom salt) high solubility used in medicine and horticulture.

Final Answer: $MgSO_4$ is most soluble $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q25

Q26.

Solution

Concept — Acid strength of halogen oxyacids: For oxyacids of the same halogen, acid strength increases with the number of electronegative O atoms (each O withdraws electron density through the O–X–O chain, weakening the O–H bond).

Step 1 — Compare $HClO_4$ and $HClO_3$: $HClO_3$: 3 O atoms on Cl (pKa ≈ -1, strong acid). $HClO_4$: 4 O atoms on Cl (pKa ≈ -10, strongest common acid).

The extra O in $HClO_4$ provides one more electron-withdrawing group, further destabilising the O–H bond and making it more acidic.

Step 2 — Option B is correct: $HClO_4$ has one more O atom $\Rightarrow$ greater inductive withdrawal from the O–H bond $\Rightarrow$ H^+ more easily released $\Rightarrow$ stronger acid.

Why not option C? Cl in $HClO_4$ is $+7$ (higher oxidation state, not lower).

Final Answer: One more O atom in $HClO_4$ increases $-I$ effect on O–H bond $\Rightarrow$ $\boxed{B}$

Answer: (B) Go Back to Q26

Q27.

Solution

Concept — Hydrolysis of nitriles to carboxylic acids: $R-C\equiv N+2H_2O\xrightarrow{H^+}R-COOH+NH_4^+$

Or: $R-C\equiv N+H_2O\rightarrow RCONH_2$ (first step: amide); $RCONH_2+H_2O\rightarrow RCOOH+NH_3$ (second step).

Step 1 — Count water: Two molecules of H_2O are consumed in the overall hydrolysis of one C≡N to COOH.

Step 1: $C\equiv N+H_2O\rightarrow CONH_2$ (1 mol H_2O) Step 2: $CONH_2+H_2O\rightarrow COOH+NH_3$ (1 mol H_2O) Total: **2 mol H_2O** consumed.

Application: Nitrile hydrolysis is used in industrial preparation of acrylic acid from acrylonitrile, and in synthesis of amino acids from α-halo acids via the Strecker synthesis.

Final Answer: 2 moles of H_2O consumed $\Rightarrow$ $\boxed{B}$

Answer: (B) Go Back to Q27

Q28.

Solution

Concept — Carbanion stability: sp hybridisation vs resonance: Stability order for carbanions: $sp > sp^2 > sp^3$ (more s character $\Rightarrow$ electrons held closer to nucleus $\Rightarrow$ more stable).

Step 1 — Evaluate options:

Methyl carbanion ($\mathrm{CH_3^-}$): sp^3; no stabilisation; most unstable.

Benzyl carbanion ($\mathrm{C_6H_5CH_2^-}$): Resonance delocalisation into ring; sp^3 carbon. Stabilised by resonance.

Allyl carbanion ($\mathrm{CH_2 = CH - CH_2^-}$): Resonance delocalisation over 3 atoms; sp^3 at carbanion centre.

Acetylide ion ($\mathrm{HC \equiv C^-}$): sp hybridisation at the carbanion carbon. sp carbon has 50% s-character (vs 33% for sp^2, 25% for sp^3). Electrons in sp orbitals are held much closer to the nucleus $\Rightarrow$ most stable carbanion. pKa(acetylene) ≈ 25 (vs pKa(ethane) ≈ 50, pKa(ethylene) ≈ 44).

Step 2 — Stability order: $\mathrm{HC \equiv C^-}$ (sp, pKa 25) $>$ $\mathrm{C_6H_5CH_2^-}$ (resonance) $>$ allylic $>$ methyl.

Final Answer: Acetylide ion $\mathrm{HC \equiv C^-}$ (sp hybridised, 50% s-character) is most stable $\Rightarrow \boxed{\mathrm{D}}$

Answer: (D) **Go Back to Q28**

Q29.

Solution

Concept — Photochemical smog formation: Photochemical smog (Los Angeles type) is formed in sunlight from NOx and unburnt hydrocarbons (from vehicle exhausts).

Step 1 — Key reactions: $NO_2 \xrightarrow{h\nu} NO + O\cdot$ (UV photolysis) $O \cdot + O_2 \rightarrow O_3$ (ozone formation) $O_3 + \text{alkenes/VOCs} \rightarrow \text{PAN, formaldehyde, etc.}$ (PAN = peroxyacetyl nitrate)

Step 2 — Major components: Ozone (O_3) and **PAN (peroxyacetyl nitrate)** are the primary irritants in photochemical smog. Both are strong oxidants. O_3 damages rubber, crops, and lung tissue. PAN causes eye irritation and kills vegetation.

Step 3 — Compare with classical smog: Classical (London-type) smog: SO_2 + smoke from coal combustion in fog ⇒ acidic. Photochemical (LA-type) smog: O_3 + PAN from vehicle exhaust + sunlight ⇒ oxidising.

Final Answer: Ozone and PAN are major components of photochemical smog ⇒ $\boxed{A}$

Answer: (A) Go Back to Q29

Q30.

Solution

Concept — Fajan's rules for covalent character: An ionic compound has more covalent character when the cation can distort (polarise) the electron cloud of the anion. This is governed by Fajan's rules:

(a) Small cation: high charge density (high polarising power)
(b) Large anion: more polarisable (easily distorted)
(c) Higher charge on cation or anion: increases covalency

Step 1 — Condition for maximum covalent character: Small cation + large anion = maximum polarisation = maximum covalent character.

Small cation has high charge density ($= z/r^2$) $\Rightarrow$ strongly polarises the large, diffuse electron cloud of the large anion $\Rightarrow$ electron cloud is distorted toward the cation $\Rightarrow$ bond has covalent character.

Step 2 — Examples: LiI: Li^+ is small, I^- is large $\Rightarrow$ most covalent LiX. NaF: Na^+ larger than Li^+, F^- smaller than I^- $\Rightarrow$ more ionic. $BeCl_2$: Be^{2+} is very small, high charge $\Rightarrow$ significantly covalent.

Final Answer: Smaller cation + larger anion $\Rightarrow$ maximum covalent character $\Rightarrow$ $\boxed{\text{B}}$

$\boxed{\textbf{Answer: (B)}}$ **Go Back to Q30**

Answer Key

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