AIIMS Paramedical Chemistry

Sample Paper – 1

Duration: 30 Minutes **Maximum Marks: 30**

Instructions

- This paper contains **30** Multiple Choice Questions (Single Correct Answer), modelled on the Chemistry portion of **AIIMS Paramedical** entrance.
- Each correct answer carries **+1 mark**. Each incorrect answer attracts a penalty of $-\frac{1}{3}$ mark. Unattempted questions score **0**.
- Only **one** option is correct. Choose carefully.
- Syllabus level: **Class 11 & 12 NCERT Chemistry**
- Use of mobile phones, calculators, or electronic gadgets is strictly prohibited.

Q1. A compound contains 40% carbon, 6.7% hydrogen and 53.3% oxygen by mass. If its molar mass is 180 g mol^{-1}, its molecular formula is:

(A) CH_2O

(B) $C_3H_6O_3$

(C) $C_6H_{12}O_6$

(D) $C_5H_{10}O_5$

Q2. The energy of an electron in the ground state of a hydrogen atom is -13.6 eV. The energy required to excite the electron from the second orbit ($n = 2$) to the third orbit ($n = 3$) is:

(A) 1.51 eV

(B) 1.89 eV

(C) 3.40 eV

(D) 12.09 eV

Q3. A 0.5 mol sample of an ideal gas occupies a volume of 12.3 L at 300 K. The pressure exerted by the gas is (take $R = 0.0821$ L atm K^{-1} mol^{-1}):

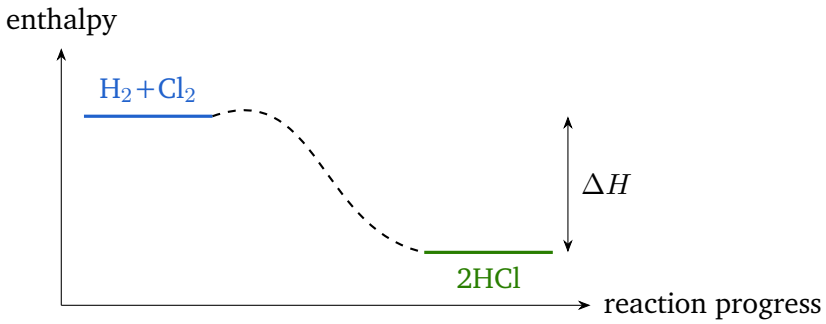
(A) 1.0 atm

(B) 2.0 atm

(C) 0.5 atm

(D) 1.5 atm

Q4. For the reaction $H_2(g) + Cl_2(g) \rightarrow 2\ HCl(g)$, the bond enthalpies are: H–H $= 436$, Cl–Cl $= 242$ and H–Cl $= 431$ kJ mol^{-1}. The enthalpy of the reaction is:



(A) $+184$ kJ mol^{-1}

(B) $+92$ kJ mol^{-1}

(C) -92 kJ mol^{-1}

(D) -184 kJ mol^{-1}

Q5. For the equilibrium $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ in a 1 L vessel, at equilibrium $[PCl_5] = 0.5$ M, $[PCl_3] = 0.2$ M and $[Cl_2] = 0.2$ M. The value of K_c is:

(A) 0.04

(B) 0.08

(C) 0.16

(D) 0.20

Q6. The pH of a 0.001 M aqueous solution of HCl at 298 K is:

(A) 3

(B) 2

(C) 11

(D) 1

Q7. The oxidation number of manganese in the permanganate ion, MnO_4^-, is:

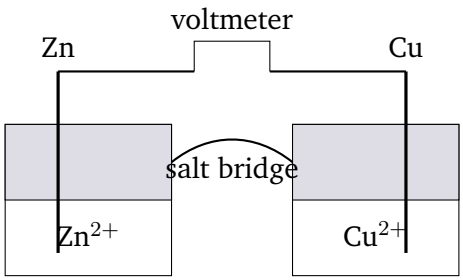
(A) $+4$

(B) $+6$

(C) $+7$

(D) $+2$

Q8. For the Daniell cell $Zn\,|\,Zn^{2+}\,||\,Cu^{2+}\,|\,Cu$, the standard electrode potentials are $E^\circ_{Zn^{2+}/Zn} = -0.76$ V and $E^\circ_{Cu^{2+}/Cu} = +0.34$ V. The standard EMF of the cell is:



(A) -1.10 V

(B) -0.42 V

(C) $+0.42$ V

(D) $+1.10$ V

Q9. For the reaction A + B $\rightarrow$ products, the following initial-rate data were obtained:

Exp.	[A] (M)	[B] (M)	Rate (M s^{-1})
1	0.1	0.1	2×10^{-3}
2	0.2	0.1	4×10^{-3}
3	0.1	0.2	8×10^{-3}

The overall order of the reaction is:

(A) 1

(B) 3

(C) 2

(D) 0

Q10. When 18 g of glucose (molar mass 180 g mol^{-1}) is dissolved in 178.2 g of water (molar mass 18 g mol^{-1}), the relative lowering of vapour pressure of the solution is:

(A) 0.100

(B) 0.050

(C) 0.010

(D) 0.001

Q11. Which of the following correctly arranges the elements in order of *decreasing* atomic radius?

(A) Na $>$ Mg $>$ Al $>$ Si

(B) Si $>$ Al $>$ Mg $>$ Na

(C) Mg $>$ Na $>$ Si $>$ Al

(D) Al $>$ Si $>$ Na $>$ Mg

Q12. The first ionization enthalpy of boron is lower than that of beryllium. The correct reason is:

(A) Boron has a smaller atomic size than beryllium

(B) Beryllium has a half-filled $2p$ subshell

(C) Boron has a higher nuclear charge that is poorly shielded

(D) The $2p$ electron removed from boron is less penetrating and less tightly held than the $2s$ electron of beryllium

Q13. The hybridization of the central carbon atom and the shape of the carbon dioxide (CO_2) molecule are, respectively:

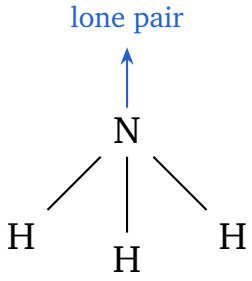
(A) sp^2, bent

(B) sp, linear

(C) sp^3, tetrahedral

(D) sp^2, trigonal planar

Q14. According to VSEPR theory, the shape of the ammonia (NH_3) molecule is:



(A) Trigonal planar

(B) Tetrahedral

(C) Trigonal pyramidal

(D) T-shaped

Q15. Which of the following pairs of metal and its characteristic flame colour is *correct*?

(A) Potassium — lilac (violet)

(B) Sodium — crimson red

(C) Calcium — apple green

(D) Strontium — yellow

Q16. In the structure of diborane (B_2H_6), the number of bridging (three-centre two-electron) hydrogen atoms and terminal hydrogen atoms are, respectively:

(A) 4 bridging, 2 terminal

(B) 0 bridging, 6 terminal

(C) 3 bridging, 3 terminal

(D) 2 bridging, 4 terminal

Q17. Carbon dioxide is a gas at room temperature whereas silicon dioxide is a high-melting solid. The best explanation is:

(A) CO_2 is ionic while SiO_2 is covalent

(B) CO_2 exists as discrete molecules with weak intermolecular forces, while SiO_2 is a giant covalent (network) solid

(C) SiO_2 contains $p\pi$–$p\pi$ double bonds whereas CO_2 does not

(D) CO_2 has a larger molar mass than SiO_2

Q18. Transition metals commonly exhibit variable oxidation states. This behaviour is mainly because:

(A) Their atomic radii are very large

(B) They have completely filled d orbitals

(C) The energies of the $(n-1)d$ and ns orbitals are close, so electrons from both can participate in bonding

(D) They are all strongly electropositive metals

Q19. The IUPAC name of the coordination compound $[Co(NH_3)_4Cl_2]Cl$ is:

(A) Tetraamminedichlorocobalt(II) chloride

(B) Dichlorotetraamminecobalt(III) chloride

(C) Tetraamminedichloridocobalt(II) chloride

(D) Tetraamminedichloridocobalt(III) chloride

Q20. The three isotopes of hydrogen — protium, deuterium and tritium — differ from one another in their number of:

(A) Neutrons

(B) Protons

(C) Electrons

(D) Valence electrons

Q21. Which of the following acids is the *strongest*?

(A) CH_3COOH (acetic acid)

(B) CCl_3COOH (trichloroacetic acid)

(C) $CHCl_2COOH$ (dichloroacetic acid)

(D) $CH_2ClCOOH$ (chloroacetic acid)

Q22. The pair of compounds $CH_3CH_2CH_2CH_3$ (n-butane) and $(CH_3)_3CH$ (isobutane) are best described as:

(A) Position isomers

(B) Functional isomers

(C) Chain isomers

(D) Identical compounds

Q23. The chlorination of methane (CH_4) in the presence of ultraviolet light to give chloromethane proceeds through a:

(A) Electrophilic addition mechanism

(B) Nucleophilic substitution mechanism

(C) Electrophilic substitution mechanism

(D) Free-radical substitution mechanism

Q24. When propene (CH_3–$CH{=}CH_2$) reacts with HBr in the absence of peroxides, the major product, in accordance with Markovnikov's rule, is:

(A) 2-bromopropane

(B) 1-bromopropane

(C) 1,2-dibromopropane

(D) propan-1-ol

Q25. Among the following haloalkanes, the one that undergoes nucleophilic substitution most readily by the S_N1 mechanism is:

(A) CH_3Cl (chloromethane)

(B) $(CH_3)_3C–Cl$ (tert-butyl chloride)

(C) CH_3CH_2Cl (chloroethane)

(D) $CH_3CH_2CH_2Cl$ (1-chloropropane)

Q26. Phenol is more acidic than ethanol. The correct reason is:

(A) Phenol has a higher molar mass than ethanol

(B) Ethanol cannot lose its –OH proton at all

(C) The phenoxide ion formed after losing a proton is stabilized by resonance (delocalization of the negative charge into the ring)

(D) Phenol contains an additional –OH group compared with ethanol

Q27. The addition of HCN to acetaldehyde (CH_3CHO) gives a cyanohydrin. This reaction is an example of:

(A) Electrophilic addition

(B) Free-radical addition

(C) Nucleophilic substitution

(D) Nucleophilic addition

Q28. Tollens' reagent (ammoniacal silver nitrate) is used to distinguish aldehydes from ketones. A positive Tollens' test is indicated by the formation of:

(A) A deep blue solution

(B) A bright silver mirror on the inner wall of the test tube

(C) A brick-red precipitate

(D) A yellow precipitate

Q29. Consider the following amines in the gas phase: (i) NH_3, (ii) CH_3NH_2, (iii) $(CH_3)_2NH$, (iv) $(CH_3)_3N$. The correct order of increasing basicity in the gas phase is:

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

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

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

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

Q30. Which of the following is a *non-reducing* sugar?

(A) Glucose

(B) Maltose

(C) Sucrose

(D) Fructose

Detailed Solutions

Q1.

Solution

Concept — Empirical and molecular formula: The empirical formula is found from the simplest whole-number ratio of moles of each element. The molecular formula is a whole-number multiple (n) of the empirical formula, where $n = \dfrac{\text{molar mass}}{\text{empirical formula mass}}$.

Step 1 — Moles of each element (per 100 g):

$$\text{C} : \frac{40}{12} = 3.33, \quad \text{H} : \frac{6.7}{1} = 6.7, \quad \text{O} : \frac{53.3}{16} = 3.33.$$

Step 2 — Simplest ratio: Divide each by the smallest value 3.33:

$$\text{C} : \frac{3.33}{3.33} = 1, \quad \text{H} : \frac{6.7}{3.33} = 2, \quad \text{O} : \frac{3.33}{3.33} = 1.$$

So the empirical formula is CH_2O.

Step 3 — Find n: Empirical formula mass of $CH_2O = 12 + 2 + 16 = 30$.

$$n = \frac{180}{30} = 6.$$

Molecular formula $= (CH_2O)_6 = C_6H_{12}O_6$.

Why other options are wrong:

- Option A (CH_2O): this is only the empirical formula, mass $30 \neq 180$.
- Option B ($C_3H_6O_3$): mass $= 90 \neq 180$.
- Option D ($C_5H_{10}O_5$): mass $= 150 \neq 180$.

Final Answer: The molecular formula is $C_6H_{12}O_6 \Rightarrow$ C

Answer: (C) Go Back to Q 1

Q2.

Solution

Concept — Bohr energy levels of hydrogen: The energy of the electron in the nth orbit of a hydrogen atom is $E_n = \dfrac{-13.6}{n^2}$ eV. The energy absorbed in a transition equals $E_{\text{final}} - E_{\text{initial}}$.

Step 1 — Energy of the $n = 2$ orbit:

$$E_2 = \frac{-13.6}{2^2} = \frac{-13.6}{4} = -3.40 \text{ eV}.$$

Step 2 — Energy of the $n = 3$ orbit:

$$E_3 = \frac{-13.6}{3^2} = \frac{-13.6}{9} = -1.51 \text{ eV}.$$

Step 3 — Energy of excitation:

$$\Delta E = E_3 - E_2 = (-1.51) - (-3.40) = +1.89 \text{ eV}.$$

Why other options are wrong:

- Option A (1.51 eV): this is the magnitude of E_3, not the difference.
- Option C (3.40 eV): this is the magnitude of E_2, not the transition energy.
- Option D (12.09 eV): this is the $n = 1 \to n = 3$ excitation energy.

Final Answer: $\Delta E = +1.89$ eV $\Rightarrow$ B

Answer: (B) Go Back to Q 2

Q3.

Solution

Concept — Ideal gas equation: The state of an ideal gas obeys $PV = nRT$, so the pressure is $P = \dfrac{nRT}{V}$.

Step 1 — List the known quantities:

$$n = 0.5 \text{ mol}, \quad V = 12.3 \text{ L}, \quad T = 300 \text{ K}, \quad R = 0.0821.$$

Step 2 — Substitute into $P = \frac{nRT}{V}$:

$$P = \frac{0.5 \times 0.0821 \times 300}{12.3}.$$

Step 3 — Evaluate the numerator and divide:

$$P = \frac{12.315}{12.3} \approx 1.0 \text{ atm}.$$

Why other options are wrong:

- Option B (2.0 atm): this would require either double the moles or half the volume.
- Option C (0.5 atm): obtained by wrongly using $n = 0.25$ mol.
- Option D (1.5 atm): not consistent with the given data.

Final Answer: $P \approx 1.0$ atm $\Rightarrow$ A

Answer: (A) Go Back to Q 3

Q4.

Solution

Concept — Reaction enthalpy from bond enthalpies: $\Delta H = \sum$(bond enthalpies of bonds broken in reactants) $-$ $\sum$(bond enthalpies of bonds formed in products).

Step 1 — Bonds broken (reactants): One H–H bond and one Cl–Cl bond.

$$\text{Energy in} = 436 + 242 = 678 \text{ kJ mol}^{-1}.$$

Step 2 — Bonds formed (products): Two H–Cl bonds are formed.

$$\text{Energy out} = 2 \times 431 = 862 \text{ kJ mol}^{-1}.$$

Step 3 — Net enthalpy change:

$$\Delta H = 678 - 862 = -184 \text{ kJ mol}^{-1}.$$

The negative sign means the reaction is exothermic, as shown in the energy profile.

Why other options are wrong:

- Option A ($+184$): correct magnitude but wrong sign (it is exothermic).
- Option B ($+92$): forgets that two H–Cl bonds form, and wrong sign.
- Option C (-92): uses only one H–Cl bond formed instead of two.

Final Answer: $\Delta H = -184$ kJ mol^{-1} $\Rightarrow$ D

Answer: (D) Go Back to Q 4

Q5.

Solution

Concept — Equilibrium constant: For $PCl_5 \rightleftharpoons PCl_3 + Cl_2$, the equilibrium constant is $K_c = \dfrac{[PCl_3][Cl_2]}{[PCl_5]}$.

Step 1 — Write the expression:

$$K_c = \frac{[PCl_3]\,[Cl_2]}{[PCl_5]}.$$

Step 2 — Substitute the equilibrium concentrations:

$$K_c = \frac{(0.2)(0.2)}{0.5}.$$

Step 3 — Evaluate:

$$K_c = \frac{0.04}{0.5} = 0.08.$$

Why other options are wrong:

- Option A (0.04): this is just the numerator, with the denominator forgotten.
- Option C (0.16): obtained by dividing by 0.25 instead of 0.5.
- Option D (0.20): equals one of the product concentrations, not K_c.

Final Answer: $K_c = 0.08 \Rightarrow$ B

Answer: (B) Go Back to Q 5

Q6.

Solution

Concept — pH of a strong acid: HCl is a strong acid and dissociates completely, so $[H^+]$ = concentration of HCl. The pH is $-\log[H^+]$.

Step 1 — Hydrogen-ion concentration: Since HCl fully ionizes,

$$[H^+] = 0.001 \text{ M} = 10^{-3} \text{ M}.$$

Step 2 — Apply the pH formula:

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

Step 3 — Evaluate:

$$\text{pH} = -(-3) = 3.$$

Why other options are wrong:

- Option B (2): would correspond to 0.01 M HCl.
- Option C (11): this is the pOH, or the pH of a 0.001 M strong base.
- Option D (1): would correspond to 0.1 M HCl.

Final Answer: $\text{pH} = 3 \Rightarrow$ A

Answer: (A) Go Back to Q 6

Q7.

Solution

Concept — Oxidation number: The sum of the oxidation numbers of all atoms in an ion equals the charge of the ion. Oxygen is usually assigned -2.

Step 1 — Set up the equation for MnO_4^-: Let the oxidation number of Mn be x.

$$x + 4(-2) = -1.$$

Step 2 — Simplify:

$$x - 8 = -1.$$

Step 3 — Solve for x:

$$x = -1 + 8 = +7.$$

Why other options are wrong:

- Option A ($+4$): would give a charge of -4, not -1.
- Option B ($+6$): corresponds to the manganate ion MnO_4^{2-}.
- Option D ($+2$): is the oxidation state of Mn in $MnCl_2$ or Mn^{2+}.

Final Answer: Oxidation number of Mn $= +7 \Rightarrow$ C

Answer: (C) Go Back to Q 7

Q8.

Solution

Concept — Standard cell EMF: For a galvanic cell, $E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$, where the cathode is the electrode with the higher (more positive) reduction potential.

Step 1 — Identify cathode and anode: Cu^{2+}/Cu ($+0.34$ V) is higher, so copper is the cathode (reduction); zinc is the anode (oxidation).

Step 2 — Apply the formula:

$$E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}} = (+0.34) - (-0.76).$$

Step 3 — Evaluate:

$$E^\circ_{\text{cell}} = 0.34 + 0.76 = +1.10 \text{ V}.$$

The positive value confirms the reaction is spontaneous, consistent with the cell diagram.

Why other options are wrong:

- Option A (-1.10 V): obtained by interchanging cathode and anode.
- Option B (-0.42 V) and C ($+0.42$ V): obtained by adding/subtracting with a wrong sign on one potential.

Final Answer: $E^\circ_{\text{cell}} = +1.10$ V $\Rightarrow$ D

Answer: (D) Go Back to Q 8

Q9.

Solution

Concept — Order from initial rates: Write rate $= k[\text{A}]^m[\text{B}]^n$. Compare experiments where only one concentration changes to find each exponent; the overall order is $m + n$.

Step 1 — Order with respect to A (Exp 1 vs 2): [B] is constant; [A] doubles ($0.1 \to 0.2$) and the rate doubles ($2 \times 10^{-3} \to 4 \times 10^{-3}$).

$$2^m = 2 \;\Rightarrow\; m = 1.$$

Step 2 — Order with respect to B (Exp 1 vs 3): [A] is constant; [B] doubles ($0.1 \to 0.2$) and the rate quadruples ($2 \times 10^{-3} \to 8 \times 10^{-3}$).

$$2^n = 4 \;\Rightarrow\; n = 2.$$

Step 3 — Overall order:

$$m + n = 1 + 2 = 3.$$

Why other options are wrong:

- Option A (1): accounts only for the order in A.
- Option C (2): uses an incorrect order in B (taking $n = 1$).
- Option D (0): the rate clearly depends on the concentrations.

Final Answer: Overall order $= 3 \Rightarrow$ B

Answer: (B) Go Back to Q 9

Q10.

Solution

Concept — Raoult's law (relative lowering of vapour pressure): For a dilute solution of a non-volatile solute, the relative lowering of vapour pressure equals the mole fraction of the solute: $\dfrac{p^\circ - p}{p^\circ} = x_{\text{solute}}$.

Step 1 — Moles of solute (glucose):

$$n_{\text{glucose}} = \frac{18}{180} = 0.1 \text{ mol}.$$

Step 2 — Moles of solvent (water):

$$n_{\text{water}} = \frac{178.2}{18} = 9.9 \text{ mol}.$$

Step 3 — Mole fraction of solute:

$$x_{\text{solute}} = \frac{0.1}{0.1 + 9.9} = \frac{0.1}{10} = 0.010.$$

This equals the relative lowering of vapour pressure.

Why other options are wrong:

- Option A (0.100): wrongly uses moles of solute over moles of solute only.
- Option B (0.050): not supported by the calculation.
- Option D (0.001): off by a factor of ten (a decimal-point error).

Final Answer: Relative lowering $= 0.010 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 10

Q11.

Solution

Concept — Atomic radius trend across a period: Across a period from left to right, the nuclear charge increases while electrons are added to the same shell, so the effective nuclear charge rises and the atomic radius decreases.

Step 1 — Identify the elements: Na, Mg, Al and Si all belong to period 3, in increasing order of atomic number $(11, 12, 13, 14)$.

Step 2 — Apply the trend: Moving left to right (Na $\rightarrow$ Si), the radius decreases. Hence decreasing radius is:

$$\text{Na} > \text{Mg} > \text{Al} > \text{Si}.$$

Why other options are wrong:

- Option B: this is increasing order of radius, the reverse of what is asked.
- Options C and D: jumbled orders that do not follow the periodic trend.

Final Answer: $\text{Na} > \text{Mg} > \text{Al} > \text{Si} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 11

Q12.

Solution

Concept — Anomaly in ionization enthalpy (Be vs B): Beryllium has the configuration $1s^2\,2s^2$ (a stable, fully filled $2s$ subshell). Boron is $1s^2\,2s^2\,2p^1$; its outermost electron is in a $2p$ orbital, which is higher in energy, less penetrating and therefore more easily removed.

Step 1 — Compare the electrons removed: In Be a $2s$ electron is removed; in B a $2p$ electron is removed. The $2p$ electron is shielded by the $2s$ electrons and is less tightly held.

Step 2 — Conclusion: Because the $2p$ electron of boron is easier to remove than the $2s$ electron of beryllium, boron has the lower first ionization enthalpy.

Why other options are wrong:

- Option A: boron is actually slightly smaller, which would tend to raise, not lower, its ionization enthalpy.
- Option B: beryllium has a fully filled $2s$, not a half-filled $2p$.
- Option C: a higher nuclear charge would raise the ionization enthalpy, the opposite of what is observed.

Final Answer: The loosely held $2p$ electron of B explains the dip $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q 12

Q13.

Solution

Concept — Hybridization and shape: The hybridization of a central atom is found from its number of sigma bonds plus lone pairs (its steric number). In CO_2, the carbon forms two sigma bonds (one to each O) and has no lone pairs.

Step 1 — Steric number of carbon: 2 sigma bonds $+0$ lone pairs $= 2$.

Step 2 — Assign hybridization: A steric number of 2 corresponds to sp hybridization.

Step 3 — Determine shape: Two electron domains arrange themselves 180° apart, giving a *linear* molecule, O=C=O.

Why other options are wrong:

- Option A (sp^2, bent): bent geometry requires lone pairs on the central atom, which CO_2 lacks.

- Option C (sp^3, tetrahedral): would need four electron domains.
- Option D (sp^2, trigonal planar): would need three electron domains.

Final Answer: sp, linear $\Rightarrow$ B

Answer: (B) Go Back to Q 13

Q14.

Solution

Concept — VSEPR theory: The shape of a molecule depends on the total number of bond pairs and lone pairs around the central atom. Lone pairs occupy positions but are not counted when naming the molecular shape.

Step 1 — Count electron domains on N in NH_3: Nitrogen has 3 bond pairs (to three H atoms) and 1 lone pair, giving 4 electron domains.

Step 2 — Base geometry: Four electron domains give a tetrahedral electron-pair arrangement.

Step 3 — Molecular shape: With one position taken by the lone pair (shown in the figure), the three N–H bonds give a *trigonal pyramidal* shape, with a bond angle of about $107°$.

Why other options are wrong:

- Option A (trigonal planar): would require no lone pair (as in BF_3).
- Option B (tetrahedral): describes the electron geometry, not the molecular shape.
- Option D (T-shaped): occurs for molecules like ClF_3 with two lone pairs.

Final Answer: NH_3 is trigonal pyramidal $\Rightarrow$ C

Answer: (C) Go Back to Q 14

Q15.

Solution

Concept — Flame test colours: When alkali and alkaline-earth metal salts are heated, electrons are excited and emit characteristic colours on relaxation, used to identify the metal.

Step 1 — Recall standard flame colours: Potassium gives a lilac (violet) flame; sodium gives a golden-yellow flame; calcium gives a brick-red flame; strontium

gives a crimson-red flame; barium gives an apple-green flame.

Step 2 — Check the options: Only option A (potassium — lilac/violet) matches the correct standard colour.

Why other options are wrong:

- Option B: sodium gives golden-yellow, not crimson red (crimson red is strontium).
- Option C: calcium gives brick-red, not apple green (apple green is barium).
- Option D: strontium gives crimson red, not yellow (yellow is sodium).

Final Answer: Potassium — lilac (violet) $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q 15

Q16.

Solution

Concept — Structure of diborane: Diborane (B_2H_6) has a non-classical structure. Four hydrogen atoms are normal terminal B–H bonds (two on each boron), and two hydrogen atoms bridge the two boron atoms through three-centre two-electron (banana) bonds.

Step 1 — Count terminal hydrogens: Each boron carries two terminal H atoms, giving $2 \times 2 = 4$ terminal hydrogens.

Step 2 — Count bridging hydrogens: The remaining $6 - 4 = 2$ hydrogens bridge the two boron atoms.

Step 3 — Conclusion: Diborane has 2 bridging and 4 terminal hydrogen atoms.

Why other options are wrong:

- Option A (4 bridging, 2 terminal): interchanges the two counts.
- Option B (0 bridging): ignores the characteristic bridge bonds of diborane.
- Option C (3 bridging, 3 terminal): not consistent with the known structure.

Final Answer: 2 bridging and 4 terminal H atoms $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q 16

Q17.

Solution

Concept — Discrete molecules vs network solids: The physical state depends on the type of structure. Small molecules held by weak intermolecular forces are volatile; giant covalent (network) solids held by a continuous lattice of strong covalent bonds have very high melting points.

Step 1 — Structure of CO_2: Carbon forms strong $p\pi$–$p\pi$ double bonds with oxygen, giving discrete O=C=O molecules. Between molecules there are only weak van der Waals forces, so CO_2 is a gas.

Step 2 — Structure of SiO_2: Silicon cannot form effective $p\pi$–$p\pi$ bonds, so each Si is singly bonded to four oxygen atoms in a three-dimensional network. Melting this network requires breaking many strong Si–O bonds, giving a high melting point.

Why other options are wrong:

- Option A: CO_2 is not ionic; both oxides are covalent.
- Option C: it is CO_2 (not SiO_2) that has $p\pi$–$p\pi$ double bonds.
- Option D: molar mass is not the reason; structure type is.

Final Answer: CO_2 is molecular; SiO_2 is a giant covalent solid $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q 17

Q18.

Solution

Concept — Variable oxidation states of transition metals: Transition metals show several oxidation states because the $(n-1)d$ and ns orbitals are very close in energy. Electrons from both sub-shells can take part in bond formation, and they can be lost one at a time.

Step 1 — Identify the cause: The small energy gap between the $4s$ and $3d$ orbitals (for the first transition series) allows successive removal of electrons.

Step 2 — Conclusion: Because electrons from both the $(n-1)d$ and ns orbitals participate, multiple oxidation states (for example Fe^{2+}/Fe^{3+}, Mn^{2+} to Mn^{7+}) become possible.

Why other options are wrong:

- Option A: atomic size alone does not produce variable oxidation states.

- Option B: completely filled d orbitals (as in zinc) actually limit variable oxidation states.
- Option D: being electropositive explains metallic character, not the variety of oxidation states.

Final Answer: Close $(n-1)d$ and ns orbital energies $\Rightarrow$ C

Answer: (C) Go Back to Q 18

Q19.

Solution

Concept — IUPAC naming of coordination compounds: Inside the bracket, ligands are named alphabetically before the metal, anionic ligands take the suffix "-ido" (e.g. chlorido), and the oxidation state of the metal is given in Roman numerals. The counter ion is named last.

Step 1 — Identify the parts of $[Co(NH_3)_4Cl_2]Cl$: Inside the coordination sphere there are four ammine (NH_3) ligands and two chlorido (Cl^-) ligands; outside is one chloride counter ion.

Step 2 — Find the oxidation state of cobalt: Let it be x. The complex ion has charge $+1$ (balanced by one Cl^-):

$$x + 4(0) + 2(-1) = +1 \;\Rightarrow\; x = +3.$$

Step 3 — Assemble the name alphabetically: "ammine" (a) before "chlorido" (c): tetraammine dichlorido cobalt(III) chloride.

Why other options are wrong:

- Options A and C: give cobalt as (II); the correct oxidation state is (III).
- Option B: uses the older "chloro" and wrong alphabetical order (dichloro before tetraammine).

Final Answer: Tetraamminedichloridocobalt(III) chloride $\Rightarrow$ D

Answer: (D) Go Back to Q 19

Q20.

Solution

Concept — Isotopes: Isotopes of an element have the same atomic number (same number of protons, hence the same number of electrons and the same chemistry) but different mass numbers, which means a different number of neutrons.

Step 1 — Compose the three isotopes: Protium (^{1}H) has 1 proton and 0 neutrons; deuterium (^{2}H) has 1 proton and 1 neutron; tritium (^{3}H) has 1 proton and 2 neutrons.

Step 2 — Identify what differs: All have 1 proton and 1 electron, so they differ only in the number of neutrons (0, 1 and 2 respectively).

Why other options are wrong:

- Options B and C: protons and electrons are identical (1 each) for all three isotopes.
- Option D: all three have the same single valence electron.

Final Answer: The isotopes differ in their number of neutrons $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q 20

Q21.

Solution

Concept — Inductive effect and acid strength: Electron-withdrawing groups (such as Cl) pull electron density away from the –COOH group through sigma bonds. This stabilizes the carboxylate anion formed after the loss of H^+, making the acid stronger. More electron-withdrawing groups means a stronger acid.

Step 1 — Count the chlorine atoms: CH_3COOH (0 Cl), $CH_2ClCOOH$ (1 Cl), $CHCl_2COOH$ (2 Cl), CCl_3COOH (3 Cl).

Step 2 — Apply the trend: More chlorine atoms means a stronger $-I$ (electron-withdrawing) effect and greater stabilization of the anion. Hence acid strength increases as $0 < 1 < 2 < 3$ chlorine atoms.

Step 3 — Conclusion: CCl_3COOH, with three chlorines, is the strongest acid.

Why other options are wrong:

- Option A (CH_3COOH): has no electron-withdrawing group, so it is the weakest.

- Options C and D: are stronger than acetic acid but weaker than trichloroacetic acid.

Final Answer: CCl_3COOH is the strongest acid $\Rightarrow$ B

Answer: (B) Go Back to Q 21

Q22.

Solution

Concept — Chain isomerism: Chain (or skeletal) isomers have the same molecular formula but differ in the arrangement (branching) of the carbon skeleton.

Step 1 — Confirm the molecular formula: Both n-butane and isobutane have the formula C_4H_{10}.

Step 2 — Compare the skeletons: n-Butane has a continuous straight chain of four carbons, while isobutane has a three-carbon chain with a methyl branch. The carbon skeletons differ.

Step 3 — Classify: Same formula but different carbon-chain arrangement means they are chain isomers.

Why other options are wrong:

- Option A (position isomers): differ in the position of a substituent or functional group on the same skeleton, not the case here.
- Option B (functional isomers): differ in functional group; both compounds here are alkanes.
- Option D (identical): they are genuinely different structures, not the same compound.

Final Answer: They are chain isomers $\Rightarrow$ C

Answer: (C) Go Back to Q 22

Q23.

Solution

Concept — Free-radical substitution: Alkanes react with halogens in the presence of UV light (or heat) by a free-radical chain mechanism, consisting of initiation, propagation and termination steps.

Step 1 — Initiation: UV light homolytically splits Cl_2 into two chlorine radicals: $Cl_2 \rightarrow 2Cl^{\bullet}$.

Step 2 — Propagation: A chlorine radical abstracts a hydrogen from CH_4 to give $CH_3^{\bullet}$, which then reacts with Cl_2 to give CH_3Cl and a new $Cl^{\bullet}$, continuing the chain.

Step 3 — Classify: A hydrogen atom of the alkane is substituted by chlorine via radical intermediates: this is a free-radical substitution.

Why other options are wrong:

- Options A: alkanes are saturated and do not undergo addition.
- Option B (nucleophilic substitution) and C (electrophilic substitution): there are no ionic nucleophile/electrophile intermediates here, only radicals.

Final Answer: Free-radical substitution mechanism $\Rightarrow$ $\boxed{D}$

Answer: (D) Go Back to Q 23

Q24.

Solution

Concept — Markovnikov's rule: When an unsymmetrical reagent HX adds to an unsymmetrical alkene, the hydrogen attaches to the doubly bonded carbon that already has more hydrogen atoms, and X attaches to the carbon with fewer hydrogen atoms (forming the more stable carbocation).

Step 1 — Identify the alkene carbons: In CH_3–CH=CH_2, carbon-1 (the terminal $=CH_2$) has two H atoms, while carbon-2 ($=CH$–) has one H atom.

Step 2 — Apply the rule: H adds to carbon-1 (more H), and Br adds to carbon-2 (fewer H). This proceeds through the more stable secondary carbocation.

Step 3 — Name the product: Br on the middle carbon gives CH_3–$CHBr$–CH_3, which is 2-bromopropane.

Why other options are wrong:

- Option B (1-bromopropane): this is the anti-Markovnikov product, formed

only with peroxides.
- Option C (1,2-dibromopropane): requires Br_2, not HBr.
- Option D (propan-1-ol): an alcohol; no –OH source is present.

Final Answer: 2-bromopropane $\Rightarrow$ A

Answer: (A) Go Back to Q 24

Q25.

Solution

Concept — S_N1 mechanism: The S_N1 reaction is a two-step process whose rate-determining step is the formation of a carbocation. It is therefore fastest for substrates that form the most stable carbocation, i.e. tertiary > secondary > primary.

Step 1 — Classify the substrates: CH_3Cl is methyl, CH_3CH_2Cl is primary, $CH_3CH_2CH_2Cl$ is primary, and $(CH_3)_3C–Cl$ is tertiary.

Step 2 — Apply carbocation stability: The tert-butyl cation $(CH_3)_3C^+$ is a tertiary carbocation, strongly stabilized by the three electron-donating methyl groups (hyperconjugation and +I effect).

Step 3 — Conclusion: tert-Butyl chloride forms the most stable carbocation and therefore undergoes S_N1 most readily.

Why other options are wrong:

- Options A, C and D: methyl and primary halides form very unstable carbocations and instead prefer the S_N2 pathway.

Final Answer: $(CH_3)_3C–Cl$ reacts fastest by S_N1 $\Rightarrow$ B

Answer: (B) Go Back to Q 25

Q26.

Solution

Concept — Acidity of phenol vs alcohol: Acidity is governed by the stability of the conjugate base. The more stabilized the anion formed on losing H^+, the more acidic the parent compound.

Step 1 — Anion from phenol: Removing the –OH proton gives the phenoxide ion. The negative charge is delocalized into the benzene ring through resonance, spreading it over several positions and stabilizing the ion.

Step 2 — Anion from ethanol: Removing the –OH proton gives the ethoxide ion, where the negative charge stays localized on oxygen with no resonance stabilization; the alkyl group even pushes electron density toward oxygen, destabilizing it.

Step 3 — Conclusion: The resonance-stabilized phenoxide ion makes phenol the stronger acid.

Why other options are wrong:

- Option A: molar mass does not determine acidity.
- Option B: ethanol can lose its proton, just less readily than phenol.
- Option D: phenol and ethanol each have a single –OH group.

Final Answer: Resonance stabilization of phenoxide $\Rightarrow$ C

Answer: (C) Go Back to Q 26

Q27.

Solution

Concept — Nucleophilic addition to carbonyl compounds: The carbonyl carbon (>C=O) is electron-deficient (electrophilic) because oxygen pulls electron density away. Nucleophiles attack this carbon, and the double bond opens up as a nucleophile adds: this is nucleophilic addition.

Step 1 — Identify the nucleophile: HCN provides the cyanide ion (CN^-), a nucleophile.

Step 2 — Mechanism: CN^- attacks the electrophilic carbonyl carbon of CH_3CHO; the C=O pi bond breaks to give an alkoxide, which is then protonated to form the cyanohydrin $CH_3CH(OH)CN$.

Step 3 — Classify: A nucleophile adds across the C=O double bond, so the reaction is nucleophilic addition.

Why other options are wrong:

- Option A (electrophilic addition): characteristic of alkenes, not carbonyls.
- Option B (free-radical addition): no radicals are involved here.
- Option C (nucleophilic substitution): no leaving group departs; an addition occurs instead.

Final Answer: Nucleophilic addition $\Rightarrow$ D

Answer: (D) Go Back to Q 27

Q28.

Solution

Concept — Tollens' test: Tollens' reagent contains the diamminesilver(I) complex $[Ag(NH_3)_2]^+$. Aldehydes reduce Ag^+ to metallic silver, which deposits as a shiny mirror on the glass. Ketones do not give this test.

Step 1 — Reaction with an aldehyde: The aldehyde is oxidized to a carboxylate while Ag^+ is reduced: the silver metal coats the test tube.

Step 2 — Observation: A positive Tollens' test is seen as a bright silver mirror on the inner wall of the tube.

Why other options are wrong:

- Option A (deep blue solution): characteristic of Fehling's/Benedict's copper(II) reagent, not Tollens'.
- Option C (brick-red precipitate): this is the positive Fehling's test (Cu_2O), not Tollens'.
- Option D (yellow precipitate): typical of the iodoform test, not Tollens'.

Final Answer: A bright silver mirror forms $\Rightarrow$ B

Answer: (B) Go Back to Q 28

Q29.

Solution

Concept — Basicity of amines in the gas phase: Basicity depends on the availability of the lone pair on nitrogen. In the gas phase (with no solvent), only the electron-donating (+I) effect of alkyl groups matters; there is no solvation to consider. More alkyl groups means a more available lone pair and greater basicity.

Step 1 — Apply the inductive effect: Each methyl group pushes electron density onto nitrogen. So the number of methyl groups raises basicity: NH_3 (0) $<$ CH_3NH_2 (1) $<$ $(CH_3)_2NH$ (2) $<$ $(CH_3)_3N$ (3).

Step 2 — Conclusion (gas phase): Increasing order of basicity is NH_3 $<$ CH_3NH_2 $<$ $(CH_3)_2NH$ $<$ $(CH_3)_3N$. (In water, solvation reverses the position of the tertiary amine, but the question specifies the gas phase.)

Why other options are wrong:

- Option B: this is exactly the reverse order.
- Options C and D: place NH_3 or the amines in an order not supported by the +I trend.

Final Answer: $NH_3 < CH_3NH_2 < (CH_3)_2NH < (CH_3)_3N \Rightarrow \boxed{A}$

Answer: (A) Go Back to Q 29

Q30.

Solution

Concept — Reducing and non-reducing sugars: A reducing sugar has a free aldehyde or ketone group (or a free anomeric –OH) that can reduce Tollens'/Fehling's reagent. A non-reducing sugar has its anomeric carbons locked in a glycosidic linkage, so it has no free reducing group.

Step 1 — Examine each option: Glucose (free –CHO) and fructose (free >C=O, which isomerizes) are reducing; maltose has a free anomeric –OH on one glucose unit and is reducing.

Step 2 — Examine sucrose: In sucrose, the anomeric carbon of glucose is joined to the anomeric carbon of fructose through the glycosidic bond, leaving no free reducing group.

Step 3 — Conclusion: Sucrose is the only non-reducing sugar among the choices.

Why other options are wrong:

- Option A (glucose), B (maltose) and D (fructose): all possess a free reducing group and are reducing sugars.

Final Answer: Sucrose is a non-reducing sugar $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q 30

Answer Key

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