# JELET Chemistry Sample Paper-7

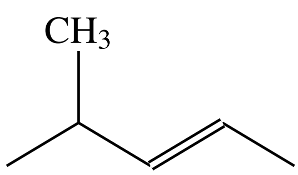
**Duration: 25 Minutes** **Maximum Marks: 25**

## Instructions

- This paper contains **20** Multiple Choice Questions divided into **2 Sections**.
- **Section A (Q1–Q15):** Each correct answer carries **+1 mark**. Incorrect answer: **−0.25** marks. Only **one** correct option.
- **Section B (Q16–Q20):** Each correct answer carries **+2 marks**. **No negative marking**. One or **more** correct options may be correct; full marks only if all correct options are marked.
- Unattempted questions carry **0** marks.
- Use of mobile phones, smartwatches, calculators, or any electronic gadgets is strictly prohibited.

**Section–A — 15 Questions × 1 Mark Each**
**(Negative Marking: −0.25) [Single Correct]**

**Q1.** The skeletal structure of an unsaturated hydrocarbon is drawn below. What is its correct IUPAC name?




(A) 4-methylpent-2-ene

(B) 2-methylpent-3-ene

(C) 4-methylhex-3-ene

(D) 3-methylhex-2-ene

**Q2.** The maximum number of electrons in an atom that can have the quantum numbers $n = 4$ and $m_s = +\frac{1}{2}$ is:

(A) 8

(B) 16

(C) 18

(D) 32

**Q3.** A buffer solution is prepared by mixing 0.20 mol of $CH_3COOH$ with 0.10 mol of $CH_3COONa$ in 1 L of water. Given $pK_a(CH_3COOH) = 4.74$, the pH of the buffer at 298 K is approximately:

(A) 4.14

(B) 4.44

(C) 4.74

(D) 5.04

**Q4.** The standard EMF of the cell Ni | $Ni^{2+}$(1 M) || $Ag^{+}$(1 M) | Ag at 298 K is 1.05 V. If the concentration of $Ag^{+}$ is reduced to $1.0 \times 10^{-3}$ M while $[Ni^{2+}]$ remains 1 M, the new EMF is closest to:

(A) 0.873 V

(B) 0.932 V

(C) 1.109 V

(D) 1.168 V

**Q5.** In the Hall–Héroult process for the extraction of aluminium, alumina is dissolved in molten cryolite and electrolyzed using carbon electrodes. The anode is periodically replaced because:

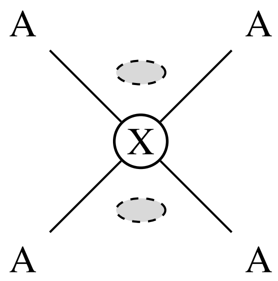
(A) Aluminium deposits on the anode and short-circuits the cell

(B) The carbon anode is consumed by reaction with oxygen liberated, forming CO and $CO_2$

(C) Cryolite reacts with the anode at high temperature

(D) Sodium discharged at the anode dissolves the carbon

**Q6.** The molecule represented below has a central atom X bonded to four atoms (A) and possessing two lone pairs (shown as shaded ellipses). Identify the molecular geometry and a representative example.




(A) Tetrahedral; $CH_4$

(B) See-saw; $SF_4$

(C) Square planar; $XeF_4$

(D) Square pyramidal; $BrF_5$

**Q7.** The aqueous solution of which of the following salts will be *acidic* in nature at 298 K?

(A) $CH_3COONa$

(B) $NH_4Cl$

(C) $KNO_3$

(D) $Na_2CO_3$

**Q8.** The oxidation state of chromium in the dichromate ion $Cr_2O_7^{2-}$ and in the peroxide $CrO_5$ (which contains two peroxo linkages) is respectively:

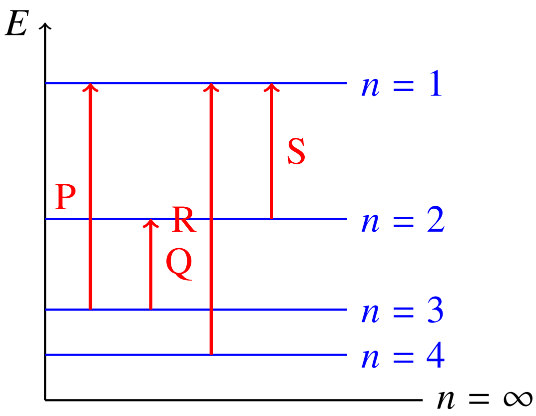
(A) +6 and +6

(B) +6 and +10

(C) +7 and +6

(D) +3 and +6

**Q9.** The energy-level diagram below shows four downward (emission) transitions in the hydrogen atom. Which transition produces a photon belonging to the visible region (Balmer series, $H_\alpha$ line)?



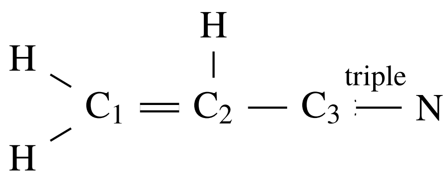

(A) Transition P ($n = 3 \rightarrow n = 1$)

(B) Transition Q ($n = 3 \rightarrow n = 2$)

(C) Transition R ($n = 4 \rightarrow n = 1$)

(D) Transition S ($n = 2 \rightarrow n = 1$)

**Q10.** In the molecule shown below, propenenitrile (acrylonitrile), the hybridization of the carbon atoms labelled $C_1$, $C_2$ and $C_3$ respectively is:




(A) $sp^2, sp^2, sp$

(B) $sp^2, sp, sp$

(C) $sp^3, sp^2, sp$

(D) $sp^2, sp^2, sp^2$

**Q11.** Chlorofluorocarbons (CFCs) released into the atmosphere catalytically destroy stratospheric ozone. The species which acts as the actual chain-carrier in the ozone depletion mechanism is:

(A) Atomic fluorine ($F^\bullet$)

(B) Atomic chlorine ($Cl^\bullet$)

(C) Hydroxyl radical ($OH^\bullet$)

(D) Nitric oxide (NO)

**Q12.** The solubility product of $Ag_2CrO_4$ at 298 K is $1.1 \times 10^{-12}$. Its molar solubility in a 0.01 M $AgNO_3$ solution is approximately:

(A) $1.1 \times 10^{-8}$ M

(B) $2.2 \times 10^{-8}$ M

(C) $1.1 \times 10^{-10}$ M

(D) $1.0 \times 10^{-6}$ M

**Q13.** The same quantity of electricity is passed through three electrolytic cells connected in series, containing aqueous solutions of $AgNO_3$, $CuSO_4$ and $AlCl_3$ respectively. If 1.08 g of silver is deposited in the first cell, the masses of Cu and Al deposited in the other cells are: (Atomic masses: Ag = 108, Cu = 63.5, Al = 27)

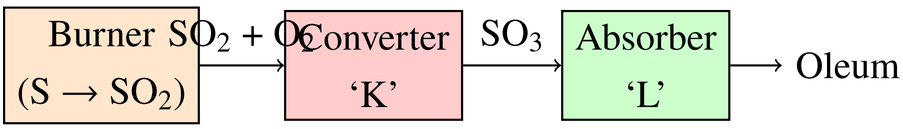
(A) 0.3175 g and 0.090 g

(B) 0.635 g and 0.180 g

(C) 0.3175 g and 0.180 g

(D) 0.635 g and 0.090 g

**Q14.** The schematic below shows three stages of an industrial process. The catalyst used in stage 'K' and the chemical absorbed in stage 'L' to produce oleum are:




(A) Finely divided Fe ; dilute $H_2SO_4$

(B) $V_2O_5$ ; concentrated $H_2SO_4$

(C) Pt-Rh gauze ; water

(D) Ni ; aqueous NaOH

**Q15.** Among the following molecules, the one that is non-polar in spite of having polar bonds is:

(A) $H_2O$

(B) $NH_3$

(C) $CO_2$

(D) $SO_2$

**Section–B — 5 Questions × 2 Marks Each (No Negative Marking) [One or More Correct]**

**Q16.** Which of the following statements about atomic orbitals and electronic configuration are *correct*?

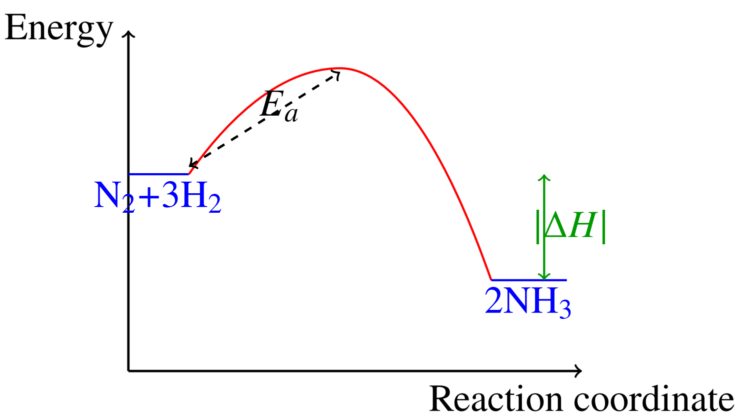
(A) The shape of an orbital is described by the azimuthal quantum number $l$.

(B) For the ground state of Cr ($Z = 24$), the electronic configuration is [Ar] $3d^5\,4s^1$ due to extra stability of a half-filled $d$-subshell.

(C) The total number of nodes (radial + angular) in a $3p$ orbital is 3.

(D) A $4f$ orbital has $l = 3$ and can have $m_l$ values $-3, -2, -1, 0, +1, +2, +3$ (seven orbitals).

**Q17.** The energy profile for the Haber process $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ is shown below. Based on this diagram and thermodynamic principles, which statements are *correct*?




(A) Operating the reactor at high pressure ($\sim$ 200 atm) shifts the equilibrium towards $NH_3$.

(B) Increasing temperature indefinitely increases the equilibrium yield of $NH_3$ because the rate increases.

(C) Using a finely divided iron catalyst (Fe/Mo) lowers $E_a$ but does not change the equilibrium constant $K_c$.

(D) Removing $NH_3$ from the reaction mixture as it forms shifts the equilibrium towards the forward direction.

**Q18.** Consider the standard electrode potentials given below at 298 K:

$$E^\circ_{Mg^{2+}/Mg} = -2.37 \text{ V},$$
$$E^\circ_{Fe^{2+}/Fe} = -0.44 \text{ V},$$
$$E^\circ_{Cu^{2+}/Cu} = +0.34 \text{ V},$$
$$E^\circ_{Ag^{+}/Ag} = +0.80 \text{ V}$$

Which of the following statements are *correct*?

(A) In a $Mg \,|\, Mg^{2+} \,||\, Cu^{2+} \,|\, Cu$ cell, the standard EMF is +2.71 V and Mg is the anode.

(B) Silver metal can spontaneously displace $Cu^{2+}$ ions from an aqueous solution of $CuSO_4$.

(C) Iron will reduce $Cu^{2+}$ ions to metallic Cu spontaneously.

(D) The strongest oxidizing agent among the listed species is $Ag^+$.

**Q19.** In the metallurgical extraction of iron from haematite ($Fe_2O_3$) in a blast furnace, which of the following statements are *correct*?

(A) Coke serves both as a fuel and as the ultimate source of the reducing agent CO.

(B) In the lower (hotter) part of the furnace, $CO_2$ reacts with red-hot coke to form CO via the Boudouard reaction $CO_2 + C \rightarrow 2CO$.

(C) Limestone is added because $CaCO_3$ itself directly reduces $Fe_2O_3$ to Fe.

(D) The molten iron tapped from the furnace is pig iron, containing about 4% carbon together with Si, Mn, P and S impurities.

**Q20.** Regarding the compound 2-methylbut-2-ene ($(CH_3)_2C{=}CH{-}CH_3$) and its isomers, which of the following statements are *correct*?

(A) The molecular formula of 2-methylbut-2-ene is $C_5H_{10}$.

(B) 2-methylbut-2-ene does not exhibit geometrical (cis–trans) isomerism.

(C) Pent-1-ene and 2-methylbut-2-ene are chain isomers of each other.

(D) On catalytic hydrogenation (Ni, $H_2$), 2-methylbut-2-ene gives 2-methylbutane.

# Detailed Solutions

## Q1.

### Solution

**Concept:**
For IUPAC naming of an alkene, (i) select the *longest* continuous carbon chain that contains the C=C bond, (ii) number the chain so that the double bond gets the lowest locant, (iii) name substituents with their locants, and (iv) indicate the position of the double bond by the lower-numbered carbon involved. The double bond takes priority over alkyl substituents while numbering.

**Solution:**

(a) In the skeletal structure, count the carbons in the longest chain that contains the C=C. The zig-zag main chain has six carbons $\Rightarrow$ *hex-* (not pent-).

(b) The double bond is located between the 3rd and 4th carbon (when numbered from the right end). Numbering from the right end gives locants: double bond at 3 and methyl substituent at 3; numbering from the left gives double bond at 3 and methyl at 4.

(c) Choose the numbering that gives the lowest locant set to the double bond first; both directions give the double bond locant 3, so we apply the next criterion (lowest locant to substituent). Numbering from the right gives the methyl group at C-3.

(d) Hence the name is 3-methylhex-2-ene? Re-check by walking from the right: C1→C2 (double bond start), C3 carries $CH_3$, C4, C5, C6.

(e) The correct IUPAC name is therefore **3-methylhex-2-ene**.

(f) Option (A) uses "pent-", missing one carbon. Option (B) reverses numbering of the parent chain. Option (C) places the double bond at position 3 instead of 2 (does not minimize the locant of =).

**Final Answer:** 3-methylhex-2-ene

**Answer: (D)**

Go Back to Question 1

# Q2.

## Solution

**Concept:**
For a principal quantum number $n$, the total number of orbitals is $n^2$, and the total number of electrons that can occupy that shell is $2n^2$ (each orbital holds 2 electrons with opposite spins). Out of these $2n^2$ electrons, exactly half have $m_s = +\frac{1}{2}$ and half have $m_s = -\frac{1}{2}$.
**Solution:**

(a) For $n = 4$: number of orbitals $= n^2 = 16$ (one $4s$, three $4p$, five $4d$, seven $4f$).

(b) Maximum electrons in this shell $= 2n^2 = 2 \times 16 = 32$.

(c) Of these 32 electrons, half have $m_s = +\frac{1}{2}$ and the other half have $m_s = -\frac{1}{2}$.

(d) Hence the number of electrons with $n = 4$ and $m_s = +\frac{1}{2}$ is $32/2 = 16$.

(e) **Trap Check:** Do not confuse "number of orbitals" ($n^2 = 16$) with "electrons of one spin" (also $n^2 = 16$, but obtained as $2n^2/2$). The answer is 16, not 32.

**Final Answer:** $\boxed{16}$

**Answer: (B)**

Go Back to Question 2

# Q3.

## Solution

**Concept:**
A buffer is a solution of a weak acid and its conjugate base. The pH is given by the *Henderson–Hasselbalch* equation:

$$\text{pH} = pK_a + \log\left(\frac{[\text{salt}]}{[\text{acid}]}\right).$$

This holds when both [salt] and [acid] are at least an order of magnitude larger than $[\text{H}^+]$.

**Solution:**

(a) $[CH_3COOH] = 0.20$ M, $[CH_3COONa] = [CH_3COO^-] = 0.10$ M, $pK_a = 4.74$.

(b) Apply Henderson–Hasselbalch: $\text{pH} = 4.74 + \log\left(\frac{0.10}{0.20}\right) = 4.74 + \log(0.5)$.

(c) $\log(0.5) = -0.301$.

(d) $\text{pH} = 4.74 - 0.30 = 4.44$.

(e) **Trap Check:** Note that [salt] < [acid] here, so the buffer is *more acidic* than $pK_a$; therefore $\text{pH} < 4.74$. Options (C) and (D) are eliminated by this qualitative check alone.

**Final Answer:** $\boxed{\text{pH} \approx 4.44}$

**Answer: (B)**

Go Back to Question 3

# Q4.

## Solution

**Concept:**

The *Nernst equation* at 298 K is

$$E_{\text{cell}} = E^\circ_{\text{cell}} - \frac{0.059}{n} \log Q,$$

where $n$ is the number of electrons transferred in the balanced cell reaction and $Q$ is the reaction quotient written in terms of products over reactants (excluding pure solids/liquids).

**Solution:**

(a) Balanced cell reaction: $\text{Ni} + 2\text{Ag}^+ \rightarrow \text{Ni}^{2+} + 2\text{Ag}$. So $n = 2$.

(b) Reaction quotient: $Q = \dfrac{[\text{Ni}^{2+}]}{[\text{Ag}^+]^2} = \dfrac{1}{(10^{-3})^2} = 10^6$.

(c) $E^\circ_{\text{cell}} = 1.05$ V (given).

(d) $E_{\text{cell}} = 1.05 - \dfrac{0.059}{2}\log(10^6) = 1.05 - \dfrac{0.059}{2} \times 6 = 1.05 - 0.177 = 0.873$ V.

(e) **Trap Check:** Since $[\text{Ag}^+]$ is reduced (cathode reactant), $Q$ increases, so $E_{\text{cell}}$ must *decrease* relative to $E^\circ$. Options (C) and (D) (which exceed $E^\circ$) are eliminated. Do not forget the square on $[\text{Ag}^+]$ in $Q$.

**Final Answer:** $\boxed{0.873 \text{ V}}$

**Answer: (A)**

**Go Back to Question 4**

# Q5.

## Solution

**Concept:**
In the Hall–Héroult process, $Al_2O_3$ dissolved in molten cryolite ($Na_3AlF_6$) is electrolyzed. The cathode reaction is $Al^{3+} + 3e^- \rightarrow Al(l)$. At the anode, $O^{2-}$ ions are discharged. Because the anode is made of carbon and the operating temperature is $\sim$ 1200 K, the liberated oxygen *reacts with the carbon anode* itself instead of evolving as $O_2$.

**Solution:**

(a) Anode reactions: $C + O^{2-} \rightarrow CO + 2e^-$ and $C + 2O^{2-} \rightarrow CO_2 + 4e^-$.

(b) As a result, the carbon anode is steadily *burnt away*; its mass keeps decreasing and shape distorts.

(c) In industrial practice, anodes must be lowered and replaced periodically to maintain the gap and current density.

(d) Option (A): Aluminium is denser than the electrolyte and collects at the *bottom*, not the anode.

(e) Option (C): Cryolite is electrochemically inert under operating conditions.

(f) Option (D): Sodium is *not* preferentially discharged; $Al^{3+}$ is, because cryolite keeps $Na^+$ tightly complexed.

(g) **Trap Check:** The cathode (lining of the cell) is also made of carbon but is *not* consumed because reduction (deposition of Al) occurs there, not oxidation.

**Final Answer:** Anode carbon is oxidized to $CO/CO_2$

**Answer: (B)**

Go Back to Question 5

# Q6.

## Solution

**Concept:**
VSEPR theory: total *steric number* (SN) = number of $\sigma$-bonded atoms + number of lone pairs on the central atom. SN governs the electron-pair geometry; lone pairs occupy positions that minimize repulsion, modifying the *molecular* shape.

**Solution:**

(a) Diagram: central atom X has 4 bonded atoms (A) and 2 lone pairs. SN = 4 + 2 = 6.

(b) Electron-pair geometry for SN = 6 is *octahedral*.

(c) Two lone pairs in an octahedron go opposite to each other (axial–axial, 180° apart) to minimise lone-pair–lone-pair repulsion.

(d) The remaining 4 bonded atoms occupy the equatorial plane ⇒ **square planar** molecular geometry.

(e) Classic example: $XeF_4$ (Xe has 8 valence $e^-$; 4 used in Xe–F bonds, 4 left as 2 lone pairs).

(f) Option (A) $CH_4$ has SN = 4, 0 LP ⇒ tetrahedral. Option (B) $SF_4$ has SN = 5, 1 LP ⇒ see-saw. Option (D) $BrF_5$ has SN = 6, 1 LP ⇒ square pyramidal.

(g) **Trap Check:** Square planar arises only when SN = 6 with *exactly two* lone pairs. With only one lone pair (and 5 bonded atoms), one gets square pyramidal instead.

**Final Answer:** Square planar; $XeF_4$

**Answer: (C)**

**Go Back to Question 6**

# Q7.

## Solution

**Concept:**

The acid–base character of a salt solution depends on which parent acid and base it is derived from:

- Strong acid + strong base $\Rightarrow$ neutral solution (no hydrolysis).
- Weak acid + strong base $\Rightarrow$ *basic* solution (anion hydrolysis).
- Strong acid + weak base $\Rightarrow$ *acidic* solution (cation hydrolysis).

**Solution:**

(a) $CH_3COONa$: salt of weak acid ($CH_3COOH$) and strong base (NaOH) $\Rightarrow$ basic.

(b) $NH_4Cl$: salt of weak base ($NH_4OH$) and strong acid (HCl) $\Rightarrow$ **acidic**. The cation hydrolyses: $NH_4^+ + H_2O \rightleftharpoons NH_4OH + H^+$.

(c) $KNO_3$: salt of strong base (KOH) and strong acid ($HNO_3$) $\Rightarrow$ neutral.

(d) $Na_2CO_3$: salt of strong base and weak acid ($H_2CO_3$) $\Rightarrow$ basic.

(e) **Trap Check:** Even though $Cl^-$ in $NH_4Cl$ is the conjugate base of HCl (a strong acid), it is too weak a base to hydrolyse; only $NH_4^+$ does, producing acidic pH.

**Final Answer:** $\boxed{NH_4Cl}$

**Answer: (B)**

Go Back to Question 7

# Q8.

## Solution

**Concept:**
The oxidation state of an element is computed using standard rules: O is normally −2, but in a *peroxo* (−O−O−) linkage each O is −1. The algebraic sum of oxidation states equals the net charge of the species.
**Solution:**

(a) In $Cr_2O_7^{2-}$: let oxidation state of Cr be $x$. Then $2x + 7(-2) = -2 \Rightarrow 2x = 12 \Rightarrow x = +6$.

(b) In $CrO_5$: structure is $Cr(O_2)_2O$, i.e. one Cr=O group and two peroxo ($O_2^{2-}$) groups. Two peroxo bridges contain 4 oxygens each in −1 state; the remaining 1 oxygen is in −2 state.

(c) Charge balance: $x + 4(-1) + 1(-2) = 0 \Rightarrow x - 6 = 0 \Rightarrow x = +6$.

(d) Hence in both compounds, the oxidation state of Cr is +6.

(e) Option (B) (+10) would result if one (incorrectly) treats all five oxygens as ordinary oxide (−2). That violates the maximum oxidation state for Cr (+6) and ignores the peroxo structure.

(f) **Trap Check:** The maximum oxidation state of any 3*d* element cannot exceed its group number. For Cr (Group 6), the max is +6. Hence the answer must be (A).

**Final Answer:** $\boxed{+6 \text{ and } +6}$

**Answer: (A)**

Go Back to Question 8

# Q9.

## Solution

**Concept:**

The Balmer series in the H atom corresponds to transitions *terminating* at $n = 2$ (emission). The longest-wavelength Balmer line, $H_\alpha$ (red, $\lambda \approx 656$ nm, visible), arises from $n = 3 \rightarrow n = 2$. Lyman series terminates at $n = 1$ (ultraviolet). Paschen series terminates at $n = 3$ (infrared).

**Solution:**

(a) Look at the four arrows in the diagram. Identify the final $n$ of each.

(b) P: $n = 3 \rightarrow n = 1$ (Lyman, ultraviolet).

(c) Q: $n = 3 \rightarrow n = 2$ ($H_\alpha$, Balmer, *visible* red).

(d) R: $n = 4 \rightarrow n = 1$ (Lyman, ultraviolet).

(e) S: $n = 2 \rightarrow n = 1$ (Lyman, ultraviolet).

(f) Only Q ends at $n = 2$ with $n_{\text{initial}} = 3$, so it is the Balmer $H_\alpha$ line in the visible region.

(g) **Trap Check:** A common mistake is to pick the transition with the *smallest* energy gap (S) thinking it gives visible light. But S is $n = 2 \rightarrow n = 1$ (Lyman), which lies in the UV.

**Final Answer:** Transition Q ($n = 3 \rightarrow n = 2$)

**Answer: (B)**

Go Back to Question 9

# Q10.

## Solution

**Concept:**
The hybridization of a carbon atom is determined by counting the number of $\sigma$-bonds and lone pairs around it (steric number). SN = 4 $\Rightarrow sp^3$, SN = 3 $\Rightarrow sp^2$, SN = 2 $\Rightarrow sp$. A double bond contributes one $\sigma$ and one $\pi$; a triple bond contributes one $\sigma$ and two $\pi$.

**Solution:**

(a) Structure: $CH_2$=CH−C≡N. Label: $C_1$ = $CH_2$, $C_2$ = CH, $C_3$ = C (bonded to N).

(b) $C_1$: bonded to 2 H and to $C_2$ via a double bond. $\sigma$-bonds: 2 (to H) + 1 (to $C_2$) = 3. No lone pair. $\Rightarrow sp^2$.

(c) $C_2$: bonded to 1 H, to $C_1$ via double bond (1 $\sigma$), and to $C_3$ via single bond (1 $\sigma$). $\sigma$-bonds: 1 + 1 + 1 = 3. No lone pair. $\Rightarrow sp^2$.

(d) $C_3$: bonded to $C_2$ via single bond (1 $\sigma$) and to N via triple bond (1 $\sigma$ + 2 $\pi$). $\sigma$-bonds: 2. No lone pair. $\Rightarrow sp$.

(e) Hence the hybridizations of $C_1, C_2, C_3$ are $sp^2, sp^2, sp$ respectively.

(f) **Trap Check:** Each multiple bond counts as *one* $\sigma$ for hybridization, regardless of bond order. Counting both bonds of a double bond as separate $\sigma$ would (wrongly) give $sp^3$ for $C_2$.

**Final Answer:** $\boxed{sp^2,\ sp^2,\ sp}$

**Answer: (A)**

**Go Back to Question 10**

# Q11.

## Solution

**Concept:**

In the stratosphere, CFCs (e.g. $CF_2Cl_2$) are photolyzed by UV radiation to release *chlorine free radicals*:

$$CF_2Cl_2 \xrightarrow{h\nu} CF_2Cl^{\bullet} + Cl^{\bullet}$$

These chlorine atoms then propagate a chain reaction that destroys ozone catalytically.

**Solution:**

(a) Initiation (photolysis of CFC): generates $Cl^{\bullet}$.

(b) Propagation step 1: $Cl^{\bullet} + O_3 \rightarrow ClO^{\bullet} + O_2$.

(c) Propagation step 2: $ClO^{\bullet} + O \rightarrow Cl^{\bullet} + O_2$.

(d) The net effect destroys $O_3$ while $Cl^{\bullet}$ is *regenerated* — a single Cl atom can destroy thousands of $O_3$ molecules before being removed by a termination step.

(e) Although NO (from supersonic aircraft) and $OH^{\bullet}$ also contribute to ozone depletion, the question explicitly refers to the CFC mechanism, in which $Cl^{\bullet}$ is the principal chain-carrier.

(f) **Trap Check:** F atoms from CFCs are quickly removed by reaction with water/$CH_4$ to form stable HF; they do *not* catalytically destroy $O_3$. This eliminates option (A).

**Final Answer:** $\boxed{Cl^{\bullet} \text{ (atomic chlorine radical)}}$

**Answer: (B)**

**Go Back to Question 11**

## Q12.

### Solution

**Concept:**
For the equilibrium $Ag_2CrO_4(s) \rightleftharpoons 2Ag^+ + CrO_4^{2-}$, the solubility product is $K_{sp} = [Ag^+]^2[CrO_4^{2-}]$. In a solution already containing the common ion $Ag^+$ (from $AgNO_3$), the silver-ion concentration is fixed by the strong electrolyte, and the solubility of the sparingly soluble salt is heavily suppressed.

**Solution:**

(a) In 0.01 M $AgNO_3$, $[Ag^+] \approx 0.01$ M (fully dissociated). The contribution $2s'$ from $Ag_2CrO_4$ is negligible (to be verified).

(b) Let molar solubility of $Ag_2CrO_4$ in this medium be $s'$. Then $[CrO_4^{2-}] = s'$.

(c) Apply $K_{sp}$: $(0.01)^2 \times s' = 1.1 \times 10^{-12}$.

(d) $10^{-4} \times s' = 1.1 \times 10^{-12} \Rightarrow s' = 1.1 \times 10^{-8}$ M.

(e) Verification: $2s' = 2.2 \times 10^{-8}$ M, which is indeed $\ll 0.01$ M. The approximation is valid.

(f) **Trap Check:** The factor of 2 from the stoichiometry $Ag_2CrO_4 \rightarrow 2Ag^+ + CrO_4^{2-}$ appears in the *exponent* of $[Ag^+]$, not as a multiplier on $s'$. Forgetting the square would give $1.1 \times 10^{-10}$ M (option C).

**Final Answer:** $\boxed{1.1 \times 10^{-8}\text{ M}}$

**Answer: (A)**

**Go Back to Question 12**

# Q13.

## Solution

**Concept:**

Faraday's second law: when the *same quantity of electricity* is passed through different electrolytes, the masses of substances deposited are proportional to their equivalent weights, $E = M/n$, where $n$ is the number of electrons per ion deposited.

**Solution:**

(a) Equivalents deposited are equal across all three cells: $\frac{m_{Ag}}{E_{Ag}} = \frac{m_{Cu}}{E_{Cu}} = \frac{m_{Al}}{E_{Al}}$.

(b) $E_{Ag} = 108/1 = 108$ g/eq. $E_{Cu} = 63.5/2 = 31.75$ g/eq. $E_{Al} = 27/3 = 9$ g/eq.

(c) Number of equivalents in Ag cell: $1.08/108 = 0.01$ eq.

(d) Mass of Cu deposited: $0.01 \times 31.75 = 0.3175$ g.

(e) Mass of Al deposited: $0.01 \times 9 = 0.090$ g.

(f) **Trap Check:** Do not use atomic masses directly. The ions discharged are $Ag^{+}, Cu^{2+}, Al^{3+}$, so divide molar mass by $n = 1, 2, 3$ respectively. Using $M/2$ for Al would erroneously give 0.135 g.

**Final Answer:** $\boxed{m_{Cu} = 0.3175 \text{ g}, \quad m_{Al} = 0.090 \text{ g}}$

**Answer: (A)**

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## Q14.

### Solution

**Concept:**
The flow diagram represents the *Contact process* for sulphuric acid: (i) sulphur is burnt to $SO_2$, (ii) $SO_2$ is catalytically oxidized to $SO_3$ in the converter, and (iii) $SO_3$ is absorbed in *concentrated* $H_2SO_4$ to form *oleum* ($H_2S_2O_7$), which is later diluted with water to yield sulphuric acid of the desired strength.

**Solution:**

(a) Stage 'K' is the catalytic converter. The reaction is $2SO_2 + O_2 \rightleftharpoons 2SO_3$, $\Delta H = -196$ kJ.

(b) The modern industrial catalyst is $V_2O_5$ (vanadium pentoxide), operating around 720–800 K. It is preferred over the older Pt catalyst because $V_2O_5$ is cheaper and resistant to arsenic poisoning.

(c) Stage 'L' is the absorption tower. $SO_3$ is absorbed in *concentrated* $H_2SO_4$ ($\sim 98\%$), not directly in water. Direct absorption in water produces a corrosive sulphuric acid mist that is hard to condense.

(d) The product is oleum: $H_2SO_4 + SO_3 \rightarrow H_2S_2O_7$.

(e) Option (A): Fe is the Haber catalyst; dilute $H_2SO_4$ would not absorb $SO_3$ effectively. Option (C): Pt-Rh is the Ostwald catalyst, and water absorption is industrially impractical. Option (D): Ni is a hydrogenation catalyst.

(f) **Trap Check:** Many students wrongly choose "water" as the absorbing medium. The correct industrial practice uses 98% $H_2SO_4$ to make oleum, which is later diluted.

**Final Answer:** $\boxed{V_2O_5;\ \text{conc. } H_2SO_4}$

**Answer: (B)**

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## Q15.

### Solution

**Concept:**
A molecule is *non-polar overall* if the vector sum of its individual bond dipoles is zero. This typically occurs when (i) the bond dipoles are equal in magnitude and (ii) the molecular geometry is symmetric (linear, trigonal planar, tetrahedral, square planar, octahedral, etc.).
**Solution:**

(a) $H_2O$: bent ($sp^3$, 2 LP). The two O–H dipoles do not cancel; net dipole $\mu \approx 1.85$ D. Polar.

(b) $NH_3$: trigonal pyramidal. Three N–H dipoles plus a lone pair give a net $\mu \approx 1.47$ D. Polar.

(c) $CO_2$: *linear* (O=C=O). The two C=O dipoles are equal in magnitude and opposite in direction; they cancel exactly. Net $\mu = 0$. Although individual bonds are polar, the molecule is non-polar.

(d) $SO_2$: bent ($sp^2$, 1 LP). The two S=O dipoles do not cancel; net $\mu \approx 1.6$ D. Polar.

(e) Therefore the non-polar molecule is $CO_2$.

(f) **Trap Check:** Do not equate "contains polar bonds" with "polar molecule". Symmetry of geometry is essential to make the net dipole zero. $CO_2$ (linear) is non-polar but $SO_2$ (bent) is polar — the geometry difference comes from the lone pair on S.

**Final Answer:** $\boxed{CO_2}$

**Answer: (C)**

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# Q16.

## Solution

**Concept:**
Atomic orbitals are characterized by four quantum numbers. The number of orbitals per shell is $n^2$; per subshell it is $2l + 1$. The number of *radial nodes* is $n - l - 1$ and the number of *angular nodes* is $l$, giving a total of $n - 1$ nodes in any orbital. The half-filled and fully-filled subshell stabilities account for anomalous configurations of Cr and Cu.
**Solution:**

(a) **Statement (A):** Correct. The azimuthal (angular momentum) quantum number $l$ determines the *shape* of the orbital ($s$-spherical, $p$-dumbbell, $d$-cloverleaf, etc.).

(b) **Statement (B):** Correct. Cr (Z = 24) has the anomalous configuration $[Ar]\,3d^5\,4s^1$ instead of $3d^4\,4s^2$, because exactly half-filled $3d^5$ together with half-filled $4s^1$ confers extra stability (exchange-energy stabilisation).

(c) **Statement (C):** *Incorrect*. For a $3p$ orbital, $n = 3$, $l = 1$. Total nodes $= n - 1 = 2$, not 3. (Radial nodes $= n - l - 1 = 1$; angular nodes $= l = 1$; total = 2.)

(d) **Statement (D):** Correct. $4f$ has $l = 3$, so $m_l = -3, -2, -1, 0, +1, +2, +3$, giving $2l + 1 = 7$ orbitals.

(e) Hence the correct statements are (A), (B), (D).

(f) **Trap Check:** A common confusion is to write the total nodes as $n$ instead of $n - 1$. Remember: total nodes $= n - 1$ in *any* orbital.

**Final Answer:** A, B, D

**Answer: (A,B,D)**

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# Q17.

## Solution

**Concept:**
Haber process: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, $\Delta H = -92$ kJ, $\Delta n_g = 2-4 = -2$. By Le Chatelier's principle, the equilibrium shifts towards the side that opposes the imposed disturbance. A catalyst alters only the *rate*, not the equilibrium position or $K$.

**Solution:**

(a) **Statement (A):** Correct. Forward reaction reduces the number of moles of gas ($4 \longrightarrow 2$). High pressure shifts the equilibrium towards fewer moles, i.e. towards $NH_3$. Industrially, $\sim 200$ atm is used.

(b) **Statement (B):** *Incorrect*. The forward reaction is exothermic ($\Delta H < 0$). Increasing temperature shifts the equilibrium *backwards*, *decreasing* the equilibrium yield, even though it raises the rate. The industrial compromise is $\sim 700$ K.

(c) **Statement (C):** Correct. A catalyst (Fe with Mo promoter) lowers the activation energy of both forward and reverse reactions equally; it speeds up attainment of equilibrium but does not alter $K_c$ or the position of equilibrium.

(d) **Statement (D):** Correct. Removing $NH_3$ as it forms reduces $[NH_3]$, which decreases $Q$ below $K$, so the reaction proceeds further to the right (Le Chatelier). Industrially, $NH_3$ is liquefied and removed continuously.

(e) Hence the correct statements are (A), (C), (D).

(f) **Trap Check:** "Higher temperature increases yield" is a frequent error. For an *exothermic* reaction, higher T *decreases* equilibrium yield, even though kinetically the reaction is faster.

**Final Answer:** $\boxed{\text{A, C, D}}$

**Answer: (A,C,D)**

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# Q18.

## Solution

**Concept:**
In an electrochemical cell, the electrode with *higher* reduction potential acts as the cathode (reduction) and that with *lower* reduction potential acts as the anode (oxidation). $E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode}$. A positive $E^\circ_{cell}$ means the reaction is spontaneous. The species with the largest (most positive) reduction potential is the strongest oxidizing agent.

**Solution:**

(a) **Statement (A):** Correct. Cu has higher $E^\circ$, so it is the cathode; Mg has lower $E^\circ$, so it is the anode. $E^\circ_{cell} = 0.34 - (-2.37) = +2.71$ V.

(b) **Statement (B):** *Incorrect*. For Ag to displace Cu, the cell $Ag \mid Ag^+ \parallel Cu^{2+} \mid Cu$ would need $E^\circ_{cell} > 0$: $E^\circ_{cell} = 0.34 - 0.80 = -0.46\text{ V} < 0$. Hence not spontaneous. (In reality the reverse occurs: Cu displaces $Ag^+$.)

(c) **Statement (C):** Correct. Cell $Fe \mid Fe^{2+} \parallel Cu^{2+} \mid Cu$ gives $E^\circ_{cell} = 0.34 - (-0.44) = +0.78$ V $> 0$, spontaneous. Therefore Fe reduces $Cu^{2+}$ to Cu.

(d) **Statement (D):** Correct. The most positive reduction potential is $E^\circ_{Ag^+/Ag} = +0.80$ V, so $Ag^+$ is the strongest oxidizing agent in this list (it has the greatest tendency to be reduced, i.e. to oxidize something else).

(e) Hence the correct statements are (A), (C), (D).

(f) **Trap Check:** Statement (B) is a classic trap. Remember the activity series: a metal can displace ions of a metal that lies *below* it in the reduction-potential table, i.e. ions of metals with *higher* reduction potential. Ag is below Cu in activity (above in reduction potential), so Ag cannot displace Cu.

**Final Answer:** $\boxed{\text{A, C, D}}$

**Answer: (A,C,D)**

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# Q19.

## Solution

**Concept:**
The blast furnace is a counter-current reactor in which the descending charge (haematite + coke + limestone) meets the ascending hot reducing gases. Different temperature zones host different reactions: combustion (bottom), Boudouard reaction (middle), stepwise reduction of oxides (upper). The product is *pig iron*, not pure Fe.

**Solution:**

(a) **Statement (A):** Correct. Coke is burnt at the tuyères to give heat ($C + O_2 \rightarrow CO_2$, exothermic), and is also the source of CO via the Boudouard reaction.

(b) **Statement (B):** Correct. The Boudouard reaction $CO_2 + C \rightarrow 2CO$ is endothermic and dominant above $\sim 1000$ K; it regenerates CO that acts as the principal reductant in the upper zones via $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$.

(c) **Statement (C):** *Incorrect*. $CaCO_3$ does *not* reduce $Fe_2O_3$. Limestone is added as a *flux*: it decomposes to CaO, which reacts with the siliceous gangue $SiO_2$ to form fusible calcium silicate slag $CaSiO_3$, which floats on molten iron.

(d) **Statement (D):** Correct. The molten metal tapped from the bottom is pig iron, $\sim 93\%$ Fe with $\sim 4\%$ C and small amounts of Si, Mn, P, S. It is brittle and is refined further to make wrought iron or steel.

(e) Hence the correct statements are (A), (B), (D).

(f) **Trap Check:** Carbon (coke) is the *ultimate* reducing agent, but in the temperature range of haematite reduction, the *actual* reductant is CO. In the lowest hottest zone (1500–2000 K), C itself can directly reduce FeO.

**Final Answer:** A, B, D

**Answer: (A,B,D)**

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## Q20.

### Solution

**Concept:**
Alkenes with general formula $C_nH_{2n}$ can show *geometrical (cis–trans) isomerism* only if *each* doubly bonded carbon carries two *different* groups. Chain isomers have the same molecular formula but different carbon skeletons. Catalytic hydrogenation of an alkene gives the corresponding alkane.

**Solution:**

(a) **Statement (A):** Correct. 2-methylbut-2-ene has 5 carbons; general formula for an alkene with one $C = C$ is $C_nH_{2n}$. So molecular formula is $C_5H_{10}$.

(b) **Statement (B):** Correct. Structure: $(CH_3)_2C{=}CH{-}CH_3$. The left $sp^2$ carbon carries two identical $CH_3$ groups. Therefore swapping the groups gives the same molecule $\Rightarrow$ no cis/trans isomerism.

(c) **Statement (C):** Correct. Pent-1-ene ($CH_2{=}CH{-}CH_2{-}CH_2{-}CH_3$) and 2-methylbut-2-ene both have molecular formula $C_5H_{10}$ but differ in the carbon skeleton (straight vs branched) and the position of the double bond — these are isomers (in fact a combination of chain and position isomerism). At the JELET level they are commonly grouped under chain isomers.

(d) **Statement (D):** Correct. $(CH_3)_2C{=}CH{-}CH_3 + H_2 \xrightarrow{Ni} (CH_3)_2CH{-}CH_2{-}CH_3$ = 2-methylbutane (isopentane).

(e) Hence all four statements (A), (B), (C), (D) are correct.

(f) **Trap Check:** For geometrical isomerism, the test is "two different groups on *each* doubly bonded carbon". If even *one* $sp^2$ carbon has two identical substituents, no cis/trans isomerism exists.

**Final Answer:** A, B, C, D

**Answer: (A,B,C,D)**

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# Answer Key

| Q | Ans | Q | Ans | Q | Ans | Q | Ans | Q | Ans |
|---|---|---|---|---|---|---|---|---|---|
| 1 | D | 2 | B | 3 | B | 4 | A | 5 | B |
| 6 | C | 7 | B | 8 | A | 9 | B | 10 | A |
| 11 | B | 12 | A | 13 | A | 14 | B | 15 | C |
| 16 | A,B,D | 17 | A,C,D | 18 | A,C,D | 19 | A,B,D | 20 | A,B,C,D |