

- 1 Under room conditions of 25°C and 1 atm, 1 mole of gas occupies 24 dm³ of space. **A**

$$\text{Moles of O}_2 \text{ gas molecules} = \frac{1}{24000} \text{ mol}$$

$$\text{Moles of O atoms} = \frac{2}{24000} \text{ mol}$$

$$\text{No of O atoms} = \frac{2 \times 6.02 \times 10^{23}}{24000} \text{ atoms}$$

- 2 **C**

	C	N
Mole ratio	46.2 / 12 = 3.85	53.8 / 14 = 3.84
Simplest ratio	1	1

Empirical formula = CN

$$n(\text{cyanogen}) = \frac{0.500}{22.4} = 0.0223 \text{ mol}$$

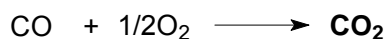
$$M_r \text{ of cyanogen} = \frac{1}{0.0223} \times 1.16 = 52$$

$$n(14+12) = 52$$

$$n = 2$$

Hence, molecular formula = C₂N₂

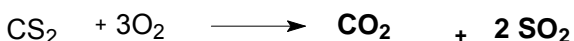
- 3 **A**



1 mol of CO produces **1 mol CO₂**



3 mol H₂S produces **3 mol SO₂**



1 mol of CS₂ produces **1 mol CO₂ 2 mol of SO₂**

Total moles of SO₂ = 3 + 2 = 5 mol

Total moles of CO₂ = 1+1 = 2 mol

Therefore ratio of SO₂ : CO₂ = 5 : 2

- 4 **D**

angle of deflection $\propto \frac{\text{charge size}}{\text{mass}}$

$$\text{for } ^1\text{H}^+, \frac{z}{m} = +\frac{1}{1}$$

$$\text{for } ^2\text{X}^{2-}, \frac{z}{m} = -\frac{2}{2}$$

Hence, angle of deflection for ²X²⁻ = -4° (i.e. in the opposite direction)

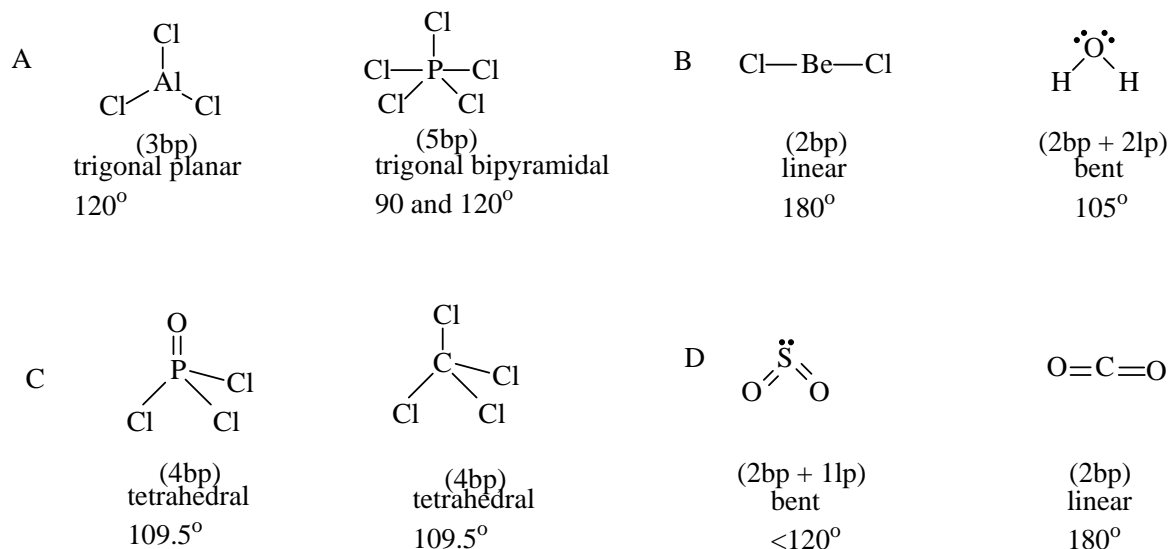
5 Hexagonal boron nitride resembles graphite, while cubic boron nitride resembles diamond. **D**

- Hence, both of them have giant molecular structures.
- Hexagonal boron nitride has strong covalent bonds between its atoms within the layer, but it has weak instantaneous dipole-induced dipole forces of attractions between its layers. Therefore, only hexagonal boron nitride is soft and slippery while cubic boron nitride is hard and rigid due to the strong, extensive covalent bonds between the B and N atoms.
- Hexagonal boron nitride resembles the structure of graphite as it also has a delocalized pi electron cloud system, which thus allows it to conduct electricity. Cubic boron nitride has no delocalised electrons to conduct electricity.

6 All molecules in the options have the same M_r and hence there is no difference in the number of electrons and the size of the electron cloud. **A**

Since $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$ has an elongated shape as compared to other branched isomers, it has the greatest surface area of contact which allow for stronger id-id attractions between the molecules.

7 Considering that the shape and bond angle are dependent on the number of electron pairs around the central atom, **C**



8 A represents E_a for forward reaction **B**
 B represents enthalpy change of reaction for reverse reaction
 C represents E_a for the reverse reaction
 D has no significance

9 $\Delta H_r = [2\Delta H_f(\text{H}_2\text{O}) + \Delta H_f(\text{O}_2)] - 2\Delta H_f(\text{H}_2\text{O}_2)$ **B**
 $= [2(-285.8) + 0] - 2(-187.8)$
 $= \underline{-196 \text{ kJ mol}^{-1}}$

10 $\Delta H_{\text{neut}} = -Q / n_{\text{H}_2\text{O}} = Vc\Delta T / n_{\text{H}_2\text{O}}$ **C**
 Volume of resultant solution of NaOH and HCl = 40 cm^3
 $n_{\text{H}_2\text{O}} \text{ formed} = n_{\text{HCl}} = 0.04 \text{ mol}$

Please note that the options given refer to the value of the ΔH_{neut} .

- 11 A. At t_1 , catalyst increases the rate of the forward and backward reaction to the same extent such that there is no change to the concentration of the reactants and products. **D**
 B. At t_1 , addition of CO_2 would have caused an immediate increase in $[\text{CO}_2]$ followed by a decrease in $[\text{CO}_2]$ since POE shift left. This however is not shown in the diagram.
 C. At t_1 , when temperature decreases for an forward exothermic reaction, POE shifts to the right increasing the conc. of CO_2 but diagram shows a decrease in concentration of CO_2 .
 D. At t_1 , an increase in temperature will cause POE to shift left, decreasing the $[\text{CO}]$ and increasing the $[\text{CO}_2]$. When volume of the system is decreased at t_2 , $[\text{CO}]$ and $[\text{CO}_2]$ will increase. By LCP, POE will shift right hence decreasing $[\text{CO}]$ and $[\text{CO}_2]$. All of these were reflected in the diagram.

- 12 $K_c = \frac{[\text{CO}]^2}{[\text{CO}_2]}$ **C**

	$\text{CO}_2(\text{g})$	+	$\text{C}(\text{s})$	\rightleftharpoons	$2\text{CO}(\text{g})$
Initial (mol)	0.10		0.20		0
Change (mol)	-0.062		$-(0.20 \times 0.31)$ $= -0.062$		$+0.062 \times 2$ $= +0.124$
Equilibrium (mol)	0.038		0.20×0.69 $= 0.138$		0.124
Equilibrium conc. (mol dm^{-3})	$0.038 / 0.10$ $= 0.38$		—		$0.124 / 0.10$ $= 1.24$

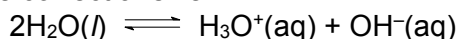
'ICE' table is not required

Equilibrium no. of moles of $\text{CO}_2 = 0.10 - (0.20 \times 0.31) = \underline{0.038 \text{ mol}}$

Equilibrium no. of moles of $\text{CO} = 0.062 \times 2 = \underline{0.124 \text{ mol}}$

$$K_c = \frac{[\text{CO}]^2}{[\text{CO}_2]} = \frac{(1.24)^2}{(0.38)} = \underline{4.0 \text{ mol dm}^{-3}}$$

- 13 **B** is the correct answer. **B**



When temperature increases, the forward endothermic reaction is favoured. Thus, the position of equilibrium shifts to the right to absorb the excess heat.

For **A**,

$$K_w = [\text{H}^+][\text{OH}^-]$$

$[\text{H}^+] = [\text{OH}^-] = \sqrt{10^{-14}} = 3.16 \times 10^{-7} \text{ mol dm}^{-3}$. Water is still a neutral liquid as the $[\text{H}^+] = [\text{OH}^-]$.

For **C**,

For $T=25^\circ\text{C}$, $[\text{H}^+] = 1.00 \times 10^{-7} \text{ mol dm}^{-3}$

For $T=62^\circ\text{C}$, $[\text{H}^+] = 3.16 \times 10^{-7} \text{ mol dm}^{-3}$

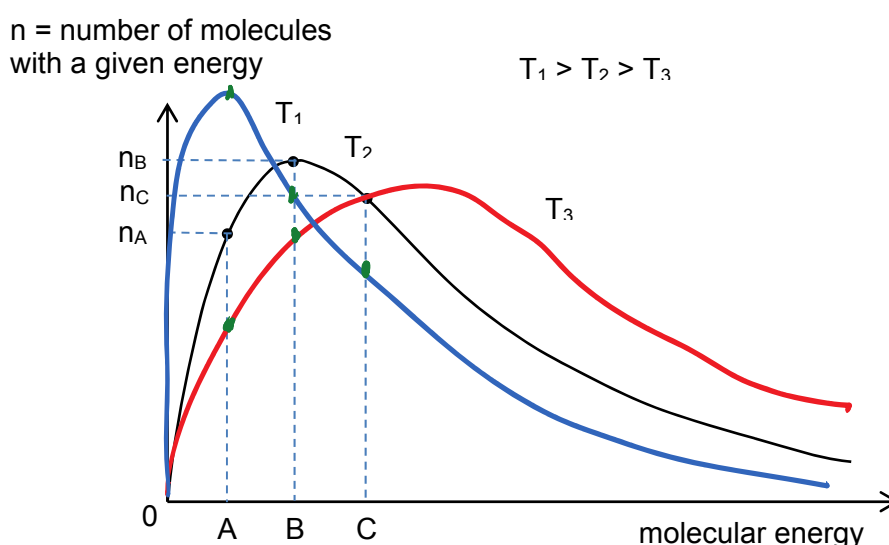
The ionic dissociation of water increases by a factor of 3.16 between 25°C and 62°C .

For **D**,

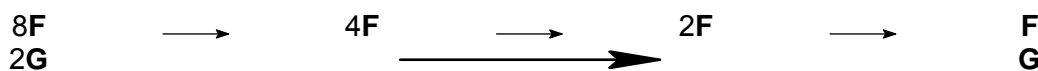
The association of water molecules by hydrogen bonding decreases as temperature rises. Molecules are moving at higher speeds, making it harder to form hydrogen bonds.

- 14 A. HNO_3 acts as a base here as H_2SO_4 , being the stronger acid, has donated a proton to HNO_3 , forming HSO_4^- and H_2NO_3^+ , which will break down to H_2O and NO_2^+ . **D**
 B. The oxidation no. of N atom remained as +5.
 C. Water is not eliminated in this reaction.
 D. H_2NO_3^+ and HNO_3 forms a conjugate acid-base pair (differ by a H^+).

- 15 Area under the graph represents total number of molecules in sample. **D**
 A is incorrect because when more gas is added to sample, no. of molecules at all energies will increase.
 B is incorrect because when temperature decreases, curve shifts to the left and has a higher peak. i.e. n_a will increase. (check graph below)
 C is incorrect because when temperature increases, curve shifts to the right and has a lower peak. i.e. n_a and n_b will decrease (check graph below)
 D is correct because the presence of a catalyst does not shift the curve at all. It only provides an alternative pathway with a lowered E_a (E_a'). Hence there is no effect on n_a , n_b and n_c .



- 16 The easiest approach to answering this question is to start from the equimolar quantities of **F** and **G** after 9 min and work backwards. **C**
 Since **F** has undergone 3 half-lives, its initial concentrations will be $8F$.
 Initial concentration of **G** will be $2G$ as it has undergone 1 half-lives.



\therefore value of $h = 4$

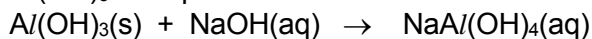
- 17 The big dip in IE shows that element C is in the next period since valence electron is further from the nucleus, resulting in lower IE. Since A to H has atomic number 3 to 20, B is Ne (period 2), C is Na (period 3). **B**
 A. D is Mg and MgCl_2 being an ionic solid will conduct electricity in the molten state.
 B. A which is F_2 which will react with C which is Na forms an ionic compound (NaF).
 C. Ne exists as a gas and Na is a solid. Hence, trend of melting point is not in the trend above.
 D. The oxide of H which is sulfur will give an acidic pH when dissolved in water.

- 18 MgO , Al_2O_3 are soluble in acid as they undergo acid–base reaction. Oxides of P are soluble in aq. acid. (Recall: Oxides of phosphorus can hydrolyse in water). SiO_2 is insoluble in acid. Thus **Z** is Si. **A**

Filtrate contains Mg^{2+} or Al^{3+} .

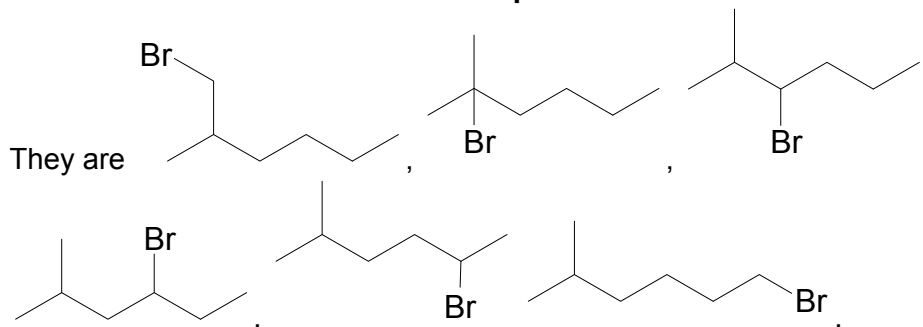
When excess NaOH is added to the filtrate, $\text{Mg}(\text{OH})_2$ is formed as white ppt.

$\text{Al}(\text{OH})_3$ is amphoteric and reacts with excess NaOH to form salt and water.



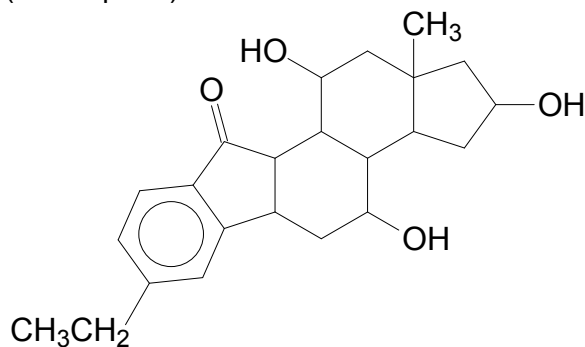
Hence, **X** is Al and **Y** is Mg.

- 19 For structure B $(\text{CH}_3)_2\text{CH}(\text{CH}_2)_3\text{CH}_3$, there are **six different hydrogen environments** i.e. **6 different monobromo–substituted products** can be obtained. **B**



The other options give less than 6 isomeric monobromo compounds with the formula $\text{C}_7\text{H}_{15}\text{Br}$.

- 20 Subjecting the molecule to heating with steam and concentrated phosphoric acid results in (electrophilic) addition of water to the alkene functional group and you get this product. **A**



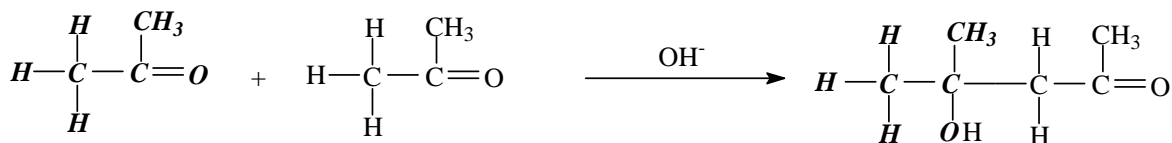
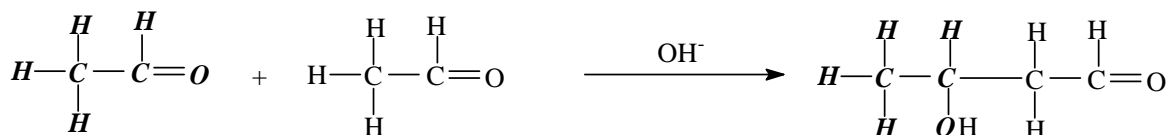
Upon heating with acidified potassium dichromate(VI), only the 3 secondary alcohols are oxidized to ketones. The ketone and the side–chain of the benzene ring does not undergo oxidation. As a result there are no carboxylic acid groups in the resultant product.

- 21 For **X**, acidified KMnO_4 is not suitable as it will cause oxidative cleavage of the double bond. **B**

For **Y**, NaBH_4 is unable to reduce the alkene double bond. LiAlH_4 will reduce the carboxylic acid to primary alcohol.

22 Making observations on the pattern in the given reaction,

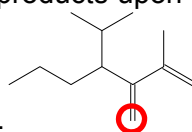
A



23 There are a few possible elimination products (Br eliminated together with a H atom on an adjacent carbon). Molecules in A – C are possible products upon elimination of 2 X H–Br.

D

Only the molecule in D has an additional carbon i.e.



24 $\begin{array}{c} \text{H} \\ | \\ \text{CH}_3-\text{C}=\text{O} \end{array}$ gives yellow ppt in iodoform test

D

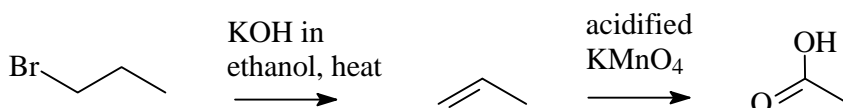
$\begin{array}{c} \text{H} \\ | \\ \text{CH}_3-\text{C}-\text{H} \\ | \\ \text{OH} \end{array}$ gives yellow ppt in iodoform test

$\begin{array}{c} \text{H} \\ | \\ \text{CH}_3-\text{C}-\text{CH}_2\text{CH}_3 \\ | \\ \text{OH} \end{array}$ gives yellow ppt in iodoform test

$\begin{array}{c} \text{O} \\ || \\ \text{CH}_3-\text{C}-\text{O}-\text{CH}_3 \end{array}$ does not give yellow ppt in iodoform test as the carbonyl carbon must be attached to only C or H

25 There is a loss of carbon atom in this reaction.

C



26 Option 1 is correct because addition of strong alkali reduces the concentration of H^+ , hence POE shifts to the right.

D

Option 2 is incorrect because K^+ does not react with any of the species present. Hence there is no effect on the position of equilibrium.

Option 3 is incorrect because both $\text{Cr}_2\text{O}_7^{2-}$ and CrO_4^{2-} have the same oxidation no. of +6 despite having different colours ($\text{Cr}_2\text{O}_7^{2-}$ is orange in colour while CrO_4^{2-} is yellow). The equilibrium is known as an acid–base reaction instead of a redox reaction.

27 2. Graph shows half-life is constant at 150 s. Hence 1st order with respect to N₂O₅. **A**

3. Gradient of curve at t = 0 = $\frac{\Delta[\text{NO}_2]}{\Delta t} = 2.0 \times 10^{-3} \text{ mol dm}^{-3} \text{ s}^{-1}$.

$$\frac{\Delta[\text{O}_2]}{\Delta t} = \frac{\Delta[\text{O}_2]}{2\Delta t} = 1.0 \times 10^{-3} \text{ mol dm}^{-3} \text{ s}^{-1}$$

1. After 200 s, the [N₂O₅] is 0.20 mol dm⁻³. This means that 0.30 mol dm⁻³ of N₂O₅ has been reacted, implying that 0.6 mol dm⁻³ of NO₂ and 0.5 mol dm⁻³ of O₂ are formed.

28 All 3 statements are true. **A**

Statement 1: pH of NaCl (7) > MgCl₂ (6.5) > AlCl₃ (3) > SiCl₄ and PCl₃ or PCl₅ (1 – 2)

Statement 2: AlCl₃(s) + 3H₂O(l) → Al(OH)₃(s) + 3HCl(g)

Similarly for SiCl₄ and PCl₅

Statement 3: Al³⁺ ⇌ Al(OH)₃ ⇌ Al(OH)₄⁻

Upon adding NaOH, white ppt of Al(OH)₃ is formed. In excess NaOH, white ppt dissolves to form complex ion Al(OH)₄⁻.

29 It will not give a brick red precipitate with alkaline Cu²⁺ solution since there is no aldehyde group. **C**

It gives an orange precipitate with 2,4-dinitrophenylhydrazine solution since there is a carbonyl group (ketone).

It decolourises aqueous bromine solution since there is a C=C bond.

30 Option 1 is correct, as ethanoic acid and butan-1-ol react to give butyl ethanoate. **B**

Since it has a molecular formula of C₆H₁₂O₂, it has an empirical formula of C₃H₆O, like propanone, CH₃COCH₃.

Option 3 is incorrect as the expected products of base hydrolysis of the ester is sodium ethanoate (CH₃COO⁻Na⁺) and butan-1-ol.