

- 1 (a) Let percentage abundance of ^{33}S be x . Percentage abundance of ^{34}S be $4.96 - x$

$$\frac{95.02}{100}(100) + \frac{0.02}{100}(36) + \frac{x}{100}(33) + \frac{(4.96 - x)}{100}(34) = 32.093$$

$$\frac{33x + 168.64 - 34x}{100} = 1.6794 = 0.7$$

$$X = 0.7$$

Percentage abundance of $^{33}\text{S} = 0.7$

Percentage abundance of $^{34}\text{S} = 4.26$

- Working 1m
- Answer 1m

(b)

$$\Delta H_c = \frac{mc\Delta T}{n_{LR}}$$

$$(-297 \times 1000)(0.05) = (815)(4.18)(\Delta T)$$

$$\Delta T = 4.36^\circ\text{C}$$

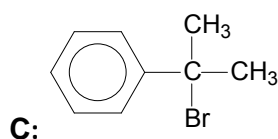
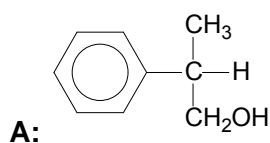
$$\text{Final Temp} = (28 + 4.36) = 32.4^\circ\text{C}$$

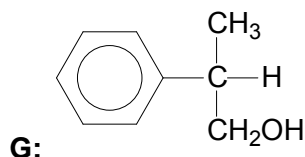
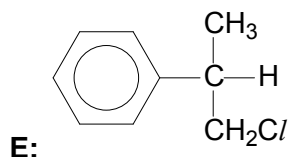
- Working 1m
- ΔT answer 1m
- Final answer 1m

- (c) (i) Negatively charged. Nuclei are positively charged(1m) since it contains protons and nuclei(1m), hence they are deflected towards negative plate.
- (ii) Beam 1. Deuterium has larger mass, hence they are deflected to a smaller bond angle (1m)
- (iii) $\frac{1}{3} \times 6 = 2^\circ$

- Correct calculation 1m
- Correct labelling on diagram 1m

2 (a)





- 1m for each correct structure.

(b) Excess conc. H_2SO_4 , 170°C (1m)

Hydrolysis (1m)

(c) The conjugate base of compound **H** is more stable/less easily protonated/ negative charge is less intensified (1m) since the negative charge can be delocalised into the benzene ring (1m), thus, compound **H** is more acidic.

- 3 (a) (i) Lattice energy $\propto \frac{q^+ \cdot q^-}{r_+ + r_-}$ Since the anion is the same but Mg^{2+} has higher charge than Na^+ while Mg^{2+} has ionic radii 0.065nm but Na^+ has ionic radii 0.095nm, lattice energy of MgO is higher, hence melting point of MgO is higher
- (ii) Both Mg and Ba contribute 2 valence electrons to the sea of delocalised electrons, but Mg^{2+} has higher $\frac{\text{charge}}{\text{size}}$ compared to Ba^{2+} (Mg^{2+} ionic radii is 0.065nm and Ba^{2+} ionic radii is 0.135nm), hence the electrostatic attraction between Mg^{2+} and the sea of delocalised electron is stronger, therefore, it has stronger metallic bond and a higher melting point.
- 1m- quote ionic radii value from data booklet
 - 1m- LE comparison in (i)
 - 1m-contribution of same no of valence electrons and c/s in (ii)
 - 1m-correct conclusion in (i) and (ii)

(b) (i) Amount of $\text{AgNO}_3 = \frac{25.00}{1000} \times 0.300 = 0.0075 \text{ mol}$

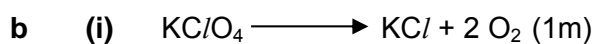
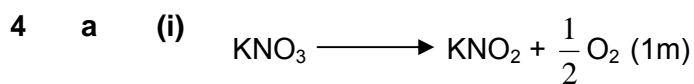
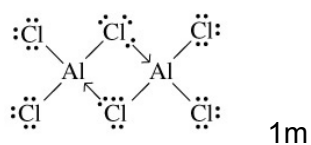
Amount of $\text{MCl}_n = 0.0025 \text{ mol}$

1 mol of MCl_n react with 3 mol of AgNO_3

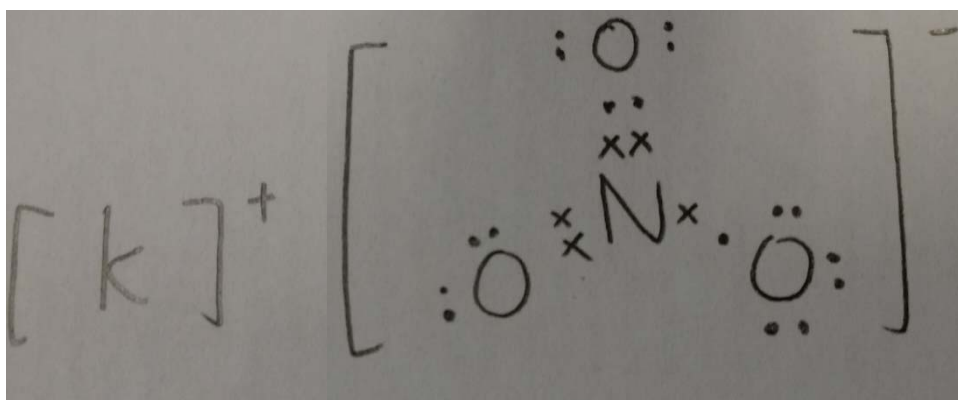
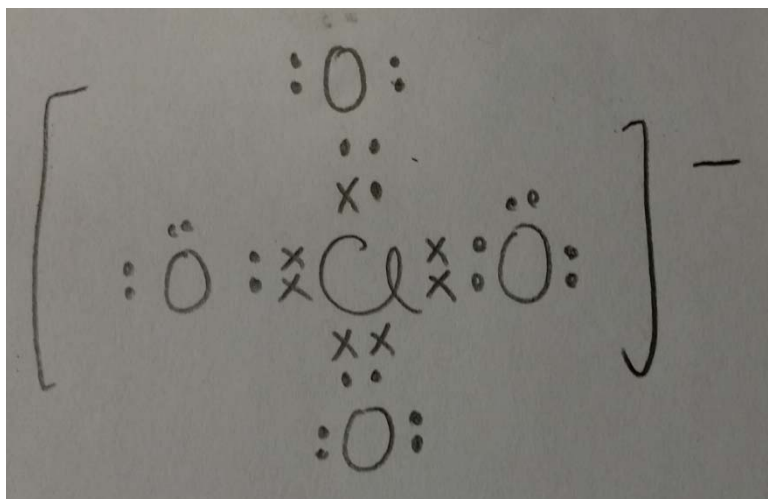
Therefore, no of mol of Cl^- released per mol of $\text{MCl}_n = 3$

- Working 1m
- Answer 1m

(ii) $\text{M} = \text{Al}$ (1m)



(ii)



(2m)

c (i) $PV = nRT$

$$P = \frac{(0.200)(8.31)(150 + 273)}{(1 \times 10^{-6})} = 7.02 \times 10^8 \text{ Pa}$$

Since pressure is higher than the minimum pressure required, the rocket will be propelled into the sky.

- 1m working (correct use of equation, correct unit conversion)
- 1m for answer
- 1m for correct conclusion based on answer

(ii) Ecf based on equation in b(i)

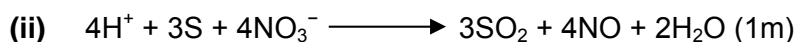


Amount of $\text{KClO}_4 = 0.100 \text{ mol}$

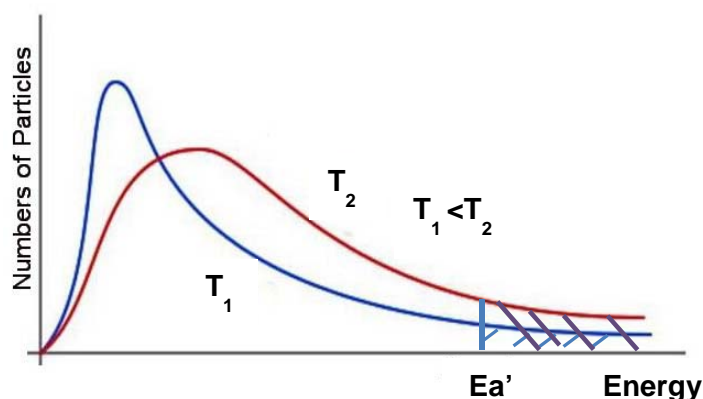
Mass of $\text{KClO}_4 = 0.100 \times (39+35.5+4 \times 16) = 13.85 \text{ g}$ (1m)

Mass of sample **Z** = $13.85 \times \frac{100}{85} = 16.3 \text{ g}$ (1m)

- d** (i) Sulfur is oxidised from 0 in S to +4 in SO_2
Nitrate is reduced from +5 in nitrate to +2 in nitrogen monoxide (1m)



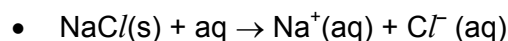
(iii)



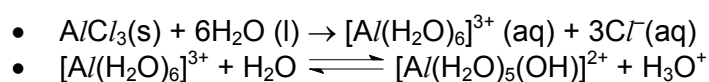
1m for axis+ label, 1m for correct shape of graph+shading

At higher temperature, there are more particles with energy greater than E_a , frequency of effective collision increases, rate of reaction increases. (1m)

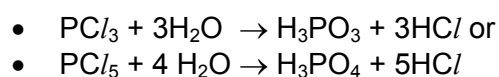
5 a



Both Na^+ and Cl^- does not hydrolyse, $\text{pH} = 7$



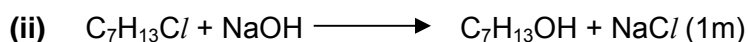
Al^{3+} undergo hydrolysis to give an acidic solution, $\text{pH} = 2$ or 3



PCl_3 (or PCl_5) undergo hydrolysis to give an acidic solution, $\text{pH} = 1$ to 2 .

1 mark for all correctly stated pH, 1m for each correct equation

b (i) Substitution (1m)



(iv) Aqueous Bromine.

Compound **P** will decolourise yellowish-brown Br₂ (aq)

Or

Bromine in CCl₄

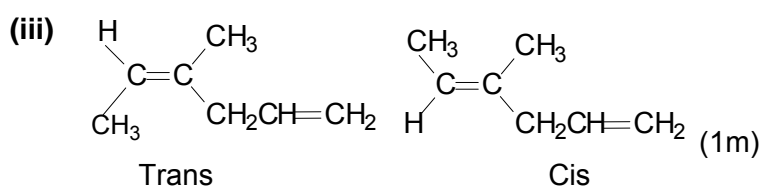
Compound **P** will decolourise reddish-brown Br₂

- 1m for reagent
- 1m for observation

(v) Presence of partial double bond character (1m) in C—C/ bond that strengthen the bond

c (i) Elimination (1m)

(ii) Ethanolic NaOH, heat (1m)



d (i) $\Delta H_{\text{formation}}(\text{MgCl}_2)$

(ii) Less exothermic (1m). I⁻ has larger ionic radii than Cl⁻, thus, electrons in I⁻ experience less nuclear attraction, thus electron affinity is less exothermic.

(iii) $\Delta H_3 = +244 \text{ kJ mol}^{-1}$
 $\Delta H_4 = +736 \text{ kJ mol}^{-1}$
 $\Delta H_5 = +1450 \text{ kJ mol}^{-1}$

(iv) $|\text{LE}| = 641 + 148 + 244 + 736 + 1450 - 698 = 2521$
 $\text{LE} = -2521 \text{ kJ mol}^{-1}$

- Working 1m
- Answer 1m

(v) LE is calculated based on the assumption of point charges, but there is some degree of covalent character in MgCl₂, thus, the values deviates. (1m)

(vi) The degree of covalent character in MgI₂ should be greater since I is more larger and more polarisable, thus, the discrepancy in MgI₂ should be larger. (1m)

6 a (i) The p-orbital of C overlaps side on with the p-orbital of O to form a pi bond. The sp² hybridised orbital of C overlaps head on with the p-orbital of O to form a sigma bond.
1m- Each correctly stated bond + correct type of overlap
1m- Each correct orbital involve in overlap

(ii) Propanone is soluble in water because it can form favourable hydrogen bonding with water. (1m)
Octanone is insoluble in water because it has long alkyl chain. Thus the dominant intermolecule forces of attraction is VDW/ tddid, which is difference

in strength to that of hydrogen bonds in water. (1m)

- b (i)** Comparing expt (1) and (4), when $[H^+]$ increase 2x, $[(CH_3)_2CO]$ and $[CN^-]$ are kept constant,
Rate of reaction remain the same.

Thus, order of reaction wrt H^+ is 0.

Comparing expt (1) and (3), when $[CN^-]$ increase $\frac{6}{5}$ times, $[(CH_3)_2CO]$ and $[H^+]$ are kept constant,

Rate of reaction increase by $\frac{6}{5}$ times.

Thus, order of reaction wrt CN^- is 1.

Comparing expt (1) and expt (2), let order wrt to $(CH_3)_2CO$

$$\frac{rate_{expt1}}{rate_{expt2}} = \frac{1.000}{0.375} = 2.67 = \frac{k(0.020)^x(0.060)}{k(0.015)^x(0.030)}$$

$$x = 1$$

Thus, order of reaction wrt $(CH_3)_2CO$ is 1.

Rate equation = $k[CN^-][(CH_3)_2CO]$

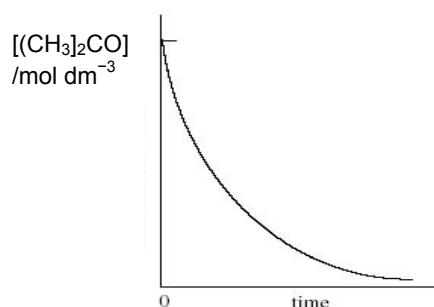
1m each for order to each reactant

1m for correct rate equation.

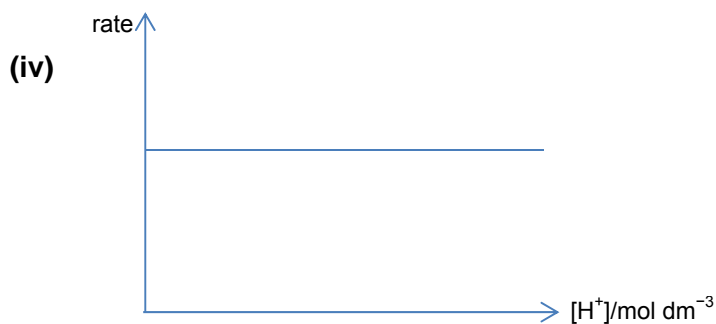
- (ii)** Using expt 1; $k = \frac{1}{0.02 \times 0.06} = 833.3 \text{ mol dm}^{-3} \text{ s}^{-1}$

- 1m for correct calculation
- 1m for unit

- (iii)**



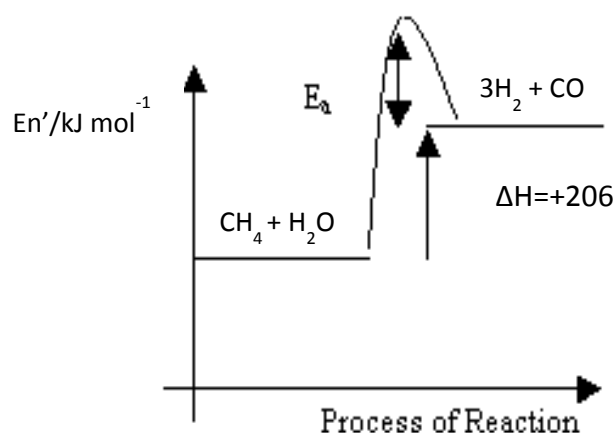
1m for correct sketch and label



1m for correct sketch and label

- c (i) More easily transported/ easier storage since it exist in the liquid form. (1m)

(ii)



1m for correct shape

1m for correct labelling

- (iii) Exothermic (1m). As temperature increases, the percentage of product at equilibrium decreases (1) because equilibrium shift LHS to partially absorb the excess heat by favouring the endothermic reaction(1m) based on LCP.

- 7 a (i) $\text{pOH}=3.5$ (1m)
 $[\text{OH}^-]= 3.16 \times 10^{-4} \text{ mol dm}^{-3}$ (1m)

- (ii) Amount of $\text{HCl} = \frac{22.75}{1000} \times 0.2 = 0.00455 \text{ mol}$
 Amount of $\text{CH}_3\text{NH}_2 = 0.00455 \text{ mol}$ (1m)
 $[\text{CH}_3\text{NH}_2] = \frac{0.00455}{\frac{25}{1000}} = 0.182 \text{ mol dm}^{-3}$ (1m)

- (iii) CH_3NH_2 did not undergo complete dissociation to give OH^- , thus it is a weak base (1m)

- (iv) Bromocresol green(1m). The working range of the indicator should fall within the steep slope of the titration curve/ coincide with equivalence point (1m).

- b** (i) $\text{CH}_3\text{NH}_3^+\text{Cl}^- / (\text{CH}_3\text{NH}_3^+)_2\text{SO}_4$, (1m)
- (ii) When small amount of OH^- is added
 $\text{CH}_3\text{NH}_3^+ + \text{OH}^- \longrightarrow \text{CH}_3\text{NH}_2 + \text{H}_2\text{O}$ (1m)
- When small amount of H^+ is added
 $\text{CH}_3\text{NH}_2 + \text{H}_3\text{O}^+ \longrightarrow \text{CH}_3\text{NH}_3^+ + \text{H}_2\text{O}$ (1m)
- c** (i) $\Delta H_{\text{rxn}} = \Delta H_f(\text{pdt}) - \Delta H_f(\text{rxn})$
- $$\Delta H_{\text{rxn}} = 2.5(-241.9) + 33 + (-93.6) - (-23) = -642.4 \text{ kJ mol}^{-1}$$
- Working 1m
 - Answer 1m
- (ii) H_2O exist as liquid, whereas bond energy only assume all species are present in gaseous state, so $\Delta H_{\text{vapourisation}}$ is not taken into account. (1m)
- d** (i) Rate of the forward and backward reactions are equal and the concentration of the reactants and the products do not change. (1m)
- (ii) $K_c = \frac{[\text{Cl}_2][\text{NO}]^2}{[\text{NOCl}]^2} \text{ mol dm}^{-3}$
- 1m expression
 - 1m units
- (iii) $[\text{NO}] = 0.60 \text{ mol dm}^{-3}$ (1m)
- (iv) $1.5 = \frac{[0.30][0.60]^2}{[\text{NOCl}]^2}$
- $$[\text{NOCl}] = 0.268 \text{ mol dm}^{-3}$$
- Working 1m
 - Answer 1m
- (v) K_c remain the same. K_c only changes with changes in temperature. (1m)