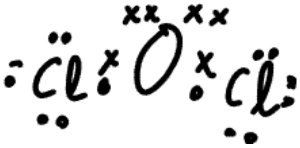
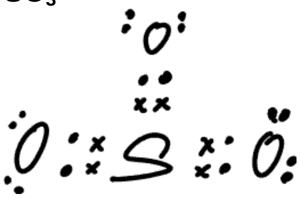
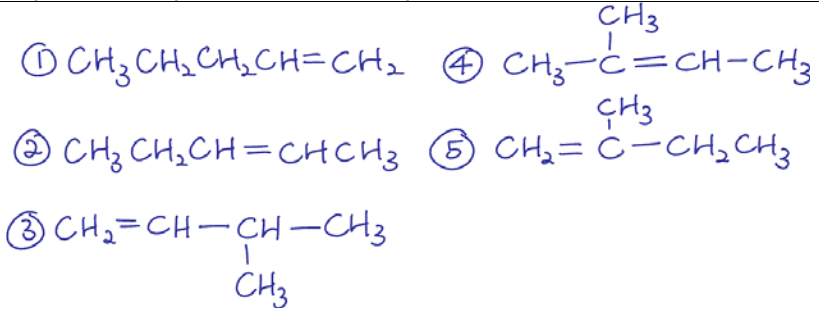
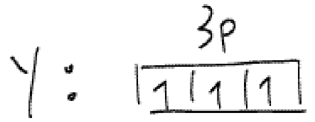
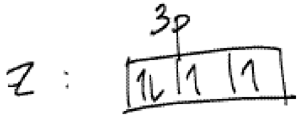
Solution to H1 Paper 2 – Section A

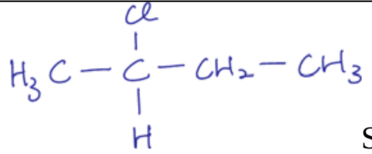
<table>
<tr><td>1a(i)</td><td><table><tr><th></th><th>C</th><th>H</th><th>O</th></tr><tr><td>Mass/g</td><td>26.64</td><td>2.22</td><td>71.14</td></tr><tr><td>No. of moles</td><td>26.64/ 12
= 2.22</td><td>2.22/1
= 2.22</td><td>71.14/16
= 4.45</td></tr><tr><td>Simplest ratio</td><td>1</td><td>1</td><td>2</td></tr></table>empirical formula = CHO_2</td></tr>
<tr><td>(ii)</td><td>no. of mol of NaOH = $\frac{50 \times 2.00}{1000} = 0.100 mol$
no. of mol of dibasic acid = 0.5 × no. of mol of NaOH = 0.0500 mol
M_r = $\frac{4.5}{0.0500} = 90$</td></tr>
<tr><td>(iii)</td><td>Molecular formula = $(CHO_2)_n$
$[12 + 1 + 2(16)]n = 90$
$n = 2$
$\therefore$ Molecular formula is $C_2H_2O_4$</td></tr>
<tr><td>(b)(i)</td><td>$C_2H_2O_4 \rightarrow 2CO_2 + 2H^+ + 2e$</td></tr>
<tr><td>(ii)</td><td>no. of mol of $C_2H_2O_4$ = $\frac{6.75}{90} = 0.075$ mol</td></tr>
<tr><td>(iii)</td><td>$C_2H_2O_4 : MnO_4^- = 5 : 2$
no of mol of MnO_4^- = $\frac{0.075 \times 2}{5} = 0.03$ mol
conc. of MnO_4^- = $\frac{0.03}{\left(25/1000\right)} = 1.2$ mol dm^{-3}</td></tr>
<tr><td>2(a)(i)</td><td>Cl_2O

Shape of molecule: Bent/ V-shaped
Bond angle: 104° or 104.5°</td></tr>
<tr><td>(ii)</td><td>SO_3

Shape of molecule: Trigonal planar
Bond angle: 120°</td></tr>
</table>

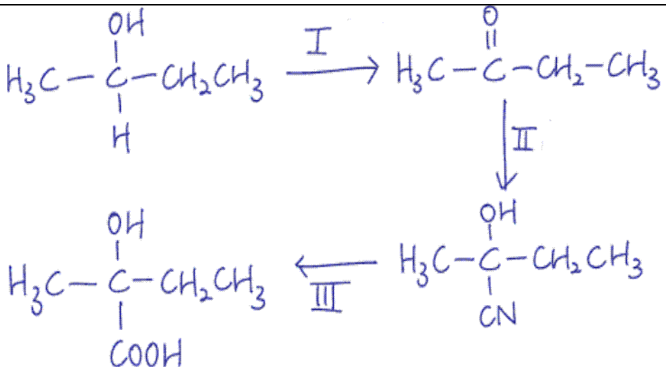
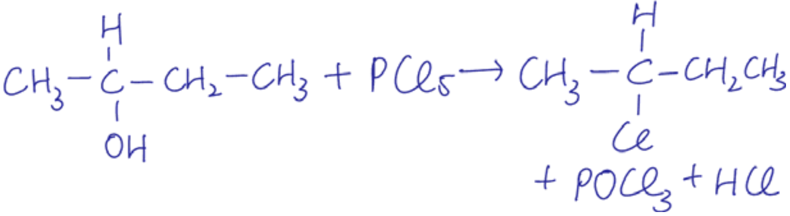
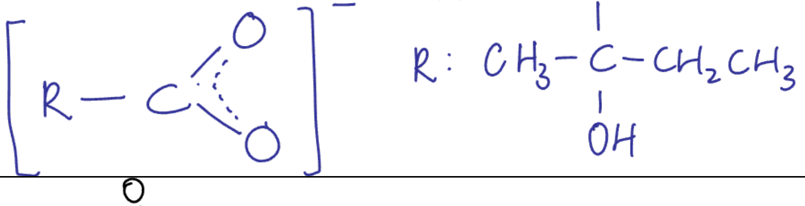
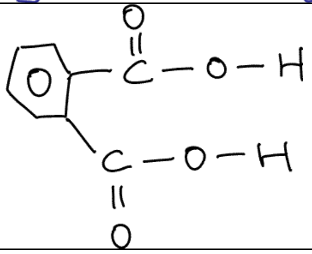
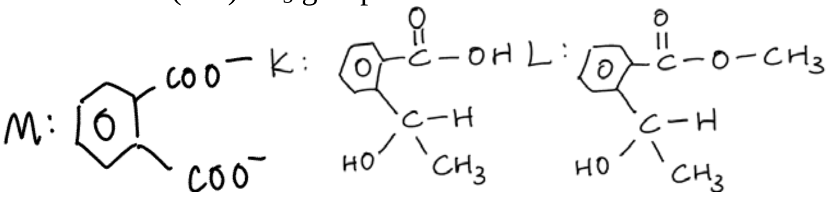
(b)(i)	Silicon oxide is a giant molecule with strong covalent bonds between Si and O atoms. Silicon chloride exists as simple covalent molecules with weak van der Waals' forces between its molecules. More energy is needed to break the covalent bonds than the van der Waals forces, hence silicon oxide has a much higher melting point.
(ii)	The decrease in bond angles is explained by the **decreasing electronegativity** going down the group from oxygen to selenium. As electronegativity decreases, the **bonding pair of electrons are less attracted to the central atom**. This results in **decrease in repulsion between the bond pairs** and hence a **smaller bond angle.**
3(a)(i)	Cracking produces branched chain alkanes in petroleum mixtures as they are more efficient fuels / combustion takes place more efficiently / reduces knocking in engines / prevents the premature explosion of fuels.
(a)(ii)	Reagent: 2,4 dinitrophenylhydrazine Condition: Warm / rtp Observation: Benzaldehyde forms an orange ppt whilst benzene will not form an orange ppt. OR Reagent: $KMnO_4$ Condition: H^+ / heat Observation: Benzaldehyde: Purple colour turns colourless whilst benzene: Purple colour remains. OR Reagent: Tollen's reagent Condition: Warm / rtp Observation: Benzaldehyde forms a silver mirror whilst benzene will not form a silver mirror
(b)	The reaction time in the engine is too short / the engine temperature is too high/knocking occurs in the engine.
(c)	 ① $CH_3CH_2CH_2CH=CH_2$ ② $CH_3CH_2CH=CHCH_3$ ③ $CH_2=CH-\underset{CH_3}{\underset{\mid}{CH}}-CH_3$ ④ $CH_3-\overset{CH_3}{\overset{\mid}{C}}=CH-CH_3$ ⑤ $CH_2=\overset{CH_3}{\overset{\mid}{C}}-CH_2CH_3$ *Other structures may be accepted if structural isomerism is shown. Other types of isomerism is unacceptable.
3(a)	(a) Group III; A*l*
(b)(i)	W^+: $1s^2\ 2s^2\ 2p^6\ 3s^2$; X^+:$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$
(ii)	2nd IE of **X** is lower than that of **W**. 3p is further away from the nucleus compared to 3s. 3p electron is better shielded compared to 3s electron. less energy required to remove 2nd electron from **X**.

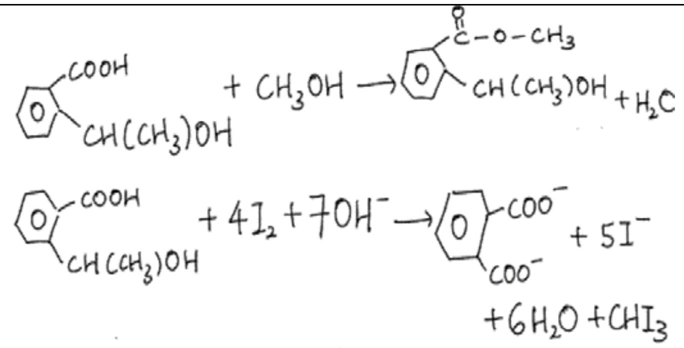
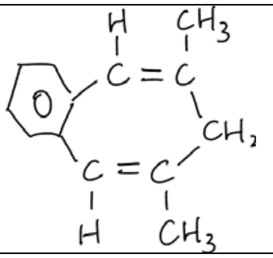
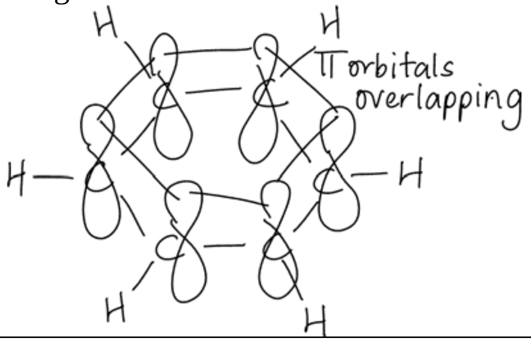
(c)	  The electron to be removed from **Z** experienced interelectronic repulsion.
4(a)(i)	**E**: Na_2O **F**: NaOH Reagent **X**: HC*l* / Cl_2 Reagent **Y**: Cl_2 / HC*l*
(ii)	$Al_2O_3 + 2NaOH + 3H_2O \rightarrow 2NaAl(OH)_4$ Neutralisation
(b) (i)	Both exist as **giant ionic lattice** held by **strong electrostatic forces of attraction between oppositely charged ions**. $LE \propto \left\| \frac{q^+q^-}{r^+ + r^-} \right\|$ q^+, q^- and r^- are the same. **r^+ of KC*l* is larger, hence numerical value of LE is lower**. Less energy is required to break the weaker lattice structure.
(ii)	NaC*l* exists as **giant ionic lattice held by strong electrostatic forces of attraction between oppositely charged ions**. $AlCl_3$ is a **simple covalent molecule with weak van der Waals' forces of attraction**. **VDW weaker than ionic bond**, less energy required.

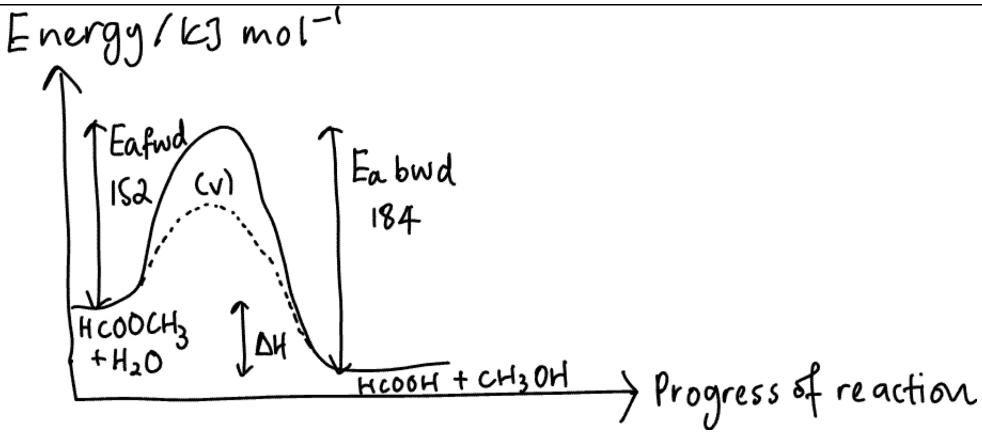
Paper 2 Section B – Answers

6(a)(i)	$K_c = \frac{[HCl]^2}{[H_2][Cl_2]}$
(ii)	$H_2 (g) + Cl_2 (g) \rightleftharpoons 2HCl (g)$ Initial / mol: 0.001, 0.001, 0 Change: -x/2, -x/2, +x Final / mol: 0.001 – x/2, 0.001 – x/2, x Final / M: 0.001 – x/2, 0.001 – x/2, x $K_c = \frac{x^2}{(0.001 - x/2)^2}$ $\sqrt{7.41 \times 10^{-3}} = \frac{x}{(0.001 - x/2)}$ $8.608 \times 10^{-5} - 0.04304 x = x$ $1.04304 x = 8.608 \times 10^{-5}$ $x = 8.25 \times 10^{-5}$ mol dm^{-3} $[HCl] = 8.25 \times 10^{-5}$ mol dm^{-3} $[H_2] = 0.001 - (8.25 \times 10^{-5} / 2) = 9.59 \times 10^{-4}$ mol dm^{-3} $[Cl_2] = 9.59 \times 10^{-4}$ mol dm^{-3}
(iii)	The concentration of HC*l* will not be affected. There will not be any effect on K_c.
(b) (i)	The forward reaction is exothermic. When temperature is increased, the concentration of Z is decreased. Equilibrium shifts to the left to remove the excess heat.

6(b)ii)	When pressure is increased, the concentration of Z is increased. Equilibrium shifts to the right where there is lesser number of gaseous molecules. Hence the products contain a higher number of gaseous molecules.
(c)(i)	Standard enthalpy change of combustion of a substance is the energy released when **1 mole** of the compound is **completely burnt in excess oxygen** under **standard conditions**.
(ii)	$CH_3CH{=}CH_2\,(g) + 9/2\,O_2\,(g) \rightarrow 3\,CO_2\,(g) + 3\,H_2O\,(l)$ * Must have state symbols
6(c)(iii)	Energy absorbed for bond –breaking in reactants = 6(410) + 350 + 610 + 9/2 (496) = + 5652 kJ mol^{-1} Energy released from bond-forming in products = 6(740) + 6(460) = 7200 kJ mol^{-1} Overall, enthalpy change of combustion for propene = -7200 + 5652 = - 1548 kJ mol^{-1}
(d)(i)	Enthalpy change of the reaction = -1548 + (-286) = - 1834 kJ mol^{-1}
(ii)	$\mathbf{\Delta H_1 = \Delta H_2 + \Delta H_3}$ Enthalpy change of the reaction = - 1834 + 2202 = + 368 kJ mol^{-1}
7(a)(i)	$CH_3CH_2\,CH(CH_3)COOH + H_2O \leftrightarrow CH_3CH_2\,CH(CH_3)COO^- + H_3O^+$
(ii)	$K_a = [CH_3CH_2\,CH(CH_3)COO^-][H_3O^+]/[\,CH_3CH_2\,CH(CH_3)COOH]$
(iii)	No. of moles 2-methyl butanoic acid=10/(60+10+32) [2-methyl butanoic acid]= 0.392 mol dm^{-3} $K_a = H_3O^+]^2/[\,CH_3CH_2\,CH(CH_3)COOH]$ $[H_3O^+] = 2.64 \times 10^{-3}$ mol dm^{-3} pH = - log $[H^+]$ = 2.57
(iv)	Colour is red since $[H_3O^+] = 2.64 \times 10^{-3}$ mol dm^{-3}
(b)	$HA + OH^- \rightarrow H_2O + A^-$ The additional OH^- ions are removed by the large concentration of HA which remains largely undissociated in the buffer
7(c)	When pH = 3.0, $[H^+]$ = 0.001 mol dm^{-3} Since $[H^+]$ = [HX]; HX is a strong acid as it fully dissociated.
7(d)(i)	Step I: Reagent: PCl_5 / PCl_3 / $SOCl_2$; Condition: room temperature Step II: Reagent: KCN (alc); Condition: heat Step III: Reagent: $LiAlH_4$; Condition: dry ether
(ii)	 $H_3C-\overset{\overset{Cl}{\vert}}{\underset{\underset{H}{\vert}}{C}}-CH_2-CH_3$ Structure of W

7(d)(iii)	 Step I: $K_2Cr_2O_7$ / HCl (aq) / heat Step II: HCN, NaOH, 10 – 20°C Step III: HCl(aq), heat
e(i)	Equation:  Type of reaction: substitution Observation: white fumes Reagent / condition : PCl_5 / room temperature
(ii)	X behaves as an acid by donating their protons and forming carboxylate ions. The carboxylate ion formed is stabilized by delocalization of the negative charge over the carbon atom and both oxygen atoms. 
8(a)(i)	
8(a)(ii)	• Since K turns damp litmus paper blue, K has a –COOH group • Since K forms a yellow ppt with alkaline aqueous iodine, K has $COCH_3$ or $CH(OH)CH_3$ group.
8(a)(ii)	

	
(b)(i)	
(ii)	Distortion of the ring structure is not feasible / requires to much energy, Q is not able to exhibit geometric isomerism.
8(c)	The benzene ring consists of overlapping pi orbitals above and below the benzene ring which allows electrons to be delocalized Diagram: 
8(d)	It is soluble in polar solvents as benzene-1,2-dicarboxylic acids is a polar molecule that is able to form pd-pd with polar solvents whilst it is soluble in non polar solvents due to the hydrophobic aromatic structure.
8(e)(i)	The order of reaction with respect to a given reactant is defined as the power to which the concentration of that reactant is raised to in the experimentally determined rate equation.
(ii)	• Proper label of axis / plotting and 2 consistent half lives shown on the graph. • $T_{1/2}$ = 15 minutes • $T_{1/2} = \ln 2/k$, Hence k = 10.4 min^{-1}
(iii)	The hydrolysis was carried out in the presence of excess acid to ensure that the rate of reaction will be independent of the acid / zero order with respect to the acid.

(iv)	 $\Delta H = -32$ kJ mol^{-1}
(v)	(See diagram in (iv))