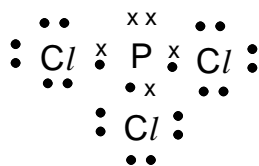
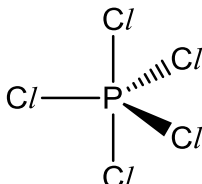


## 2015 MJC Prelim H1 Paper 2 Suggested Answers

1 (a)(i)



(ii)



(b) Both  $\text{PCl}_3$  and  $\text{PCl}_5$  have simple molecular structure.

Size of electron cloud:  $\text{PCl}_3 < \text{PCl}_5$

Extent of polarisation of electron cloud:  $\text{PCl}_3 < \text{PCl}_5$

Extent of van der Waals' forces between molecules:  $\text{PCl}_3 < \text{PCl}_5$

Energy required to break forces between molecules:  $\text{PCl}_3 < \text{PCl}_5$

Boiling point:  $\text{PCl}_3 < \text{PCl}_5$

(c) (i). Rate of forward reaction = the rate of reverse reaction.

$$(ii) \quad K_c = \frac{[\text{PCl}_3][\text{Cl}_2]}{[\text{PCl}_5]} \text{ mol dm}^{-3}$$

$$(iii) \quad K_c = \frac{(0.1016)(0.1016)}{(0.0984)} = 0.105 \text{ mol dm}^{-3}$$

(iv) When volume is decreased, pressure is increased. The equilibrium position shifts to the left to reduce number of mole of gas to decrease pressure. When pressure increased, concentration of reactant particles increases and particles are closer to each other. Frequency of effective collision of reactant particles increases so rate of reaction increases.

(v) Reduction is due to oxidation number of P decrease from +5 in  $\text{PCl}_5$  to +3 in  $\text{PCl}_3$ . Oxidation is due to oxidation number of Cl increases from -1 in  $\text{PCl}_5$  to 0 in  $\text{Cl}_2$ .

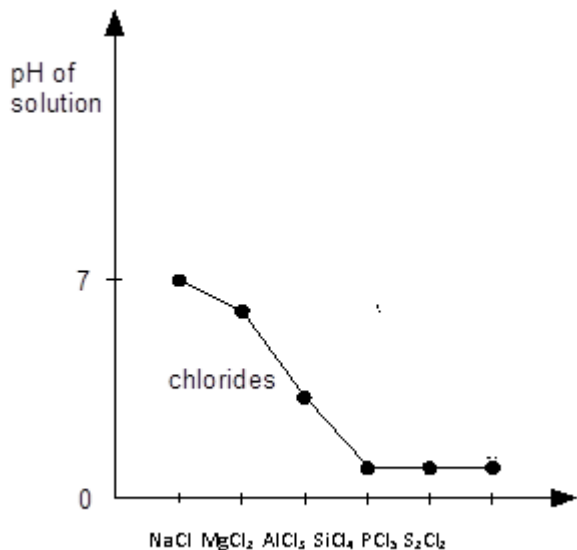
2(a)(i)  $\text{Al (g)} \rightarrow \text{Al}^+ \text{(g)} + \text{e}$

(ii) Across the period, increase in nuclear charge outweighs negligible increase in screening effect. Effective nuclear charge increases across the period. Stronger

electrostatic attraction between nucleus and first valence electrons. First ionisation energy generally increases.

- (iii) .The 3p electron in Al is further away from the nucleus than the 3s electron in Mg.

(b)(i)



- (bii)  $\text{SiCl}_4 + 2\text{H}_2\text{O} \longrightarrow \text{SiO}_2 + 4\text{HCl}$   
 $\text{PCl}_5 + 4\text{H}_2\text{O} \longrightarrow \text{H}_3\text{PO}_4 + 5\text{HCl}$

(ci)

BeO	Na <sub>2</sub> O	Al <sub>2</sub> O <sub>3</sub>	SO <sub>2</sub>
1.87	2.52	1.83	0.86

- (ii) 1. giant ionic lattice structure with strong electrostatic force between oppositely charged ions  
 2. amphoteric

- (iii)  $\text{Al}_2\text{O}_3 + 6\text{HCl} \rightarrow 2\text{AlCl}_3 + 3\text{H}_2\text{O}$   
 $\text{Al}_2\text{O}_3 + 2\text{NaOH} + 3\text{H}_2\text{O} \rightarrow 2\text{NaAl(OH)}_4$

3(a)(i)  $\Delta H_{\text{rxn}} = [2(350) + 610 + 8(410) + 2(460)] - [3(350) + 360 + 460 + 9(410)]$   
 $= -50 \text{ kJ mol}^{-1}$

- (ii) The bond energies from the *Data Booklet* are average values.

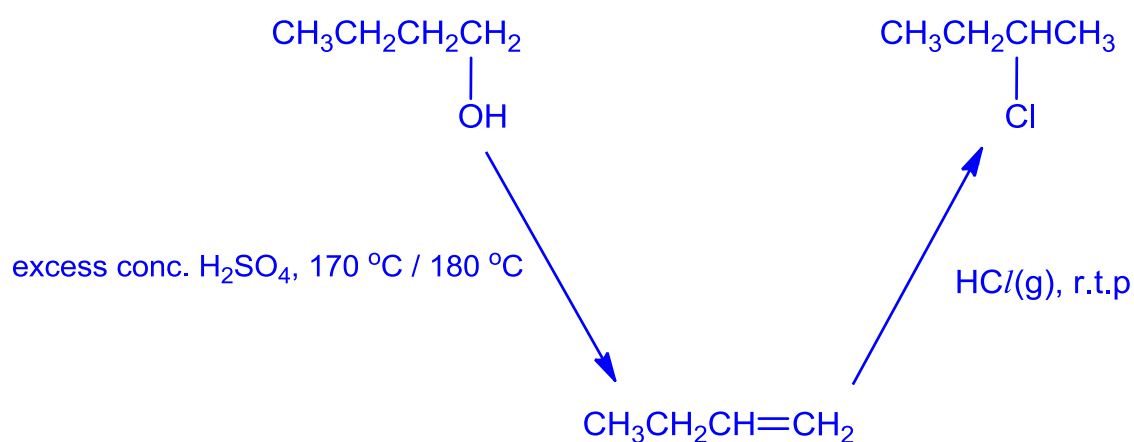
(bi) No. of moles of butan-1-ol =  $\frac{0.972}{74.0} = 0.01314 \text{ mol}$   
 Quantity of heat absorbed by water = 20482 J

$$\text{Quantity of heat released by reaction} = \frac{100}{80} \times 20482 \text{ J}$$

$$\Delta H_c(\text{butan-1-ol}) = - \frac{25602.5}{0.01314} = -1950 \text{ kJ mol}^{-1}$$

- (ii) The process is not 100% efficient. Some of the heat released by the combustion of butan-1-ol is lost to the surrounding.
- (c) Add aqueous iodine in sodium hydroxide to each alcohol respectively and heat.  
 Yellow ppt of tri-iodomethane,  $\text{CHI}_3$ , is observed for the secondary alcohol.  
 No yellow ppt is observed for butan-1-ol.

(d)



## Section B : Free Response Questions

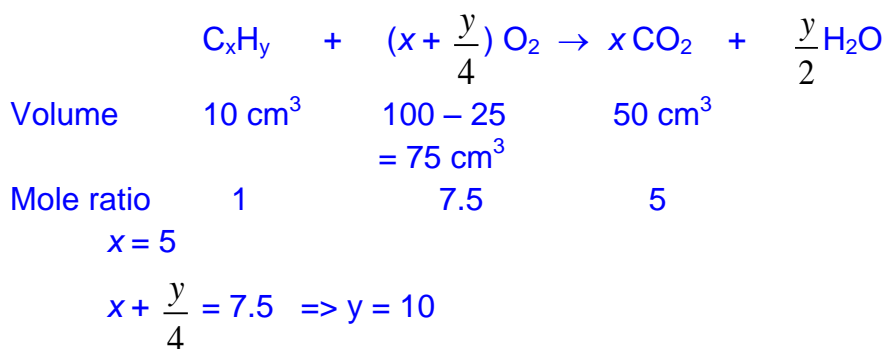
- 4 (ai) Starting material to synthesize polypropene (used as plastic in food containers).
- (ii) Carbon monoxide causes blood poisoning which prevents transport of oxygen by haemoglobin. Unburnt hydrocarbon causes photochemical smog.

(b)

	C	H
Percentage	82.8%	17.2%
Divide by Ar	$82.8/12 = 6.9$	17.2
Simplest ratio	2	5

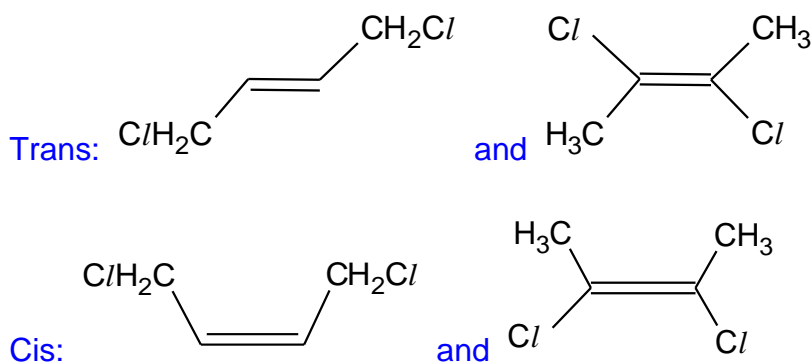
Empirical formula =  $C_2H_5$ Molecular formula of T is  $C_4H_{10}$ .

(c)

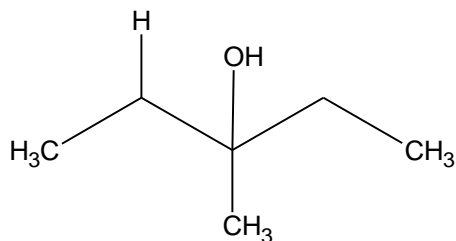
Molecular formula of fragment W is  $C_5H_{10}$ .

(d)(i) Ultraviolet light

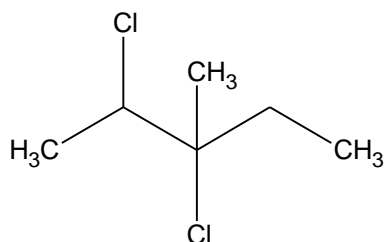
(ii)



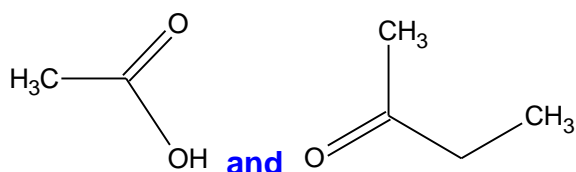
(e)(i)



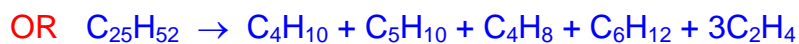
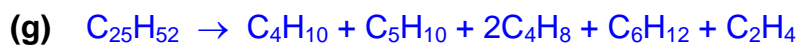
(ii)



(iii)



(f) Angle of deflection for  $\text{C}_2\text{H}_4^- = -(4 \div \frac{3}{52}) \times \frac{1}{28} = -2.5^\circ$



5(ai) To slow down / stop the reaction while preparing for titration.

(iii) |Gradient| of reaction 1 =  $\frac{20}{44} = 0.455$

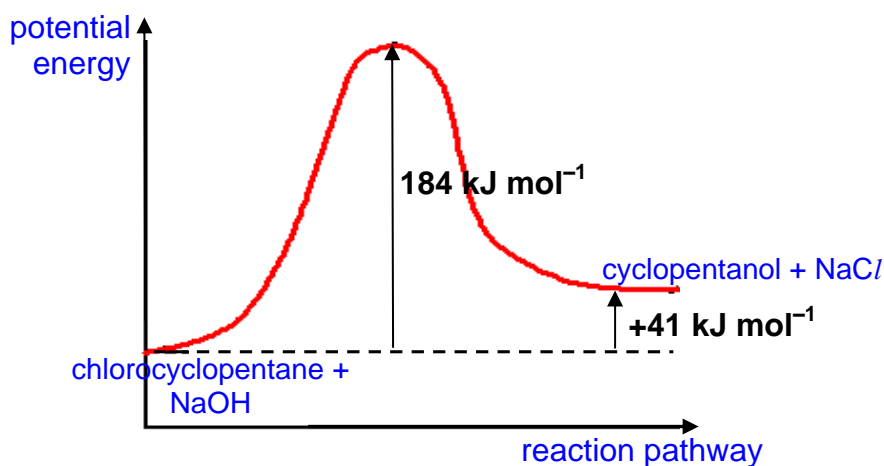
|Gradient| of reaction 2 =  $\frac{20}{83} = 0.241$

Since [chlorocyclopentane] doubles, rate of reaction doubles, order of reaction w.r.t chlorocyclopentane is 1. Order of reaction w.r.t.  $\text{OH}^-$  is 1 since reaction 1 has a constant half-life of 30 s.

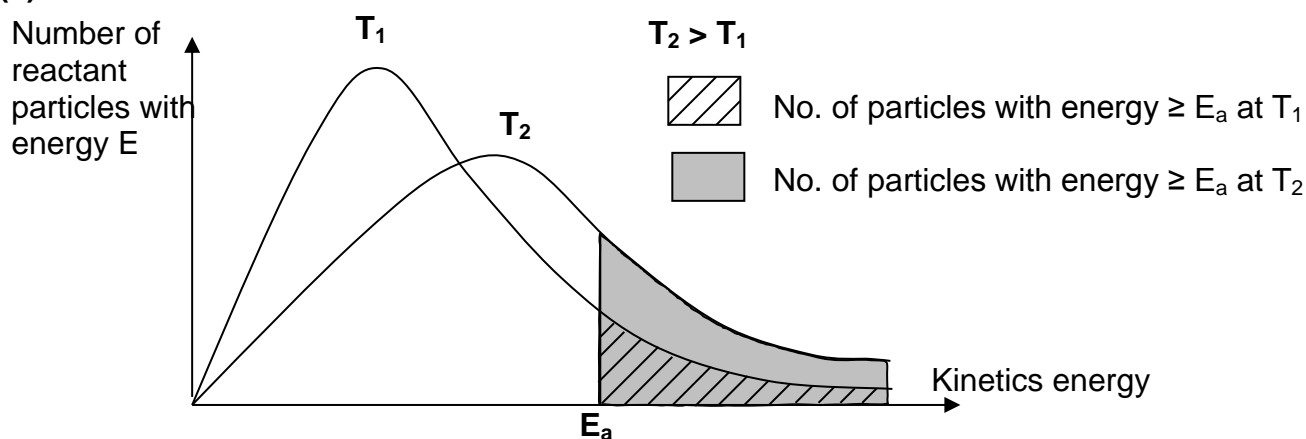
(iv) No change

(v) Mechanism 1, because the order of reaction for each of NaOH and chlorocyclopentane is 1.

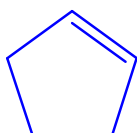
(b)(i)



(ii)



(c)(i)



(ii)

Step I – alcoholic NaOH, heat  
 Step II – Br<sub>2</sub> in CCl<sub>4</sub>, r.t.p.

(iii)

Heat each compound with aqueous NaOH followed by the addition of excess dilute HNO<sub>3</sub> and lastly, add in AgNO<sub>3</sub>(aq). If a white ppt of AgCl is formed, the compound is J. If a cream ppt of AgBr is formed, the compound is L.

(iv)

- 1 BrCH<sub>2</sub>CH<sub>2</sub>OH
- 2 Substitution reaction

6(a)(i) Concentration of NaOH in g dm<sup>-3</sup> =  $\frac{0.70}{10} = 0.070 \text{ g dm}^{-3}$

Concentration of NaOH in mol dm<sup>-3</sup> =  $\frac{0.070}{23 + 16 + 1} = 1.75 \times 10^{-3} \text{ mol dm}^{-3}$

(ii) No. of moles of NaOH needed for neutralisation =  $\frac{40.0}{1000} \times 1.75 \times 10^{-3}$

No. of moles of tartaric acid =  $3.50 \times 10^{-5}$  mol

Concentration of tartaric acid =  $3.50 \times 10^{-5} \div \frac{25.0}{1000} = 1.40 \times 10^{-3} \text{ mol dm}^{-3}$

- (iii) The pH transition range of methyl orange does not lie within the range of rapid pH change over the equivalence point.

(b)(i)  $K_a = \frac{[\text{H}^+][\text{C}_4\text{H}_5\text{O}_6^-]}{[\text{C}_4\text{H}_6\text{O}_6]}$

(ii)

	$\text{C}_4\text{H}_6\text{O}_6(\text{aq}) \rightleftharpoons \text{C}_4\text{H}_5\text{O}_6^-(\text{aq}) + \text{H}^+(\text{aq})$		
Initial conc	2	0	0
Change in conc	$-0.1 \times 2 = -0.2$	+0.2	+0.2
Equilibrium conc	1.8	0.2	0.2

$K_a = [0.2]^2 / 1.8 = 0.0222 \text{ mol dm}^{-3}$

- (c) A buffer solution is a solution which resists changes in pH when a small amount of acid and base is added to it.

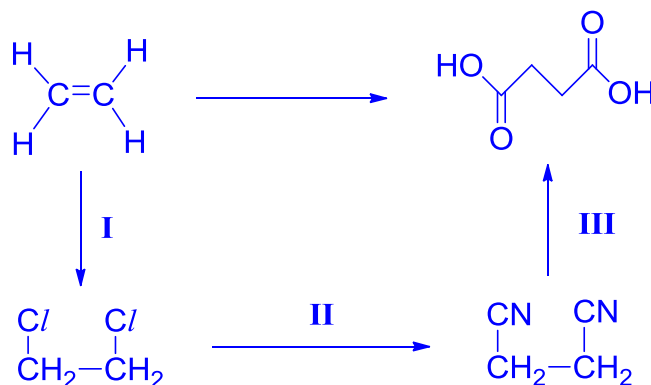
When a small amount of acid,  $\text{H}^+$  is added,



When a small amount of base,  $\text{OH}^-$  is added,



- (d) Step I:  $\text{Cl}_2$  in  $\text{CCl}_4$  or  $\text{Cl}_2(\text{g})$ , r.t.p in the dark  
 Step II: ethanolic KCN, heat  
 Step III:  $\text{HCl}(\text{aq})$  or  $\text{H}_2\text{SO}_4(\text{aq})$ , heat



- (e) Acetoin undergoes condensation with 2,4-DNPH,  
 → Acetoin has ketone or aldehyde group.

Acetoin undergoes oxidation with alkaline iodine.

→ Acetoin has the  $\text{-COCH}_3$  and/or  $\text{CH}_3\text{CH(OH)-}$  structure.

After acetoin undergoes oxidation with  $\text{KMnO}_4/\text{H}^+$ , product of acetoin did not undergo neutralisation reaction with  $\text{Na}_2\text{CO}_3$ .

→ Product of oxidation did not have carboxylic acid group.

→ Acetoin has  $2^\circ$  alcohol group.

E undergoes neutralisation reaction with  $\text{Na}_2\text{CO}_3$ .

→ E has carboxylic acid group.

E undergoes substitution with bromine under UV light to give 2 monobromo compounds.

→ E contains 2 types of H atom for substitution.

