2013 MJC H1 Suggested Answers

Section A: Structured Questions

1(a) (i) Percentage abundance of Te-130
= 34.48

Isotopic mass x % abundance of Te-128
= 4069

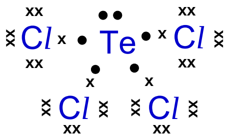
Isotopic mass x % abundance of Te-130
= 4482

Relative atomic mass of Te

= 127.7

(ii) There is inter-electron repulsion between the paired electrons in the 5p orbital of Te.

(b) (i)



(ii) There are 4 bond pairs and 1 lone pair around Te atom.
To minimise repulsion, the 5 electron pairs are directed to the corners of a trigonal bipyramid.

Since lone pair-bond pair repulsion > bone pair-bond pair repulsion, the shape of $TeCl_4$ is distorted tetrahedral.

(iii) Te has empty and energetically assessible 5d orbitals to accept electrons and expands its octet structure.

(c) $TeCl_4$ undergoes complete hydrolysis to form strongly acidic solutions with pH= 2

$TeCl_4 + 2H_2O \rightarrow TeO_2 + 4HCl$

$AlCl_3$ undergoes hydration and slight hydrolysis to form an acidic solution with pH=3.0

$AlCl_3\ (s) \xrightarrow{H_2O} Al^{3+}\ (aq) + 3Cl^-\ (aq)$

$[Al(H_2O)_6]^{3+} \rightleftharpoons [Al(H_2O)_5(OH)]^{2+} + H^+$

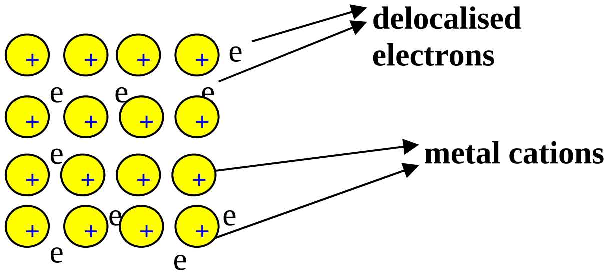
2(a) (i) W. It has the highest $\frac{q^+}{r^+}$ value

(ii) V (or Cr or W)

(b) Adding carbon atoms into the space between the iron atoms in the lattice will prevent the iron atoms from sliding over each other easily and hence do not go out of shape easily.

(c) Cr forms an oxide layer and prevents oxygen from reacting with the iron.

(d) Metallic bonds are strong electrostatic forces of attraction between the cations and sea of delocalised electrons in a giant metallic lattice structure.



(e) (i) FeO_4^{2-}
-0.4 to -0.6V

(ii) $6e + 5H_2O + 2FeO_4^{2-} \rightarrow Fe_2O_3 + 10OH$

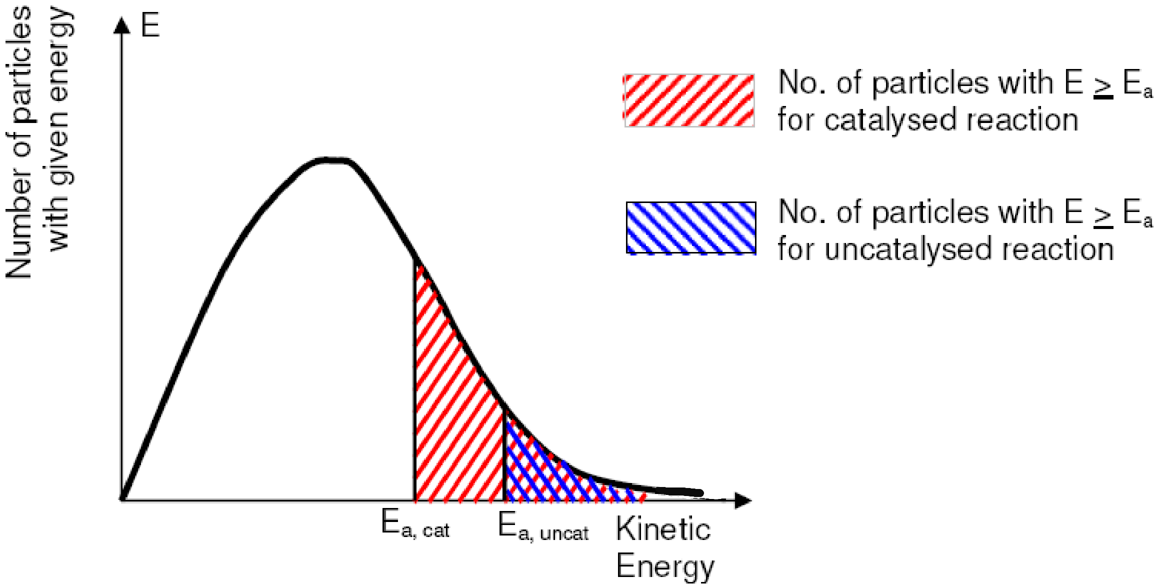
(f) (i) No of moles of I^-= 1.293 x 10^{-2}
No of mole of Fe^{3+} = 1.29x 10^{-2}

(ii) $x = 3$.

(iii) +2 and +3

(g)

Maxwell-Boltzmann Distribution Curve



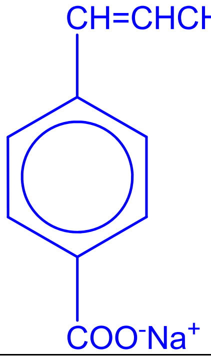
E_a is lowered due to an alternative reaction pathway.

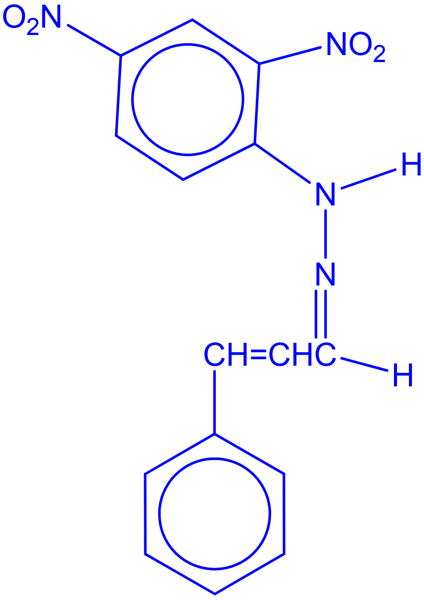
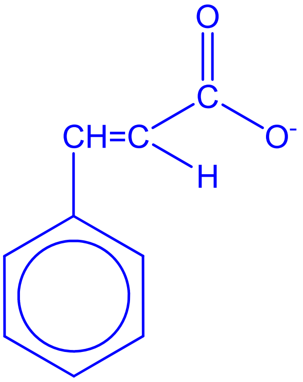
Number of reactant particles with E ≥ Ea increases.

Frequency of effective collisions increases.

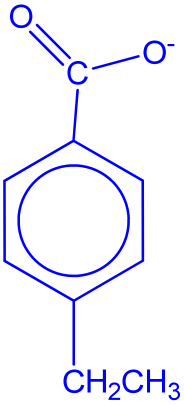
Rate of reaction is proportional to frequency of effective collisions.

3(a)

Reagent	Compound A, B or C	Structural formula of the organic product
Na_2CO_3 (aq)	C	

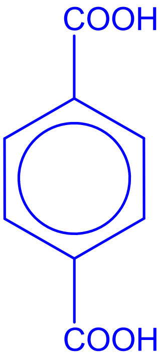
2,4-DNPH	A	
Tollens' reagent	A	

(b)(i)

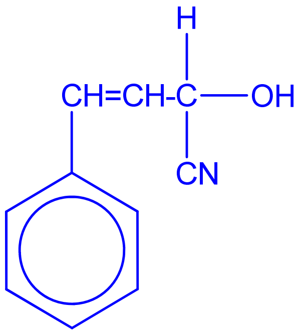


CHI_3

(ii)



(c)(i)



D

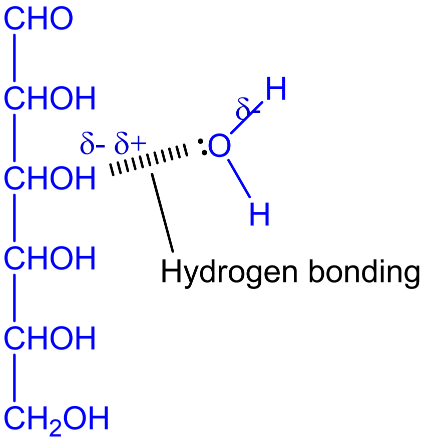
(ii) Step I

HCN Conditions: trace amount of NaOH or NaCN, cold

Step II

Dilute H_2SO_4 heat

(d)



Section B: Free Response Questions C

4(a) Standard enthalpy change of formation is the energy change when one mole of product is formed from its elements at 298K and 1 atm.

(b) ΔH_c (*ETBE*) = -3.75×10^3 kJ mol^{-1}

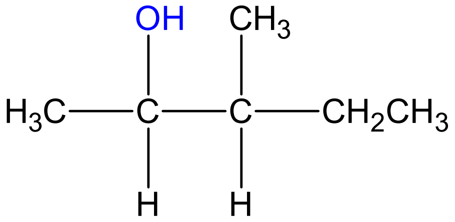
(c) -610 kJ mol^{-1}

(d) In the internal combustion engine, where the temperature is very high, nitrogen react with oxygen in the air to form nitrogen oxide. Nitrogen oxides cause acid rain.

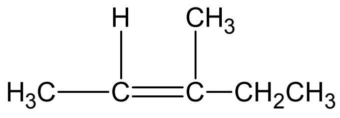
(e)(i) K has a molecular formula of $C_6H_{14}O$

K undergoes oxidation with warm alkaline iodine. K contains the structure CH_3-CH(OH)

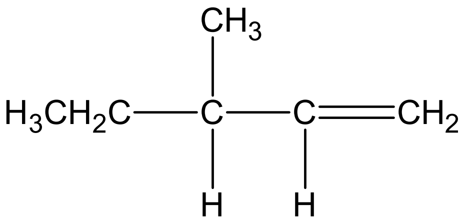
K undergoes acid-metal displacement with sodium. K is an alcohol
K undergoes elimination to give alkenes L and M.
L undergoes oxidation with acidified $KMnO_4$ to produce N. N is a carbonyl compound.
Since N undergoes condensation with 2,4-DNPH, but does not undergo oxidation with Tollen's reagent,N is not an aldehyde or is a ketone


$CH_3CH(OH)CH(CH_3)CH_2CH_3$

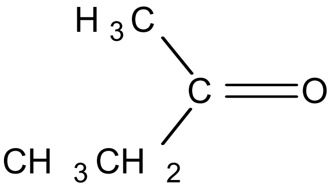
K


$CH_3CH=C(CH_3)CH_2CH_3$

L


$CH_3CH_2CH(CH_3)CH=CH_2$

M



N

(ii) Functional group isomerism.

(f) MgO is a basic oxide.
$MgO + 2H^+ \longrightarrow Mg^{2+} + H_2O$

P_4O_{10} is an acidic oxide.
$P_4O_{10} + 12OH^- \longrightarrow 4PO_4^{3-} + 6H_2O$

Al_2O_3 is an amphoteric oxide.
$Al_2O_3 + 6H^+ \longrightarrow 2\ Al^{3+} + 3H_2O$

$Al_2O_3 + 2OH^- + 3H_2O \longrightarrow 2[Al(OH)_4]^-$

The in-between behavior of Al_2O_3 is due to the high charge density of Al^{3+} ion polorising the O^{2-} anion hence resulting in partial covalent nature of Al-O interaction.

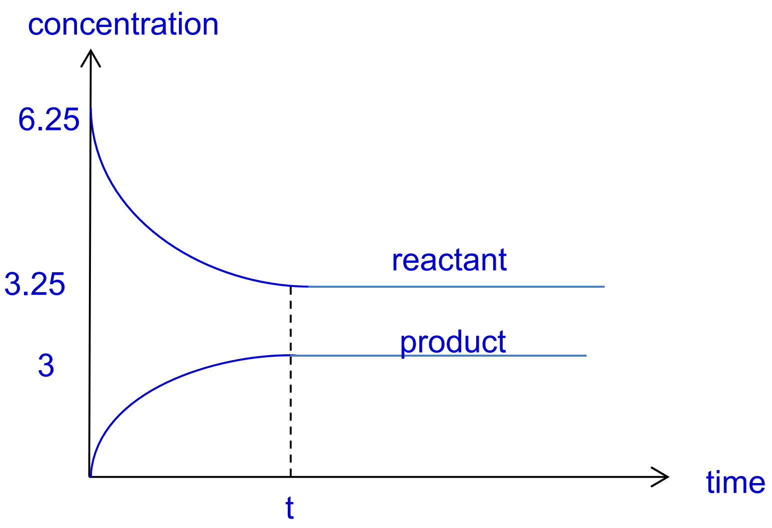
5(a) $$K_c = \frac{[CH_3CH_2CH_2CHO]}{[CH_3CH=CH_2][CO][H_2]}$$ Unit: $mol^{-2}\ dm^6$

(b)(i)

	$CH_3CH{=}CH_2$	+ CO	+ H_2	⇔ $CH_3CH_2CH_2CHO$
Initial conc / mol dm^{-3}	6.25	6.25	6.25	0
Change in conc / mol dm^{-3}	-3	-3	-3	+3
Final conc / mol dm^{-3}	**3.25**	**3.25**	**3.25**	**3.00**

(ii) **0.0874 mol^{-2} dm^{6}**

(iii)



(iv) -137 kJ mol^{-1}

(v) By Le Chatelier's Principle, an increase in temperature would cause the equilibrium position to shift to the left towards the endothermic reaction to absorb heat.

The formation of butanal is not favoured.

(c) (i) Reaction II: $KMnO_4$, H_2SO_4 (aq), heat
Or $K_2Cr_2O_7$, H_2SO_4 (aq), heat

Reaction III: $LiAlH_4$ in dry ether, r.t.p.
Or $NaBH_4$ in ethanol, r.t.p.

(ii) Reagents & conditions: PCl_5, r.t.p. (absence of water)

Reagents & conditions for step 1: Conc H_2SO_4 at 180 °C

Reagents & conditions for step 2: HCl gas, r.t.p.

(d) (i) Bond strength: C-C*l* bond > C-I bond .Bond energy: C-I < C-C*l*

(ii) Heat each mixture with aqueous NaOH followed by the addition of dilute HNO_3 and $AgNO_3$(aq).If a white ppt of AgC*l* is formed, the compound is 2-chlorobutane

$CH_3CH(Cl)CH_2CH_3 + NaOH \longrightarrow CH_3CH(OH)CH_2CH_3 + Na^+ + Cl^-$

$Ag^+ + Cl^- \longrightarrow AgBr$

(e) 3 : 2.

6(a) (i) 0.0960 mol dm^{-3}

(ii) 1.72×10^{-4} mol dm^{-3}

(iii) No. Since this is a strong base – weak acid titration, the pH at equivalence point is basic. The pH transition range of chlorophenol red does not lie within the range of rapid pH change over the equivalence point.

(iv)

When a small amount of acid, H^+ is added:

$CH_3CH(OH)COO^- + H^+ \rightarrow CH_3CH(OH)COOH$

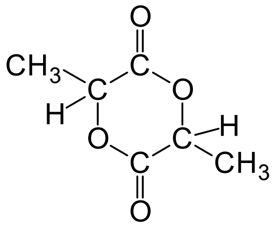
The added H^+ is removed as CH_3 CH(OH)COOH. Hence pH remains fairly constant

When a small amount of base, OH^- is added:

$CH_3CH(OH)COOH + OH^- \rightarrow CH_3CH(OH)COO^- + H_2O$

The added OH^- is removed as $CH_3CH(OH)COO^-$ and H_2O. Hence pH remains fairly constant

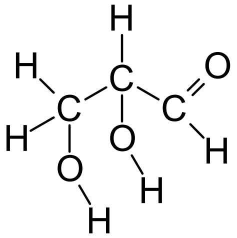
(b) D does not undergo acid-metal displacement with Na hence does not contain an alcohol or carboxylic acid group.
Lactic acid undergoes self- esterification to form D with no of C atoms doubled hence D is a diester.



(c) (i) E undergoes oxidation with Fehling's solution. E is an aliphatic aldehyde.

E Ξ H_2 There are two alcohol groups.
One mole of E undergoes substitution with two moles of PCl_5. There are two alcohol groups.

E is



(ii) In the carboxylate anion, the negative charge is delocalised over the 2 O atoms. Thereby stabilising the carboxylate ion relative to lactic acid

(d) (i) Cis-trans isomerism arises when rotation of a double bond is restricted due to the presence of π bond It also arises since different substituent groups are bonded to each C atom of the C=C bond.

(ii) Due to the proximity of the two –COOH groups, cis-somer is capable of intramolecular hydrogen bonding. Hence the cis-isomer possesses less extensive intermolecular hydrogen bonding.

Since more energy is required to overcome the more extensive hydrogen bonds between the trans-butenedioic acid molecules, Trans-butenedioic acid has a higher boiling point.