	Class	Reg Number
Candidate's Name: ____________________________		

MERIDIAN JUNIOR COLLEGE
JC 2 Preliminary Examination
Higher 1

Chemistry

8872/01

22 September 2017

Paper 1 Multiple Choice

50 minutes

Additional Materials: OMR Sheet and *Data Booklet*

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number in the spaces provided at the top of this page.

There are **thirty** questions in this section. Answer **all** questions. For each question, there are four possible answers labelled **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in soft pencil on the OMR answer sheet.

Read very carefully the instructions on the use of OMR answer sheet.

You are advised to fill in the OMR Answer Sheet as you go along; no additional time will be given for the transfer of answers once the examination has ended.

Use of OMR Answer Sheet

Ensure you have written your name, class register number and class on the OMR Answer Sheet.

Use a **2B** pencil to shade your answers on the ***OMR sheet***; erase any mistakes cleanly. Multiple shaded answers to a question will not be accepted.

For shading of class register number on the ***OMR sheet***, please follow the given examples:
If your register number is **1**, then shade **01** in the index number column.
If your register number is **21**, then shade **21** in the index number column.

This document consists of **13** printed pages

Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

1 *Use of the Data Booklet is relevant to this question.*

The relative abundances of the isotopes of a sample of zirconium are shown in the table below.

relative isotopic mass	90	91	92	94	96
relative abundance (%)	51.3	11.3	17.2	17.4	2.8

What is the relative atomic mass of zirconium in this sample?

A 91.21

B 91.22

C 91.31

D 91.32

2 Hydrocarbon **E** consists of ~~84.3~~ 85.7% carbon. What could hydrocarbon **E** be?

A hexane

B hexene

C cyclohexene

D benzene

3 When 7.5×10^{-3} mole of gaseous chlorine at room temperature and pressure is reacted with 50 cm^3 hot excess aqueous sodium hydroxide, the following reaction occurs.

$$3Cl_2\,(g) + 6OH^-\,(aq) \rightarrow 5Cl^-\,(aq) + ClO_3^-\,(aq) + 3H_2O\,(l)$$

The resulting solution is diluted to 250 cm^3. It was found that 25.0 cm^3 of this resulting solution required 21.00 cm^3 of 0.10 mol dm^{-3} aqueous hydrochloric acid for complete reaction.

What is the initial concentration of the hot aqueous sodium hydroxide used?

A 0.12 mol dm^{-3}

B 0.36 mol dm^{-3}

C 0.57 mol dm^{-3}

D 0.72 mol dm^{-3}

4 Ions of vanadium with different oxidation states can exhibit various colours as shown in the following table.

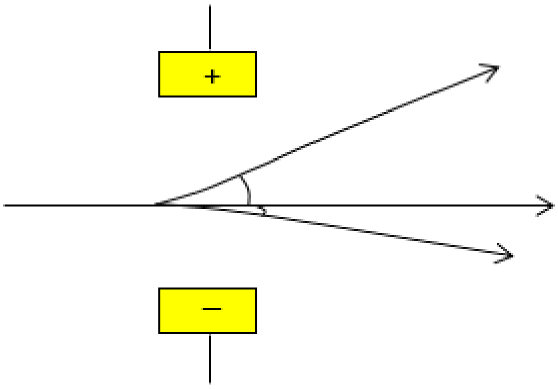
Ions	V^{2+}	V^{3+}	VO^{2+}	VO_2^+	VO_3^-
Colours	violet	green	blue	yellow	yellow

A sample of 0.015 mole of zinc powder reacts exactly with 0.010 mole ammonium vanadate(V), NH_4VO_3.

What is the final colour seen for the solution?

A violet **B** green **C** blue **D** yellow

5 A beam of particles containing $^{27}Al^{2+}$, ^{35}Cl atoms and $^{35}Cl^{3-}$ was passed through an electric field. The angle of deflection for $^{35}Cl^{3-}$ is 4.5°.



Which of the following statements is correct?

A Both ^{35}Cl atoms and $^{35}Cl^{3-}$ ions will deflect towards the positive terminal.

B The ^{35}Cl atoms will deflect towards both the positive and negative terminals.

C The $^{27}Al^{2+}$ ions have an angle of deflection of 3.9°.

D The $^{27}Al^{2+}$ ions will have a larger angle of deflection than $^{35}Cl^{3-}$ ions.

6 Which of the following statements is true for Cr^+?

A There are a total of six p orbitals being occupied.

B There are a total of three d orbitals being occupied.

C There are a total of four s subshells being occupied.

D There are a total of seven s, p and d subshells being occupied.

7 Four substances **F**, **G, H** and **I** have physical properties as shown.

substance	melting point/ °C	boiling point/ °C	electrical conductivity	
			of solid	of liquid
F	17	45	Poor	Poor
G	64	759	Good	Good
H	1132	1950	Poor	Good
I	3550	3825	Good	Unknown

What could be the identities of **F**, **G**, **H** and **I**?

	F	**G**	**H**	**I**
A	PCl_5	SO_3	Na_2O	Al_2O_3
B	PCl_5	Al_2O_3	K	Na_2O
C	SO_3	PCl_5	C (graphite)	Na_2O
D	SO_3	K	Na_2O	C (graphite)

8 Which pair of compounds below satisfy the following conditions?

- The first compound has a larger bond angle than the second compound.
- The first compound is more polar than the second compound.

	first compound	second compound
A	NF_3	SF_6
B	$AlCl_3$	PCl_3
C	CO_2	SO_2
D	ICl_5	PCl_5

9 The enthalpy changes for two reactions are given below.

$$2Cr\,(s) + \frac{3}{2}O_2\,(g) \rightarrow Cr_2O_3\,(s) \qquad \Delta H_f = -1120 \text{ kJ mol}^{-1}$$

$$C\,(s) + \frac{1}{2}O_2\,(g) \rightarrow CO\,(g) \qquad \Delta H_f = -110 \text{ kJ mol}^{-1}$$

What is the quantity of heat absorbed when 19.2 moles of chromium is obtained from the reduction of chromium(III) oxide using excess carbon?

$$3C\,(s) + Cr_2O_3\,(s) \rightarrow 2Cr\,(s) + 3CO\,(g)$$

A 82 kJ

B 7 580 kJ

C 15 200 kJ

D 22 800 kJ

10 In aqueous solution, dichromate (VI) ions exist in equilibrium with chromate (VI) ions.

$$\underset{\text{orange}}{Cr_2O_7^{2-}(aq)} + H_2O\,(l) \rightleftharpoons \underset{\text{yellow}}{2CrO_4^{2-}(aq)} + 2H^+(aq) \qquad \Delta H > 0$$

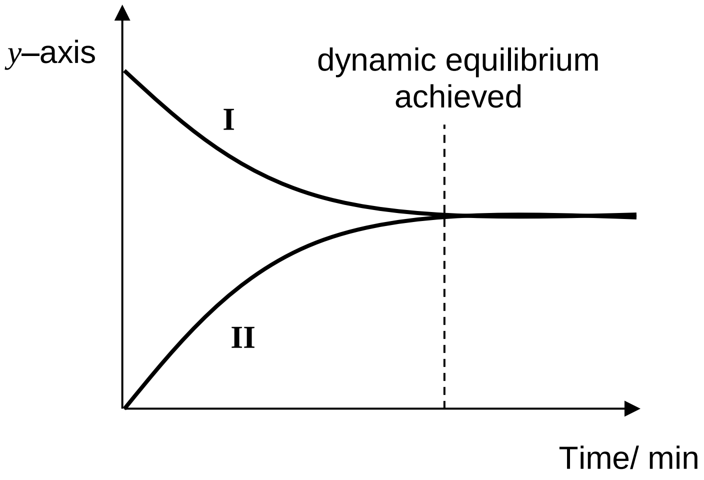
What is the colour of the solution under the following conditions?

	high temperature	high pH
A	yellow	orange
B	yellow	yellow
C	orange	yellow
D	orange	orange

11 At 250 °C, NOC*l* readily dissociates into NO and C*l*$_2$.

$$2\,NOCl\,(g) \rightleftharpoons 2\,NO\,(g) + Cl_2\,(g)$$

The following plot is obtained during the dissociation of NOC*l*.



Which of the following best describes the *y*–axis and the labels **I** and **II**?

	y–axis	**I**	**II**
A	concentration	[NOC*l*]	[NOC*l*] + [C*l*$_2$]
B	concentration	[NOC*l*] + [C*l*$_2$]	[NOC*l*]
C	rate	rate of forward reaction	rate of backward reaction
D	rate	rate of backward reaction	rate of forward reaction

12 The reaction between concentrated sulfuric acid and concentrated nitric acid occurs in the following steps.

$$H_2SO_4 + HNO_3 \rightleftharpoons HSO_4^- + H_2NO_3^+$$
$$H_2NO_3^+ \rightleftharpoons H_2O + NO_2^+$$
$$H_2O + H_2SO_4 \rightleftharpoons HSO_4^- + H_3O^+$$

Which of the following species is a conjugate acid in these reactions?

A $H_2NO_3^+$

B HSO_4^-

C NO_2^+

D H_2O

13 Some data on two acid–base indicators are shown in the table below:

Indicator	Approximate working range	Colour in	
		Acid	Alkali
methyl orange	3.2 – 4.4	red	yellow
cresol red	7.5 – 8.8	yellow	purple

Which one of the following conclusions can be drawn about a solution in which both methyl orange and cresol red is yellow?

A It is weakly acidic.

B It is weakly basic.

C It is neutral.

D No conclusion can be drawn.

14 Elements **X** and **Y** react vigorously with chlorine to form compounds **P** and **Q** respectively. Element **Z** reacts slowly with chlorine to form compound **R**.

When dissolved in water, **P** gives a neutral solution while **R** gives a strongly acidic solution. **Q** reacts with a few drops of water to give off white fumes and a white solid.

Given that elements **X**, **Y** and **Z** are Period 3 elements, what are the possible identities for **X**, **Y** and **Z**?

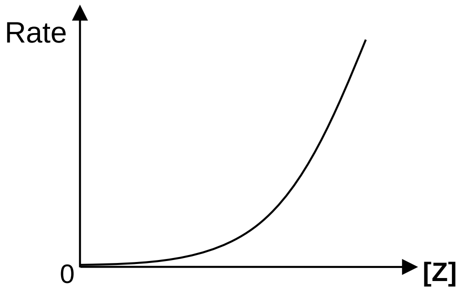
	X	**Y**	**Z**
A	Na	A*l*	P
B	Na	Si	P
C	Mg	A*l*	P
D	Mg	Si	A*l*

15 The rate equation for the following reaction is rate = k[**Y**]^2[**Z**].

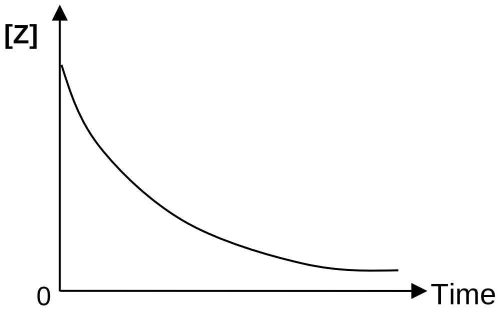
$$\mathbf{X}(aq) + 2\mathbf{Y}(aq) + \mathbf{Z}(aq) \rightarrow 2\mathbf{W}(aq) + \mathbf{U}(aq)$$

Which of the following graphs is correct when **Y** is in large excess?

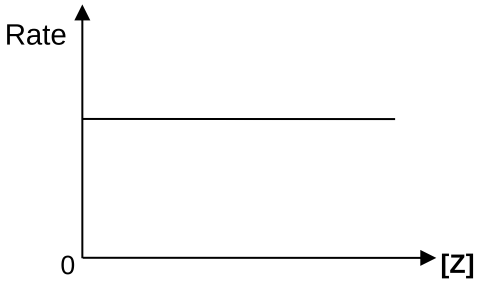
A



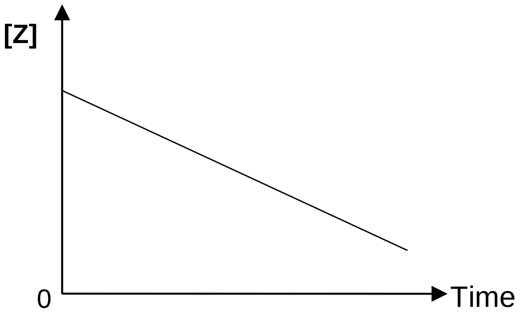
B



C



D



16 **L** and **M** are Period 3 elements. **M** has a larger atomic number than **L**.

The number of moles of chlorine that react with 1 mole of **M** is twice the number of moles of chlorine that react with 1 mole of **L**.

L burns vigorously in oxygen with a bright white flame.

Which of the following statement is **incorrect**?

A **M** is a solid at room temperature which is a poor conductor of electricity.

B Oxide of **M** is insoluble in water.

C **L** can form a basic oxide.

D **L** is in Group 13.

17 Which property generally decreases from sodium to aluminum?

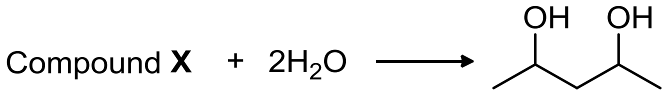
A Electrical conductivity

B Electronegativity

C Ionic radius

D First ionisation energy

18 Compound **X** reacts with two moles of H_2O (g) according to the following reaction:



Given that there are no adjacent carbon–carbon double bonds in **X**, what is the total number of cis–trans isomers that **X** can exhibit?

A 1 **B** 2 **C** 3 **D** 4

19 At gas stations, there are 4 different grades of gasoline for choice. The grade of the gasoline is dependent on the percentage by mass of octane (e.g. Grade 92 indicates 92% by mass of octane).

It was determined that 1 kg of a certain grade of gasoline requires 2.58 m^3 of oxygen for complete combustion at room temperature and pressure according to the following equation.

$$C_8H_{18} + \frac{25}{2}O_2 \rightarrow 8\ CO_2 + 9\ H_2O$$

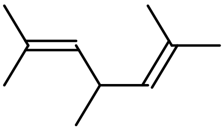
What is the grade of this particular gasoline?

A 90 **B** 92 **C** 95 **D** 98

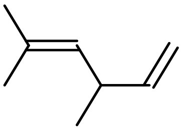
20 Hydrocarbon **W** produces ~~carbon dioxide,~~ CH_3COCH_3 and $CH_3CH(CO_2H)_2$ as the only organic products on heating with an excess of hot concentrated acidic $KMnO_4$.

Which of the following **cannot** be **W**?

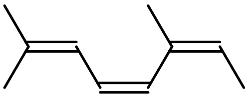
A



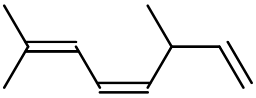
B



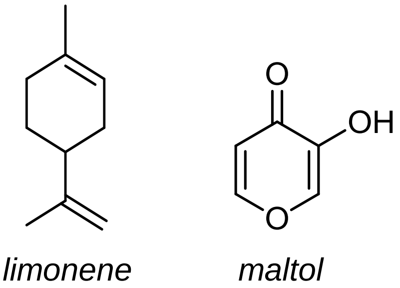
C



D



21 *Limonene* and *maltol* are some flavouring agents commonly used in food products.



Which of the following reagents, when added separately to the two compounds, would enable them to be distinguished from one another, assuming that the ether group, R–O–R, is unreactive?

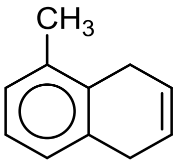
A hot acidified $KMnO_4$

B cold alkaline $KMnO_4$

C hot acidified $K_2Cr_2O_7$

D aqueous Br_2

22 Compound **Z** has the following structure as shown.



compound **Z**

Z undergoes both substitution and addition reactions with excess bromine in the presence of iron.

Which of the following statements is **false** about compound **Z**?

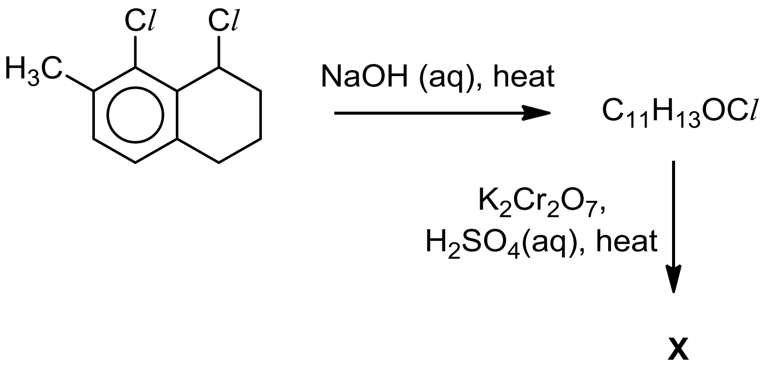
A All carbon atoms lie on the same plane.

B The π–bonding electrons are localised between two carbon atoms in the alkene.

C The π–electrons of benzene ring are delocalised throughout the ring, which makes the benzene ring very stable.

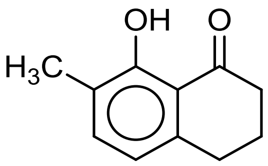
D Benzene would undergo substitution but not addition reaction to preserve the stable aromatic benzene ring structure.

23 The reaction scheme below shows the synthesis of compound **X**.

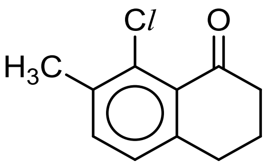


Which of the following shows the structural formula of **X**?

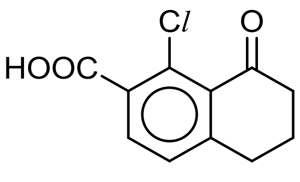
A



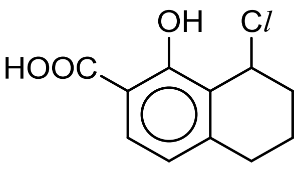
B



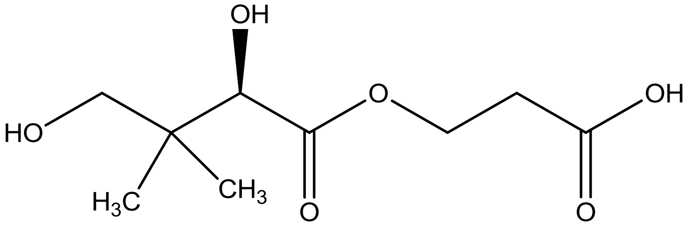
C



D



24 Vitamin B5 has the following structure.



Which of the following statement is correct?

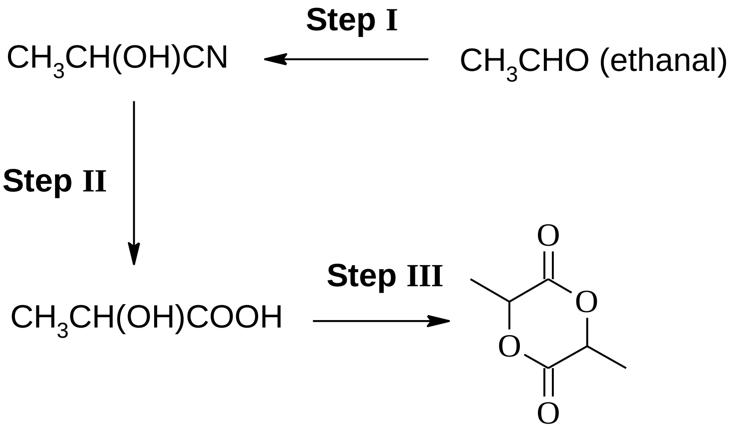
A One mole of Vitamin B5 reacts with three moles of Na.

B One mole of Vitamin B5 reacts with three moles of cold KOH (aq).

C One mole of Vitamin B5 after heating with HC*l* (aq), reacts with two moles of Na_2CO_3.

D One mole of Vitamin B5 reacts with two moles of 2,4–DNPH.

25 Ethanal**,** CH_3CHO, undergoes the reactions in the following reaction scheme.



Which are the types of reaction for steps **I, II** and **III**?

	Step I	**Step II**	**Step III**
A	addition	hydrolysis	addition
B	addition	hydrolysis	substitution
C	reduction	acidification	addition
D	reduction	acidification	substitution

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to place a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	**B**	**C**	**D**
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

26 What factors contribute to the lattice energy of $MgCl_2$ being numerically greater than that of NaBr?

1 The radius of the chloride ion is smaller than that of the bromide ion.

2 The charge on the magnesium ion is greater than that on the sodium ion.

3 Chlorine is more electronegative than bromine.

27 $AlCl_3$ dimerises to form Al_2Cl_6.

Which statements about Al_2Cl_6 are correct?

1 It is an ionic compound.

2 It contains coordinate (dative) bonding between the A*l* and C*l* atom.

3 The bonds around A*l* atoms are tetrahedrally arranged.

28 Which of the following reactions have only one pi–bond broken in the organic reactant?

1 Reaction of propanone with hot alkaline I_2.

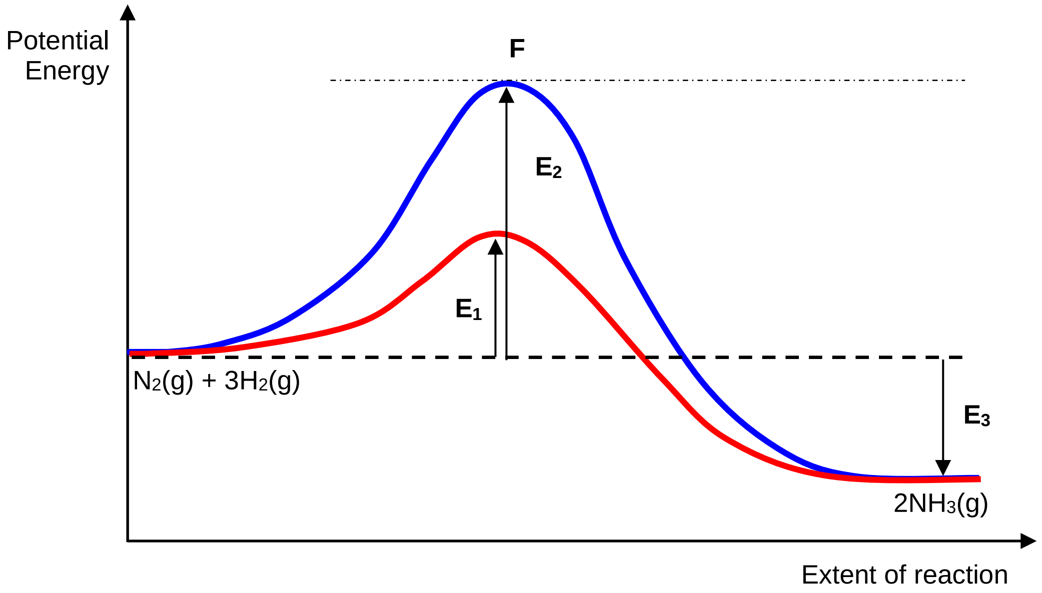
2 Reaction of propene with cold, alkaline $KMnO_4$.

3 Reaction of propanal with HCN with trace NaCN.

29 The diagram below illustrates the energy profile diagram for the Haber Process in the presence of iron catalyst.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

Which of the following statements are true about the energy profile diagram below?



1 **E_1** corresponds to the activation energy of the reaction pathway of the catalysed reaction.

2 The reaction is exothermic.

3 **F** is the intermediate formed.

30 Compound **R** undergoes the following reaction scheme.

$$\textbf{R} \xrightarrow{\text{ethanolic KOH}} C_5H_{10} \xrightarrow{KMnO_4/H_2SO_4} CH_3COCH_2CH_3 + CO_2$$

Which reagents can be used in a chemical test to confirm that all reactants and intermediates have been converted to products?

1 2,4–DNPH

2 aqueous NaOH with $AgNO_3$

3 aqueous Br_2

End of Paper 1

Paper 1 Answers

1	2	3	4	5	6	7	8	9	10
D	**B**	**D**	**A**	**C**	**A**	**D**	**A**	**B**	**B**
11	12	13	14	15	16	17	18	19	20
C	**A**	**D**	**A**	**B**	**D**	**C**	**B**	**D**	**C**
21	22	23	24	25	26	27	28	29	30
A	**A**	**B**	**A**	**B**	**B**	**C**	**C**	**B**	**C**

2017 MJC H1 Chemistry Prelim Paper 2

Section A

Answer **all** the questions in this section in the spaces provided.

1 Vitamins and minerals are essential nutrients that perform many roles in the body. They help to build bones, heal wounds, bolster the immune system and convert food into energy. Young children require many essential minerals such as calcium, magnesium, iodine, iron and zinc to develop and grow.

Table 1.1 shows the recommended daily intake of some essential minerals for children.

Table 1.1

mineral	recommended daily intake for children / mg	
	age group	
	1 – 3 years	4 – 8 years
Calcium	500	700
Iodine	0.090	0.090
Iron	9	10
Magnesium	80	130
Phosphorus	460	500
Zinc	3	4

Table 1.2 shows part of a nutrition label on a tin of powdered milk formula.

Table 1.2

Nutrition Information Standard Dilution (per 100 mL)	
Nutrients:	
Protein	2.2 g
Fat	5.1 g
Carbohydrate	11.2 g
Minerals:	
Sodium	39 mg
Potassium	106 mg
Chloride	79 mg
Calcium	119 mg
Phosphorus	69 mg
Magnesium	7.8 mg
Iron	1.03 mg
Zinc	0.7 mg
Copper	0.056 mg
Manganese	0.0094 mg
Iodine	0.011 mg

(a) Zinc helps the immune system to fight off invading bacteria and viruses.

A 2–year old child takes an average of 3 feeds of milk formula per day, with a quantity of 180 mL per feed.

Using the information provided, determine if the zinc obtained from the milk formula meets the recommended quantity for daily intake and comment if there is a need for the child to supplement his diet with zinc from other sources.

[2]

Many of the minerals in formula milk are compounds of the elements found in the Periodic Table.

(b) **L** and **M** are unknown elements of increasing atomic number in Period 3 of the Periodic Table. Each of these elements has an atomic number below 20.

(i) The successive ionisation energies, in kJ mol^{-1}, of element **L** are given below.

494 4560 6940 9540

Deduce which Group element **L** belongs to.

[2]

(ii) Hence, write the full electronic configuration of element **L** in its ground state.

[1]

(iii) The oxide of **M** dissolves partially in water to give an alkaline solution while its chloride readily dissolves in water to give a slightly acidic solution.

1. Identify element **M**.

[1]

2. State the pH of the resultant solution when the oxide and chloride of **M** are added to water separately. Write appropriate equations to support your answer.

[3]

	equations for reaction with water	pH of resultant solution
oxide of **M**		
chloride of **M**		

(c) Aluminium and sulfur are elements in Period 3.

(i) Their oxides show different behaviours in acids and bases.

With the aid of appropriate equations, describe the acid–base nature of Al_2O_3 and SO_3.

[3]

(ii) State and explain the difference in the *first* ionisation energy between aluminium and sulfur.

[2]

[Total: 14]

[Turn Over

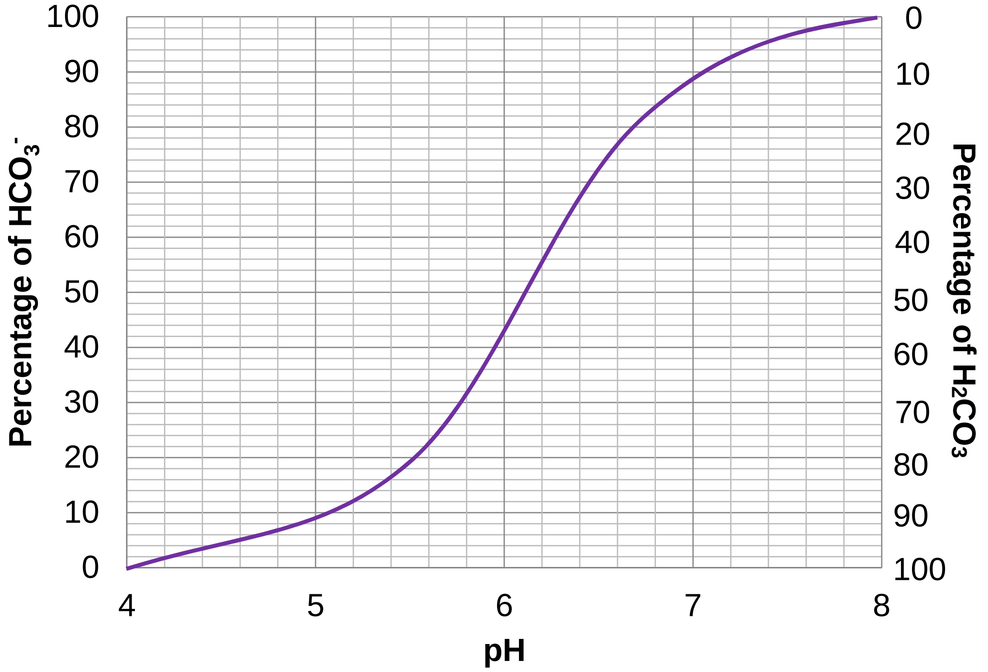
2 Many of the chemical reactions that occur in living systems are extremely sensitive to changes in pH. As a result, the human body maintains a remarkably intricate system of buffers, both within tissue cells and in the fluids that transport blood cells.

The buffer system that is used to control the pH of blood is the carbonic acid–hydrogen carbonate buffer system in the blood plasma.

$$HCO_3^- + H^+ \rightleftharpoons H_2CO_3$$

(a) **Graph 2.1** shows how the percentage of carbonic acid and hydrogen carbonate in blood plasma responds to changes in pH.

Graph 2.1



(i) Using information from the graph above, calculate the ratio of $\frac{[HCO_3^-]}{[H_2CO_3]}$ in the blood plasma for the body to function properly at a pH of 7.4.

[1]

(ii) Explain with the aid of equations, how the buffer system in blood plasma helps to control pH.

[3]

(b) Plasma contains mostly water, which accounts for 91.5% of the plasma content. Salts such as sodium, potassium, and hydrogen carbonate which are soluble in plasma can perform many important biological processes.

(i) Draw the dot–and–cross diagram for HCO_3^-.

[1]

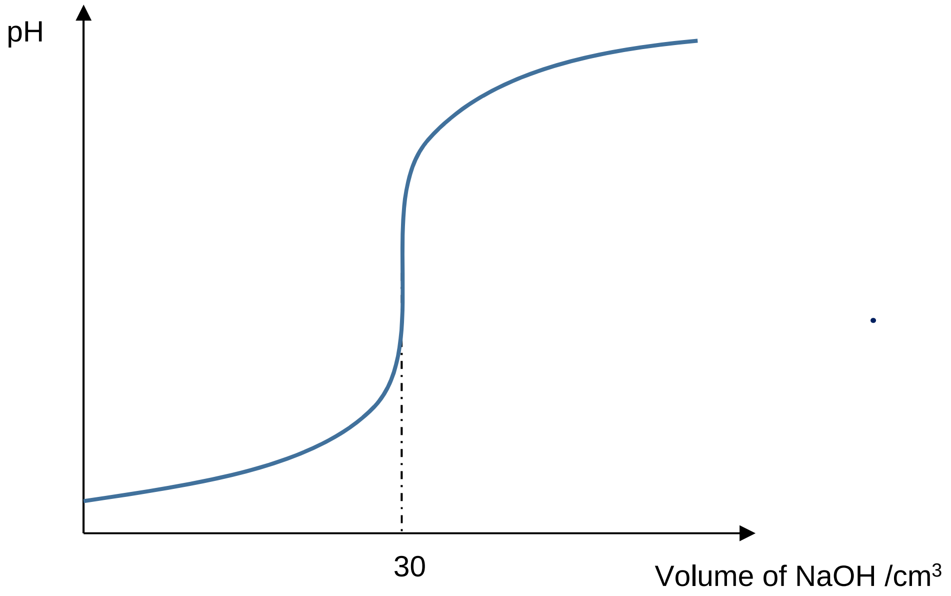
(ii) Explain why HCO_3^- is soluble in plasma. Support your answer using a labelled sketch of the interactions present.

[2]

(c) Both sulfuric acid, H_2SO_4, and carbonic acid, H_2CO_3, are dibasic acids which undergo neutralisation with sodium hydroxide.

(i) 25 cm^3 of sulfuric acid was titrated against 0.25 mol dm^{-3} sodium hydroxide. The change in pH during the titration is shown in **Graph 2.2**.

Graph 2.2



Calculate the initial pH of the sulfuric acid that is used in this experiment.

[2]

(ii) The pH of two separate samples of carbonic acid and sulfuric acid of identical concentrations are measured using a pH meter.

Explain why the sample of carbonic acid registers a higher pH value than that of sulfuric acid.

[2]

[Total: 11]

3 The Contact process is the current method of producing sulfuric acid in the industry. The key reaction in the process is as follows.

$$2SO_2\,(g) + O_2\,(g) \rightleftharpoons 2SO_3\,(g)$$

When a 2:1 ratio of SO_2 and O_2 at a total initial amount of 3 moles is passed over V_2O_5 catalyst in a closed 5.00 dm^3 reaction chamber at 430 ^oC, 1.9 moles of SO_3 is formed at equilibrium.

(a) Calculate the concentrations of SO_2 and O_2 formed at equilibrium.

[2]

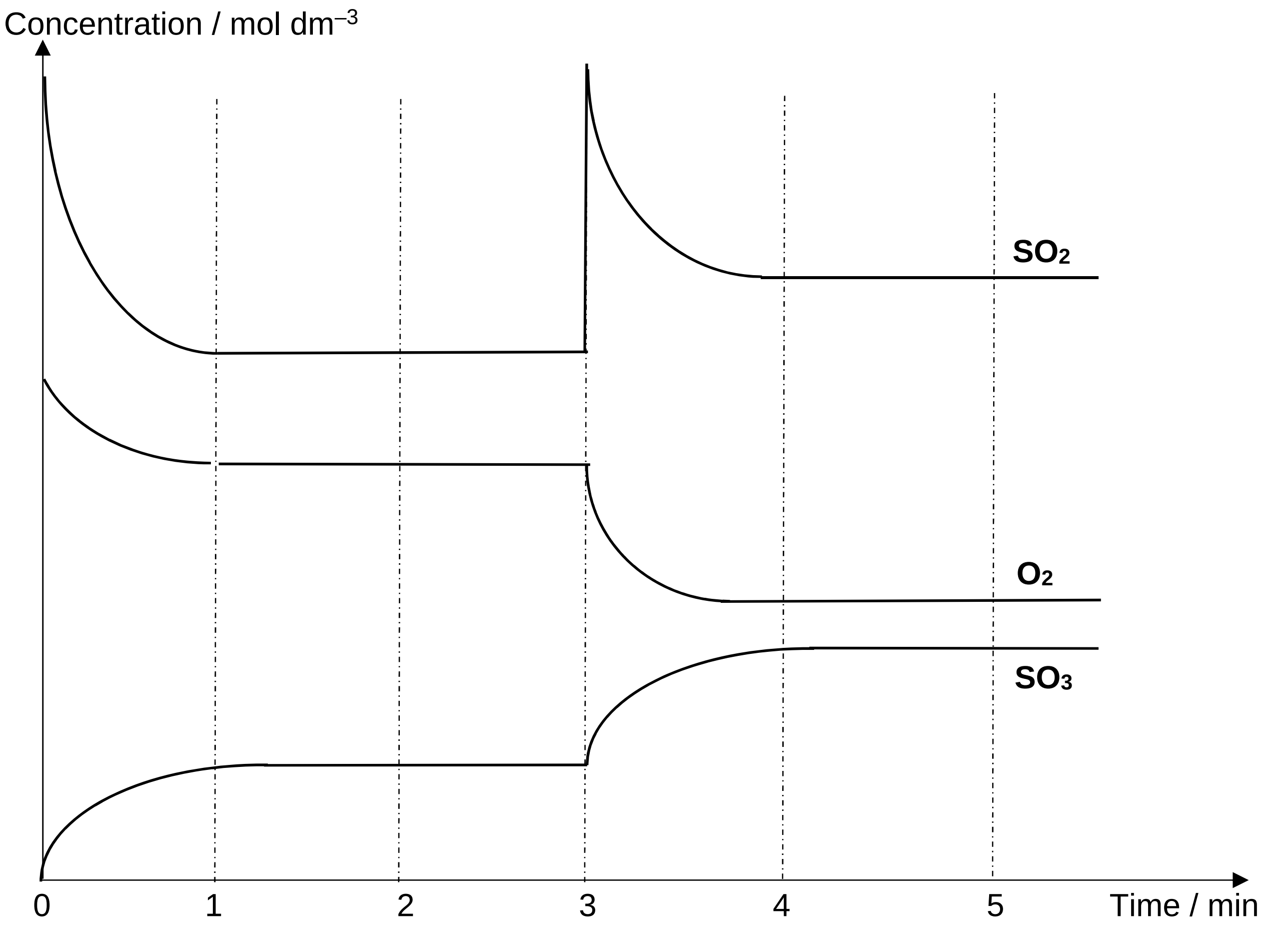
(b) Write an expression for the equilibrium constant, $K_c{}'$ of the **reverse reaction** for the formation of SO_2 and O_2 at 430 ^oC. Calculate the value of $K_c{}'$, stating its units.

[2]

(c) When a sample of SO_2 and O_2 were was in a closed vessel, the system was allowed to reach equilibrium.

The concentrations of all gases were measured at one minute intervals. At t = 3 min, one of the operating conditions was altered. The effects are shown graphically below.

Graph 3.1

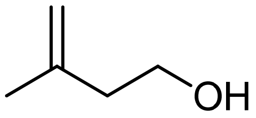


What change to the operating condition of the system has been made at t = 3 min? Account for the observed changes in the concentrations of the gases as a result of this change.

[3]

[Total: 7]

4(a) Ylang–ylang essential oil and lemongrass are often used as insect repellents. 3–methyl–3–buten–1–ol is a constituent of Ylang–ylang oil.



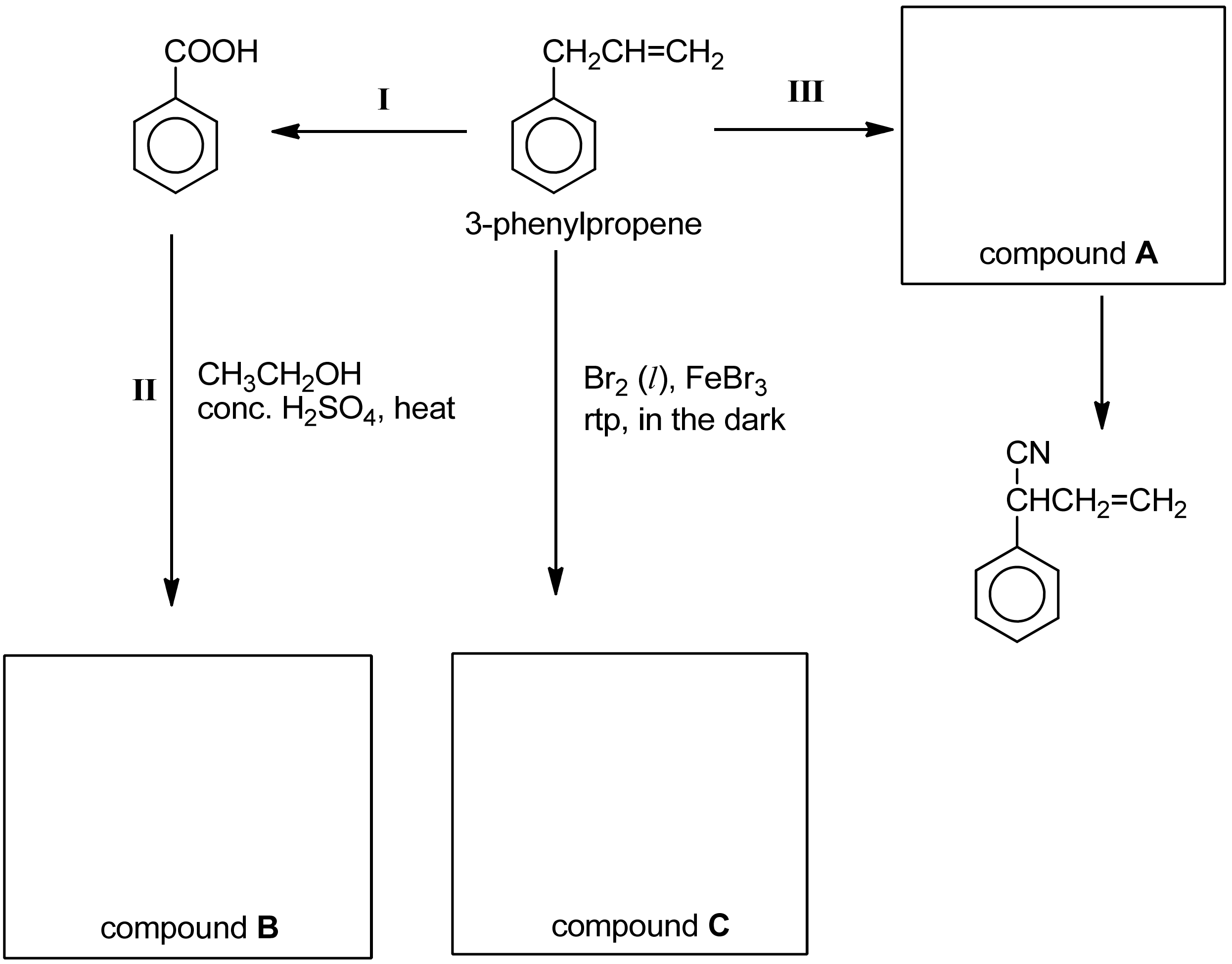
3–methyl–3–buten–1–ol

Draw the structure of the organic products formed when 3–methyl–3–buten–1–ol reacts with each of the following reagents.

reagents and conditions	organic product(s) formed
cold alkaline $KMnO_4$	
excess concentrated H_2SO_4, heat	

[2]

(b) Another ingredient that can be found in insecticides is 3–phenylpropene. It can be converted to various products as shown below.



(i) Draw the structures of compounds **A**, **B** and **C** in the boxes provided.

[3]

(ii) State the reagents and conditions for the conversion in reactions **I** and **III.**

[2]

Reaction **I**:

Reaction **III**:

(iii) Name the type of reaction for **II**.

[1]

[Total: 8]

End of Section A

Section B: Free Response Questions

Answer **two** questions from this section on separate answer papers.

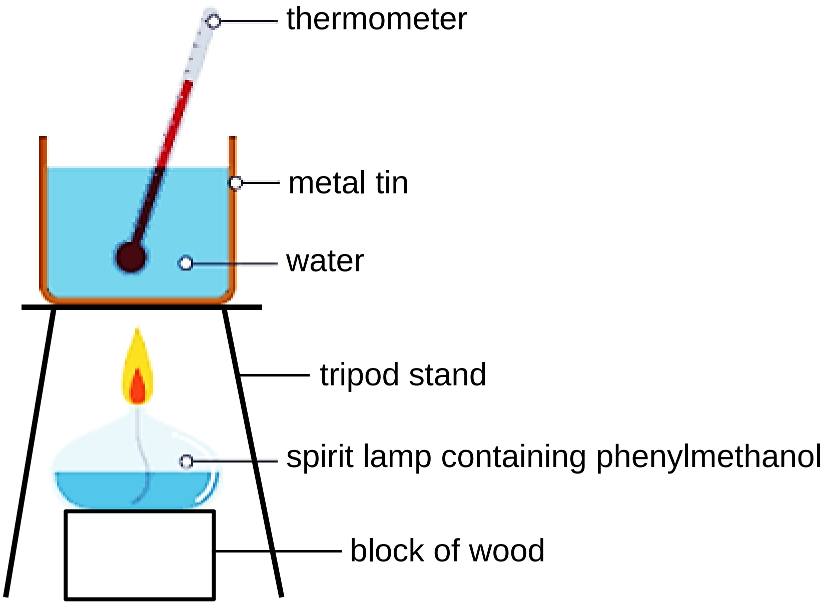
5 The *Cannizzaro* reaction which produces phenylmethanol and a benzoate salt is first discovered in 1853 by Stanislao Cannizzaro.

$$\underset{\text{benzaldehyde}}{2C_6H_5CHO} + KOH \rightarrow \underset{\text{phenylmethanol}}{C_6H_5CH_2OH} + \underset{\text{benzoate salt}}{C_6H_5CO_2K}$$

(a) In the *Cannizzaro* reaction, benzaldehyde is simultaneously reduced and oxidised when reacted with a strong base. Name the type of reaction taking place.

[1]

(b) A sample of phenylmethanol in a spirit lamp is used to heat 200 cm^3 of water in a metal tin.



The data for the experiment are as shown below.

mass of spirit lamp with phenylmethanol before heating = 113.25 g
mass of spirit lamp with phenylmethanol after heating = 112.22 g
temperature of water before heating = 27.8 ^oC
temperature of water after heating = 40.6 ^oC
molar mass of phenylmethanol = 108 g mol^{-1}

(i) Define what is meant by *standard enthalpy change of combustion*.

[1]

(ii) Calculate the standard enthalpy change of combustion of phenylmethanol. The reaction is known to be only 30% efficient.

[2]

(iii) State one assumption you have made in your calculation.

[1]

(c) Another value for the enthalpy change of combustion of phenylmethanol can be calculated using the following energy cycle.

$$\begin{tikzcd}
C_6H_5CH_2OH(\mathit{l}) + \frac{17}{2}\,O_2(g) \arrow[r, "\Delta H_1"'] \arrow[d, "\Delta H_2"] & 7CO_2(g) + 4H_2O(\mathit{l}) \arrow[d, "\Delta H_3"] \\
C_6H_5CH_2OH(g) + \frac{17}{2}\,O_2(g) \arrow[r, "\Delta H_4"] & 7CO_2(g) + 4H_2O(g)
\end{tikzcd}$$

(i) Using relevant data from the *Data Booklet*, calculate a value for ΔH_4.

[3]

(ii) Enthalpy change of vapourisation, ΔH_{vap}, of a substance is the energy absorbed when one mole of the substance is vapourised from the liquid to the gaseous state. Using the following enthalpy changes of vapourisation, your answer in **(c)(i)** and the given energy cycle above, calculate the enthalpy change of combustion of phenylmethanol, ΔH_1.

[2]

$\Delta H_{vap}(C_6H_5CH_2OH)$ = +63 kJ mol^{-1}
$\Delta H_{vap}(H_2O)$ = +41 kJ mol^{-1}

(iii) Sketch a clearly labelled reaction pathway diagram for the combustion reaction of phenylmethanol.

[2]

(d) The two products of the *Cannizzaro* reaction, $C_6H_5CH_2OH$ and $C_6H_5CO_2K$, can be used for ester formation. The benzoate salt is first converted to benzoic acid before esterification takes place.

(i) The acid dissociation constant, K_a, of benzoic acid and phenylmethanol are given in **Table 5.1**.

Table 5.1

compound	acid dissociation constant, K_a / mol dm^{-3}
benzoic acid, $C_6H_5CO_2H$	6.3×10^{-5}
phenylmethanol, $C_6H_5CH_2OH$	4.0×10^{-16}

Explain the large difference in the K_a values between benzoic acid and phenylmethanol.

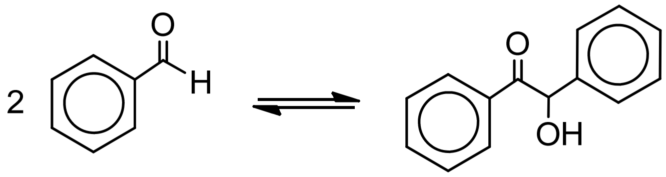
[3]

(ii) Isotope labelling is employed such that the oxygen atom in phenylmethanol is oxygen–18 (i.e. $C_6H_5CH_2{}^{18}OH$), while that in benzoic acid is oxygen–16.

Draw the structure of the organic product of the esterification reaction, labelling clearly the oxygen–18 in the product.

[1]

(e) Besides the *Cannizaro* reaction, another reaction involving benzaldehyde is the benzoin condensation shown below.



compound **J**

(i) Describe a simple chemical test to distinguish between the benzaldehyde and compound **J**.

[2]

(ii) The molecular formula of compound **J** is $C_{14}H_{12}O_2$. Compound **K** is an aromatic structural isomer of compound **J**. Compound **K** can exhibit cis–trans isomerism. Draw and label the isomers of compound **K**.

[2]

[Total: 20]

6 This question is about aldehydes, a class of organic compounds.

(a) The *Hydroformylation* reaction is an industrial process in which an alkene combines directly with carbon monoxide and hydrogen under high temperature and pressure to form an aldehyde. The reaction with ethene is shown below.

$$CH_2{=}CH_2 + CO + H_2 \xrightarrow{\text{catalyst}} CH_3CH_2CHO$$

A series of experiments is carried out to investigate the kinetics of the *Hydroformylation* reaction with ethene. The following results are obtained.

Table 6.1

experiment	$[CH_2{=}CH_2]$ / mol dm^{-3}	[CO] / mol dm^{-3}	$[H_2]$ / mol dm^{-3}	time / s
1	0.100	0.200	1.000	250
2	0.200	0.400	0.250	250
3	0.200	0.400	0.500	125

It is determined that the *order of reaction* with respect to carbon monoxide is 1.

(i) Explain the meaning of *order of reaction*.

[1]

(ii) What is the relationship between the time taken for the reaction and the initial rate of the reaction?

[1]

(iii) Using data from the table above, determine the order of reaction with respect to $CH_2{=}CH_2$ and H_2.

[3]

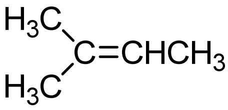
(iv) Hence, write the rate equation for the reaction.

[1]

(v) Explain quantitatively how the rate of reaction will change if the concentration of ethene is tripled while the concentration of carbon monoxide and hydrogen is each halved simultaneously.

[1]

(vi) Draw the structural formula of the product of the *Hydroformylation* reaction if the starting alkene used is 2–methylbut–2–ene instead.



$(H_3C)_2C{=}CHCH_3$

[1]

(vii) The *Hydroformylation* reaction can be catalysed using platinum metal. Explain the catalytic effect on the rate of reaction with the aid of the Maxwell–Boltzmann distribution curve.

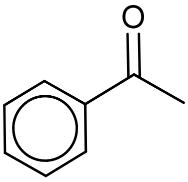
[3]

(b) Besides using the *Hydroformylation* reaction, propanal can be prepared from bromoethane, using propanoic acid as one of the intermediates.

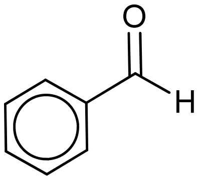
Propose a reaction pathway, of **not more than 4 steps**, for this conversion. Your answer should include the reagents and conditions, as well as the structures of the intermediates formed.

[3]

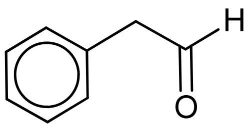
(c) The labels of three test–tubes containing the individual compounds **P**, **Q** and **R** were mixed up.



compound **P**



compound **Q**



compound **R**

(i) Suggest how you can carry out two chemical tests to distinguish the three compounds. For each test, state the reagents, conditions and their observations.

[4]

(ii) One of the above three compounds reacts with NaBH$_4$ in ethanol to give compound **D**, C_7H_8O. Name the reaction and suggest the structure of compound **D**.

[1]

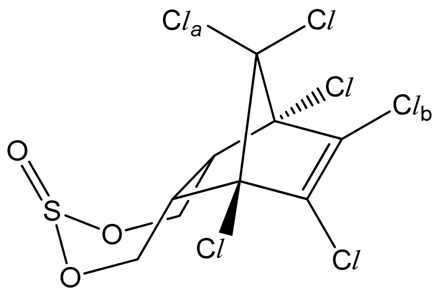
(iii) Compound **P** reacts with 2,4–DNPH to give an orange crystalline solid. Write the equation for this reaction.

[1]

[Total: 20]

7(a) *Endosulfan* is an off–patent organochlorine insecticide. It was recommended for use in India as a means of pest control against the *common lime caterpillar*, which has caused widespread damage to the agriculture in India. However, due to its threats to human health and the environment, a global ban on the manufacture and use of *endosulfan* was negotiated under the Stockholm Convention in April 2011**.**

The structure of *endosulfan* is shown below.



(i) *Endosulfan* has a solubility of 0.32 mg/L in water. However, it has a solubility of 2.40 mg/L in hexane.

Using structure and bonding, explain why *endosulfan* has a higher solubility in hexane but a lower solubility in water.

[3]

(ii) Predict and explain the bond angle and shape about the sulfur atom in *endosulfan*.

[5]

(iii) The reactivity of the organochlorine functional groups in *endosulfan* was investigated by treating separate samples of *endosulfan* with nitric acid, followed by silver nitrate solution. The results obtained were shown in **Table 7.1**.

Table 7.1

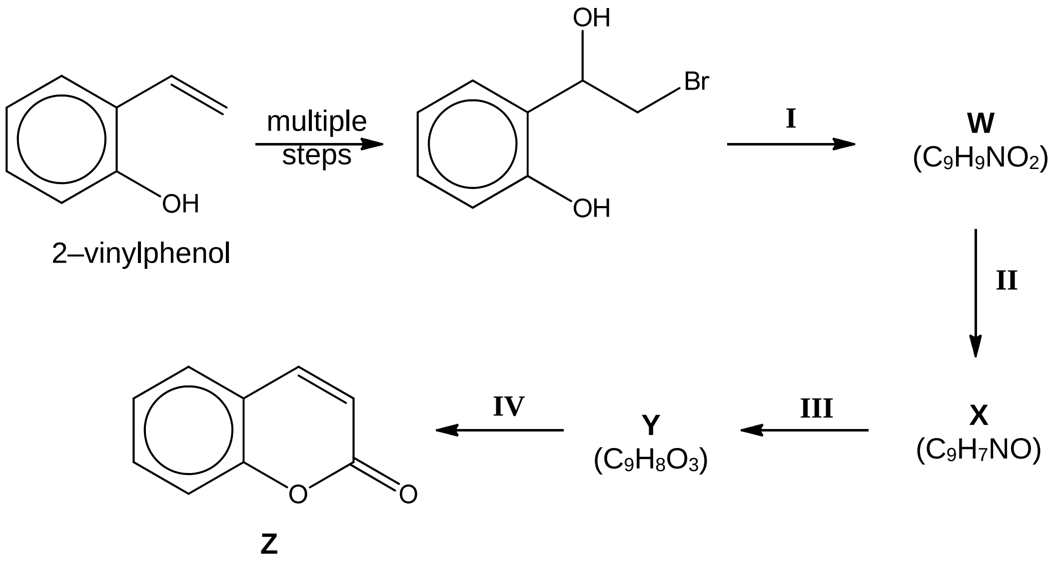
chlorine atom being reacted	time taken for white precipitate to form
C*l*a	≈ 1 hour
C*l*b	≈ 15 hours

Explain why the relative rate of formation of the white precipitate for C*l*b is much slower than C*l*a.

[2]

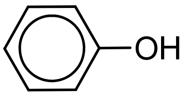
(b) *Cassia* is commonly used in traditional Chinese medicine.

The organic compound **Z** shown below, is present in *cassia*, and may be toxic to humans if consumed in large amounts. Compound **Z** can be prepared using 2–vinylphenol as the starting material using the following synthetic scheme.



(i) Chemical tests were conducted on compounds **X** and **Y**. It was found that compound **X** decolourises bromine water while effervescence was observed when solid sodium carbonate was added to compound **Y**.

Using the information given above, deduce the structural formula for compounds **W**, **X** and **Y** and explain the chemistry of the reaction involved.

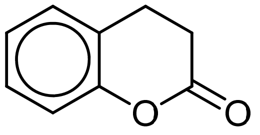
The phenol group,  may be considered to be unreactive from steps **I** to **III**.

[5]

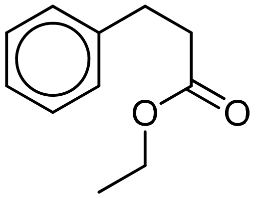
(ii) Hence, or otherwise, state the reagents and conditions needed for steps **I**, **II** and **III**.

[3]

(iii) Describe a chemical test that would allow you to distinguish between compounds **Z** and **A**, giving a positive result for compound **A**.



compound **Z**



compound **A**

[2]
[Total: 20]

End of Section B

MERIDIAN JUNIOR COLLEGE
JC 2 Preliminary Examination
H1 Chemistry Paper 2

1(a) Zn obtained from daily feed = 0.7 × (180/100) × 3 = 3.78 mg

It MEETS the recommended quantity for daily intake. There is no need for the child to supplement his / her diet with Zn from other sources.

(b) (i) Biggest increase is between 1st and 2nd ionization energy.

The 2nd electron is removed from the inner quantum shell.Hence, there is stronger electrostatic force of attraction between 2nd electron and nucleus.

Thus the element has 1 valence electron. The element belongs to Group 1

(ii) $1s^2 2s^2 2p^6 3s^1$

(iii) 1. Element M is Mg.
2.

	equations for reaction with water	pH of resultant solution
oxide of M	$MgO(s) + H_2O(l) \rightleftharpoons Mg(OH)_2(s)$	9
chloride of M	Hydration $MgCl_2(s) + 6H_2O(l) \rightarrow [Mg(H_2O)_6]^{2+}(aq) + Cl^-(aq)$ Slight Hydrolysis $[Mg(H_2O)_6]^{2+}(aq) \rightleftharpoons [Mg(H_2O)_5(OH)]^+(aq) + H^+(aq)$	6.5

(c) (i) Al_2O_3 is amphoteric due to its ionic with partial covalent character. It reacts with both acids and bases.

$Al_2O_3(s) + 6\ HCl(aq) \rightarrow 2\ AlCl_3(aq) + 3\ H_2O(l)$
$Al_2O_3(s) + 2\ NaOH(aq) + 3\ H_2O(l) \rightarrow 2\ NaAl(OH)_4(aq)$

SO_3 is acidic and reacts only with bases.

$SO_3(g) + 2\ NaOH(aq) \rightarrow Na_2SO_4(aq) + H2O(l)$

(ii) From aluminium to sulfur,

- Nuclear charge increases but shielding effect is relatively constant
- Effective nuclear charge increases.

- There is stronger electrostatic force of attraction between nucleus and valence electrons. More energy is required to remove the valence electron.

- Therefore, 1st I.E. of S is greater than A*l*.

2(a) (i)

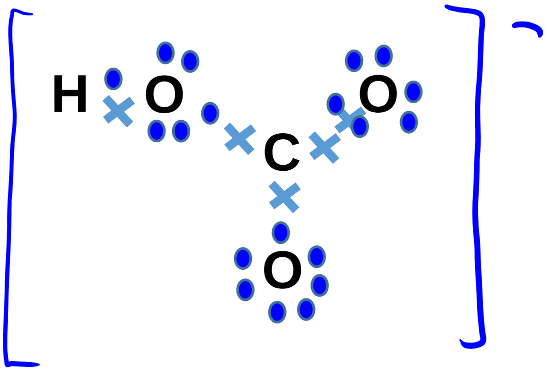
$$\frac{(96)}{(4)} = 24.0$$

(ii) $HCO_3^- + H^+ \rightarrow H_2CO_3$

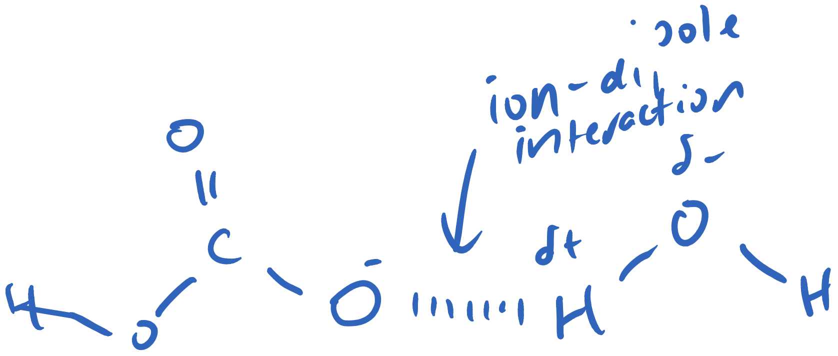
The added H^+ is removed as H_2CO_3.
$[H^+]$ is slightly changed hence pH *remains* fairly *constant*.

$H_2CO_3 + OH^- \rightarrow HCO_3^- + H_2O$
The added OH^- is removed as HCO_3^- and H_2O.
$[OH^-]$ is slightly changed hence pH *remains* fairly *constant*.

(b) (i)



(ii) There is the formation of ion-dipole interactions between HCO_3^- and water molecules.



(c) (i) No of mol of NaOH used = $\frac{30}{1000} \times 0.25 = 7.50 \times 10^{-3}$ mol

No of mol of H^+ present = 7.50×10^{-3} mol

Concentration of H^+ $= \dfrac{7.5 \times 10^{-3}}{\frac{25}{1000}} = 0.300$ mol dm^{-3}

pH = 0.50

(ii) Carbonic acid is a weak acid and it dissociates partially. Sulfuric acid is a strong acid and it dissociates completely. Concentration of H^+ in the carbonic acid solution will be less than than the concentration of H^+ in sulfuric acid resulting in the pH to be higher

3(a)

	$2SO_2(g)$ +	$O_2(g)$ $\rightleftharpoons$	$2SO_3(g)$
Initial amount /mol	2	1	0
Change in amount /mol	-1.9	-0.95	+1.9
Amount at new equilibrium / atm	0.1	0.05	1.9

Concentration of SO_2 at equilibrium = $\dfrac{0.1}{5}$ = 0.02 moldm^{-3}

Concentration of O_2 at equilibrium = $\dfrac{0.05}{5}$ = 0.01 moldm^{-3}

(b) K_c' $= \dfrac{(0.02)^2(0.01)}{(0.38)^2}$

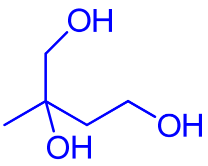
$= 2.77 \times 10^{-5}$ mol dm^{-3}

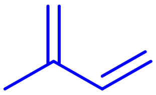
(c) At t = 3 min, concentration of SO_2 is increased.

By *Le Chatelier's Principle*, when concentration of SO_2 is increased, the equilibrium position shifts to the right to decrease the concentration of SO_2.

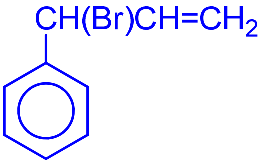
Overall, concentration of SO_2 still increases while concentration of O_2 is decreased as some O_2 reacted with the added SO_2 to form SO_3.

4(a)

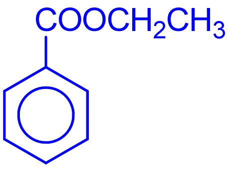




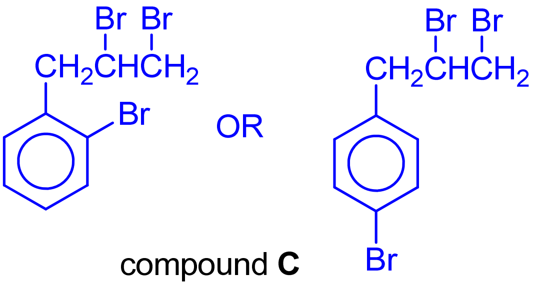
(b)



compound **A**



compound **B**



compound **C**

(ii) Reaction **I**: $KMnO_4$, H_2SO_4 (aq) , heat

Reaction **III**: limited Br_2 , UV light

(iii) Substitution

5(a) disproportionation

(b) **(i)** Energy released when one mole of substance is completely burnt in excess oxygen under standard conditions.

(ii) Heat absorbed by water= 200 x 4.18 x (40.6 – 27.9) = 10701 J

$$\text{Heat released by reaction} = \frac{10701}{30/100} = 35669 \text{ J}$$

$$\text{Amount of phenylmethanol burnt} = \frac{113.25 - 112.22}{108} = 9.538 \times 10^{-3} \text{ mol}$$

$$\Delta H^{\ominus}_c(C_6H_5CH_2OH) = -\frac{35669}{9.538 \times 10^{-3}}$$

$$= -3.74 \times 10^{6} \text{ J mol}^{-1} \text{ or } -3740 \text{ kJ mol}^{-1}$$

(iii) density of water is 1.0 g cm^{-3} *other accurate reasons acceptable*

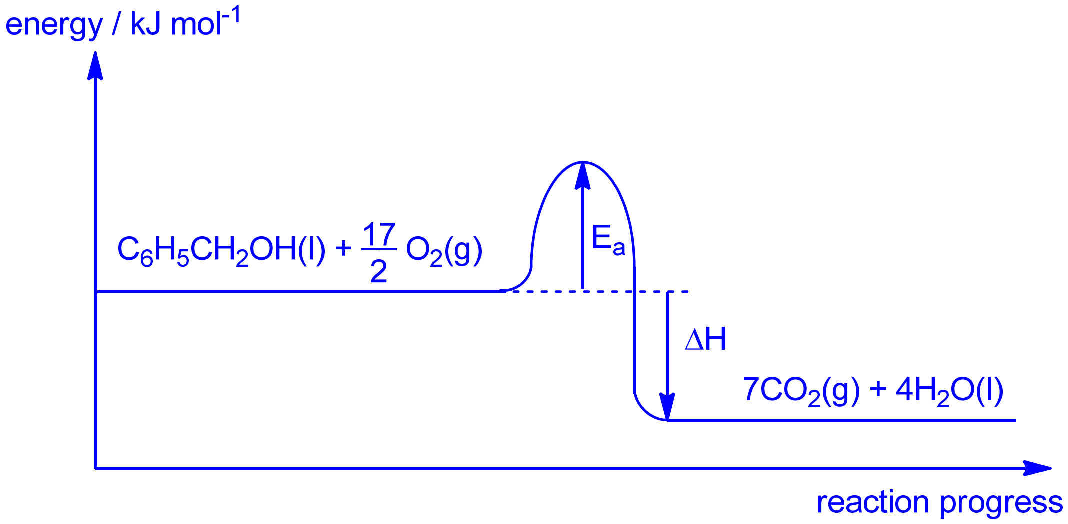
(c) **(i)** $\Delta H_1 = 6(520) + 350 + 7(410) + 360 + 460 + 17/2(496) - 14(740) - 8(460)$

$= -2660$ kJ mol^{-1} (3 s.f.)

(ii) $-2660 + 63 = 164 + \Delta H_4$

$\Delta H_4 = -2660 + 63 - 164 = -2761$ kJ mol^{-1}

(iii)

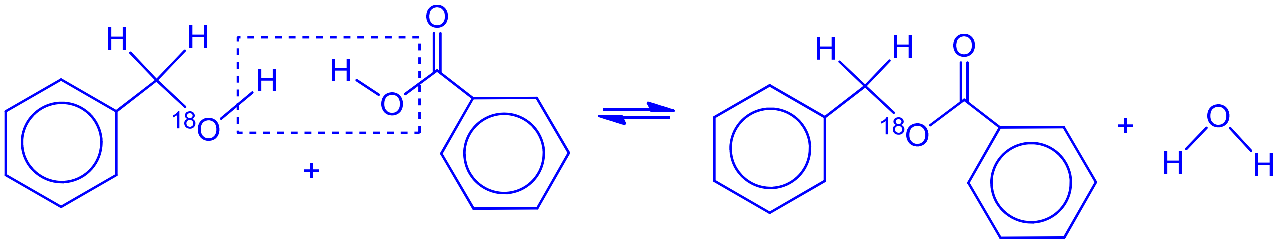


(d) **(i)** For alcohol / phenylmethanol: Electron-donating alkyl group increases the intensity of negative charge on oxygen atom of the alkoxide ion, destabilising the alkoxide ion.

For carboxylic acid / benzoic acid: Carboxylate ion is resonance stabilized; decreases intensity of negative charge on oxygen atom of the carboxylate ion, stabilising the carboxylate ion

Hence, K_a of carboxylic acid is higher because carboxylic acid is more acidic.

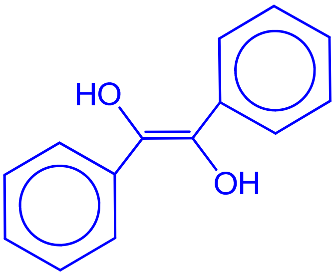
(ii)



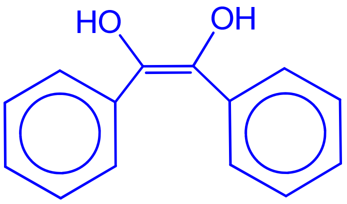
(e) **(i)**

Test (either one)	benzaldehyde	compound **J**
Tollens' reagent, heat	silver mirror formed	no silver mirror
PCl_5, r.t.p.	no white fumes	white fumes of HCl formed

(ii)



trans-isomer



cis-isomer

6(a) (i) Order of reaction is the power to which the concentration of a reactant is raised in the rate equation.

(ii) $\text{time taken } \alpha \ \dfrac{1}{\textit{initial rate of reaction}}$

(iii) Comparing Experiment 2 and 3,
While keeping [CH_2=CH_2] and [CO] constant, when [H_2] doubles, rate of the reaction also doubles.

Hence it is 1st order of reaction with respect to H_2.

Comparing Experiment 1 and 3,

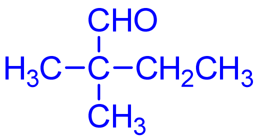
When [CH_2=CH_2] and [CO] doubles, [H_2] halves, rate of the reaction doubles. Since [CO] and [H_2] are 1st order, expected rate should be unchanged but doubling [CH_2=CH_2] doubles the rate of reaction.

Hence it is 1st order of reaction with respect to CH_2=CH_2.

(iv) rate = k[CH_2=CH_2][CO][H_2]

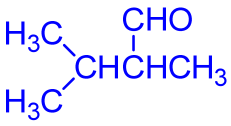
(v) The new rate will be ¾ times the original rate

(vi)

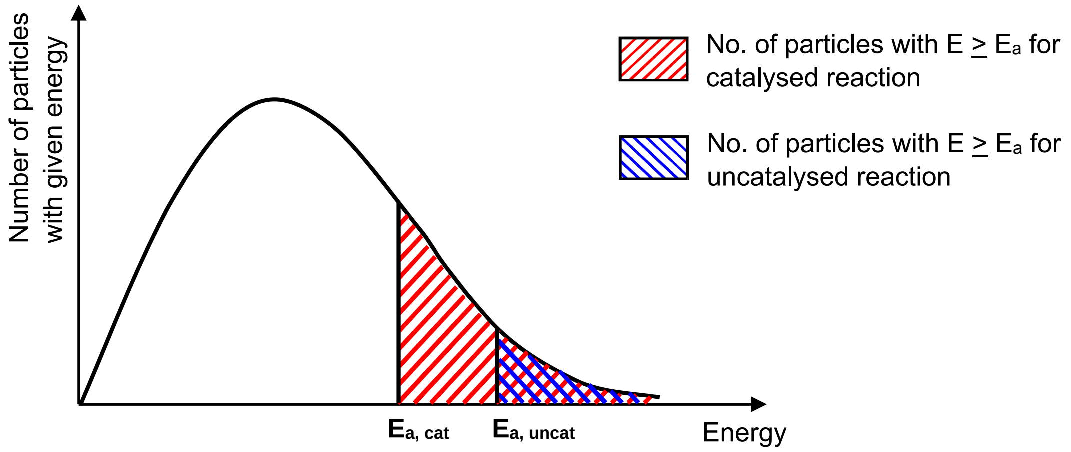


$$H_3C-\overset{\overset{CHO}{|}}{\underset{\underset{CH_3}{|}}{C}}-CH_2CH_3$$

OR

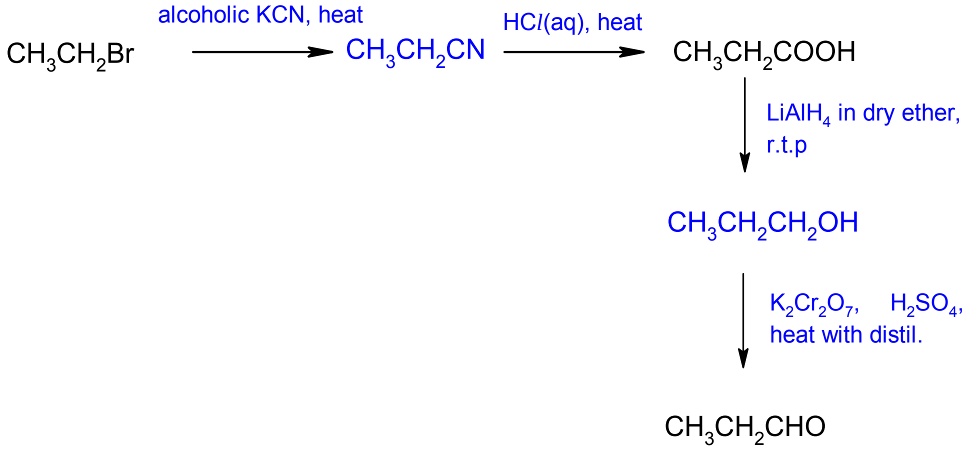


(vii)



Catalyst increases the rate of reaction by providing an alternative pathway of lower activation energy. Number of reactant particles with E ≥ E_a increases. Frequency of effective collisions increases. Since rate of reaction is proportional to the frequency of effective collisions, rate of reaction increases.

(b)



$$CH_3CH_2Br \xrightarrow{\text{alcoholic KCN, heat}} CH_3CH_2CN \xrightarrow{\text{HC}l\text{(aq), heat}} CH_3CH_2COOH$$

$$CH_3CH_2COOH \xrightarrow{LiAlH_4 \text{ in dry ether, r.t.p}} CH_3CH_2CH_2OH \xrightarrow{K_2Cr_2O_7,\ H_2SO_4, \text{ heat with distil.}} CH_3CH_2CHO$$

(c) **(i)** Test 1:

Add Tollens' reagent , heat.

Silver mirror is observed for compound Q and R.

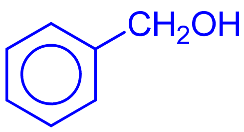
No silver mirror is observed for compound Q and R.

Test 2:

Add Fehling's solution , heat the mixtures.

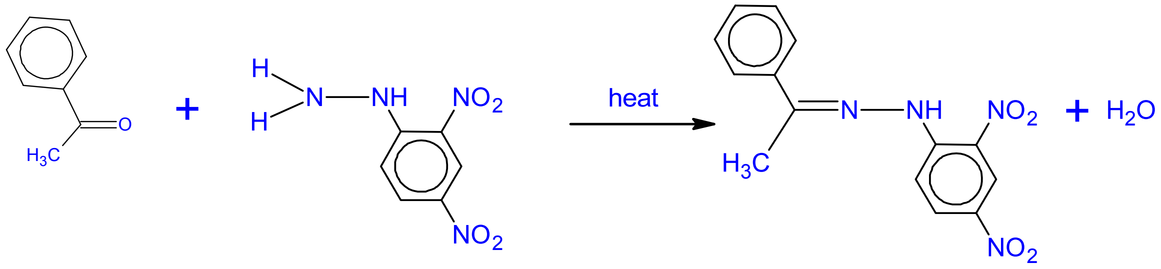
In the test tube containing compound R (the aliphatic aldehyde), a brick red ppt of Cu_2O is formed.In the test tube containing compound Q, no brick red ppt is formed.

(ii) Reduction



Compound **D**

(iii)



(Orange crystalline solid)

7(a) **(i)** *Endosulfan* has a simple molecular structure.

In water

- Strong hydrogen bonding between water molecules is not compatible to the weak van der Waals' forces between *endosulfan* molecules.
- *Endosulfan* is less soluble in H_2O.

In hexane

- Weak van der Waals' forces of attraction between *endosulfan* molecules is similar in strength / compatible to the weak van der Waals' forces of attraction between hexane molecules.
- *Endosulfan* is more soluble in hexane.

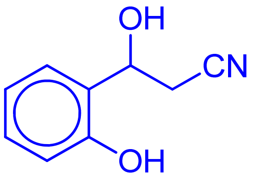
(ii) There are 3 bond pairs and 1 lone pair around the S atom.

- To minimise repulsion and maximise stability, the 4 electron pairs are directed to the corners of a regular tetrahedron.
- But lone pair–bond pair repulsion > bond pair–bond pair repulsion,
- Bond angle is 107°.
- Shape about the sulfur atom in *endosulfan* is trigonal pyramidal.

(iii)

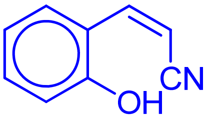
- One lone electron pair of Cl_b atom is delocalised with the adjacent C=C.
- This strengthens the carbon-chlorine bond in the alkene due to presence of partial double bond character, hence substitution is difficult under normal conditions.

(b) **(i)** Structure of W:



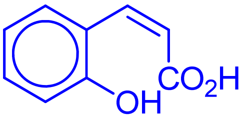
Structure of X:

- Compound X undergoes addition with bromine.
- X contains alkene functional group.



Structure of Y:

- Compound Y undergoes acid–carbonate with solid sodium carbonate.
- Y contains carboxylic acid functional group.



(ii) Step I: KCN in ethanol, heat

Step II: Excess concentrated H_2SO_4, 170°C

Step III: HC*l* (aq) , heat

(iii) Reagents and condition: Aqueous alkaline iodine, heat
Compound A: Yellow precipitate of CHI_3 observed
Compound Z: No yellow precipitate of CHI_3 observed