

Name: _____

Class: 15 _____

Reg Number: _____



MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examination
 Higher 1

Chemistry**8872/02****Paper 2****14 September 2016****2 hours**

Additional Materials: *Data Booklet*
Writing Papers

READ THESE INSTRUCTIONS FIRST

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

This booklet contains Section **A** and Section **B**.

Section A: Pg 2 to 13

Answer **all** questions in Section **A** in the spaces provided on the question paper. You are advised to spend about **1 h** on Section **A**.

Section B: Pg 14 to 21

Answer **2 out of 3** questions in Section **B**. You are advised to spend about **1 h** on Section **B**.

Hand in Section **B** *separately* from Section **A**.

Fasten your answers for Section **B** behind the given **Cover Page**. Detach the **Cover Page** from the last page behind this booklet.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [] at the end of each question or part question.

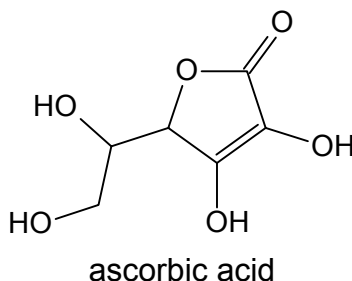
Examiner's Use		
Paper 1	MCQ	/ 30
		/ 33 %
Paper 2 Section A	Q1	/ 10
	Q2	/ 10
	Q3	/ 11
	Q4	/ 9
Paper 2 Section B		/ 40
Paper 2 Total		/ 80
		/ 67 %
Grand Total		/ 100 %
Grade		

This document consists of **22** printed pages (including this cover page).

Section A

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

- 1 Vitamin C also known as ascorbic acid, is an essential nutrient for humans. Ascorbic acid, $C_6H_8O_6$ is a naturally-occurring organic compound with anti-oxidant properties. It is very soluble in water to give weakly acidic solutions.



Vitamin C supplements are commonly consumed for the purpose of supplementing the diet and enhancing health. Vitamin C supplements are currently not subjected to approvals, licensing or registration from Health Sciences Authority (HSA) in Singapore before being sold in the local markets. However, health supplement dealers are responsible for portraying accurate and truthful claims of their products. The label and packaging material should also provide sufficient information to enable consumers to make informed decisions when purchasing and consuming the products.

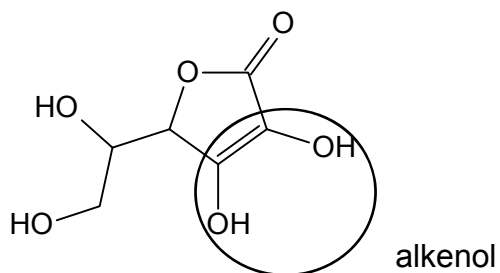
A Vitamin C tablet has the following information on its packaging.

SUPPLEMENT FACTS		
Serving Size: 1 Tablet		
Serving per Container: 20 Tablets		
Amount per tablet	% of Daily Value	
Calories	9.16	
Total Carbohydrates	0.40 g	0 %
Sugar	0 g	0 %
Vitamin C (Ascorbic acid)	1000 mg	1666 %
Sodium	225 mg	9 %
Amino Acid	3 mg	—
Proprietary		
Alanine, Lysine, Serine, Threonine, Tyrosine, Valine, Arginine, Glutamic Acid, Aspartic Acid, Phenylalanine, Glycine, Histidine, Isoleucine, Leucine		
*Percent Daily Values are based on a 2000 Calories diet.		
*1.0 mg (milligram) = 1.0×10^{-3} g		

DOSAGE INSTRUCTIONS
Adults and children over 12 years old: Take 2 tablets per day with a glass of water, best taken first thing in the morning, can be used every day throughout the year.
Taking more than the recommended daily intake may be harmful.
Regular usage is recommended due to the body inability to store Vitamin C.
Food supplements should not be used as a substitute for a varied diet or healthy lifestyle.
STORAGE INSTRUCTIONS
Keep out of sight and reach of young children.
Keep the container closed and protect from heat and moisture.
Do not use after the best before end date.

- (a) (i) On the structure below, circle and name fully three functional groups present in ascorbic acid. You need not consider the alkenol part of the molecule in your answer.

[2]



- (ii) Draw a labelled diagram to explain why ascorbic acid is very soluble in water.

[1]

- (iii) The packaging says "Keep the container closed and protect from heat and moisture." By considering your answer in (a)(i), suggest why the Vitamin C tablets should be stored under such conditions.

[1]

- (b) Iodometric titration can be used to determine the amount of ascorbic acid in samples of Vitamin C supplements. During this reaction, the iodine is rapidly reduced to iodide ions, while ascorbic acid, $C_6H_8O_6$, is oxidised to produce dehydroascorbic acid, $C_6H_6O_6$.
- (i) Use the above information to construct a balanced equation between ascorbic acid and iodine.

[1]

To validate the amount of ascorbic acid as claimed on the packaging, one Vitamin C tablet was dissolved completely. The volume was made up to 500 cm^3 with deionised water.

25.0 cm^3 of this solution required 17.40 cm^3 of 0.015 mol dm^{-3} of iodine solution for complete reaction, using starch as an indicator.

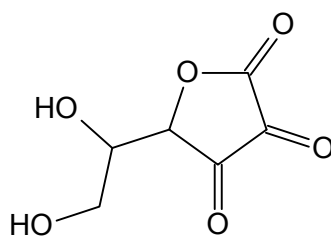
- (ii) Calculate the amount of ascorbic acid that has reacted with iodine.

[1]

- (iii) Determine the mass (in mg) of ascorbic acid present in one Vitamin C tablet. Hence, state if the information on the packaging is accurate.

[2]

- (iv) The structure of dehydroascorbic acid, the oxidised form of ascorbic acid is shown below.



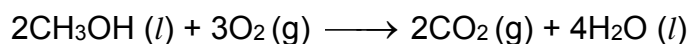
dehydroascorbic acid

Suggest a simple chemical test to distinguish between ascorbic acid and dehydroascorbic acid. State only the positive observation you would make.

[2]

[Total: 10]

- 2 With dwindling supplies of fossil fuels, renewable sources of fuels such as biofuels have been touted as a sustainable alternative to meet the world's growing energy need. Bio-methanol, CH₃OH is a potential fuel for ground transportation, as it could be easily adapted for conventional gasoline internal combustion engines with minimum modification. The combustion of methanol is as follows:



- (a) Define the term *standard enthalpy change of combustion of methanol*.

[1]

- (b) Using relevant data in the *Data Booklet*, calculate the standard enthalpy change of combustion of methanol.

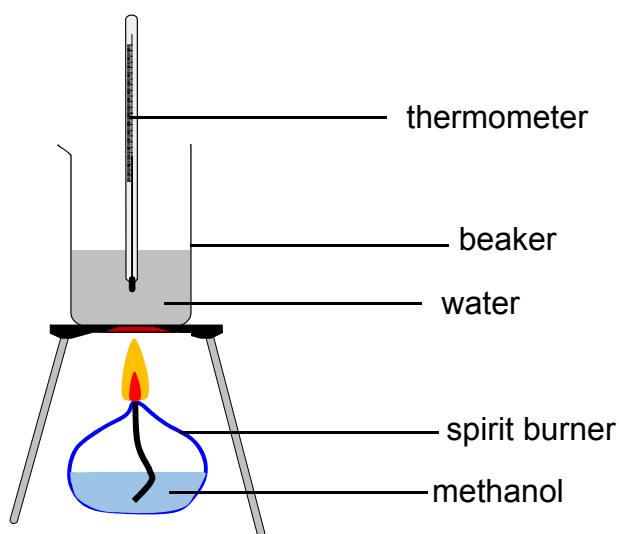
[2]

- (c) The widely accepted value for the standard enthalpy change of combustion of methanol is $-715.0 \text{ kJ mol}^{-1}$.

Suggest why there is a discrepancy between your answer in (b) and this widely accepted value.

[1]

- (d) Methanol was combusted completely under a beaker of water, as shown in the diagram.



The experimental results obtained are shown below.

Mass of water in beaker = 800 g

Initial temperature of water = 25.8 °C

Initial mass of burner and methanol = 356.8 g

Final mass of burner and methanol = 350.9 g

The specific heat capacity of water is 4.18 J g⁻¹ K⁻¹.

Given that this process is 60% efficient, and using the value of standard enthalpy change of combustion of methanol in (c), calculate the final temperature of the water in the beaker.

[2]

Bio-methanol, CH_3OH is also currently studied as a potential green fuel which reduces the pollution to the environment. One of the common pollutants due to the combustion of fossil fuels is sulfur dioxide, SO_2 . In the presence of excess oxygen, sulfur dioxide can be catalytically oxidised to form sulfur trioxide, SO_3 .

- (e) Draw the dot-and-cross diagram of SO_2 . Suggest a value for the bond angle in the SO_2 molecule and explain in detail how this angle arises.

[3]

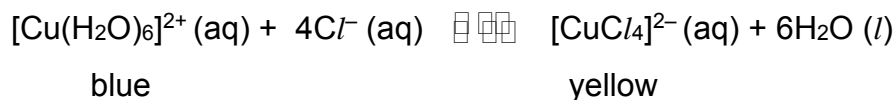
- (f) Suggest why SO_3 exists but CO_3 does not.

[1]

[Total: 10]

3 The elements found between Group II and Group III of the Periodic Table are called d-block elements, which exhibit very different properties from the other elements in the Periodic Table. Copper is an example of a d-block element, and it forms compounds that have chemical properties that differ from compounds of Period 3 elements.

- (a)** When a soluble copper(II) salt is dissolved in water, the aqueous ion $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ is formed. When concentrated HCl is added to the solution, $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ is converted to $[\text{CuCl}_4]^{2-}$ according to the following equilibrium.



- (i)** Write the expression for the equilibrium constant, K_c , for this reaction.

[1]

- (ii)** A solution is prepared in which the initial concentration of $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ and Cl^{-} ions are 1.00 mol dm^{-3} and 4.00 mol dm^{-3} respectively. After equilibrium is established, the concentration of $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ is $0.075 \text{ mol dm}^{-3}$.

Calculate the value of K_c for this equilibrium and state its units.

[2]

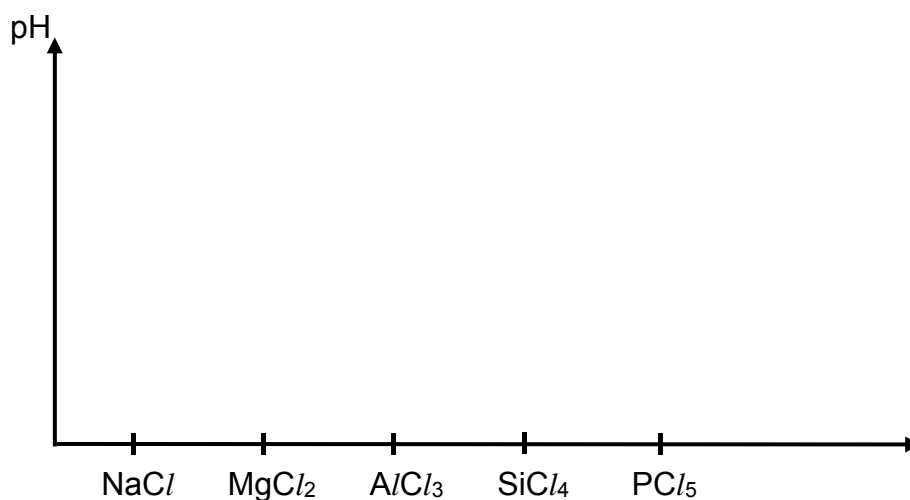
- (iii) Describe and explain what you would observe when water is added to a solution of $[\text{CuCl}_4]^{2-}$ (aq) ions.

[2]

- (b) When heated in chlorine, Period 3 elements form chlorides.

- (i) Complete the sketch for **chlorides** of Period 3 to show how the pH for 1 mol dm^{-3} aqueous solutions changes along the period.

[2]



- (ii) Account for the pH of the aluminium chloride solution, writing equations where appropriate.

[2]

- (iii) Using structure and bonding, account for the relative melting points of MgCl_2 and SiCl_4 .

[2]

[Total: 11]

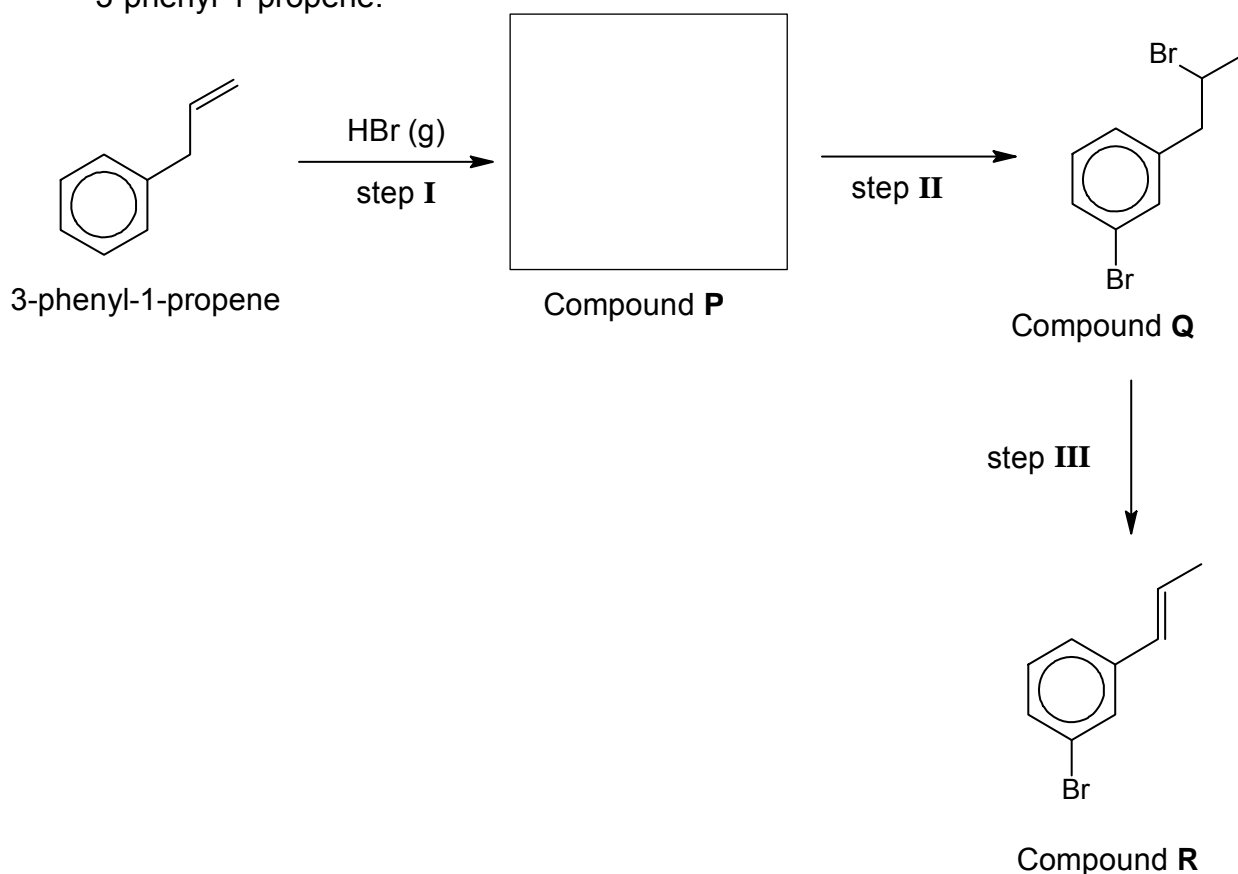
- 4 Benzene is a natural constituent of crude oil and is used as a precursor to the manufacture of other derivatives with more complex structures.

(a) Describe the bonding in benzene in terms of orbital overlap.

[2]

- (b) Benzene is used to synthesise phenylpropenes. Phenylpropenes have been used as starting materials for a variety of effective insecticides.

The following depicts a 3-step synthesis route to produce compound **R** from 3-phenyl-1-propene.



(i) Draw the structure of compound **P** in the box provided.

[1]

(ii) State the type of reaction and the required reagents and conditions for steps **II** and **III**.

[2]

	Type of reaction	Reagents and conditions
Step II		
Step III		

(c) Benzene can be converted to compound **S**, $C_6H_3Br_3$, under appropriate conditions.

(i) Suggest **two** possible structures for compound **S** and state the name of each structure you have drawn.

[2]

(ii) Hot acidified $KMnO_4$ can be used to distinguish between compound **S** and ethylbenzene. State the expected observations when hot acidified $KMnO_4$ is added separately to compound **S** and ethylbenzene. Write a balanced equation to account for the observation taking place.

[2]

[Total: 9]

END OF SECTION A

Section B

Answer any **two** questions from this section on separate answer paper.
Begin each question on a **fresh sheet** of writing paper.

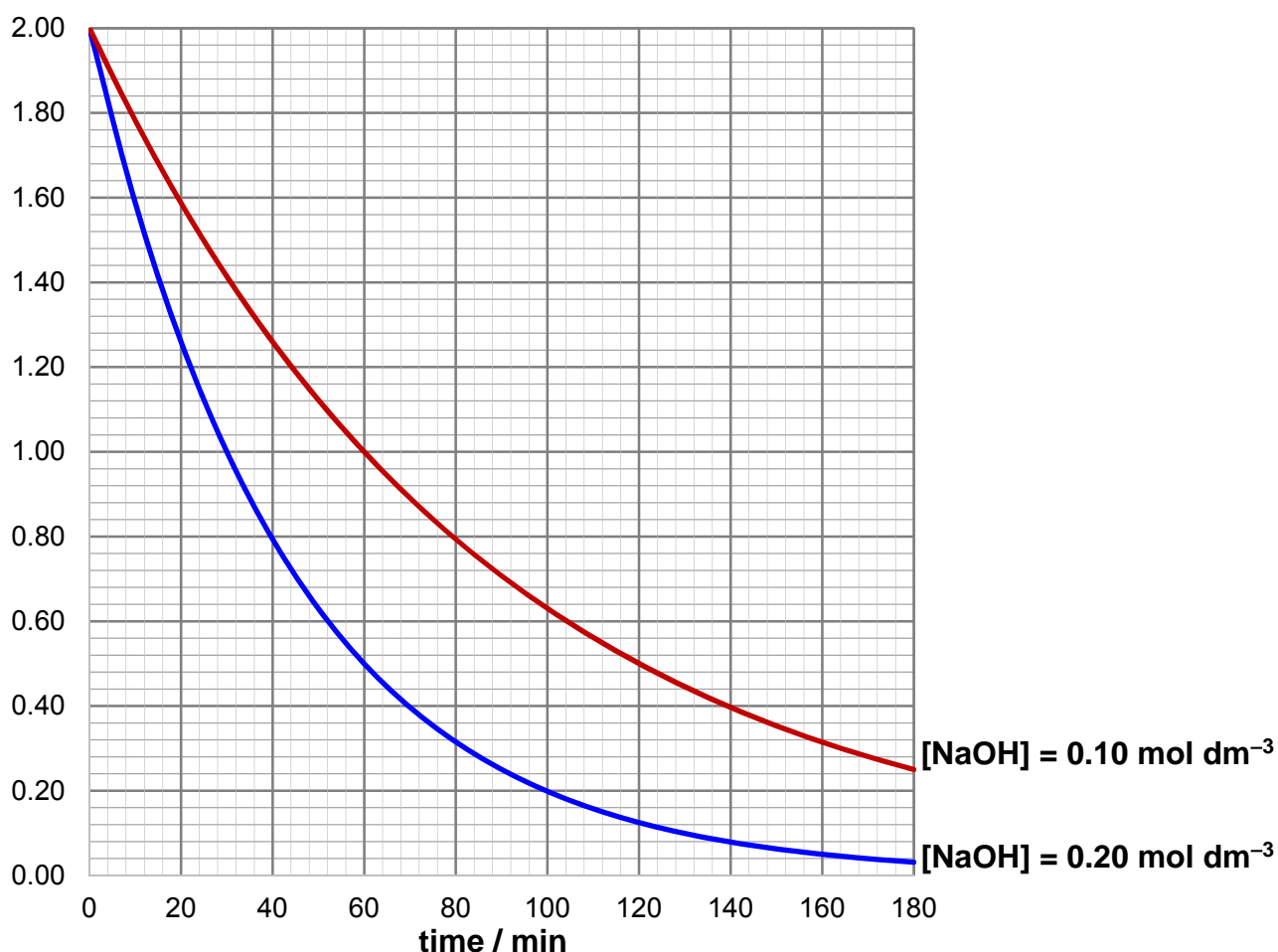
- 5 Both 2-chloro-1-phenylethanone, $\text{C}_6\text{H}_5\text{COCH}_2\text{Cl}$ and sodium hydroxide are caustic in nature.

2-chloro-1-phenylethanone has been used as a component for some tear gases. Its irritant properties is a result of its reaction with water in body tissues to produce hydrochloric acid. Articles contaminated with 2-chloro-1-phenylethanone can be washed with hot aqueous sodium hydroxide.

- (a) Write a balanced equation of the reaction between $\text{C}_6\text{H}_5\text{COCH}_2\text{Cl}$ and NaOH (aq) .
[1]

- (b) The following graphs were obtained from two experiments on such hydrolysis. In each experiment, the overall $[\text{NaOH(aq)}]$ remained virtually constant at the value given.

$[\text{C}_6\text{H}_5\text{COCH}_2\text{Cl}]$
 $/ 10^{-2} \text{ mol dm}^{-3}$



- (i) Use the graphs to calculate the order of reaction with respect to $\text{C}_6\text{H}_5\text{COCH}_2\text{Cl}$ and NaOH . Show all relevant working.

[3]

- (ii) Hence, write the rate equation for this reaction.

[1]

- (iii) In a different experiment, when $[\text{C}_6\text{H}_5\text{COCH}_2\text{Cl}] = 0.200 \text{ mol dm}^{-3}$ and $[\text{NaOH}] = 0.200 \text{ mol dm}^{-3}$, the initial rate is $4.64 \times 10^{-3} \text{ mol dm}^{-3} \text{ min}^{-1}$. Determine the rate constant for this reaction and state its units.

[2]

- (c) The addition of a catalyst increases the rate of reaction between $\text{C}_6\text{H}_5\text{COCH}_2\text{Cl}$ and NaOH .

With the aid of the *Boltzmann distribution* curve, state and explain the effect of a catalyst on the rate of reaction.

[3]

- (d) Same amounts of 2-chloro-1-phenylethanone and 2-bromo-1-phenylethanone were treated separately with hot aqueous sodium hydroxide followed by treatment with acidified silver nitrate solution. The following results were obtained:

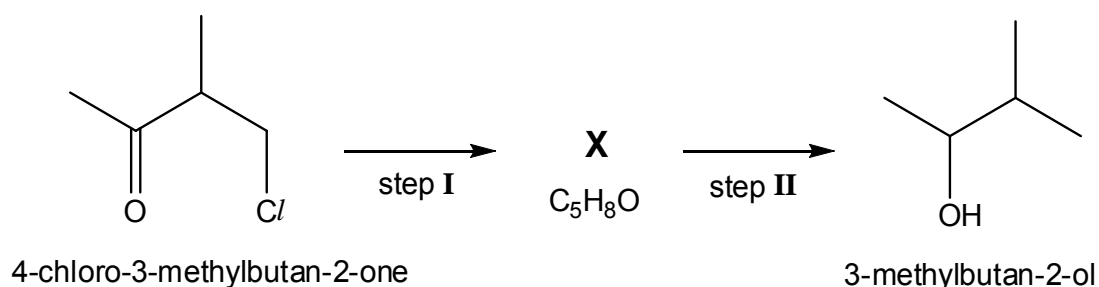
compound	observations upon adding acidified AgNO_3 solution
2-chloro-1-phenylethanone	ppt forms slowly after 10 minutes
2-bromo-1-phenylethanone	ppt forms after 2 minutes

Account for the above observations fully. In your answer, you should clearly explain for the relative rates and state the identity and colour of the ppt formed.

[3]

- (e) Halogen derivatives react with sodium hydroxide differently under different conditions.

A reaction scheme involving 4-chloro-3-methylbutan-2-one is shown below.



- (i) Suggest reagents and conditions for steps I and II.

[2]

- (ii) Suggest the structure of compound X.

[1]

- (iii) The table below gives the boiling points of two organic compounds.

	<i>M_r</i>	boiling point / °C
4-chloro-3-methylbutan-2-one	120	154
3-methylbutan-2-ol	88.0	110

Account for the observed boiling points. In your answer, you should state the predominant type of interactions present in the two compounds.

[2]

- (iv) Explain why solid NaOH is able to dissolve in 3-methylbutan-2-ol.

[1]

- (f) Sodium hydroxide reacts with hydrofluoric acid and hydrochloric acid to form sodium fluoride and sodium chloride respectively.

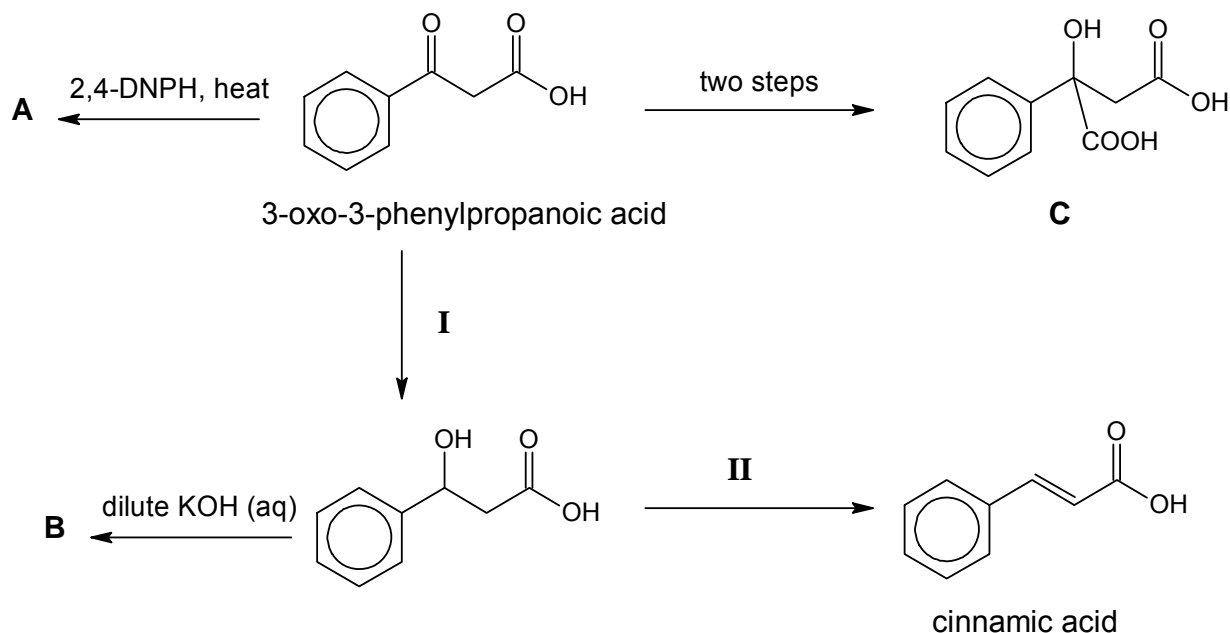
Quoting appropriate data from the *Data Booklet*, explain why the melting point of the sodium fluoride is higher than that of sodium chloride.

[1]

[Total: 20]

- 6 Cinnamic acid is an organic acid that is obtained from the oil of cinnamon. It is also possible to synthesise cinnamic acid from 3-oxo-3-phenylpropanoic acid.

The synthetic pathways below show reactions using 3-oxo-3-phenylpropanoic acid as a starting material.



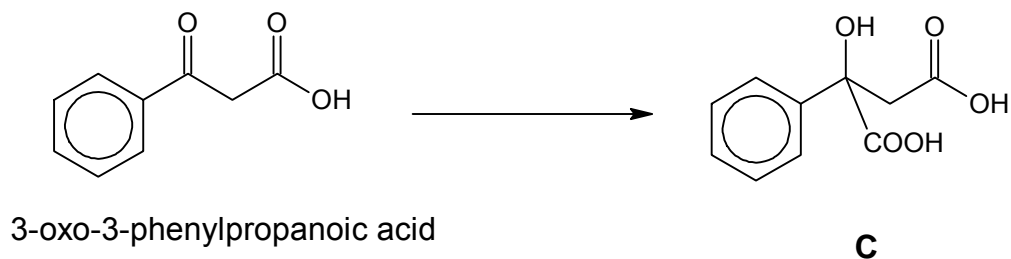
- (a) State the reagents, conditions and the type of reaction for each of the reactions I and II.

[3]

- (b) Draw the structural formulae of the compounds A and B.

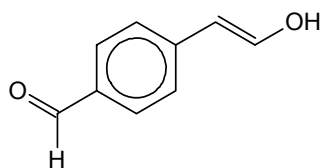
[2]

- (c) Suggest a **two**-step reaction sequence with appropriate intermediate, reagents and conditions for the synthesis of C from 3-oxo-3-phenylpropanoic acid.

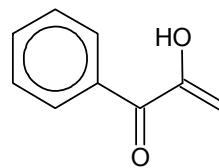


[2]

- (d) Compounds **D** and **E** are isomers of cinnamic acid.



compound **D**



compound **E**

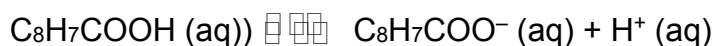
- (i) Describe a chemical test that would show a positive result with **D** and a negative test with **E**.

[2]

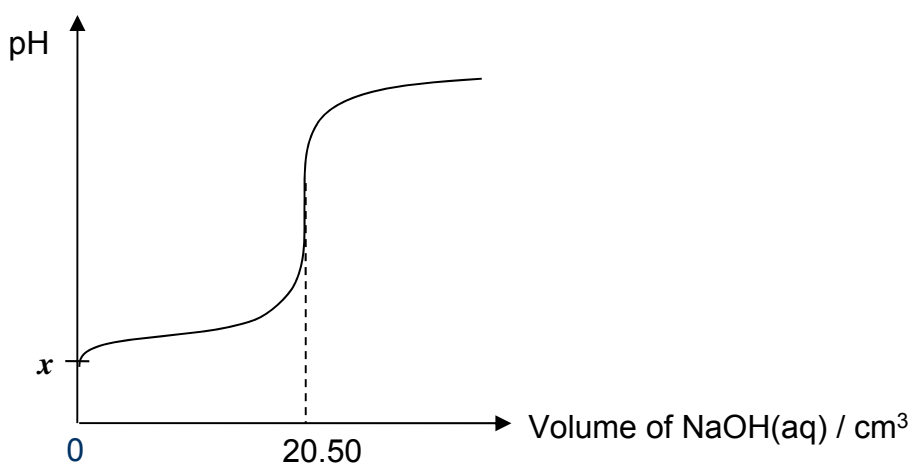
- (ii) Write a balanced equation to account for the positive observation for the chemical test you have described in (d)(i).

[1]

- (e) Cinnamic acid, $\text{C}_8\text{H}_7\text{COOH}$, is a monobasic acid with an acid dissociation constant of $3.63 \times 10^{-5} \text{ mol dm}^{-3}$.



The following titration curve is obtained when 25.0 cm^3 of a solution of cinnamic acid is titrated against a solution of $0.015 \text{ mol dm}^{-3}$ of sodium hydroxide.



- (i) Write the K_a expression for cinnamic acid.
- (ii) Use data from the graph to calculate the concentration of the cinnamic acid used.

[1]

[1]

(iii) Using your answers in (e)(i) and (e)(ii), determine the initial pH (represented by x on the graph) of the cinnamic acid solution.

[2]

(iv) Deduce if the standard enthalpy change of neutralisation of sodium hydroxide with hydrochloric acid would be more or less exothermic as compared with cinnamic acid. Explain your answer.

[2]

(f) A 1.00 dm³ buffer solution at pH 4.3 was prepared by mixing sodium cinnamate, C₈H₇COONa and cinnamic acid.

(i) What do you understand by the term *buffer solution*?

[1]

(ii) Write an equation to illustrate how this solution acts as a buffer when a small amount of sodium hydroxide is added.

[1]

(iii) The pH of an acidic buffer can be calculated by using this formula.

$$\text{pH} = \text{pK}_a + \lg \frac{[\text{salt}]}{[\text{acid}]}$$

Calculate the ratio of $\frac{[\text{salt}]}{[\text{acid}]}$ in this buffer solution.

[2]

[Total: 20]

7 This question involves the various elements in third period (sodium to argon).

(a) Describe and explain briefly the variation in the atomic radius of the elements for the third period. [2]

(b) Describe the variation in melting point of the elements for the third period. [2]

(c) Aluminium reacts with chlorine and oxygen to form aluminium trichloride, $AlCl_3$, and aluminium oxide, Al_2O_3 , respectively.

Solid $AlCl_3$ sublimes into a gas at $180\text{ }^\circ\text{C}$ while Al_2O_3 melts at $2072\text{ }^\circ\text{C}$.

Suggest the type of structure and bonding present in gaseous $AlCl_3$ and solid Al_2O_3 . [3]

(d) Describe what would be observed when sodium and sulfur are separately burned in oxygen. Write balanced equations for any reactions that occur. [2]

(e) **Figure 1** shows the variation in second ionisation energy (IE) of the elements in the third period and **Figure 2** shows the successive ionisation energy of element **G** in the third period.

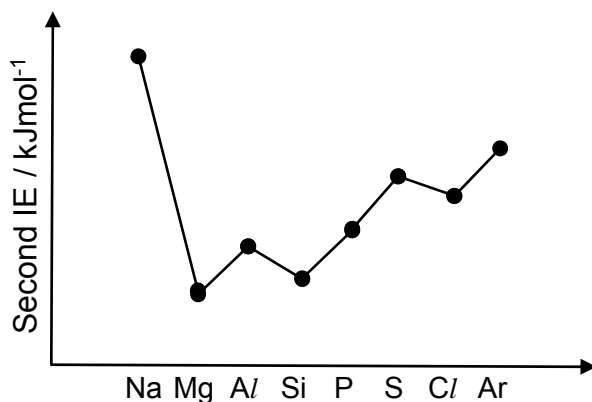


Figure 1

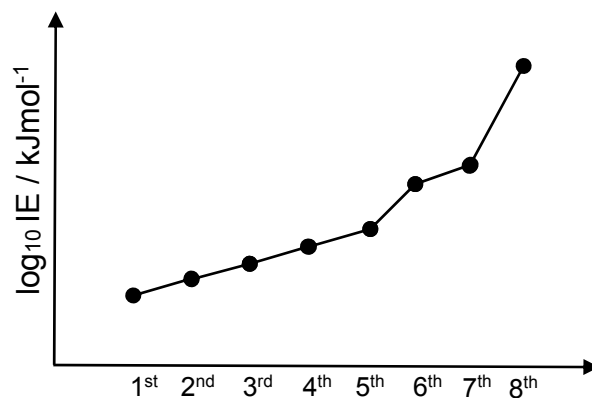


Figure 2

(i) Explain why the second ionisation energy of sulfur is higher than that of either of the elements immediately preceding or following it. [2]

(ii) Explain why the second ionisation energy of silicon is lower than that of aluminium. [1]

(iii) State the group to which element **G** is likely to belong. [1]

- (f) Chlorine exists in various oxidation states in different compounds. It undergoes *disproportionation* with hot sodium hydroxide according to the equation below.



- (i) Explain what is meant by the term *disproportionation*, using the reaction of chlorine with hot sodium hydroxide as an example.

[1]

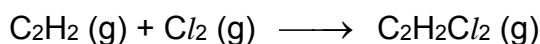
- (ii) Draw a dot-and-cross diagram to illustrate the bonding in ClO_3^- , showing the outermost shell electrons only. Suggest the shape of the ion.

[2]

- (iii) Define the term *enthalpy change of formation* of aqueous NaClO_3 .

[1]

- (g) Ethyne, C_2H_2 , undergoes addition reaction with limited chlorine to form $\text{C}_2\text{H}_2\text{Cl}_2$.



- (i) Two possible products are formed at the end of the addition reaction.

Draw the structures of the two products. Indicate which product is polar and explain briefly your choice.

[2]

- (ii) Midway into the reaction, a sample of reaction mixture was passed through an ioniser which ionises the molecules into ions. These ions are subjected to an electric field which causes the ions to be deflected and then detected.

The identity of the ions and their masses are given in the table below.

ion	mass
$(\text{Cl}_2)^+$	71
$(\text{C}_2\text{H}_2\text{Cl}_2)^+$	97
$(\text{C}_2\text{H}_2\text{Cl}_2)^{2+}$	97

Suggest with a reason, the ion which would be most easily deflected.

[1]

[Total: 20]

END OF SECTION B

