NAME _____ CLASS **18S**

JURONG PIONEER JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION 2019

CHEMISTRY **9729/02**

Higher 2

Paper 2 Structured Questions

17 September 2019
2 hours

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, class and exam index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a HB pencil for any diagrams, graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.
The use of an approved scientific calculator is expected, where appropriate.
A *Data Booklet* is provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/17
2	/17
3	/19
4	/22
Penalty (delete accordingly)	
Bond linkages	**–1 / NA**
Total	/75

This document consists of **18** printed pages.

Answer **all** the questions.

For Examiner's Use

1 Copper, a transition element, and iodine, a Group 17 halogen, are both shiny crystalline solids. The crystal structures of copper and iodine are both face–centred cubic. **Figure 1.1** shows the arrangement of the particles in this type of crystal lattice.

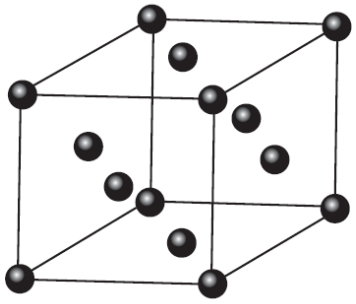

Figure 1.1

In **Figure 1.1**, the particles present are represented by ●.

(a) **(i)** What type of particles is present in the copper crystal? State the interactions within the crystal.

Particles : .....

Interactions : ..... [1]

(ii) What type of particles is present in the iodine crystal? State the interactions within the crystal.

Particles : .....

Interactions : ..... [1]

(b) Explain why copper is malleable and ductile.

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..... [1]

(c) Give an example of another physical property that is present in one of the above solids but absent in the other. Explain.

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..... [2]

(d) A sample of copper contains the two isotopes ^{63}Cu and ^{65}Cu only. An experiment is conducted to find the relative atomic mass of this sample and is found to be 63.9.

(i) Explain why the value found is not a whole number.

..... [1]

(ii) Suggest why the relative atomic mass stated above differs from the value obtained from the Periodic Table.

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..... [1]

(e) When separate beams of $^{63}Cu^{2+}$ and $^{127}I^{-}$ are passed through an electric field in **Figure 1.2**, they behave differently.

On **Figure 1.2**, sketch the paths taken by beams of $^{63}Cu^{2+}$ and $^{127}I^{-}$ in the presence of electric field, given that the angle of deflection of the Cu^{2+} beam is 7.0 °.

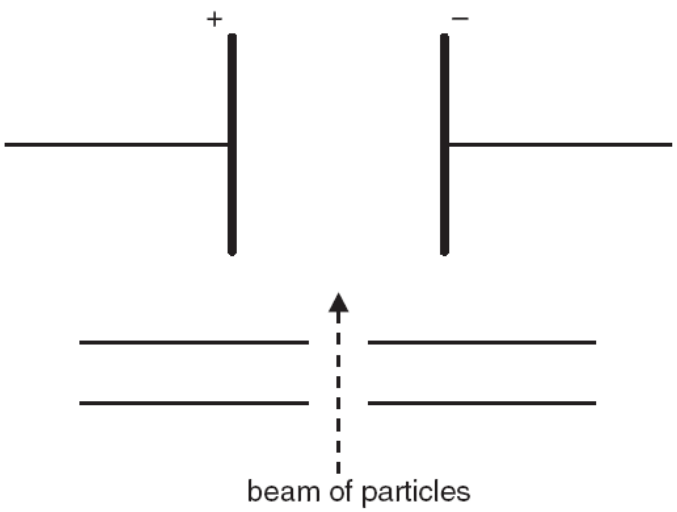

Figure 1.2

[2]

For Examiner's Use

(f) Group 17 halogens Cl_2, Br_2 and I_2 are often used as oxidising agents in chemical reactions.

Describe, using relevant *E* values from the *Data Booklet*, the trend in the reactivity of the halogens, Cl_2, Br_2 and I_2 as oxidising agents.

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..... [2]

(g) In acidic solutions, H_2O_2 is one of the most powerful oxidising agents known and is stronger than the halogens. H_2O_2 reacts with aqueous iodine as shown in equation **1**.

equation **1** $I_2(aq) + 5H_2O_2(aq) \rightarrow 2IO_3^-(aq) + 2H^+(aq) + 4H_2O(l)$

$E_{cell} = +0.57$ V

(i) Write the half–equations for the above reaction between H_2O_2 and I_2. Hence, use relevant data from the *Data Booklet to* calculate E (IO_3^-/I_2).

[2]

For Examiner's Use

(ii) Draw a fully labelled diagram of the electrochemical cell you would set up in order to measure the cell potential of reaction **1** under standard conditions.

In your answer, you should include the following:

- describe the measurement you would make determine the cell potential,
- polarity of electrodes and,
- direction of electron flow.

[4]

[Total: 17]

For Examiner's Use

2 **Table 2.1** lists the solubility of the Group 2 carbonates at 25 °C.

Table 2.1

Group 2 element, **M**	Solubility of **M**CO_3 / mol dm^{-3}
Mg	1.87×10^{-4}
Ca	6.16×10^{-5}
Sr	1.05×10^{-5}

(a) By considering the relationship between ΔH_{soln}, lattice energy and ΔH_{hyd}, explain why the solubility of Group 2 carbonates, decreases down the group.

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..... [2]

(b) Selective precipitation is a technique of separating two or more ions from a solution by adding a suitable reagent that selectively precipitates one ion over the other ions.

A student carried out a selective precipitation experiment by slowly adding, dropwise, volumes of aqueous $Sr(NO_3)_2$ solution to 1.0 dm^3 solution containing 0.020 mol of $CO_3^{2-}(aq)$ and 0.10 mol of $F^-(aq)$ at 25 °C.

You may assume that the volume of aqueous $Sr(NO_3)_2$ added is negligible to the total volume of the solution in the experiment.

(i) Calculate the value of K_{sp} for strontium carbonate, $SrCO_3$.

[1]

For Examiner's Use

(ii) Given that at 25 °C, the numerical value of the solubility product, K_{sp}, for strontium fluoride, SrF_2, is 2.5×10^{-9} and using your answer in **(b)(i)**, deduce which salt will precipitate first in the selective precipitation experiment.

Show your working clearly.

[3]

(c) A teacher asked the students in her class to explain which compound, calcium carbonate or strontium carbonate, has a higher decomposition temperature.

The following response was given by one of her students:

'Calcium carbonate has a higher decomposition temperature than strontium carbonate. The Ca^{2+} ion is a smaller ion than Sr^{2+}, hence the lattice energy of calcium carbonate is more exothermic than that of strontium carbonate.'

Comment on the student's response.

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..... [3]

For Examiner's Use

(d) A current is passed through three cells connected in series, as shown in **Figure 2.2**.

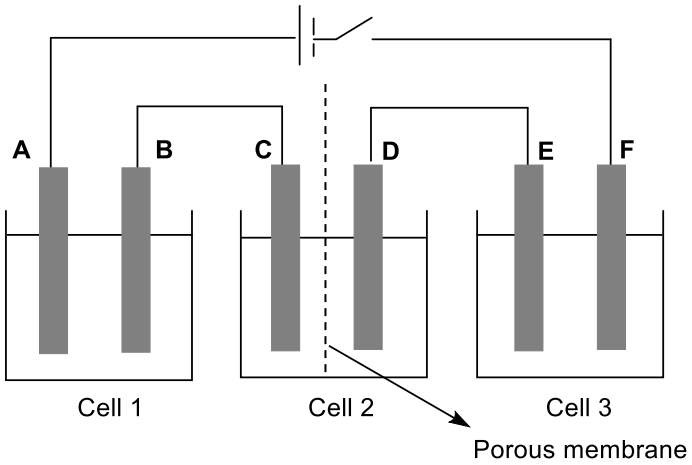


Figure 2.2

Cell 1 contains lead electrodes, **A** and **B**, and electrolyte $Pb(NO_3)_2(aq)$.

Cell 2 contains platinum electrodes, **C** and **D**, and electrolyte $Mg(OH)_2(l)$.

Cell 3 contains platinum electrodes, **E** and **F**, and electrolyte containing $X^{n+}(aq)$.

(i) Give the ion–electron equations for the reactions that occur at each of the electrodes, **A** to **C**, when the switch is closed.

Electrode **A**: .....

Electrode **B**: .....

Electrode **C**: ..... [3]

(ii) It was found that 3240 coulombs of electricity cause the deposition of 1 g of **X** (A_r = 119) at electrode **F** in Cell 3.

Find the value of n in $\mathbf{X}^{n+}$ (aq).

[2]

For Examiner's Use

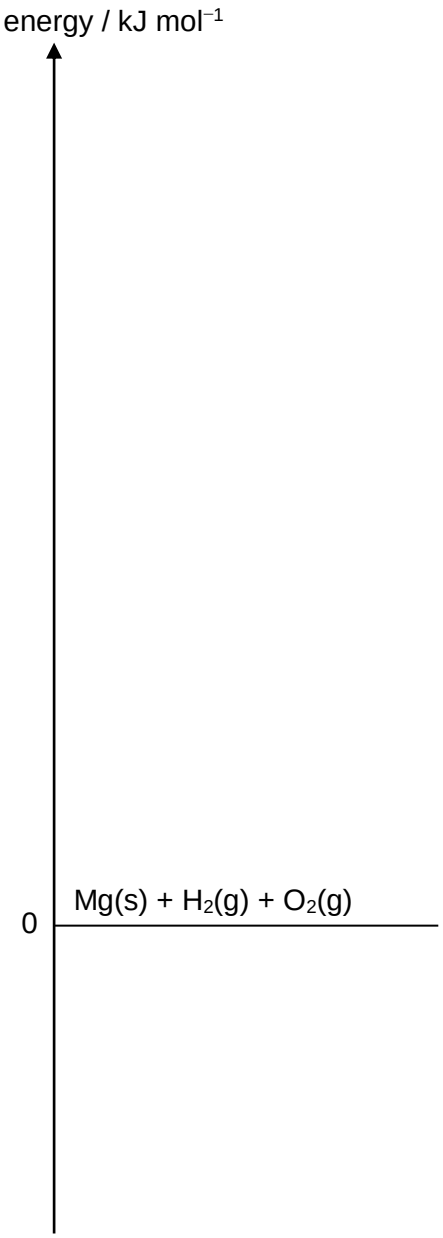
(e) The equation for the formation of the gaseous hydroxide ion is shown below.

$$\tfrac{1}{2}H_2(g) + \tfrac{1}{2}O_2(g) + e^- \rightarrow OH^-(g) \qquad \Delta H^{\theta}_f(OH^-(g))$$

Using the data in **Table 2.3** and relevant data from the *Data Booklet*, complete the energy level diagram to calculate $\Delta H^{\theta}_f(OH^-(g))$.

Table 2.3

Enthalpy change of atomisation of Mg(s)	+148 kJ mol^{-1}
Enthalpy change of formation of $Mg(OH)_2(s)$	–925 kJ mol^{-1}
Lattice energy of $Mg(OH)_2(s)$	–2993 kJ mol^{-1}



[3]

[Total: 17]

For Examiner's Use

3 **(a)** Amines are found commonly in polymers used in plastics or textiles.

Compound **D** is an amino–containing monomer, which is used in polymerisation to form plastic materials. **Figure 3.1** outlines the formation of compound **D** from **A**.

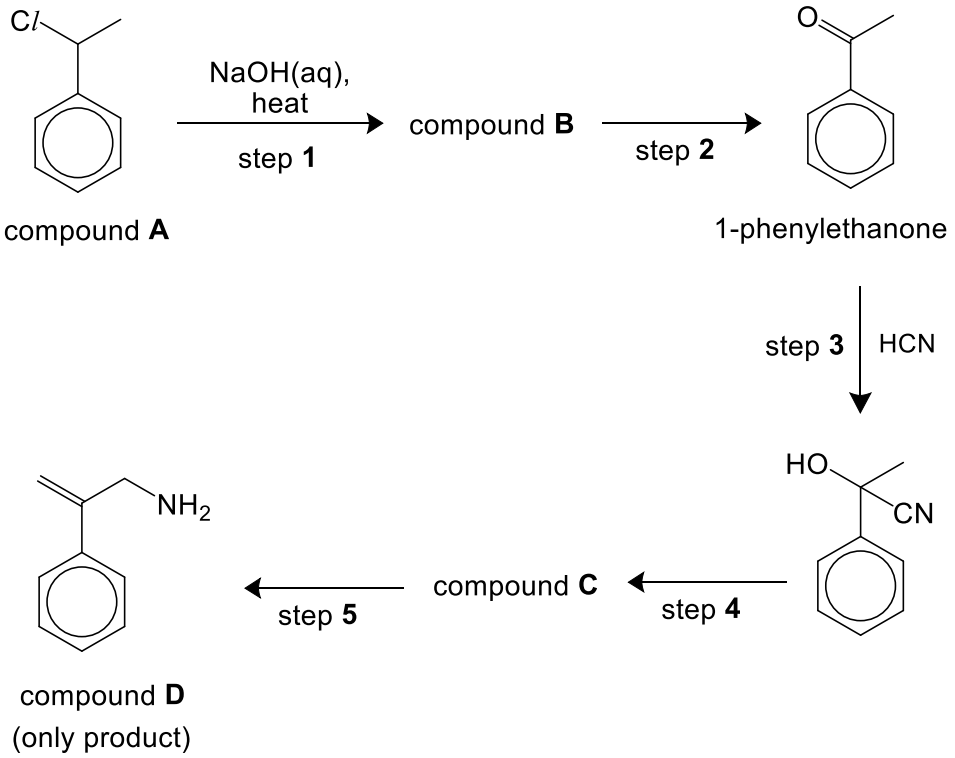


Figure 3.1

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

Compound **B**	Compound **C**

[2]

(ii) Give the reagents and conditions for steps **2**, **4** and **5**.

step **2** : .....

step **4** : .....

step **5** : ..... [3]

For Examiner's Use

(iii) Name and describe the mechanism of the reaction that occurs in step **3**.

Show relevant lone pairs and dipoles, and use curly arrows to indicate the movement of electron pairs.

Type of mechanism: .....

[4]

Question 3 continues on the next page.

For Examiner's Use

(b) Compound **A**, $C_6H_5CH(CH_3)Cl$**,** undergoes hydrolysis reaction according to the following equation.

$$C_6H_5CH(CH_3)Cl + CH_3O^- \rightarrow C_6H_5CH(CH_3)OCH_3 + Cl^-$$

The graphs in **Figure 3.2** were obtained from two hydrolysis experiments. In each experiment, the overall $[CH_3O^-]$ remained virtually constant.

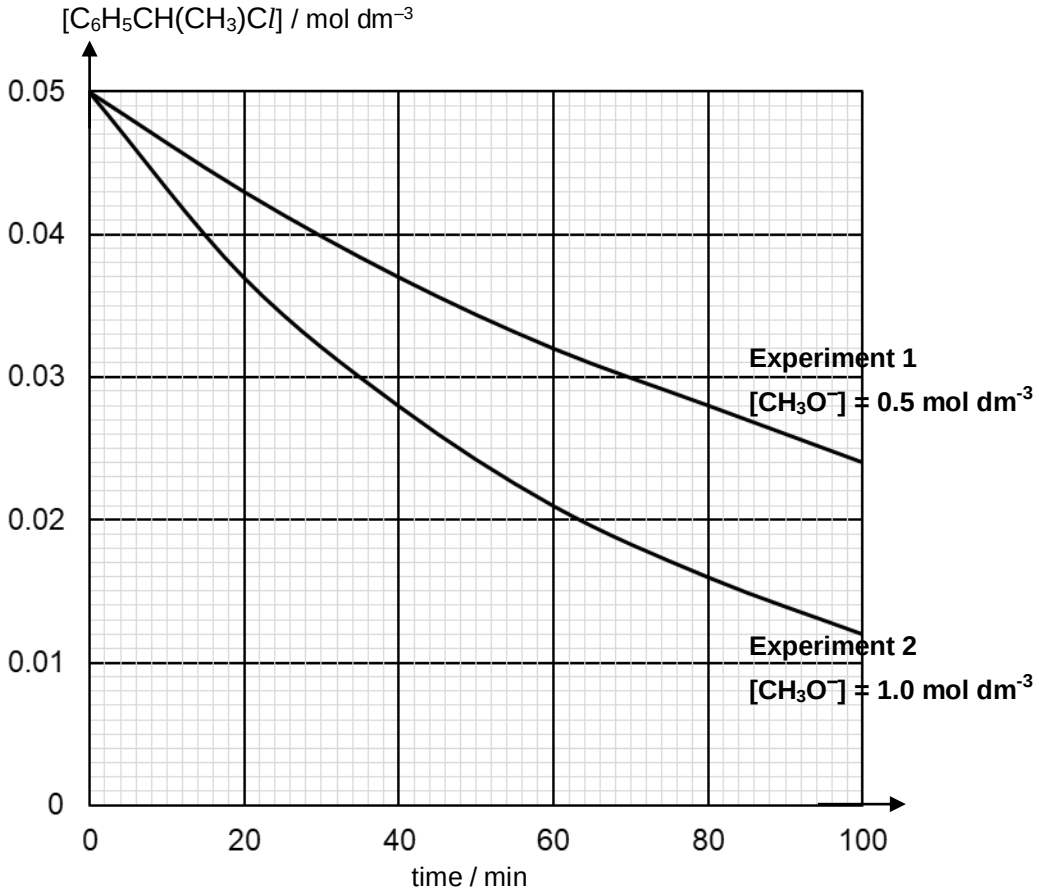


Figure 3.2

(i) Deduce the order of reaction with respect to $[C_6H_5CH(CH_3)Cl]$.

.....

..... [2]

(ii) Deduce the order of reaction with respect to $[CH_3O^-]$.

[2]

For Examiner's Use

(iii) Hence, construct a rate equation for the reaction, stating clearly the units for the rate constant.

.....

..... [1]

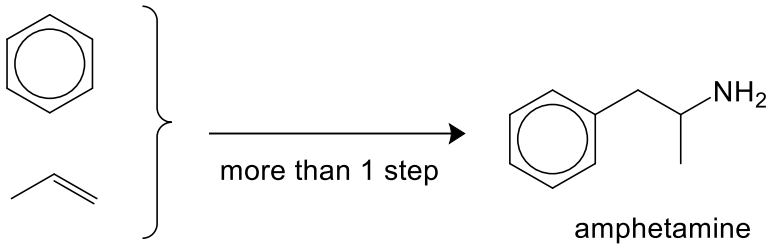
(iv) Determine the half–life of the reaction if Experiment 3 is repeated with both the concentrations of CH_3O^-(aq) and $C_6H_5CH(CH_3)Cl$ doubled that in Experiment 2.

..... [1]

(c) Amphetamine, $C_6H_5CH_2CH(CH_3)NH_2$, is a central nervous system stimulant that is used to improve brain development and nerve growth, and the treatment of obesity.

Suggest a synthesis of amphetamine starting from benzene and propene.

Include reagents and conditions for all reactions and the structures of all other intermediate compounds, in your answer.



[4]

[Total: 19]

For Examiner's Use

4 **(a)** Methanoic acid, HCO_2H, was formerly known as formic acid because it is present in the sting of ants and the Latin name for ant is *formica*. It was first isolated in 1671 by John Ray who collected a large number of dead ants and extracted the acid from them by distillation.

When stung by one typical ant, about 80 % of its methanoic acid is injected into the skin. This volume of methanoic acid injected is equivalent to 7.5×10^{-3} cm^3 of a laboratory–prepared solution **A** which contains 50 % by volume of pure methanoic acid.

The sting of bees also contain high amounts of methanoic acid. In a typical bee sting, the mass of methanoic acid injected into skin is 5.4×10^{-3} g.

The lethal dose of formic acid on mouse is 1.8 g per kg of mouse.

One simple treatment for ant or bee stings is to use washing soda, which contain sodium carbonate.

(i) Use the given information, calculate how many ants would have to be distilled to produce at least 1 cm^3 of pure methanoic acid.

[2]

(ii) Determine the number of ants required to inject a lethal dose on a 0.2 kg mouse.

The density of pure methanoic acid is 1.2 g cm^{-3}.

[2]

(iii) Write a balanced chemical equation for the reaction between methanoic acid and sodium carbonate.

..... [1]

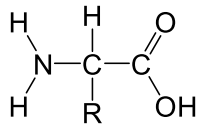
(iv) Calculate the mass of sodium carbonate required to neutralise one bee sting.

[2]

For Examiner's Use

(b) Many ants forage at extrafloral nectar on plants and provide the plant with some measure of protection from herbivory. These nectars contain sugars, amino acids and, often, other compounds.

Amino acids are the building blocks of protein. The general structure of amino acid is as shown below



where R represents the side–chain on the α–carbon of amino acid.

Information on three amino acids is given in **Table 4.1**.

Table 4.1

Amino Acid	Formula of side–chain (R in $NH_2CHRCOOH$)	pK_a		
		α–COOH	α–NH_2	R group
aspartic acid (asp)	$-CH_2COOH$	1.88	9.60	3.65
glutamic acid (glu)	$-CH_2CH_2COOH$	2.19	9.67	4.25
lysine (lys)	$-(CH_2)_4NH_2$	2.18	8.95	10.53

Electrophoresis is a technique of separating and identifying amino acids.

A solution of amino acids is absorbed into paper that is moistened with a buffer solution and stretched between two electrodes.

An electrophoresis experiment is run on a solution containing aspartic acid, lysine, and glutamic acid in **Table 4.1** at pH 5.60. The relative positions of the three amino acids obtained after electrophoresis is as shown **Figure 4.2**.

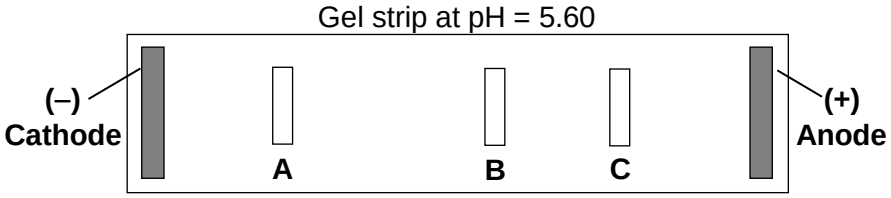


Figure 4.2

Draw the structural formulae of the species found at positions **A**, **B** and **C** at the end of the experiment.

A	B	C

[3]

For Examiner's Use

(c) Compound **J**, which contains only carbon, hydrogen and oxygen atoms, is a non–narcotic analgesic commonly sold in pharmacy.

The chemical composition of liquid **J** can be analysed by combustion:

- 0.1 cm^3 of liquid **J** was burnt with 150 cm^3 of oxygen gas.
- Before cooling to room temperature, the gaseous mixture was passed through a tube containing anhydrous calcium chloride. The mass of the tube increased by 0.038 g.
- The resulting gas mixture was then cooled to room temperature and the volume of the gaseous mixture is 140 cm^3.
- The gaseous mixture further contracted by 90 cm^3 when it is passed through aqueous sodium hydroxide.
- All volumes are measured at room temperature and pressure.

(i) Using the combustion data of compound **J**, show that the molecular formula of compound **J** is $C_9H_{10}O_3$.

[3]

In another experiment, compound **J** is hydrolysed with hot NaOH(aq) and the resulting mixture acidified with a mineral acid such as sulfuric acid. Two products **K** and **M** are formed. Methanoic acid, HCO_2H, is **not** among the products.

Table 4.3 shows the results of the analysis of compounds **K** and **M** with the following reagents.

Table 4.3

Reaction	Reagent and condition	Result
1	excess Br_2(aq)	Only **K** forms a white solid, **L** (M_r = 295.8) but not **M**.
2	Na_2CO_3(aq)	Effervescence observed for **K** but not **M**.
3	Na(s)	Effervescence observed for both **K** and **M**.
4	NaOH(aq), I_2(aq), heat	Pale yellow precipitate observed for **M** but not **K**.

For Examiner's Use

(ii) Name the functional group that reactions **1** and **2** show to be present in compound **K**.

reaction **1** .....

reaction **2** ..... [2]

(iii) Give the molecular formula of compound **K**.

..... [1]

(iv) State the structural feature present in compound **M**.

..... [1]

(v) Use the deduction made in **(c)(i)** to **(c)(iv)**, suggest a possible structural formulae for the compound **J,** $C_9H_{10}O_3$.

[1]

Question 4 continues on the next page.

Values of the acid dissociation constants, K_a, for some organic acids are given in **Table 4.4** below.

Table 4.4

acid	Formula	K_a / mol dm^{-3}
benzoic acid	$C_6H_5CO_2H$	6.3×10^{-5}
phenol	C_6H_5OH	1.3×10^{-10}
ethanoic acid	CH_3CO_2H	1.8×10^{-5}
trifluoroethanoic acid	CF_3CO_2H	5.0×10^{-3}

(vi) After compound **J** is hydrolysed with hot NaOH(aq), the resulting mixture acidified with a mineral acid such as sulfuric acid to give compound **K**.

Suggest, whether ethanoic acid or trifluoroethanoic acid, can be used as a replacement for sulfuric acid. Explain your answer.

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..... [2]

(vii) With reference to **Table 4.4**, account for the difference in K_a values of:

- K_a of ethanoic acid is higher than that of phenol,

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- K_a of trifluoroethanoic acid is higher than that of ethanoic acid.

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..... [2]

[Total: 22]