Index No.	Name	Form Class	Tutorial Class	Subject Tutor

ANGLO-CHINESE JUNIOR COLLEGE
DEPARTMENT OF CHEMISTRY
Preliminary Examination

CHEMISTRY 9647/02
Higher 2

Paper 2 Structured Questions **22 August 2012**
2 hours

Candidates answer on the Question Paper
Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, index number, form class, tutorial class and subject tutor's name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
A Data Booklet is provided.

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

For Examiner's Use	
Question no.	**Marks**
1	
2	
3	
4	
5	
6	
7	
TOTAL	

This document consists of **22** printed pages and **1** blank page

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For Examiner's use

1 Planning (P)

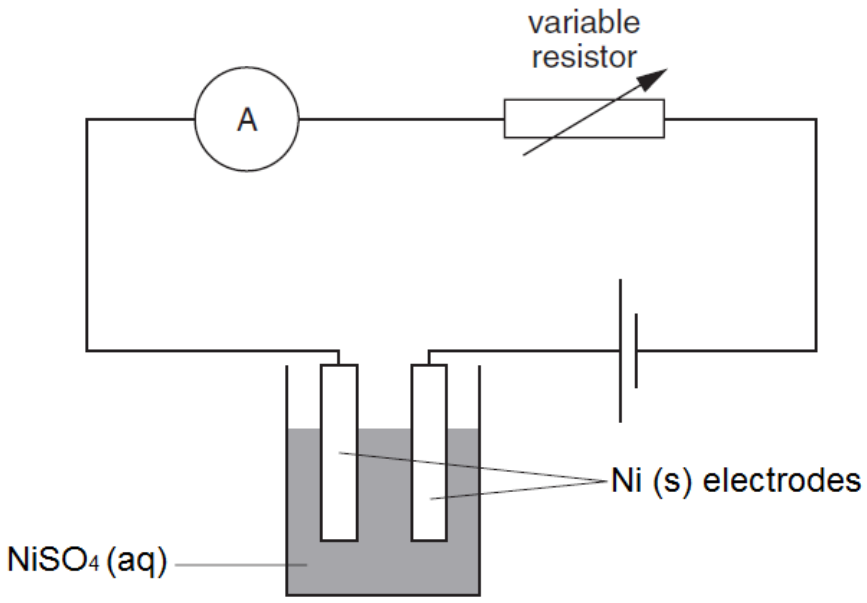
A student is interested to determine the Faraday constant. He proposed that the value of the Faraday constant can be determined experimentally using the electrolysis of aqueous nickel (II) sulfate.

The student did some research and made the following notes.

General information

- Reaction at the cathode: Ni^{2+} (aq) + 2e → Ni (s)
- Reaction at the anode: Ni (s) → Ni^{2+} (aq) + 2e
- 1 mol of Ni (s) is deposited at the cathode by 2 mol of electrons.
- The Faraday constant is the charge in coulombs, C, carries by 1 mol of electrons.
- The Faraday constant = 96500 C mol^{-1}

Experimental setup



The experimental setup for the electrolysis of nickel (II) sulfate solution is shown above. The student will electrolyse some nickel (II) sulfate solution using nickel electrodes. Before the nickel cathode is placed into the electrolyte, it will be cleaned and weighed.

The current that passes through the electrolyte will be kept constant at 0.3 A for 40 min by adjusting a variable resistor in the experiment. At the end of 40 min, the nickel cathode will be weighed.

The experiment will be repeated for another 7 times at 40 min intervals.

For Examiner's use

(a) Based on the information given under experimental setup, give a full description of the procedures you would use in **Step A (Start of experiment)** in the space provided. **Step B (Rinsing and reweighing of cathode)** is provided.

Experimental method

Step A (Start of experiment)

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[2]

Step B (Rinsing and reweighing of cathode)

1. The cathode is removed from the solution and carefully washed with distilled water to remove any nickel (II) sulfate solution.
2. Distilled water is removed from the cathode by rinsing it with propanone in which the water dissolves.
3. The cathode is finally dried by allowing the propanone to evaporate from the surface.
4. The cathode is reweighed and placed back to the solution.
5. A constant current of 0.3 A is passed for a further 40 mins when the rinsing, drying and weighing are repeated.

This procedure (Step A and B) is repeated for a further 6 times.

For Examiner's use

(b) The student performed the experiment using the experimental setup and method above.

The results of his experiment are recorded below.

Time/ min	Mass of cathode/ g	Charge passed/ C	Mass of Ni (s) deposited on the cathode/ g
0	115.74	0	0
40	115.97	720	0.23
80	116.22	1440	0.48
120	116.46	2160	0.72
160	116.70		
200	116.94	3600	1.20
240	117.19	4320	1.45
280	118.01	5040	2.27
320	117.67	5760	1.93

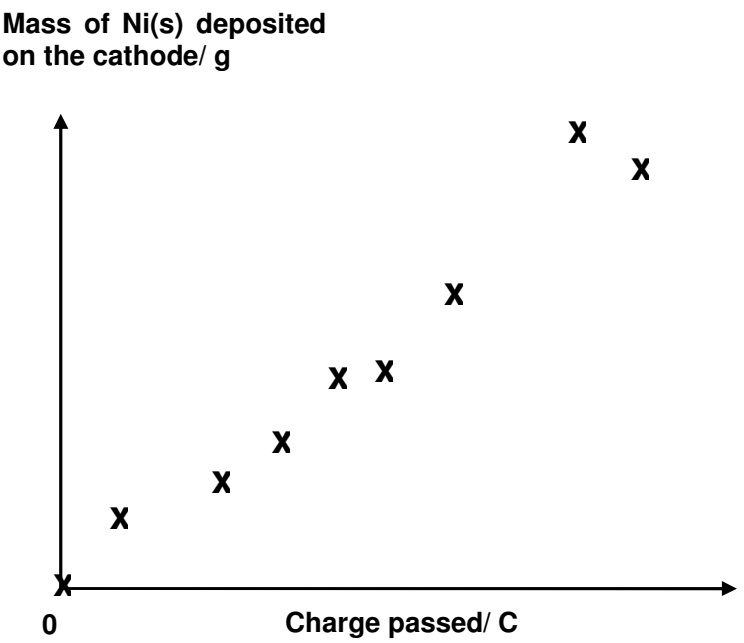
Calculate and record the charge passed and the mass of nickel deposited on the cathode at **160 min** in the space given above.

[1]

For Examiner's use

(c) The student plotted the data on the graph of mass of Ni (s) deposited on the cathode against charge passed.

Draw a best-fit line on the graph below.



[1]

(d) With reference to part **(b)** and part **(c)**, state the anomalous point. Based on the procedures for the experiment, explain for the anomaly.

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[2]

(e) The weighing balance used by the student weighed to 2 decimal places. With reference to the results of the experiment, explain why it is not appropriate to use a weighing balance accurate to 2 decimal places.

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[1]

For Examiner's use

(f) The student calculated the value of the gradient in part **(c)**.

Gradient of the line = 3.05×10^{-4} g C^{-1}

Using the information provided, calculate a numerical value of the Faraday constant.

[2]

(g) What other measurements could be made during the course of the experiment to provide alternative data to confirm the determined value of the Faraday constant?

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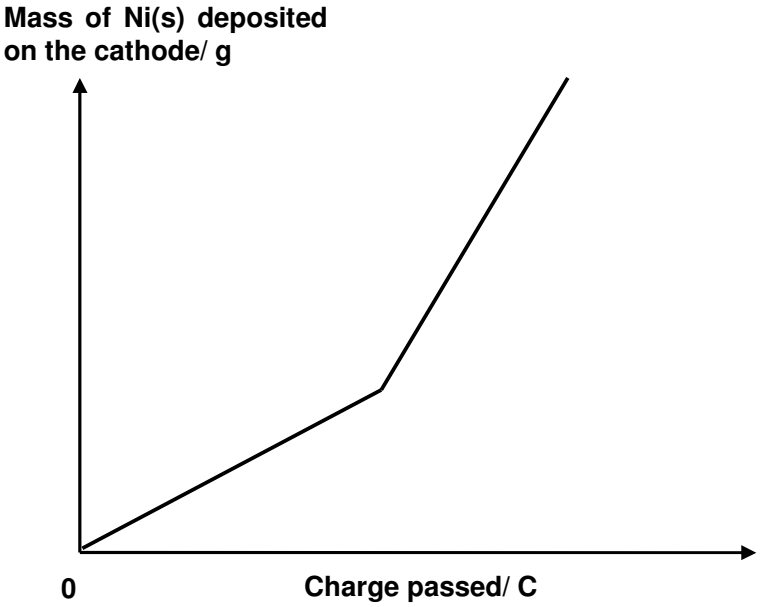
[1]

For Examiner's use

(h) The same experiment was performed by another student. The plotted mass of nickel deposited against charge passed was obtained below.



Suggest an explanation for the shape of this graph. Hence, comment on the accuracy of the value of the Faraday constant obtained by this student.

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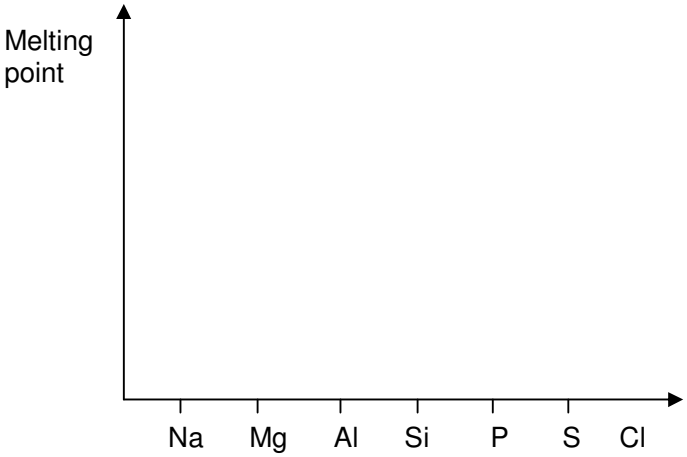
[2]

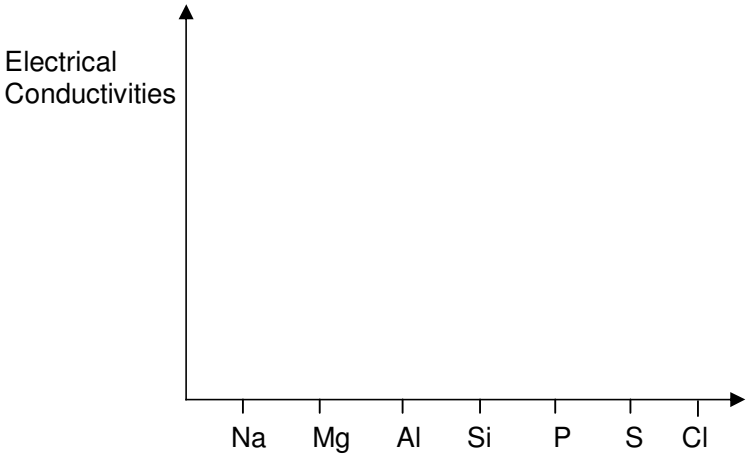
[Total: 12 marks]

For Examiner's use

2 Period 3 elements vary in their melting points and electrical conductivities.

(a) **(i)** On the axes below, sketch these trends for the stated elements.





[4]

(ii) Phosphorus reacts with chlorine to form mixtures of PCl_3 and PCl_5 which are commonly used in organic reaction synthesis. Draw and name the shapes of PCl_3 and PCl_5, and state clearly the bond angles.

[4]

For Examiner's use

(b) The second ionisation energies of Period 3 elements from sodium to phosphorus are given in the table below.

Element	Second Ionisation Energy / kJ mol^{-1}
Sodium	4560
Magnesium	1450
Aluminium	1820
Silicon	1580
Phosphorus	1900

(i) Explain why the second ionisation energy of sodium is the highest.

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

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(iii) Generally, second ionisation energy of an element is more endothermic than its first ionisation energy. Explain why this is so. Include the equations for the first and second ionisation energy of an element in your answer. You may use element 'X' to write the equations.

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[4]

[Total: 12 marks]

For Examiner's use

3 (a) Aluminium reacts with various non-metals to form simple compounds.

(i) Aluminium reacts with phosphorus to form aluminium phosphide, A*l*P which is used as a rodenticide.

Aluminium phosphide is hydrolysed by water to generate the highly toxic gas phosphine, PH_3. NH_3 is a polar molecule with a dipole moment of 1.47 D while PH_3 has a dipole moment of 0.58 D. Predict whether PH_3 is acidic, neutral or basic.

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Solutions of aluminium chloride and lithium hydride in ethoxyethane are mixed together and the resultant white precipitate filtered off. The filtrate is carefully evaporated to dryness and white crystals, compound **A**, are obtained. They contain:

Li,18.2%; *Al*,71.2%; H,10.6% by mass

(ii) Suggest the identity of compound **A** and write a balanced equation for the formation of compound **A**.

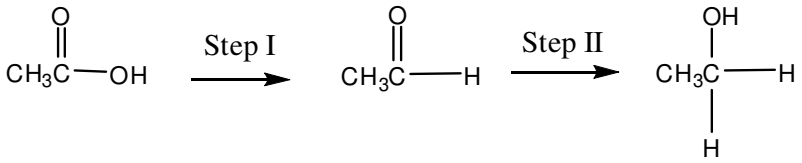
(iii) Compound **A** reacts violently with water, producing hydrogen gas and a white precipitate. Write a balanced equation for the reaction of **A** with water.

……..

For Examiner's use

(iv) Draw the structural formula of compound **A**, clearly illustrating its shape and bondings.

(v) Compound **A** is one of the most useful reducing agents in organic chemistry. It serves generally as a source of H^-, the hydride ion. Reduction of ethanoic acid to ethanol by compound **A** occurs in two steps as shown:



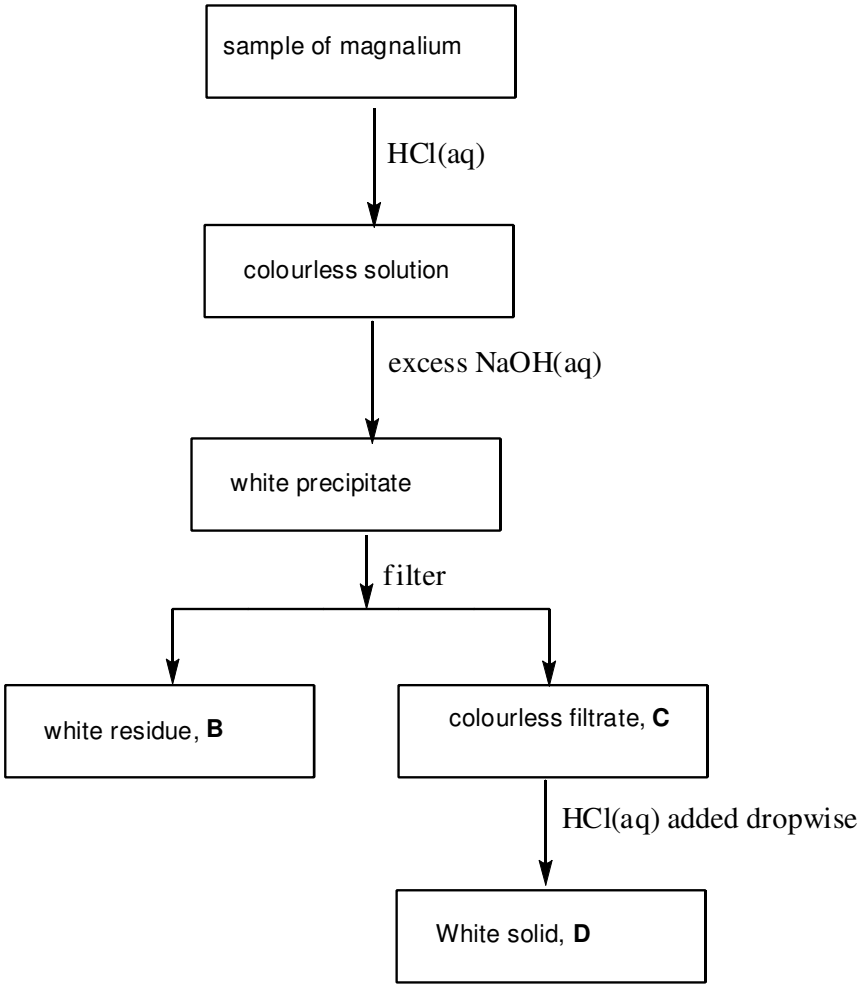
In step II, the aldehyde is rapidly reduced further to the primary alcohol and cannot be isolated. State the types of reaction mechanism that occur in Step I and Step II.

	Type of reaction mechanism
Step I	
Step II	

[7]

For Examiner's use

(b) Magnalium is an alloy of aluminium and magnesium which is used in boat-building. The diagram below shows some reactions of magnalium.



(i) Identify **B**,**C** and **D**

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For Examiner's use

(ii) When 1.75 g sample of magnalium is used in the above reactions, it is found that 0.18 g of compound **B** is obtained. Determine the percentage by mass of magnesium and aluminium in the magnalium sample.

[5]

(c) Across Period 3, the types of oxides vary from basic oxide to amphoteric oxide to acidic oxide.

In Group IV, the most typical oxides of tin and lead are SnO, SnO_2, PbO and PbO_2.

The following two generalisations can be made about the oxides of the elements in group IV.

- As the metallic character of the elements increases down the Group, the oxides become more basic.
- The oxides of the elements in their higher oxidation states are more acidic than the oxides of the elements in their lower oxidation states.

Use these generalisations to suggest which of the above oxides of tin or lead is most likely to react with each of the following reagents.

(i)	With NaOH(aq)	Formula of oxide:
(ii)	With HCl(aq)	Formula of oxide:

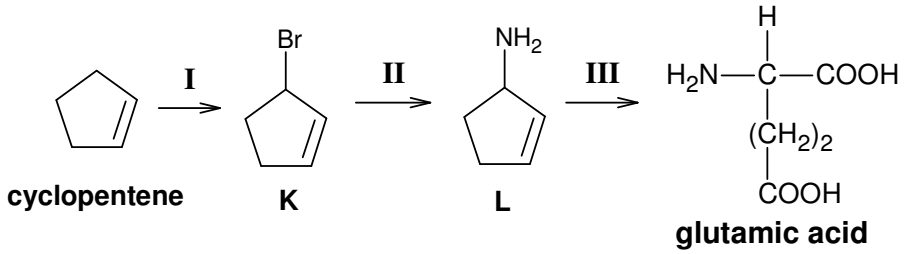
[2]

[Total: 14 marks]

For Examiner's use

4 (a) Fibrinogen is produced by the liver and it is used for blood coagulation. This protein is converted by thrombin into fibrin, which is cross-linked for a blood clot to be formed. One of the amino acids in fibrinogen is glutamic acid.

Glutamic acid can be synthesized from cyclopentene (M_r of 68) by the following route.



cyclopentene **K** **L** **glutamic acid**

(i) Suggest the reagents and conditions for steps **I**, **II** and **III**.

Step **I**: ……

Step **II**: ……

Step **III**: …….. **[3]**

(ii) Suggest a simple chemical test by which compounds **K** and **L** could be distinguished from each other. Write any appropriate equation.

[3]

For Examiner's use

(iii) State the name of the reaction in step **I**.

The reaction in step **I** also produces small quantities of compound **M** which has a M_r of 134. Draw the structure of **M**.

[2]

(iv) State two reasons to explain why the yield of step **I** may be small.

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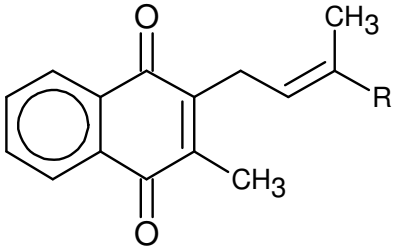
[2]

(b) Vitamin K is a fat-soluble vitamin that is essential to allow blood clotting to occur. There are three basic forms of vitamin K and they are K1, K2 and K3. All the three basic forms contain two rings fused together.

The following is the structure of Vitamin K1.



R is an alkyl group and it contains 16 carbons. You can assume that R remains inert for the reactions below.

Draw the structures of organic compounds formed when vitamin K1 reacts with each of the following reagents:

For Examiner's use

(i) conc. H_2SO_4, conc. HNO_3, heat	**(ii)** $KMnO_4/H^+$, heat
(iii) $LiAlH_4$, in dry ether.	**(iv)** HCN with traces of NaCN, followed by heating with aqueous sodium hydroxide.

[5]

[Total: 15 marks]

For Examiner's use

5 (a) Hydrogen is made from methane via a process known as steam reforming.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3\ H_2(g) \quad \Delta H = +206\ kJ\ mol^{-1}$$

The value of the equilibrium constant, K_p, for this reaction is 1.80×10^{-7} at 600 K.

(i) Gaseous CH_4, H_2O and CO are introduced into an evacuated container at 600 K and their initial partial pressures (before reaction) are 1.40 atm, 2.30 atm and 1.60 atm respectively.

Determine the partial pressure of H_2 (g) when equilibrium is reached. (You may assume that the extent of the forward reaction is small.)

(ii) Should the temperature of the reaction be raised or lowered to increase the yield of H_2? Explain your answer.

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[5]

For Examiner's use

(b) Additional hydrogen can be recovered using the carbon monoxide produced in another reaction known as the water-gas shift reaction.

$$CO(g) + H_2O(g) \longrightarrow CO_2(g) + H_2(g)$$

Given that the above reaction was conducted at 400 ^oC and 1 atm, calculate the volume of H_2 that can be recovered from 10 kg of CO.
(You may assume that H_2 behaves as an ideal gas)

[3]

[Total: 8 marks]

For Examiner's use

6 Calcium (Ca^{2+}) ions play an important role in the clotting of blood as well as other cellular processes. As such, an abnormal Ca^{2+} concentration is of concern.

To determine the Ca^{2+} concentration, 1.00 cm^3 of human blood is treated with aqueous $Na_2C_2O_4$ solution. The resulting CaC_2O_4 precipitate is filtered and then treated with H_2SO_4 to release the $C_2O_4^{2-}$ ions into solution. This solution is then titrated with acidified $KMnO_4$.

2.05 cm^3 of 4.88 x 10^{-4} mol dm^{-3} $KMnO_4$ was required to reach the end-point for a particular blood sample.

(a) Given that $C_2O_4^{2-}$ is oxidised to CO_2, write a balanced ionic equation for the reaction between MnO_4^- and $C_2O_4^{2-}$.

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[1]

(b) Calculate the amount of Ca^{2+} present in the blood sample.

[2]

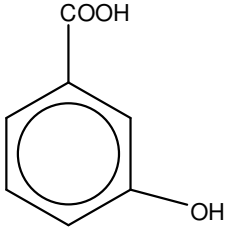
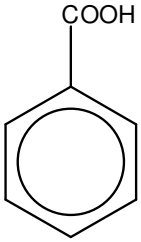
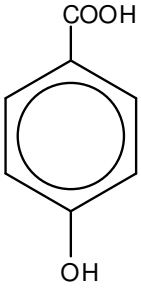
(c) Given that the normal concentration of Ca^{2+} is 90 – 110 mg / L blood, show whether the concentration of Ca^{2+} in the sample is acceptable.

[2]

[Total: 5 marks]

For Examiner's use

7 The acid dissociation constants, K_a, of three acids are shown as follows:

compound		**K_a/ mol dm^{-3}**
3-hydroxybenzoic acid		8.7×10^{-5}
Benzoic acid		6.3×10^{-5}
4-hydroxybenzoic acid		3.3×10^{-5}

(a) (i) Explain the trend of decreasing K_a values of the three acids.

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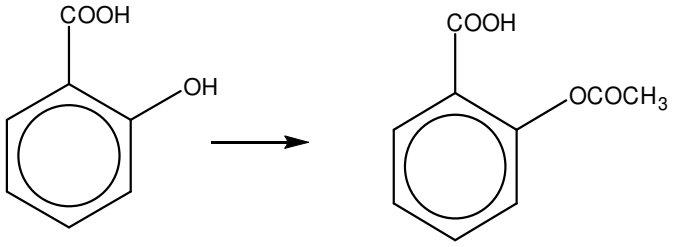
For Examiner's use

(ii) Calculate the pH of 0.0180 mol dm^{-3} solution of benzoic acid?

[3]

(b) **(i)** State the reagents and condition required to convert salicyclic acid to aspirin.



salicyclic acid aspirin

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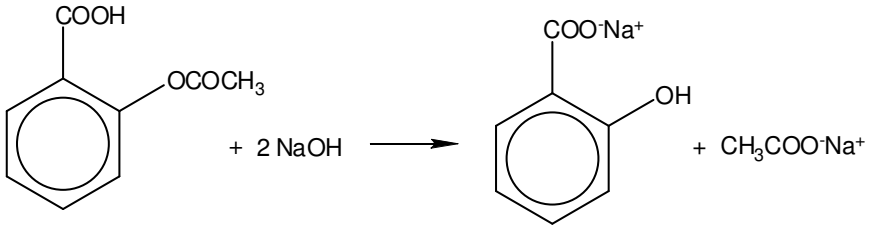
(ii) The purity of the aspirin obtained is often estimated by hydrolysis with an excess of aqueous sodium hydroxide. The equation for the hydrolysis is



The amount of excess sodium hydroxide is found by titration with hydrochloric acid.

Although phenol reacts with sodium hydroxide, the hydrolysis equation indicates that the hydroxyl group in salicyclic acid does not. With the aid of a diagram, suggest a reason for this behaviour.

For Examiner's use

(iii) When 0.10 mol of aspirin was treated with 0.30 mol of aqueous sodium hydroxide, the excess sodium hydroxide reacts with 0.15 mol of hydrochloric acid. Calculate the percentage purity of the aspirin prepared.

[3]

[Total: 6 marks]

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