Name:		Class:	

ST ANDREW'S JUNIOR COLLEGE

JC2 Preliminary Examinations

Chemistry Higher 2 **9647 / 02**

Paper 2 **02 September 2013**
2 hours

Candidates answer in the spaces provided on the question paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

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.

You are reminded of the need for good English and clear presentation in your answers.

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

For Examiner's Use:

Question	Marks	Question	Marks
1		3	
2		4	
TOTAL	/72		

This document consists of **18** printed pages including this page.

1. Planning (P)

The solubility of solid lead iodate (V), $Pb(IO_3)_2$, in water is low. When a sample of this salt is mixed with water, a small amount dissolves and an equilibrium between the solid salt and its aqueous ions is established.

$Pb(IO_3)_2(s) \rightleftharpoons Pb^{2+}(aq) + 2IO_3^-(aq)$ $\qquad K_{sp} = [Pb^{2+}][IO_3^-]^2\ mol^3\ dm^{-9}$

The concentration of iodate (V) ions present in the saturated solution is described as follows:

- Iodine is liberated when excess potassium iodide, KI, is added to an acidified solution containing iodate (V) ions.

$$IO_3^-(aq) + 5I^-(aq) + 6H^+(aq) \rightarrow 3I_2(aq) + 3H_2O(l)$$

- The liberated iodine can then be reacted with a standard solution of sodium thiosulfate.

$$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

You are to design a titrimetric experiment to determine the solubility product of lead iodate (V).

1. (a) You are provided the following:

- Solid lead iodate (V)
- Solid potassium iodide
- 1 mol dm^{-3} hydrochloric acid
- 0.0200 mol dm^{-3} sodium thiosulfate
- Starch indicator
- Distilled water
- And any other standard laboratory apparatus.

Describe, step-by-step (including quantities of reagents used), the procedure involved in your experiment.

[4]

(b) Suggest one possible error that may occur during the experiment.

[1]

1. (c) Calculate the solubility product of lead iodate (V) given that 25.0 cm^3 of the saturated solution requires ***v*** cm^3 of $Na_2S_2O_3$.

[3]

1. (d) A solution contains a mixture of chloride ions and iodide ions.

You are provided with the reagents HC*l* (aq), NH_3 (aq), $AgNO_3$ (aq), HNO_3 (aq) and distilled water together with test tubes, a filter funnel and filter papers.

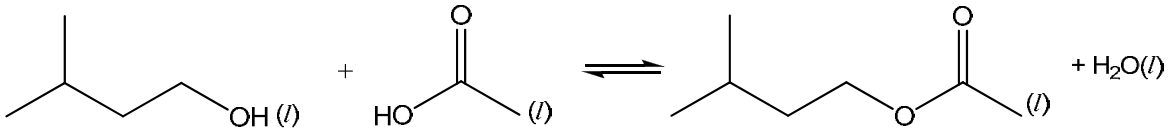
Devise a sequence of steps by which, using only the above materials, the two anions could be separately obtained as precipitates.

Test	**Expected Observations**	**Deduction**

[4]

[Total: 12 marks]

2. Isopentyl acetate is also widely referred to as banana oil for its odour.



Isopentyl alcohol **Ethanoic acid** **Isopentyl acetate**

(a) Banana oil can be synthesized through a simple esterification method. The laboratory synthesis of banana oil is carried out as follows.

Step 1	15 cm^3 of isopentyl alcohol and 20 cm^3 of ethanoic acid are added to a 100 cm^3 round bottomed flask.
Step 2	4 cm^3 of 1.5 mol dm^{-3} sulfuric acid is added dropwise to the flask with constant swirling. The mixture was heated under reflux for 1 hour. During reflux, the top of the reflux condenser was left open to the atmosphere. The mixture was then allowed to cool to room temperature.
Step 3	The cooled mixture was poured into a separating funnel and 55 cm^3 of cold water was added. The separating funnel was shaken several times and the mixture was allowed to stand before discarding the aqueous layer.
Step 4	Solid Na_2CO_3 was added to the organic layer and the mixture was swirled with the top of the separating funnel opened. Pure isopentyl acetate was finally obtained through distillation

(i) Explain why isopentyl acetate can be separated from water using a separating funnel.

2. (a) (ii) Isopentyl acetate has a higher boiling point than isopentyl alcohol. Explain.

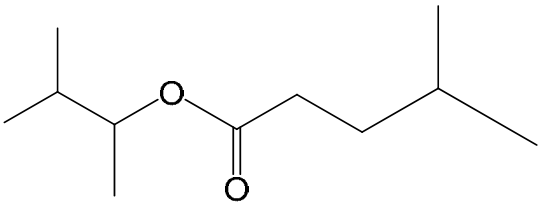
(iii) With reference to **Step 2**, suggest why the reflux condenser was left open during the refluxing process to increase the yield of the ester.

(iv) Suggest why Na_2CO_3 was added to the organic layer.

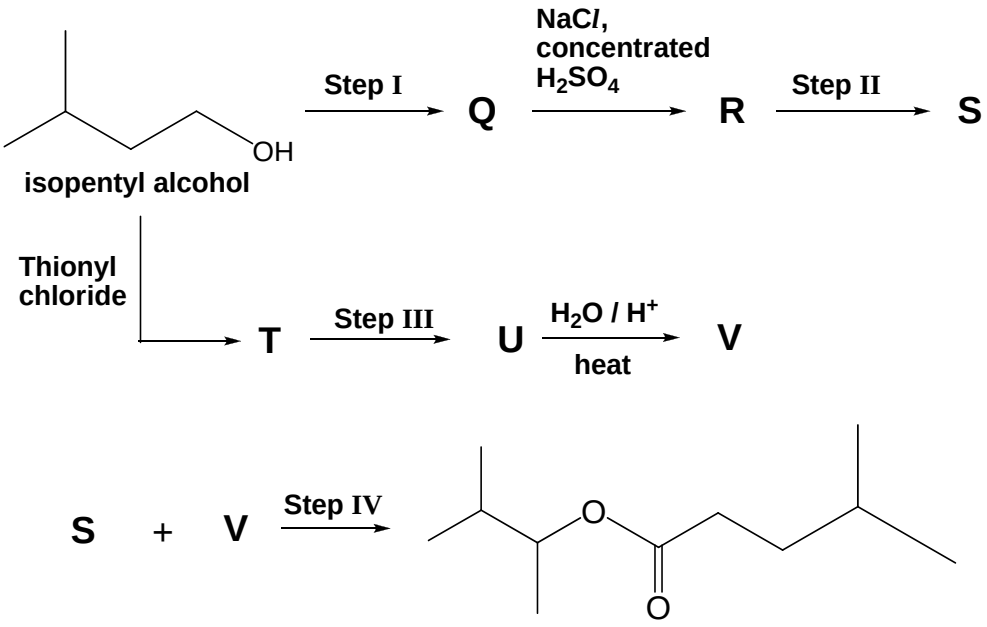
(v) Why was it necessary to ensure that the top of the separating funnel was opened while swirling in **Step 4**?

[9]

2. (b) The following ester can be formed using isopentyl alcohol as the only organic starting material.



The synthesis of the ester is as shown in the reaction sequence below.



2. (b) (i) State the reagents and conditions needed for

Step I	
Step II	
Step III	
Step IV	

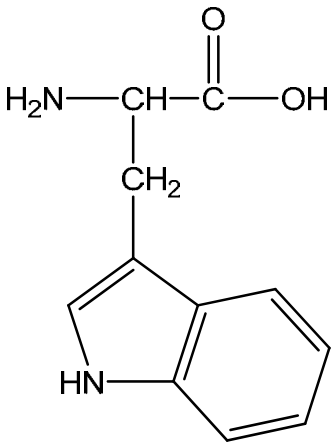
2. (b) (ii) Draw the structural formulae of **Q**, **R**, **S**, **T**, **U** and **V**.

Q	**R**
S	**T**
U	**V**

(b) (iii) Compound **W** is an isomer of the isopentyl alcohol. **W** has a chiral centre and gives no yellow precipitate with alkaline aqueous iodine. Suggest the structural formula of **W** and indicate the chiral centre on **W** with an asterisk (*).

[7]

2. (c) Isopentyl alcohol is one of the main ingredients for Kovac's reagent. Kovac's reagent is used to determine the ability of an organism to split the bicylic structure from the amino acid tryptophan.

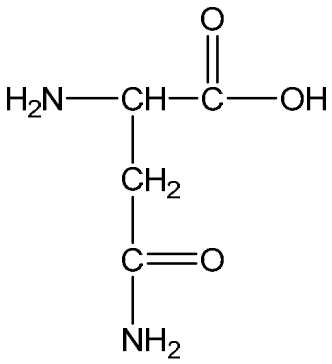


Tryptophan

(i) Explain why tryptophan is a crystalline solid at room temperature.

(ii) With the aid of a diagram, explain why tryptophan is soluble in water.

2. (c) (iii) Draw the dipeptide formed between tryptophan and asparagine.



Asparagine

(iv) Describe a simple chemical test to distinguish between tryptophan and asparagine.

2. (c) (v) Describe one way by which the tertiary structure of proteins can be stabilised between the amino acid residues of tryptophan and asparagine.

[9]

[Total: 25 marks]

3. (a) The following experiments were carried out to determine the solubility product of calcium hydroxide.

Different volumes of 0.01 mol dm^{-3} NaOH was added separately to different dry conical flasks. A fixed amount of deionised water was added to the respective conical flask according to the following table.

Experiment	Vol. of 0.01 mol dm^{-3} NaOH / cm^3	Vol. of water / cm^3
1	0.00	100.00
2	20.00	80.00
3	40.00	60.00
4	60.00	40.00
5	80.00	20.00
6	100.00	0.00

Excess solid calcium hydroxide was added to each conical flask before it was stoppered and shaken for a few minutes. The solution was then filtered into separate dry conical flask.

(i) Why was calcium hydroxide added in excess?

_____

(ii) Suggest why the conical flasks are kept dry.

_____

[2]

(b) 10.0 cm^3 of the filtrate collected in each conical flask was titrated against 0.05 mol dm^{-3} HC*l* using a suitable indicator. The average volume of HC*l* used for the titration of the filtrate from Experiment 6 is 10.4 cm^3.

(i) Suggest a suitable indicator and state the colour change.

Suitable indicator: _____

Colour change: _____

3. (b) (ii) Write the K_{sp} expression for $Ca(OH)_2$.

(iii) Calculate the K_{sp} of $Ca(OH)_2$.

(iv) Using your answer in **(b)(iii)**, calculate the volume of HC*l* required for the titration in **Experiment 1**.

[9]

[Total: 11 marks]

4. (a) Aluminium can be obtained by two ways:

- The first method involves recycling the metal. The metal needs only to undergo melting to be recycled. The ΔG required to recycle aluminium is approximately +26 kJ mol^{-1}.

- The second method involves electrolysis. It can be produced by the Hall-Heroult process. Alumina, Al_2O_3 is dissolved with cryolite and aluminium fluoride. The mixture undergoes electrolysis in a graphite lined container which acts as the anode. Carbon dioxide is produced as a result. The overall reaction has a ΔH of +568 kJ mol^{-1} and ΔS of +158 J mol^{-1} K^{-1}.

(i) Write a balanced overall equation between alumina and graphite for the second method.

_____

(ii) The graphite lining for the electrolysis needs to be replaced frequently. Suggest a reason.

_____

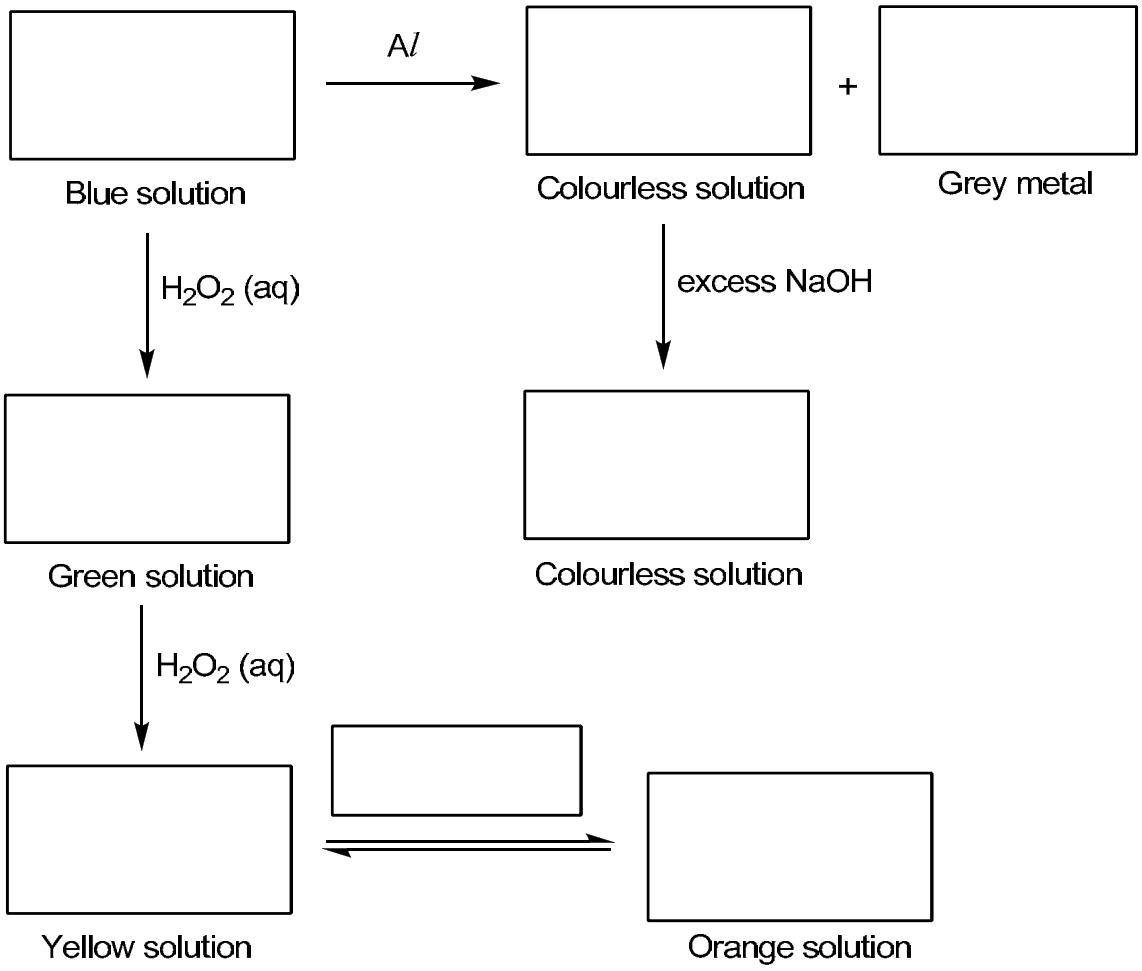
_____

(iii) Calculate the Gibbs free energy for the electrolysis reaction at 1000 ^oC and hence explain which method is preferred for obtaining aluminium.

4. (a) (iv) The main energy input for recycling metal is for melting. Explain why the energy required for recycling copper is higher than that for aluminium.

[8]

(b) (i) An aqueous solution of a transition metal ion undergoes the following reaction. With the aid of the Data Booklet, fill in the spaces provided.



4. (b) (ii) Explain why transition metal ions tend to form coloured ions.

[7]

(c) A*l*Cl_3 and A*l*F$_3$ are common compounds of aluminium. However, they have very different properties.

(i) Write a balanced chemical equation when solid A*l*Cl_3 dissolves in water.

(ii) When NaC*l* dissolves in water, the highly ordered crystal mixes with water and the hydrated ions becomes dispersed randomly in solution. Thus, the entropy increases when NaC*l* dissolves in water. However, the entropy decreases when A*l*Cl_3 dissolves in water. Explain.

(iii) A*l*Cl_3 is used as a catalyst in the reaction between Cl_2 and chlorobenzene. Outline the mechanism.

4. (c) (iv) Using the values in the table below, construct an energy level diagram to calculate the enthalpy change of solution for AlF_3.

	/ kJ mol^{-1}
Lattice energy of AlF_3	-5924
Hydration energy of Al^{3+}	-4665
Hydration energy of F^-	-505

Energy / kJ mol^{-1}

[9]

[Total: 24 marks]

~~~~ THE END ~~~~