

Centre Number						Candidate Number				
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For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
TOTAL	



General Certificate of Education
Advanced Level Examination
June 2014

Applied Science

SC11

Unit 11 Controlling Chemical Processes

Monday 9 June 2014 1.30 pm to 3.00 pm

For this paper you must have:

- a pencil
- a ruler
- a calculator.

Time allowed

- 1 hour 30 minutes

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show the working of your calculations.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.
- You will be marked on your ability to
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.
- You are expected to use a calculator where appropriate.



J U N 1 4 S C 1 1 0 1

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

1 Aluminium and its alloys have many different uses including aircraft construction and making drinks cans and overhead power cables.

1 (a) The extraction of aluminium is a continuous process. Many continuous processes are more economical than batch processes.

1 (a) (i) What is meant by a **continuous** process?

[2 marks]

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1 (a) (ii) What is meant by a **batch** process?

[2 marks]

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1 (a) (iii) Give **one** example of a situation where a batch process would be considered more useful than a continuous process. Explain the reason for your choice.

[2 marks]

Example

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Reason.....

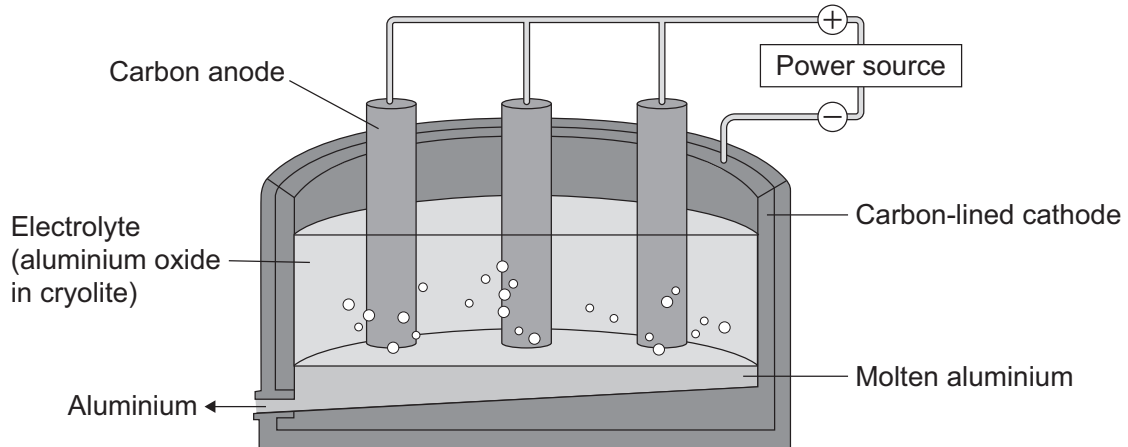
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- 1 (b) Aluminium is extracted from its ore using electrolysis. A diagram of one type of cell used is shown in **Figure 1**.

Figure 1



Explain what **electrolysis** is and what it does.

[2 marks]

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- 1 (c) (i) Chemical engineers consider costs when developing industrial processes. Electricity is a direct cost in the extraction of aluminium.

Explain what is meant by a **direct cost**.

[2 marks]

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Question 1 continues on the next page

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- 1 (c) (ii)** Identify **one** indirect cost and **one** capital cost in the extraction of aluminium. **[2 marks]**

Indirect cost

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Capital cost

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- 1 (d) (i)** Balance this half equation for the reaction that occurs at the carbon anode in **Figure 1**: **[2 marks]**



- 1 (d) (ii)** The electrolysis reaction involves reactants and products in different states. What term describes a reaction of this type? **[1 mark]**

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- 1 (d) (iii)** The carbon anodes have to be replaced periodically. Suggest why. **[1 mark]**

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- 1 (d) (iv)** Give the oxidation states of carbon in carbon dioxide and in carbon. **[2 marks]**

carbon dioxide

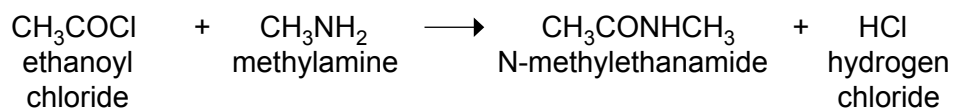
carbon

- 1 (d) (v)** What type of reaction is the production of aluminium from aluminium oxide? **[1 mark]**

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- 2 Organic research chemists develop synthetic pathways for many different compounds. N-methylethanamide is a compound that is used in the production of pharmaceuticals and as an additive for concrete. It can be produced by the reaction of ethanoyl chloride with methylamine:



- 2 (a) (i) Calculate the relative molecular masses, M_r , of ethanoyl chloride and N-methylethanamide.
(Relative atomic masses: C = 12, N = 14, O = 16, Cl = 35.5, H = 1)

[2 marks]

CH₃COCl

M_r =

CH₃CONHCH₃

M_r =

- 2 (a) (ii) Calculate the mass of N-methylethanamide produced when 50 kg ethanoyl chloride is reacted with an excess of methylamine. Assume that a 100% yield is achieved. Give the correct unit in your answer.

[3 marks]

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Mass of N-methylethanamide =

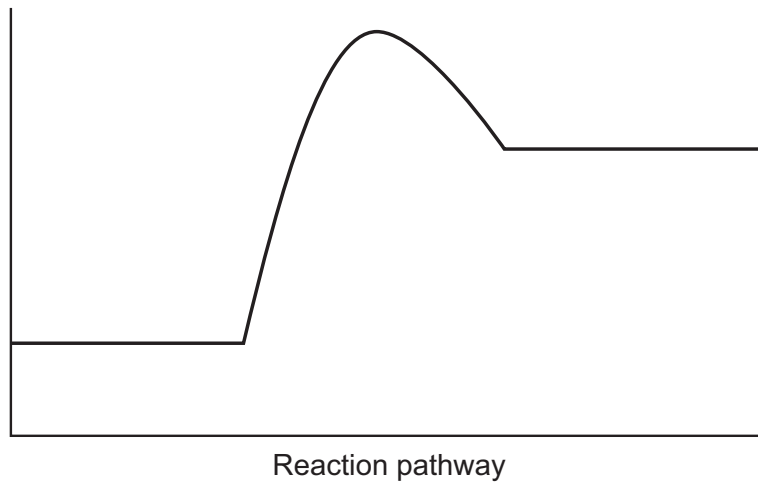
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2 (d) The reaction profile for another reaction is shown in **Figure 2**.

Figure 2



2 (d) (i) Add the appropriate label to the *y*-axis on **Figure 2**. Also label the reactants, the products and the activation energy on **Figure 2**.

[3 marks]

2 (d) (ii) Energetically, what type of reaction is this?

[1 mark]

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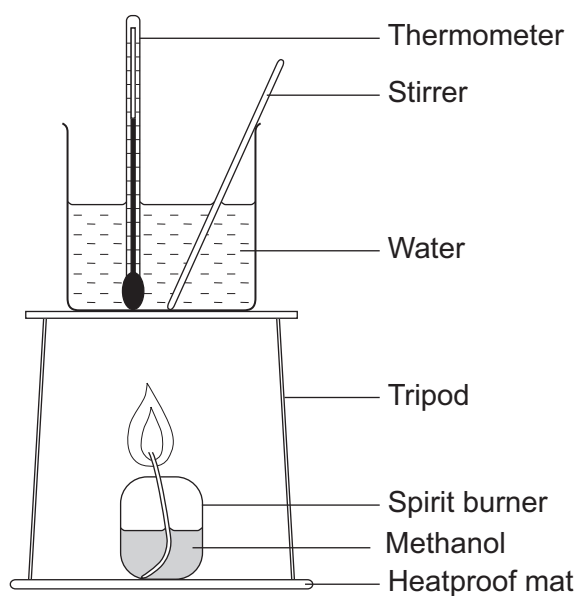
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3 Methanol, CH_3OH , is a useful starting material for many chemical processes as well as being a fuel.

3 (a) A student did an experiment to determine the enthalpy of combustion of methanol. The apparatus she used is shown in **Figure 3**.

Figure 3



The results of her experiment are shown in **Table 2**.

Table 2

Mass of spirit burner and methanol before experiment	56.86 g
Mass of spirit burner and methanol after experiment	54.93 g
Mass of water	150.00 g
Temperature of the water before experiment	23 °C
Temperature of the water after experiment	81 °C

3 (a) (i) What is the temperature rise of the water in this experiment?

[1 mark]

..... °C



- 3 (a) (ii)** Calculate the heat energy transferred to the water in this experiment.
Give the correct unit in your answer.
(Specific heat capacity of water = $4.2 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$)

[4 marks]

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Heat energy transferred =

- 3 (a) (iii)** The relative molecular mass, M_r , of methanol is 32.
Calculate the number of moles of methanol burned in this experiment.

[2 marks]

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Number of moles of methanol =

- 3 (a) (iv)** Use your answers to parts **(a)(ii)** and **(a)(iii)** to calculate the experimentally determined enthalpy of combustion for methanol.

[2 marks]

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Enthalpy of combustion = kJ mol^{-1}

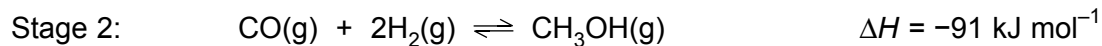
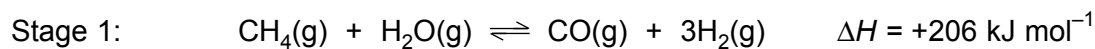
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- 3 (b)** Industrial chemists must take into account many factors when considering different ways of producing methanol.

Methanol can be prepared in two stages from methane and steam:



The reactions in both stages are reversible and so a dynamic equilibrium can be established.

- 3 (b) (i)** What is a **reversible** reaction?

[1 mark]

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- 3 (b) (ii)** What condition is required for a dynamic equilibrium to be established?

[1 mark]

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- 3 (b) (iii)** Write an expression for the equilibrium constant, K_c , for the reaction in Stage 1.

[2 marks]

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3 (c) The enthalpy change of combustion of methanol can be calculated using enthalpy data and Hess's law.

3 (c) (i) Define the term **enthalpy change of combustion**.

[2 marks]

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3 (c) (ii) Use the enthalpies of combustion given in **Table 3** and the overall enthalpy change for Stage 2, shown below, to calculate the enthalpy of combustion of methanol.

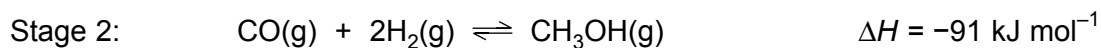


Table 3

Substance	Hydrogen	Carbon monoxide
Enthalpy of combustion (kJ mol^{-1})	-286	-283

[4 marks]

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Enthalpy of combustion = kJ mol^{-1}

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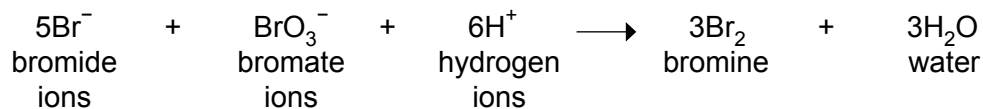
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4 Research chemists often study rates of reactions to discover information about how particles collide.

4 (a) The reaction between bromide ions and bromate ions in acid solution is:



The reaction is first order with respect to bromide ions, first order with respect to bromate ions and second order with respect to hydrogen ions.

4 (a) (i) Write the rate equation for this reaction.

[3 marks]

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4 (a) (ii) What is the overall order of the reaction?

[1 mark]

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4 (a) (iii) Explain what **second order** means.

[2 marks]

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4 (a) (iv) What would happen to the rate of the reaction if the concentration of bromide ions were halved?

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[1 mark]



4 (b) Industrial chemists often use catalysts as well as reactants.

4 (b) (i) Explain what is meant by a **reactant**.

[1 mark]

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4 (b) (ii) Explain what is meant by a **catalyst**.

[2 marks]

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4 (c) Use the idea of activation energy to explain how a catalyst works.

[3 marks]

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5 An analytical chemist wants to check the enthalpy of neutralisation of hydrochloric acid by sodium hydroxide. He plans to use only laboratory apparatus that would be available in a school.

5 (a) List the apparatus you would expect the chemist to use.

[3 marks]

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5 (b) Describe how the analytical chemist would use the apparatus to check the enthalpy of neutralisation of hydrochloric acid by sodium hydroxide.

You will be assessed on the quality of written communication in your answer.

[5 marks]

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5 (c) Suggest **two** ways that the analytical chemist could ensure that the results of his experiment were valid.

[2 marks]

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