

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

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



General Certificate of Education
Advanced Level Examination
June 2011

Applied Science

SC11

Unit 11 Controlling Chemical Processes

Wednesday 15 June 2011 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 1 S C 1 1 0 1

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

1 Industrial chemists must consider the rates of reactions. They have to find conditions that provide the required product in a short time.

1 (a) Explain what is meant by *rate of reaction*.

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(2 marks)

1 (b) Industrial chemists studied the rate of reaction when solutions of **X** and **Y** reacted with each other.

The results of the investigation are shown in the table.

Experiment	Initial concentration of X (mol dm ⁻³)	Initial concentration of Y (mol dm ⁻³)	Initial rate of reaction (mol dm ⁻³ s ⁻¹)
1	0.1	0.1	4.0×10^{-2}
2	0.1	0.3	1.2×10^{-1}
3	0.2	0.1	4.0×10^{-2}

1 (b) (i) Use the results in the table to determine the order of reaction with respect to each of the reactants **X** and **Y**. Explain how you arrive at your answers.

Order with respect to **X**

Explanation

.....

Order with respect to **Y**

Explanation

.....

(4 marks)

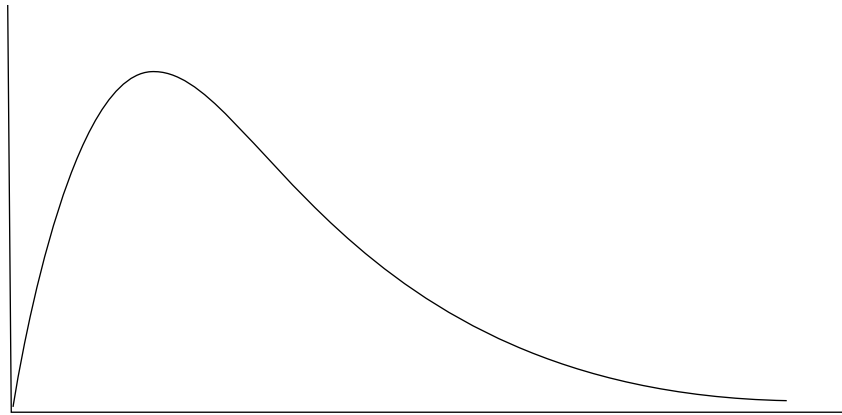
1 (b) (ii) Suggest **one** factor that must be kept constant so that this investigation is a fair test.

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(1 mark)



- 1 (c)** Industrial chemists often use high temperatures to give a satisfactory rate of reaction. A Maxwell–Boltzmann curve showing the distribution of energies of particles can be used to explain why an increase in temperature increases the rate of a reaction. Such a curve is shown below.



- 1 (c) (i)** Add the correct labels to the vertical and horizontal axes on the graph. (2 marks)

- 1 (c) (ii)** On the graph, sketch the curve you would expect for the same particles at a higher temperature. (2 marks)

- 1 (c) (iii)** Define the term *activation energy*.

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 (2 marks)

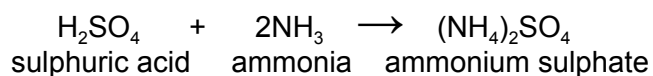
- 1 (c) (iv)** Use the idea of activation energy to explain why an increase in temperature increases the rate of a reaction.

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 (3 marks)



- 2** Many useful agrochemicals can be made by neutralising acids with ammonia. Ammonium sulphate, which can be used as a fertiliser, is produced by neutralising sulphuric acid with ammonia. Chemical engineers must know the reacting quantities required for a certain yield.



- 2 (a) (i)** Calculate the relative molecular masses of ammonia and ammonium sulphate. (Relative atomic masses: N=14, O=16, H=1, S=32)

M_r ammonia

.....

M_r ammonium sulphate

.....

(2 marks)

- 2 (a) (ii)** What mass of ammonia would be required to produce 20 tonnes of ammonium sulphate? Assume there is a 100% yield. (1 tonne = 1000 kg)

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(3 marks)



2 (b) Chemical engineers also need to know the enthalpy change for the production of ammonium sulphate.
An analytical chemist at an agrochemical plant has been asked to check the enthalpy change when sulphuric acid is neutralised with ammonia solution.

2 (b) (i) List the apparatus you would use in an experiment to determine the enthalpy of neutralisation of sulphuric acid with ammonia.

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(3 marks)

2 (b) (ii) Describe how you would carry out the experiment.

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

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(5 marks)

Question 2 continues on the next page

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2 (b) (iii) State what precautions must be taken to ensure that the results of your experiment are accurate.

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(2 marks)

2 (b) (iv) The equation used to calculate the heat energy released in the reaction is: $q = mc\Delta T$.

State what is represented by

m

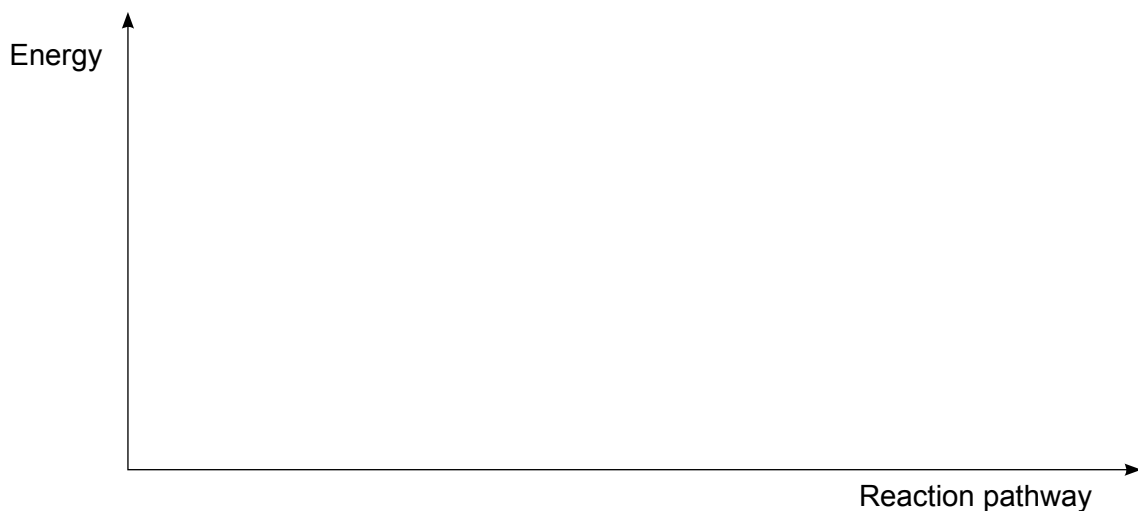
ΔT

(2 marks)

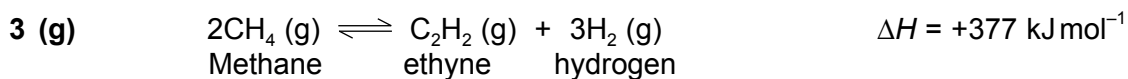
17



- 3 (f)** Sketch the reaction profile you would expect for the production of ethyne on the axes provided.



(3 marks)



- 3 (g) (i)** Calculate the number of moles in 336 dm^3 of methane under standard conditions.
 (one mole of any gas occupies 22.4 dm^3 under standard conditions)

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(1 mark)

- 3 (g) (ii)** Calculate the energy change you would expect if 336 dm^3 of methane were reacted to make ethyne and hydrogen.

.....

 kJ

(2 marks)

20

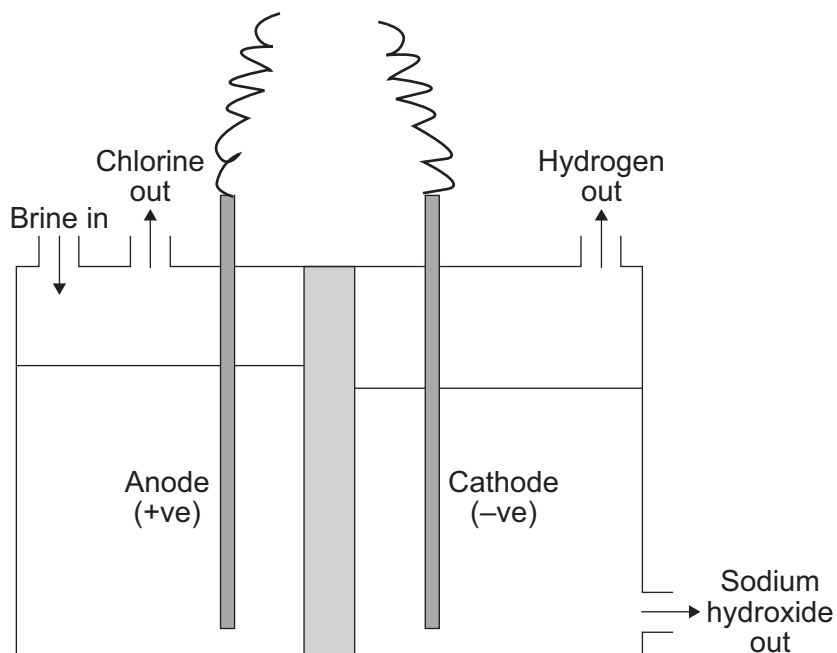
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- 4 Large underground deposits of salt are found in Cheshire. Most of the salt extracted from the Cheshire deposits is turned into brine.

The chlor-alkali industry produces three useful substances from brine – sodium hydroxide, chlorine and hydrogen.

The diagram below shows one of the types of cell that is used.



- 4 (a) Name the process that happens in the cell.

.....
(1 mark)

- 4 (b) State **one** hazard of each of these substances.

Hydrogen

Chlorine
(2 marks)

- 4 (c) Suggest an appropriate safety precaution to be taken when handling concentrated sodium hydroxide.

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(1 mark)



4 (d) The costs involved in industrial processes must be considered by development chemists.

4 (d) (i) Define the term *capital cost*.

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.....

(1 mark)

4 (d) (ii) Identify **one** direct cost, **one** indirect cost, and **one** capital cost for the production of sodium hydroxide, chlorine and hydrogen from brine.

Direct cost

Indirect cost

Capital cost

(3 marks)

4 (e) This operation is run as a continuous process.
What is meant by a *continuous process*?

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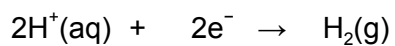
(2 marks)

Question 4 continues on the next page

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4 (f) The ionic half equations for the processes occurring at the electrodes are



4 (f) (i) Give the oxidation state of chlorine in chloride ions and in chlorine molecules.

Chloride ions, Cl^-

Chlorine molecules, Cl_2

(2 marks)

4 (f) (ii) Use your answers to part (f)(i) to decide whether chlorine has been oxidised or reduced in this process. Explain how you arrived at your answer.

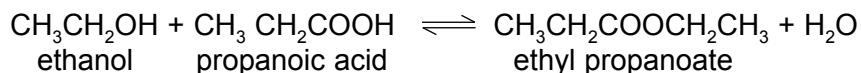
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(1 mark)

13



- 5** Ethyl propanoate, $\text{CH}_3\text{CH}_2\text{COOCH}_2\text{CH}_3$ is often used in the manufacture of fragrances and flavourings. It can be produced by the reaction of ethanol with propanoic acid.



- 5 (a)** An analytical chemist, who works for the company that manufactures ethyl propanoate, wants to determine the enthalpy change for this reaction. Enthalpy of formation data can be used to calculate this enthalpy change.

- 5 (a) (i)** Explain what the term *molar enthalpy of formation* means.

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(2 marks)

- 5 (a) (ii)** Use the following enthalpy of formation data to calculate the enthalpy change when one mole of ethyl propanoate is made from ethanol and propanoic acid.

	$\text{CH}_3\text{CH}_2\text{COOH}$	$\text{CH}_3\text{CH}_2\text{OH}$	$\text{CH}_3\text{CH}_2\text{COOCH}_2\text{CH}_3$	H_2O
Enthalpy of formation/ kJ mol^{-1}	-510.7	-277.1	-502.7	-237.2

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(4 marks)

Question 5 continues on the next page

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- 5 (b)** This reaction is reversible and therefore, after some time, a dynamic equilibrium is established.

An expression for the equilibrium constant for this reaction is:

$$K_c = \frac{[\text{H}_2\text{O}][\text{CH}_3\text{CH}_2\text{COOCH}_2\text{CH}_3]}{[\text{CH}_3\text{CH}_2\text{COOH}][\text{CH}_3\text{CH}_2\text{OH}]}$$

- 5 (b) (i)** Calculate a value for the equilibrium constant when the equilibrium concentrations are:

$\text{CH}_3\text{CH}_2\text{COOH}$	$= 1.5 \text{ mol dm}^{-3}$
$\text{CH}_3\text{CH}_2\text{OH}$	$= 1.5 \text{ mol dm}^{-3}$
$\text{CH}_3\text{CH}_2\text{COOCH}_2\text{CH}_3$	$= 2.4 \text{ mol dm}^{-3}$
H_2O	$= 5.2 \text{ mol dm}^{-3}$

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(2 marks)

- 5 (b) (ii)** What are the units of this equilibrium constant?

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(1 mark)

- 5 (c)** Sulphuric acid acts as a catalyst for this reaction.
What effect will sulphuric acid have on the position of equilibrium? Explain your answer.

Effect

Explanation

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(2 marks)



5 (d) Often, the manufacture of fine fragrances is carried out as a batch process.

5 (d) (i) What is meant by a *batch process*?

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(2 marks)

5 (d) (ii) Suggest why chemists may consider a batch process advantageous for the manufacture of fine fragrances.

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(1 mark)

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END OF QUESTIONS



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