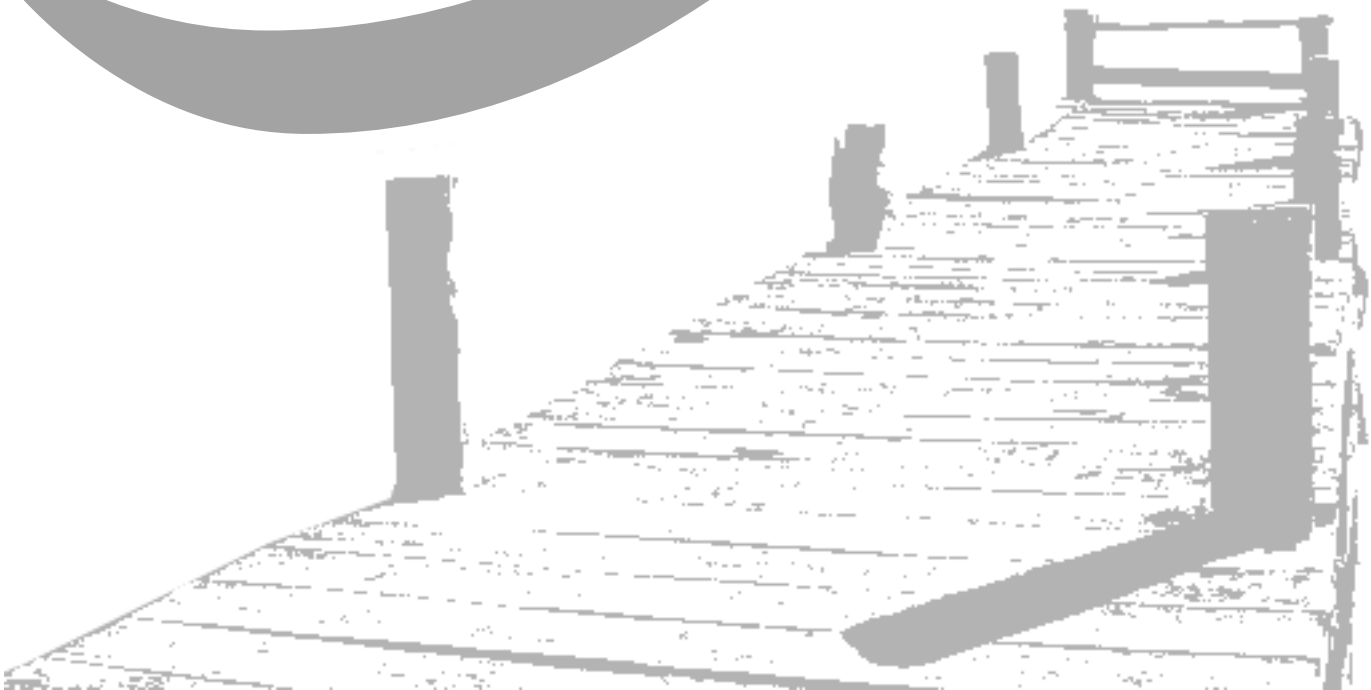
GCE
AS and A Level

Chemistry

AS exams 2009 onwards
A2 exams 2010 onwards

Unit 2:
Specimen question paper

Version 1.1



Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

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General Certificate of Education
2009
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

CHEMISTRY CHEM2
Unit 2 Chemistry In Action

SPECIMEN PAPER

For this paper you must have
- A calculator
- Data Sheet / Periodic Table

Time allowed: 1¾ hours

Instructions
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.

Information
- The maximum mark for this paper is 100.
- The marks for the questions are shown in brackets.
- You are reminded of the need for good English and clear presentation in your answers.

For Examiner's Use			
Number	Mark	Number	Mark
1		6	
2		7	
3		8	
4		9	
5			
Total (Column 1)			
Total (Column 2)			
TOTAL			
Examiner's Initials			

SECTION A

Answer **all** questions in the spaces provided

1 The combustion of hydrocarbons is an important source of energy.

(a) Define the term *standard enthalpy of combustion*.

.....

.....

.....

(3 marks)

(b) (i) Write an equation for the complete combustion of ethane, C_2H_6.

.....

(ii) Use the standard enthalpies of formation given below to calculate the standard enthalpy of combustion of ethane.

Formula and state of compound	$C_2H_6(g)$	$CO_2(g)$	$H_2O(l)$
Standard enthalpy of formation (at 298 K)/kJ mol^{-1}	–85	–394	–286

.....

.....

.....

.....

(4 marks)

(c) A container and its contents of total heat capacity 120 J K^{-1} were heated using a methane burner. Calculate the maximum theoretical temperature rise when 0.10 g of methane was completely burned. The standard enthalpy of combustion of methane is –890 kJ mol^{-1}.

.....

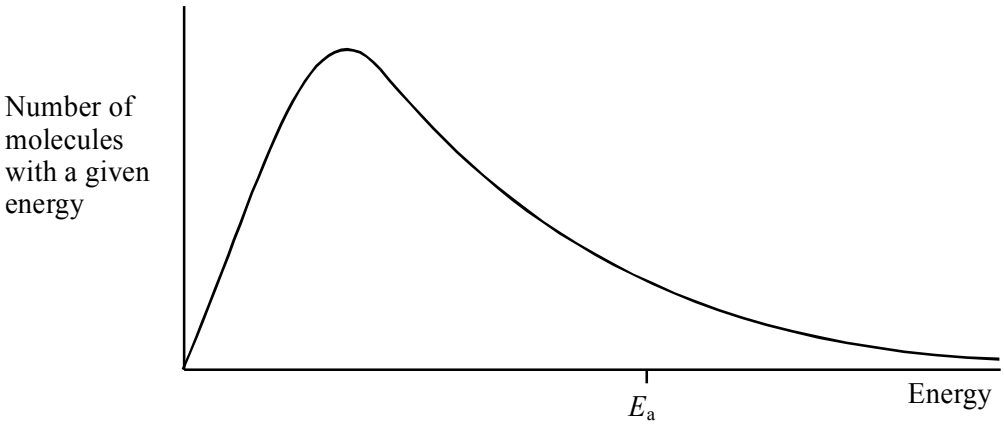
.....

.....

(4 marks)

11

2 The diagram below shows the Maxwell–Boltzmann energy distribution curve for a sample of gas at a fixed temperature. E_a is the activation energy for the decomposition of this gas.



(a) On this diagram sketch the distribution curve for the same sample of gas at a higher temperature.

(3 marks)

(b) (i) What is the effect of an increase in temperature on the rate of a chemical reaction? Explain your answer with reference to the Maxwell–Boltzmann distribution.

Effect .....

Explanation .....

.....

.....

(ii) What is the effect of the addition of a catalyst on the rate of a chemical reaction? Explain your answer with reference to the Maxwell–Boltzmann distribution.

Effect .....

Explanation .....

.....

.....

(6 marks)

9

3 Methanol is a useful liquid fuel that can be produced by direct combination of carbon monoxide and hydrogen.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H^{\ominus} = -91 \text{ kJ mol}^{-1}$$

(a) Explain why a low temperature and a high pressure favour a high yield of methanol in this reaction.

Low temperature .....

.....

.....

High pressure .....

.....

.....

(4 marks)

(b) The industrial manufacture of methanol using this reaction is carried out at a compromise temperature of 400 °C under a pressure of 20 MPa in the presence of a Cr_2O_3/ZnO catalyst.

(i) Justify the use of a compromise temperature.

.....

.....

(ii) What effect, other than on the yield, does the use of high pressure have on the reaction?

.....

(3 marks)

7

4 Oxidation and reduction can de defined in terms of electron transfer.

(a) Define the term *reduction* in terms of electrons.

.....

(1 mark)

(b) The oxide of nitrogen formed when copper reacts with nitric acid depends upon the concentration and the temperature of the acid. The reaction of copper with cold, dilute acid produces NO as indicated by the following equation.

$$3Cu + 8H^+ + 2NO_3^- \rightarrow 3Cu^{2+} + 4H_2O + 2NO$$

In warm, concentrated acid, NO_2 is formed.

Oxidation states can be used to understand electron transfer in these reactions.

(i) Give the oxidation states of nitrogen in NO_3^-, NO_2 and NO

Oxidation state in NO_3^- .....

Oxidation state in NO_2 .....

Oxidation state in NO .....

(ii) Identify, as oxidation or reduction, the formation of NO_2 from NO_3^- ions in the presence of H^+ ions. Deduce the half-equation for the reaction.

NO from NO_3^- .....

Half-equation .....

(iii) Deduce the half-equation for the formation of NO_2 from NO_3^- ions in the presence of H^+ ions.

.....

.....

(iv) Deduce the overall equation for the reaction of copper with NO_3^- ions and H^+ ions to produce Cu^{2+} ions, NO_2 and water.

.....

.....

(8 marks)

9

5 Metals can be extracted from their ores by reduction. This question refers to the metals copper, iron and titanium.

(a) A common ore of copper is malachite which contains copper carbonate ($CuCO_3$). Copper was first extracted about 3000 BC in Anatolia (now Turkey) by smelting copper ore in 'Fire Pits'. The ore was smelted with charcoal to produce impure copper.

(i) Write an equation for the smelting of malachite with charcoal to produce copper and carbon dioxide.

.....

(ii) State the chemical acting as the reducing agent in the smelting process.

.....

(2 marks)

(b) A common ore of iron is haematite which contains iron(III) oxide. Iron was not extracted from this ore until about 1500 BC.

(i) Suggest why it took another 1500 years before iron was extracted from its ore.

.....

(ii) Name a gaseous reducing agent which can reduce iron(III) oxide to iron. Write an equation for the reaction.

.....

(2 marks)

(c) Titanium metal has only been extracted from its ore rutile (TiO_2) in the last 50 years. It is a very expensive two–stage process. Give an equation for each stage of the process.

Stage 1 .....

Stage 2 .....

(4 marks)

(d) Suggest how metals can be extracted from their sulfide ores. Explain how pollution problems can arise from such extractions.

Extraction .....

.....

.....

Pollution problems .....

.....

.....

(4 marks)

12

Turn over for the next question

There are no questions printed on this page

6 The elements in Group 2 can be used to show the trends in properties down a group in the Periodic Table.

(a) State the trend in atomic radius down Group 2 from Mg to Ba and give a reason for this trend.

Trend .....

Reason .....

.....

(2 marks)

(b) State and explain the trend in melting points of the elements down Group 2 from Mg to Ba.

Trend .....

Explanation .....

.....

.....

.....

(3 marks)

(c) State the trend in reactivity with water of the elements down Group 2 from Mg to Ba. Write an equation for the reaction of magnesium with steam and an equation for the reaction of strontium with water.

Trend .....

Equation for magnesium .....

Equation for strontium .....

(3 marks)

(d) Sulfates of the Group 2 elements from Mg to Ba have different solubilities. Give the formula of the least soluble of these sulfates and state **one** use that depends upon the insolubility of this sulfate.

Formula .....

Use .....

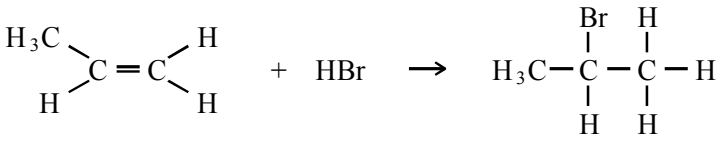
(2 marks)

10

7 Organic reaction mechanisms help to develop an understanding of how and why reactions occur.

(a) Propene reacts with hydrogen bromide by an electrophilic addition mechanism forming 2-bromopropane as the major product.

The equation for this reaction is shown below.



(i) Outline the mechanism for this reaction, showing the structure of the intermediate carbocation formed.

(ii) Give the structure of the alternative carbocation which could be formed in the reaction between propene and hydrogen bromide.

(5 marks)

(b) A substitution reaction occurs when 2-bromopropane reacts with aqueous sodium hydroxide.

(i) Draw the structure of the organic product of this reaction and give its name.

Structure

Name .....

(ii) Name and outline the mechanism for this reaction.

Name of mechanism .....

Mechanism

(5 marks)

(c) Under different conditions, 2-bromopropane reacts with sodium hydroxide to produce propene.

(i) Name the mechanism for this reaction

.....

(ii) State the role of sodium hydroxide in this reaction

.....

(2 marks)

12

SECTION B

Answer both questions in the space provided on pages 12 to 16

8 (a) In Peru, chlorine was removed from the water supply due to concerns about it reacting with organic chemicals in the water to produce toxic substances. This resulted in the death of ten thousand people due to cholera. The cholera epidemic ceased when chlorination of the water supply was restarted.

State why chlorine is added to the water supply and give a reason why the amount of chlorine must be carefully monitored. Write an equation for the reaction of chlorine with water.

(3 marks)

(b) How can the addition of an aqueous solution of chlorine be used to distinguish between aqueous solutions of sodium bromide and sodium iodide?

State any observations you would make and write equations for the reactions occurring.

(4 marks)

(c) How can reactions with concentrated sulphuric acid be used to distinguish between solid samples of sodium bromide and sodium iodide?

State the observations you would make and give all the oxidation and reduction products formed in both reactions. Using half-equations, construct an overall equation for **one** of these redox reactions.

(11 marks)

9 (a) Alcohols can be classed as primary, secondary or tertiary. Draw possible structures for a primary, a secondary and a tertiary alcohol which have the molecular formula C_4H_8O. Which of the structures you have drawn cannot be oxidised by potassium dichromate in acid solution?

(4 marks)

(b) Explain what is meant by the fingerprint region of an infra-red spectrum. State how it is used to confirm the identity of organic molecules such as the primary, secondary and tertiary alcohols of molecular formula C_4H_8O.

(2 marks)

(c) Each of the parts below concerns a different pair of isomers. Deduce one possible structural formula for each of the species **A** to **F**. Use, where appropriate, the table of infra-red absorption data given on the data sheet.

(i) **A** and **B** have the molecular formula C_3H_8O. **A** has a broad absorption band at 3300 cm^{-1} in its infra-red spectrum, but **B** does not.

(ii) **C** and **D** have the molecular formula C_5H_{10}. **C** has a weak absorption band at 1650 cm^{-1} in its infra-red spectrum, but **D** does not.

(iii) **E** and **F** have the molecular formula C_3H_6O and both have strong absorption bands at about 1700 cm^{-1} in their infra-red spectra. **E** reacts with Tollens' reagent but **F** does not.

(6 marks)

END OF QUESTIONS

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