Candidate Name	Centre Number	Candidate Number
		2

WJEC CBAC

GCE AS/A level

1091/01 **New AS**

CHEMISTRY CH1

P.M. FRIDAY, 9 January 2009

1½ hours

FOR EXAMINER'S USE ONLY		
Section	Question	Mark
A	1-4	
B	5	
	6	
	7	
	8	
	9	
TOTAL MARK		

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:
- calculator;
- copy of the **Periodic Table** supplied by WJEC. Refer to it for any **relative atomic masses** you require.

INSTRUCTIONS TO CANDIDATES

Write your name, centre number and candidate number in the spaces at the top of this page.

Section A Answer **all** questions in the spaces provided.
Section B Answer **all** questions in the spaces provided.

Candidates are advised to allocate their time appropriately between **Section A (10 marks)** and **Section B (70 marks)**.

INFORMATION FOR CANDIDATES

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

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

You are reminded that marking will take into account the Quality of Written Communication used in all written answers.

Page 18 may be used for rough work.

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SECTION A

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

1. An isotope of magnesium, ^{27}Mg, is used to detect leaks in water pipes.

(a) It decays by β–emission with a half life of 9·5 minutes.

(i) Give the symbol and mass number of the atom formed by the loss of one β particle from an atom of ^{27}Mg. [1]

.....

(ii) Calculate how long it will take for the activity of the isotope to decay to $\frac{1}{16}^{th}$ of its original activity. [1]

..... minutes

(b) Complete the boxes below, by inserting arrows to represent electrons, to show the electronic configuration of an atom of magnesium. [1]

2. Calcium oxide is made by heating calcium carbonate in air.

$$\underset{1 \text{ mole}}{CaCO_3} \longrightarrow \underset{1 \text{ mole}}{CaO} + CO_2$$

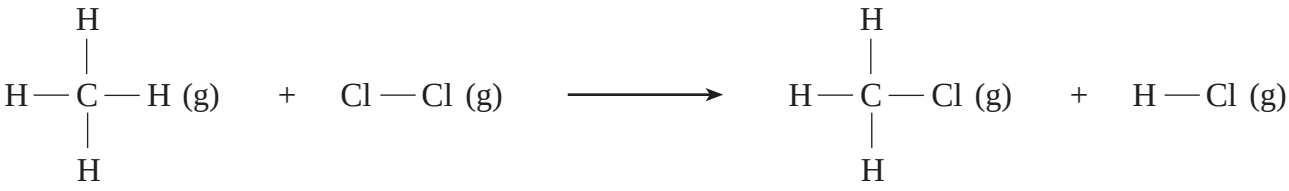
Calculate the maximum mass of calcium oxide formed when 0·500 mole of pure calcium carbonate is heated. [2]

.....

.....

.....

3. Chloromethane, CH_3Cl, is made by reacting methane, CH_4, with chlorine.



(i) The total enthalpy changes of formation from gaseous atoms (calculated from bond energies) of the species involved are shown in the table below.

Species	*Total enthalpy change of formation from gaseous atoms* / kJ mol^{-1}
CH_4	1652
Cl_2	243
CH_3Cl	1585
HCl	432

Use the values in the table to calculate the enthalpy change for the reaction above. [1]

.....

.....

..... kJ mol^{-1}

(ii) The atom economy of a reaction is given by the formula

$$\text{atom economy} = \frac{\text{theoretical mass of required product} \times 100}{\text{total mass of reactants used}} \ \%$$

Calculate the atom economy of the reaction above, where chloromethane, CH_3Cl, is the required product. [1]

.....

.....

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4. The values for some standard molar ionisation energies are given in the table.

Element	*Standard molar ionisation energies* / kJ mol^{-1}	
	First	*Second*
Argon	1521	2666
Potassium	419	3051

(i) Give **two** reasons why the **first** standard molar ionisation energy for potassium is much less than that of argon. [2]

1. .....

.....

2. .....

.....

(ii) Give a reason why the value for the **second** standard molar ionisation energy of potassium is larger than that of argon. [1]

.....

.....

Section A Total [10]

Examiner only

SECTION B

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

5. *(a)* Polluting gases such as sulfur dioxide, SO_2, produced from power stations, can cause the acidification of lakes far from the source of the pollution. At a lake-water pH of 6·0, water snails start to die and when the pH reaches 5·5, fish also begin to die.

State how you would explain to the general public how the pH scale is used to describe levels of acidity. [2]

.....

.....

.....

(b) An equation for the reaction of sulfur dioxide with water is shown below.

$$SO_2(aq) + H_2O(l) \rightleftharpoons H^+(aq) + HSO_3^-(aq)$$

(i) Use the equation to explain why sulfur dioxide is described as an acidic oxide. [1]

.....

.....

(ii) A solution of sulfur dioxide in water reaches a position of *dynamic equilibrium*. Explain what is meant by the term ***dynamic equilibrium***. [1]

.....

.....

(iii) Use Le Chatelier's principle to explain how the concentration of hydrogen ions, $H^+(aq)$, would change if more sulfur dioxide were dissolved in a solution that had reached dynamic equilibrium. [2]

.....

.....

.....

(c) One method of removing sulfur dioxide from power station emissions is to react the flue gases with moist calcium carbonate (limestone), giving hydrated calcium sulfate (gypsum) and carbon dioxide.

$$2SO_2 + 2CaCO_3 + 4H_2O + O_2 \longrightarrow 2CaSO_4.2H_2O + 2CO_2$$

One **advantage** of this process is that the gypsum can be used for the production of plaster.
State two **disadvantages** of this method of sulfur dioxide removal, apart from cost. [2]

Disadvantage 1 .....

.....

Disadvantage 2 .....

.....

(d) Some students measured the concentration of sulfur dioxide in the air.
They pumped air at a rate of 20 dm^3 per hour for 5 days through a suitable solution that absorbed the sulfur dioxide present.
The resulting solution was then treated to give 0·0047 g of barium sulfate, $BaSO_4$.
You should assume that 1 mole of sulfur dioxide gives 1 mole of barium sulfate.

(i) Calculate the total volume of air passed through the solution in 5 days. [1]

.....

..... dm^3

(ii) Calculate the relative molecular mass of barium sulfate. [1]

.....

.....

(iii) Use your answer to (ii) to calculate the number of moles of barium sulfate present. [1]

.....

.....

.....

(iv) State the number of moles of sulfur dioxide present in the sampled air. [1]

.....

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(v) Calculate the volume of sulfur dioxide present in the sampled air. [1]
[One mole of sulfur dioxide has a volume of 24·0 dm^3 under these conditions.]

.....

..... dm^3

(vi) Calculate the percentage by volume of sulfur dioxide in the sampled air. [1]

.....

.....

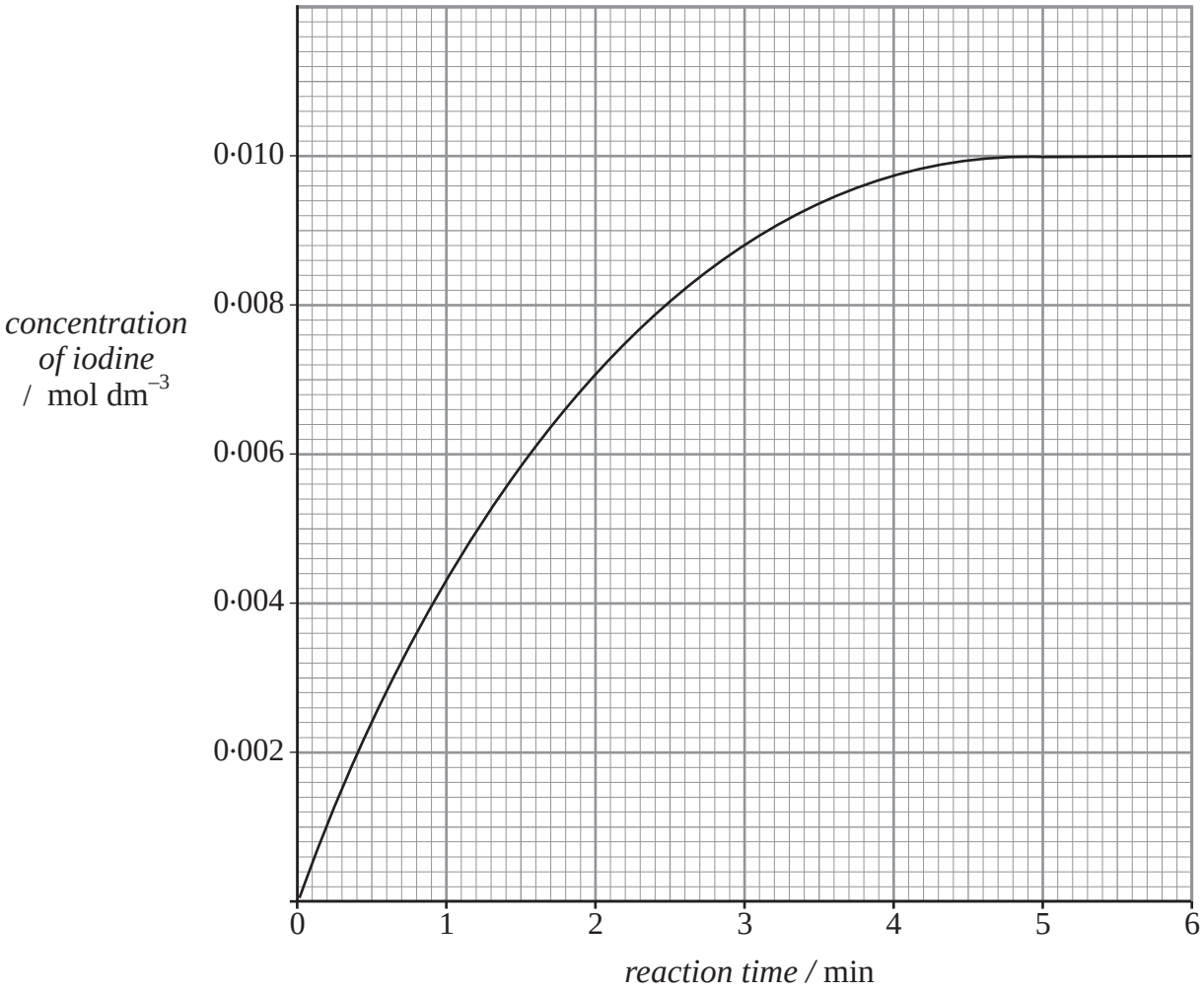
Total [14]

6. *(a)* Iodine is slowly produced, as a red-brown solution, by the reaction of aqueous peroxodisulfate ions, $S_2O_8^{2-}$, with a large excess of aqueous iodide ions, $I^-(aq)$.

$$S_2O_8^{2-}(aq) + 2I^-(aq) \longrightarrow 2SO_4^{2-}(aq) + I_2(aq)$$

colourless colourless colourless red-brown

The graph below was produced from one set of experimental results.



(i) State the time taken for all the peroxodisulfate ions to react. [1]

..... minutes

(ii) Suggest a method of measuring the rate of this reaction. [1]

.....

.....

.....

(iii) I. Sketch on the graph the line that would be obtained when the reaction is carried out at an increased temperature but keeping the other factors constant. [2]

II. Explain your answer to I. [2]

.....

.....

.....

(iv) State the concentration of the peroxodisulfate ions at the start of the reaction, explaining your answer. [2]

.....

.....

(v) Use the graph to calculate the initial rate of the reaction. [2]

.....

..... mol dm^{-3} min^{-1}

(b) A diluted solution of ethane-1,2-diol is used as an antifreeze.
This compound is made from epoxyethane and water in two different ways, either in neutral solution or in acidic solution using dilute sulfuric acid as a homogeneous catalyst.

Conditions	*Pressure* / atm	*Temperature* / °C	*Relative volume of water used*	*Catalyst*
neutral	14	200	smaller	none
acidic	1	60	larger	sulfuric acid (aq)

(i) Use the information in the table to suggest two reasons why the acid catalysed system is the preferred method. [2]

1. .....

2. .....

(ii) The acid catalysed system does, however, have some disadvantages.
Use the information given to suggest and explain one disadvantage of this system. [1]

.....

.....

(iii) The acid method uses a homogeneous catalyst.
Give an example of a process that uses a **heterogeneous** catalyst, stating the process and the name of the catalyst. [2]

Process .....

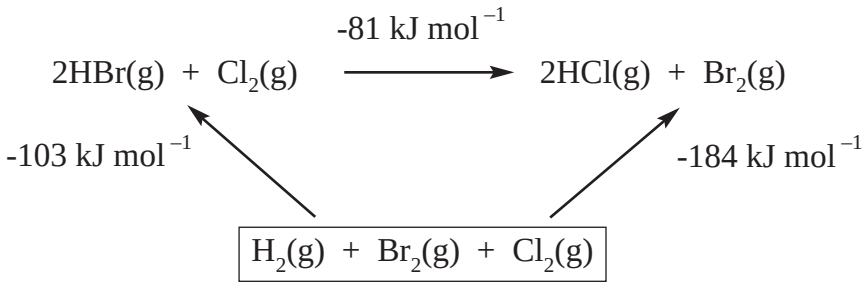
Catalyst .....

Total [15]

7. *(a)* The enthalpy change of formation of a compound is usually quoted per mole, at standard conditions. Define the term ***standard conditions***. [1]

.....

(b) The energy cycle below shows the enthalpy changes that occur when hydrogen bromide reacts with chlorine.



(i) State Hess's Law. [1]

.....

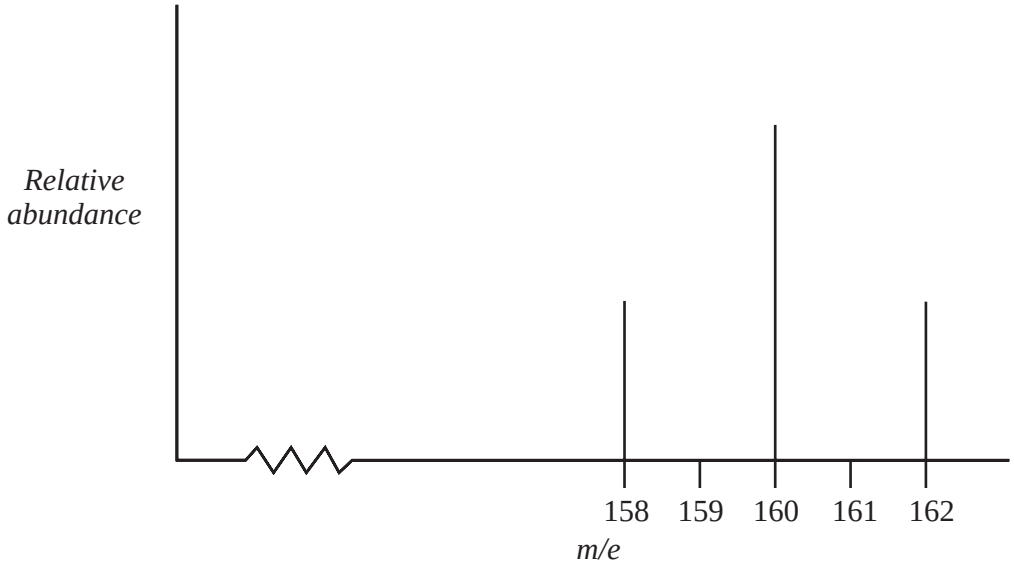
.....

(ii) Show that the values in the energy cycle above obey the principle of the conservation of energy. [1]

.....

.....

(iii) The products of the reaction were examined using a mass spectrometer. The molecular ion peaks for Br_2^+ are shown in the diagram.



Use this information to

I. state the relative isotopic masses of the two bromine atoms, ^{x}Br, [1]

.....

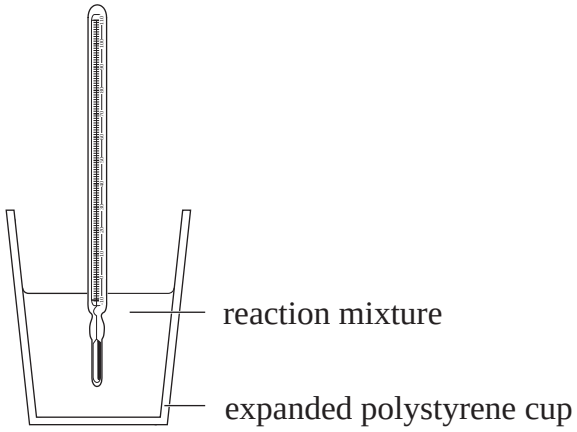
II. find the relative abundance of the two bromine isotopes, giving a reason for your answer. [2]

.....

.....

(c) Elfed carried out an experiment, using the simple apparatus shown below, to find the enthalpy change for the reaction between hydrobromic acid, HBr(aq), and aqueous sodium hydroxide.

$$HBr(aq) + NaOH(aq) \longrightarrow NaBr(aq) + H_2O(l)$$



He used 50·0 cm^3 of hydrobromic acid of concentration 2·00 mol dm^{-3} and 75·0 cm^3 of sodium hydroxide solution of concentration 2·00 mol dm^{-3}.

He measured the temperature before and after mixing.

Temperature of the solutions before mixing = 21·5 °C
Maximum temperature of the mixture = 32·1°C

He used the equation

$$\Delta H = \frac{-mc\Delta T}{n}$$

where m is the total mass of the solutions used, n is the number of moles of hydrobromic acid used and ΔT is the temperature rise.

He assumed that c, the specific heat capacity of the mixture, had the value 4·2 J g^{-1} K^{-1}, and that 1cm^3 of each solution had a mass of 1g.

(i) Calculate the number of moles of hydrobromic acid used. [1]

.....

.....

(ii) Use your answer to (i) to calculate ΔH, the enthalpy change of reaction, in kJ mol^{-1}. [4]

.....

.....

..... kJ mol^{-1}

(iii) The accepted value for this reaction is –57·6 kJ mol^{-1}.
State why values obtained are often smaller than this value. [1]

.....

.....

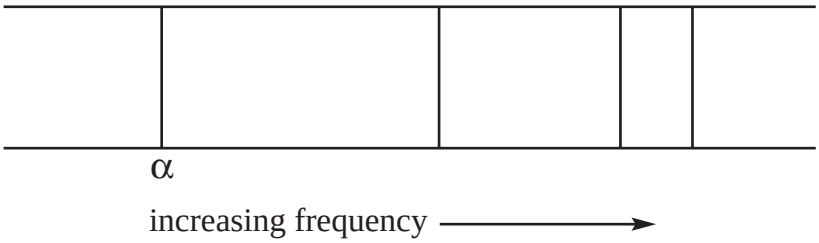
(iv) Explain why the calculation used the number of moles of hydrobromic acid rather than the number of moles of sodium hydroxide. [1]

.....

.....

Total [13]

8. *(a)* The diagram below shows the first four lines of the visible atomic emission spectrum for hydrogen (part of the Balmer series).



(i) Explain why the spectrum is seen as a series of sharp lines and not as a continuous spectrum. [2]

QWC [1]

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(ii) The line labelled α, the first line of the Balmer series, has a wavelength of 657 nm.
The visible emission spectrum of neon shows a prominent line at 585 nm.
State the relationship between energy, frequency and wavelength and use this to complete the table below, using the words *higher* or *lower*. [4]

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.....

Wavelength / nm	*Frequency* / Hz	*Energy* / J
585		
657		

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(b) Neon, discovered in 1898, has three naturally occurring isotopes, of which ^{20}Ne is the most abundant. It is unreactive and forms no compounds.
Use this information to help you answer the questions below.

(i) One reason that neon does not react with other elements is because its first standard molar ionisation energy is very high, having a value of 2081 kJ mol^{-1}. Write an equation that represents the first standard molar ionisation energy of neon. [2]

.....

(ii) Explain the meaning of the term ***relative isotopic mass***. [2]

.....

.....

(iii) Explain, how the ***relative atomic mass*** differs from the ***relative isotopic mass***. [1]

.....

.....

(iv) At a certain temperature and pressure, 0·890 g of ^{20}Ne occupies a volume of 1 dm^3. Use this value to find the volume occupied by 1 mole of neon at this temperature and pressure. [2]

.....

.....

..... dm^3

Total [14]

9. Sodium hydroxide and chlorine are important industrial chemicals.
Two methods for making them from sodium chloride solution (brine) are the mercury cell and the diaphragm cell.

Process	*Operation*	*Quality of product*
Diaphragm cell	Needs diaphragm replacing regularly. High electrical current needed.	Contains unreacted sodium chloride. Concentration varies and is relatively low.
Mercury cell	No diaphragm used. High electrical current.	Pure sodium hydroxide solution produced at high concentration.

(a) (i) Use the table to suggest **one** important consideration when choosing which process to use. [1]

.....

(ii) If a new process is to be developed as an **alternative** to the two processes outlined above, suggest **two** environmental or technical factors that should be considered when developing this new process. [2]

1. .....

.....

2. .....

.....

(b) Some students obtained a sample of the sodium hydroxide solution from the diaphragm cell process.

(i) This solution was too concentrated for a normal titration and they needed to dilute it **exactly** ten times using water.
Describe, stating the apparatus used and any essential details, how this dilution was done.
You should assume that you need 250 cm^3 of the diluted solution. [4]
QWC [2]

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(ii) $20{\cdot}0\,cm^3$ of the diluted sodium hydroxide solution reacted with 0·00500 mole of hydrochloric acid.

$$NaOH + HCl \longrightarrow NaCl + H_2O$$

I. State the number of moles of sodium hydroxide present in the $20{\cdot}0\,cm^3$ sample. [1]

.....

II. Calculate the concentration of the **diluted** sodium hydroxide solution. [2]

.....

.....

..... mol dm^{-3}

III. State the concentration of the **original** sodium hydroxide solution. [1]

.....

.....

..... mol dm^{-3}

IV. State how you would identify the end-point of this titration. [1]

.....

Total [14]

Section B Total [70]

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Rough Work