Candidate Name	Centre Number					Candidate Number				
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GCE AS/A LEVEL CHEMISTRY

AS UNIT 1

The Language of Chemistry, Structure of Matter and Simple Reactions

SPECIMEN PAPER

1 hour 30 minutes

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1. to 6.**	**10**	
Section B	**7.**	**16**	
	8.	**15**	
	9.	**17**	
	10.	**15**	
	11.	**7**	
	Total	**80**	

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a data sheet and a calculator.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.

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

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

INFORMATION FOR CANDIDATES

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

The assessment of the quality of extended response (QER) will take place in question 9.

SECTION A

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

1. A radioactive isotope of boron has a half-life of 5×10^{-3} seconds. Calculate how long it will take for 0.32 g of the isotope to decay to 0.04 g. [1]

Time taken = ……..…… s

2. *(a)* State the meaning of the term *dynamic equilibrium* for a chemical system. [1]

……..……..

.....……..

(b) Explain how you would tell, from the properties of the system, that equilibrium has been reached. [1]

……..……

……..……...

3. Cyanogen is a compound containing only carbon and nitrogen.

It has a relative molecular mass of 52.

(a) State the molecular formula of cyanogen. …… [1]

(b) State the empirical formula of cyanogen. …… [1]

4. Sulfur hexafluoride reacts with hydrogen sulfide in a redox reaction.

$$SF_6 + 3H_2S \rightarrow 6HF + 4S$$

Complete the table below, giving the oxidation states of the sulfur atoms present and use these to explain how hydrogen sulfide is the reducing agent in this reaction. [2]

Oxidation state of sulfur in SF_6	Oxidation state of sulfur in H_2S	Oxidation state of sulfur in sulfur, S

……..……

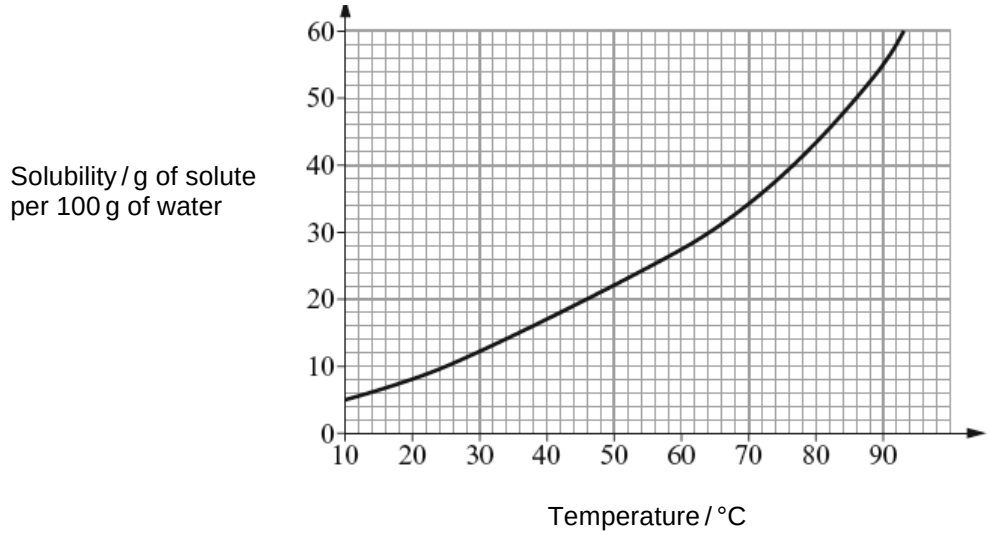
……..……...

5. Calculate the pH of a 0.01 mol dm^{-3} solution of sulfuric acid. [2]

pH = ...

6. A solid was prepared in an impure state and it was then purified by recrystallisation. The solid was dissolved in the minimum amount of water at 90 °C and the solution was cooled to 25 °C.

The solubility curve for the solid in water is shown below.



Use the solubility curve to find the maximum mass of solid that would form from 20 g of water cooled from 90 °C to 25 °C. [1]

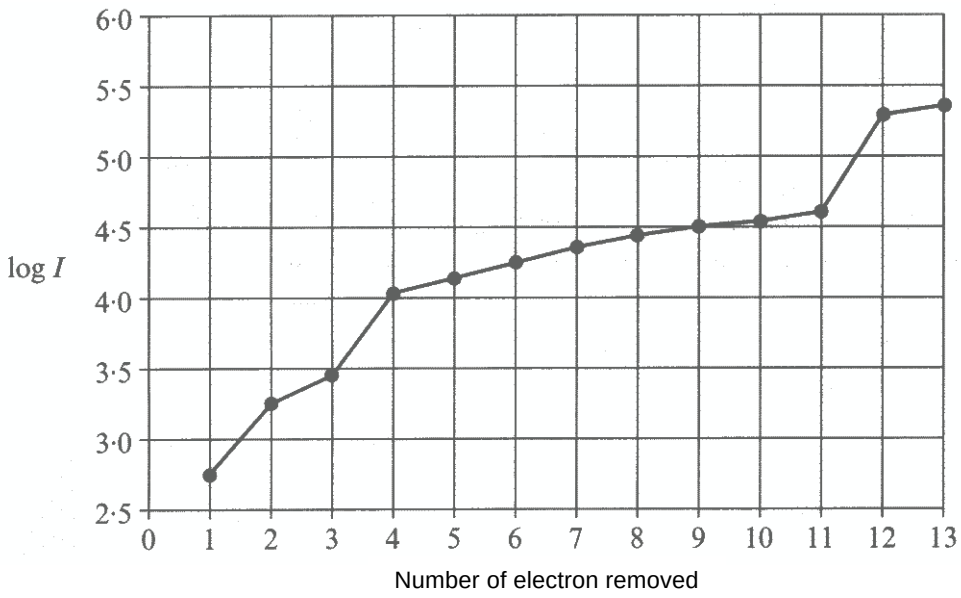
Maximum mass = …… g

10

SECTION B

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

7. *(a)* The graph below shows a plot of the logarithm of the successive ionisation energies of an element.



(i) State what this graph tells us about the way electrons are arranged in an atom. [1]

……

……

(ii) Explain the significant difference in value between the energy required to remove the third and fourth electrons. [2]

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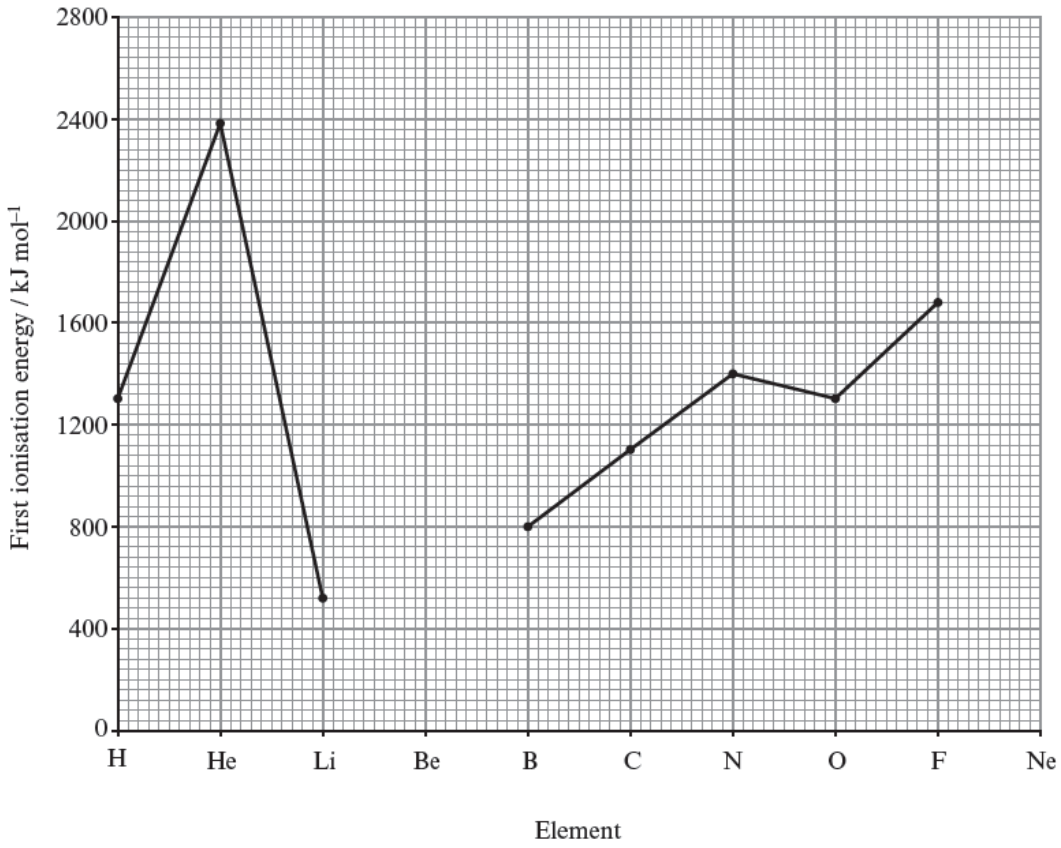
(b) The graph below shows the first molar ionisation energies for a selection of the first ten elements.



(i) Complete the graph by adding points that represent the first ionisation energies for the elements beryllium and neon. [1]

(ii) Write an equation to represent the first ionisation of a beryllium atom. [1]

.....

(iii) Explain why nitrogen has a higher first ionisation energy than oxygen. [2]

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.....

(c) (i) Electrons are thought to exist in shells. Explain how **both** parts *(a)* and *(b)* provide evidence for this theory. [2]

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(ii) Compare the evidence for electronic structure from parts *(a)* and *(b)* to decide which gives a clearer picture of electronic structure. [1]

……

……

(d) The diagram below shows the first four lines of the atomic spectrum for hydrogen in the ultra-violet region of the electromagnetic spectrum (part of the Lyman series).

line A

increasing frequency ⟶

(i) Line A represents the convergence limit of this series and is found at a wavelength of 91.2×10^{-9} m.

Use the equation below to calculate the frequency, f, of line A and hence its energy, E, in Joules (J). Show your working. [3]

$$c = f \times \lambda$$

$c = 2.99 \times 10^{8}\ m\,s^{-1}$ $h = 6.63 \times 10^{-34}\ J\,s$

Energy = …… J

(ii) There are 6.02×10^{23} hydrogen atoms in 1 mol. Use your answer to part (i) and this information to calculate the energy in kJ mol^{-1}. [2]

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

(iii) State the significance of the value calculated in part (ii) and represented by the convergence limit of the Lyman series. [1]

.....

16

8. This question involves two different methods to determine the percentage of sodium carbonate in a mixture.

(a) Elinor is given the mixture and she carries out a two-step experiment to determine the percentage of sodium carbonate in the mixture.

In step 1, she accurately weighs 2.05 g of the mixture, transfers all of it to an appropriate container, adds 100 cm^3 of distilled water to ensure that it all dissolves and accurately makes up the solution to 250 cm^3 with distilled water.

In step 2, she pipettes 25.0 cm^3 of the solution into a container, adds 3 drops of an appropriate indicator and titrates this solution with hydrochloric acid of concentration 0.100 mol dm^{-3}. She repeats this procedure three times and obtains the following results.

Titration	1	2	3	4
Final reading (cm^3)	23.50	24.10	24.10	23.40
Initial reading (cm^3)	0.40	0.15	0.90	0.25
Titre (cm^3)				

(i) Name a suitable container to make up the solution that could be used in step 1. [1]

……

(ii) Calculate the mean titre that Elinor should use in her calculations. [2]

Mean titre = ... cm^3

(iii) The equation for the reaction between sodium carbonate and hydrochloric acid is given below.

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

I. Use your answer to part (ii) to calculate the number of moles of HCl used in the titration and hence deduce the number of moles of Na_2CO_3 in 25.0 cm^3 of the solution in step 2. [2]

Number of moles of Na_2CO_3 = ... mol

II. Calculate the percentage of Na_2CO_3 in the original mixture. [3]

Percentage of Na_2CO_3 = …..... %

(b) In a separate experiment Robert was asked to analyse the mixture by means of a precipitation reaction.

Robert measured exactly 2.1 g of the mixture and dissolved it in an excess of distilled water. To this solution he added an excess of barium nitrate solution. A precipitate of barium carbonate, $BaCO_3$, was formed according to the following equation.

$$Na_2CO_3(aq) + Ba(NO_3)_2(aq) \rightarrow BaCO_3(s) + 2NaNO_3(aq)$$

The precipitate was filtered. The mass of barium carbonate formed in the experiment was 2.3 g.

(i) Explain why the volume of distilled water used to dissolve the original mixture was not measured accurately. [1]

.....

(ii) Use the mass of barium carbonate formed to calculate the mass of Na_2CO_3 in the original mixture and hence the percentage of Na_2CO_3 in the mixture. [3]

Percentage of Na_2CO_3 = ... %

(c) (i) Explain which of the two methods described in parts *(a)* and *(b)* is likely to give the more accurate results. [1]

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(ii) Suggest possible improvements to the method which gave the less accurate result. [2]

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9. *(a)* The melting temperature and electrical conductivity were measured for the following five substances.

sodium chloride
diamond
graphite
iron
iodine

The results of the experiment are shown in the table:

Substance	Melting temperature / °C	Conditions required for electrical conductivity
A	3550	does not conduct in any state
B	801	conducts when molten
C	3642	conducts as a solid
D	1535	conducts as a solid
E	114	does not conduct in any state

(i) State, explaining how you reached your conclusion, which of the substances is sodium chloride. [2]

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(ii) I. Identify the two substances which are diamond and iodine. [1]

…… and …….

II. State which of the above physical properties would allow you to distinguish between these two solids. Include in your answer the reasons for the two solids behaving differently. [2]

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(iii) Describe a **different** physical property which could be used to distinguish between iodine and sodium chloride. Include in your answer the reasons for the two solids behaving differently. [3]

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(b) Use the VSEPR theory to deduce the shapes of BF_3 and NH_3. Explain the difference in the shapes of BF_3 and NH_3. [6 QER]

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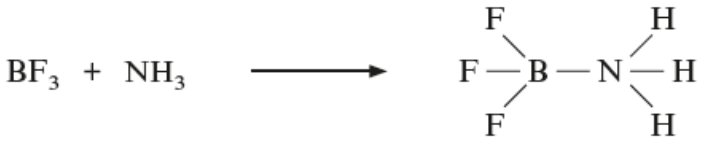
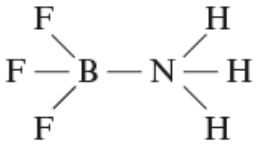
(c) Boron fluoride reacts with ammonia, NH_3, to make the compound shown in the following equation.



(i) Name the type of bond formed between N and B. [1]

……..

(ii) Suggest a value for the F–B–F bond angle in this molecule.



Bond angle …… [1]

(iii) Explain your answer to part (ii). [1]

……..

……..

17

10. *(a)* Bromine is produced commercially from bromide ions in sea water by reaction with chlorine.

(i) Give the equation for this reaction. [1]

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(ii) Using oxidation states, show that chlorine is behaving as the oxidising agent in this reaction. [2]

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(iii) Air is then blown through the bromine-containing mixture to remove bromine as its vapour.

Iodine can be produced in a similar way from the iodide ions present in sea water but it is more difficult to produce iodine vapour from its solution because iodine is less volatile than bromine.

Explain, in terms of bonding, why iodine is less volatile than bromine. [2]

……

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(b) On Earth, iodine occurs as only one stable isotope, ^{127}I.

(i) Using your understanding of the mass spectrum of chlorine, Cl_2, sketch and label the mass spectrum of a sample of iodine. [2]

(ii) A sample of iodine extracted from a meteorite was found to have a relative atomic mass of 128.7. State what this tells you about the composition of the iodine within the meteorite. [1]

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(c) Edmund carries out some experiments with Group 2 metals.

(i) In the first experiment, he adds a piece of calcium to cold water.

I. State what he would **observe** in this reaction. [2]

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……

II. Write a balanced chemical equation for the reaction. [1]

……

……

III. The experiment is repeated with a piece of magnesium. State what he now observes. [1]

……

(ii) In the next experiment, Edmund reacts pieces of calcium with 19.4 cm^3 of 2.02 mol dm^{-3} hydrochloric acid.

$$Ca(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2(g)$$

I. Calculate the minimum mass of calcium needed to react completely with the acid. [2]

Mass of calcium = ……g

II. Calculate the total volume of hydrogen evolved during this reaction when it is carried out at room temperature and pressure. [1]

[1 mol of any gas occupies a volume of 24.0 dm^3 under these conditions]

Volume = …… dm^3

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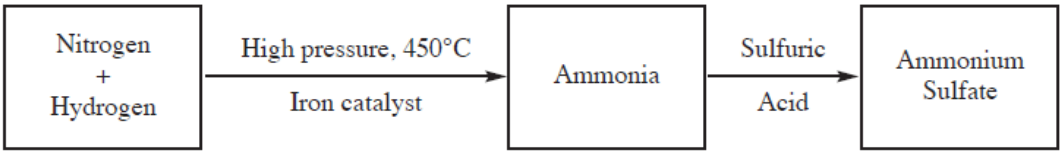
11. Ammonia, a very important industrial product, is produced by the Haber process.

Ammonia can be converted to ammonium sulfate, $(NH_4)_2SO_4$, a common fertiliser, by reacting it with sulfuric acid, H_2SO_4.



(a) Explain why ammonia behaves as a base in the formation of ammonium sulfate. [1]

……..

The Haber process can be represented by the following equation.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H^{\ominus} = -92 \text{ kJ mol}^{-1}$$

(b) For the equilibrium reaction, explain why

(i) a high pressure is used, [2]

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(ii) ammonia is removed from the equilibrium mixture as it forms. [2]

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(c) Predict and explain the effect of increasing the temperature of the surroundings on the value of the equilibrium constant, K_c, for the reaction. [2]

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