Candidate Name	Centre Number					Candidate Number				

AS CHEMISTRY

COMPONENT 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 7.**	**10**	
Section B	**8.**	**11**	
	9.	**13**	
	10.	**13**	
	11.	**7**	
	12.	**7**	
	13.	**12**	
	14.	**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.

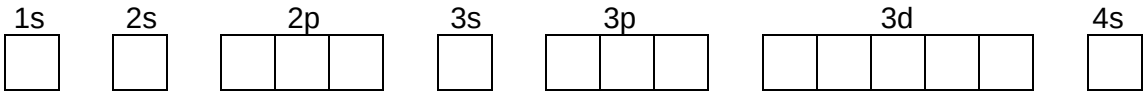
You are reminded of the need for good English and orderly, clear presentation in your answers.

No certificate will be awarded to a candidate detected in any unfair practice during the examination.

SECTION A

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

1. By inserting arrows to represent electrons, complete the boxes below to show the electronic configuration of a calcium atom. [1]



2. An oxide of nitrogen has a relative molecular mass of 92. It contains 30.4 % of nitrogen and 69.6 % of oxygen, by mass.

(a) Calculate the empirical formula of this oxide. Show your working. [1]

Empirical formula .....

(b) Calculate its molecular formula. [1]

Molecular formula .....

3. Complete the table below. [2]

Molecule	Number of bonding pairs of electrons in outer shell	Number of lone pairs of electrons in outer shell	Shape of molecule
$BeCl_2$		0	linear
PCl_3	3	1	

4. Ammonia is produced from hydrogen and nitrogen in the Haber process.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

Write the expression for the equilibrium constant in terms of concentration, K_c, for this reaction. [1]

5. Write the equation that represents the **second** ionisation energy of gallium. [1]

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6. Calculate the mass of methane, CH_4, that contains the same number of molecules as there are in 96 g of silane, SiH_4. [1]

Mass = ... g

7. The emission spectrum of sodium includes a bright yellow line corresponding to an energy of 3.4×10^{-19} J. Calculate the frequency, in Hz, of this line. [2]

$h = 6.6 \times 10^{-34}$ Js

Frequency = ... Hz

10

SECTION B

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

8. Potassium metal was discovered in 1807 by the British chemist Sir Humphrey Davy.

(a) The mass spectrum of a naturally occurring sample of potassium gave the following results.

Isotope	% abundance
^{39}K	93.26
^{40}K	0.0117
^{41}K	6.730

Calculate the relative atomic mass of the sample, giving your answer to the appropriate number of significant figures. [2]

Relative atomic mass = ……..……..

(b) This mass spectrum was produced by potassium ions in a mass spectrometer.

(i) State how a solid sample of potassium is made into potassium ions in a mass spectrometer. [2]

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(ii) Describe how potassium ions are separated in a mass spectrometer. [2]

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(c) Potassium-40 is a radioactive isotope that decays with a half-life of 1.25×10^9 years.

(i) Describe how it decays by electron capture to form argon-40. [2]

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(ii) Calculate how long it will take for the activity of the isotope to decay to ⅛th of its original activity. [1]

Time taken = ……..…….. years

(d) Some information relating to three other radioisotopes are given in the table.

Isotope	Half-life	Radioactive emission
^{60}Co	5 years	γ
^{63}Ni	100 years	β
^{66}Cu	30 seconds	β

Use all the information to suggest which radioisotope would be the most suitable for use in a gauge to measure the thickness of aluminium foil. Explain your reasoning. [2]

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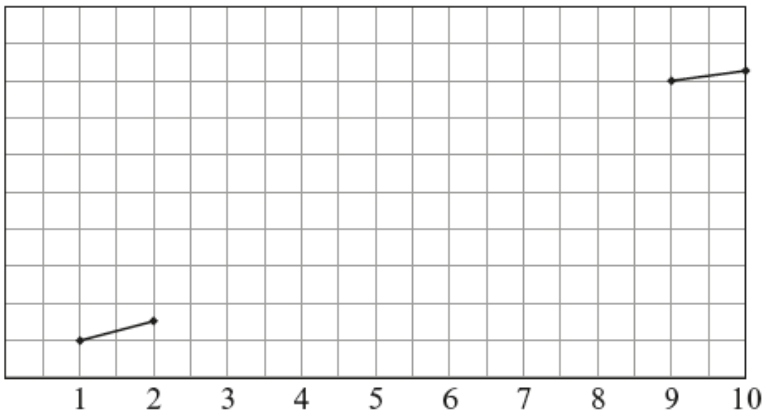
11

9. The noble gases (Group 0) are a group of very unreactive elements. The first members of the group (helium, neon and argon) do not form any compounds, however it is possible to form a few compounds of krypton and xenon.

(a) Neon has ten electrons in each atom. The sketch below shows the first two and the final two ionisation energies for a neon atom.

(i) Sketch the pattern you would expect to see for the remaining six ionisation energies of neon. [2]

log (ionisation energy)



Number of electrons removed

(ii) Explain any significant changes in slope on the graph you have sketched. [2]

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(b) (i) The first compound of a noble gas was formed from Xe atoms and PtF_6. It was the ionic compound $Xe^+ PtF_6^-$. Explain why it is not possible to form a similar ionic compound of argon, $Ar^+ PtF_6^-$. [2]

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(ii) Draw the likely shape for the PtF_6^- ion. [1]

(c) Helium was identified in the Sun by its atomic absorption spectrum. Explain how an atomic absorption spectrum forms. [3]

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(d) Xenon trioxide, XeO_3, is a compound which decomposes explosively according to the following equation at 323 K and 1 atm pressure.

$$2XeO_3(s) \rightarrow 2Xe(g) + 3O_2(g)$$

Calculate the volume of gas, in dm^3, released by the decomposition of 1 mol of XeO_3 under these conditions. [3]

[1 mol of any gas at 298 K and 1 atm occupies a volume of 24.0 dm^3]

Volume = ……. dm^3

13

10. Sodium hydroxide and chlorine are important industrial chemicals made from sodium chloride solution (brine). This can take place in the mercury cell and the diaphragm cell.

Process	Operation	Quality of product
diaphragm cell	diaphragm must be regularly replaced high electrical current needed	contains unreacted sodium chloride concentration varies and is relatively low
mercury cell	no diaphragm used high electrical current needed	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]

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(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. [2]

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

(i) This solution was too concentrated to be used in a normal titration. It needed to be diluted exactly 10 times using water to produce 250 cm^3 of solution. Describe how this dilution should be carried out. Include the names of all pieces of apparatus used and any essential details. [3]

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(ii) 20.0 cm^3 of the diluted sodium hydroxide solution reacted with 0.00512 mol of hydrochloric acid.

I Calculate the concentration of the original sodium hydroxide solution. [3]

Concentration = …… mol dm^{-3}

II One of the students carried out the titration using a 2.0 mol dm^{-3} hydrochloric acid solution whilst the other used a 0.2 mol dm^{-3} solution. State which student is likely to have got the more accurate result for the concentration of the sodium hydroxide solution. Justify your answer. [2]

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III Calculate the pH of a 0.2 mol dm^{-3} hydrochloric acid solution. [2]

pH = ……

11. *(a)* Chloroethane, C_2H_5Cl, can be made from ethene by the addition of hydrogen chloride, HCl.

C_2H_4 + HCl → C_2H_5Cl Reaction **A**

M_r values 28.0 36.5 64.5

(i) Calculate the maximum possible mass of chloroethane obtainable from 42.0 g of ethene and 43.8 g of hydrogen chloride. [3]

Mass = …….. g

(ii) The actual mass of chloroethane obtained from 42.0 g of ethene in an experiment was 65.0 g. Calculate the percentage yield in this experiment. [1]

Percentage yield = ……. %

(b) Chloroethane can be formed by another reaction as in the following equation.

C_2H_5OH + NaCl + H_2SO_4 → C_2H_5Cl + $NaHSO_4$ + H_2O Reaction **B**

M_r values 46 58.5 98

(i) The atom economy for reaction **A** is 100 %. Calculate the atom economy for reaction **B**. [2]

Atom economy for reaction **B** = ……. %

(ii) Suggest **one** possible reason for choosing to produce chloroethane by reaction **B** rather than reaction **A**. [1]

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7

12. Polluting gases such as sulfur dioxide, produced by power stations, can cause the acidification of lakes far from the source of the pollution.

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

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

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]

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(b) 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.

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

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

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(c) Some students wanted to measure the concentration of sulfur dioxide in the air. They pumped air at a rate of 2.2×10^4 cm^3 per hour for 5 days through a solution that absorbed the sulfur dioxide present. The resulting solution was then treated to give 0.0047 g of barium sulfate, $BaSO_4$.

(i) Calculate the total volume of air passed through the solution in 5 days. Give your answer in dm^3.

[1]

Volume = …….. dm^3

(ii) Calculate the number of moles of sulfur dioxide present in the sampled air. You should assume that 1 mol of sulfur dioxide gives 1 mol of barium sulfate. [2]

Number of moles = ……. mol

7

13. *(a)* Outline the way in which pure dry calcium carbonate could be prepared in the laboratory using a precipitation reaction. Include an ionic equation for the reaction taking place. [6]

(Your ability to construct an extended response will be assessed in this question.)

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(b) Limestone contains calcium carbonate. A 0.497 g sample of ground limestone was placed in a flask and exactly 25.0 cm^3 of hydrochloric acid of concentration 0.515 mol dm^{-3} was added using a volumetric pipette. The mixture was stirred until no more bubbles of carbon dioxide were formed. The unreacted acid in the flask was titrated against 0.188 mol dm^{-3} sodium hydroxide and required 24.8 cm^3 for neutralisation.

(i) Calculate the number of moles of hydrochloric acid used up in the reaction with limestone. [3]

Number of moles = ... mol

(ii) Calculate the percentage of calcium carbonate in the limestone sample.

[3]

Percentage of calcium carbonate = ... %

12

14. *(a)* Ice and graphite both have crystalline structures containing covalent bonds.

(i) Describe the bonding and structure in ice. [3]

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(ii) Explain why graphite conducts electricity whilst ice does not. [2]

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(b) Iodine, I_2, also contains covalent bonds. Explain why solid iodine can be converted into a vapour at a much lower temperature than graphite. [2]

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