A

AQA

Surname _____

Other Names _____

Centre Number _____

Candidate Number _____

Candidate Signature _____

AS
CHEMISTRY

Paper 1 Inorganic and Physical Chemistry

7404/1

Tuesday 22 May 2018 **Morning**

Time allowed: 1 hour 30 minutes

For this paper you must have:
- **the Periodic Table/Data Sheet, provided as an insert (enclosed)**
- **a ruler with millimetre measurements**
- **a scientific calculator, which you are expected to use where appropriate.**

At the top of the page, write your surname and other names, your centre number, your candidate number and add your signature.

[Turn over]

J U N 1 8 7 4 0 4 1 0 1

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INSTRUCTIONS

- **Use black ink or black ball-point pen.**
- **Answer ALL questions.**
- **You must answer the questions in the spaces provided. Do NOT write on blank pages.**
- **All working must be shown.**
- **Do all rough work in this book. Cross through any work you do not want to be marked.**

INFORMATION

- **The marks for questions are shown in brackets.**
- **The maximum mark for this paper is 80.**

ADVICE

- **You are advised to spend about 65 minutes on SECTION A and 25 minutes on SECTION B.**

DO NOT TURN OVER UNTIL TOLD TO DO SO

SECTION A

Answer ALL questions in this section.

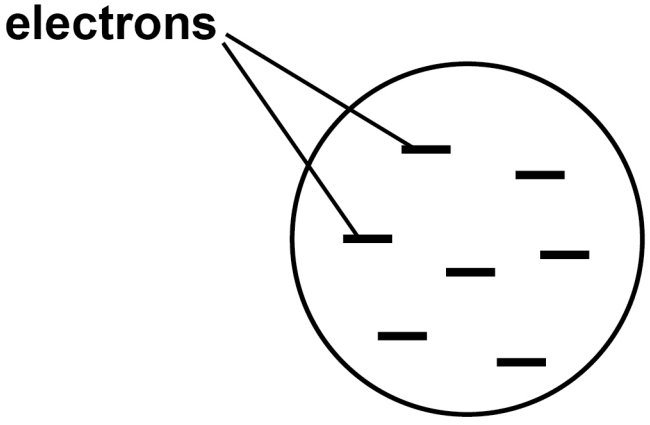
0 1 **This question is about atomic structure.**

In the nineteenth century JJ Thomson discovered the electron. He suggested that negative electrons were found throughout an atom like 'plums in a pudding of positive charge'.

FIGURE 1 shows an atom of element R using the 'plum pudding' model.

An atom of R contains seven electrons.

FIGURE 1



0 1 . 1 **State TWO differences between the 'plum pudding' model and the model of atomic structure used today. [2 marks]**

1 _____

_____

_____

2 _____

_____

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0 1 . 2 **Deduce the full electron configuration of an atom of element R. [1 mark]**

0 1 . 3 **Identify R and deduce the formula of the compound formed when R reacts with the Group 2 metal in the same period as R. [1 mark]**

4

0 2 **This question is about sodium fluoride (NaF).**

Some toothpastes contain sodium fluoride. The concentration of sodium fluoride can be expressed in parts per million (ppm). 1 ppm represents a concentration of 1 mg in every 1 kg of toothpaste.

0 2 . 1 **A 1.00 g sample of toothpaste was found to contain 2.88×10^{-5} mol of sodium fluoride.**

Calculate the concentration of sodium fluoride, in ppm, for the sample of toothpaste.

Give your answer to 3 significant figures.
[4 marks]

Concentration of sodium fluoride

_____ **ppm**

[Turn over]

0 2 . 2 **Sodium fluoride is toxic in high concentrations. Major health problems can occur if concentrations of sodium fluoride are greater than 3.19×10^{-2} g per kilogram of body mass.**

Deduce the maximum mass of sodium fluoride, in mg, that a 75.0 kg person could swallow without reaching the toxic concentration.
[1 mark]

Mass of sodium fluoride _____ **mg**

0 2 . 3 **The concentration of sodium fluoride in a prescription toothpaste is 2800 ppm.**

Use your answer to Question 02.2 to deduce the mass of toothpaste, in kg, that a 75.0 kg person could swallow without reaching the toxic concentration. [1 mark]

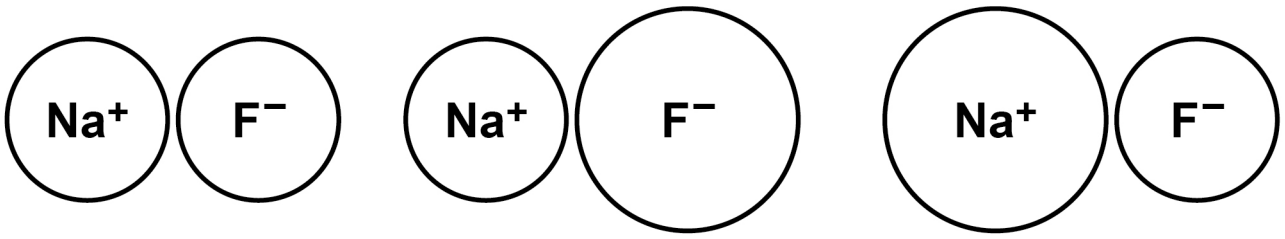
Mass of toothpaste _____ **kg**

[Turn over]

0 2 . 4 **Identify the diagram in FIGURE 2 that shows the correct relative sizes of the ions in sodium fluoride.**

Justify your answer. [3 marks]

FIGURE 2



A **B** **C**

Diagram _____

Justification _____

_____

_____

_____

_____

_____

_____

_____

9

[Turn over]

0 3 **A student heated a solid sample of $Na_2CO_3.\ xH_2O$ for 1 minute to remove water and determine a value for x**

FIGURE 3 shows the apparatus used. TABLE 1 shows the results recorded.

FIGURE 3

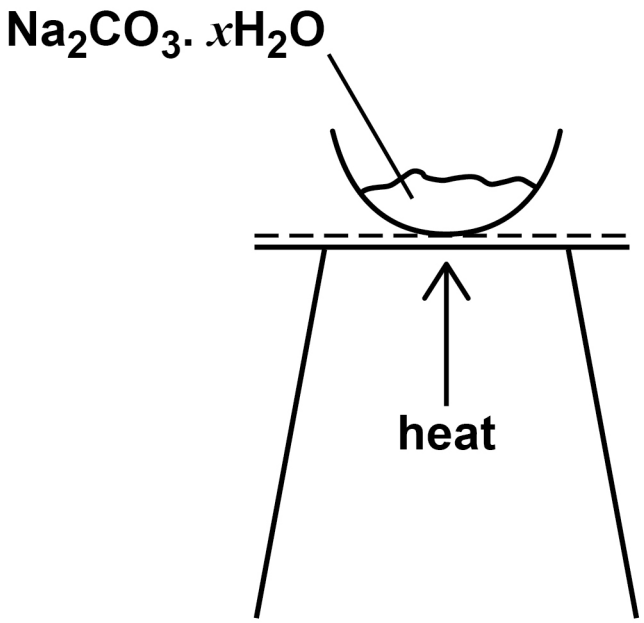


TABLE 1

Mass of empty evaporating basin	**24.35 g**
Mass of evaporating basin and solid before heating	**25.47 g**
Mass of evaporating basin and solid after heating for 1 minute	**24.92 g**

0 3 . 1 **Use the data in TABLE 1 to calculate a value for x in the formula $Na_2CO_3 . xH_2O$**

Give your answer to 2 decimal places.
[5 marks]

Value for x _____

[Turn over]

0 3 . 2 **The correct value for x is 10**

Suggest a reason for the difference between the experimental value for x and the correct value.

(If you were unable to calculate an experimental value for x assume it was 8.05. This is NOT the correct experimental value.)
[1 mark]

0 3 . 3 **Suggest how the procedure could be improved, using the same apparatus, to give a more accurate value for x**

Justify your answer. [2 marks]

Suggestion

Justification

[Turn over]

8

0 4 . 1 **Separate unlabelled solid samples of three anhydrous sodium compounds are provided for a student to identify.**

These compounds are known to be sodium carbonate, sodium fluoride and sodium chloride but it is not known which sample is which.

Outline a logical sequence of test-tube reactions that the student could carry out to identify each of these compounds.

Include the observations the student would expect to make.

Give equations, including STATE SYMBOLS, for any reactions that would take place.
[6 marks]

6

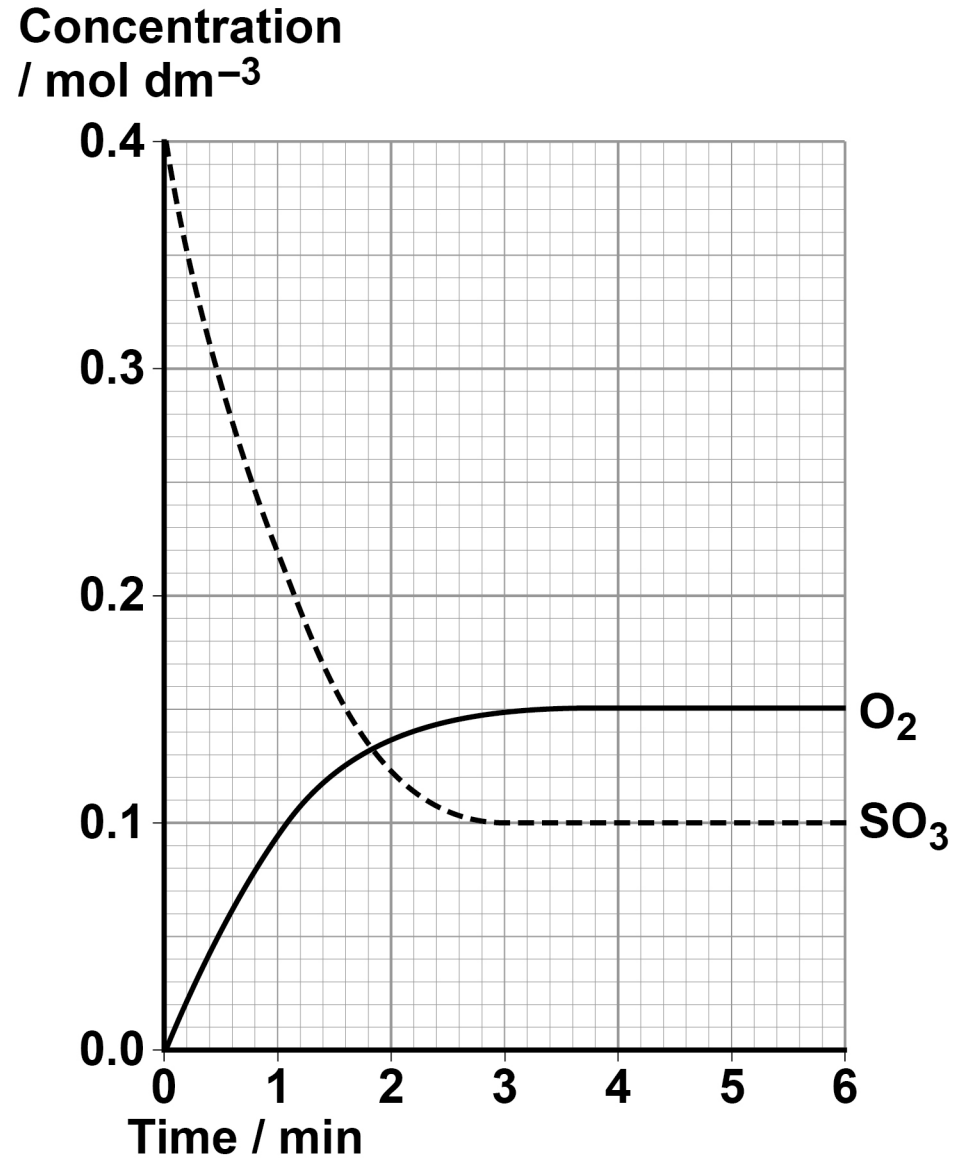
0 5 **This question is about equilibrium.**

Sulfur trioxide decomposes to form sulfur dioxide and oxygen at temperature T_1 according to the equilibrium shown.

$$2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g) \quad \Delta H = +196 \text{ kJ mol}^{-1}$$

The graph in FIGURE 4 shows the concentrations of sulfur trioxide and of oxygen over a period of 6 minutes at temperature T_1

FIGURE 4



0 5 . 1 **State the time, to the nearest minute, when equilibrium is first established.**

Explain your answer. [2 marks]

Time _____ **minutes**

Explanation _____

_____

_____

_____

_____

_____

_____

_____

0 5 . 2 **Sketch on the graph in FIGURE 4 how the concentration of sulfur dioxide changes over these 6 minutes at temperature T_1 [2 marks]**

[Turn over]

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0 5 . 3 **The temperature of the mixture was changed to T_2 and the mixture left to establish a new equilibrium.**

In the new equilibrium mixture the concentration of sulfur trioxide was found to be 0.07 mol dm^{-3}

Deduce which of T_1 and T_2 is the higher temperature.

Explain your deduction. [2 marks]

Higher temperature _____

Explanation _____

_____

_____

_____

_____

_____

_____

6

0 6 **A student determined the relative molecular mass, M_r, of an unknown volatile liquid Y in an experiment as shown in FIGURE 5 on page 27.**

The student used a hypodermic syringe to inject a sample of liquid Y into a gas syringe in an oven.

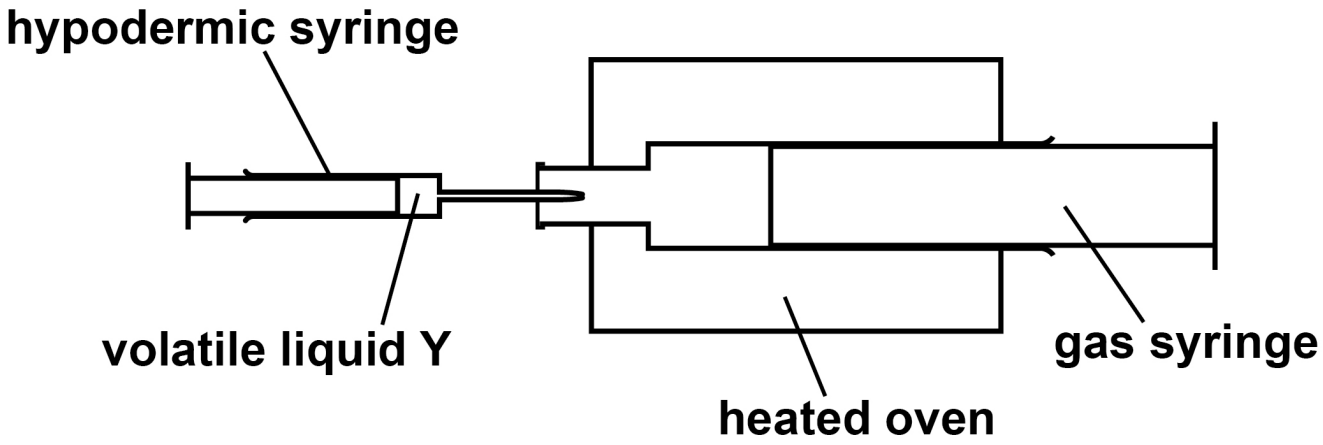
At the temperature of the oven, liquid Y vaporised.

The student's results are shown in TABLE 2.

TABLE 2

Mass of hypodermic syringe and liquid Y before injection	**10.91 g**
Mass of hypodermic syringe and liquid Y after injection	**10.70 g**
Oven temperature	**98.1 °C**
Atmospheric pressure	**102 kPa**
Increase in volume in gas syringe after injection of Y	**85.0 cm^3**

FIGURE 5



0 6 . 1 Define the term relative molecular mass (M_r).

Use the experimental results in TABLE 2 to determine the relative molecular mass of Y.

The gas constant R = 8.31 J K^{-1} mol^{-1}

[5 marks]

0 6 . 2 **Some of the liquid injected did not evaporate because it dripped into the gas syringe nozzle outside the oven.**

Explain how this would affect the value of the M_r of Y calculated from the experimental results. [2 marks]

7

0 7 **Chlorine is used to decrease the numbers of microorganisms in water.**

When chlorine is added to water, there is a redox reaction, as shown by the equation

$$Cl_2 + H_2O \rightleftharpoons HClO + HCl$$

0 7 . 1 **Deduce the oxidation state of chlorine in HClO and the oxidation state of chlorine in HCl**
[1 mark]

Oxidation state of chlorine in HClO

Oxidation state of chlorine in HCl

0 7 . 2 **Give two half-equations to show the oxidation and reduction processes that occur in this redox reaction. [2 marks]**

Oxidation half-equation

Reduction half-equation

0 7 . 3 **Chlorine is reacted with cold, aqueous sodium hydroxide in the manufacture of bleach.**

Give an equation for this reaction between chlorine and sodium hydroxide. [1 mark]

0 7 . 4 The concentration of ClO^- ions in bleach solution can be found by reaction with iodide ions.

The overall equation for this reaction is shown.

$$ClO^- + 2I^- + 2H^+ \rightarrow I_2 + Cl^- + H_2O$$

A sample of bleach solution was found to contain ClO^- ions with a concentration of $0.0109 \text{ mol dm}^{-3}$

Potassium iodide is added to a 20.0 cm^3 portion of this bleach solution.

Calculate the mass, in mg, of potassium iodide needed to react with all of the ClO^- ions in the sample of bleach.

Give your answer to the appropriate number of significant figures.

Give ONE observation during this reaction.
[4 marks]

Mass of potassium iodide _____ **mg**

Observation _____

_____

_____

_____

_____

_____

[Turn over]

0 7 . 5 **Potassium chlorate(VII), $KClO_4$, is used in fireworks. When potassium chlorate(VII) decomposes, it produces potassium chloride and oxygen.**

Give an equation for the decomposition of potassium chlorate(VII).

Use the data in TABLE 3 to calculate the enthalpy change for this reaction. [2 marks]

TABLE 3

Substance	$\Delta_f H$ / kJ mol^{-1}
$KClO_4(s)$	– 434
KCl(s)	– 436

Equation _____

Enthalpy change _____ **kJ mol^{-1}**

10

0 8 A sample of bromine was analysed in a time of flight (TOF) mass spectrometer and found to contain two isotopes, ^{79}Br and ^{81}Br

After electron impact ionisation, all of the ions were accelerated to the same kinetic energy (*KE*) and then travelled through a flight tube that was 0.950 m long.

0 8 . 1 The $^{79}Br^{+}$ ions took 6.69×10^{-4} s to travel through the flight tube.

Calculate the mass, in kg, of one ion of $^{79}Br^{+}$
Calculate the time taken for the $^{81}Br^{+}$ ions to travel through the same flight tube. **[5 marks]**

The Avogadro constant, $L = 6.022 \times 10^{23}$ mol^{-1}

$$KE = \frac{1}{2} mv^2$$

where m = mass (kg) and v = speed (m s^{-1})

$$v = \frac{d}{t}$$ where d = distance (m) and t = time (s)

Mass of one ion of $^{79}Br^{+}$ _____ kg

Time taken by $^{81}Br^{+}$ ions _____ s

[Turn over]

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0 8 . 2 **Explain how ions are detected and relative abundance is measured in a TOF mass spectrometer. [2 marks]**

7

0 9 **This question is about compounds containing fluorine.**

0 9 . 1 **Draw the shape of a molecule of krypton difluoride (KrF_2).**

Include in your answer any lone pairs of electrons that influence the shape.

Name the shape produced by the atoms in a KrF_2 molecule and suggest a bond angle.

[3 marks]

Name of shape _____

Bond angle _____

_____

[Turn over]

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0 9 . 2 **There are two lone pairs of electrons on the oxygen atom in a molecule of oxygen difluoride (OF_2).**

Explain how the lone pairs of electrons on the oxygen atom influence the bond angle in oxygen difluoride. [2 marks]

0 9 . 3 **Silicon tetrafluoride (SiF_4) is a tetrahedral molecule.**

Deduce the type of intermolecular forces in SiF_4

Explain how this type of intermolecular force arises and why no other type of intermolecular force exists in a sample of SiF_4 [3 marks]

Intermolecular forces in SiF_4

Explanation

8

[Turn over]

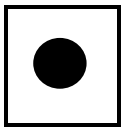
SECTION B

Answer ALL questions in this section.

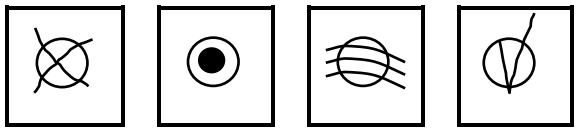
Only ONE answer per question is allowed.

For each answer completely fill in the circle alongside the appropriate answer.

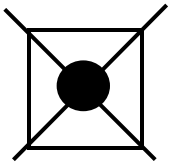
CORRECT METHOD



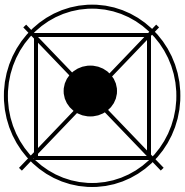
WRONG METHODS



If you want to change your answer you must cross out your original answer as shown.



If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown.



You may do your working in the blank space around each question but this will not be marked.

Do NOT use additional sheets for this working.

1 0 **Which row shows the bonding in ammonium chloride? [1 mark]**

		COVALENT	DATIVE COVALENT	IONIC
A	○	✓	✗	✗
B	○	✓	✓	✗
C	○	✓	✓	✓
D	○	✗	✗	✓

1 1 **How many protons are there in 6.0 g of nitrogen gas?**

Avogadro constant, L = 6.022 x 10^{23} mol^{-1}
[1 mark]

○ **A 1.3 x 10^{23}**

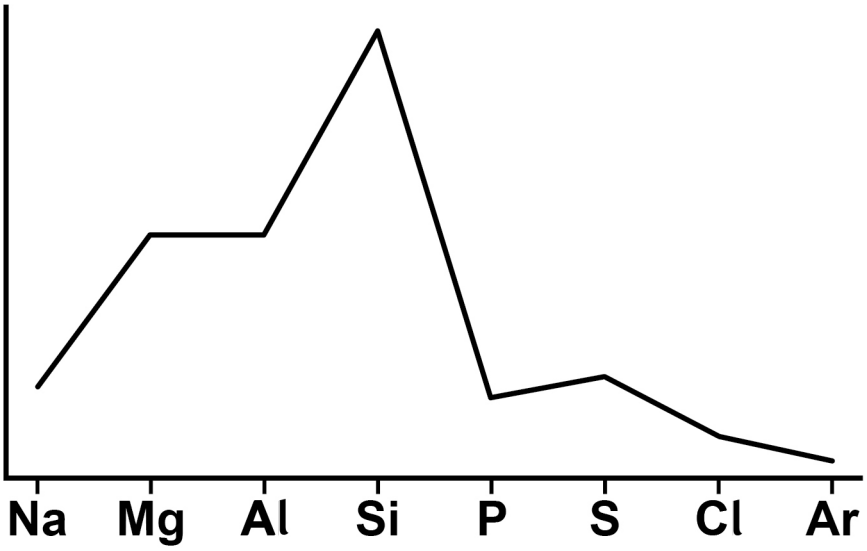
○ **B 9.0 x 10^{23}**

○ **C 1.8 x 10^{24}**

○ **D 3.6 x 10^{24}**

[Turn over]

1 2 **The diagram shows how a property of Period 3 elements varies across the period.**



What is the property? [1 mark]

- ○ **A Atomic radius**
- ○ **B Electronegativity**
- ○ **C First ionisation energy**
- ○ **D Melting point**

1 3 **A 30 cm^3 sample of nitrogen was reacted with a 60 cm^3 sample of fluorine according to the equation**

$$\frac{1}{2}N_2(g) + \frac{3}{2}F_2(g) \rightarrow NF_3(g)$$

What is the volume of the gas mixture after the reaction, at constant temperature and pressure? [1 mark]

- ○ **A 20 cm^3**
- ○ **B 30 cm^3**
- ○ **C 40 cm^3**
- ○ **D 50 cm^3**

1 4 **Which substance is used to reduce titanium(IV) chloride in the extraction of titanium metal? [1 mark]**

○ **A Magnesium**

○ **B Manganese**

○ **C Vanadium**

○ **D Zinc**

1 5 **Which statement about barium sulfate is correct? [1 mark]**

○ **A It is soluble in water at a temperature of 100 °C.**

○ **B It is used in medicine because it does not dissolve in body fluids.**

○ **C It is a pale yellow solid.**

○ **D It reacts with acidified barium chloride solution.**

1 6 **Which statement is correct about the reaction between concentrated sulfuric acid and solid sodium bromide? [1 mark]**

○ **A Bromide ions are reduced.**

○ **B Hydrogen bromide and sulfur are formed.**

○ **C Sulfuric acid acts as an oxidising agent.**

○ **D Bromine and hydrogen sulfide are formed.**

1 7 **Which compound is used to treat the symptoms of indigestion? [1 mark]**

○ **A MgO**

○ **B $Mg(OH)_2$**

○ **C CaO**

○ **D $Ca(OH)_2$**

[Turn over]

1 8 **Which element has the highest first ionisation energy? [1 mark]**

○ **A Aluminium**

○ **B Phosphorus**

○ **C Silicon**

○ **D Sulfur**

1 9 **A solution of volume 500 cm^3 contains 150 g of ammonia.**

What is the concentration, in mol dm^{-3}, of ammonia in this solution? [1 mark]

○ **A 0.51**

○ **B 8.82**

○ **C 16.7**

○ **D 17.6**

[Turn over]

Refer to the following information when answering Questions 20, 21, 22, 23 and 24.

A student devised an experiment to find the concentration of sulfuric acid in a sample of battery acid.

- **A measuring cylinder was used to transfer 10 cm^3 of battery acid to a volumetric flask.**
- **Distilled water was added to the volumetric flask until the volume reached 250 cm^3**
- **A 25.0 cm^3 sample of diluted acid was transferred from the volumetric flask to a conical flask using a pipette.**
- **A few drops of methyl orange indicator were added to the acid in the conical flask before titrating the acid with sodium hydroxide.**
- **The titration was repeated five times but concordant results were NOT obtained. (Note: Methyl orange is red in acid and yellow in alkali.)**

2 0 **Which suggestion would improve the chances of obtaining concordant titres? [1 mark]**

○ **A Invert the volumetric flask several times after adding the distilled water.**

○ **B Wash the pipette with distilled water between each titration.**

○ **C Add extra drops of indicator to the sample when nearing the end point in each titration.**

○ **D Use a more concentrated solution of sodium hydroxide in the burette.**

[Turn over]

2 1 **Which suggestion about rinsing the conical flask between each titration would improve the accuracy of the titrations? [1 mark]**

○ **A Rinsing with acid.**

○ **B Rinsing with alkali.**

○ **C Rinsing with water.**

○ **D No rinsing with any liquid.**

2 2 **Which suggestion would reduce the overall measurement uncertainty in the titration? [1 mark]**

○ **A Use less concentrated alkali in the burette.**

○ **B Use phenolphthalein indicator instead of methyl orange.**

○ **C Use smaller samples of the diluted acid in each titration.**

○ **D Begin each titration with the burette filled to the 0.00 cm^3 mark.**

2 3 **Which of these is important in ensuring that the student's experiment is safe? [1 mark]**

- ○ **A Do the titration in a fume cupboard.**
- ○ **B Wear gloves when measuring out the battery acid.**
- ○ **C Wash hands before doing the titration.**
- ○ **D Carry the burette horizontally when collecting the apparatus.**

2 4 **Which colour change is observed at the end point in each titration? [1 mark]**

- ○ **A Yellow to red**
- ○ **B Red to orange**
- ○ **C Yellow to orange**
- ○ **D Red to yellow**

END OF QUESTIONS

15

There are no questions printed on this page

For Examiner's Use	
Question	Mark
1	
2	
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7	
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Section B	
TOTAL	