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Pearson
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Centre Number

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Candidate Number

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Chemistry

Advanced Subsidiary

Paper 1: Core Inorganic and Physical Chemistry

Tuesday 22 May 2018 – Morning

Time: 1 hour 30 minutes

Paper Reference

8CH0/01

**Candidates must have: Scientific calculator
Data Booklet**

Total Marks

Instructions

- Use **black** ink or **black** ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
– *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*
- For the question marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically showing the points that you make are related or follow on from each other where appropriate.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Check your answers if you have time at the end.
- Show all your working in calculations and include units where appropriate.

Turn over ►

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Answer ALL questions.

Some questions must be answered with a cross ☐.
If you change your mind about an answer, put a line through the box ☒
and then mark your new answer with a cross ☐.

1 This question is about covalent bonds.

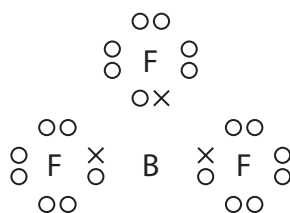
(a) State what is meant by the term covalent bond.

(2)

(b) Draw a diagram of the ammonia molecule, clearly showing its shape.
Include any lone pairs of electrons and the value of the bond angle.

(2)

(c) The dot-and-cross diagram of BF_3 is



What is the bond angle in BF_3 ?

(1)

- ☒ A 90°
☒ B 107°
☒ C 109.5°
☒ D 120°



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2 This question is about hydrogen, the element with atomic number $Z = 1$.

- (a) (i) Hydrogen has two stable isotopes, ${}^1_1\text{H}$ and ${}^2_1\text{H}$. Complete the table to show the number of subatomic particles present in the nuclei of these two isotopes of hydrogen.

(1)

Isotope	Number of protons	Number of neutrons
${}^1_1\text{H}$		
${}^2_1\text{H}$		

- (ii) Use the data in the table to explain the term isotopes.

(2)

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- (b) The relative atomic mass of hydrogen in the Periodic Table is 1.0.
This is correct to two significant figures.

The table gives data for the relative isotopic mass and natural abundance of the two stable isotopes of hydrogen.

Isotope	Relative isotopic mass	Percentage abundance
${}^1_1\text{H}$	1.007825	99.9885
${}^2_1\text{H}$	2.014101	0.0115

- (i) Using the data in the table, give a reason why it can be estimated that the relative atomic mass of hydrogen is greater than 1.0.

(1)

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- (ii) Calculate the relative atomic mass of hydrogen from these data, giving your answer to **four** decimal places.

(2)

- (c) (i) Write an equation to represent the first ionisation energy of hydrogen. Include state symbols.

(2)

- (ii) The sequence of the first three elements in the Periodic Table is hydrogen, helium and then lithium.

Explain why the first ionisation energy of hydrogen is less than that of helium, but greater than that of lithium.

(4)

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- (d) Hydrogen can be placed in several different positions in periodic tables. One is immediately above lithium in Group 1. Another is in the centre of the first row, as shown in the Periodic Table on the back cover.

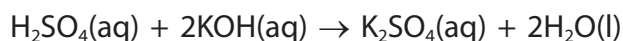
Criticise the position of hydrogen immediately above lithium by giving one reason in favour and two against.

(3)

(Total for Question 2 = 15 marks)



- 3 The reaction of sulfuric acid with potassium hydroxide is a neutralisation.
The equation for this reaction is



A titration was carried out using the following method.

1. Potassium hydroxide solution of unknown concentration was placed in a burette and the initial reading was recorded.
2. 25.0 cm^3 of sulfuric acid solution, concentration $0.0800\text{ mol dm}^{-3}$, was transferred to a conical flask.
3. Three drops of phenolphthalein indicator were added to the sulfuric acid.
4. Potassium hydroxide was added from the burette until the solution just changed colour and then the burette reading was recorded.
5. Repeat titrations were carried out until concordant titres were obtained.

- (a) Select the most appropriate piece of apparatus to measure the 25.0 cm^3 of sulfuric acid.

(1)

- ☐ A burette
- ☐ B measuring cylinder
- ☐ C pipette
- ☐ D volumetric flask

- (b) What is the colour of the solution when neutralisation has just occurred?

(1)

- ☐ A colourless
- ☐ B orange
- ☐ C pale pink
- ☐ D red



- (c) (i) Complete the table of results for titration number 1, using the diagrams to find the initial and final burette readings.

(2)

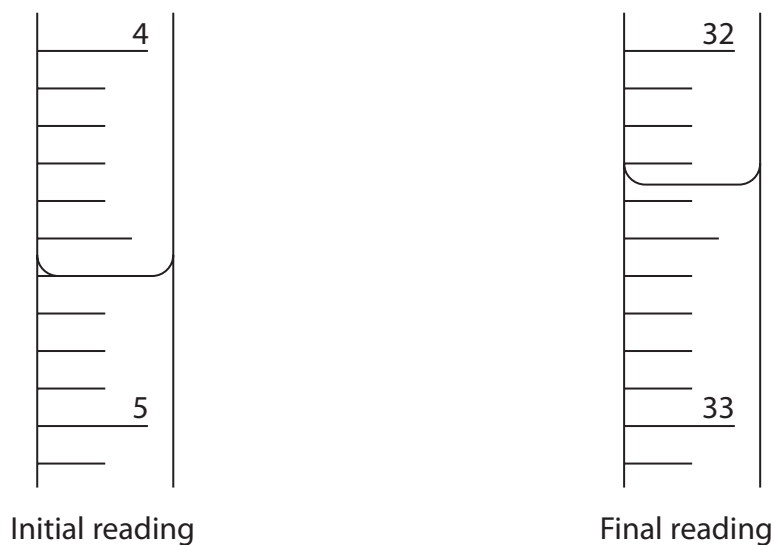


Table of results

Titration number	Final reading / cm ³	Initial reading / cm ³	Titration volume / cm ³
1			
2	28.05	1.10	26.95
3	37.65	10.20	27.45
4	32.05	5.00	27.05

- (ii) The best value for the mean titre of this reaction is

(1)

- ☐ **A** 27.00 cm³
- ☐ **B** 27.15 cm³
- ☐ **C** 27.25 cm³
- ☐ **D** 27.30 cm³



- (iii) Calculate the concentration, in mol dm^{-3} , of the potassium hydroxide solution, giving your answer to an appropriate number of significant figures.

(3)

(Total for Question 3 = 8 marks)



P 5 1 4 5 9 A 0 9 2 4

- 4 An ionic compound contains a metal cation and a non-metal anion in a 1 : 1 ratio, and water of crystallisation. The compound can be represented as $MN \cdot xH_2O$, where x is the number of moles of water of crystallisation per mole of MN .

A sample of $MN \cdot xH_2O$ was dissolved in distilled water to produce a colourless solution, with a concentration of about 0.5 mol dm^{-3} . 2 cm^3 of the resulting solution was transferred to each of two test tubes.

The following tests were carried out to identify the ions present.

(a) **Test 1**

- (i) Addition of a few drops of a solution of barium chloride to one of the test tubes gave a white precipitate.

Identify, by name or formula, **two** possible anions that would give this result.

(1)

- (ii) Addition of 1 cm^3 of dilute hydrochloric acid to the test tube in (a)(i) resulted in no further change.

Give the **formula** of the anion.

(1)

- (iii) What is the charge on the cation?

(1)

- ☐ **A** +1
☐ **B** -1
☐ **C** +2
☐ **D** -2



(b) Test 2

A flame test on a sample of solid $MN \cdot xH_2O$ gave no change in the flame colour.

Give a possible identity of the cation, M.

(1)

- (c) Heating the hydrated compound results in the formation of the anhydrous ionic solid MN by the following reaction:



Heating a sample of the hydrated compound reduced the mass to 48.9% of its original value.

Use this information and your answer to (a)(ii) and (b) to calculate the value of x.

[*Note: If you have been unable to identify MN, you may use this hydrated compound, $CoCl_2 \cdot yH_2O$ in which the sample reduced in mass to 54.6% of its original value. Use this information to calculate the value of y.*]

(4)

(Total for Question 4 = 8 marks)



- 5 A student made crystals of a metal chloride, $\text{JCl}_2 \cdot 6\text{H}_2\text{O}$, by reacting the metal carbonate, JCO_3 , with hydrochloric acid, $\text{HCl}(\text{aq})$. The product was purified.

Procedure

Step 1 150 cm^3 of hydrochloric acid, concentration 0.80 mol dm^{-3} , was transferred to a 400 cm^3 conical flask. The flask was warmed gently using a Bunsen burner. A spatula measure (about 1.0 g) of metal carbonate was added to the acid.

Step 2 When the reaction in Step 1 was finished, more metal carbonate was added until the metal carbonate was in excess.

Step 3 The resulting mixture was filtered into an evaporating basin.

Step 4 The evaporating basin was heated using a Bunsen burner to concentrate the solution. The concentrated solution was allowed to cool and crystallise.

Step 5 Once crystal formation was complete, the resulting mixture was filtered for a second time.

Step 6 The resulting white crystals were rinsed with a small volume of ice-cold water.

The equation for the reaction between the metal carbonate and hydrochloric acid is



- (a) (i) Describe **two** observations that the student might make which show that the reaction in Step 1 has finished.

(2)

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- (ii) State the purpose of the filtration in Step 3.

(1)

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(iii) Explain the use of a small volume of ice-cold water in Step 6.

(2)

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(b) The student obtained a mass of 14.26 g of hydrated crystals.
Assuming that the percentage yield is 100%, use the information in the procedure
to give a possible identity of J.

(5)

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- (c) The student was surprised by the white colour of the crystals of $\text{JCl}_2 \cdot 6\text{H}_2\text{O}$ in Step 6. This did not agree with the possible identity for J from the calculation in (b). The student decided to perform a flame test on the crystals.

(i) Explain why the student was surprised and decided to carry out a flame test.

(2)

(ii) The flame test colour was crimson red. Identify J.

(1)

- ☐ A barium
- ☐ B calcium
- ☐ C lithium
- ☐ D strontium

(iii) Calculate the actual percentage yield of the reaction, which produced 14.26 g of crystals.

Give your answer to **two** significant figures.

(2)

(Total for Question 5 = 15 marks)



6 Chlorine and iodine are in the same group in the Periodic Table.

- (a) (i) Complete the electronic configuration of chlorine using the s, p, d notation. (1)

1s².....

- (ii) Explain why iodine and chlorine have many similar chemical reactions. (2)

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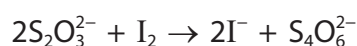
- (b) Members of the same group sometimes react in different ways.

Iodine and chlorine react differently with thiosulfate ions, S₂O₃²⁻.
Iodine gives S₄O₆²⁻, whilst chlorine gives SO₄²⁻.

- (i) Complete the table by identifying the oxidation numbers of sulfur in the three sulfur-containing ions. (2)

Ion	Oxidation number of sulfur
S ₂ O ₃ ²⁻	
SO ₄ ²⁻	
S ₄ O ₆ ²⁻	

- (ii) The equation for the reaction of iodine with thiosulfate ions is



State, in terms of electrons, why iodine is classified as an oxidising agent in this reaction.

(1)

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- (iii) Use your answer to b(i) to show that chlorine is a stronger oxidising agent than iodine.

(1)

- (iv) Chlorine reacts in aqueous solution with $\text{S}_2\text{O}_3^{2-}$ to give SO_4^{2-} .
The ionic half-equation for the reaction of chlorine is



Write the ionic half-equation for the reaction of aqueous $\text{S}_2\text{O}_3^{2-}$ to give SO_4^{2-} .
State symbols are not required.

(2)

- (v) Use your answer to (b)(iv) and the half-equation for chlorine, to write the overall ionic equation for the reaction between chlorine and thiosulfate ions.
State symbols are not required.

(1)

(Total for Question 6 = 10 marks)



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- *7 The compounds hydrogen fluoride, water and methane, all have simple molecular structures, but they have significantly different boiling temperatures.

Discuss the reasons for the differences in the boiling temperatures of the three compounds, using the data in the table and the Pauling electronegativity values in the Data Booklet.

Compound	Boiling temperature /°C	Number of electrons
CH ₄	-161.5	10
H ₂ O	100.0	10
HF	19.5	10

(6)



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(Total for Question 7 = 6 marks)



P 5 1 4 5 9 A 0 1 9 2 4

8 This question is about ionic bonding.

(a) The elements sodium and fluorine react together to form an ionic compound.

(i) Select the correct equation for this reaction.

(1)

- ☐ **A** $\text{Na(s)} + \text{F(g)} \rightarrow \text{NaF(s)}$
- ☐ **B** $2\text{Na(s)} + \text{F}_2\text{(g)} \rightarrow 2\text{NaF(s)}$
- ☐ **C** $\text{Na(s)} + \text{F}_2\text{(g)} \rightarrow \text{NaF}_2\text{(s)}$
- ☐ **D** $2\text{Na(s)} + \text{F(g)} \rightarrow \text{Na}_2\text{F(s)}$

(ii) Draw dot-and-cross diagrams of the ions in sodium fluoride, showing all the electrons.

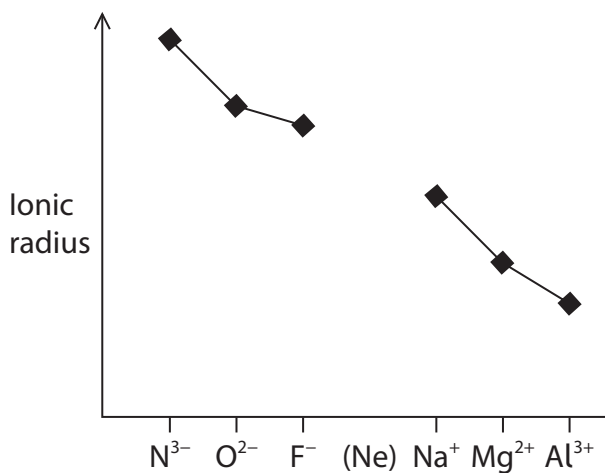
Use your diagram to explain why the ions are described as isoelectronic.

(3)

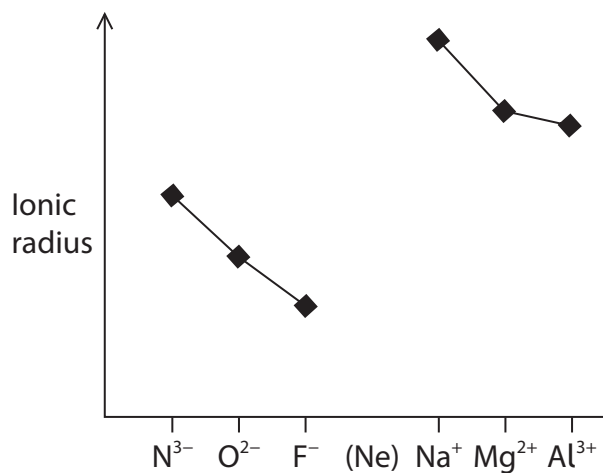


(iii) Which diagram shows the trend in ionic radius for the isoelectronic ions N^{3-} to Al^{3+} ? (1)

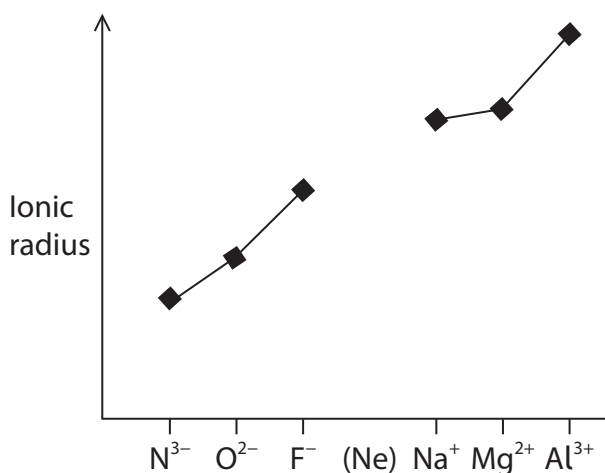
☒ A



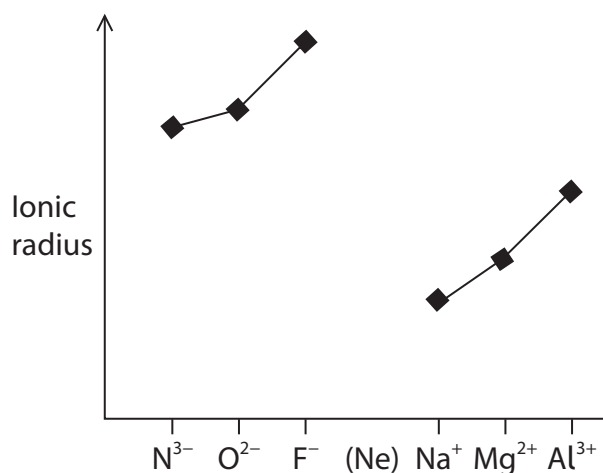
☒ B



☒ C



☒ D



(iv) Explain your answer to (a)(iii) in terms of the structure of the ions. (2)

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- (b) The strength of ionic bonding in different compounds can be compared by using the amount of energy required to separate the ions. Some values for this energy are given in the table.

Compound	Amount of energy required to separate the ions / kJ mol^{-1}
LiF	1031
KF	817
CaF_2	2957

Using the data provided, explain how changes in the cation affect the bond strength in an ionic compound.

(2)

(Total for Question 8 = 9 marks)

TOTAL FOR PAPER = 80 MARKS



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- * Lanthanide series
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