Write your name here

Surname	Other names
Model Answers	

Pearson Edexcel GCE

Centre Number	Candidate Number

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

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

Pearson

Answer ALL questions.

Some questions must be answered with a cross in a box ☒.
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.

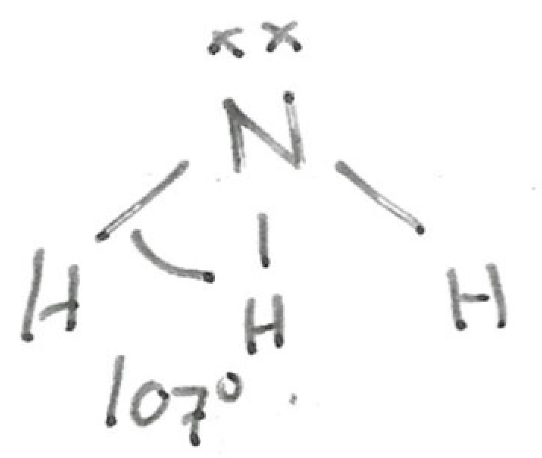
(a) State what is meant by the term covalent bond.

(2)

A covalent bond is a shared pair of electrons. There is a strong electrostatic attraction between the positive nuclei and the shared electron pair.

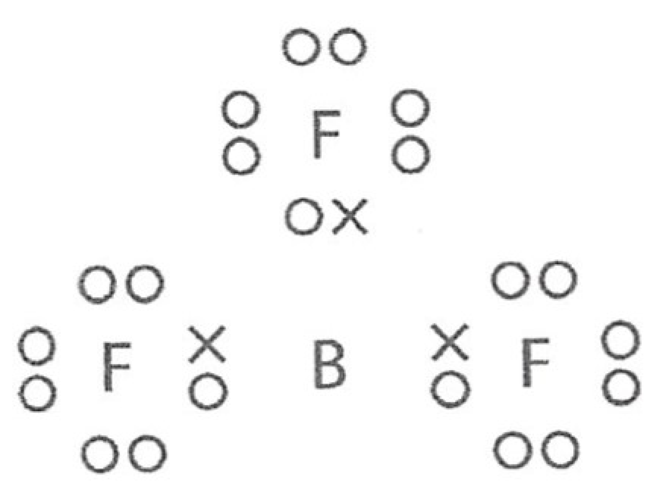
(b) Draw a diagram of the ammonia molecule, clearly showing its shape. Include any lone pairs of electrons and the value of the bond angle.

(2)



pyramidal

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



B = grp 3

NO LONE PAIRS

∴ trigonal planar (120°)

What is the bond angle in BF_3?

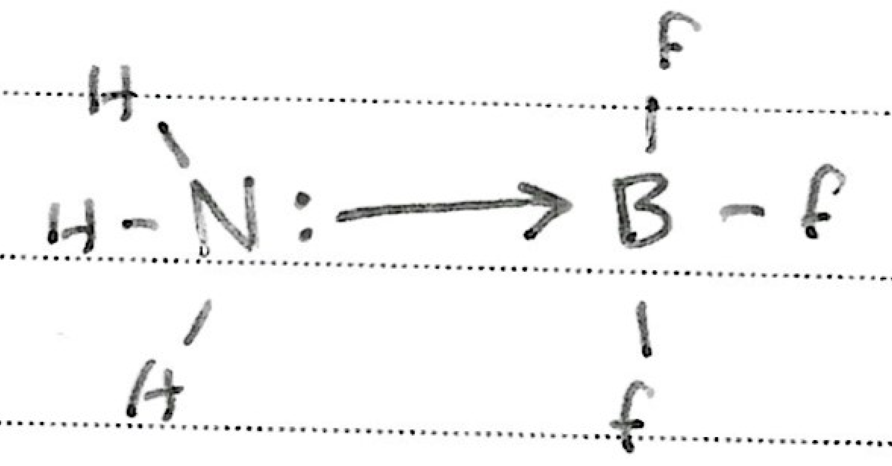
(1)

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

(d) (i) Ammonia and boron trifluoride react to form a compound NH_3BF_3 which contains a dative covalent bond. Each of the molecules, NH_3 and BF_3, has a different feature of its electronic structure that allows this to happen.
Use these two different features to explain how a dative covalent bond is formed.

(2)

The lone pair of electrons on the Nitrogen atom of ammonia is donated to the Boron atom of boron trifluoride



(ii) During this reaction, the bond angles about the nitrogen atom and the boron atom change.

State the new H—N—H and F—B—F bond angles.

(2)

Both now tetrahedral, therefore both bond angles are 109.5°.

(Total for Question 1 = 9 marks)

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

(a) (i) Hydrogen has two stable isotopes, $^{1}_{1}H$ and $^{2}_{1}H$. 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
$^{1}_{1}H$	1	0
$^{2}_{1}H$	1	1

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

(2)

An atom of an element with the same no. of protons but a different no. of neutrons.

(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
$^{1}_{1}H$	1.007825	99.9885
$^{2}_{1}H$	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)

Both isotopes have relative isotopic masses over 1.0.

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

(2)

$$\frac{(1.007825 \times 99.9885) + (2.014101 \times 0.0115)}{100}$$

$= 1.0079$

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

$H_{(g)} \rightarrow H^{+}(g) + e^{-}$

(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)

Lithium has the lowest ionisation energy because even though it has the most protons (greatest nuclear charge) its outer shell electron is furthest away and hence weakest attraction to the nucleus - easiest to remove. it is also more shielded by the inner electrons (1s).
Helium's first ionisation is higher than hydrogen as it has a greater nuclear charge (more protons) but same energy level as hydrogen, therefore requires more energy to remove.

DO NOT WRITE IN THIS AREA

(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)

In favour: • It has one electron in its outer shell like other group 1 elements.

Against: • It is not a metal

• It does not react in a similar way to other group 1 elements.

(Total for Question 2 = 15 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

P 5 1 4 5 9 A 0 6 2 4

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

$$H_2SO_4(aq) + 2KOH(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$$

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 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.

pink in alkali
colourless in 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

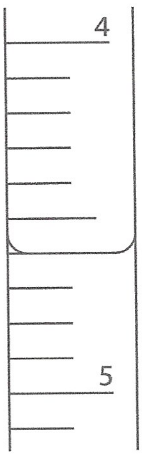
☐ **B** orange

☒ **C** pale pink

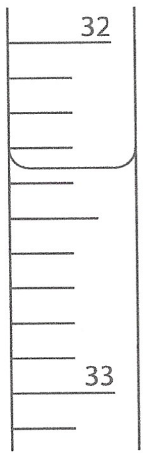
☐ **D** red

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

(2)



Initial reading



Final reading

Table of results

Titration number	Final reading / cm^3	Initial reading / cm^3	Titration volume / cm^3
1	32.35	4.60	27.75
2	28.05	1.10	26.95 *
3	37.65	10.20	27.45
4	32.05	5.00	27.05 *

concordant results

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

(1)

☒ **A** 27.00 cm^3

☐ **B** 27.15 cm^3

☐ **C** 27.25 cm^3

☐ **D** 27.30 cm^3

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

(3)

$H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$

$27.00 cm^3$ of KOH.

$25.00 cm^3$ of H_2SO_4 of $0.0800 mol dm^{-3}$

$C \times V = mol$ $\quad 0.08 \times \left(\frac{25}{1000}\right) = 2 \times 10^{-3}$ moles of H_2SO_4

$2 \times 10^{-3} \times 2 = 4 \times 10^{-3}$ moles of KOH

$C = \frac{mol}{vol}$ $\quad c = \frac{4 \times 10^{-3}}{\left(27.00/1000\right)} = 0.148\dot{} \; mol dm^{-3}$

(Total for Question 3 = 8 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

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 $MN.xH_2O$, where x is the number of moles of water of crystallisation per mole of MN.

A sample of $MN.xH_2O$ 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.

negative

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

(1)

SO_4^{2-} and CO_3^{2-}

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

negative

Give the **formula** of the anion.

(1)

SO_4^{2-}

(iii) What is the charge on the cation?

(1)

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

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(b) **Test 2**

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

Give a possible identity of the cation, M.

(1)

Mg^{2+}

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

$$MN.xH_2O(s) \rightarrow MN(s) + xH_2O(g)$$

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, $CoCl_2.yH_2O$ in which the sample reduced in mass to 54.6% of its original value. Use this information to calculate the value of y.*]

(4)

$MgSO_4.xH_2O$

$MgSO_4 = 48.9\%$

Mr 120.3

$\frac{48.9}{120.4} = 0.406$

$\frac{0.406}{0.406} = 1$

$H_2O = 51.1\%$

Mr 18

$\frac{51.1}{18} = 2.838$

$\frac{2.838}{0.406} = 6.99$ or 7

$x = 7$

$MgSO_4.7H_2O$.

(Total for Question 4 = 8 marks)

DO NOT WRITE IN THIS AREA

5 A student made crystals of a metal chloride, $JCl_2.6H_2O$, by reacting the metal carbonate, JCO_3, with hydrochloric acid, HCl(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

$$JCO_3(s) + 2HCl(aq) \rightarrow JCl_2(aq) + H_2O(l) + CO_2(g)$$

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

(2)

· Metal carbonate 'dissolved'/ disappears.
· fizzing stopped.

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

(1)

To remove excess metal carbonate.

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

(2)

• To remove soluble impurites
• to ensure that as little product as possible dissolves.

(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)

$C = \frac{m}{V}$

$0.80 \times \frac{150}{1000} = 0.12$ moles of HCl $\div 2 = 0.06$ moles of H_2O.

$\times 18 = 1.08 \times 6 = 6.48$

$14.26 - 6.48 = 7.78$ g of SCl_2

moles = $\frac{mass}{mr}$ $\frac{mass}{moles} = mr$ $\frac{7.78}{0.06} = 129.66 - 71 = 58.66 = Ni$

mass = mr × mol

Turn over

(c) The student was surprised by the white colour of the crystals of $JCl_2.6H_2O$ 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)

Transition metals usually form coloured compounds. The flame test allow us to identify the metal ion based on its colour.

(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)

$SrCl_2 . 6H_2O$

Mr = 87.6 + 71 + 108 =

0.06 × 266.6 = 15.996

$\frac{14.26}{15.996} \times 100 =$ 89.15% so **89%**

(Total for Question 5 = 15 marks)

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

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

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)

$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^5$

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

(2)

Both have 7 electrons on the outer shell and it is the electronic structure that determines reactivity.

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

Iodine and chlorine react differently with thiosulfate ions, $S_2O_3^{2-}$.
Iodine gives $S_4O_6^{2-}$, whilst chlorine gives SO_4^{2-}.

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

(2)

Ion	Oxidation number of sulfur
$S_2O_3^{2-}$	+2
SO_4^{2-}	+6
$S_4O_6^{2-}$	+2.5

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

$$2S_2O_3^{2-} + I_2 \rightarrow 2I^- + S_4O_6^{2-}$$

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

(1)

Because Iodine has been reduced - gained electrons.

$I_2 + 2e^- \rightarrow 2I^-$

DO NOT WRITE IN THIS AREA

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

(1)

0 +2 -1 +6

$Cl_2 + S_2O_3^{2-} \rightarrow 2Cl^- + SO_4^{2-}$

Cl_2 + $S^{+2} \rightarrow S^{+6}$ I_2 $S^{+2} \rightarrow S^{+2.5}$

(iv) Chlorine reacts in aqueous solution with $S_2O_3^{2-}$ (+2) to give SO_4^{2-} (+6).
The ionic half-equation for the reaction of chlorine is

$$Cl_2 + 2e^- \rightarrow 2Cl^-$$

Write the ionic half-equation for the reaction of aqueous $S_2O_3^{2-}$ to give SO_4^{2-}.
State symbols are not required.

(2)

$5H_2O + S_2O_3^{2-} \rightarrow 2SO_4^{2-} + 8e^- + 10H^+$

(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)

$5H_2O + S_2O_3^{2-} \rightarrow 2SO_4^{2-} + 8e^- + 10H^+$

$\times 4$ $4Cl_2 + 8e^- \rightarrow 8Cl^-$

$5H_2O + S_2O_3^{2-} + 4Cl_2 \rightarrow 2SO_4^{2-} + 10H^+ + 8Cl^-$

(Total for Question 6 = 10 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

BLANK PAGE

*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_2O	100.0	10
HF	19.5	10

(6)

* CH_4 - strongest IMF = London forces.
H_2O - strongest IMF = Hydrogen bonding (2 per molecule).
HF - strongest IMF = Hydrogen bonding (1 per molecule).

strongest ⟶ weakest.
2 Hydrogen bonds > 1 hydrogen bond > London forces.

All have amount of London forces as they have similar no. of electrons. Hydrogen bonding occurs with F, N and O directly attached to a H due to very large electronegativity differences.

Hydrogen bonds strongest as lots of energy needed to break them.

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** $Na(s) + F(g) \rightarrow NaF(s)$

☒ **B** $2Na(s) + F_2(g) \rightarrow 2NaF(s)$

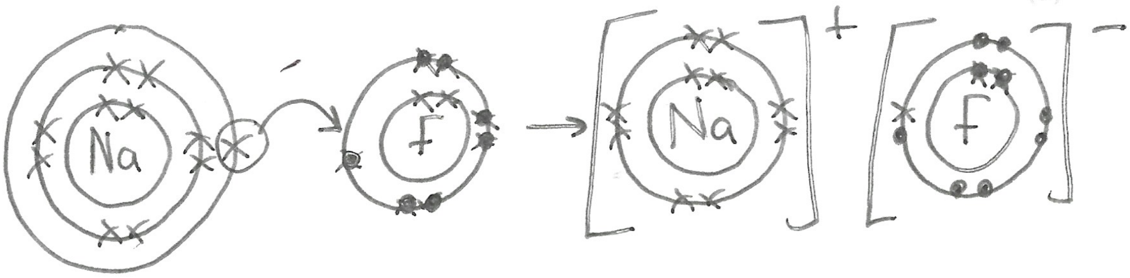
☐ **C** $Na(s) + F_2(g) \rightarrow NaF_2(s)$

☐ **D** $2Na(s) + F(g) \rightarrow Na_2F(s)$

(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)



Isoelectronic ions have the same electron configuration.

$1s^2 2s^2 2p^6$

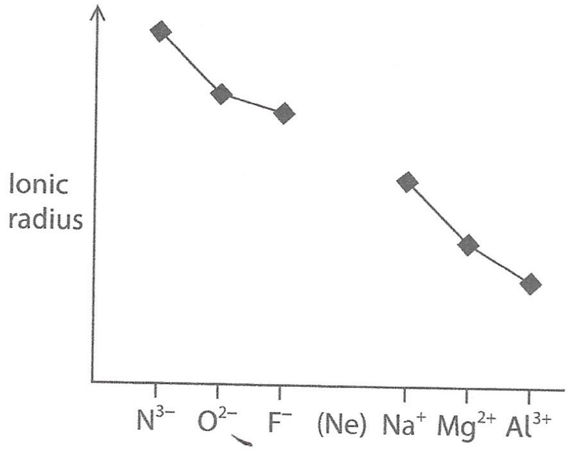
P 5 1 4 5 9 A 0 2 0 2 4

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

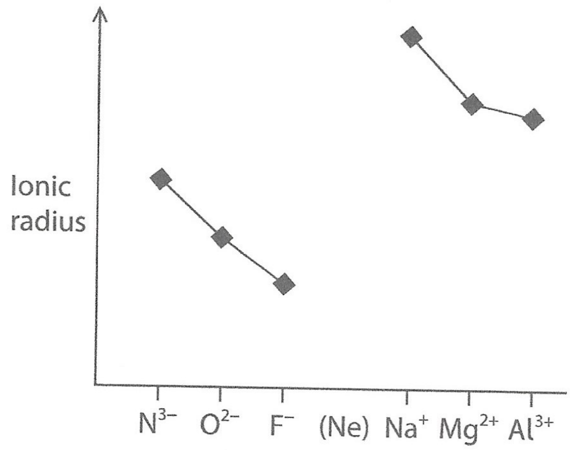
(iii) Which diagram shows the trend in ionic radius for the isoelectronic ions N^{3-} to Al^{3+}?

(1)

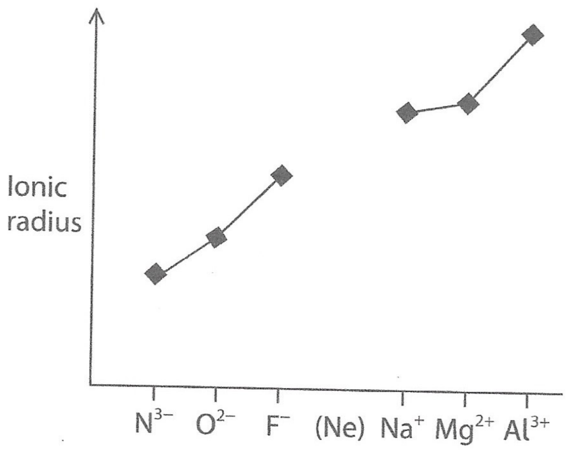
☒ **A**



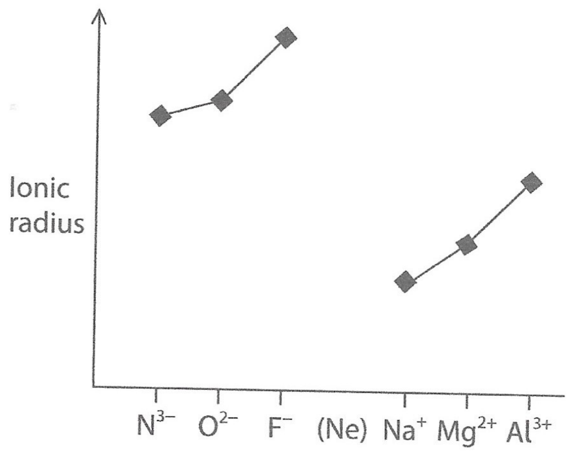
☐ **B**



☐ **C**



☐ **D**



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

(2)

More protons in nucleus - increase the attraction to the electrons, making the ionic radii smaller.

(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)

smaller radii between ions - stronger bond so LiF stronger than Kf.
Higher charge - increased attraction ∴ Caf2 stronger than Kf.

(Total for Question 8 = 9 marks)

TOTAL FOR PAPER = 80 MARKS

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