Write your name here

Surname	Other names

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 ▶

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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)

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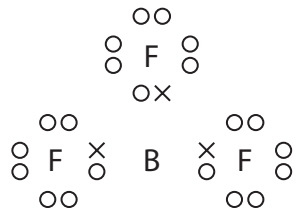
(b) Draw a diagram of the ammonia molecule, clearly showing its shape.
Include any lone pairs of electrons and the value of the bond angle.

(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°

(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)

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(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)

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(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
$^{1}_{1}H$		
$^{2}_{1}H$		

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

(2)

(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)

(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)

(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

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

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.

(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

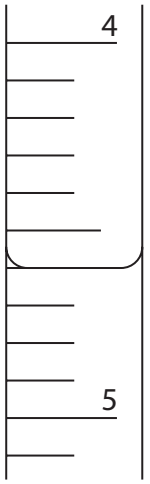
☒ **B** orange

☒ **C** pale pink

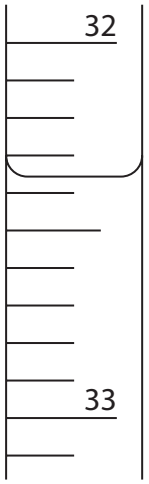
☒ **D** red

(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			
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 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)

(Total for Question 3 = 8 marks)

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.

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

(1)

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(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)

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(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 $MN.xH_2O$ 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:

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

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)

(Total for Question 4 = 8 marks)

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)

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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)

(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)

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(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)

$1s^2$

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

(2)

(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
$S_2O_3^{2-}$	
SO_4^{2-}	
$S_4O_6^{2-}$	

(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)

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

(1)

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(iv) Chlorine reacts in aqueous solution with $S_2O_3^{2-}$ to give SO_4^{2-}.
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)

(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_2O	100.0	10
HF	19.5	10

(6)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(Total for Question 7 = 6 marks)

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.

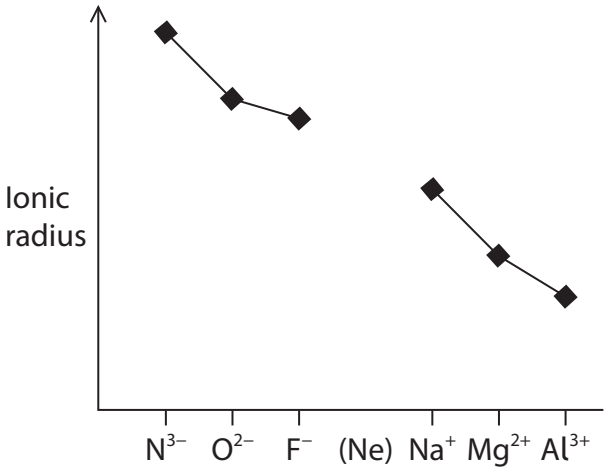
Use your diagram to explain why the ions are described as isoelectronic.

(3)

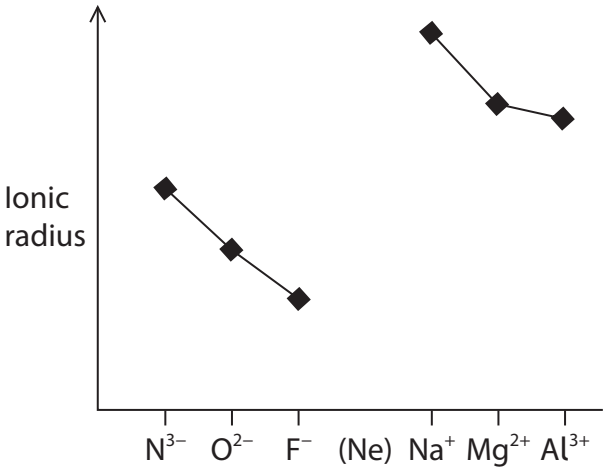
(iii) Which diagram shows the trend in ionic radius for the isoelectronic ions N^{3-} to Al^{3+}?

(1)

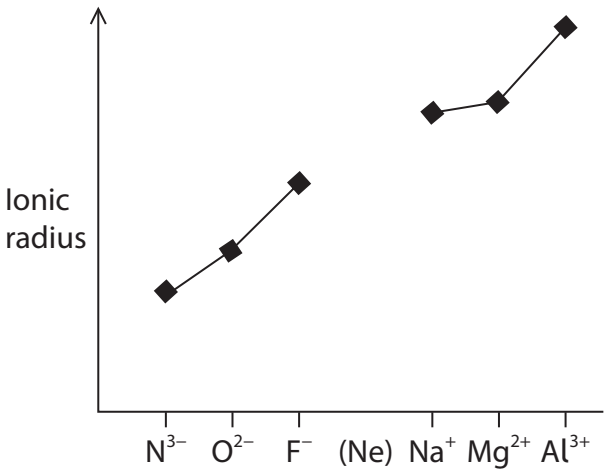
☒ **A**



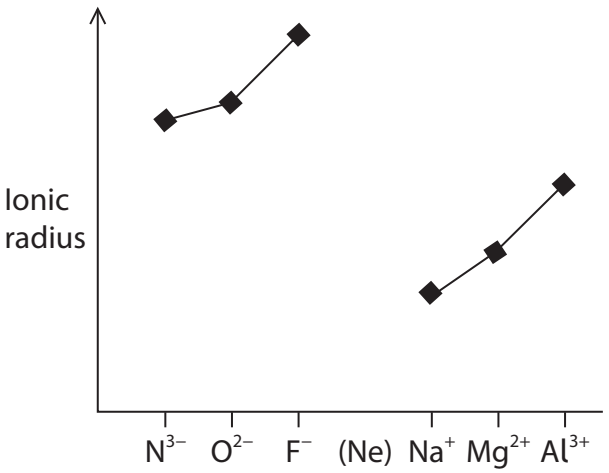
☒ **B**



☒ **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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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103