Write your name here

| Surname | Other names |
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**Pearson**
**Edexcel GCE**

Centre Number | Candidate Number

# Chemistry

## Advanced Subsidiary

## Paper 1: Core Inorganic and Physical Chemistry

Friday 26 May 2017 – Morning
**Time: 1 hour 30 minutes**

Paper Reference
**8CH0/01**

**You must have:**
Data Booklet
Scientific calculator, ruler

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.*
- You may use a scientific calculator.
- For questions 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.

## Advice

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

*Turn over* ▶



6/6/6/6/


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** The presence of some ions in compounds can be identified using a Bunsen burner flame.

(a) (i) Some metal ions give characteristic colours in a flame test.

Describe how to carry out a flame test on an unknown solid.

**(2)**

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(ii) Which of the following ions does **not** give a red flame?

**(1)**

☒ **A** barium

☒ **B** calcium

☒ **C** lithium

☒ **D** strontium

(iii) Some anions can also be identified by heating in a Bunsen burner flame. A compound heated in a test tube in a Bunsen burner flame gave off a brown gas and caused a glowing splint to relight. The formula of the ion responsible is

**(1)**

☒ **A** $Br^-$

☒ **B** $NO_2^-$

☒ **C** $NO_3^-$

☒ **D** $O^{2-}$

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(b) A flame test on a white powder gave a lilac flame colour. Dilute hydrochloric acid was added to a second sample of the same powder in a boiling tube and the gas produced bubbled into limewater. The limewater turned cloudy.

Give a possible **formula** for the white powder.

**(2)**

**(Total for Question 1 = 6 marks)**

**2** This question is about water.

(a) Water is a polar covalent molecule. The strongest intermolecular forces between water molecules are hydrogen bonds.

(i) The O—H bond in water is polar because, when compared with the hydrogen atom, the oxygen atom has

**(1)**

- ☒ **A** a higher mass number
- ☒ **B** a larger atomic radius
- ☒ **C** greater electronegativity
- ☒ **D** more electrons

(ii) Draw a diagram of a hydrogen bond between two water molecules in ice.

Show the value of the H—O—H angle within a molecule and the value of the O—H—O angle between the two molecules.

**(2)**

(iii) Explain why hydrogen bonding causes ice to be less dense than liquid water.

**(2)**

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(b) Liquid water is a good solvent for many, but not all, ionic compounds. Which is **least** soluble in water?

**(1)**

- ☒ **A** barium hydroxide
- ☒ **B** calcium hydroxide
- ☒ **C** magnesium hydroxide
- ☒ **D** sodium hydroxide

**(Total for Question 2 = 6 marks)**

**3** Electrons in atoms occupy orbitals.

(a) Draw in the boxes the shape of an s-orbital and a p-orbital.

| s-orbital | p-orbital |
|---|---|

**(2)**

(b) State what is meant by the term **first ionisation energy**.

**(3)**

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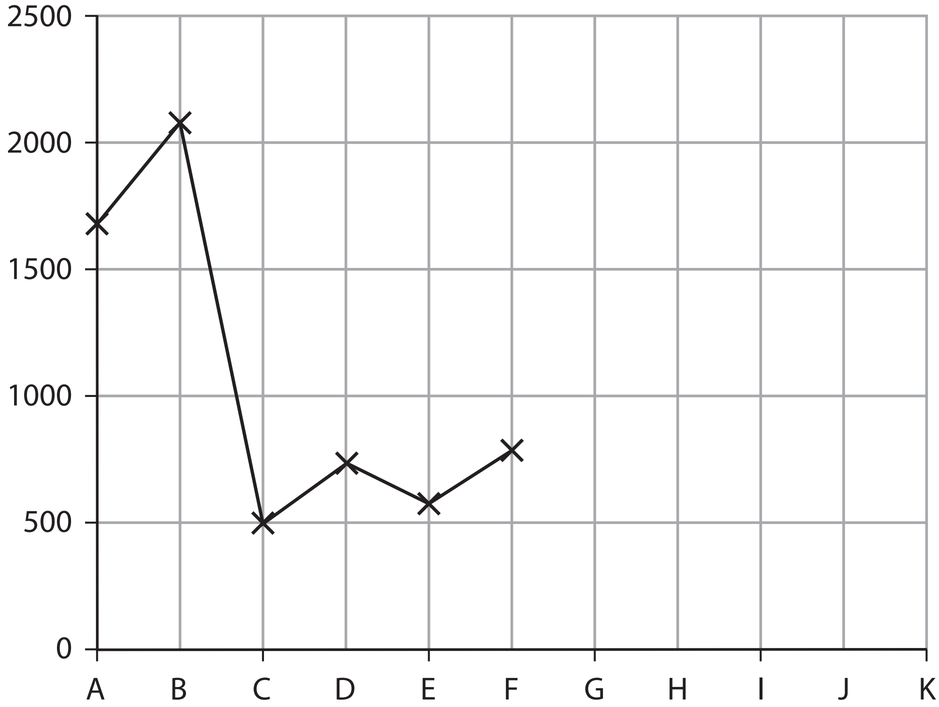
(c) (i) The graph shows the first ionisation energies for a series of six consecutive elements **A**–**F**. The letters are not their chemical symbols.

Complete the graph of the first ionisation energies for the next five elements.

**(3)**




(ii) Explain why the value of the first ionisation energy for **D** is **greater** than for **C**.

**(2)**

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(iii) Explain why the value of the first ionisation energy of **E** is **less** than for **D**.

**(2)**

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(d) Successive ionisation energies can give information about the electronic structure of an element.

Which of the following sets of data showing the first four ionisation energies, in $kJ\,mol^{-1}$, of four elements is most likely to belong to boron?

**(1)**

☒ **A** 1086, 2353, 4621, 6223.

☒ **B** 900, 1757, 14 849, 21 007.

☒ **C** 801, 2427, 3660, 25 026.

☒ **D** 578, 1817, 2745, 11 578.

**(Total for Question 3 = 13 marks)**

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**4** This question is about redox chemistry.

(a) (i) Write an ionic half-equation for the reduction of chlorine molecules to chloride ions.
State symbols are not required.

**(1)**

(ii) Write an ionic half-equation for the oxidation of chlorine molecules to chlorate(I) ions in the presence of cold, aqueous hydroxide ions.
State symbols are not required.

**(1)**

(iii) Combine the two equations in (a)(i) and (ii) to give the ionic equation for the reaction of chlorine molecules with cold, aqueous hydroxide ions.

**(1)**

(iv) Use your answer to (a)(iii) to explain why the reaction is described as a **disproportionation** reaction.

**(2)**

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(b) A different ion containing chlorine is formed if the solution of aqueous hydroxide ions is hot.

Give the formula of the chlorine-containing ion **and** the oxidation number of chlorine in this ion.

**(2)**

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(c) (i) Bromine can be extracted from seawater containing bromide ions using chlorine.

Write the ionic equation for this reaction. State symbols are not required.

**(1)**

(ii) Identify **one** hazard associated with carrying out this reaction in a school laboratory and a safety precaution other than wearing a laboratory coat and eye protection.

**(2)**

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**(Total for Question 4 = 10 marks)**

**5** This question is about magnesium.

(a) (i) Complete the electronic structure of a magnesium atom.

**(1)**

$1s^2$ ........................................................................................................

(ii) The bonding in magnesium results from

**(1)**

☒ **A** strong electrostatic attractions between oppositely charged ions

☒ **B** strong electrostatic attractions between the nuclei of magnesium atoms and a shared pair of electrons

☒ **C** strong electrostatic attractions between positively charged ions and a sea of delocalised electrons

☒ **D** weak dispersion forces between magnesium atoms

(b) Magnesium exists as three stable isotopes. One isotope has a relative isotopic mass of 25.0.

State what is meant by the term **relative isotopic mass**.

**(2)**

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(c) What are the numbers of protons, neutrons and electrons in an atom of magnesium which has a mass number of 25?

**(1)**

☒ **A** 12 protons, 13 neutrons and 12 electrons

☒ **B** 12 protons, 25 neutrons and 12 electrons

☒ **C** 13 protons, 12 neutrons and 13 electrons

☒ **D** 25 protons, 13 neutrons and 12 electrons.

(d) The relative atomic mass of a sample of magnesium was found to be 24.3. The percentage composition for two of the three isotopes is given in the table. Use these data to calculate the percentage composition of the third isotope and hence its relative isotopic mass. Give your answer to an appropriate number of significant figures. You **must** show your working.

| Relative isotopic mass | Percentage abundance |
|---|---|
| 25.0 | 10.00 |
| 26.0 | 11.01 |

**(4)**

**(Total for Question 5 = 9 marks)**

**6** Boron and aluminium are in the same group of the Periodic Table. Both form compounds with chlorine and with fluorine.

(a) Boron reacts directly with chlorine to produce a covalently bonded compound, $BCl_3$.

(i) Write the equation for this reaction. State symbols are not required.

**(1)**

(ii) Draw a dot-and-cross diagram for $BCl_3$ showing only the outer shell electrons of the atoms.

**(1)**

(iii) Use your diagram to explain why $BCl_3$ has a trigonal planar shape with bond angles of 120°.

**(2)**

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(b) Aluminium also reacts directly with chlorine to form a compound, aluminium chloride, containing only aluminium and chlorine.

A 0.500 g sample of aluminium chloride was analysed and found to contain 0.101 g of aluminium.

Another 0.500 g sample was heated to 473 K. The gas produced occupied a volume of 73.6 $cm^3$ at a pressure of $1.00 \times 10^2$ kPa.

Determine the molecular formula of the gas.

You will need to use the equation $pV = nRT$ and $R = 8.31\ J\ mol^{-1}\ K^{-1}$

**(6)**

*(c) Aluminium fluoride and aluminium chloride are both crystalline solids at room temperature. Aluminium fluoride sublimes to form a gas at 1291 °C (1564 K), whilst aluminium chloride sublimes at 178 °C (451 K).

Use the Pauling electronegativity values in the Data Booklet to explain these differences in sublimation temperature.

**(6)**

**(Total for Question 6 = 16 marks)**

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**7** Hydrochloric acid is prepared by dissolving hydrogen chloride gas in water. It is difficult to dissolve a known amount of hydrogen chloride, so the exact concentration of such solutions is uncertain. A solution of hydrochloric acid of concentration between 0.095 mol dm$^{-3}$ and 0.105 mol dm$^{-3}$ was prepared.

Before a class attempted a practical using this solution, a technician standardised the hydrochloric acid with sodium carbonate solution. The technician dissolved 1.30 g of anhydrous sodium carbonate in water and made up the solution to 100 cm$^3$.

The equation for the reaction which occurs is shown.

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

A 10.0 cm$^3$ portion of the sodium carbonate solution was transferred to a conical flask. Three drops of methyl orange indicator were added and the solution titrated with hydrochloric acid. The results for the experiment are shown.

| **Titration** | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|
| Final burette reading / cm$^3$ | 26.00 | 34.00 | 36.10 | 24.15 | 48.20 |
| Initial burette reading / cm$^3$ | 0.00 | 10.00 | 11.00 | 0.05 | 24.15 |
| Titre / cm$^3$ | | | | | |
| Concordant results (✓) | | | | | |

(a) Complete the table and determine the concentration, in mol dm$^{-3}$ , of the hydrochloric acid solution, giving the answer to an appropriate number of significant figures.

**(5)**

(b) The colour change at the end-point when methyl orange is used as an indicator for this titration is from

**(1)**

☒ **A** orange to yellow

☒ **B** red to orange

☒ **C** yellow to orange

☒ **D** yellow to red

(c) Explain **three** actions the technician might take in the procedure, just before the end-point of the titration, to ensure that the volume of acid added at the end-point is accurate.

**(3)**

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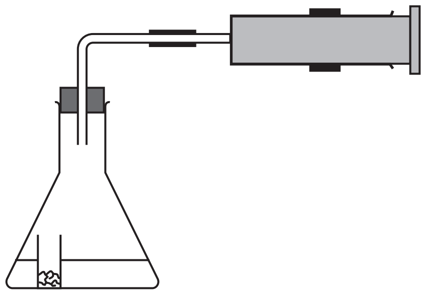
**(Total for Question 7 = 9 marks)**

**8** A student wanted to measure the volume of a gas and use the results to find the volume occupied by one mole of the gas. The following method was used.

- A sample of calcium carbonate was weighed out in a small plastic container.
- 20 $cm^3$ of hydrochloric acid of concentration 2.00 mol $dm^{-3}$ was added to a conical flask. A small pinch of calcium carbonate was added to the acid.
- The container was placed in the conical flask and a gas syringe was connected to the top of the conical flask.
- The flask was carefully shaken so that the small plastic container fell over, allowing the acid and calcium carbonate to mix.

The apparatus set up is shown.



The student repeated the experiment five times using different masses of calcium carbonate on each occasion, with the concentration and volume of the hydrochloric acid constant.

| Experiment number | Mass / g | Volume of $CO_2$ / $cm^3$ |
|---|---|---|
| 1 | 0.10 | 23 |
| 2 | 0.20 | 44 |
| 3 | 0.30 | 67 |
| 4 | 0.40 | 96 |
| 5 | 0.50 | 115 |

(a) (i) Write the equation for the reaction between calcium carbonate and hydrochloric acid. Include state symbols.

**(2)**

(ii) Calculate the molar mass of calcium carbonate.

**(1)**

.............................................. g $mol^{-1}$

(iii) Show that, in each experiment, the hydrochloric acid is in excess.

**(2)**

(b) (i) Plot a graph of volume of carbon dioxide produced against mass of calcium carbonate on the grid. Include a line of best fit.

**(2)**

(ii) State how your graph supports the idea that the volume of gas produced depends directly on the mass of calcium carbonate added.

**(1)**

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(c) Calculate the volume, under these conditions, of one mole of carbon dioxide gas from these data. Give your answer in $dm^3$ to **two** significant figures.

**(2)**

(d) Give a reason why the student added a small pinch of calcium carbonate to the acid before starting the reaction.

**(1)**

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**(Total for Question 8 = 11 marks)**

**TOTAL FOR PAPER = 80 MARKS**

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P 4 9 8 5 8 A 0 2 3 2 4

# The Periodic Table of Elements

**Key**

relative atomic mass
**atomic symbol**
name
atomic (proton) number

| 1 (1) | 2 (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | 3 (13) | 4 (14) | 5 (15) | 6 (16) | 7 (17) | 0 (8) (18) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1.0 **H** hydrogen 1 | | | | | | | | | | 4.0 **He** helium 2 |
| 6.9 **Li** lithium 3 | 9.0 **Be** beryllium 4 | | | | | | | | | | | 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 | | | | | | | | | | | 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

| Series | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| * 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 |