Please check the examination details below before entering your candidate information

| Candidate surname | Other names |
|---|---|
| | |

**Pearson Edexcel Level 3 GCE**

| Centre Number | Candidate Number |
|---|---|
| | |

**Time** 1 hour 30 minutes

**Paper reference** **8CH0/01**

# Chemistry

## Advanced Subsidiary

## PAPER 1: Core Inorganic and Physical Chemistry

**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.
- Show all your working in calculations and include units where appropriate.
- Check your answers if you have time at the end.
- Good luck with your examination.

*Turn over* ▶

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P 6 7 0 8 3 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** Bromine exists as two stable isotopes. The two isotopes are represented by the symbols $^{79}_{35}Br$ and $^{81}_{35}Br$.

(a) Give one similarity and one difference between these two isotopes by referring to the **number of particles** in the nuclei of the two isotopes.

**(2)**

(b) The relative abundance of the two isotopes in a sample cannot be found in a chemical test.

(i) Give the reason why, despite the difference in atomic structure, the isotopes have the same chemical reactions.

**(1)**

(ii) State how the relative abundance of the two isotopes can be found.

**(2)**

DO NOT WRITE IN THIS AREA

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(c) (i) Complete the electronic configuration of a bromine atom.

**(1)**

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

(ii) What is the number of electrons in the fourth quantum shell of bromine?

**(1)**

☒ **A** 2

☒ **B** 7

☒ **C** 17

☒ **D** 18

**(Total for Question 1 = 7 marks)**

**2** This question is about sodium carbonate.

(a) Sodium carbonate forms a number of hydrates with the general formula $Na_2CO_3.xH_2O$.

A 250 $cm^3$ standard solution of one of these hydrates contained 10.0 g of the compound.

Describe, including the names of any relevant apparatus, how to make this standard solution when provided with 10.0 g of the hydrate in a beaker.

**(5)**

(b) 25.0 $cm^3$ portions of the standard solution described in (a) are titrated with hydrochloric acid solution of concentration 0.300 mol $dm^{-3}$, using methyl orange as an indicator.

The table shows the results for this titration.

| | Titration **1** | Titration **2** | Titration **3** |
|---|---|---|---|
| Final volume / $cm^3$ | 30.25 | 29.75 | 31.25 |
| Initial volume / $cm^3$ | 0.30 | 0.90 | 2.60 |
| Total titre / $cm^3$ | 29.95 | 28.85 | 28.65 |

(i) What is the colour change at the end-point of the reaction?

**(1)**

| | From | To |
|---|---|---|
| ☒ **A** | red | orange |
| ☒ **B** | red | yellow |
| ☒ **C** | yellow | orange |
| ☒ **D** | yellow | red |

(ii) State why the value for the total titre in Titration **1** should not be used to calculate the mean titre.

**(1)**

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.....

.....

(iii) Calculate the mean titre.

**(1)**

(iv) Calculate the relative formula mass, $M_r$, of the hydrated sodium carbonate, $Na_2CO_3.xH_2O$.

The equation for the reaction in the titration is

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

**(4)**

(c) In an experiment, the $M_r$ of a **different** hydrated sodium carbonate was found to be 286 g mol$^{-1}$.

(i) Calculate the relative formula mass of anhydrous sodium carbonate, $Na_2CO_3$.

**(1)**

(ii) Calculate the number of molecules of water of crystallisation, $x$, for this hydrated sodium carbonate, $Na_2CO_3.xH_2O$.

**(1)**

(d) Sodium carbonate is manufactured from sodium chloride in a two-stage process.

$$NaCl + NH_3 + CO_2 + H_2O \rightarrow NaHCO_3 + NH_4Cl$$
$$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$$

Calculate the maximum mass of sodium carbonate, $Na_2CO_3$, which could be obtained from 500 kg of sodium chloride.

**(3)**

**(Total for Question 2 = 17 marks)**

**3** Ammonia reacts with sodium to form sodium amide, $NaNH_2$, and hydrogen.

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

**(1)**

(ii) Draw diagrams showing the 3-dimensional shape of an ammonia molecule and of an amide ion, $NH_2^-$.
Include any lone pairs of electrons in each species.

**(3)**

ammonia molecule

amide ion

(iii) What is the H—N—H bond angle in an ammonia molecule?

**(1)**

☒ **A** 104.5°

☒ **B** 107°

☒ **C** 109.5°

☒ **D** 120°

(iv) Explain the difference between the H—N—H bond angle in ammonia and in the amide ion.

**(2)**

(b) Give a possible reason why samples of sodium amide are stored in oil.

**(1)**

**(Total for Question 3 = 8 marks)**

**4** Sulfur is a bright yellow crystalline solid at room temperature.

Sulfur forms rings of 8 sulfur atoms so the formula of the yellow solid is $S_8$.

(a) A section of a periodic table showing values of first ionisation energy in kJ mol$^{-1}$ is shown.

| | | |
|---|---|---|
| N<br>1400 | O<br>1310 | F<br>1680 |
| P<br>1010 | S<br>1000 | Cl<br>1250 |
| As<br>950 | Se<br>940 | Br<br>1140 |

(i) Which equation represents the first ionisation energy of sulfur?

**(1)**

☒ **A** $S(s) \rightarrow S^+(g) + e^-$

☒ **B** $S_8(s) \rightarrow S_8^+(g) + e^-$

☒ **C** $S(g) \rightarrow S^+(g) + e^-$

☒ **D** $S_8(g) \rightarrow S_8^+(g) + e^-$

(ii) Explain the trend in the values of the first ionisation energies for the group containing sulfur.

**(3)**

(iii) Explain why the first ionisation energy of sulfur is lower than that of chlorine.

**(2)**

(iv) Explain why the first ionisation energy of sulfur is lower than that of phosphorus.

**(2)**

(b) Compound **X** is an oxide of sulfur. A gaseous sample of 0.318 g of **X** occupied a volume of 132 $cm^3$ at a temperature of 420 K and pressure of 105 kPa.

The number of moles of a gas and the volume occupied by it can be found using the ideal gas equation

$$pV = nRT$$

Calculate the relative molecular mass of **X** and hence its molecular formula.
You must show **all** your working.

[$R = 8.31\ J\,mol^{-1}\,K^{-1}$]

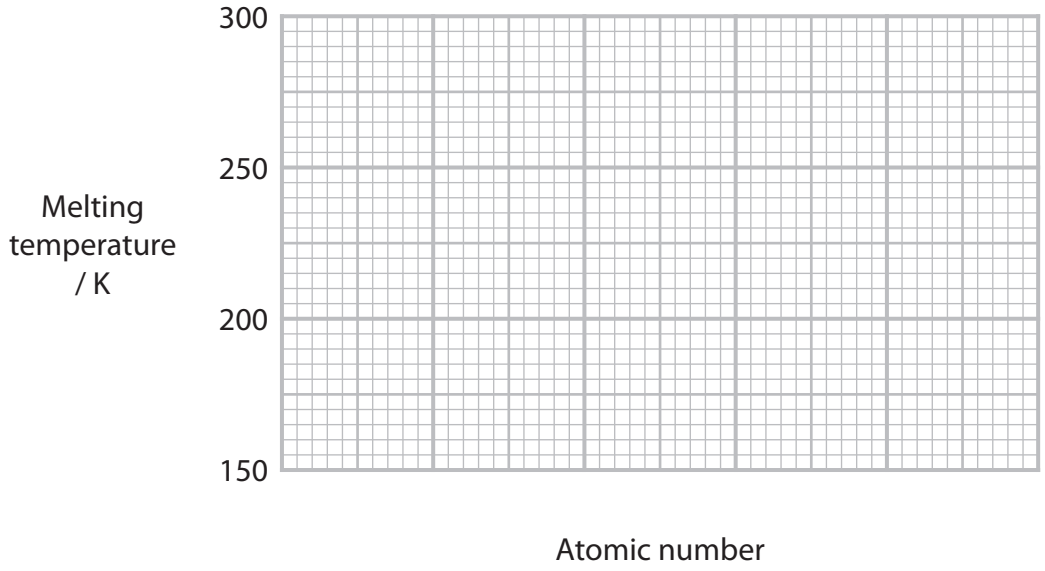
**(5)**

(c) Sulfur and the other elements in Group 6 form dihydrogen compounds.

| Compound | Atomic number of Group 6 element | Melting temperature / K |
|---|---|---|
| $H_2O$ | 8 | 273 |
| $H_2S$ | 16 | To be estimated |
| $H_2Se$ | 34 | 207 |
| $H_2Te$ | 52 | 224 |
| $H_2Po$ | 84 | 238 |

(i) Plot a graph of atomic number of the Group 6 element on the *x*-axis against melting temperature of the dihydrogen compound on the *y*-axis.

**(2)**




(ii) Give an estimate of the melting temperature of $H_2S$.

**(1)**

.....

**(Total for Question 4 = 16 marks)**

**5** This question is about crystalline solids.

(a) Iodine and diamond are crystalline solids at room temperature.

Explain why diamond has a much higher melting temperature than iodine.

**(5)**

(b) Graphite is also a crystalline solid at room temperature.
Unlike diamond, graphite conducts electricity.

Describe the key feature of the bonding of the carbon atoms in graphite that results in it being an electrical conductor.

**(2)**

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**(Total for Question 5 = 7 marks)**

**6** This question is about the reactions of the halogens and their salts.

(a) The potassium halides react with concentrated sulfuric acid to form hydrogen halides.

(i) The equation for this reaction for potassium chloride can be written

$$KCl + H_2SO_4 \rightarrow HCl + KHSO_4$$

The hydrogen chloride does not react further.

State why this reaction is not a redox reaction.

**(1)**

(ii) On descending Group 7, the hydrogen halides become better reducing agents.

Explain how the reactions of potassium chloride, potassium bromide and potassium iodide with concentrated sulfuric acid provide evidence for this statement.

No explanation of the trend is required.

**(3)**

(b) The reaction that occurs between chlorine and sodium hydroxide depends on the temperature.

(i) At room temperature the reaction that occurs is

$$Cl_2 + NaOH \rightarrow NaClO + NaCl$$

Explain, with reference to oxidation numbers, why this is a disproportionation reaction.

**(2)**

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(ii) With hot sodium hydroxide solution, a different disproportionation reaction occurs. Sodium chlorate(V) is one of the products.

Complete the equation for this reaction. State symbols are not required.

**(2)**

.....$Cl_2$ + .....NaOH $\rightarrow$

(c) Chlorine is used as a bleach in the textiles industry. Any excess chlorine can be removed by reduction to chloride ions.

The half-equation for the reaction of chlorine is

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

In one reaction, 768 $cm^3$ of chlorine gas was reduced.

(i) Calculate the number of moles of electrons gained by chlorine molecules during this reaction.
[Under these conditions one mole of gas occupies 24 $dm^3$]

**(2)**

(ii) The reducing agent was a solution containing thiosulfate ions, $S_2O_3^{2-}$.
The chlorine reacted with 40 $cm^3$ of a 0.20 mol $dm^{-3}$ solution of these ions.

Deduce the number of moles of electrons lost by each atom of sulfur in the thiosulfate ion, and hence the final oxidation state of the sulfur in the product.

**(3)**

**(Total for Question 6 = 13 marks)**

**7** The nitrates of lithium, rubidium and strontium are all white solids. The compounds are held together by ionic bonds.

(a) State the meaning of the term 'ionic bond'.

**(2)**

.....

.....

.....

.....

(b) What is the percentage by mass of strontium in strontium nitrate?

**(1)**

- ☒ **A** 38.0 %
- ☒ **B** 41.4 %
- ☒ **C** 58.6 %
- ☒ **D** 74.5 %

(c) These three compounds cannot be identified with certainty from a flame test as the colours seen are similar.

Concentrated hydrochloric acid is used in a flame test procedure.

(i) Which of the following is a reason for dipping the flame test wire in concentrated hydrochloric acid during a flame test procedure?

**(1)**

☒ **A** it dissolves metal ions from the wire

☒ **B** it neutralises hydroxide ions that might colour the flame

☒ **C** it reduces the metal ions to metal atoms

☒ **D** it reacts with the compounds to form volatile chlorides

(ii) The flame colour given by these three solids in the flame test are shades of

**(1)**

☒ **A** green

☒ **B** lilac

☒ **C** red

☒ **D** yellow

(iii) What is the best explanation for why metal ions produce different flame colours?

**(1)**

Different wavelengths of light energy are

☒ **A** required to promote electrons to higher energy levels

☒ **B** released because electrons move from lower to higher energy levels

☒ **C** released due to different gaps between energy levels

☒ **D** required for electron transfer from non-metal ions to metal ions

*(d) Devise a procedure to **identify** the nitrates of lithium, rubidium and strontium using the effect of heat on the three solids and any precipitation reactions of the compounds.

Practical details are not required, but you should give the observations expected in each case.

**(6)**

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**(Total for Question 7 = 12 marks)**

**TOTAL FOR PAPER = 80 MARKS**

# 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<br>atomic symbol<br>name<br>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

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |
| 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 |

* Lanthanide series

* Actinide series