AQA

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

AS CHEMISTRY

Paper 1 Inorganic and Physical Chemistry

Monday 18 May 2020 Morning Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:
- the Periodic Table/Data Sheet, provided as an insert (enclosed)
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do **not** write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
Section B	
TOTAL	

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

Advice

You are advised to spend about 65 minutes on **Section A** and 25 minutes on **Section B**.

Do not write outside the box

Section A

Answer **all** questions in this section.

0 1 This question is about atomic structure.

0 1 . 1 There is a general trend for an increase in ionisation energy across Period 3.
Give **one** example of an element that deviates from this trend.

Explain why this deviation occurs.

[3 marks]

Element Aluminium

Explanation The outer 3p electron is at higher energy than the 3 s Sub shell so requires less energy to remove

0 1 . 2 Give an equation, including state symbols, to represent the process that occurs when the **third** ionisation energy of sodium is measured.

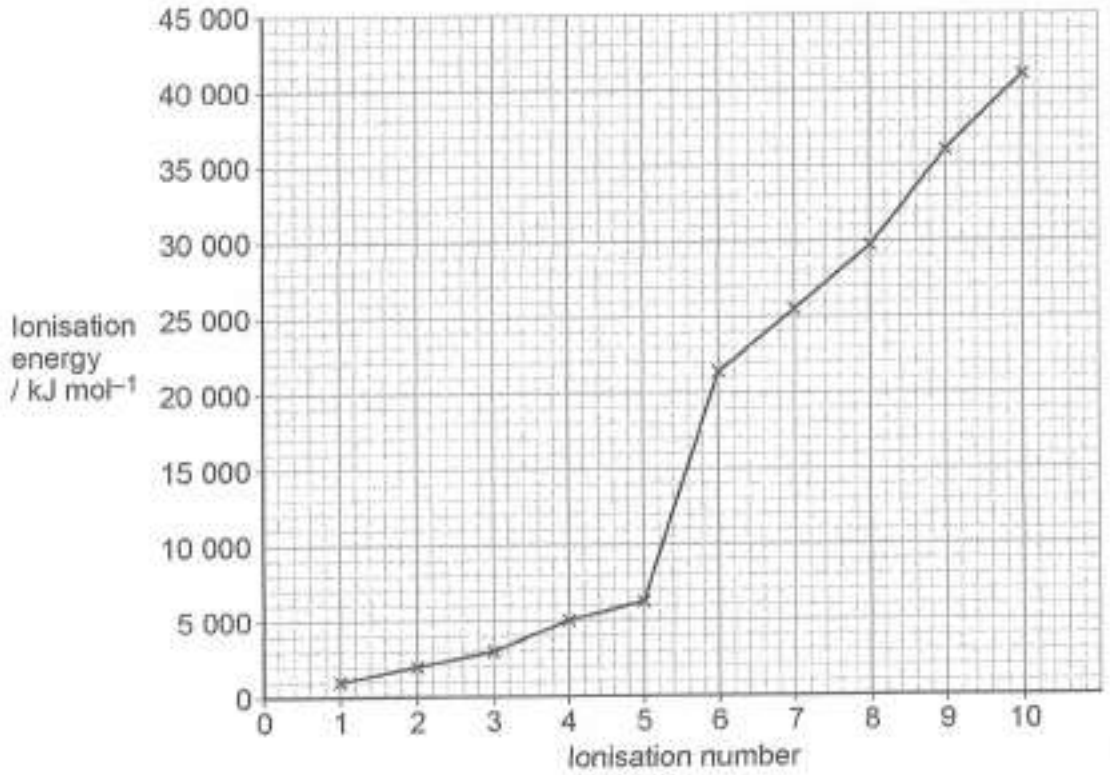
[1 mark]

$Na^{2+}(g) \longrightarrow Na^{3+}(g) + e^-$

Do not write outside the box

0 1 . 3 **Figure 1** shows the successive ionisation energies of a Period 3 element, **X**.

Figure 1



Identify element **X**.
Explain your choice.

[3 marks]

Element Phosphorus

Explanation There is a large jump in the ionisation energy after the removal of the 5th electron. This shows the move to removing electrons from the next shell down.

7

Turn over for the next question

Do not write outside the box

0 2 This question is about a titration.

A student dissolves an unknown mass of sodium hydroxide in water to make 200 cm^3 of an aqueous solution.

A 25.0 cm^3 sample of this sodium hydroxide solution is placed in a conical flask and is titrated with 0.150 mol dm^{-3} sulfuric acid.

The equation for this reaction is shown.

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

Table 1 shows the results of the titrations.

Table 1

Titration	Rough	1	2	3
Final reading / cm^3	20.75	40.35	21.05	40.60
Initial reading / cm^3	0.00	20.75	1.20	21.05
Titre / cm^3	20.75	19.60	19.85	19.55

0 2 . 1 Calculate the mass of sodium hydroxide used to make the original solution. **[5 marks]**

$n NaOH = 2n H_2SO_4$

$V_{H_2SO_4} = \frac{19.60 + 19.55}{2} = 19.575\ cm^3$

$n H_2SO_4 = Conc \times Volume = 0.150 \times \frac{19.575}{1000}$

$= 2.936 \times 10^{-3}$ mole

$n NaOH$ in 25 $= 2.936 \times 10^{-3} \times 2 = 5.87 \times 10^{-3}$ moles

$n NaOH$ in 200 $= 5.87 \times 10^{-3} \times 8 = 0.04698$ moles

mass $= 0.04698 \times 40 = 1.88$ g

Mass of sodium hydroxide 1.88 g

Do not write outside the box

0 2 . 2 The student uses a funnel to fill the burette with sulfuric acid before starting the titration. After filling, the student forgets to remove the funnel from the top of the burette.

Suggest why this might affect the titre volume recorded.

[1 mark]

Additional drops of solution may have entered the burette from the funnel

0 2 . 3 State **one** advantage of using a conical flask rather than a beaker for the titration.

[1 mark]

Less chance of losing reaction mixture when stirring

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Turn over for the next question

Do not write outside the box

0 3 This question is about time of flight (TOF) mass spectrometry.

0 3 . 1 Define the term relative atomic mass.

[2 marks]

The average mass of an atom of an element relative to 1/12th the mass of Carbon-12

0 3 . 2 A sample of krypton is ionised using electron impact.

The mass spectrum of this sample of krypton has four peaks.

Table 2 shows data from this spectrum.

Table 2

m/z	82	83	84	86
Relative intensity	6	1	28	8

Calculate the relative atomic mass (A_r) of this sample of krypton.

Give your answer to 1 decimal place.

[2 marks]

$$R.A.M = \frac{(82\times6)+(83\times1)+(84\times28)+(86\times6)}{43}$$

$$= \frac{3615}{43} = 84.1$$

A_r 84.1

Do not write outside the box

0 3 . 3 In a TOF mass spectrometer, ions are accelerated to the same kinetic energy (*KE*).

The kinetic energy of an ion is given by the equation $KE = \frac{1}{2}mv^2$

Where:
KE = kinetic energy / J
m = mass / kg
v = speed / $m\,s^{-1}$

In a TOF mass spectrometer, each $^{84}Kr^+$ ion is accelerated to a kinetic energy of 4.83×10^{-16} J and the time of flight is 1.72×10^{-5} s

Calculate the length, in metres, of the TOF flight tube.

The Avogadro constant, $L = 6.022 \times 10^{23}\,mol^{-1}$

[4 marks]

$$\text{mass} = \frac{84\ g\ mol^{-1}}{6.022 \times 10^{23}\ mol^{-1}} = 1.3948 \times 10^{-22}\ g$$

$$= 1.3948 \times 10^{-25}\ kg$$

$$E_k = \frac{1}{2}mv^2$$

$$\sqrt{\frac{2E_k}{m}} = v \qquad v = \frac{d}{t} \qquad d = t\sqrt{\frac{2E_k}{m}}$$

$$d = \sqrt{\frac{2 \times 4.83 \times 10^{-16}}{1.3948 \times 10^{-25}}} \times 1.72 \times 10^{-5}$$

$$= 1.43\ m$$

Length of flight tube 1.43 m

8

Turn over for the next question

Do not write outside the box

0 4 This question is about enthalpy changes.

0 4 . 1 State the meaning of the term enthalpy change as applied to a chemical reaction.

[1 mark]

Heat energy change at constant pressure

0 4 . 2 A student determines the enthalpy change for the reaction between calcium carbonate and hydrochloric acid.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

The student follows this method:

- measure out 50 cm^3 of 1.00 mol dm^{-3} aqueous hydrochloric acid using a measuring cylinder and pour the acid into a 100 cm^3 glass beaker
- weigh out 2.50 g of solid calcium carbonate on a watch glass and tip the solid into the acid
- stir the mixture with a thermometer
- record the maximum temperature reached.

The student uses the data to determine a value for the enthalpy change.

Explain how the experimental method and use of apparatus can be improved to provide more accurate data.

Describe how this data from the improved method can be used to determine an accurate value for the temperature change.

[6 marks]

Firstly, a burette should be used instead of a measuring cylinder to give a more accurate volume reading. A polystyrene cup should be used instead of a beaker to prevent heat loss. The watch glass should be reweighed after adding the solid to determine the mass lost to residue and fully powdered solid should be used.

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The initial temperature of the solution should be recorded for a few minutes before the addition of the solid to get an accurate measure. The temperature should then be measured at regular intervals (30 or 60 s) for a further 10 minutes to properly show any trend. To determine the temperature change, plot the results on a graph against time. extrapolate the two temperature data sets to the point of addition. Use the distance between the two lines at the point of addition to determine the value of ΔT.

Question 4 continues on the next page

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0 4 . 3 In a different experiment 50.0 cm^3 of 0.500 mol dm^{-3} aqueous hydrochloric acid are reacted with 50.0 cm^3 of 0.500 mol dm^{-3} aqueous sodium hydroxide.

$$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l) \quad \Delta H = -57.1 \text{ kJ mol}^{-1}$$

The initial temperature of each solution is 18.5 °C

Calculate the maximum final temperature of the reaction mixture.

Assume that the specific heat capacity of the reaction mixture, $c = 4.18 \text{ J K}^{-1} \text{ g}^{-1}$

Assume that the density of the reaction mixture = 1.00 g cm^{-3}

[5 marks]

$$n HCl = n NaOH = \frac{50 \times 0.500}{1000} = 0.025 \text{ moles}$$

$$q = -\Delta H \times = -(57.1) \times 0.025 = 1.4275 \text{ kJ}$$

$$\Delta T = q/mc = \frac{1.4275 \times 10^3}{100 \times 4.81}$$

$$= 3.42^\circ C$$

$$\text{Final Temp} = 18.5 + 3.42 = 21.9^\circ C$$

Final temperature 21.9 °C

0 4 . 4 Suggest how, without changing the apparatus, the experiment in Question **04.3** could be improved to reduce the percentage uncertainty in the temperature change.

[1 mark]

Increase the Concentration of the Solutions

13

Do not write outside the box

0 5 This question is about Group 2 elements and their compounds.

0 5 . 1 Explain why the melting point of magnesium is higher than the melting point of sodium.

[2 marks]

Mg^{2+} ions have a higher charge to mass ratio than Na^{+} ions. Therefore they attracted more strongly to the sea of delocalised electrons, requiring more energy to be seperated.

0 5 . 2 Give an equation to show how magnesium is used as the reducing agent in the extraction of titanium.

Explain, in terms of oxidation states, why magnesium is the reducing agent.

[2 marks]

Equation $2Mg + TiCl_4 \rightarrow 2MgCl_2 + Ti$

Explanation

Mg changes oxidation state from 0 to 2+ so it is loosing 2 electrons

Question 5 continues on the next page

Do not write outside the box

0 5 . 3 State what is observed when dilute aqueous sodium hydroxide is added to separate solutions of magnesium chloride and barium chloride.

[2 marks]

Observation with magnesium chloride white precipitate

Observation with barium chloride No visible change

6

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0 6 This question is about shapes of molecules and ions.

Draw the shape of NCl_3 and of NCl_4^+

Include any lone pairs of electrons that influence the shape.

Name the shape of NCl_3

State and explain the bond angle in NCl_4^+

[5 marks]

Shape of NCl_3

Shape of NCl_4^+

Name of shape of NCl_3 Pyramidal

Bond angle in NCl_4^+ 109.5°

Explanation of bond angle in NCl_4^+ all electron pairs in NCl_4^+ repel eachother equally to be as far apart as possible

5

Turn over for the next question

Do not write outside the box

0 7 This question is about Group 7 elements and their compounds.

0 7 . 1 Chlorine is used to treat water even though it is toxic to humans.

Give **one** reason why water is treated with chlorine.

Explain why chlorine is added to water even though it is toxic.

Give an equation for the reaction of chlorine with cold water.

[3 marks]

Reason to Sterilise the water

Explanation It is only used in low Concentration So the benifits of Sterilisation out weigh the risk

Equation

$Cl_2 + H_2O \rightleftharpoons HCl + HClO$

Do not write outside the box

0 7 . 2 Solid sodium iodide reacts with concentrated sulfuric acid to form iodine and sulfur in a redox reaction.

Give a half-equation to show the conversion of iodide ions to iodine.

Give a half-equation to show the conversion of sulfuric acid to sulfur.

Give an overall equation for this redox reaction.

Identify one other sulfur-containing reduction product formed when solid sodium iodide reacts with concentrated sulfuric acid.

[4 marks]

Half-equation for the conversion of iodide ions to iodine

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

Half-equation for the conversion of sulfuric acid to sulfur

$H_2SO_4 + 6H^+ + 6e^- \longrightarrow S + 4H_2O$

Overall equation

$6H^+ + 6I^- + H_2SO_4 \longrightarrow 3I_2 + S + 4H_2O$

Other sulfur-containing reduction product

SO_2

Question 7 continues on the next page

Do not write outside the box

A student completes an experiment to determine the percentage by mass of sodium chloride in a mixture of sodium chloride and sodium iodide.

The student uses this method.

- 600 mg of the mixture are dissolved in water to form a solution.
- An excess of aqueous silver nitrate is added to the solution. This forms a precipitate containing silver chloride and silver iodide.
- Excess dilute ammonia solution is then added to the precipitate. The silver chloride dissolves.
- The silver iodide is filtered off from the solution, and is then washed and dried.

The mass of the silver iodide obtained is 315 mg

0 7 . 3 Silver nitrate is added to the solution.

Suggest why an excess is used.

[1 mark]

To ensure that all the halide ions have reacted

0 7 . 4 Calculate the amount, in moles, of silver iodide obtained.

$M_r(AgI) = 234.8$

[1 mark]

$$n_{AgI} = \frac{0.315}{234.8} = 1.34 \times 10^{-3} \text{ moles}$$

Amount of silver iodide 1.34×10^{-3} mol

Do not write outside the box

0 7 . 5 Calculate, using your answer to Question **07.4**, the mass, in grams, of sodium iodide in the mixture.

M_r(NaI) = 149.9

[1 mark]

$n NaI = 1.34 \times 10^{-3}$ moles

$mass = 1.34 \times 10^{-3} \times 149.9 = 0.201 g$

Mass of sodium iodide 0.201 g

0 7 . 6 Calculate, using your answer to Question **07.5**, the percentage by mass of sodium chloride in the mixture.

[2 marks]

Mass NaCl = 600 − 201 = 399 mg

$\%\ NaCl = \frac{399}{600} \times 100 = 66.5\%$

Percentage of sodium chloride 67%

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Turn over for the next question

0 8 This question is about a volatile liquid, **A**.

0 8 . 1 A student does an experiment to determine the relative molecular mass (M_r) of liquid **A** using the apparatus shown in **Figure 2**.

The student injects a sample of **A** into a gas syringe in an oven.

At the temperature of the oven, liquid **A** vaporises.

Figure 2

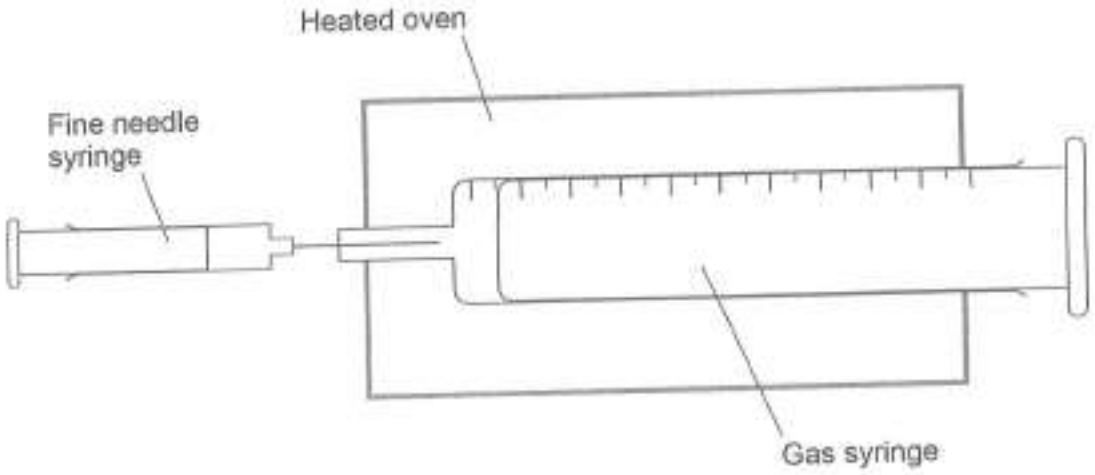

Table 3 shows the student's results.

Table 3

Mass of fine needle syringe and contents before injecting	11.295 g
Mass of fine needle syringe and contents after injecting	10.835 g
Volume reading on gas syringe before injecting	0.0 cm^3
Volume reading on gas syringe after injecting	178.0 cm^3
Pressure of gas in syringe	100 kPa
Temperature of oven	120 °C

Do not write outside the box

Calculate the M_r of **A**.

Give your answer to 3 significant figures.

The gas constant, $R = 8.31\ J\ K^{-1}\ mol^{-1}$

$pV = nRT$

[4 marks]

$n = pV/RT$ $\quad n = \dfrac{100{,}000 \times 1.78 \times 10^{-8}}{8.31 \times (273 + 120)}$

$= 5.45 \times 10^{-3}$ moles

$M_r = \dfrac{m}{n} = \dfrac{0.460}{5.45 \times 10^{-3}}$

$= 84.4$

M_r 84.4

0 8 . 2 The student noticed that some of the liquid injected into the gas syringe did **not** vaporise.

Explain the effect that this has on the M_r calculated by the student.

[2 marks]

The Calculated Mr would be higher than the actual as a lower volume would have been Recorded than Should have been

Question 8 continues on the next page

Do not write outside the box

Table 3 is repeated here.

Table 3

Mass of fine needle syringe and contents before injecting	11.295 g
Mass of fine needle syringe and contents after injecting	10.835 g
Volume reading on gas syringe before injecting	0.0 cm^3
Volume reading on gas syringe after injecting	178.0 cm^3
Pressure of gas in syringe	100 kPa
Temperature of oven	120 °C

0 8 . 3 Each reading on the balance used to record the mass of the fine needle syringe and contents had an uncertainty of ±0.001 g

Calculate the percentage uncertainty in the mass of liquid **A** injected in this experiment.

[1 mark]

$$\%\text{ uncertainty} = \frac{2 \times 0.001}{0.460} \times 100$$

$$= \pm 0.435\%$$

Percentage uncertainty 0.435 %

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Do not write outside the box

Section B

Answer **all** questions in this section.

Only **one** answer per question is allowed.
For each answer completely fill in the circle alongside the appropriate answer.

CORRECT METHOD ● WRONG METHODS ⊗ ⊘ ⊘ ⊘

If you want to change your answer you must cross out your original answer as shown. ⊠

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown. ⊗

You may do your working in the blank space around each question but this will not be marked. Do **not** use additional sheets for this working.

0 9 Which atom has the smallest number of neutrons?

[1 mark]

A ^{3}H ○

B ^{4}He ○

C ^{5}He ○

D ^{4}Li ●

1 0 Which species contains bonds that have different polarities?

[1 mark]

A NH_4^+ ○

B CCl_4 ○

C CH_3Cl ●

D H_3O^+ ○

Do not write outside the box

1 1 Which compound has hydrogen bonding?

[1 mark]

A NaH

B NH_3

C HI

D SiH_4

1 2 Which reaction has an enthalpy change equal to the standard enthalpy of formation of lithium fluoride?

[1 mark]

A $Li(g) + \frac{1}{2}F_2(g) \rightarrow LiF(s)$

B $Li^+(g) + F^-(g) \rightarrow LiF(s)$

C $Li^+(aq) + F^-(aq) \rightarrow LiF(s)$

D $Li(s) + \frac{1}{2}F_2(g) \rightarrow LiF(s)$

1 3 NO_2^- ions can be reduced in acidic solution to NO
How many electrons are gained when each NO_2^- ion is reduced?

[1 mark]

A 1

B 2

C 3

D 4

Do not write outside the box

1 4 Which is the electron configuration of an atom with **only two** unpaired electrons?

[1 mark]

A $1s^2 2s^2 2p^3$ ○

B $1s^2 2s^2 2p^4$ ●

C $1s^2 2s^2 2p^6 3s^2 3p^5$ ○

D $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$ ○

1 5 Which represents the correct order of increasing radius of the ions?

[1 mark]

A F^- O^{2-} Li^+ Be^{2+} ○

B Li^+ Be^{2+} O^{2-} F^- ○

C Be^{2+} Li^+ F^- O^{2-} ●

D O^{2-} F^- Li^+ Be^{2+} ○

1 6 Which compound contains a co-ordinate bond?

[1 mark]

A HF ○

B NH_3 ○

C $CHCl_3$ ○

D NH_4Cl ●

Do not write outside the box

1 7 Which property increases down Group 7?

[1 mark]

A ability to oxidise a given reducing agent

B boiling point

C electronegativity

D first ionisation energy

1 8 Which of these elements has the highest melting point?

[1 mark]

A Argon

B Chlorine

C Silicon

D Sulfur

1 9 Which statement is **not** always correct for a reaction at equilibrium?

$$\text{reactants} \rightleftharpoons \text{products}$$

[1 mark]

A The concentrations of the reactants and products are equal.

B The equilibrium can be achieved starting from the reactants.

C The equilibrium can be achieved starting from the products.

D The rate of the forward reaction is equal to the rate of the reverse reaction.

Do not write outside the box

2 0 Two reactions of iron with oxygen are shown.

$$Fe(s) + \frac{1}{2}O_2(g) \rightarrow FeO(s) \qquad \Delta H = -272 \text{ kJ mol}^{-1}$$

$$2Fe(s) + \frac{3}{2}O_2(g) \rightarrow Fe_2O_3(s) \qquad \Delta H = -822 \text{ kJ mol}^{-1}$$

What is the enthalpy change, in kJ mol^{-1}, for this reaction?

$$2FeO(s) + \frac{1}{2}O_2(g) \rightarrow Fe_2O_3(s)$$

[1 mark]

A +550

B –278

C –1094

D –1372

2 1 Which compound contains chlorine in an oxidation state of +1?

[1 mark]

A Cl_2O

B $KClO_3$

C ClF_3

D CCl_4

Turn over for the next question

Do not write outside the box

2 2 Which equation shows a redox reaction that does **not** occur?

[1 mark]

A $Br_2(aq) + 2KI(aq) \rightarrow I_2(aq) + 2KBr(aq)$ ○

B $Cl_2(g) + 2KI(aq) \rightarrow I_2(aq) + 2KCl(aq)$ ○

C $Cl_2(g) + 2KBr(aq) \rightarrow Br_2(aq) + 2KCl(aq)$ ○

D $I_2(aq) + 2KBr(aq) \rightarrow Br_2(aq) + 2KI(aq)$ ●

2 3 Which molecule has a permanent dipole?

[1 mark]

A CF_4 ○

B PCl_5 ○

C CO_2 ○

D Cl_2O ●

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END OF QUESTIONS