Cherry Hill Tuition AQA Chemistry AS. Paper 7

1 The element rubidium exists as the isotopes ^{85}Rb and ^{87}Rb

1 (a) State the number of protons and the number of neutrons in an atom of the isotope ^{85}Rb

Number of protons .....

Number of neutrons .....

(2 marks)

1 (b) (i) Explain how the gaseous atoms of rubidium are ionised in a mass spectrometer.

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(2 marks)

1 (b) (ii) Write an equation, including state symbols, to show the process that occurs when the **first** ionisation energy of rubidium is measured.

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(1 mark)

1 (c) The table shows the first ionisation energies of rubidium and some other elements in the same group.

Element	sodium	potassium	rubidium
First ionisation energy / kJ mol^{-1}	494	418	402

State **one** reason why the first ionisation energy of rubidium is lower than the first ionisation energy of sodium.

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(1 mark)

1 (d) (i) State the block of elements in the Periodic Table that contains rubidium.

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(1 mark)

1 (d) (ii) Deduce the full electron configuration of a rubidium atom.

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(1 mark)

1 (e) A sample of rubidium contains the isotopes ^{85}Rb and ^{87}Rb only.
The isotope ^{85}Rb has an abundance 2.5 times greater than that of ^{87}Rb

Calculate the relative atomic mass of rubidium in this sample.
Give your answer to one decimal place.

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(3 marks)

1 (f) By reference to the relevant part of the mass spectrometer, explain how the abundance of an isotope in a sample of rubidium is determined.

Name of relevant part .....

Explanation .....

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(2 marks)

1 (g) Predict whether an atom of ^{88}Sr will have an atomic radius that is larger than, smaller than or the same as the atomic radius of ^{87}Rb. Explain your answer.

Atomic radius of ^{88}Sr compared to ^{87}Rb .....

Explanation .....

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(3 marks)

2)

The following equation shows the reaction of a phosphine molecule (PH_3) with an H^+ ion.

$$PH_3 + H^+ \longrightarrow PH_4^+$$

(a) Draw the shape of the PH_3 molecule. Include any lone pairs of electrons that influence the shape.

(1 mark)

(b) State the type of bond that is formed between the PH_3 molecule and the H^+ ion.
Explain how this bond is formed.

Name of bond .....

How bond is formed .....

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(2 marks)

(c) Predict the bond angle in the PH_4^+ ion.

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(1 mark)

(d) Although phosphine molecules contain hydrogen atoms, there is no hydrogen bonding between phosphine molecules.
Suggest an explanation for this.

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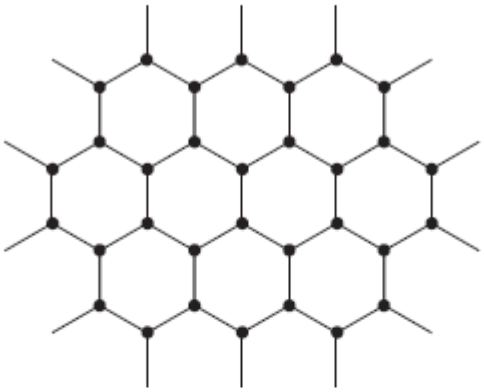
(1 mark)

3(a) Graphene is a new material made from carbon atoms. It is the thinnest and strongest material known. Graphene has a very high melting point and is an excellent conductor of electricity.
Part of the structure of graphene is illustrated in the diagram.



(a) (i) Deduce the type of crystal structure shown by graphene.

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(1 mark)

(a) (ii) Suggest why graphene is an excellent conductor of electricity.

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(2 marks)

(a) (iii) Explain, in terms of its structure and bonding, why graphene has a high melting point.

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(b) Titanium is also a strong material that has a high melting point. It has a structure similar to that of magnesium.

(b) (i) State the type of crystal structure shown by titanium.

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(1 mark)

(b) (ii) Explain, in terms of its structure and bonding, why titanium has a high melting point.

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(2 marks)

(c) Titanium can be hammered into objects with different shapes that have similar strengths.

(c) (i) Suggest why titanium can be hammered into different shapes.

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(1 mark)

(c) (ii) Suggest why these objects with different shapes have similar strengths.

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(1 mark)

(d) Magnesium oxide (MgO) has a melting point of 3125 K.
Predict the type of crystal structure in magnesium oxide and suggest why its melting point is high.

Type of crystal structure .....

Explanation .....

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(3 marks)

4 (a) Boron trichloride (BCl_3) can be prepared as shown by the following equation.

$$B_2O_3(s) + 3C(s) + 3Cl_2(g) \longrightarrow 2BCl_3(g) + 3CO(g)$$

A sample of boron oxide (B_2O_3) was reacted completely with carbon and chlorine.
The two gases produced occupied a total volume of 5000 cm^3 at a pressure of 100 kPa and a temperature of 298 K.

Calculate the mass of boron oxide that reacted.
Give your answer to 3 significant figures.

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

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(5 marks)

(Extra space) .....

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(b) Boron trichloride can also be prepared from its elements.

Write an equation for this reaction.
Explain why boron trichloride has a trigonal planar shape with equal bond angles.

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(3 marks)

(Extra space) .....

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(c) (i) Boron trichloride is easily hydrolysed to form two different acids as shown in the following equation.

$$BCl_3(g) + 3H_2O(l) \longrightarrow H_3BO_3(aq) + 3HCl(aq)$$

Calculate the concentration, in mol dm^{-3}, of hydrochloric acid produced when 43.2 g of boron trichloride are added to water to form 500 cm^3 of solution.
Give your answer to 3 significant figures.

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(4 marks)

(Extra space) .....

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(c) (ii) Boric acid (H_3BO_3) can react with sodium hydroxide to form sodium borate and water.
Write an equation for this reaction.

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(1 mark)

(d) Boron trichloride can be reduced by using hydrogen to form pure boron.

$$BCl_3(g) + 1\tfrac{1}{2}H_2(g) \longrightarrow B(s) + 3HCl(g)$$

Calculate the percentage atom economy for the formation of boron in this reaction.

Apart from changing the reaction conditions, suggest **one** way a company producing pure boron could increase its profits from this reaction.

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(3 marks)

(Extra space) .....

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(e) A different compound of boron and chlorine has a relative molecular mass of 163.6 and contains 13.2% of boron by mass.

Calculate the molecular formula of this compound.
Show your working.

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(4 marks)

(Extra space) .....

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Hydrazine (N_2H_4) decomposes in an exothermic reaction. Hydrazine also reacts exothermically with hydrogen peroxide when used as a rocket fuel.

5 (a) Write an equation for the decomposition of hydrazine into ammonia and nitrogen only.

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(1 mark)

(b) State the meaning of the term *mean bond enthalpy*.

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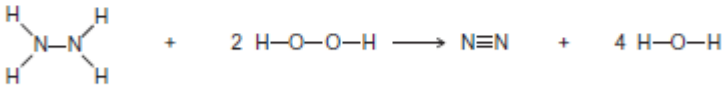
(2 marks)

(c) Some mean bond enthalpies are given in the table.

	N—H	N—N	N≡N	O—H	O—O
Mean bond enthalpy / kJ mol^{-1}	388	163	944	463	146

Use these data to calculate the enthalpy change for the gas-phase reaction between hydrazine and hydrogen peroxide.



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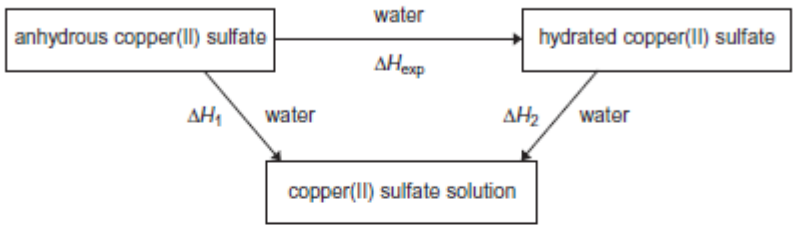
(3 marks)

6 A student used Hess's Law to determine a value for the enthalpy change that occurs when anhydrous copper(II) sulfate is hydrated.
This enthalpy change was labelled ΔH_{exp} by the student in a scheme of reactions.



(a) State Hess's Law.

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(1 mark)

(b) Write a mathematical expression to show how ΔH_{exp}, ΔH_1 and ΔH_2 are related to each other by Hess's Law.

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(1 mark)

(d) The student added 0.0210 mol of pure anhydrous copper(II) sulfate to 25.0 cm^3 of deionised water in an open polystyrene cup. An exothermic reaction occurred and the temperature of the water increased by 14.0 °C.

(d) (i) Use these data to calculate the enthalpy change, in $kJ\,mol^{-1}$, for this reaction of copper(II) sulfate. This is the student value for ΔH_1

In this experiment, you should assume that all of the heat released is used to raise the temperature of the 25.0 g of water. The specific heat capacity of water is $4.18\,J\,K^{-1}\,g^{-1}$.

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(3 marks)

(d) (ii) Suggest **one** reason why the student value for ΔH_1 calculated in part **(d) (i)** is less accurate than the data book value given in part **(c)**.

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(1 mark)

(e) Suggest **one** reason why the value for ΔH_{exp} **cannot** be measured directly.

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(1 mark)

(Extra space) .....

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