1 Fluorine forms many compounds that contain covalent bonds.

1 (a) (i) State the meaning of the term *covalent bond*.

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(1 mark)

1 (a) (ii) Write an equation to show the formation of one molecule of ClF_3 from chlorine and fluorine molecules.

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(1 mark)

1 (b) Draw the shape of a dichlorodifluoromethane molecule (CCl_2F_2) and the shape of a chlorine trifluoride molecule (ClF_3). Include any lone pairs of electrons that influence the shape.

Shape of CCl_2F_2 Shape of ClF_3

(2 marks)

1 (c) Suggest the strongest type of intermolecular force between CCl_2F_2 molecules.

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(1 mark)

2 Ammonium sulfate reacts with sodium hydroxide to form ammonia, sodium sulfate and water as shown in the equation below.

$$(NH_4)_2SO_4(s) + 2NaOH(aq) \longrightarrow 2NH_3(g) + Na_2SO_4(aq) + 2H_2O(l)$$

2 (a) A 3.14 g sample of ammonium sulfate reacted completely with 39.30 cm^3 of a sodium hydroxide solution.

2 (a) (i) Calculate the amount, in moles, of $(NH_4)_2SO_4$ in 3.14 g of ammonium sulfate.

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(2 marks)

2 (a) (ii) Hence calculate the amount, in moles, of sodium hydroxide which reacted.

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(1 mark)

2 (a) (iii) Calculate the concentration, in mol dm^{-3}, of the sodium hydroxide solution used.

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(1 mark)

2 (b) Calculate the percentage atom economy for the production of ammonia in the reaction between ammonium sulfate and sodium hydroxide.

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(2 marks)

2 (c) Ammonia is manufactured by the Haber Process.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

Calculate the percentage atom economy for the production of ammonia in this process.

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(1 mark)

2 (d) A sample of ammonia gas occupied a volume of 1.53×10^{-2} m^3 at 37 °C and a pressure of 100 kPa.
(The gas constant $R = 8.31\,J\,K^{-1}\,mol^{-1}$)

Calculate the amount, in moles, of ammonia in this sample.

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(3 marks)

(Extra space) .....

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2 (e) Glauber's salt is a form of hydrated sodium sulfate that contains 44.1% by mass of sodium sulfate. Hydrated sodium sulfate can be represented by the formula $Na_2SO_4.xH_2O$ where x is an integer. Calculate the value of x.

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3 In this question give all your answers to three significant figures.

Magnesium nitrate decomposes on heating to form magnesium oxide, nitrogen dioxide and oxygen as shown in the following equation.

$$2Mg(NO_3)_2(s) \longrightarrow 2MgO(s) + 4NO_2(g) + O_2(g)$$

3 (a) Thermal decomposition of a sample of magnesium nitrate produced 0.741 g of magnesium oxide.

3 (a) (i) Calculate the amount, in moles, of MgO in 0.741 g of magnesium oxide.

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(2 marks)

3 (a) (ii) Calculate the total amount, in moles, of gas produced from this sample of magnesium nitrate.

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(1 mark)

3 (b) In another experiment, a different sample of magnesium nitrate decomposed to produce 0.402 mol of gas. Calculate the volume, in dm^3, that this gas would occupy at 333 K and 1.00×10^5 Pa.
(The gas constant $R = 8.31\,J\,K^{-1}\,mol^{-1}$)

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(3 marks)

(Extra space) .....

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3 (c) A 0.0152 mol sample of magnesium oxide, produced from the decomposition of magnesium nitrate, was reacted with hydrochloric acid.

$$MgO + 2HCl \longrightarrow MgCl_2 + H_2O$$

3 (c) (i) Calculate the amount, in moles, of HCl needed to react completely with the 0.0152 mol sample of magnesium oxide.

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(1 mark)

3 (c) (ii) This 0.0152 mol sample of magnesium oxide required 32.4 cm^3 of hydrochloric acid for complete reaction. Use this information and your answer to part **(c) (i)** to calculate the concentration, in mol dm^{-3}, of the hydrochloric acid.

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(1 mark)

4 There are several oxides of nitrogen.

4 (a) An oxide of nitrogen contains 25.9% by mass of nitrogen. Determine the empirical formula of this oxide.

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(3 marks)

(Extra space) .....

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4 (b) Give **one** reason why the oxide NO is a pollutant gas.

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(1 mark)

4 (c) The oxide NO reacts with oxygen to form nitrogen dioxide. Write an equation for this reaction.

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(1 mark)

4 (d) Explain how NO is produced in the engine of a motor vehicle.

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4 (e) Write an equation to show how NO is removed from the exhaust gases in motor vehicles using a catalytic converter.

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(1 mark)

5) N/A
6) N/A

7 Iodine and graphite are both solids. When iodine is heated gently a purple vapour is seen. Graphite will not melt until the temperature reaches 4000 K. Graphite conducts electricity but iodine is a very poor conductor of electricity.

7 (a) State the type of crystal structure for each of iodine and graphite.

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(2 marks)

7 (b) Describe the structure of and bonding in graphite and explain why the melting point of graphite is very high.

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(4 marks)

(Extra space) .....

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7 (c) Explain why iodine vaporises when heated gently.

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(2 marks)

7 (d) State why iodine is a very poor conductor of electricity.

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(1 mark)

8 (a) Define the term *mass number* of an atom.

The mass number of an isotope of nitrogen is 15. Deduce the number of each of the fundamental particles in an atom of ^{15}N

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(3 marks)

(Extra space) .....

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8 (b) Define the term *relative atomic mass*.

An organic fertiliser was analysed using a mass spectrometer. The spectrum showed that the nitrogen in the fertiliser was made up of 95.12% ^{14}N and 4.88% ^{15}N

Calculate the relative atomic mass of the nitrogen found in this organic fertiliser.
Give your answer to two decimal places.

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(4 marks)

(Extra space) .....

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8 (c) In a mass spectrometer, under the same conditions, $^{14}N^+$ and $^{15}N^+$ ions follow different paths. State the property of these ions that causes them to follow different paths.

State **one** change in the operation of the mass spectrometer that will change the path of an ion.

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(2 marks)

8 (d) Organic fertilisers contain a higher proportion of ^{15}N atoms than are found in synthetic fertilisers.

State and explain whether or not you would expect the chemical reactions of the nitrogen compounds in the synthetic fertiliser to be different from those in the organic fertiliser. Assume that the nitrogen compounds in each fertiliser are the same.

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(2 marks)