1 Mass spectrometry can be used to identify isotopes of elements.

1 (a) (i) In terms of fundamental particles, state the difference between isotopes of an element.

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(1 mark)

1 (a) (ii) State why isotopes of an element have the same chemical properties.

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(1 mark)

1 (b) Give the meaning of the term *relative atomic mass.*

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(2 marks)

(Extra space).....

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1 (c) The mass spectrum of element **X** has four peaks. The table below gives the relative abundance of each isotope in a sample of element **X**.

m/z	64	66	67	68
Relative abundance	12	8	1	6

1 (c) (i) Calculate the relative atomic mass of element **X**.
Give your answer to one decimal place.

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(3 marks)

1 (c) (ii) Use the Periodic Table to identify the species responsible for the peak at *m/z* = 64

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(2 marks)

1 (d) Suggest **one** reason why particles with the same mass and velocity can be deflected by different amounts in the same magnetic field.

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(1 mark)

2 Norgessaltpeter was the first nitrogen fertiliser to be manufactured in Norway.
It has the formula $Ca(NO_3)_2$

2 (a) Norgessaltpeter can be made by the reaction of calcium carbonate with dilute nitric acid as shown by the following equation.

$$CaCO_3(s) + 2HNO_3(aq) \longrightarrow Ca(NO_3)_2(aq) + CO_2(g) + H_2O(l)$$

In an experiment, an excess of powdered calcium carbonate was added to 36.2 cm^3 of 0.586 mol dm^{-3} nitric acid.

2 (a) (i) Calculate the amount, in moles, of HNO_3 in 36.2 cm^3 of 0.586 mol dm^{-3} nitric acid.
Give your answer to 3 significant figures.

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(1 mark)

2 (a) (ii) Calculate the amount, in moles, of $CaCO_3$ that reacted with the nitric acid.
Give your answer to 3 significant figures.

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(1 mark)

2 (a) (iii) Calculate the minimum mass of powdered $CaCO_3$ that should be added to react with all of the nitric acid.
Give your answer to 3 significant figures.

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(2 marks)

2 (a) (iv) State the type of reaction that occurs when calcium carbonate reacts with nitric acid.

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(1 mark)

2 (b) Norgessaltpeter decomposes on heating as shown by the following equation.

$$2Ca(NO_3)_2(s) \longrightarrow 2CaO(s) + 4NO_2(g) + O_2(g)$$

A sample of Norgessaltpeter was decomposed completely.

The gases produced occupied a volume of $3.50 \times 10^{-3}\,m^3$ at a pressure of 100 kPa and a temperature of 31 °C.
(The gas constant $R = 8.31\,J\,K^{-1}\,mol^{-1}$)

2 (b) (i) Calculate the total amount, in moles, of gases produced.

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(3 marks)

2 (b) (ii) Hence calculate the amount, in moles, of oxygen produced.

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(1 mark)

2 (c) Hydrated calcium nitrate can be represented by the formula $Ca(NO_3)_2.xH_2O$ where x is an integer.

A 6.04 g sample of $Ca(NO_3)_2.xH_2O$ contains 1.84 g of water of crystallisation.

Use this information to calculate a value for x.
Show your working.

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(3 marks)

3 Fluorine and iodine are elements in Group 7 of the Periodic Table.

3 (a) Explain why iodine has a higher melting point than fluorine.

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(2 marks)

(Extra space).....

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3 (b) (i) Draw the shape of the NHF_2 molecule and the shape of the BF_3 molecule.
Include any lone pairs of electrons that influence the shape.
In each case name the shape.

Shape of NHF_2 Shape of BF_3

Name of shape of NHF_2 .....

Name of shape of BF_3 .....

(4 marks)

3 (b) (ii) Suggest a value for the F—N—F bond angle in NHF_2

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(1 mark)

3 (c) State the strongest type of intermolecular force in a sample of NHF_2

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(1 mark)

3 (d) A molecule of NHF_2 reacts with a molecule of BF_3 as shown in the following equation.

$$NHF_2 + BF_3 \longrightarrow F_2HNBF_3$$

State the type of bond formed between the N atom and the B atom in F_2HNBF_3
Explain how this bond is formed.

Name of type of bond .....

How bond is formed .....

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(2 marks)

4 There are several types of crystal structure and bonding shown by elements and compounds.

4 (a) (i) Name the type of bonding in the element sodium.

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(1 mark)

4 (a) (ii) Use your knowledge of structure and bonding to draw a diagram that shows how the particles are arranged in a crystal of sodium.
You should identify the particles and show a minimum of six particles in a two-dimensional diagram.

(2 marks)

4 (b) Sodium reacts with chlorine to form sodium chloride.

4 (b) (i) Name the type of bonding in sodium chloride.

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(1 mark)

4 (b) (ii) Explain why the melting point of sodium chloride is high.

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(2 marks)

(Extra space) .....

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4 (c) The table below shows the melting points of some sodium halides.

	NaCl	NaBr	NaI
Melting point / K	1074	1020	920

Suggest why the melting point of sodium iodide is lower than the melting point of sodium bromide.

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(1 mark)

5 This question is about the first ionisation energies of some elements in the Periodic Table.

5 (a) Write an equation, including state symbols, to show the reaction that occurs when the first ionisation energy of lithium is measured.

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(1 mark)

Methanol (CH_3OH) is an important fuel that can be synthesised from carbon dioxide.

6 (a) The table shows some standard enthalpies of formation.

	$CO_2(g)$	$H_2(g)$	$CH_3OH(g)$	$H_2O(g)$
$\Delta H_f^{\ominus}$ / kJ mol^{-1}	– 394	0	– 201	– 242

(a) (i) Use these standard enthalpies of formation to calculate a value for the standard enthalpy change of this synthesis.

$$CO_2(g) + 3H_2(g) \rightleftharpoons CH_3OH(g) + H_2O(g)$$

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(3 marks)

(Extra space) .....

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(a) (ii) State why the standard enthalpy of formation for hydrogen gas is zero.

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(1 mark)

(b) State and explain what happens to the yield of methanol when the total pressure is increased in this synthesis.

$$CO_2(g) + 3H_2(g) \rightleftharpoons CH_3OH(g) + H_2O(g)$$

Effect on yield .....

Explanation .....

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(3 marks)

(Extra space) .....

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(c) The hydrogen required for this synthesis is formed from methane and steam in a reversible reaction. The equation for this reaction is shown below.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H = +206\,kJ\,mol^{-1}$$

State and explain what happens to the yield of hydrogen in this reaction when the temperature is increased.

Effect on yield .....

Explanation .....

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(3 marks)