

**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.

<i>m/z</i>	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.

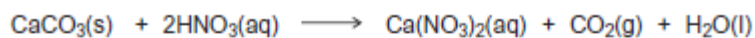
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(1 mark)

**2** Norgessalpeter was the first nitrogen fertiliser to be manufactured in Norway. It has the formula  $\text{Ca}(\text{NO}_3)_2$

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



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

**2 (a) (i)** Calculate the amount, in moles, of  $\text{HNO}_3$  in  $36.2 \text{ cm}^3$  of  $0.586 \text{ mol dm}^{-3}$  nitric acid. Give your answer to 3 significant figures.

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 (1 mark)

**2 (a) (ii)** Calculate the amount, in moles, of  $\text{CaCO}_3$  that reacted with the nitric acid. Give your answer to 3 significant figures.

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 (1 mark)

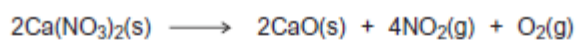
**2 (a) (iii)** Calculate the minimum mass of powdered  $\text{CaCO}_3$  that should be added to react with all of the nitric acid. Give your answer to 3 significant figures.

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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) Norgessalt peter decomposes on heating as shown by the following equation.



A sample of Norgessalt peter was decomposed completely.

The gases produced occupied a volume of  $3.50 \times 10^{-3} \text{ m}^3$  at a pressure of 100 kPa and a temperature of 31 °C.

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

- 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  $\text{Ca}(\text{NO}_3)_2 \cdot x\text{H}_2\text{O}$  where  $x$  is an integer.

A 6.04 g sample of  $\text{Ca}(\text{NO}_3)_2 \cdot x\text{H}_2\text{O}$  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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 (Extra space)..... (2 marks)  
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3 (b) (i) Draw the shape of the  $\text{NHF}_2$  molecule and the shape of the  $\text{BF}_3$  molecule. Include any lone pairs of electrons that influence the shape. In each case name the shape.

Shape of  $\text{NHF}_2$

Shape of  $\text{BF}_3$

Name of shape of  $\text{NHF}_2$  .....  
 Name of shape of  $\text{BF}_3$  ..... (4 marks)

3 (b) (ii) Suggest a value for the F—N—F bond angle in  $\text{NHF}_2$

..... (1 mark)

3 (c) State the strongest type of intermolecular force in a sample of  $\text{NHF}_2$

..... (1 mark)

3 (d) A molecule of  $\text{NHF}_2$  reacts with a molecule of  $\text{BF}_3$  as shown in the following equation.



State the type of bond formed between the N atom and the B atom in  $\text{F}_2\text{HNBF}_3$ . 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)

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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<sub>3</sub>OH) is an important fuel that can be synthesised from carbon dioxide.

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

	CO <sub>2</sub> (g)	H <sub>2</sub> (g)	CH <sub>3</sub> OH(g)	H <sub>2</sub> O(g)
$\Delta H_f^\ominus / \text{kJ mol}^{-1}$	- 394	0	- 201	- 242

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



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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.



Effect on yield .....

Explanation .....

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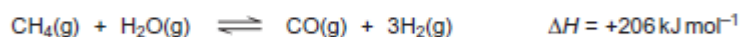
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(3 marks)

(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.



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)