

OCR A-Level Chemistry A

# Atomic structure and isotopes

Questions only

All 6 atomic structure and isotopes questions

Questions

**6**

Total marks

**28**

Time allowed

**38 min**

Name

Class or teacher

Date

## Instructions

- Answer all questions in the spaces provided.
- Use black ink. Show your working for every calculation.
- You may use a scientific calculator and the OCR Data Sheet.
- Print the separate mark scheme when you are ready to mark your answers.

## For marking

| Q | Source      | Marks | Score |
|---|-------------|-------|-------|
| 1 | 2017 P1 Q1  | 1     |       |
| 2 | 2018 P1 Q1  | 1     |       |
| 3 | 2022 P3 Q1  | 16    |       |
| 4 | 2025 P1 Q1  | 1     |       |
| 5 | 2025 P2 Q11 | 1     |       |
| 6 | 2025 P3 Q1  | 8     |       |

**Total** \_\_\_\_\_ / 28      **Percentage** \_\_\_\_\_ %

Questions from OCR past papers, 2017–2025, reproduced for revision. Practise these topics online, with instant marking:

[whiteboardchemistry.com/revision/exam-questions/ocr-a-level-chemistry/?topics=atoms-and-isotopes&len=0](https://whiteboardchemistry.com/revision/exam-questions/ocr-a-level-chemistry/?topics=atoms-and-isotopes&len=0)

## Questions

Atomic structure and isotopes · 6 questions · 28 marks · time allowed 38 min

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**Q1 · June 2017 · Paper 1 (Periodic table, elements and physical chemistry) · Q1 · [1 mark]**

Which atom is not an isotope of iodine?

*Tick (✓) one box.*

- ☐ **A** Number of neutrons: 72 · Mass number: 125
  - ☐ **B** Number of neutrons: 74 · Mass number: 127
  - ☐ **C** Number of neutrons: 75 · Mass number: 128
  - ☐ **D** Number of neutrons: 77 · Mass number: 129
- 

**Q2 · June 2018 · Paper 1 (Periodic table, elements and physical chemistry) · Q1 · [1 mark]**

A sample of boron contains the isotopes  $^{10}\text{B}$  and  $^{11}\text{B}$ .

The relative atomic mass of the boron sample is 10.8.

What is the percentage of  $^{11}\text{B}$  atoms in the sample of boron?

*Tick (✓) one box.*

- ☐ **A** 8.0%
  - ☐ **B** 20%
  - ☐ **C** 80%
  - ☐ **D** 92%
- 

**Q3 · June 2022 · Paper 3 (Unified chemistry) · Q1 · [16 marks]**

This question also needs Electrons, bonding and structure, NMR spectroscopy and Transition elements.

These questions are from different areas of chemistry.

Ammonia,  $\text{NH}_3$ , and ammonium nitrate,  $\text{NH}_4\text{NO}_3$ , are compounds of nitrogen.

**1(a)(i)** The boiling point of  $\text{NH}_3$  is  $-33\text{ }^\circ\text{C}$ .

The boiling point of  $\text{NH}_4\text{NO}_3$  is  $210\text{ }^\circ\text{C}$ .

Explain why there is a large difference in boiling points.

[2 marks]

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**1(a)(ii)** Two students discuss the oxidation numbers in ammonium nitrate,  $\text{NH}_4\text{NO}_3$ .

One student claims that the two nitrogen atoms have the same oxidation number. The other student disagrees and claims that the nitrogen atoms have different oxidation numbers.

Explain with reasons which student is correct.

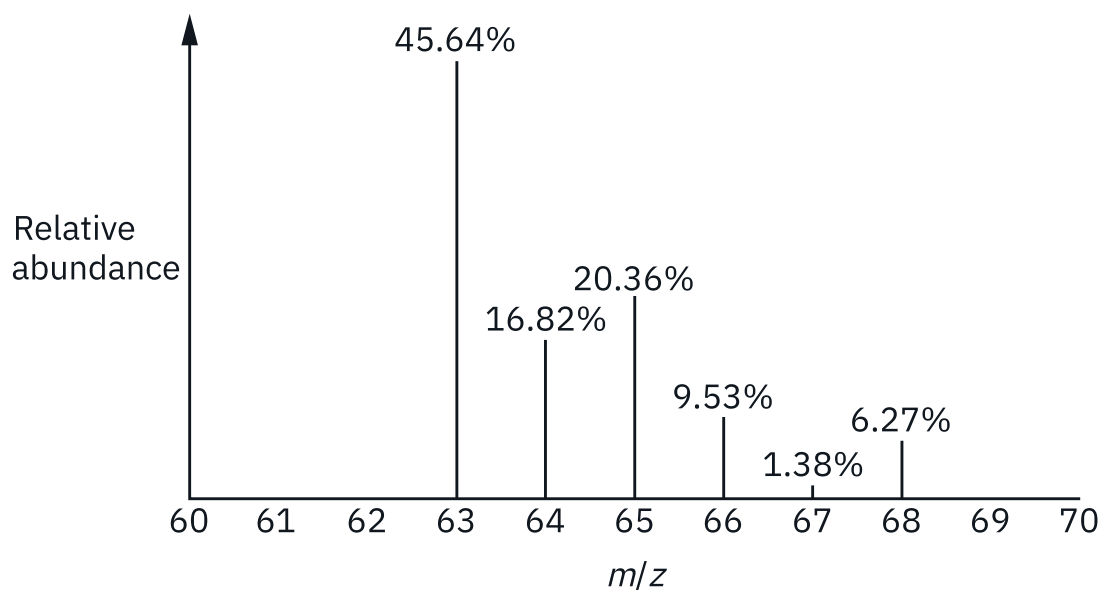
[1 mark]

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Brass is an alloy of copper and zinc.

The mass spectrum of a sample of brass is shown below.



The peaks at  $m/z = 63$  and  $m/z = 65$  are from the  $^{63}\text{Cu}$  and  $^{65}\text{Cu}$  isotopes of copper.

The remaining four peaks are from isotopes of zinc.

**1(b)(i)** What are the percentage compositions of copper and zinc in the brass sample?

Cu = % Zn = %

[1 mark]

**1(b)(ii)** Calculate the relative atomic mass of zinc in the sample of brass.

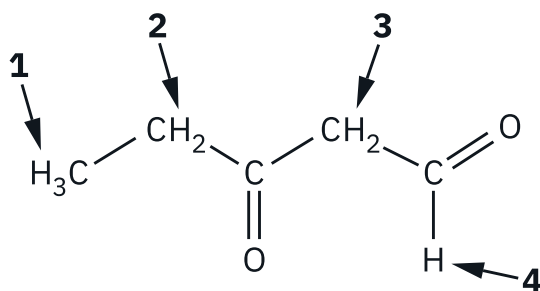
Give your answer to **2** decimal places.

relative atomic mass =

[2 marks]

The structure of an organic compound is shown below.

The protons are in four different environments, which are labelled **1–4**.



**1(c)(i)** Fill in the table to predict the splitting patterns in the **proton** NMR spectrum of the organic compound.

| Proton environment | Splitting pattern |
|--------------------|-------------------|
| 1                  |                   |
| 2                  |                   |
| 3                  |                   |
| 4                  |                   |

[2 marks]

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**1(c)(ii)** The table shows the chemical shifts for the peaks in the **proton** NMR spectrum at proton environments **2** and **3**.

|                          |         |         |
|--------------------------|---------|---------|
| Proton environment       | 2       | 3       |
| Chemical shift, $\delta$ | 2.5 ppm | 3.6 ppm |

Suggest why the peaks for proton environments **2** and **3** have the chemical shifts which are shown in the table.

[2 marks]

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Glycine,  $\text{H}_2\text{NCH}_2\text{COOH}$ , is an  $\alpha$ -amino acid.

**1(d)(i)** Glycine reacts with  $\text{NaOH}$  to form the salt  $\text{H}_2\text{NCH}_2\text{COONa}$ .

Glycine reacts with  $\text{HCl}$  to form the salt  $\text{HOOCCH}_2\text{NH}_3\text{Cl}$ .

The salts have different  $\text{H}-\text{N}-\text{H}$  bond angles.

State the different  $\text{H}-\text{N}-\text{H}$  bond angles and explain why they are different.

$\text{H}_2\text{NCH}_2\text{COONa}$   $\text{H}-\text{N}-\text{H}$  bond angle =  $^\circ$

$\text{HOOCCH}_2\text{NH}_3\text{Cl}$   $\text{H}-\text{N}-\text{H}$  bond angle =  $^\circ$

explanation

[3 marks]

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**1(d)(ii)** Glycine reacts with aqueous copper(II) ethanoate to form copper(II) glycinate,  $\text{Cu}(\text{H}_2\text{NCH}_2\text{COO})_2$ , and ethanoic acid. Copper(II) glycinate is a complex which exists as two square planar isomers.

Write an equation for this reaction and draw the structures of the two square planar isomers of the complex  $\text{Cu}(\text{H}_2\text{NCH}_2\text{COO})_2$ .

[3 marks]

equation

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structures

**Q4 · June 2025 · Paper 1 (Periodic table, elements and physical chemistry) · Q1 · [1 mark]**

The table shows the number of protons and neutrons in four different atoms.

| Atom | Number of protons | Number of neutrons |
|------|-------------------|--------------------|
| W    | 17                | 18                 |
| X    | 18                | 18                 |
| Y    | 19                | 18                 |
| Z    | 18                | 19                 |

Which two atoms are isotopes of the same element?

Tick (✓) one box.

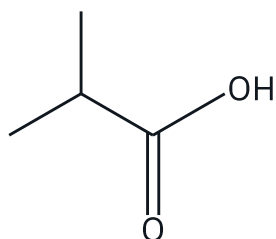
- ☐ **A** W and X
- ☐ **B** X and Y
- ☐ **C** X and Z
- ☐ **D** Y and Z

**Q5 · June 2025 · Paper 2 (Synthesis and analytical techniques) · Q11 · [1 mark]**

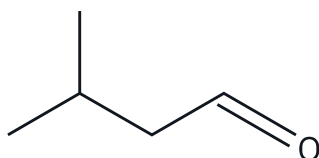
Which molecule does **not** produce a mass spectrum containing a peak at  $m/z = 29$ ?

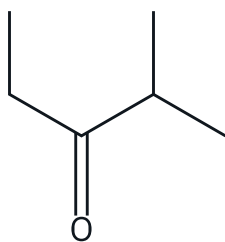
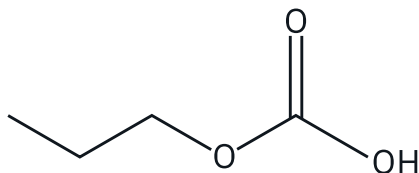
Tick (✓) one box.

☐ **A**



☐ **B**



☐ C☐ D**Q6 · June 2025 · Paper 3 (Unified chemistry) · Q1 · [8 marks]**

This question also needs NMR spectroscopy.

This question is about spectra.

The mass spectrum for Br<sub>2</sub> has peaks at m/z values of 79, 81, 158, 160 and 162.

The peaks at m/z 79 and 81 have virtually the same relative abundance.

**1(a)(i)** Complete the table to show the number of protons, neutrons and electrons in the particles that cause the peaks at m/z 79 and 81.

| m/z | Number of protons | Number of neutrons | Number of electrons |
|-----|-------------------|--------------------|---------------------|
| 79  |                   |                    |                     |
| 81  |                   |                    |                     |

[2 marks]

**1(a)(ii)** Explain why there are peaks with  $m/z$  values of 158, 160 and 162 and predict their relative abundances.

[3 marks]

Explanation

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Relative abundances

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**1(b)** This question looks at proton NMR spectra of dibromoalkanes.

Predict the following.

| Compound                                       | Number of peaks | $\text{CH}_2$ splitting pattern(s) |
|------------------------------------------------|-----------------|------------------------------------|
| $\text{BrCH}_2\text{CH}_2\text{Br}$            |                 |                                    |
| $\text{BrCH}_2\text{CH}_2\text{CH}_2\text{Br}$ |                 |                                    |

[3 marks]

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