

**Q1.** The manufacturer supplying concentrated ethanoic acid for the production of vinegar also supplied other acids. The label had come off a batch of one of these other acids. A sample of this unknown acid was analysed and found to contain 54.5% of carbon and 9.10% of hydrogen by mass, the remainder being oxygen.

- (a) Use these data to calculate the empirical formula of the unknown acid. Show your working.

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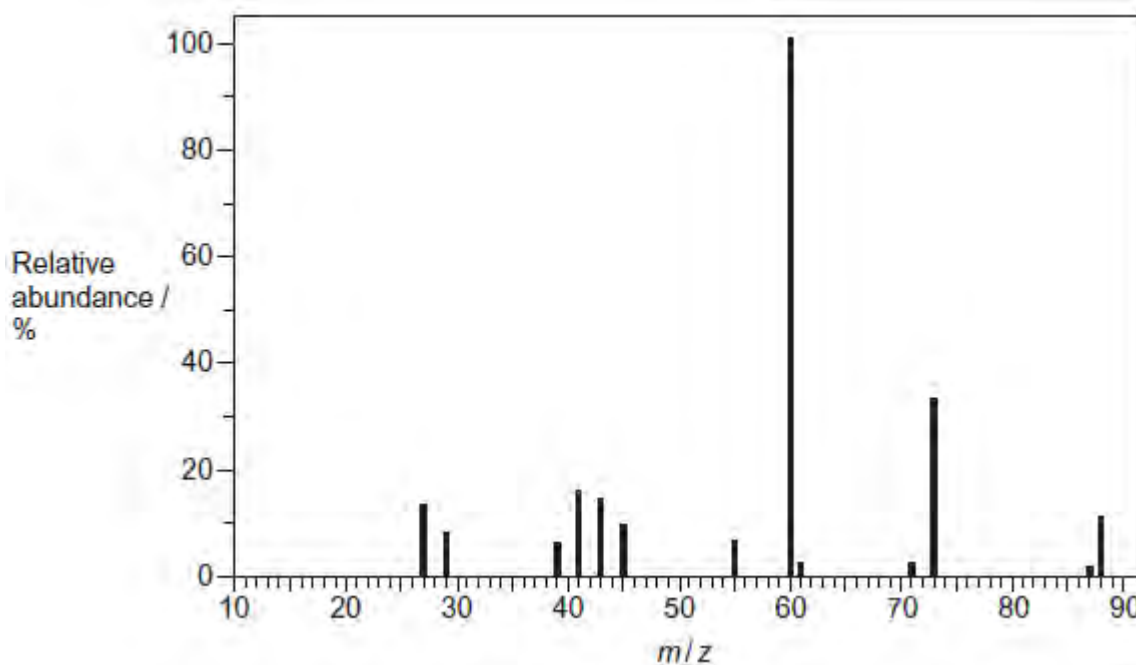
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(3)

- (b) A sample of the unknown acid was analysed in a mass spectrometer. The mass spectrum obtained is shown below.



Use the mass spectrum to determine the  $M_r$  of the unknown acid.

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(1)

- (c) Use your answers from parts (a) and (b) to determine the molecular formula of the

unknown acid.

(If you could not answer part (b), you should assume that the  $M_r$  of the acid is 132.0 but this is **not** the correct value.)

Show your working.

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(2)  
(Total 6 marks)

**Q2.** A mass spectrometer can be used to investigate the isotopes in an element.

(a) Define the term *relative atomic mass* of an element.

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(2)

(b) Element **X** has a relative atomic mass of 47.9

Identify the block in the Periodic Table to which element **X** belongs and give the electron configuration of an atom of element **X**.

Calculate the number of neutrons in the isotope of **X** which has a mass number 49

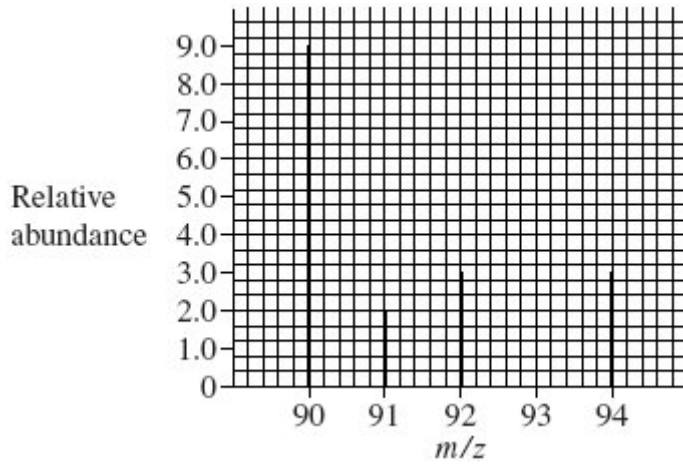
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(3)

(c) The mass spectrum of element **Z** is shown below.

Use this spectrum to calculate the relative atomic mass of **Z**, giving your answer to one decimal place.

Identify element **Z**.



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(4)

(d) State how vaporised atoms of **Z** are converted into **Z<sup>+</sup>** ions in a mass spectrometer.

State and explain which of the **Z<sup>+</sup>** ions formed from the isotopes of **Z** in part (c) will be deflected the most in a mass spectrometer.

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(4)

- (e) Explain briefly how the relative abundance of an ion is measured in a mass spectrometer.

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(2)  
(Total 15 marks)

**Q3.** In 1913 Niels Bohr proposed a model of the atom with a central nucleus, made up of protons and neutrons, around which electrons moved in orbits. After further research, the model was refined when the existence of energy levels and sub-levels was recognised.

- (a) Complete the following table for the particles in the nucleus.

Particle	Relative charge	Relative mass
proton		
neutron		

(2)

- (b) State the block in the Periodic Table to which the element tungsten, W, belongs.

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(1)

- (c) Isotopes of tungsten include  $^{182}\text{W}$  and  $^{186}\text{W}$

- (i) Deduce the number of protons in  $^{182}\text{W}$

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(1)

(ii) Deduce the number of neutrons in  $^{186}\text{W}$

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(1)

(d) In order to detect the isotopes of tungsten using a mass spectrometer, a sample containing the isotopes must be vaporised and then ionised.

(i) Give **two** reasons why the sample must be ionised.

1 .....

2 .....

(2)

(ii) State what can be adjusted in the mass spectrometer to enable ions formed by the different isotopes to be directed onto the detector.

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(1)

(e) State and explain the difference, if any, between the chemical properties of the isotopes  $^{182}\text{W}$  and  $^{186}\text{W}$

Difference .....

Explanation .....

.....

(2)

(f) The table below gives the relative abundance of each isotope in the mass spectrum of a sample of tungsten.

$m/z$	182	183	184	186
Relative abundance /%	26.4	14.3	30.7	28.6

Use the data above to calculate a value for the relative atomic mass of this sample of tungsten. Give your answer to 2 decimal places.

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(2)  
(Total 12 marks)

**Q4.** (a) Complete the following table.

	Relative mass	Relative charge
Proton		
Electron		

(2)

(b) An atom of element **Q** contains the same number of neutrons as are found in an atom of  $^{27}\text{A}1$ . An atom of **Q** also contains 14 protons.

(i) Give the number of protons in an atom of  $^{27}\text{A}1$ .

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(ii) Deduce the symbol, including mass number and atomic number, for this atom of element **Q**.

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(3)

(c) Define the term *relative atomic mass* of an element.

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(2)

(d) The table below gives the relative abundance of each isotope in a mass spectrum

of a sample of magnesium.

<i>m/z</i>	24	25	26
Relative abundance (%)	73.5	10.1	16.4

Use the data above to calculate the relative atomic mass of this sample of magnesium.

Give your answer to one decimal place.

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(2)

- (e) State how the relative molecular mass of a covalent compound is obtained from its mass spectrum.

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(1)

(Total 10 marks)

**Q5.** In one model of atomic structure, the atom has a nucleus surrounded by electrons in levels and sub-levels.

- (a) Define the term *atomic number*.

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(1)

- (b) Explain why atoms of an element may have different mass numbers.

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(1)

(c) The table below refers to a sample of krypton.

Relative $m/z$	82	83	84	86
Relative abundance / %	12	12	50	26

(i) Name an instrument which is used to measure the relative abundance of isotopes.

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(ii) Define the term *relative atomic mass*.

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(iii) Calculate the relative atomic mass of this sample of krypton.

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(5)

(d) Give the complete electronic configuration of krypton in terms of s, p and d sub-levels.

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(1)

(e) In 1963, krypton was found to react with fluorine. State why this discovery was unexpected.

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(1)

(f) Use a suitable model of atomic structure to explain the following experimental observations.

(i) The first ionisation energy of krypton is greater than that of bromine.



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(ii) The first ionisation energy of aluminium is less than the first ionisation energy of magnesium.

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**(4)**  
**(Total 13 marks)**