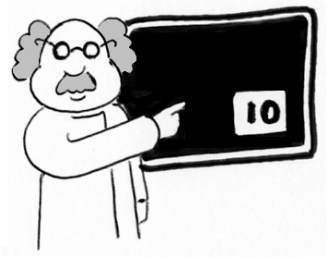


STARTER FOR 10...!

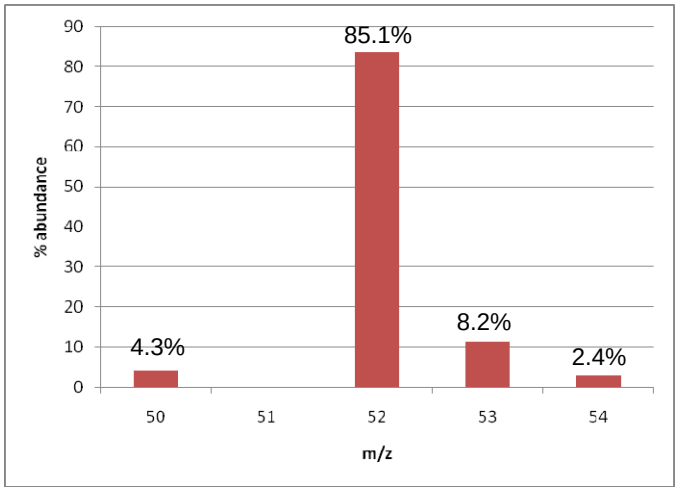
10.1.2. Isotopic abundance

1. The ratio of the different isotopes of certain elements can be used to identify objects from outer space. By comparing the isotope patterns with samples known to originate on earth the scientists can determine the origins of unknown objects.

The mass spectrum opposite is of a sample of chromium extracted from a rock recently found in the Nevada desert. Scientists believe it may be from a meteor.

Use the mass spectrum to determine the relative atomic mass of the chromium in the rock. Based on your result, suggest the origin of the rock sample.

(3 marks)



2. The data below gives the *m/z* ratio and relative abundance of different isotopes of an element X. Determine the relative atomic mass of the element X to 1 d.p.

Suggest an identity for X. (4 marks)

m/z	204	205	206	207	208
Abundance	2.7	0.0	46.0	42.2	100.0

3. The element magnesium (relative atomic mass 24.3) has three naturally occurring isotopes, ^{24}Mg, ^{25}Mg and ^{26}Mg. If the percentage of the heaviest isotope is 11.0%, what is the percentage of the lightest isotope present? (3 marks)

STARTER FOR 10...

10. Analysis answers

10.1. Mass spectrometry

10.1.1. The mass spectrometer

1.
1. vaporisation
2. ionisation
3. acceleration
4. deflection
5. detection (5 marks)

2.

Statement	Stage
The atoms are turned into ions	*2*
The ions are deflected. The size of the deflection depends upon the ratio of the ion's mass to its charge.	**4**
A current is generated the size of which is proportional to the abundance of each ion	**5**
$X(l) \rightarrow X(g)$	**1**
The positive ions are attracted towards negatively charged plates	**3**
$X(g) \rightarrow X^{+}(g)$	**2**

(5 marks)

10.1.2. Isotopic abundance

1. $\dfrac{(4.3\% \times 50) + (85.1\% \times 52) + (8.2\% \times 53) + (2.4\% \times 54)}{100\ \%} = \mathbf{52.0}$ (2 marks)

As this is the relative atomic mass of chromium found on earth, this strongly suggests that the rock sample is indeed **from earth** and not a meteor. (1 mark)

2. $\dfrac{(2.7 \times 204) + (46.0 \times 206) + (42.2 \times 207) + (100 \times 208)}{(2.7 + 46.0 + 42.2 + 100.0)} = \mathbf{207.2}$ (2 marks)

(1 d.p. 1 mark)

Based on its atomic mass, X is likely to be **Pb, lead** (1 mark)

3. If there is 11% of the heaviest isotope present we can say that the percentage of the lightest isotope present is 'y' and therefore the percentage of the remaining isotope present must be;

$100\% - 11\% - y\% = 89\% - y$ (1 mark)

Therefore substituting these numbers into our equation;

$$\frac{(26 \times 11\%) + (24 \times y\%) + [25 \times (89 - y)\%]}{100\ \%} = 24.3$$

$286.0 + 24\,y\% + 2225 - 25\,y\% = 2430$

$2511 - y\% = 2430$ (1 mark)

81 = y% (1 mark)

Therefore the percentage of the lightest isotope present is **81%**

10.1.3. Molecular mass spectrometry

(1 mark for calculations, 1 mark for empirical formula, 1 mark for molecular formula of each unknown)

Unknown A

(1-aminopropane)

	C	H	N
Mass in 100 g	61.02	15.25	23.73
Moles in 100 g	5.09	15.25	1.70
Ratio	3	9	1

Empirical formula = $\mathbf{C_3H_9N}$

Molecular weight of empirical formula = 59 = M^+, therefore molecular formula = $\mathbf{C_3H_9N}$

Unknown B

(caffeine)

	C	H	N	O
Mass in 100 g	49.48	5.15	28.87	16.49
Moles in 100 g	4.12	5.15	2.06	1.03
Ratio	4	5	2	1

Empirical formula = $\mathbf{C_4H_5N_2O}$

Molecular weight of empirical formula = 97; M^+ = 194, therefore molecular formula = $\mathbf{C_8H_{10}N_4O_2}$

Unknown C

(1,4-dichlorobenzene)

	C	H	Cl
Mass in 100 g	49.02	2.74	48.23
Moles in 100 g	4.09	2.74	1.36
Ratio	3	2	1

Empirical formula = $\mathbf{C_3H_2Cl}$

Molecular weight of empirical formula = 73.5; M^+ = 146/148/150, therefore molecular formula = $\mathbf{C_6H_4Cl_2}$

BONUS MARK – The mass spectrum of unknown C appears to have three molecular ion peaks owing to the common isotopes of Cl, ^{35}Cl and ^{37}Cl which are found naturally in a 3:1 ratio. As the unknown contains two chlorine atoms, this results in three possible combinations of these isotopes in the molecule.

Chlorine Isotopes in unknown C	Molecular weight of molecule containing these isotopes	Probability
^{35}Cl : ^{35}Cl	146	3 × 3 = 9
^{35}Cl : ^{37}Cl	148	3 × 1 = 3
^{37}Cl : ^{35}Cl	148	1 × 3 = 3
^{37}Cl : ^{37}Cl	150	1 × 1 = 1

(3 + 3 = 6)