1. Time of flight (TOF) mass spectrometry is an important analytical technique.

A mixture of three compounds is analysed using a TOF mass spectrometer.
The mixture is ionised using electrospray ionisation.
The three compounds are known to have the molecular formulas:

$C_3H_5O_2N$
$C_3H_7O_3N$
$C_3H_7O_2NS$

(a) Describe how the molecules are ionised using electrospray ionisation.

___

___

___

___

___

___

___

___

(3)

(b) Give the formula of the ion that reaches the detector first in the TOF mass spectrometer.

___

(1)

(c) A sample of germanium is analysed in a TOF mass spectrometer using electron impact ionisation.

Give an equation, including state symbols, for the process that occurs during the ionisation of a germanium atom.

___

(1)

(d) In the TOF mass spectrometer, a germanium ion reaches the detector in 4.654×10^{-6} s

The kinetic energy of this ion is 2.438×10^{-15} J

The length of the flight tube is 96.00 cm

The kinetic energy of an ion is given by the equation $KE = \frac{1}{2}mv^2$

where

m = mass / kg

v = speed / m s^{-1}

The Avogadro constant $L = 6.022 \times 10^{23}$ mol^{-1}

Use this information to calculate the mass, in g, of one mole of these germanium ions.

Use your answer to state the mass number of this germanium ion.

Mass of one mole of germanium ions ____________________ g

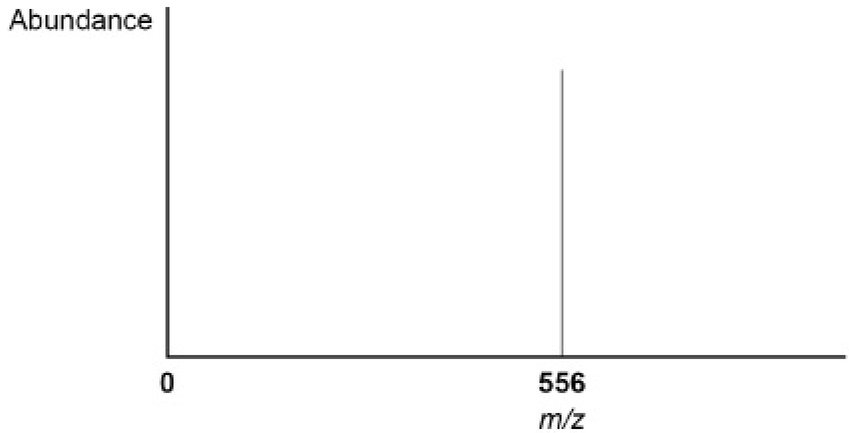
Mass number of ion ____________________

(5)

(Total 10 marks)

2. Time of flight (TOF) mass spectrometry can be used to analyse large molecules such as the pentapeptide, leucine encephalin (**P**).

P is ionised by electrospray ionisation and its mass spectrum is shown in the diagram.



(a) Describe the process of electrospray ionisation.

Give an equation to represent the ionisation of **P** in this process.

Description ____

____

____

____

____

____

____

____

____

Equation

____

(4)

(b) What is the relative molecular mass of **P**?
Tick (✓) **one** one box.

555 ☐ 556 ☐ 557 ☐

(1)

(c) A molecule **Q** is ionised by electron impact in a TOF mass spectrometer.
The Q^+ ion has a kinetic energy of 2.09×10^{-15} J
This ion takes 1.23×10^{-5}s to reach the detector.
The length of the flight tube is 1.50 m

Calculate the relative molecular mass of **Q**.

$KE = \frac{1}{2}mv^2$ where m = mass (kg) and v = speed (m s^{-1})
The Avogadro constant, $L = 6.022 \times 10^{23}$ mol^{-1}

Relative molecular mass ________________________________

(5)
(Total 10 marks)

3. A sample of bromine was analysed in a time of flight (TOF) mass spectrometer and found to contain two isotopes, ^{79}Br and ^{81}Br

After electron impact ionisation, all of the ions were accelerated to the same kinetic energy (KE) and then travelled through a flight tube that was 0.950 m long.

(a) The $^{79}Br^+$ ions took 6.69×10^{-4} s to travel through the flight tube.

Calculate the mass, in kg, of one ion of $^{79}Br^+$
Calculate the time taken for the $^{81}Br^+$ ions to travel through the same flight tube.

The Avogadro constant, $L = 6.022 \times 10^{23}$ mol^{-1}

$KE = \frac{1}{2}mv^2$ where m = mass (kg) and v = speed (m s^{-1})

$v = \frac{d}{t}$ where d = distance (m) and t = time (s)

Mass of one ion of $^{79}Br^+$ ____________________ kg

Time taken by $^{81}Br^+$ ions ____________________ s

(5)

(b) Explain how ions are detected and relative abundance is measured in a TOF mass spectrometer.

___

___

___

___

___

___

(2)

(Total 7 marks)

4. This question is about s-block metals.

(a) Give the full electron configuration for the calcium ion, Ca^{2+}

___

(1)

(b) Explain why the second ionisation energy of calcium is lower than the second ionisation energy of potassium.

___

___

___

___

___

(2)

(c) Identify the s-block metal that has the highest first ionisation energy.

___

(1)

(d) Give the formula of the hydroxide of the element in Group 2, from Mg to Ba, that is least soluble in water.

___

(1)

(e) A student added 6 cm^3 of 0.25 mol dm^{-3} barium chloride solution to 8 cm^3 of 0.15 mol dm^{-3} sodium sulfate solution.
The student filtered off the precipitate and collected the filtrate.

Give an ionic equation for the formation of the precipitate.
Show by calculation which reagent is in excess.
Calculate the total volume of the other reagent which should be used by the student so that the filtrate contains only one solute.

Ionic equation ___

Reagent in excess ___

Total volume of other reagent ___

___

___

___

___

(3)

(f) A sample of strontium has a relative atomic mass of 87.7 and consists of three isotopes, ^{86}Sr, ^{87}Sr and ^{88}Sr

In this sample, the ratio of abundances of the isotopes ^{86}Sr : ^{87}Sr is 1:1

State why the isotopes of strontium have identical chemical properties.

Calculate the percentage abundance of the ^{88}Sr isotope in this sample.

Why isotopes of strontium have identical chemical properties

____

____

____

Percentage abundance of ^{88}Sr ____________________ %

(4)

(g) A time of flight (TOF) mass spectrum was obtained for a sample of barium that contains the isotopes ^{136}Ba, ^{137}Ba and ^{138}Ba

The sample of barium was ionised by electron impact.

Identify the ion with the longest time of flight.

____

(1)

(h) A $^{137}Ba^{+}$ ion travels through the flight tube of a TOF mass spectrometer with a kinetic energy of 3.65×10^{-16} J
This ion takes 2.71×10^{-5} s to reach the detector.

$KE = \frac{1}{2}mv^2$ where m = mass (kg) and v = speed (m s^{-1})

The Avogadro constant, $L = 6.022 \times 10^{23}$ mol^{-1}

Calculate the length of the flight tube in metres.

Give your answer to the appropriate number of significant figures.

Length of flight tube ____________________ m

(5)

(Total 18 marks)

5. Which statement about time of flight mass spectrometry is correct?

A The current in the detector is proportional to the ion abundance ⬭

B Sample particles gain electrons to form positive ions ⬭

C Particles are detected in the order of their kinetic energies ⬭

D Ions are accelerated by a magnetic field ⬭

(Total 1 mark)

6. A sample of titanium was ionised by electron impact in a time of flight (TOF) mass spectrometer. Information from the mass spectrum about the isotopes of titanium in the sample is shown in the table.

m/z	46	47	48	49
Abundance / %	9.1	7.8	74.6	8.5

(a) Calculate the relative atomic mass of titanium in this sample.

Give your answer to one decimal place.

Relative atomic mass of titanium in this sample ____________________

(2)

(b) Write an equation, including state symbols, to show how an atom of titanium is ionised by electron impact and give the m/z value of the ion that would reach the detector first.

Equation ____

m/z value ____

(2)

(c) Calculate the mass, in kg, of one atom of ^{49}Ti

The Avogadro constant $L = 6.022 \times 10^{23}\ mol^{-1}$

Mass ____________________ kg

(1)

(d) In a TOF mass spectrometer the time of flight, t, of an ion is shown by the equation

$$t = d\sqrt{\frac{m}{2E}}$$

In this equation *d* is the length of the flight tube, m is the mass, in kg, of an ion and *E* is the kinetic energy of the ions.

In this spectrometer, the kinetic energy of an ion in the flight tube is 1.013×10^{-13} J

The time of flight of a $^{49}Ti^{+}$ ion is 9.816×10^{-7} s

Calculate the time of flight of the $^{47}Ti^{+}$ ion.

Give your answer to the appropriate number of significant figures.

Time of flight ____________________ s

(3)

(Total 8 marks)

7. Magnesium exists as three isotopes: ^{24}Mg, ^{25}Mg and ^{26}Mg

(a) In terms of sub-atomic particles, state the difference between the three isotopes of magnesium.

____

____

____

(1)

(b) State how, if at all, the chemical properties of these isotopes differ.

Give a reason for your answer.

Chemical properties ____

____

Reason ____

____

____

(2)

(c) ^{25}Mg atoms make up 10.0% by mass in a sample of magnesium.

Magnesium has A_r = 24.3

Use this information to deduce the percentages of the other two magnesium isotopes present in the sample.

^{24}Mg percentage = ________ % ^{26}Mg percentage = ________ %

(4)

(d) In a TOF mass spectrometer, ions are accelerated to the same kinetic energy (KE).

$KE = \frac{1}{2}mv^2$ where m = mass (kg) and v = velocity ($m\ s^{-1}$)

$v = \frac{d}{t}$ where d = distance (m) and t = time (s)

In a TOF mass spectrometer, each $^{25}Mg^{+}$ ion is accelerated to a kinetic energy of 4.52×10^{-16} J and the time of flight is 1.44×10^{-5} s.
Calculate the distance travelled, in metres, in the TOF drift region.
(The Avogadro constant L = $6.022 \times 10^{23}\ mol^{-1}$)

Distance = ___________________ m

(4)

(Total 11 marks)

8. This question is about time of flight (TOF) mass spectrometry.

(a) The mass spectrum of element **Q** has peaks with *m*/*z* values shown in the table.

m*/*z	82	83	84	86
Relative intensity	5	3	26	7

Calculate the relative atomic mass of **Q** and give your answer to one decimal place.
Identify the element **Q**.

Relative atomic mass of **Q** ________

Element **Q** ____________________

(3)

(b) A sample of the element **Q** consists of several isotopes. All of the **Q**+ ions in the sample of **Q** that has been ionised in a TOF mass spectrometer have the same kinetic energy.

kinetic energy of each ion = $\frac{1}{2}mv^2$

where *m* is the mass, in kg, of one ion of an isotope and *v* is the velocity of an ion in m s^{-1}

$v = \frac{d}{t}$

where *d* is the length, in m, of the flight tube and *t* is the time taken, in s, for an ion to reach the detector

The time of flight of a ^{82}**Q**$^+$ ion is 1.243×10^{-5} s.

Calculate the time of flight of the ^{86}**Q**$^+$ ion.

Time of flight of the ^{86}**Q**$^+$ ion _____ s

(3)

(Total 6 marks)

9. (a) A sample of sulfur consisting of three isotopes has a relative atomic mass of 32.16. The following table gives the relative abundance of two of these isotopes.

Mass number of isotope	32	33
Relative abundance / %	91.0	1.8

Use this information to determine the relative abundance and hence the mass number of the third isotope.
Give your answer to the appropriate number of significant figures.

Mass number = ____________________

(4)

(b) Describe how ions are formed in a time of flight (TOF) mass spectrometer.

(2)

(c) A TOF mass spectrometer can be used to determine the relative molecular mass of molecular substances.

Explain why it is necessary to ionise molecules when measuring their mass in a TOF mass spectrometer.

(2)

(Total 8 marks)

10. A sample of ethanedioic acid was treated with an excess of an unknown alcohol in the presence of a strong acid catalyst. The products of the reaction were separated and analysed in a time of flight (TOF) mass spectrometer. Two peaks were observed at m / z = 104 and 118.

(a) Identify the species responsible for the two peaks.

(2)

(b) Outline how the TOF mass spectrometer is able to separate these two species to give two peaks.

____

____

____

____

____

____

____

____

(4)

(Total 6 marks)

11. (a) Explain how ions are accelerated, detected and have their abundance determined in a time of flight (TOF) mass spectrometer.

____

____

____

____

____

(3)

(b) Calculate the mass, in kg, of a single $^{52}Cr^{+}$ ion.
Assume that the mass of a $^{52}Cr^{+}$ ion is the same as that of a ^{52}Cr atom.

(The Avogadro constant L = 6.022×10^{23} mol^{-1})

____

____

(1)

(c) In a TOF mass spectrometer the kinetic energy (KE) of a $^{52}Cr^{+}$ ion was 1.269×10^{-13} J

Calculate the velocity of the ion using the equation.

$$KE = \frac{1}{2}mv^2$$

(m = mass/kg and v = velocity/ms^{-1})

___

___

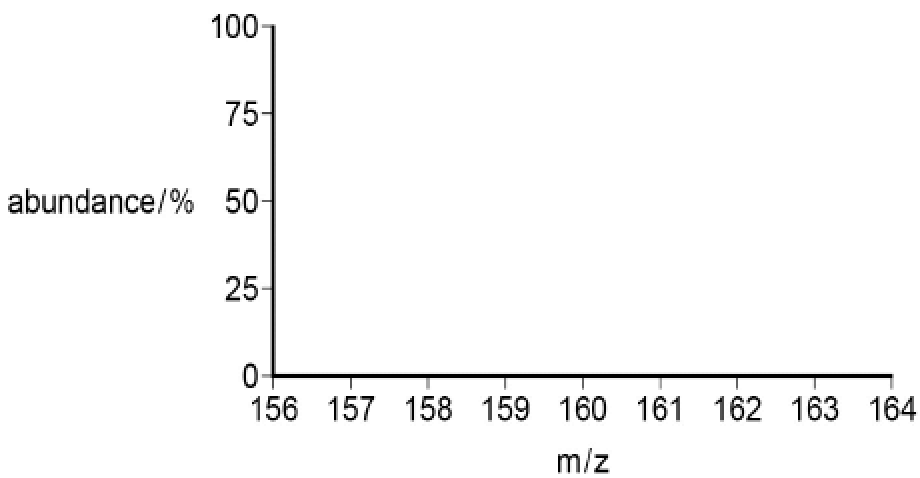
___

___

(2)

(d) Bromine has two isotopes, ^{79}Br and ^{81}Br, in approximately equal abundance. In a TOF mass spectrometer bromine forms ions with formula $[Br_2]^{+}$

Sketch the pattern of peaks you would expect to see in the mass spectrum of a sample of bromine.



(2)

(e) A sample of xenon has A_r = 131.31. The sample consists of four isotopes. The abundances of three of the isotopes are shown in the table below. The data for one of the isotopes, ^{m}Xe, is missing.

Isotope	^{129}**Xe**	^{131}**Xe**	^{132}**Xe**	^{m}**Xe**
% abundance	28.0	25.0	27.0	To be calculated

Use the data to calculate the abundance of isotope ^{m}Xe and calculate m, the mass number of ^{m}Xe. Show your working.

____

____

____

____

____

____

____

(4)

(Total 12 marks)

Mark schemes

1. (a) (Sample is) dissolved (in a volatile solvent)

Allow named solvent (eg water/methanol)

1

(Injected through) needle/nozzle/capillary at high voltage/positively charged

Ignore pressure

1

Each molecule/particle gains a proton/H^+

Allow M3 from a suitable equation (ignore state symbols)

Do not allow atoms gain a proton for M3

Ignore references to electron gun ionisation

Mark each point independently

1

(b) $C_3H_6O_2N^+$ / $C_3H_5O_2NH^+$

Must be charged

1

(c) Ge(g) + e^- → Ge+(g) + 2 e^-

OR

Ge(g) → Ge+(g) + e^-

State symbols essential

(d) **M1** v = length/t = 0.96 / 4.654 × 10^{-6}

v = 206274 m s^{-1}

m = 2*KE*/v^2

M1 = working (or answer)

1

M2 mass of one ion = 1.146 × 10^{-25} kg

*M2 = answer conseq on **M1***

1

M3 mass of 1 mole ions = 1.146 × 10^{-25} × 6.022 × 10^{23} = (0.06901 kg)

***M3** = **M2** × 6.022 × 10^{23}*

1

M4 = 69(.01) g

***M4** = **M3** × 1000*

***M3**/**M4** could be in either order*

1

M5 mass number = 69

***M5** must have whole number for mass no*

1

[10]

2. (a) **M1**: P dissolved or put in/added to a solvent

***M1**: Allow named solvent eg water or methanol*

1

M2: (injected through) a needle or nozzle or capillary <u>and</u> at high voltage/4000 volts or high potential

***M2**: Allow needle is positively charged*

1

M3: Gains a proton / H^+

***M3**: Not atoms gain a proton*

***M3**: Could be scored from equation*

1

M4: $P + H^+ \rightarrow PH^+$

*Correct equation gains **M3** and **M4***

Ignore state symbols

1

(b) 555

1

(c) **M1** V = d/t or = 1.22×10^5 ms^{-1}

Recall this equation

1

M2 $m = \frac{2KE}{v^2}$ or $\frac{2 \times 2.09 \times 10^{-15}}{(1.22 \times 10^5)^2}$

or

M2 $m = \frac{2KE \times t^2}{d^2}$ or $\frac{2 \times 2.09 \times 10^{-15} \times (1.23 \times 10^{-5})^2}{1.50^2}$

Rearrangement to give m

1

M3 m = $\underline{2.8(1) \times 10^{-25}}$ (kg)

***M3**: Calculation of m.*

1

M4 = 2.81×10^{-25} $\underline{\times L}$ = 0.169

***M4**: Allow **M3** × L*

1

M5 0.169 $\underline{\times 1000}$ = 169.(2)

***M5**: Allow **M4** × 1000*

169 only scores 5 marks

Allow answers to 2 significant figures or more ignore units

1

[10]

3. (a) = 79 / (1000 × 6.022×10^{23}) = 1.31×10^{-25} kg

1

Then either follow **method 1** (or **method 2** below)

Do not mix and match methods

Method 1

$V_{79} = \frac{d}{t}$ = 0.950 / 6.69×10^{-4}

= 1420 ms^{-1}

In method 1, M2 can be awarded in M3

1

KE = ½ mv^2

= ½ × 1.312×10^{-25} × $(1420)^2$

= 1.32×10^{-19} J

Mark consequential to their velocity and mass. Allow mass of 79 etc.

1

$V_{81} = \sqrt{(\frac{2KE}{m})}$

$= \sqrt{1.963 \times 10^6}$

$= 1.40 \times 10^3$ ms^{-1}

(allow 1.398×10^3 - 1.402×10^3)

Mark consequential to their velocity and mass. Allow mass of 81 etc.

1

$t = \frac{d}{v} = \frac{0.950}{v_{81}}$

$= 6.80 \times 10^{-4}$ s

Mark consequential to their M4

Accept 6.77 – 6.80 × 10^{-4} s

1

Method 2

$m_1(d/t_1)^2 = m_2 (d/t_1)^2$
or
$m_1 / t_1^2 = m_2 / t_2^2$

1

$t_2^2 = t_1^2 (m_2/m_1)$
Or
$t_2^2 = (6.69 \times 10^{-4})2 \times (81/79)$

1

$t_2^2 = 4.59 \times 10^{-7}$

Mark consequential to their M3

1

$t = 6.77 \times 10^{-4}$ s

Mark consequential to their M4

Accept 6.77 – 6.80 × 10^{-4} s

1

(b) ion hits the detector / negative plate and gains an electron

1

Not positive plate

(relative) abundance is proportional to (the size of) the current

1

[7]

4. (a) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ (4s^0)$

1

(b) **M1** In $Ca^{(+)}$ (outer) electron(s) is further from nucleus

Or $Ca^{(+)}$ loses electron from a higher (energy) orbital

Or $Ca^{(+)}$ loses electron from a 4(s) orbital or 4th energy level or 4th energy shell <u>and</u> $K^{(+)}$ loses electron from a 3(p) orbital or 3rd energy level or 3rd energy shell

Must be comparative

Allow converse arguments

1

M2 More shielding (in Ca^{+})

1

(c) Be /Beryllium

1

(d) $Mg(OH)_2$

1

(e) $Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$

Ignore state symbols

1

n $BaCl_2$ (6/1000 × 0.25) = 1.5×10^{-3} and n Na_2SO_4 = (8/1000 × 0.15) = 1.2×10^{-3} <u>and</u> $BaCl_2$ /barium chloride in excess

Working required or 3×10^{-4} of $BaCl_2$

1

<u>10 cm</u>^{3} (of 0.15 mol dm^{-3} sodium sulfate)

or <u>0.01dm</u>^{3}

1

(f) **M1** Same electronic configuration / same number of electrons (in outer shell) / all have 37 electrons (1)

Ignore protons and neutrons unless incorrect numbers

Not just electrons determine chemical properties

1

M2 $\frac{86x + 87x + 88(100-2x)}{100} = 87.7$ = 87.7

Alternative M2:

$\frac{86 + 87 + 88y}{1 + 1 + y} = 87.7$

1

M3 x = 10% (or × = 0.1)

M3 y = 8

1

M4 (% abundance of 88 isotope is 100 – 2x10) = <u>80(.0)%</u>

M4 % of 88 isotope is 100 – 10y = 80(.0) %

Allow other alternative methods

1

(g) $^{138}Ba^{+}$

1

(h) **M1** mass = $\frac{137 \times 10^{-3}}{6.022 \times 10^{23}}$ = 2.275×10^{-25} (kg)

Calculation of m in kg

If not converted to kg, max 4

If not divided by L lose M1 and M5, max 3

1

M2 $v^2 = \frac{2KE}{m} = \frac{2 \times 3.65 \times 10^{-16}}{2.275 \times 10^{-25}} = 3.2088 \times 10^{9}$

For re-arrangement

1

M3 $v = \sqrt{2KE/m}$ ($v = 5.6646 \times 10^{4}$)

For expression with square root

1

M4 v = d/t or d = vt or with numbers

1

M5 d = ($5.6646 \times 10^{4} \times 2.71 \times 10^{-5}$) = 1.53 - 1.54 (m)

M5 must be to 3sf

If not converted to kg, answer = 0.0485-0.0486 (3sf). This scores 4 marks

1

Alternative method

M1 $m = \frac{137 \times 10^{-3}}{6.022 \times 10^{23}}$ = 2.275×10^{-25}

M1 Calculation of m in kg

1

M2 v = d/t

M2, M3 and M4 are for algebraic expressions or correct expressions with numbers

1

M3 $d^2 = \frac{KE \times 2 t^2}{m}$

1

M4 $d = \sqrt{\frac{KE \times 2t^2}{m}}$ $(= \sqrt{(3.65 \times 10^{-16} \times 2 \times (2.71 \times 10^{-5})^2 / 2.275 \times 10^{-25})})$

1

M5 d = 1.53 – 1.54 (m)

M5 must be to 3sf

1

[18]

5. **A**

[1]

6. (a) $\frac{(46 \times 9.1) + (47 \times 7.8) + (48 \times 74.6) + (49 \times 8.5)}{100} = \frac{4782.5}{100}$

1

= 47.8

Correct answer scores 2 marks.

Allow alternative methods.

Allow 1dp or more.

Ignore units

1

(b) $Ti(g) \longrightarrow Ti^{+}(g) + e^{-}$

or $Ti(g) + e^{-} \longrightarrow Ti^{+}(g) + 2e^{-}$

or $Ti(g) - e^{-} \longrightarrow Ti^{+}(g)$

State symbols essential

Allow electrons without $^{-}$ *charge shown.*

1

46

1

(c) $8.1(37) \times 10^{-26}$

1

(d) M1 is for re-arranging the equation

$$d = t\sqrt{\frac{2E}{m}} \quad or \quad d = \frac{t}{\sqrt{\frac{m}{2E}}} \quad or \quad d^2 = t^2 \times \frac{2E}{m}$$

Allow t α square root of m

1

$$d = t_{47}\sqrt{\frac{2E}{47 \times 10^{-3} / L}} = t_{49}\sqrt{\frac{2E}{49 \times 10^{-3} / L}}$$

Or

d = 1.5(47)

This scores 2 marks

Allow this expression for M2

$$\frac{t_{47}}{\sqrt{47}} = \frac{t_{49}}{\sqrt{49}}$$

1

= 9.6(14) × 10^{-7}

Correct answer scores 3 marks.

1

[8]

7. (a) ^{24}Mg has 12n; ^{25}Mg has 13n; ^{26}Mg has 14n

OR They have different numbers of neutrons

1

(b) No difference in chemical properties

1

Because all have the same electronic structure (configuration)

OR they have the same number of outer electrons

1

(c) If fraction with mass 24 = x

Fraction with mass 26 = 0.900 − x

Fraction with mass 25 = 0.100

1

A_r = 24x + (25 × 0.100) + 26(0.900 − x)

1

24.3 = 24x + 2.50 + 23.4 −26x

2x = 1.60

x = 0.800 i.e. percentage ^{24}Mg = 80.0(%) (80.0% 3sf)

1

^{26}Mg = 0.900 − 0.800 = 0.100 ie percentage ^{26}Mg = 10.0(%)

1

(d) $m = {}^{25/1000}/_{6.022 \times 10^{23}}$

1

$v^2 = 2ke/m$ or $v^2 = \frac{2 \times (4.52 \times 10^{-16}) \times (6.022 \times 10^{23})}{25/1000}$

1

$V = \sqrt{2.18 \times 10^{10}} = 1.48 \times 10^{5}\ (ms^{-1})$

1

D = vt =1.48 × 10^5 × 1.44 × 10^{-5}

D = 2.13 (m)

1

[11]

8. (a) $\frac{(82 \times 5) + (83 \times 3) + (84 \times 26) \times (86 \times 7)}{41} = \frac{3445}{41}$

1

84.0

1

Kr

1

(b) $82/(1.243 \times 10^{-5})^2 = 86 / t^2$

So $t^2 = 86 / 82 \times (1.243 \times 10^{-5})^2$

1

$t^2 = 1.6204 \times 10^{-10}$

1

$t = 1.273 \times 10^{-5}$ (s)

1

[6]

9. (a) Abundance of third isotope = 100 – 91.0 –1.8 = 7.2%

1

$$\frac{(32 \times 91) + (33 \times 1.8) + (y \times 7.2)}{100} = 32.16$$

1

7.2y = 32.16 × 100 – 32 × 91 – 33 × 1.8 = 244.6

1

y = 244.6 / 7.2 = 33.97

y = 34

Answer must be rounded to the nearest integer

1

(b) (for electrospray ionisation)

A high voltage is applied to a sample in a polar solvent

1

the sample molecule, M, gains a proton forming MH^+

1

OR

(for electron impact ionisation)

the sample is bombarded by high energy electrons

1

the sample molecule loses an electron forming M^+

1

(c) Ions, not molecules, will interact with and be accelerated by an electric field

1

Only ions will create a current when hitting the detector

1

[8]

10. (a) $[CH_3OCOCOOH]^+$

Allow names

1

$[CH_3OCOCOOCH_3]^+$

Do not allow molecular formula

1

(b) Positive ions are accelerated by an electric field

1

To a constant kinetic energy

1

The positive ions with m / z of 104 have the same kinetic energy as those with m / z of 118 and move faster

1

Therefore, ions with m / z of 104 arrive at the detector first

1

[6]

11. (a) (Ions accelerated by) attraction to negatively charged plate / electric field

Mark independently

1

Ions detected by gaining electrons

Allow the transfer of electrons

1

Abundance determined by (size) of current flowing (or amount of electrons gained) in the detector

Allow current is proportional to abundance

1

(b) Mass = $\frac{52/1000}{6.022\times10^{23}}$

Mass = $8.6(4) \times 10^{-26}$

1

(c) $V^2 = (2 \times 1.269 \times 10^{-13}) / 8.64 \times 10^{-26}$

Allow correct rearrangement for V or V^2

1

$V = 1.71 \times 10^6\ ms^{-1}$

Allow ecf from (b) (note if 8.6×10^{-23} in (b) leads to approx. $5.4 \times 10^4\ ms^{-1}$)

1

(d) Sketch with peaks at 158, 160, 162

Mark independently

1

In ratio 25%:50%:25%

Allow approx. ratio 1:2:1

1

(e) % abundance ^{m}Xe = 20(%)

Working must be shown

1

131.31 = (0.28*129) + (0.25*131) + (0.27*132) + (0.20*m)

1

131.31 – 104.51 = 0.2m

1

Mass number = 134

Answer must be an integer

1

[12]