Mark schemes

Q1.

(a) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^5$

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$

1

(b) $Br_2(g) \rightarrow Br_2^+(g) + e^-$

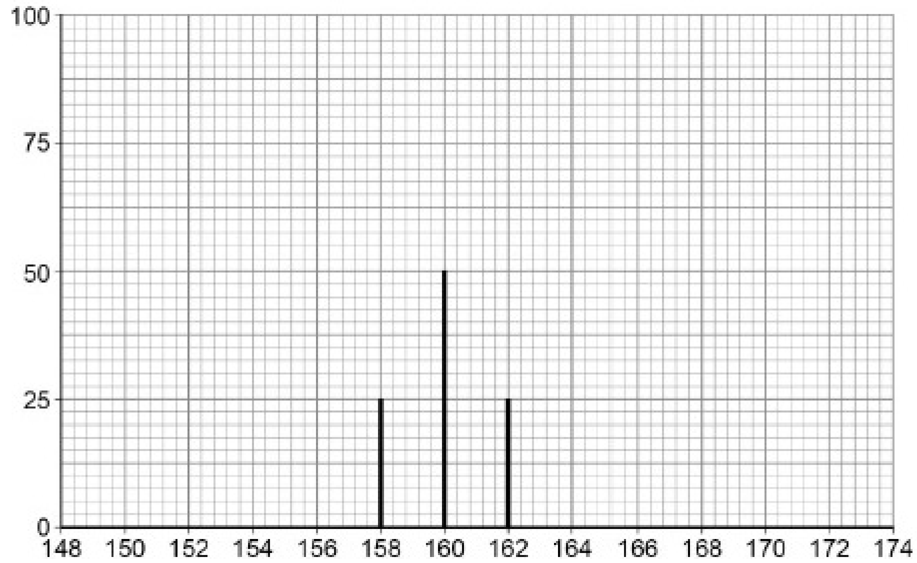
OR

$Br_2(g) + e^- \rightarrow Br_2^+(g) + 2e^-$

Do not penalise the inclusion of a radical dot

1

(c)



M1: both axes labelled

y-axis = (relative) abundance **or** %

x-axis = m/z

M2: two additional peaks at m/z = 160 and 162

M3: peaks at 158,160 and 162 in the relative heights 1:2:1

3

(d) The (relative) abundance is proportional to the size of the current.

1

[6]

Q2.

(a) B/Boron

Any 2 from:

Protons in the centre of the atom/nucleus

Electrons are in shells/energy levels (around the nucleus)

Neutrons in the centre of the atom/nucleus

Most of the atom is empty space/most of mass in nucleus

3

(b) **Definition**

$\frac{\text{Average / mean mass of 1 atom (of an element) (1)}}{\text{1/12 mass of one atom of } ^{12}\text{C (1)}}$

Or

$\frac{\text{Average / mean mass of atoms of an element}}{\text{1/12 mass of one atom of } ^{12}\text{C}}$

Or

$\frac{\text{Average / mean mass of atoms of an element} \times 12}{\text{mass of one atom of } ^{12}\text{C}}$

Or

$\frac{\text{(Average) mass of one mole of atoms}}{\text{1/12 mass of one mole of } ^{12}\text{C}}$

Or

$\frac{\text{(Weighted) average mass of all the isotopes}}{\text{1/12 mass of one atom of } ^{12}\text{C}}$

Or

Average mass of an atom/isotope
compared to/relative to C-12 on a scale in which an atom of C-12 has a mass of 12

Justification

Tellurium has Z = 52 but iodine has Z = 53
Or
Te has **one** fewer proton than I / I has **one** more proton
Or
Tellurium has 6 outer shell electrons/valence electrons but iodine has 7
Or
Te has similar chemistry/chemical properties to other Group 6 elements
Or
I has similar chemistry/chemical properties to other Group 7 elements

3

(c) $Te(g) + e^- \rightarrow Te^+(g) + 2\,e^-$

Or

$Te(g) \rightarrow Te^+(g) + e^-$

1

(d)

M1 $v = \frac{d}{t} = 4.17 \times 10^6$ (m s^{-1})

M2 $m = \frac{2KE \times t^2}{d^2}$ or $m = \frac{2KE}{v^2}$ or $\frac{2 \times 1.88 \times 10^{-12}}{(4.17 \times 10^6)^2}$

M3 m = 2.16 x 10^{-25} to 2.17 × 10^{-25} (kg)

M4 mass of 1 mole of ions = *L* × 1000 × M3 = 130.4 (g)

M4 Allow 130 to 131 (3 or more significant figures)

M5 y = 130 or 131

M5 Must be an integer

5

(e) The *KE* of $^{126}Te^+$ is the same as the *KE* of $^{124}Te^+$

1

[13]

Q3.

(a) $1s^2 2s^2 2p^6 3s^2 3p^6$

1

(b) $Na^+(g) \rightarrow Na^{2+}(g) + e^-$

Ignore state symbol on electron, even if wrong.

Allow

$Na^+(g) + e^- \rightarrow Na^{2+}(g) + 2e^-$

$Na^+(g) - e^- \rightarrow Na^{2+}(g)$

1

(c) **M1** sulfur / S

M2 large jump after the sixth electron is removed due to the 7th electron being removed / large difference between ionisation energy 6 and 7

M3 electron removed from the (2p) orbital / (second) energy level / (second) shell which is closer to the nucleus / lower in energy / has less shielding

Both ideas needed for mark

3

[5]

Q4.

(a) **M1**

$v = \frac{d}{t} = \frac{0.750}{2.48 \times 10^{-5}}$ = 30241.9 $m\ s^{-1}$

M1 Calculation of v

M2

$m = \frac{2ke}{v^2} = \frac{2 \times 1.36 \times 10^{-16}}{(\text{ans to M1})^2}$

M2 Calculation of m (in kg)

$m = \frac{2ke}{v^2} = \frac{2 \times 1.36 \times 10^{-16}}{(30241.9)^2}$ = 2.974 × 10^{-25} kg

M3

m = (ans to M2) × 1000

M3 calculation of m (in g)

m = 2.974 × 10^{-25} × 1000 = 2.974 × 10^{-22} g

M4

mass = (ans to M3) × 6.022 × 10^{23}

M4 calculation of mass of one mole of ions

mass = 2.974 × 10^{-22} × 6.022 × 10^{23} = 179(.1)

M5

Mass of one mole = (ans to M4) - 1 = 178(.1)

M5 subtracts 1 for mass of H^+

Mass of one mole = 179.1 - 1 = 178(.1)

5

(b) (High energy) electrons (from an electron gun) are used to knock out an electron (from each molecule or atom.)

1

(c) Ion that reaches detector last: CO^{2+}

Justification: Has the highest mass (to charge ratio) (so will travel the slowest)

2

(d) **M1** (ions hit a detector and) each ion gains an electron (generating a current)

M2 (the abundance is) proportional to (the size of) the current

Allow the use of electron multiplier to amplify the current

2

[10]

Q5.

(a) $Sr(g) + e^- \rightarrow Sr^+(g) + 2e^-$

Allow $Sr(g) \rightarrow Sr^+(g) + e^-$

1

(b) M1 V = (d÷t =) 0.950 ÷ 9.47 × 10^{-4} OR 1003 m s^{-1}

Recall and conversion of d into metres

M2 $m = \frac{2KE}{v^2}$ or $\frac{2 \times 7.02 \times 10^{-20}}{1003^2}$ (= 1.396 x 10^{-25} kg)

Allow $\frac{2 \times 7.02 \times 10^{-20}}{M1^2}$ *or* $\frac{2KE\,t^2}{d^2}$

M3 mass of ion = 1.396 × 10^{-22} (g)

M3 = M2 x1000

M4 mass of one mol of ions in g =

1.396 × 10^{-22} × 6.022 x 10^{23} (= 84.04)

M4 = M3 x Avogadro's number

Conversion to g may be seen in M4

M5 mass number = 84

Answer as whole number

5

(c) **M1** (Ions hit a detector/electron multiplier and) each ion gains an electron (generating a current)

M2 current is proportional to abundance

2

(d) **M1** Abundance ^{87}Sr = 2 × 18 ÷ 3 = 12(%)

M2 $A_r = \frac{(82 \times 88) + (12 \times 87) + (6 \times 86)}{100}$

M3 = 87.8

Answer to 1 decimal place

3

(e) the protein (ion) does not break up/fragment

1

[12]

Q6.

Mass of one ion of $^{121}Sb^{+}$ =121 / (1000 × 6.022 × 10^{23})
= 2.009 × 10^{-25} kg

1

V = d/t

= 1.050 / 5.93 × 10^{-4}
= 1770.658 (m s^{-1})

Alternative method

KE = ½ m d^2/t^2

1

KE = ½ m v^2

= ½ × 2.009 × 10^{-25} × $(M2)^2$ (or = ½ × M1 × $(M2)^2$)
= 3.1493 × 10^{-19} (J)

$m_{121}/t_{121}^2 = m_{123}/t_{123}^2$

1

$V_{123} = \sqrt{\left(\frac{2KE}{m}\right)}$

= √ [2(M3) / 2.0425 × 10^{-25}]
= √ 3083769.889
= 1756.07 (m s^{-1})

$T_{123}^2 = 123/121 \times t_{121}^2$

$= 3.57 \times 10^{-7}$ *(s^2)*

1

t = d / v

= 1.050 / (M4)
= 5.98 × 10^{-4} s

$t_{123} = \sqrt{M4}$

1

[5]

Q7.

(a) $\frac{\text{average/mean mass of 1 atom (of an element)}}{\text{1/12 mass of one atom of } ^{12}\text{C}}$

or

$\frac{\text{average/mean mass of atoms of an element}}{\text{1/12 mass of one atom of } ^{12}\text{C}}$

or

$\frac{\text{average/mean mass of atoms of an element} \times 12}{\text{mass of one atom of } ^{12}\text{C}}$

or

$\frac{\text{(average) mass of one mole of atoms}}{\text{1/12 mass of one mole of } ^{12}\text{C}}$

or

$\frac{\text{(weighted) average mass of all the isotopes}}{\text{1/12 mass of one atom of } ^{12}\text{C}}$

or

average mass of an atom/isotope (compared to C−12) on a scale in which an atom of C−12 has a mass of 12

M1 = top line 1

M2 = bottom line 1

if moles and atoms/isotopes mixed max = 1

(b) **M1** $186.3 = \frac{(185 \times 10) + (\mathbf{X} \times 17)}{27}$

correct expression 1

M2 (relative isotopic mass) = 187(.1) 1

(c) same electron configuration

allow same number of electrons

allow same electron structure

ignore same number of protons

ignore different number of neutrons

*do **not** accept same number of neutrons* 1

(d) **M1** mass ^{185}Re $\left(= \frac{185}{6.02 \times 10^{23} \times 1000}\right)$ = 3.072 × 10^{-25}

calculate mass in kg

1

M2 $v = \frac{d}{t}$

recall of $v = d/t$

1

M3 $v^2 = \frac{2KE}{m}$ **or** 7.5(0) × 10^{11}

rearrangement to get v^2

1

M4 $v = \sqrt{\frac{2KE}{m}}$ **or** 8.66 × 10^5

allow $\sqrt{\frac{2 \times 1.153 \times 10^{-13}}{M1}}$

1

M5 $t\left(= \frac{1.45}{8.66 \times 10^5}\right)$ = 1.67 × 10^{-6} (s)

M5 $t = \frac{1.45}{M4}$

allow 1.67 × 10^{-6} to 1.68 × 10^{-6} (s)

1

alternative method:

M1 mass ^{185}Re $\left(= \frac{185}{6.02 \times 10^{23} \times 1000}\right)$ = 3.072 × 10^{-25}

calculate mass in kg

1

M2 $v = \frac{d}{t}$ **or** $KE = \frac{md^2}{2t^2}$

recall of $v = d/t$

1

M3 $t^2 = \frac{md^2}{2KE}$

rearrangement to get t^2

1

M4 $t = d\sqrt{\frac{m}{2KE}}$ **or** $\sqrt{\frac{md^2}{2KE}}$ **or** $\sqrt{\frac{3.072 \times 10^{-25}}{2 \times 1.153 \times 10^{-13}}}$

allow $\sqrt{\frac{M1}{2 \times 1.153 \times 10^{-13}}}$

1

M5 $t = 1.67 \times 10^{-6}$ (s)

allow 1.67×10^{-6} *to* 1.68×10^{-6} *(s)*

1

(e) at the detector/(negative) plate the ions/Re^+ gain an electron

1

(relative) abundance depends on the size of the current

1

alternative answer

M1 ion knocks out an electron into electron multiplier

M2 signal from electron multiplier proportional to number of ions

[12]