Atomic Structure and Mass Spectroscopy Answers

1. (a) number of protons **(1)** 1

(b) different number of neutrons **(1)** 1

they are 'isotopes' – not enough for the mark

(c) (i) mass spectrometer **(1)**

allow spectroscope

(ii) (or average)

$$\frac{\text{mean mass of an atom}}{\text{(mass) 1 atom of } ^{12}\text{C}} \times 12 \quad \textbf{(1)}$$

$$\text{or } \frac{\text{mass of 1 mol of atoms}}{\text{mass of 1 mol of } ^{12}\text{C atoms}} \times 12 \quad \textbf{(1)}$$

or mean mass of an atom **(1)**

or compared with {an atom of ^{12}C taken as 12

{$\frac{1}{12}$ of a ^{12}C atom

If molecule, element or entity instead of 'atom' lose 1 mark 1

(iii) $\frac{(82\times12)+(83\times12)+(84\times50)+(86\times26)}{100}$ **(1)** = 84.16 **(1)** 5

allow 84.1 to 84.2 ignore units

(d) $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,4s^2\,3d^{10}\,4p^6$ **(1)**

not allow [Ar]

(e) more protons **(1)**

or increased nuclear charge

attracting electrons in the same {shell

{orbital

{sub–shell

{energy level

or similar shielding 2

(f) outer electron in Rb is in 5th shell (or additional shell) **(1)**
further away (or more shielded) from nucleus **(1)**

mark independently but if there is contradiction – no marks 2

[12]

2. (a) ^{34}S **(1)**

16 **(1)** 2

(b) $1s^2\ 2s^2\ 2p^6$ **(1)** 1

(c) not accelerated **(1)** 1

(d) 1.65×10^{-24} **(1)**

$\frac{2 \cdot 158 \times 10^{-23}}{1 \cdot 993 \times 10^{-23}} \times 12$ **(1)** = 12·99 **(1)**

or $6.023 \times 10^{23} \times 2.158 \times 10^{-23}$
= 12.998 **(1)**

any use of ^{12}C & ^{13}C **(1)**

$\frac{12 \times 98 \cdot 9}{100} + \frac{13 \times 1 \cdot 1}{100}$ **(1)**

= 12·01 **(1)** 6

[10]

3. (a) *First ionisation energy equation* $Li(g) \rightarrow Li^+(g) + e^-$ **(1)**

Second ionisation energy equation $Li^+(g) \rightarrow Li^{2+}(g)\ e^-$ **(1)**
tate symbols **(1)** 3

(b) (i) He's electron in 1s **(1)**
closer to nucleus (or no shielding) **(1)**
(or converse argument for Li)

(ii) Be's outer electron in 2s **(1)**
lower in energy than 2p **(1)**

(iii) Electron removed from positive ion **(1)**
which attracts the electron more **(1)**
(allow ½ for 2nd electron nearer to the nucleus) 6

[9]

4. (a) (i) proportion / ratio / frequency / percentage / abundance of each isotope / different type of atom / specific atom
not amount unless relative amount compared to total amount **(1)**

present in the (natural) isotopic mixture / sample of the element / compound containing the element **(1)**

reference to relative atomic mass worth zero marks 2

(ii) $(0.0802 \times 46) + (0.0731 \times 47) + (0.7381 \times 48) + (0.0554 \times 49) + (0.0532 \times 50)$ **(1)**
$= 47.9$ (ignore units) **(1)** 2

(b) (i) total of three peaks (two extra peaks) **(1)**

in a ratio of 1 : 2 : 1 with first peak at 158 and middle peak height 3.5 → 4.5cm **(1)**
at positions 158, 160, 162 **(1)**

for 2 peaks only, allow 1 mark if ratio 1: l and 2nd peak at 162 3

(ii) 3 different permutations $^{79}Br - {}^{79}Br$; $^{79}Br - {}^{81}Br$; $^{81}Br - {}^{81}Br$ **(1)**
(allow this mark for appropriate argument, if 2 peaks given in (i)) 1

(iii) $^{79}Br - {}^{81}Br$ statistically twice as likely as $^{79}Br - {}^{79}Br$ or $^{81}B - {}^{81}Br$ /
4 possible permutations, with $^{79}Br - {}^{81}Br$ and $^{81}Br - {}^{79}Br$ being identical **(1)**
(don't allow this mark if 2 peaks given in (i)) 72.759 1

(c) PV=nRT (1)

$18.6dm^3 = 0.0186m^3$ AND 2.35atm = 238113.75Pa (1)

n=PV/RT n=238113.75 x 0.0186 / 8.31 x 293 (1)

n= 1.82 (1)

1.82 x 40 (mr of Argon) = 72.8g (1)

5

(d) appropriate diagram, with one lone pair and three bonding pairs for ammonia **(1)**

appropriate diagram with two bonding pairs joining C to each O in CO_2 and
two lone pairs on each oxygen **(1)**

if inner electrons are shown they must be correct 2

[16]

5. (a)

protons	mass +1	charge + **(1)**
neutrons	mass +1	charge zero **(1)**
electrons	mass ~ zero (or<1/1800),	charge – **(1)**

nitrogen –14 has a <u>nucleus</u> with 7 protons and 7 neutrons **(1)**
surrounded by electrons in shells (or orbitals) (or 2,5) **(1)**
with configuration $1s^2\ 2s^2 2p^3$ (scores last 2 marks) **(1)** 6

(b) isotopes have the same atomic number (or same number of protons or same element) **(1)**
but different number of neutrons (or mass number) **(1)** 2

(c) sample introduced at low pressure (or gas or vapour or vacuum) **(1)**
electron gun (or bombarded with electrons) **(1)**
which knocks out an electron (or removes an electron) **(1)**
producing a <u>positive</u> ion **(1)**
the ions are accelerated **(1)**
and focused (or made into a beam) **(1)**
by an electric field (or negative plates or electric plates) **(1)**
magnetic field (or magnet) **(1)**
ions are deflected **(1)**
deflection depends on *m/z* of each ion **(1)**
lightest (or smallest m/z) deflected most **(1)**
ions go to a detector **(1)**
a small current is produced (or abundance counted) **(1)**
which is fed to a computer (or recorder or display or chart etc) **(1)**
electric field (or magnet) adjusted to collect ions of different mass **(1)**

Note: a picture of a spectrum can score the chart mark and the abundance mark (if the 'y'axis is labelled 'abundance' or '%'. max 14

(d) fraction of each component is rel. int./44 **(1)**
[the mark is for 44, if 42 max 1]
relative atomic mass
$= 1 \times 80/44 + 5 \times 82/44 + 5 \times 83/44 + 25 \times 84/44 + 8 \times 86/44$ **(1)**
$= 83.9$ **(1)**
Krypton **(1)** 4

(e) percentage by mass of oxygen = 38.0% **(1)**
ratio of elements = 42.9/12 : 2.4/1 : 16.7/14 : 38.0/16 **(1)**
= 3.6 : 2.4 : 1.2 : 2.4
empirical formula is $C_3H_2NO_2$ **(1)**
molecular formula is $C_6H_4N_2O_4$ **(1)** 4

[30]