M1.(a) $5s^2\ 4d^{10}\ 5p^4$ / $4d^{10}\ 5s^2\ 5p^4$

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^4$
or $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^2\ 5p^4$
Allow any order but must finish with $5p^4$

1

(b) (i) $\frac{(124\times2)+(126\times4)+(128\times7)+(130\times6)}{19}$ or $\frac{2428}{19}$

M1 for top line

1

127.8

M2 for correct denominator

1

127.8 with no working shown scores 3 marks

1

Or

$$\frac{(124\times10.5)+(126\times21.1)+(128\times36.8)+(130\times31.6)}{100}$$

1

Mark for 100 dependent on top line correct

1

127.8

1

(ii) Other isotopes present / some isotopes absent / different abundances of isotopes

1

(c) $Te^+ + e^{(-)} \rightarrow Te$

Ignore state symbols
Allow $Te^{2+} + 2e^{(-)} \rightarrow Te$

1

(d) 128

Only

1

Most abundant ion (QoL − superlative)

M2 dependent on correct M1

1

(e) 2+ ion formed / 2 electrons removed

Due to $^{128}Te^{2+}$ = 2 marks

1

From ^{128} (Te)

Mark independently

1

(f) Same

If not same CE = 0 / 2

1

(Each isotope has the) same number of protons / same nuclear charge and same number of electrons / electronic configuration

Ignore more neutrons in ^{130}Te

1

[12]

M2.(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

$7.2y = 32.16 \times 100 – 32 \times 91 – 33 \times 1.8 = 244.6$

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]

M3.D

[1]

M4.(a) (Total number of) protons and neutrons (in nucleus of atom)

(number of) nucleons

1

(b) Zn

Do not allow Zn^{-1} or Zn^{+1} or ZN
Ignore numbers

1

(c) (i) P = ionise (sample)

Allow removing an electron / forms (+) ions

1

Q = accelerate (sample)

Allow speeds (ions) up
Penalise molecules / atoms

1

(ii) m / z

Allow mass / charge

1

(relative) abundance / (relative) intensity

QoL
Allow M1 + M2 in any order

1

(d) (i) $\frac{206 + 207 + (208 \times 2)}{4} = \frac{(829)}{4}$

M1 = topline

1

M2 = ÷ 4

1

= 207.3

Only
207.3 = 3 marks

1

(ii) Lead / Pb

Not PB

1

(iii) Same number of electrons (in outer shell) / same electronic configuration

Ignore electrons determine chemical properties
Ignore reference to p and n if correct
Penalise if incorrect

1

[11]

M5.(a) Average / mean mass of 1 atom (of an element)
1/12 mass of one atom of ^{12}C

If moles and atoms mixed, max = 1

1

Mark top and bottom line independently.
All key terms must be present for each mark.

1

OR

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

OR

Average / mean mass of atoms of an element ×12
mass of one atom of ^{12}C

OR

(Average) mass of one mole of atoms
1/12 mass of one mole of ^{12}C

OR

(Weighted) average mass of all the isotopes
1/12 mass of one atom of ^{12}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

This expression = 2 marks.

(b) $$\frac{(70 \times 3) + (72 \times 4) + 73 + (74 \times 5)}{13} = \frac{941}{13}$$

1
1

= 72.4

72.4 only

1

(c) $^{(72)}\underline{Ge^{+}}$ or $\underline{germanium^{+}}$

Must show '+' sign.

Penalise wrong mass number

1

(d) 70

If M1 incorrect or blank CE = 0/2

Ignore symbols and charge even if wrong.

1

Lowest mass / lowest m/z

Accept lightest.

Accept fewest neutrons.

1

(e) Electron(s) transferred / flow (at the detector)

M1 must refer to electron flow at the detector.

If M1 incorrect CE = 0/2

1

(From detector / plate) to the (+) ion

Do not allow from a charged plate.

1

(f) They do not have the same electron configuration / they have different number of electrons (in the outer shell)

Ignore electrons determine the properties of an atom.

Ignore they are different elements or different number of protons.

1

[11]

M6.(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]

M7.(a) (i) 1.6734×10^{-24} (g)

Only.

1.6734×10^{-27} kg

Not 1.67×10^{-24} (g).

1

(ii) **B**

1

(b) (i) $\frac{10x + 11y}{x + y} = 10.8$

OR ratio 10:11 = 1:4 **OR** 20:80 etc

Allow idea that there are 5 × 0.2 divisions between 10 and 11.

1

abundance of ^{10}B is 20(%)

OR

$$\frac{10x}{100} + \frac{11(100-x)}{100} = 10.8$$

$10x + 1100 - 11x = 1080$

$\therefore x = 1100 - 1080 = 20\%$

Correct answer scores M1 and M2.

1

(ii) Same number of electrons (in outer shell or orbital)

Ignore electrons determine chemical properties.

Same electronic configuration / arrangement

Ignore protons unless wrong.

1

(c) Range between 3500 and 10 000 kJ mol^{-1}

1

(d) $B^+(g) \longrightarrow B^{2+}(g) + e^{(-)}$

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

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

Ignore state symbol on electron even if wrong.

1

(e) Electron being removed from a positive ion (therefore needs more energy) / electron being removed is closer to the nucleus

Must imply removal of an electron.

Allow electron removed from a + particle / species or from a 2+ ion.

Not electron removed from a higher / lower energy level / shell.

Not electron removed from a higher energy sub-level / orbital.

Ignore electron removed from a lower energy sub-level /

orbital.
Ignore 'more protons than electrons'.
Not 'greater nuclear charge'.
Ignore 'greater effective nuclear charge'.
Ignore shielding.

1

[8]