3.1.1.3 Mass numbers & Isotopes

289 minutes

283 marks

M1. (a) number of protons in one atom or nucleus **(1)**

Allow protons & electrons

do not allow protons + electrons or electrons

1

(b) $^{23}_{11}$ **(1)** Na **(1)**

OR Na^{23}_{11} *or Na (1) + unambiguous statement of mass no. and atomic no.*

2

(c) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$ **(1)**

Allow Ne $3s^2\ 3p^1$

1

(d) 14 **(1)**

1

(e) $\frac{\text{average mass of an atom (or isotope)}}{\text{mass of one atom of } ^{12}C}$ **(1)** × 12 **(1)**

Reference to mass number not mass C.E. = 0
OR stated in moles

OR compared with 1/12 of a ^{12}C *atom or relative to* ^{12}C *when taken as 12*

2

(f) (i) electron gun **(1)**

(ii) (particles must be charged) (ions) before attraction to a charged plate (or electric field) **(1)**

(or only ions can be attracted or accelerated by an electric field)

or converse; if not charged not attracted to electric field

(iii) magnetic field (or magnet) **(1)**

(iv) magnetic field **(1)** or (accelerating potential or strength of magnet)

allow magnet

4

(g) (i) $\frac{24.0 \times 64.2 + 25.0 \times 20.3 + 26.0 \times 15.5}{100}$ **(1)**

(1) mark for any m/z × relative abundance

If numerator is correct but 100 has A.E. conseq A.E. -1

If A.E. on 100 allow conseq correct answer provided numerator is correct

= 24.5 **(1)**

Allow 24.5 to 24.52

ignore units

(ii) magnesium **(1)** (or Mg) (allow conseq on wrong A_r)

(iii) abundance of <u>isotopes</u> is <u>different</u> **(1) (or different isotopes)**

5

[16]

M2. (a) Proton: mass 1, charge + 1 **(1)**
Neutron: mass 1, charge 0 **(1)**
Electron mass 1/1840, charge -1 **(1)**

Allow mass = 0, or negligible, or 1/1800 to 1/2000

Isotopes have the same number of protons **(1)**

OR atomic number

different number of neutrons **(1)**

Isotopes have the same electronic configuration **(1)**

OR same number of electrons

Chemical properties depend on electrons **(1)**

7

(b) $\frac{\text{average (1) mass of an atom/isotopes}}{\text{mass of 1 atom of } ^{12}\text{C}} \times 12$ **(1)**

OR $\frac{\text{mass of 1 mol of atoms}}{\text{mass of 1 atom of } ^{12}\text{C}} \times 12$ *or in words*

Spectrum gives (relative) abundance **(1)**

OR % or amount

And *m/z* **(1)**
Multiply *m/z* by relative abundance for each isotope **(1)**

Allow instead of m/z mass no, A_r or actual value from example

Sum these values **(1)**
Divide by the sum of the relative abundances **(1)**

only award this mark if previous 2 given
Max 2 if e.g. has only 2 isotopes

7

[14]

M3. (a) Ionisation **(1)**

High speed **or** high energy electrons **or** electron gun **(1)**

NOT bombard
NOT beam or stream of electrons

Knocks out (outer) electron **(1)**

Forming positive ion - could be from $Ti \rightarrow Ti^{+} + e^{-}$ **(1)**

Accept + ion later in question to clarify charge of ion

$Ti + e^{-} \rightarrow Ti^{+} + 2\ e^{-}$ worth 2 marks
Ignore state symbols

Acceleration **(1)**

By electric field **or** attraction to negative plate **or** electrostatic attraction **(1)**

NOT repelled by + plate
Allow passed through positive & negative plates / oppositely charged plates
Not just charged plates

Deflection **(1)**

By magnetic field or magnet **or** electromagnet **(1)**

Detection **(1)**

Idea that ions collected at detector and generate current **(1)**

Both ions have the same m / z value (of 24) **or** valid arguments in terms of the doubled charge on $^{48}Ti^{2+}$ exactly counteracting its doubled mass **(1)**

Deflected equally (so detected together) **or** deflection dependent on m / z value **(1)**

Can't get this from previous section

10

(b) Differ in mass number **or** number of neutrons **(1)**
Same proton / atomic number **(1)**

Ignore reference to electrons here

Isotopes have the same chemical properties **(1)**

because all have the same electron configuration **or** number of electrons **or** same number of valence electrons (so no chemical difference) **(1)**

This mark is tied to the above mark or near miss [similar etc] in M3

4

(c) Mean mass of an atom or (isotope) **(1)** [NOT mass of average atom]

Relative to 1/12 mass of ^{12}C atom atc. **Or** to ^{12}C taken as 12.000 or exactly 12 **(1)**

Isotope can be accepted

OR $\frac{\text{mean average mass of an atom}}{\text{mass of 1 atom of } ^{12}C}$ *(1) × 12 (1)*

OR $\frac{\text{mass of 1 mol of atoms}}{\text{mass of 1 mol of } ^{12}C}$ *(1) × 12 (1)*

A_r = (46 × .0802) + (47 × .0731) + (48 × .7381) + (49 × .0554)

+ (50 × .0532) **(1)**

= 47.93 answer to 2 d.p **(1)**

47.92 is acceptable
Must be 5 sets of values
Ignore transcription errors BUT DON'T ignore missing 100 C.E.
If missing isotope C.E.

4

[18]

M4. (a)

Particle	Relative charge	Relative mass	
Proton	+1 **or** 1+	1	**(1)**
Neutron	0 **or** no charge/neutral/zero	1 (not – 1)	**(1)**
Electron	–1 or 1–	1/1800 to 1/2000	**(1)**

or negligible
or zero
or 5.0×10^{-4} to 5.6×10^{-4}

if 'g' in mass column - wrong
penalise once

3

(b) $^{38}_{18}Ar$ **(1)(1)**

Allow numbers before or after Ar

2

(c) *S*: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$ **(1)**

Allow upper case letters

S^{2-}: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$ **(1)**

If use subscript penalise once

2

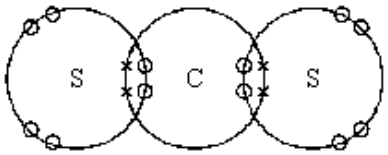
(d) *Block*: p **(1)**
Explanation: Highest energy or outer orbital is (3) p
OR outer electron, valency electron in (3) p
NOT 2p etc.

2

(e) (i) *Bonding in Na_2S*: ionic **(1)**
Bonding in CS_2: covalent **(1)**
ignore other words such as dative / polar / co-ordinate

(ii) Clear indication of electron transfer from Na to S **(1)**
1 e^- from each (of 2) Na atoms or 2 e^- from 2 Na atoms **(1)**
QoL correct English

(iii)



Correct covalent bonds **(1)**
<u>All correct</u> including <u>lone pairs</u> **(1)**
Allow all •s or all ×s
M2 tied to M1
NOT separate e^-s in S•- 2 l p

(iv) $CS_2 + 2H_2O \rightarrow CO_2 + 2H_2S$ **(1)**
Ignore state symbols even if wrong

7

[16]

M5. (a) Relative charge –1 **(1)**

Relative mass $\leq$ 1/1800 or $\leq$ 5.55×10^{-4} **(1)**
Accept zero / negligible

2

(b) (i) Protons = 24 **(1)**

(ii) Neutrons = 28 **(1)**

(iii) Need (relative) abundance or peak height or intensity / amount / number / % / fraction of each element **(1)**
Not: 'ratio of each isotope'

3

(c) (i) *Reason 1:* To allow particles to be accelerated / deflected / detected **or** to count

Reason 2: Charged particles **or** to generate a current in the detector
Any 2 **(2)**

Not: 'to allow m/z to be measured'

(ii) Magnetic field or electric field or electromagnet **(1)**

(iii) Deflection depends on mass or m/z **(1)**

4

(d) (i) (simplest) ratio of atoms of each element in compound **(1)**

(ii) % oxygen = 39.5% **(1)**

Na 28.4/23	Cr 32.1/52	O 39.5/16 **(1)**
= 1.23	= 0.617	= 2.47

(2:1:4) so empirical formula = Na_2CrO_4 **(1)**

If % oxygen not calculated, only M2 available; if A_r values wrong, only M1 available

4

[13]

M6. (a) High speed electrons OR electrons from an electron gun **(1)**

Knocks out an (outer-shell) electron (on the chromium atom) **(1)**

Accept $Cr(g) + e^- \rightarrow Cr^+(g) + 2e^-$

NOT e^- gun alone / beam of e^- / bombardment with e^-

2

(b) Electric field OR (attraction to) -ve plate OR electrostatic attraction **(1)**
OR (repelled by) +ve plate OR charged plate

NOT high p.d. / electromagnetic field / electric plates

1

(c) Magnet OR magnetic field OR electromagnet**(1)**

1

(d) A_r = (50 × 0.043) + (52 × 0.838) + (53 × 0.095) + (54 × 0.024) **(1)**

52.06 OR 52.05 **(1)**

Mark consequentially on transcription, or addition of %, error

2

[6]

M7. (a) (i) Atoms with the same number of protons / proton number **(1)**

NOT same atomic number

with different numbers of neutrons **(1)**

***NOT** different mass number / fewer neutrons*

(ii) Chemical properties depend on the number or amount of (outer) electrons **(1)** OR, isotopes have the same electron configuration / same number of e^-

(iii) $23/6.023 \times 10^{23}$ **(1)**

CE = 0 if inverted or multiplied

tied to M1 $3.8(2) \times 10^{-23}$ [2-5 sig figs] **(1)**

5

(b) $1s^2\ 2s^2\ 2p^6\ 3s^1$ **(1)**

accept subscripted figures

1

(c) Highest energy e^- / outer e^-s / last e^- in (3)d sub-shell **(1)**

OR d sub-shell being filled / is incomplete
OR highest energy sub-shell is (3)d
NOT transition element / e^- configuration ends at 3d
Q of L

1

(d) $^{15}_{7}N$ N correct symbol **(1)**

allow N^{15}_{7}

Mass number = 15 AND atomic number = 7 **(1)**

2

[9]

M8. (a) Proton mass = 1 charge = +1

Electron mass $\leq$ 1/1800 Or $\leq 5.6 \times 10^{-4}$ charge = –1

(Do not accept +1 for proton mass or 'g' units)

2

(b) (i) 13

1

(ii) Si

1

Mass number = 28 **and** atomic number = 14

(Do not accept 28.1 or 28.0 or 'Silicon')

5

(c) Mean (average) mass of an atom / all the isotopes

1/12th mass of atom of ^{12}C

Or Mass of 1 mole of atoms of an element **(1)**

1/12th mass of 1 mole of ^{12}C **(1)**

Or Average mass of an atom / all the isotopes **(1)**

relative to the mass of a ^{12}C atom taken as exactly 12 / 12.000 **(1)**

(Penalise 'weight' once only) (Ignore 'average' mass of ^{12}C)

(Do not allow 'mass of average atom')

2

(d) A_r = (24 × 0.735) + (25 × 0.101) + (26 × 0.164) 1 = 24.4 1

(mark M2 conseq on transcription error or incorrect addition of %)

(e) M_r = highest m/z value 1

(NOT 'highest/largest/right-hand' peak)

3

[10]

M9. (a) (i) p + n / number of nucleons

(accept protons and neutrons)

(Incorrect reference to electrons = contradiction)

1

(ii) Mean /average mass of a molecule/entity/formula

1

1/12th mass of atom of ^{12}C

[Not 1/12th mass of molecule of ^{12}C]

(mark independently)

1

OR Mass of 1 mole of molecules/entities (1)

1/12thmass of 1 mole of ^{12}C (1)

OR Average mass of a molecule/entity (1)

Relative to the mass of a ^{12}C atom taken as 12 / 12.000 (1)

(Mean/average = stated or explained)

(mass = stated or explained)

(Penalise 'weight' once only)

(Ignore 'average ' mass of ^{12}C)

(Do not allow 'mass of average molecule)

(b) (i) $2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$

(accept $3d^9 4s^2$)

(accept subscripts or caps)

[Penalise missing shell numbers]

1

(ii) d / D [NOT 3d/ 'transition element]

1

(iii) 36 [NOT 36.0]

1

(c) (i) More ^{63}Cu atoms than ^{65}Cu atoms

(idea of more abundant ^{63}Cu isotope - NOT just reference to peak heights)

1

(ii) Electron from electron gun / high speed electron / high energy electron

(accept electron gun fired at)
[NOT 'bombarded with electrons]

1

knock electron off (Cu atom) / idea of loss of e^- / appropriate equation

(Mark independently)

1

(iii) $^{63}Cu^{2+}$ or equivalent [NOT 63.0 - penalise this error once only]

1

m/z = 63/2 (=31.5) or equivalent

1

More energy needed to remove second electron **OR**

$^{63}Cu^{2+}$ statistically less likely to remove second electron

(Idea that not many $^{63}Cu^{2+}$ ions formed **OR** explains why few are formed e.g. more energy needed)

If '^{63}Cu' not given, can only award M2 & M3

1

Notes on [If 65 used, lose M1 **and** M2]

(c) (iii) [If mass number missing from identity but appears in explanation, penalise Ml but allow M2 if earned]

[12]

M10. (a) (i) (atoms with the) same number of protons / same atomic number / atoms of the same element;

1

(molecules = contradiction)
But different number of neutrons / different mass number;
(not different atomic mass or A_r)

1

(ii) detected by: +ve ions collide with / are directed or deflected to / are collected at the detector;

1

causing current to flow / detected electrically / idea of electricity or voltage generated;

1

(not 'charge produced' or 'detected electronically')
abundance measured: idea that current depends on abundance/number of ions hitting detector;

1

(b) (i) <u>mean /average mass of an atom / all the isotopes;</u>
1/12th mass of atom of ^{12}C ;
(mark independently)

OR

<u>mass of 1 mole of atoms (of an element)</u>;
1/12th mass of 1 mole of ^{12}C;

OR

average mass of a molecule/entity;
relative to the mass of a ^{12}C atom taken as 12 / 12.000;

2

(penalise 'weight' once only)
(ignore 'average' mass of ^{12}C)
(do not allow 'mass of average atom)

(ii) $\frac{(54 \times 5.8)+(56 \times 91.6)+(57 \times 2.6)}{100}$;

1

= 55.9;

1

(c) (i) $1s^2\ 2s^2 2p^6 3s^2 3p^6$;
(accept subscripts or caps; ignore 4s°) (penalise missing shell numbers)

1

(ii) highest energy level / last sub-shell to be filled / is (3)d;

OR

outermost electrons in the d sub-shell/orbital;

(not incomplete d sub-shell)
(not valance electron in d sub-shell)

1

(iii) no difference;
same e^- arrangement / same number of e^- / same valence e^-.

2

OR

same chemical properties;

OR

chemical properties determined by electrons;

(M2 tied to correct answer for M1)

1

[13]

M11. (a) Atoms/isotopes/particles/species with the same (number of) <u>protons</u> and different (number of) <u>neutrons</u>

[Not atomic number/mass number/molecules/same element/diff electrons]

1

(b) $^{37}_{17}Cl$ Mass number

1

17 & Cl

1

[Not 37.0] [Mark independently] [ignore charges]

(c) (i) $2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^2$

[allow reversed $4s^2\ 3d^{10}$]
[allow capitals/subscripts]

1

(ii) $A_r = \frac{(70 \times 24.4) + (72 \times 32.4) + (74 \times 43.2)}{100}$

[Wrong approach or not dividing by 100 = CE = 0]

1

= <u>72.4</u>

[Answer to 1 d.p.] [Mark conseq on transcription error]

1

(iii) Magnet/electromagnet/magnetic field / electric field/charge on negative/accelerator plate

1

Correct link between deflection and <u>*m/z*</u>

1

Correct link between deflection and field

[Penalise 'reflected'/'diffracted' once only]

[Ignore references to molecules/atoms/particles]

[Consolation mark: allow correct link between mass and deflection for 1 mark out of the 2]

1

(iv) $^{72}Ge^{2+}$ <u>only</u>

1

<u>*Same*</u> *m/z as* $^{36}S^{+}$

[Mark independently]

1

[11]

M12. (a) Number of protons in the nucleus

1

(b) They may have different numbers of neutrons

1

(c) (i) Mass spectrometer

1

(ii) $\frac{\text{Mean mass of an atom}}{\text{Mass of 1 atom of } ^{12}C} \times 12$

2

(iii) $A_r = \frac{\text{sum of relative m/z} \times \text{rel. abundance}}{\text{Total abundance}}$

1

= (82 × 12 + 83 × 12 + 84 × 50 + 86 × 26)/100 = 84.16

1

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

1

(e) Krypton was thought to be an inert gas
(or has 8 electrons in outer shell)

1

(f) (i) Krypton has more protons than bromine

1

But its outer electrons are in the same shell
(or have similar shielding)

1

(ii) Al electron is in a 3p orbital, magnesium in 3s

1

Energy of 3p is greater than 3s

1

[13]

M13. (a)

Particle	Relative Charge	Relative mass
Proton	+1	1
Neutron	0	1

1

1

Need +1 for proton

(b) d block/ D block;

Or D or d

1

(c) (i) 74;

Not 74.0

1

(ii) 112;

Not 112.0

1

(d) (i) To accelerate/ make go faster;

1

To deflect/ to bend the beam;

Any order
Not just attract to negative plate

1

(ii) Electromagnet / magnet / electric field /accelerating potential or voltage;

Not electric current
Not electronic field

1

(e) None/ nothing;

If blank mark on.
If incorrect CE = 0

1

Same number of electrons (in outer orbital/shell)/ both have 74 electrons/same electron configuration;

Not just electrons determine chemical properties
Ignore protons and neutrons unless wrong statement.

1

(f) $\frac{(182 \times 26.4) + (183 \times 14.3) + (184 \times 30.7) + (186 \times 28.6)}{100}$;

If transcription error then
M1 = AE = –1 and mark
M2 consequentially

1

= 183.90; allow range from 183.90 – 184.00;

1

[12]

M14. (a) (i) Average/mean mass of 1 atom (of an element);

Average mass of 1 atom × 12.

1

Mass 1/12 atom of ^{12}C;

Mass 1 atom of ^{12}C.
QWC.

1

(ii) Other isotope = 46.0%;

1

$107.9 = \frac{(54 \times 107.1) + (46 \times ?)}{100}$;

M2 whole expression.

1

108.8;

Answer 108.8 (3 marks).
Answer min 1 d.p..

1

Same electronic configuration/ same number of electrons (in outer shell)/ both have 47 electrons;

Ignore protons and neutrons unless incorrect.
Not just electrons determine chemical properties.

1

(b) Ionisation;

1

high energy electrons fired at sample;

Allow electron gun /blasted with electrons.

1

Acceleration;

1

With electric field/accelerating potential/potential difference;

Allow by negative plate.

1

Deflection;

1

With electromagnet/ magnet/ magnetic field;

M2 dependent on M1.
M4 dependent on M3.
M6 dependent on M5.

1

(c) (Silver) metallic (bonding);

Vdw/molecules CE=0.

1

Regular arrangement of same sized particles;

1

+ charge in each ion;

Ignore multiple positive charges.
Candidates do not need to show delocalised electrons.

1

(d) Ionic (bonds);

1

Minimum 4 ions shown in 2D square arrangement placed Correctly;

Do not allow multiple charges on ions.

1

Further 3 ions shown correctly in a cubic lattice;

1

Strong (electrostatic) forces/bonds;

If vdw/molecules/covalent mentioned CE = 0 for M4 and M5.

1

Between <u>+ and – ions</u>;

Accept between <u>oppositely charged ions</u>.

1

[20]

##

(a) <u>Average/mean mass of (1) atom(s) (of an element)</u>

1/12 mass of one atom of ^{12}C

1

If moles and atoms mixes Max = 1

1

OR

<u>(Average) mass of one mole of atoms</u>

1/12 mass of one mole of ^{12}C

OR

<u>(Weighted) average mass of all the isotopes</u>

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) d block

Allow 3d/D
Other numbers lose M1
Ignore transition metals

1

[Ar] $3d^2 4s^2$

1

Can be written in full
Allow subscripts
$3d^2$ and $4s^2$ can be in either order

27

1

(c) $\frac{(90 \times 9) + (91 \times 2) + (92 \times 3) + (94 \times 3)}{17}$

(= 1550)

1

(or ∑ their abundances)

If one graph reading error lose M1 and allow consequential M2 and M3.
If 2 GR errors penalise M1 and M2 but allow consequential M3
If not 17 or ∑ their abundances lose M2 and M3

1

= 91.2

91.2 = 3 marks provided working shown.

1

Zr/Zirconium

M4 -allow nearest consequential element from M3
accept Zr in any circumstance

1

(d) High energy electrons/bombarded or hit with electrons

accept electron gun

1

knocks out electron(s) (to form ions)

1

Z^+ = <u>90</u> deflected most

If not 90 lose M3 and M4
If charge is wrong on 90 isotope lose M3 only
Accept any symbol in place of Z

1

since lowest mass/lowest m/z

Allow lightest

1

(e) (ions hit detector and) cause current/(ions) accept electrons/cause electron flow

QWC

1

bigger current = more of that isotope/current proportional to abundance

Implication that current depends on the number of ions

1

[15]

M16. (a) Average/mean mass of (1) atom(s) (of an element)

1

1/12 mass of one atom of ^{12}C

Accept answer in words
Can have top line × 12 instead of bottom line ÷ 12

1

OR

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

OR

<u>(Weighted) average mass of all the isotopes</u>
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

$$\frac{(95.12 \times 14) + (4.88 \times 15)}{100}$$

Allow 95.12 + 4.88 instead of 100

1

= 14.05

If not to 2 d.p. then lose last mark
Not 14.04

1

(b) ^{15}N is heavier/^{15}N has a bigger m/z/different m/z values

Not different no's of neutrons
Not ionisation potential

1

Electromagnet/electric field/magnet/accelerating
potential or voltage/electric current

1

(c) No difference

1

Same no of electrons (in outer orbital/shell/sub shell)/same
electron configuration

M2 dependent on M1
Not just electrons determine chemical properties
Ignore protons

1

[8]

M17. Mass number = number of protons + neutrons (in the nucleus/atom)

Not in a substance or compound or element

1

7 protons <u>and</u> 7 electrons

1

8 neutrons

1

[3]

M18. (a) $4d^{10}\ 5s^{2}\ 5p^{1}$ in any order

Allow subscripts for numbers

Allow capitals

1

(b) (i) Using an electron gun/(beam of) high energy/fast moving electrons

Ignore 'knocks out an electron'

1

(ii) $In(g) + e^- \rightarrow In^+(g) + 2e^-$

OR

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

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

The state symbols need not be present for the electron - but if they are they must be (g)

No need to show charge on electron

If I CE = 0

Ignore any equations using M

1

(iii) So no more than 1 electron is knocked out/so only one electron is knocked out/prevent further ionisation

Allow stop 2+ and 3+/other ions being formed

Not to get wrong m/z

1

(iv) Any two processes from

- Accelerate (owtte)
- Deflect (owtte)
- Detect (owtte)

Ignore wrong causes of process

2 max

(c) (i) <u>Average/mean mass of (1) atom(s) (of an element)</u>

1

1/12 mass of one atom of ^{12}C

1

OR

<u>(Average) mass of one mole of atoms</u>

1/12 mass of one mole of ^{12}C

OR

<u>(Weighted) average mass of all the isotopes</u>

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

Not average mass of 1 molecule

Allow the wording Average mass of 1 atom of an element compared to 1/12 mass atom of ^{12}C (or mass 1/12 atom of ^{12}C)

Allow if moles of atoms on both lines

Accept answer in words

Can have top line × 12 instead of bottom line ÷12

If atoms/moles mixed, max = 1

(ii) $\frac{113x + 115y}{x + y} = 114.5$

Allow idea that there are 4 × 0.5 divisions between 113 and 115

1

ratio (113:115) = 1:3 **OR** 25:75 **OR** 0.5:1.5 etc

Correct answer scores M1 and M2

If 1:3 for In(115):In(113), max = 1

1

(d) None

1

Same no of electrons (in the outer shell)/same electron configuration)

Ignore electrons determine chemical properties/ignore protons

M2 dependent on M1 being correct

1

(e) 29.0%/29% O

If no O calculated, allow M2 if In and H divided by the correct A_r

1

$\frac{69.2}{114.8/114.5}$ $\frac{1.8}{1}$ $\frac{29.0}{16}$

1

or

0.603 1.8 1.81

1 3 3

EF = In H_3O_3

Allow $In(OH)_3$

Do not allow last mark just for ratio 1:3:3

If InO_3H_3 given with no working then allow 3 marks

If I not In, lose M3

1

[15]

M19. (a) (i) Different number / amount of neutrons

Not different neutrons

Ignore same protons and/or electrons

CE incorrect statement relating to protons / electrons

1

(ii) Same electron configuration / same number of electrons (in the outer shell)

Ignore same no of protons

Ignore electrons determine chemical properties

CE if wrong statement relating to protons / neutrons

1

(b) <u>Average mass of 1 atom (of an element)</u>
1/12 mass atom of ^{12}C

OR

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

OR

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

OR

<u>(Weighted) average mass of all the isotopes</u>
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

If moles and atoms mixes Max = 1
Mark top and bottom line independently
1/12 on bottom line can be represented as x 12 on top line
This expression = 2 marks

2

(c) (i) $\frac{(64 \times 12) + (66 \times 8) + (67 \times 1) + (68 \times 6)}{27} \; \frac{(= 1771)}{27}$

= <u>65.6</u>

If not 27 max 1 mark (for top line)
Mark is for dividing by 27 or string
*If **evidence** of arithmetic or transcription error seen in M1 or M2 allow consequential M3 and consequential (c)(ii)*
65.6 = 3 marks

3

(ii) $^{64}Zn^{+}$

M1 for identifying Zn / zinc
M2 is for the + sign and the 64
M2 is dependent on M1

2

(d) Size of the charge (on the ion) / different charges / different m/z

Allow forms 2+ ions

QWC

1

(e) (ions hit detector and) cause current/(ions) accept electrons/cause electron flow/electric pulse caused

bigger current = more of that isotope/current proportional to abundance

Implication that current depends on the number of ions

M2 dependent on M1

2

[12]

M20. (a) $\frac{(82 \times 2) + (83 \times 2) + (84 \times 10) + (86 \times 3)}{17}$ $\frac{(1428)}{(17\quad)}$

M1 for the top line

M2 is for division by 17

1

1

= <u>84.0</u>

Not 84

No consequential marking from M1 or M2

Ignore units

1

The A_r in the Periodic table takes account of the <u>other isotopes</u> / <u>different amounts of isotopes</u> (or words to that effect regarding isotopes)

Award independently

Comparison implied

Isotope(s) alone, M4 = 0

1

(b) (Beam of electrons from) an electron gun / high speed / high energy electrons

1

Knocks out electron(s) (to form a positive ion)

1

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

State symbols must clearly be (g)

1

OR

$Kr(g) \rightarrow Kr^+(g) + e(^-)$ / $Kr(g) - e(^-) \rightarrow Kr^+(g)$

The ^{84}Kr isotope

One mark for identifying the 84 isotope

1

Has 2 electrons knocked out / gets a 2+ charge

One mark for the idea of losing 2 electrons (from this isotope)

1

[9]

M21. (a) 37

These answers only.

Allow answers in words.

1

48

Ignore any sum(s) shown to work out the answers.

1

(b) (i) Electron gun / high speed/high energy electrons

Not just electrons.

Not highly charged electrons.

1

Knock out electron(s)

Remove an electron.

1

(ii) $Rb(g) \rightarrow Rb^{+}(g) + e^{(-)}$

OR

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

OR

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

Ignore state symbols for electron.

1

(c) Rb is a bigger (atom) / e further from nucleus / electron lost from a higher energy level/ More shielding in Rb / less attraction of nucleus in Rb for outer electron / more shells

Answer should refer to Rb not Rb molecule

If converse stated it must be obvious it refers to Na

Answer should be comparative.

1

(d) (i) s / block s / group s

Only

1

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

Allow $3d^{10}$ before $4s^2$

Allow in any order.

1

(e) $\frac{(85 \times 2.5) + 87 \times 1}{3.5}$

M1 is for top line

1

1

= 85.6

Only

1

OR

$\frac{(58 \times 5) + 87 \times 2}{7}$

M1 ^{85}Rb 71.4% and ^{87}Rb 28.6%

M2 divide by 100

1

1

85.6

M3 = 85.6

1

(f) Detector

Mark independently

Allow detection (plate).

1

Current / digital pulses / electrical signal related to abundance

Not electrical charge.

1

(g) Smaller

Chemical error if not smaller, CE = 0/3

If blank mark on.

1

Bigger nuclear charge / more protons in Sr

Not bigger nucleus.

1

Similar/same shielding

QWC

(Outer) electron entering same shell/sub shell/orbital/same number of shells.

Do not allow incorrect orbital.

1

[16]

M22. (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]

M23. (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) $^{(72)}Ge^{+}$ or 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]