1. *(penalty for sig fig error =1mark per question)*

(a) neutron: relative mass = 1 relative charge = 0 1
(not 'neutral')

electron: relative mass = 1/1800 → 0/negligible *or*
$5.56 \times 10^{-4} \rightarrow 0$ relative charge = –1 1

(b) $^{17}O/O^{17}$ mass number (*Do not accept 17.0*) 1

oxygen symbol 'O' 1
(if 'oxygen' + — 'mass number = 17'(1))
(if 'oxygen'+ — 'mass number = 17'(0))
(if at N^0 given but ≠ 8, treat as 'con' for M2)
(if lp on Be, diagram = 0)
(ignore bond angles)
(not dot and cross diagrams)

[4]

2. (a) (i) p + n / <u>number</u> of nucleons *(accept protons and neutrons)* 1
(Incorrect reference to electrons = contradiction)

(ii) <u>Mean /average mass of a molecule/entity/formula</u> 1
l/12th mass of atom of ^{12}C 1
[Not 1/12th mass of molecule of ^{12}C] (mark independently)

OR Mass of 1 mole of molecules/entities (1)
l/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 $3d^{\,9} 4s^2$)* 1
(accept subscripts or caps)
[Penalise missing shell numbers]

(ii) d / D *[NOT 3d/ 'transition element]* 1

(iii) 36 *[NOT 36.0]* 1

(c) (i) More ^{63}Cu atoms than ^{65}Cu atoms 1
(idea of more abundant ^{63}Cu isotope - NOT just reference to peak heights)

(ii) Electron from electron gun / high speed electron / high energy electron 1
(accept electron gun fired at)
[NOT 'bombarded with electrons]

knock electron off (Cu atom) / idea of loss of e^- / appropriate equation 1
(Mark independently)

(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** 1
$^{63}Cu^{2+}$ 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

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]

3. (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; 1
(not different atomic mass or A_r)

(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>
l/12th mass of atom of ^{12}C ;
(mark independently)

OR

<u>mass of 1 mole of atoms (of an element)</u>;
l/12thmass of l 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) $1s^2\ 2s^2 2p^6 3s^2 3p^6$; 1
(accept subscripts or caps; ignore 4s°) (penalise missing shell

numbers)

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

OR

outermost electrons in the d sub-shell/orbital; 1
(not incomplete d sub-shell)
(not valance electron in d sub-shell)

(iii) no difference; 1
same e^- arrangement / same number of e^- / same valence e^-.

OR

same chemical properties;

OR

chemical properties determined by electrons; 1
(M2 tied to correct answer for M1)

[13]

4. (a)

Particle	Relative charge	Relative mass	
Proton	+1 **or** 1+	1	**(1)**
Neutron	0 **or** no charge/neutral/zero	1 (<u>not</u> – 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

[9]

5. (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) $\frac{\text{average mass of an atom (or isotope)}}{\text{mass of 1 atom of } ^{12}\text{C}}$ **(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 charge not attracted to electric field

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

(iv) magnetic field **(1)** (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]

6. (a) (i) **A** = electron, **B =** neutron and **C** = proton **all** correctly identified **(1)**

do not give if any reference to cation / anion 1

(ii) neutron / n^0 / **B** has no charge and so is undeflected **(1)**

proton / p^+ / **C** and electron / e^- / **A** attracted to –ve and +ve plates respectively **(1)**

correct direction and shape for one particle gains one mark

mass p > mass e^- so deflected less / mass **C** > mass **A** so deflected less **(1)**

allow this mark for valid difference in property and explanation of shape

allow reference to other particles here 3

(b) (i) to produce high speed electrons / stream of electrons **or** to fire electrons **or** to bombard with electrons **or** is an electron gun **(1)**

which remove electrons from species cause formation of positive ions **not** to ionise **(1)** 2

(ii) to accelerate / speed up positive ions / ions / fragments **(1)**
not electrons atoms / molecule / sample
allow particles / molecular ion

to deflect / bend ions / ion stream (not to provide magnetic field)
or separate ions accordingly to mass / charge ratio **(1)**

to detect positive ions / ions / particles / fragments / molecular ion **(1)**
allow purpose of specific detector or ion detector
not just detector or collector

allow second and third marks if wrong type of particle given 3

[11]

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

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

they are 'isotopes' – not enough for the mark 1

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

allow spectroscope

(ii) (or average)

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

(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)**

allow 84.1 to 84.2 ignore units 5

(d) 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

[9]

8. (a) (i) the number of protons and neutrons / number of nucleons in the nucleus / atom 1

not in an element

(ii) weighted average / mean mass of the isotopes or of atoms **not** of an element / average mass in an isotopic mixture / average mass of all naturally occurring isotopes **(1)**

measured on the ^{12}C scale / relative to $^{1}/_{12}$ th the mass of one atom of the ^{12}C isotope **(1)** 2

independent of first mark

(b) $\frac{32 \times 95 + 33 \times 0.8 + 34 \times 4.2}{100}$ **(1)**

32.1 (ignore units) – answer only gets both marks **(1)** 2

[5]

9. (a) Number of protons & number of neutrons **(1)** 1

(b) $^{17}_{8}O$ **(1)** 2

(1)

(c) (i)

Particle	proton	neutron	Electron
Mass /g	1.6725×10^{-24}	1.6748×10^{-24}	0.0009×10^{-24}
Relative charge	***+1***	***0***	***–1***

(ii) 1.6734×10^{-24} g **(1)**

(iii) 1.0078 g **(1)**

(iv) other isotopes present **(1)** 4

(d) (i) electric field (or charged plate) **(1)**

(ii) magnet **(1)**

(iii) different isotopes **(1)**

(or different masses)

(iv) accelerate ions more

(or reduce magnetic field) **(1)**

(v) *Measurement 1* $^{m}/_{z}$ **(1)**

Measurement 2 abundance **(1)** 6

[13]

10. (a) electron gun **(1)** 1

(b) accelerated **(1)** 1

(c) speed **(1)** 1

(d) $\frac{82\times1+83\times1+84\times5+86\times2}{9}$ **[1]**

= 84.1 **(1)** 3

[6]

11. (a) Atoms/isotopes/particles/species with the same (number of) <u>protons</u> and different (number of) <u>neutrons</u> 1

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

(b) $^{37}_{17}Cl$ 17 & Cl 1

Mass number 1

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

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

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

[allow capitals/subscripts]

(ii) $A_r = \frac{(70\times24.4)\ +\ (72\times32.4)\ +\ (74\times43.2)}{100}$ 1

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

= <u>72.4</u> 1

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

(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 1

[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]

(iv) $^{72}Ge^{2+}$ <u>only</u> 1

<u>*Same*</u> *m/z as* $^{36}S^+$ 1

[Mark independently]

[11]

12. (a) *aluminium*: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$ **(1)**

vanadium: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^3$ **or** $3d^3\ 4s^2$ **(1)** 2

(b) s-block 1

[3]

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

16 **(1)** 2

(b) 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

[8]

14.

(a) Electron gun **(1)**
knocks out electron(s) from the particle **(1)** 2

(b) *Reason 1* acceleration **(1)**

Reason 2 deflection **(1)** 2

(c) $\frac{20}{100} \times 10 + \frac{80}{100} \times 11$ **(1)**

= 10.8 **(1)** 2

[6]

15. (a) $(1s^2 2s^2)\ 2p^6 3s^2 3p^2$ **(1)** 1

(b) $Si(g) \rightarrow Si^+(g) + e^-$ balanced **(1)**

$Si^+(g) \rightarrow Si^{2+}(g) + e^-$ balanced **(1)**

correct state symbols in both equations (allow even if not balanced) **(1)** 3

[4]

16. (a) 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

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

[4]

17. (a) $1s^2\ 2s^2 2p^6$ (accept capitals and subscripts) 1

(b) 's' block (not a specific 's' orbital – e.g. 2s) 1

(c) $\underline{Mg^{2+}}$ ion smaller than Ne atom / Mg^{2+} e^- closer to nucleus 1
(Not 'atomic' radius fo Mg^{2+})

$\underline{Mg^{2+}}$ has more protons than Ne / higher nuclear charge or 1

$\underline{e^-}$ is removed from a charged Mg^{2+} ion / neutral neon atom
(accept converse arguments)

*(If used 'It' or Mg/magnesium/Mg^{3+} etc. & 2 correct reasons, allow **(1)**)*

(d) (i) trend: increases *(if 'decreases', CE = 0/3)* 1

Expl^n: more protons / increased proton number / increased nuclear charge 1
(NOT increased atomic number)

same shell / same shielding / smaller size 1

(ii) **QoL** reference to the e^- pair in the 3p sub-level 1
(penalise if wrong shell, e.g. '2p', quoted)

repulsion between the e^- in this e^- pair 1
(if not stated, 'e^- pair' must be clearly implied)
(mark M4 and M5 separately)

[9]

18. (a) Spin **(1)** 1

(b) Further from nucleus **(1)**
(or more shielded) 1

(c) Energy to remove 1 electron **(1)** (or 1 mol electrons)
from a gaseous atom **(1)** (or molecule or 1 mol of atoms/molecules) 2

(d) Be's outer electron is in an s (2s) orbital **(1)**
B's outer electron is in a p (2p) orbital **(1)**
B's outer electron is higher in energy **(1)** 3

(e) Electron is not shielded from nucleus **(1)** 1

[8]

19.

(a) (i) increases; 1

(ii) lower than expected / lower than Mg / 1
less energy needed to ionise; e^- removed from (3)p sub-level; 1
('e^- removed' may be implied)
of higher energy / further away from nucleus / shielded by 3s e^-s; 1

(b) $Al^+(g) \rightarrow Al^{2+}(g) + e^-$; 1

[5]

20. (a) $Na(g) \rightarrow Na^+(g) + e^-$
OR $Na(g) + e^- \rightarrow Na^+(g) + 2e^-$
(-) on electron not essential
equation (1)
state symbols (1)
Ignore state symbols on electrons

2

(b) *Trend* : Increases **(1)**

Explanation : Increased nuclear charge or proton number **(1)**
Stronger attraction (between nucleus and (outer) e^-) **(1)**
Trend wrong
Allow M2 only if M3 correct (con)

3

(c) *How values deviate from trend*: (both values) too low **(1)**
Explanation for Al: e^- removed from (3) p **(1)**
e^- or orbital is higher in energy level or better shielded than (3)**s**
or p electron is shielded by 3s electrons **(1)**
Allow e^- is further away
Mark independently

Explanation for S: e^- removed from (3)p electron pair **(1)**
repulsion between paired e^- (reduces energy required) **(1)**
Mark separately
If deviation wrong allow M2 and M4
If M3 and / or M5 right 0 (con)
If used 'd' rather than 'p' orbital - lose M2 + M4 but may get M3, M5 (explanation marks)

5

[10]

21. (a) Heat / enthalpy / energy for removal of one electron **(1)** from a gaseous atom **(1)**
can score in an equation
must have first mark to score the second

2

(b) (i) 2 **(1)**

(ii) Two elements (or Na / Mg) before the drop (in energy) to Al **(1)**

(iii) ionisation energy of Al < that for Mg **(1)**

(iv) fall in energy from P to S **(1)**
or discontinuity in trend

From Al to P there are 3 additional electrons **(1)**
or three elements

5

For second mark idea of block of 3 elements

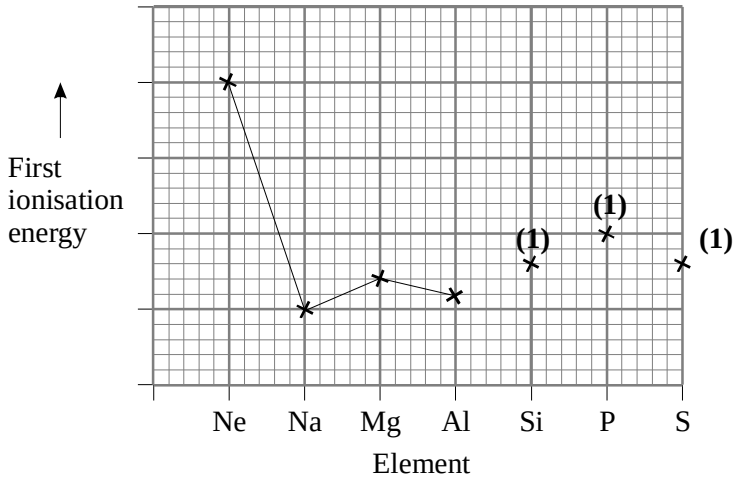
[7]

22. Number of protons increases **(1)**
Electrons in same shell **(1)** (or same shielding) 2

[2]

23.

(a)



3

(b) $Ne \longrightarrow Ne^+ + e^-$ **(1)** 1

(c) *Explanation for neon* Neon's electron is in a lower (2p) shell **(1)**
attracted more strongly to (or less shielded from) the nucleus **(1)**
Explanation for magnesium more protons **(1)**
electrons in same shell
or similar shielding **(1)** 4

(d) Als outer electron is in a 3p sub-shell **(1)**

higher in energy than 3s in Magnesium **(1)** 2

[10]

24. increased nuclear charge / nuclear attraction number of protons **(1)**

same shielding / electrons added to same or outer shell / increase in number of electrons in outer shell **(1)**

therefore (outer) electrons attracted / pulled in more strongly or more closely **(1)**

'increased effective nuclear charge' worth 2 marks

[3]

25. (a) Proton: mass 1, charge + 1 **(1)**
Neutron: mass 1, charge 0 **(1)**
Electron 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 7

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

OR $\frac{\textbf{mass of 1 mol of atoms}}{\textbf{mass of 1 atom of } {}^{12}\textbf{C}}$ **× 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]

26. (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 $\frac{\text{mean (average) mass of an atom}}{\text{mass of an atom of } ^{12}C}$ **(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]

27. (a)

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

nitrogen –14 has a nucleus 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) fraction of each component is rel. int./44 **(1)**
[the mark is for 44, if 42 max 1]
relative atomic mass
= 1 × 80/44 + 5 × 82/44+ 5 × 83/44 + 25 × 84/44 + 8 × 86/44 **(1)**
= 83.9 **(1)**
Krypton **(1)** 4

[12]

28. (a) Mean (average) mass of an atom / all the isotopes or 1

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

Mass of 1mole of atoms of an element or
$1/12^{th}$ mass of 1mole of ^{12}C

average mass of an atom / all the isotopes
Relative to the mass of a ^{12}C atom taken as exactly 12 / 12.000

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

(b) $A_2 = (64 \times 0.389) + (66 \times 0.278) + (67 \times 0..147) + (68 \times 0.186)$ 1
$= 65.7$

(mark M2 conseq on transcription error or incorrect addition of %) 1

identity: zinc / Zn 1

(Conseq on A_2 but only if their A_2 is within range of Periodic Table)

(c) electron gun (fires) electrons or high speed/energy electrons 1
(not just 'bombarded by electrons' or 'bombarded by electron gun')

knocks off e^- from **Q** 1
(may be earned from a real or generic equation)

Reasons: to allow ions to be: 1
accelerated (by an electric field)

deflected (by a magnet/magnetic field) 1

detected / description of current formed at the detector/sensor 1

(accept in any order)
(allow clear descriptions of 'accelerated', 'deflected', 'detected')

[10]

29. general increase across period **(1)**

can score this and points 4, 7 on graph

because number of protons (or nuclear charge) increases **(1)**

but electrons in same shell (or similar shielding) **(1)**

fall from Mg to Al **(1)**

Al's outer electron is in a <u>p</u> orbital **(1)**

higher in energy than <u>s</u> electron in Mg **(1)**
if wrong period –1

fall from *P* to *S* **(1)**

two of the *p* electrons in *S* are paired (or in same orbital) **(1)**

[9]