M1.(a) (i) d (block) **OR** D (block)

Ignore transition metals / series.

Do not allow any numbers in the answer.

1

(ii) Contains positive (metal) ions or protons or nuclei and <u>delocalised / mobile / free / sea of</u> electrons

Ignore atoms.

1

<u>Strong attraction</u> between them or <u>strong metallic</u> bonds

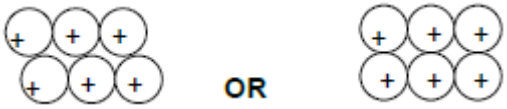
Allow 'needs a lot of energy to break / overcome' instead of 'strong'.

If strong attraction between incorrect particles, then CE = 0 / 2.

If molecules / intermolecular forces / covalent bonding / ionic bonding mentioned then CE=0.

1

(iii)



M1 is for regular arrangement of atoms / ions (min 6 metal particles).

M2 for + sign in each metal atom / ion.

Allow 2^+ sign.

2

(iv) <u>Layers / planes / sheets of atoms or ions</u> can slide over one another

QoL.

1

(b) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8\ (4s^0)$

Only.

1

(ii) $NiCl_2.6H_2O$ + **6** $SOCl_2$ $\longrightarrow$ $NiCl_2$ + **6** SO_2 + **12** HCl

Allow multiples.

1

$NaOH$ / NH_3 / $CaCO_3$ / CaO

Allow any name or formula of alkali or base.

Allow water.

1

[9]

M2. (a) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$ **(1)**

Allow subscripted electron numbers

(ii) p (block) **(1)**

Allow upper or lower case 's' and 'p' in (a)(i) and (a)(ii)

2

(b) Lattice of metal / +ve ions/ cations / atoms **(1)**

Not +ve nuclei/centres

Accept regular array/close packed/tightly packed/uniformly arranged

(Surrounded by) <u>delocalised</u> electrons **(1)**

Note: Description as a 'giant ionic lattice' = CE

2

(c) Greater nuclear or ionic charge or more protons **(1)**

Smaller atoms / ions **(1)**

Accept greater charge density for either M1 or M2

More delocalised electrons / e^- in sea of e^- / free e^- **(1)**

Stronger attraction between ions and delocalised / free electrons etc. **(1)**

Max 3

Note: 'intermolecular attraction/ forces' or covalent molecules = CE

Accept stronger 'electrostatic attraction' if phrase prescribed elsewhere

Ignore references to m/z values

If Mg or Na compared to Al, rather than to each other, then:
Max 2
*Treat description that is effectively one for Ionisation Energy as a '**contradiction**'*

3

(d) (Delocalised) electrons **(1)**

Move / flow in a given direction (idea of moving non-randomly)
or under the influence applied pd *QoL mark* **(1)**

Allow 'flow through metal'

Not: 'Carry the charge'; 'along the layers'; 'move through the metal'

2

[9]

M3. (a) enthalpy/energy change/required when an electron is removed/ knocked out / displaced/ to form a uni-positive ion

(ignore 'minimum' energy)

1

from a gaseous atom

(could get M2 from a correct equation here)
(accept 'Enthalpy/energy change for the process...' followed by an appropriate equation, for both marks)
(accept molar definitions)

1

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

(accept capitals and subscripts)

1

(c) 's' block

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

1

(d) $Mg^+(g) \rightarrow Mg^{2+}(g) + e^-$ or

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

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

1

(e) Mg^{2+} ion smaller than Ne atom / Mg^{2+} e^- closer to nucleus

(Not 'atomic' radius fo Mg^{2+})

1

Mg^{2+} has more protons than Ne / higher nuclear charge or
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)**)*

1

(f) (i) trend: increases

(if 'decreases', CE = 0/3)

1

Expl^n: more protons / increased proton number / increased nuclear charge

(NOT increased atomic number)

1

same shell / same shielding / smaller size

1

(ii) QoL reference to the e^- pair in the 3p sub-level

(penalise if wrong shell, e.g. '2p', quoted)

1

repulsion between the e^- in this e^- pair

(if not stated, 'e^- pair' must be clearly implied)

(mark M4 and M5 separately)

1

[12]

M4. (a) Outer electrons are in p orbitals

1

(b) decreases

1

Number of protons increases

1

Attracting outer electrons in the same shell (or similar shielding)

1

(c) Sulfur molecules (S_8) are larger than phosphorus (P_4)

1

Therefore van der Waals' forces between molecules are stronger

1

Therefore more energy needed to loosen forces between molecules

1

(d) Argon particles are single atoms with electrons closer to nucleus

1

Cannot easily be polarised (or electron cloud not easily distorted)

1

[9]

M5. (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

(58 × 5) + 87 ×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]

M1. (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.

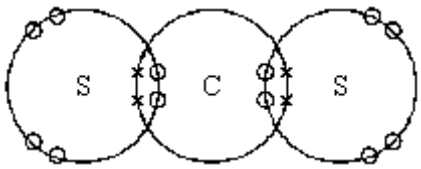
2

(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]

M2. (a) Elements in the p block have their outer electron(s) in
p orbital(s) or levels or sub-shells **(1)**
example of element **(1)**
correct electronic configuration **(1)**

3

(b) Pattern in the change in the properties of a row of elements **(1)**
OR Trend in the properties of elements across a period

Repeated in the next row **(1)**
OR element underneath (or in same group) has similar properties

atomic radius
decreases across the row **(1)**

CE if trend is wrong

number of protons increases **(1)** (or nuclear charge increases)
more attraction for electrons in the same shell **(1)**

electronegativity
increases across the row **(1)**
number of protons increases **(1)** (or nuclear charge)
atomic radius decreases **(1)** (or shielding remains the same or electrons in the same shell) more attraction for bonding or shared electrons **(1)**

conductivity
decreases row **(1)**

OR significant drop from Al to Si

Na–Al metals **(1)**

OR metallic bonding or description of metallic bonding

Two of Si - Ar non metals **(1)**

OR molecular or covalent

EITHER electrons free to move (or delocalised) in metals
OR electrons unable to move in non-metals **(1)**

13

[16]

M1.(a) Silicon / Si

If not silicon then CE = 0 / 3

1

covalent (bonds)

M3 dependent on correct M2

1

Strong or many of the (covalent) bonds need to be broken / needs a lot of energy to break the (covalent) bonds

Ignore hard to break

1

(b) Argon / Ar

If not argon then CE = 0 / 3. But if Kr chosen, lose M1 and allow M2+M3

1

Large(st) number of protons / large(st) nuclear charge

Ignore smallest atomic radius

1

Same amount of shielding / same number of shells / same number of energy levels

Allow similar shielding

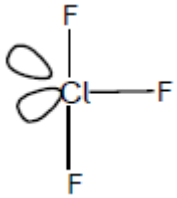
1

(c) Chlorine / Cl

*Not Cl_2, Not C**L**, Not Cl^2*

1

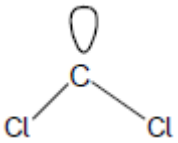
(d) (i)



Or any structure with 3 bonds and 2 lone pairs

Ignore any angles shown

1



Or a structure with 2 bonds and 1 lone pair

1

(ii) Bent / v shape

Ignore non-linear, angular and triangular

Apply list principle

1

(iii) $\frac{1}{2}Cl_2 + \frac{3}{2}F_2 \longrightarrow ClF_3$

No multiples

Ignore state symbols

1

[11]

M2. (a) $\underline{4d^{10}\ 5s^2\ 5p^1}$ 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]

M3. A

[1]

M4. (a) $Li(g) \rightarrow Li^{+}(g) + e^{-}(g)$

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

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

One mark for balanced equation with state symbols

Charge and state on electron need not be shown

1

(b) Increases

If trend wrong then CE = 0/3 for (b). If blank mark on.

1

Increasing nuclear charge / increasing no of protons

Ignore effective with regard to nuclear charge

1

Same or similar shielding / same no of shells / electron (taken) from same (sub)shell / electron closer to the nucleus / smaller atomic radius

1

(c) Lower

If not lower then CE = 0/3

1

Paired electrons in a (4) p orbital

If incorrect p orbital then M2 = 0

1

(Paired electrons) repel

If shared pair of electrons M2 + M3 = 0

1

(d) Kr is a bigger atom / has more shells / more shielding in Kr / electron removed further from nucleus/ electron removed from a higher (principal or main) energy level

CE if molecule mentioned

Must be comparative answer
QWC

1

(e) 2 / two / II

1

(f) Arsenic / As

1

[10]

M5.(a) The number of protons increases (across the period) / nuclear charge increases

1

Therefore, the attraction between the nucleus and electrons increases

Can only score M2 if M1 is correct

1

(b) S_8 molecules are bigger than P_4 molecules

Allow sulfur molecules have bigger surface area and sulfur molecules have bigger M_r

1

Therefore, van der Waals / dispersion / London forces between molecules are stronger in sulfur

1

(c) Sodium oxide contains O^{2-} ions

1

These O^{2-} ions react with water forming OH^- ions

$O^{2-} + H_2O \longrightarrow 2OH^-$ scores M1 and M2

1

(d) $P_4O_{10} + 12OH^- \longrightarrow 4PO_4^{3-} + 6H_2O$

1

[7]

M6.(a) Carbon / C

If M1 incorrect, CE = 0 / 3

1

Fewest protons / smallest nuclear charge / least attraction between protons (in the nucleus) and electrons / weakest nuclear attraction to electrons

Allow comparative answers.

Allow converse answers for M2

1

Similar shielding

Allow same shielding.

1

(b) Increase

1

Oxygen / O

If not oxygen, then cannot score M2, M3 and M4

1

Paired electrons in a (2)p orbital

If paired electrons in incorrect p orbital, lose M3 but can award M4

1

(Paired electrons in a p orbital) repel

1

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

OR

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

OR

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

Ignore state symbols for electron.

1

(d) (More energy to) remove an electron from a (more) positive ion / cation

Allow electron closer to the nucleus in the positive ion.

1

(e) Lithium / lithium / Li

If formula given, upper and lower case letters must be as shown.

1

[10]

M1. (a) Macromolecular/giant covalent/giant molecular/giant atomic

If IMF/H-bonds/Ionic/metallic CE = 0/3

covalent bond between molecules CE = 0/3

If giant unqualified M1 = 0 but mark on

1

Many/strong covalent bonds

M2 and M3 can only be scored if covalent mentioned in answer

Ignore metalloid and carbon

Ignore bp

1

Bonds must be broken/overcome

Ignore numbers of bonds and references to energy

1

(b) (Simple) <u>molecular</u>

QoL

Do not allow simple covalent for M1

Giant covalent/ionic/metallic, CE = 0

If breaking covalent bonds CE= 0/3

1

S bigger <u>molecule</u> (than P) or S_8 and P_4 references

QoL

Allow more electrons in sulfur <u>molecule</u> or S_8

Do not allow S is bigger then P

Allow S <u>molecule</u> has a bigger M_r

Do not allow contradictions

1

So more/stronger <u>van der Waals'</u> forces (to be broken or overcome)

Not just more energy to break

1

(c) Regular arrangement of minimum of 6 particles in minimum of 2 rows

Ignore e–

Do not allow ring arrangements OR structures bonded with electrons

1

+ charge in each one (of 6)

Allow +, (1+, 2+ or 3+) in ions/or in words

1

Rows/planes/sheets/layers (of atoms/ions) can slide (owtte) over one another

M3 independent

If ionic bonding/molecules/IMF/vdw/covalent, penalise M3

Ignore layers of electrons sliding

1

(d) Bigger charge (3+ compared to 1+)

CE = 0 if molecules, ionic, covalent, IMF

(Allow Al^{2+})

OR smaller atom/ion in Al/more protons/bigger nuclear charge

1

More free/delocalised electrons (in Al)/bigger sea of electrons in Al

Accept 2 or 3 delocalised electrons compared to 1 in Na

1

Stronger metallic bonding/stronger (electrostatic) attraction between the (+) ions or nuclei and the (delocalised) electrons (or implied)

Must be implied that the electrons are the delocalised ones not the electrons in the shells.

Accept converse arguments

1

[12]

M2. (a) Cross between the Na cross and the Mg cross

1

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

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

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

One mark for state symbols consequential on getting equation correct.

Electron does not have to have the – sign on it

Ignore (g) if put as state symbol with e^- but penalise state symbol mark if other state symbols on e^-

2

(c) 2nd/second/2/II

Only

1

(d) Paired electrons in (3)p orbital

Penalise wrong number
If paired electrons repel allow M2

1

repel

1

(e) Neon/Ne

No consequential marking from wrong element

1

$1s^2 2s^2 2p^6$/[He}$2s^2 2p^6$

Allow capital s and p
Allow subscript numbers

1

(f) Decreases

CE if wrong

1

Atomic radius increases/electron removed further from nucleus or nuclear charge/electron in higher energy level/Atoms get larger/more shells

Accept more repulsion between more electrons for M2
Mark is for distance from nucleus
Must be comparative answers from M2 and M3
CE M2 and M3 if mention molecules
Not more sub-shells

1

As group is descended more shielding

1

[11]

M3. (a) $2s^2 2p^6 3s^1$

$1s^2$ can be rewritten
Allow $2s^2 2p_x^2 2p_y^2 2p_z^2 3s^1$
Allow subscripts and capitals

1

(b) (i) Energy/enthalpy (needed) to remove one mole of electrons from one mole of atoms/compounds/molecules/elements

1

OR

Energy to form one mole of positive ions from one mole of atoms

OR

Energy/enthalpy to remove one electron from one atom

In the gaseous state (to form 1 mol of gaseous ions)

Energy given out loses M1
M2 is dependent on a reasonable attempt at M1
Energy needed for this change
$X(g) \rightarrow X^+(g) + e^{(-)}$ = 2 marks
This equation alone scores one mark

1

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

Do not penalise MG
Not equation with X

1

(iii) Electron being removed from a positive ion (therefore need more energy)/electron being removed is closer to the nucleus/Mg^+ smaller (than Mg)/Mg^+ more positive than Mg

Allow from a + particle/species
Not electron from a higher energy level/or higher sub-level
More protons = 0

1

(iv) Range from 5000 to 9000 kJ mol^{-1}

1

(c) Increase

If decrease CE = 0/3
If blank mark on

1

Bigger nuclear <u>charge</u> (from Na to Cl)/more <u>protons</u>

QWC

1

electron (taken) from same (sub)shell/similar or same shielding/
electron closer to the nucleus/smaller atomic radius

If no shielding = 0
Smaller ionic radius = 0

1

(d) Lower

If not lower CE = 0/3
If blank mark on
Allow does not increase

1

Two/pair of electrons in (3)p orbital or implied

Not 2p

1

repel (each other)

M3 dependent upon a reasonable attempt at M2

1

(e) Boron/B or oxygen/O/O_2

1

[13]

M4. (a) $2s^2\ 2p^6$;

If ignored the $1s^2$ given and written $1s^2 2s^2 2p^6$ mark as correct
Allow capitals and subscripts

1

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

One mark for equation and one mark for state symbols

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

M2 dependent on M1
Allow $Na^{+}(g) - e^{(-)} \rightarrow Na(g)$
Allow $X^{+}(g) \rightarrow X^{2+}(g) + e$ = 1 mark

2

(ii) $Na^{(2+)}$ requires loss of e^{-} from a 2(p) orbital or 2nd energy level or 2nd shell and $Mg^{(2+)}$ requires loss of e^{-} from a 3(s) orbital or 3rd energy level or 3rd shell / $Na^{(2+)}$ loses e from a lower (energy) orbital/ or vice versa;

Not from 3p

1

Less shielding (in Na);

Or vice versa for Mg

1

$e^{(-)}$ closer to nucleus/ more attraction (of electron to nucleus) (in Na);

M3 needs to be comparative

1

(iii) Aluminium /Al;

1

(c) Decreases;

If not decreases CE = 0
If blank, mark on

1

Increasing nuclear charge/ increasing number of protons;

1

Electrons in same shell or level/ same shielding/ similar shielding;

1

(d) Answer refers to Na;

Allow converse answers relating to Mg.

Na fewer protons/smaller nuclear charge/ fewer delocalised electrons;

Allow Mg is 2+ and Na is +.
If vdw CE = 0.

1

Na is a bigger ion/ atom;

1

Smaller attraction between nucleus and delocalised electrons;

If mentioned that charge density of Mg^{2+} is greater then allow first 2 marks.
(ie charge / size / attraction).
M3 allow weaker metallic bonding.

1

(e) (Bent) shape showing 2 lone pairs + 2N−H bond pairs;

Atoms must be labelled.
Lone pairs can be with or without lobes.

1

Bent / v shape/ triangular;

Not tetrahedral.
Allow non-linear.
Bent-linear = contradiction.

1

(f) Ne has full sub-levels/ can't get any more electrons in the sub-levels/ Ne has full shells;

Not $2s^2\ 2p^6$ alone.
Not stable electron configuration.

1

[16]

M1. (a) enthalpy/energy change/required when an electron is removed/ knocked out / displaced/ to form a uni-positive ion

(ignore 'minimum' energy)

1

from a gaseous atom

(could get M2 from a correct equation here)
(accept 'Enthalpy/energy change for the process...' followed by an appropriate equation, for both marks)
(accept molar definitions)

1

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

(accept capitals and subscripts)

1

(c) 's' block

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

1

(d) $Mg^+(g) \rightarrow Mg^{2+}(g) + e^-$ or

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

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

1

(e) Mg^{2+} ion smaller than Ne atom / Mg^{2+} e^- closer to nucleus

(Not 'atomic' radius fo Mg^{2+})

1

Mg^{2+} has more protons than Ne / higher nuclear charge or
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)**)*

1

(f) (i) trend: increases

(if 'decreases', CE = 0/3)

1

Expl^n: more protons / increased proton number / increased nuclear charge

(NOT increased atomic number)

1

same shell / same shielding / smaller size

1

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

1

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

1

[12]

M2. B

[1]

M3. (a) $2Al + 3CuCl_2 \rightarrow 2AlCl_3 + 3Cu$;
(accept multiples/fractions)

OR

$2Al + 3Cu^{2+} \rightarrow 2Al^{3+} + 3Cu$;

1

(b) (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 <u>3s</u> e^-s;

1

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

1

(d) trend: increases;

1

more protons / higher charge on cation / more delocalised e^{-} / smaller atomic/ionic radius;
stronger attraction between (cat)ions and delocalised/free/mobile e^{-}

1

OR

stronger metallic bonding;

1

[9]

M4. (a) (i) Energy/enthalpy (change)/ΔH/ needed to remove 1 mole of electrons;

Allow 1 electron
Not heat alone

1

From 1 mol of gaseous atoms;

From 1 gaseous atom
Not mix and match moles and one electron.
Allow 1 for balanced eq with ss

1

(ii) Increase;

If blank mark on
If incorrect CE = 0

1

Increasing nuclear charge/ increasing number of protons;

Not increasing atomic number

1

Same or similar shielding /same number of shells or energy

levels/ (atomic) radius decreases/electron closer to nucleus;

Not same distance from nucleus.

1

(iii) Aluminium/Al;

If incorrect CE = 0

1

Electron in higher energy /p or 3p orbital;

Not 2p
Ignore shielding

1

Less energy needed to lose electron/ electron more easily lost/ ionisation energy less;

1

(b) Silicon/Si;

If incorrect CE = 0
If silicone, silica Si_8, Si_4 mark on.

1

Macromolecular/ Giant molecular or atomic or covalent;

If IMFor ionic or metallic in Silicon then CE = 0 for explanation

1

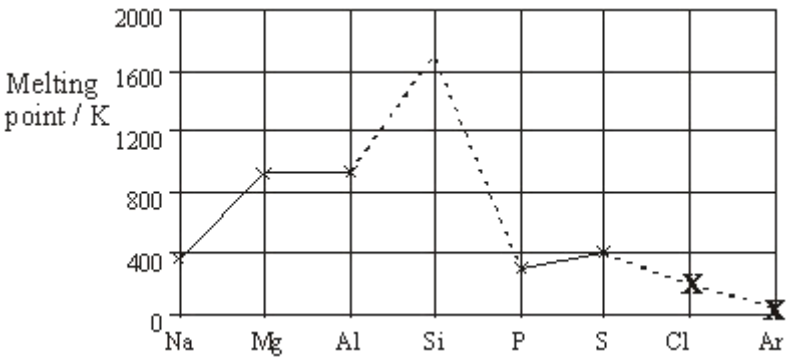
Many or strong covalent bonds need to be broken/ lots of energy needed to break the covalent bonds;

Not loosened bonds

1

[11]

M5. (a) (i)



M1 Si: cross ≥ 1200

1

M2 Cl: cross below S

1

M3 Ar: cross below Cl

[allow, even if M2 wrong)

[If Cl cross missing and Ar below S, allow M3]

1

(ii) Si is macromolecular/giant molecular/giant covalent/ giant atomic

1

Covalent bonds need to be broken/accept 'overcome'

[Not loosened/weakened]

1

Covalent bonds are strong / many covalent bonds involved/ requires much energy/hard to break

[Tied to 'break' or near miss in M2] [Not 'structure' is broken]

[Must mention 'covalent' somewhere in part (a)(ii) to earn M2/M3]

[If van der Waals'/IMF mentioned M2/M3 = CE = 0.

[If ions mentioned M1/M2/M3 = CE = 0]

1

(iii) Intermolecular force = van der Waals'/induced dipole–dipole/dispersion forces

1

QoL Sulphur has greater M_r / size / surface area/more electrons/more atoms **so** stronger intermolecular forces (comparison)

[Mark separately] [Not 'more shells']

1

(b) Trend: Decreases

[If trend wrong = CE = 0]

1

Increase in size of ion/atom / more shells / decrease in charge density / decrease in charge size ratio

1

Weaker attraction for delocalised/free/sea of electrons / weaker metallic bonding

[Ignore shielding]

[van der Waals' etc. = CE = 0 for M2 and M3]

1

[11]

M6. (a) Outer electrons are in p orbitals

1

(b) decreases

1

Number of protons increases

1

Attracting outer electrons in the same shell (or similar shielding)

1

(c) Sulfur molecules (S_8) are larger than phosphorus (P_4)

1

Therefore van der Waals' forces between molecules are stronger

1

Therefore more energy needed to loosen forces between molecules

1

(d) Argon particles are single atoms with electrons closer to nucleus

1

Cannot easily be polarised (or electron cloud not easily distorted)

1

[9]

M1. (a) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$ **(1)**

Allow subscripted electron numbers

(ii) p (block) **(1)**

Allow upper or lower case 's' and 'p' in (a)(i) and (a)(ii)

2

(b) Lattice of metal / +ve ions/ cations / atoms **(1)**

Not +ve nuclei/centres

Accept regular array/close packed/tightly packed/uniformly arranged

(Surrounded by) <u>delocalised</u> electrons **(1)**

Note: Description as a 'giant ionic lattice' = CE

2

(c) Greater nuclear or ionic charge or more protons **(1)**

Smaller atoms / ions **(1)**

Accept greater charge density for either M1 or M2

More delocalised electrons / e^- in sea of e^- / free e^- **(1)**

Stronger attraction between ions and delocalised / free electrons etc. **(1)**

Max 3

Note: 'intermolecular attraction/ forces' or covalent molecules = CE

Accept stronger 'electrostatic attraction' if phrase prescribed elsewhere
Ignore references to m/z values
If Mg or Na compared to Al, rather than to each other, then: ***Max 2***
*Treat description that is effectively one for Ionisation Energy as a '**contradiction**'*

3

(d) (Delocalised) electrons **(1)**

Move / flow in a given direction (idea of moving non-randomly) **or** under the influence applied pd *QoL mark* **(1)**

Allow 'flow through metal'

Not: 'Carry the charge'; 'along the layers'; 'move through the metal'

2

[9]

M2. (a) Elements in the p block have their outer electron(s) in p orbital(s) or levels or sub-shells **(1)**
example of element **(1)**
correct electronic configuration **(1)**

3

(b) Pattern in the change in the properties of a row of elements **(1)**
OR Trend in the properties of elements across a period

Repeated in the next row **(1)**
OR element underneath (or in same group) has similar properties

atomic radius
decreases across the row **(1)**
CE if trend is wrong

number of protons increases **(1)** (or nuclear charge increases)
more attraction for electrons in the same shell **(1)**

electronegativity
increases across the row **(1)**
number of protons increases **(1)** (or nuclear charge)
atomic radius decreases **(1)** (or shielding remains the same or electrons in the same shell) more attraction for bonding or shared electrons **(1)**

conductivity
decreases row **(1)**
OR significant drop from Al to Si

Na–Al metals **(1)**

OR metallic bonding or description of metallic bonding

Two of Si - Ar non metals **(1)**

OR molecular or covalent

EITHER electrons free to move (or delocalised) in metals
OR electrons unable to move in non-metals **(1)**

13

[16]

M3. (a) Ability (or power) of an atom to attract electron density
(or electrons or - ve charge) **(1)**
in a covalent bond **(1)**

or shared pair
If remove an electron lose first mark

2

(b) *Trend:* increases **(1)**
Explanation: nuclear charge (number of protons) increases **(1)**
electrons in same shell **(1)**

OR similar shielding
OR atoms similar size or smaller
OR 1 mol of e^-

3

(c) 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

(d) (i) 2 **(1)**

(ii) <u>Two elements</u> (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

For second mark idea of block of 3 elements

5

[12]

M4. (a) (i) Deductions:

Ionic **(1)**
Ions not free to move in the solid state **(1)**
Ions free to move when molten or in aqueous solution **(1)**
Identity of **P**: Na_2O or sodium oxide **(1)**

N.B. If a formula given this must be correct

Equation: $Na_2O + H_2O \rightarrow 2\ NaOH$ **(1)**

5

(ii) Deductions:

Covalent
Intermolecular forces are weak or van der Waals forces,
or dipole-dipole

N.B. Any answer including a reference to hydrogen bonding is incorrect

Identity of **Q**: SO_2 or sulphur dioxide **(1)**

Equation: $SO_2 + H_2O \rightarrow H_2\ SO_3$ **(1)**

NB Allow max one for SO_3

4

(b) (i) Amphoteric **(1)**

(ii) Equation with NaOH

$Al(OH)_3 + NaOH \rightarrow NaAl(OH)_4$

OR $Al(OH)_3(H_2O)_3 + OH^- \rightarrow [Al(OH)_4(H_2O)_2]^- + H_2O$
OR $Al(OH)_3 + OH^- \rightarrow [Al(OH)_4]^-$

R identified as $Al(OH)_3$ or $Al(OH)_3(H_2O)_3$ **(1)**

A balanced equation **(1)**

N.B. Allow equation with six co-ordinate Aluminium and up to six OH^- ligands
N.B. Allow equation mark if $M(OH)_3$ given in a balanced equation

Equation with H_2SO_4

$2Al(OH)_3 + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 6H_2O$

OR $Al(OH)_3(H_2O)_3 + H^+ \rightarrow [Al(OH)_2(H_2O)_4]^+ + H_2O$

NB Allow equations with six co-ordinate Aluminium and up to six H_2O ligands NB Allow equation mark if $M(OH)_3$ given in a balanced equation

Correct Al species as product **(1)**
A balanced equation **(1)**

(iii) Large lattice energy
or strong covalent bonds
or ΔH_{soln} is very positive
or ΔG is positive
or sum of hydration energies less than covalent bond energies **(1)**

6

[15]