M1. (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]

M2.   (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 <u>gaseous</u> atom
(could get M2 from a correct equation here)

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*(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)   <u>Mg^{2+}</u> ion smaller than Ne atom / Mg^{2+} e⁻ closer to nucleus
(Not '<u>atomic</u>' radius fo Mg^{2+})

1

<u>Mg^{2+}</u> has more protons than Ne / higher nuclear charge or
e⁻ <u>is removed</u> from a charged Mg^{2+}ion / neutral neon atom
(accept converse arguments)
*(If used 'It' or Mg/magnesium/Mg^{3+} etc. & <u>2</u> 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
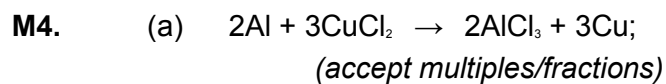*(penalise if wrong shell, e.g. '2p', quoted)*

1

repulsion between the e- in this e-pair

(if not stated, 'e- pair' must be clearly implied)
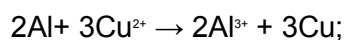
(mark M4 and M5 separately)

1

[12]

M3. A

[1]

M4. (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

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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]

M5. D

[1]

M6.   (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 <u>and</u> $Mg^{(2+)}$ 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

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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 few<u>er</u> protons/small<u>er</u> nuclear charge/ fewer delocalised electrons;

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

1

Na is a bigg<u>er</u> ion/ atom;

1

Small<u>er</u> attraction between nucleus and delocalised electrons;

If mentioned that charge density of Mg^{2+} is great<u>er</u> then allow first 2 marks.
(ie charge / size / attraction).
M3 allow weak<u>er</u> 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

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(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]