1

(a) Chloride (ions) are smaller (than bromide ions)

Must state or imply ions.

Allow chloride has greater charge density (than bromide).

Penalise chlorine ions once only (max 2 / 3).

1

So the force of attraction between chloride ions and water is stronger

This can be implied from M1 and M3 but do not allow intermolecular forces.

1

Chloride ions attract the δ+ on H of water / electron deficient H on water

Allow attraction between ions and polar / dipole water.

*Penalise H^+ (ions) and mention of hydrogen bonding for **M3***

Ignore any reference to electronegativity.

Note: If water not mentioned can score M1 only.

1

(b) $\Delta H_{solution} = \Delta H_L + \Delta H_{hyd}\ K^+$ ions $+ \Delta H_{hyd}\ Br^-$ ions / = 670 − 322 − 335

Allow $\Delta H_{solution} = \Delta H_L + \Sigma \Delta H_{hyd}$

1

= (+)13 (kJ mol^{-1})

Ignore units even if incorrect.

+13 scores M1 and M2

−13 scores 0

−16 scores M2 only (transcription error).

1

(c) (i) The entropy change is positive / entropy increases

ΔS is negative loses M1 and M3

1

Because 1 mol (solid) → 2 mol (aqueous ions) / no of particles increases

Allow the aqueous ions are more disordered (than the solid).

Mention of atoms / molecules loses M2

1

Therefore $\underline{T\Delta S > \Delta H}$

1

(ii) Amount of KCl = $5/M_r = 5/74.6 = \underline{0.067(0)\ mol}$

If moles of KCl not worked out can score M3, M4 only (answer to M4 likely to be 205.7 K)

1

Heat absorbed = 17.2 × 0.0670 = 1.153 kJ

Process mark for M1 × 17.2

1

Heat absorbed = mass × sp ht × Δ*T*

(1.153 × 1000) = 20 × 4.18 × Δ*T*

If calculation uses 25 g not 20, lose M3 only (M4 = 11.04, M5 = 287)

1

Δ*T* = 1.153 × 1000 / (20 × 4.18) = 13.8 K

If 1000 not used, can only score M1, M2, M3

M4 is for a correct ΔT

Note that 311.8 K scores 4 (M1, M2, M3, M4).

1

T = 298 − 13.8 = 284(.2) K

If final temperature is negative, M5 = 0

Allow no units for final temp, penalise wrong units.

1

[13]

2 (a) $MgCl_2(s) \rightarrow Mg^{2+}(g) + 2Cl^-(g)$

1

(b) The magnesium <u>ion</u> is smaller / has a smaller radius / greater charge density (than the calcium ion)

If not ionic or if molecules / IMF / metallic / covalent / bond pair / electronegativity mentioned, CE = 0

1

Attraction between ions / to the chloride ion stronger

Allow ionic bonds stronger

Do not allow any reference to polarisation or covalent character

Mark independently

1

(c) The oxide ion has a greater charge / charge density than the chloride ion

If not ionic or if molecules / IMF / metallic / covalent / bond pair mentioned, CE = 0

Allow oxide ion smaller than chloride ion

1

So it attracts the magnesium ion more strongly

Allow ionic bonds stronger

Mark independently

1

(d) $\Delta H_{solution} = \Delta H_L + \Sigma\Delta H_{hyd}$ Mg^{2+} ions + $\Sigma\Delta H_{hyd}$ Cl^- ions

Allow correct cycle

1

$-155 = 2493 + \Delta H_{hyd}$ Mg^{2+} ions $- 2 \times 364$

ΔH_{hyd} Mg^{2+} ions $= -155 - 2493 + 728$

1

$= -1920$ (kJ mol^{-1})

Ignore units

Allow max 1 for +1920

Answer of + or −1610, CE = 0

Answer of −2284, CE = 0

1

(e) Water is polar / O on water has a delta negative charge

Allow O (not water) has lone pairs (can score on diagram)

1

Mg^{2+} ion / $^{+}$ve ion / + charge attracts (negative) O on a water molecule

Allow Mg^{2+} attracts lone pair(s)

M2 must be stated in words (QoL)

Ignore mention of co-ordinate bonds

CE = 0 if O^{2-} or water ionic or H bonding

1

(f) Magnesium oxide reacts with water / forms $Mg(OH)_2$

Allow MgO does not dissolve in water / sparingly soluble / insoluble

1

[11]

3

(a) Enthalpy change/heat energy change when one mole of gaseous atoms

Allow explanation with an equation that includes state symbols

1

Form (one mole of) gaseous negative ions (with a single charge)

If ionisation/ionisation energy implied, CE=0 for both marks

Ignore conditions

1

(b) Fluorine (atom) is smaller than chlorine/shielding is less/ outer electrons closer to nucleus

Fluorine molecules/ions/charge density CE=0 for both marks

1

(Bond pair of) electrons attracted more strongly to the nucleus/protons

1

(c) Fluoride (ions) smaller (than chloride) / have larger charge density

Any reference to electronegativity CE=0

1

So (negative charge) attracts (δ+ hydrogen on) water more strongly

Allow H on water, do not allow O on water

Allow F^- hydrogen bonds to water, chloride ion does not

Mark independently

1

(d) (i) ΔH(solution) = LE + Σ(hydration enthalpies) / correct cycle

AgF_2 or other wrong formula CE = 0

Ignore state symbols in cycle

1

LE = -20 -(-464 + -506)

1

= (+) 950 kJ mol^{-1}

Ignore no units, penalise M3 for wrong units

-950 scores max 1 mark out of 3

990 loses M3 but M1 and M2 may be correct

808 is transfer error (AE) scores 2 marks

848 max 1 if M1 correct

1456 CE=0 (results from AgF_2)

1

(ii) There is an increase in the number of particles / more disorder / less order

Allow incorrect formulae and numbers provided number increases

Do not penalise reference to atoms/molecules

Ignore incorrect reference to liquid rather than solution

1

(iii) Entropy change is positive/entropy increases and enthalpy change negative/exothermic

1

So ΔG is (always) negative

1

[12]

4 (a) Enthalpy change when 1 mol of an (ionic) compound/lattice (under standard conditions)

Allow heat energy change

1

Is dissociated/broken/separated into its (component) ions

1

The ions being in the gaseous state (at infinite separation)

Mark independently. Ignore any conditions.

1

(b) There is an attractive force between the nucleus of an O atom and an external electron.

Allow any statement that implies attraction between the nucleus and an electron

1

(c) $Mg^{2+}(g) + O(g) + 2e^-$

Ignore lack of state symbols

Penalise incorrect state symbols

1

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

1

$Mg^{2+}(g) + O^{2-}(g)$

1

First new level for Mg^{2+} and O above last on L

If levels are not correct allow if steps are in correct order with arrows in the correct direction and correct ΔH values

1

Next level for Mg^{2+} and O^- below that

Next level for Mg^{2+} and O^{2-} above that and also above that for Mg^{2+} and O

Allow +124

Allow M4 with incorrect number of electrons

(d) LE MgO = 602 + 150 + 736 + 1450 + 248 – 142 + 844

Note use of 124 instead of 248 CE=0

1

= +3888 kJ mol^{-1}

Allow 1 for –3888

Allow no units

Penalise wrong units

1

(e) Forms a protective layer/barrier of MgO / MgO prevents oxygen attacking Mg

Allow activation energy is (very) high

Allow reaction (very) slow

1

(f) $\Delta G = \Delta H - T\Delta S$

$$\Delta S = \frac{(\Delta H - \Delta G)}{T}$$

1

$\Delta S = (–602 – (–570)) \times 1000/ 298$

1

= –107 J K^{-1} mol^{-1} / –0.107 kJ K^{-1} mol^{-1}

If units not correct or missing, lose mark

Allow –107 to –108

+107 with correct units scores max 1/3

1

(g) 1 mol of solid and 0.5 mol of gas reactants form 1 mol solid products

Decrease in number of moles (of gas/species)

Allow gas converted into solid

Numbers of moles/species, if given, must be correct

1

System becomes more ordered

Allow consequential provided ΔS is –ve in 1(f)

If ΔS is +ve in 1(f) can only score M1

1

[16]

5

(a) Standard pressure (100 kPa) (and a stated temperature)

Allow standard conditions. Do not allow standard states

Allow any temperature

Allow 1 bar but not 1atm

Apply list principle if extra wrong conditions given

Penalise reference to concentrations

1

(b) Hydrogen bonds between water molecules

1

Energy must be supplied in order to break (or loosen) them

Allow M2 if intermolecular forces mentioned

Otherwise cannot score M2

CE = 0/2 if covalent or ionic bonds broken

1

(c) $T = \Delta H/\Delta S$

1

= (6.03 × 1000)/22.1

1

= 273 K

Allow 272 to 273; units K must be given
Allow 0°C if units given
0.273 (with or without units) scores 1/3 only
Must score M2 in order to score M3
Negative temperature can score M1 only

1

(d) The heat given out escapes

1

(e) (Red end of white) light (in visible spectrum) absorbed by ice

Allow complementary colour to blue absorbed

1

Blue light / observed light is reflected / transmitted / left

Penalise emission of blue light

1

[9]

6 (a) (i) (Enthalpy change for formation of) 1 mol (of CaF_2) from its ions

allow heat energy change
do not allow energy or wrong formula for CaF_2
penalise 1 mol of ions
CE=0 if atoms or elements or molecules mentioned
ignore conditions

1

ions in the gaseous state

ions can be mentioned in M1 to score in M2
allow fluorine ions
$Ca^{2+}(g) + 2F^-(g) \rightarrow CaF_2$ scores M1 and M2

1

(ii) (enthalpy change when) 1 mol of gaseous (fluoride) ions (is converted) into aqueous ions / an aqueous solution

allow $F^-(g) \rightarrow F^-(aq)$ (ignore + aq)
do not penalise energy instead of enthalpy
allow fluorine ions
do not allow F^- ions surrounded by water

1

(b) water is polar / H on water is $\delta+$ / is electron deficient / is unshielded

1

penalise H^+ on water 1 mark

(F^- ions) attract water / $\delta+$ on H / hydrogen

allow H on water forms H-bonds with F^-

allow fluorine ions

penalise co-ordinate bonds for M2

penalise attraction to O for M2

1

(c) $\Delta H = -(-2611) - 1650 + 2x - 506$

ignore cycles

M1 is for numbers and signs correct in expression

1

$= -51$ (kJ mol^{-1})

correct answer scores 2

ignore units even if incorrect

1

[7]

7 (a) Enthalpy change for the formation of 1 mol of gaseous atoms

allow heat energy change for enthalpy change

1

From the element (in its standard state)

ignore reference to conditions

1

Enthalpy change to separate 1 mol of an ionic lattice/solid/compound

enthalpy change not required but penalise energy

1

Into (its component) gaseous ions

mark all points independently

1

(b) $\Delta H_L = {}^{-}\Delta H_f + \Delta H_a$ + I.E. + 1/2E(Cl-Cl) + EA

Or correct Born-Haber cycle drawn out

1

= +411 + 109 + 494 + 121 – 364

1

= +771 (kJ mol^{-1})

–771 scores 2/3

+892 scores 1/3

–51 scores 1/3

–892 scores zero

+51 scores zero *ignore units*

1

(c) (i) Ions are perfect spheres (or point charges)

1

Only electrostatic attraction/no covalent interaction

mention of molecules/intermolecular forces/covalent bonds CE = 0

allow ionic bonding only

If mention of atoms CE = 0 for M2

1

(ii) Ionic

Allow no covalent character/bonding

1

(iii) Ionic with additional covalent bonding

Or has covalent character/partially covalent

Allow mention of polarisation of ions or description of polarisation

1

[11]