M1.(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) $\Delta G = \Delta H - T\Delta S$

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

    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

System becomes more ordered

Allow consequential provided ∆S is –ve in 1(f)
If ∆S is +ve in 1(f) can only score M1

[16]

M2. (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

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

(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

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

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]

M3.   (a)   <u>Enthalpy change</u> for the formation of <u>1 mol</u> of <u>gaseous atoms</u>
allow <u>heat energy change</u> for <u>enthalpy change</u>

1

From the <u>element</u> (in its standard state)
ignore reference to conditions

1

Enthalpy change to separate <u>1 mol</u> of an <u>ionic</u> lattice/solid/compound
enthalpy change not required but penalise energy

1

Into (its component) <u>gaseous ions</u>
mark all points independently

1

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

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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
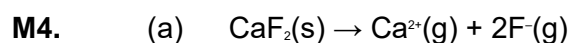*Allow no covalent character/bonding*

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]

M4. (a) $CaF_2(s) \rightarrow Ca^{2+}(g) + 2F^-(g)$

1

(b) (i) Enthalpy change for formation of 1 mol of substance
Allow heat energy change, NOT energy

1

From its elements

1

Reactants and products/all substances in their standard states
Or normal states at 298 K, 1 bar (100 kPa)

1

(ii) $Ca(s) + F_2(g) \rightarrow CaF_2(s)$

1

(iii) $\Delta H_f(CaF_2) = \Delta H_a(Ca) + 1st\ IE(Ca) + 2^{nd}\ IE(Ca) + BE(F_2) +$
          $2 \times EA(F) - \Delta H_L(CaF_2)$
              Or labelled diagram

1

          $= 193 + 590 + 1150 + 158 + (2 \times -348) - 2602$

1

          $= -1207\ kJ\ mol^{-1}$
              Correct answer scores 3
              -842 scores 2 (transfer error)
              -859 scores 1 only (using one E.A.)
              Units not required, wrong units lose 1 mark

1

(c)   Electrostatic attraction stronger/ionic bonding stronger/attraction
        between ions stronger/more energy to separate ions
              Molecular attraction/atoms/intermolecular forces CE=0

1

        Because fluoride (ion) smaller than chloride
              Do not allow F or fluorine

1

(d)   (i) $\Delta H = \Delta H_L + \Sigma\Delta H_{hyd} = 2237 - 1650 + (2 \times -364)$
                  Can be on cycle/diagram

1

                $= -141\ kJ\ mol^{-1}$
                  Correct answer scores 2
                  Units not required, wrong units lose 1 mark

1

        (ii)   Decreases
                  If ans to (d)(i) positive allow increases

1

                Reaction exothermic/ΔH –ve
                  If (d)(i) +ve allow endothermic/ΔH + ve

1

                (Equilibrium) shifts to left/backwards
                (as temperature rises)/equilibrium

opposes the change

*If (d) (i) +ve allow shifts to right/forwards/equilibrium opposes
the change*

If no answer to (d) (i) assume −ve ΔH used
*If effect deduced incorrectly from any ΔH CE = 0 for these 3
marks*

1

(e)   u.v. absorbed: electrons/they move to higher energy
(levels)/electrons excited

1

visible light given out: electrons/they fall back down/move to
lower energy (levels)

*Must refer to absorbing u.v. NOT visible light or this must be
implied.*

1

[17]