

Solutions

Original marking guidance: M1 method, A1 accuracy, B1 explanation.

2.1 Enthalpy change when one mole of ionic solid forms from its gaseous ions under stated standard conditions.

2.2 $\Delta H_{sol} = +850 - 820 = +30 \text{ kJ mol}^{-1}$.

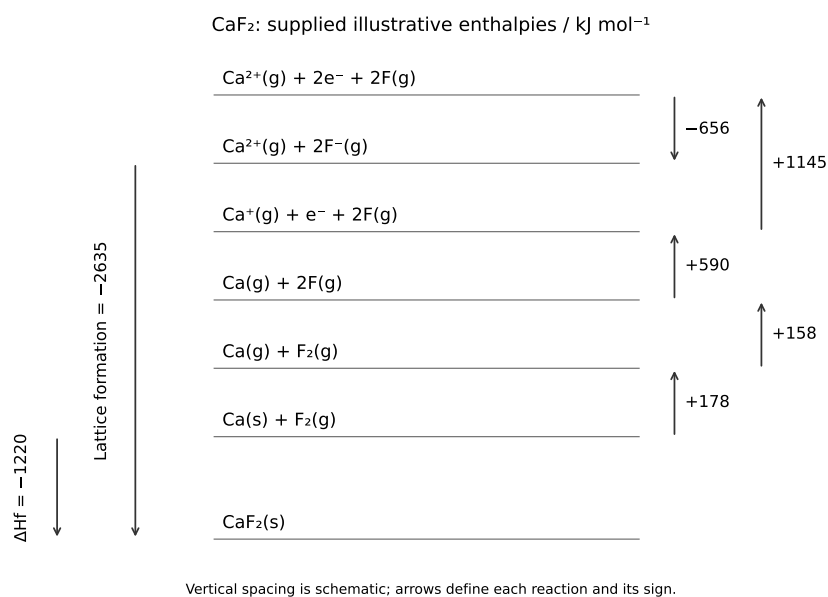
2.3 An electron approaches an already negative O^- ion; energy is needed to overcome electron-ion repulsion.

3.1 $-642 = 148 + 2(121) + 738 + 1451 + 2(-349) + \Delta H_{latt}$. Other steps sum to 1881, giving $\Delta H_{latt} = -2523 \text{ kJ mol}^{-1}$.

3.2 Extra stabilisation can support covalent character, from cation polarisation of anion electron density. Dissolution also involves entropy, so enthalpy alone does not determine the total entropy change.

3.3 For A, $\Delta H_{sol} = 2500 - 2510 = -10 \text{ kJ mol}^{-1}$; for B, $2450 - 2420 = +30 \text{ kJ mol}^{-1}$. A: $\Delta S_{total} = 40 - (-10000/298) = +73.6 \text{ J mol}^{-1} \text{ K}^{-1}$. B: $40 - 30000/298 = -60.7 \text{ J mol}^{-1} \text{ K}^{-1}$. A has favourable positive total entropy; hydration and lattice terms compete and entropy must also be included. These are illustrative data, not measured values assigned to named salts.

3.4 A complete construction is shown below. Ca atomisation contributes +178 and two fluorine atomisations +158 with correct gaseous-atom states. Both calcium ionisations contribute +590 +1145, with $\text{Ca}^+/\text{Ca}^{2+}$ and one/two electrons correctly shown. Two electron affinities contribute -656 and produce two gaseous F^- ions. The formation arrow goes from $\text{Ca(s)} + \text{F}_2(\text{g})$ to $\text{CaF}_2(\text{s})$, -1220; lattice formation goes from $\text{Ca}^{2+}(\text{g}) + 2\text{F}^-(\text{g})$ to the solid. Hess route: $-1220 = 178 + 2(79) + 590 + 1145 + 2(-328) + \Delta H_{latt}$, hence $\Delta H_{latt} = -2635 \text{ kJ mol}^{-1}$. Accept an equivalent complete cycle with directions and signs consistent.



3.5 Hydration: $\text{Cl}^-(\text{g}) \rightarrow \text{Cl}^-(\text{aq})$, for one mole of gaseous chloride ions under stated

standard conditions. Solution: $\text{MgCl}_2(\text{s}) \rightarrow \text{Mg}^{2+}(\text{aq}) + 2\text{Cl}^{-}(\text{aq})$, for one mole of solid in sufficient water that further dilution causes no enthalpy change, under stated standard conditions. The cycle separates the lattice to $\text{Mg}^{2+}(\text{g}) + 2\text{Cl}^{-}(\text{g})$, +2523, then hydrates one Mg^{2+} and two Cl^{-} ions. Total hydration = $-1920 + 2(-381) = -2682 \text{ kJ mol}^{-1}$. The solution arrow and indirect route have matching initial/final species and signs, giving $\Delta H_{\text{sol}} = 2523 - 2682 = -159 \text{ kJ mol}^{-1}$.

