Question number	Answer	Marks	Guidance
1 (a) (i)	(At 0 K) particles are stationary / not moving / not vibrating No disorder / perfect order / maximum order	1 1	Allow have zero energy. Ignore atoms / ions. Mark independently.
1 (a) (ii)	As *T* increases, particles start to move / vibrate Disorder / randomness increases / order decreases	1 1	Ignore atoms / ions. Allow have more energy. If change in state, CE = 0
1 (a) (iii)	Mark on temperature axis vertically below second 'step'	1	Must be marked as a line, an 'x', *Tb* or 'boiling point' on the temperature axis.
1 (a) (iv)	L_2 corresponds to boiling / evaporating / condensing / l → g / g → l And L_1 corresponds to melting / freezing / s →l / l →s Bigger change in disorder for L_2 / boiling compared with L_1 / melting	1 1	There must be a clear link between L_1, L_2 and the change in state. M2 answer must be in terms of changes in state and not absolute states, for example, must refer to change from liquid to gas not just gas. Ignore reference to atoms even if incorrect.
1 (b) (i)	$\Delta G = \Delta H - T\Delta S$ $\Delta H = c$ and $(-)\Delta S$ = m / ΔH and ΔS are constants (approx)	1 1	 Allow ΔH is the intercept, and $(-)\Delta S$ is the slope / gradient. Can only score M2 if M1 is correct.
1 (b) (ii)	Because the entropy change / ΔS is positive / $T\Delta S$ gets bigger	1	Allow $-T\Delta S$ gets more negative.
1 (b) (iii)	Not feasible / unfeasible / not spontaneous	1	
1 (c) (i)	+ 44.5 J K^{-1} mol^{-1}	1	Allow answer without units but if units given they must be correct (including mol^{-1})

1 (c) (ii)	At 5440 $\Delta H = T\Delta S$ = 5440 × 44.5 = 242 080 (OR using given value = 5440 × 98 = 533 120) ΔH = 242 kJ mol^{-1} (OR using given value ΔH = 533 kJ mol^{-1})	1 1 1	 Mark is for answer to (c)(i) × **5440** Mark is for correct answer to M2 with correct units (J mol^{-1} or kJ mol^{-1}) linked to answer. If answer consequentially correct based on (c)(i) except for incorrect sign (e.g., −242), max 1/3 provided units are correct.
2 (a)	$\Delta G = \Delta H - T\Delta S$		Ignore ⊖
2 (b)	0.098 or 98 kJ K^{-1} mol^{-1} J K^{-1} mol^{-1} $-\Delta S/\Delta S$	1 1 1	Allow 0.097 to 0.099/97 to 99 Allow 0.1 only if 0.098 shown in working Allow in any order Unless slope is approx. 100(90-110) accept only kJ K^{-1} mol^{-1}. If no slope value given, allow either units
2 (c)	ΔG becomes negative So reaction becomes spontaneous/feasible	1 1	Mark independently unless ΔG positive then CE= 0 Or reaction can occur below this temperature Or reaction is not feasible above this temperature
2 (d)	Ammonia liquefies (so entropy data wrong/different)	1	Allow any mention of change in state or implied change in state even if incorrect For example, freezing/boiling
3 (a)	Enthalpy change when 1 mol of an (ionic) compound/lattice (under standard conditions) Is dissociated/broken/separated into its (component) ions The ions being in the gaseous state (at infinite separation)	1 1 1	Allow heat energy change Mark independently. Ignore any conditions.

3 (b)	There is an attractive force between the nucleus of an O atom and an external electron.	1	Allow any statement that implies attraction between the nucleus and an electron
3 (c)	$Mg^{2+}(g) + O(g) + 2e^-$ $Mg^{2+}(g) + O^-(g) + e$ $Mg^{2+}(g) + O^{2-}(g)$ First new level for Mg^{2+} and O above last on L 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	1 1 1 1	Ignore lack of state symbols Penalise incorrect state symbols If levels are not correct allow if steps are in correct order with arrows in the correct direction and correct ΔH values Allow +124 Allow M4 with incorrect number of electrons
3 (d)	LE MgO = 602 + 150 + 736 + 1450 + 248 − 142 + 844 = +3888 kJ mol^{-1}	1 1	Note use of 124 instead of 248 CE=0 Allow 1 for -3888 Allow no units Penalise wrong units
3 (e)	Forms a protective layer/barrier of MgO / MgO prevents oxygen attacking Mg	1	Allow activation energy is (very) high Allow reaction (very) slow
3 (f)	$\Delta G = \Delta H - T\Delta S$ ΔS = (−602 − (−570)) × 1000 / 298 = −107 J K^{-1} mol^{-1} / −0.107 kJ K^{-1} mol^{-1}	1 1 1	$\Delta S = (\Delta H - \Delta G) / T$ If units not correct or missing, lose mark Allow −107 to −108 +107 with correct units scores max 1/3
3 (g)	1 mol of solid and 0.5 mol of gas reactants form 1 mol solid products System becomes more ordered	1 1	Decrease in number of moles (of gas/species) Allow gas converted into solid Numbers of moles/species, if given, must be correct Allow consequential provided ΔS is negative in 1(f) If ΔS is positive in 1(f) can only score M1