

Question number	Answer	Marks	Guidance
1 (a) (i)	(At 0 K) particles are stationary / not moving / not vibrating	1	Allow have zero energy. Ignore atoms / ions.
	No disorder / perfect order / maximum order	1	Mark independently.
1 (a) (ii)	As $T$ increases, particles start to move / vibrate	1	Ignore atoms / ions. Allow have more energy. If change in state, CE = 0
	<u>Disorder / randomness</u> increases / order decreases	1	
1 (a) (iii)	Mark <u>on temperature axis</u> vertically below second 'step'	1	Must be marked as a line, an 'x', $T_b$ or 'boiling point' <u>on the temperature axis</u> .
1 (a) (iv)	$L_2$ corresponds to boiling / evaporating / condensing / $l \rightarrow g / g \rightarrow l$ And $L_1$ corresponds to melting / freezing / $s \rightarrow l / l \rightarrow s$	1	There must be a clear link between $L_1$ , $L_2$ and the change in state.
	Bigger change in <u>disorder</u> for $L_2$ / boiling compared with $L_1$ / melting	1	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)	$\Delta G = \Delta H - T\Delta S$	1	
	$\Delta H = c$ and $(-)\Delta S = m / \Delta H$ and $\Delta S$ are constants (approx)	1	Allow $\Delta H$ 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 / $\Delta S$ is positive / $T\Delta S$ gets bigger	1	Allow $-T\Delta S$ gets more negative.
1 (b) (iii)	<u>Not</u> feasible / <u>un</u> feasible / <u>not</u> spontaneous	1	
1 (c) (i)	$+ 44.5 \text{ J K}^{-1} \text{ mol}^{-1}$	1	Allow answer without units but if units given they must be correct (including $\text{mol}^{-1}$ )

1 (c) (ii)	At 5440 $\Delta H = T\Delta S$	1	Mark is for answer to (c)(i) $\times$ <b>5440</b>
	$= 5440 \times 44.5 = 242\,080$ (OR using given value $= 5440 \times 98 = 533\,120$ )	1	
	$\Delta H = 242 \text{ kJ mol}^{-1}$ (OR using given value $\Delta H = 533 \text{ kJ mol}^{-1}$ )	1	
2 (a)	$\Delta G = \Delta H - T\Delta S$	1	Ignore $\ominus$
2 (b)	0.098      or      98	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 $\text{kJ K}^{-1} \text{ mol}^{-1}$ . If no slope value given, allow either units
	$\text{kJ K}^{-1} \text{ mol}^{-1}$ $\text{J K}^{-1} \text{ mol}^{-1}$	1	
	$-\Delta S/\Delta S$	1	
2 (c)	$\Delta G$ becomes negative	1	Mark independently unless $\Delta G$ positive then CE= 0  Or reaction can occur below this temperature Or reaction is not feasible above this temperature
	So reaction becomes spontaneous/feasible	1	
2 (d)	Ammonia liquefies (so entropy data wrong/different)	1	Allow any mention of <u>change</u> in state or implied change in state even if incorrect For example, freezing/boiling
3 (a)	<u>Enthalpy change</u> when <u>1 mol</u> of an (ionic) compound/lattice (under standard conditions)	1	Allow heat energy change  Mark independently. Ignore any conditions.
	Is dissociated/broken/separated into its (component) ions	1	
	The ions being in the <u>gaseous</u> state (at infinite separation)	1	

3 (b)	There is an <u>attractive</u> force between the <u>nucleus</u> of an O atom and an external <u>electron</u> .	1	Allow any statement that implies attraction between the nucleus and an electron
3 (c)	$\text{Mg}^{2+}(\text{g}) + \text{O}(\text{g}) + 2\text{e}^{-}$  $\text{Mg}^{2+}(\text{g}) + \text{O}^{-}(\text{g}) + \text{e}$  $\text{Mg}^{2+}(\text{g}) + \text{O}^{2-}(\text{g})$  First new level for $\text{Mg}^{2+}$ and O above last on L Next level for $\text{Mg}^{2+}$ and $\text{O}^{-}$ below that Next level for $\text{Mg}^{2+}$ and $\text{O}^{2-}$ above that and also above that for $\text{Mg}^{2+}$ 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 $\Delta H$ values Allow +124 Allow M4 with incorrect number of electrons
3 (d)	$\text{LE MgO} = 602 + 150 + 736 + 1450 + 248 - 142 + 844$  $= +3888 \text{ kJ mol}^{-1}$	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)	$\Delta G = \Delta H - T\Delta S$  $\Delta S = (-602 - (-570)) \times 1000 / 298$  $= -107 \text{ J K}^{-1} \text{ mol}^{-1} / -0.107 \text{ kJ K}^{-1} \text{ mol}^{-1}$	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 $\Delta S$ is negative in 1(f) If $\Delta S$ is positive in 1(f) can only score M1