

Answers to examination-style questions

Answers	Marks	Examiner's tips
1 a) $1s^2 2s^2 2p^6 3s^2 3p^6$	1	
b) $S^-(g)$		The state symbol must be included.
c) The negative $S^-$ ion repels the electron being added.	2	
d) i) enthalpy of atomisation of sulfur ii) second ionisation enthalpy of calcium iii) second electron affinity of sulfur	3	Learn what the steps are called in a Born–Haber cycle and the equations to go with each step.
e) The electron is more strongly attracted to the nucleus or to the $Ca^+$ ion.	2	
f) $+178 + 279 + 590 + 1145 - 200 + \Delta H^\circ - 3013 + 482 = 0$ $\Delta H^\circ = 539 \text{ kJ mol}^{-1}$	2	If you get this the wrong way round, there is a penalty. Allow one mark for $-539 \text{ kJ mol}^{-1}$ . If you have put all the numbers in the right place and made an arithmetic error, then you could possibly get the two marks.
2 a) Particles are in a maximum state of order.	1	Accept: no disorder or that entropy is zero at 0 K by definition.
b) Ice melts.	1	Accept the reverse, i.e. water freezes. Accept water changes from solid to liquid or from liquid to solid.
c) The increase in disorder is bigger at $T_2$ .	2	
d) i) Moles of water = $\frac{1.53}{18} = 0.085$ Heat change per mole = $\frac{3.49}{0.085} = 41.1 \text{ kJ mol}^{-1}$ ii) $\Delta G = \Delta H - T\Delta S$ iii) $\Delta H = T\Delta S$ $\Delta S = \frac{41.1}{373} = 0.110 \text{ kJ K}^{-1} \text{ mol}^{-1}$ or $110 \text{ JK}^{-1} \text{ mol}^{-1}$	6	This is an endothermic change so the heat change is +. If you put a – sign in your answer this will be penalised.  If the alternative data of $45 \text{ kJ mol}^{-1}$ was used, the answer is $0.12 \text{ kJ K}^{-1} \text{ mol}^{-1}$ . One mark is awarded for the value and one for the units.

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<p>3 a) i)</p> <p>ii)</p> $\Delta H_a^\circ(\text{Ba}) + 1\text{st IE}(\text{Ba}) + 2\text{nd IE}(\text{Ba}) + 2\Delta H_a^\circ(\text{Cl}) + 2\text{EA}(\text{Cl}) + \text{LE} - \Delta H_f^\circ(\text{BaCl}_2) = 0$ $+180 + 503 + 965 + (2 \times 122) + 2\text{EA}(\text{Cl}) - 2056 + 859 = 0$ $\text{EA} = -\frac{695}{2} = -347.5$	9	<p><math>\Delta H_a^\circ</math> = enthalpy of atomisation</p> <p><math>\Delta H_{\text{sub}}^\circ</math> = enthalpy of sublimation i.e. solid to gas <math>H</math></p> <p><math>\Delta H_f^\circ</math> = enthalpy of formation</p> <p>EA = electron affinity</p> <p>IE = ionisation energy</p> <p>In this Born–Haber cycle the Ba has a first and a second ionisation energy</p> <p>In this type of calculation there is a one mark penalty for each error. Keep going and gain as many marks as possible.</p>
<p>b) <math>\Delta S = \Sigma S \text{ products} - \Sigma S \text{ reactants}</math></p> $= 63 + 223 - 124 = 162$ $\Delta G = \Delta H - T\Delta S$ <p>or since <math>\Delta G = 0</math>, <math>\Delta H = T\Delta S</math></p> $\Delta H = 859 \times 10^3 = T \times 162$ $T = 5302 \text{ K}$	4	<p>The units are K. If you put <math>^\circ\text{C}</math>, this will be penalised.</p> <p>There is a mark lost for each error, but the calculation is marked consequentially on your value of <math>\Delta S</math>.</p> <p><math>\Delta H = 859 \times 10^3</math>, since this refers to the dissociation of barium chloride and not the formation as given in the table of data. You also need to factor in the 1000 for J rather than kJ, since entropy is in J.</p>

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<p>4 a) i) <math>\Delta H_{\text{R}}^{\circ} = \Sigma \Delta H_{\text{f}}^{\circ}(\text{products}) - \Sigma \Delta H_{\text{f}}^{\circ}(\text{reactants})</math> 9</p> $\Delta H_{\text{R}}^{\circ} = ([2 \times 0] + [3 \times -393.5]) - (-824.2 + [3 \times -110.5])$ $= -24.8 \text{ kJ mol}^{-1}$ $\Delta S = \Sigma S(\text{products}) - \Sigma S(\text{reactants})$ $\Delta S = ([2 \times 27.3] + [3 \times 213.6]) - (87.4 + [3 \times 197.6])$ $= (54.6 + 640.8) - (87.4 + 592.8)$ $= 15.2 \text{ J K}^{-1} \text{ mol}^{-1}$ <p>ii) <math>\Delta G = \Delta H - T\Delta S</math>  <math>\Delta H</math> is negative and <math>-T\Delta S</math> is negative (or <math>\Delta S</math> positive)  Hence <math>\Delta G</math> is always negative.</p>		<p>If you get the equations the wrong way round you can only score a maximum of one mark for each, since your answers will have the wrong sign.</p> <p>Accept 'the reaction is feasible when <math>\Delta G \leq 0</math>'.</p>
<p>b) <math>\Delta G = 0 = \Delta H - T\Delta S</math>  Hence <math>\Delta H = T\Delta S</math></p> $T = \frac{\Delta H}{\Delta S} = 492.7 \times \frac{1000}{542.6}$ $= 908 \text{ K}$	3	If you miss out the 1000, you will lose one mark.
<p>c) <math>\Delta G(b) = \Delta G(a)</math>  <math>(492.7 \times 10^3 - T \times 542.6) = (-24.8 \times 10^3 - T \times 15.2)</math></p> $517.5 \times 10^3 = 527.4 T$ $T = 981.2 \text{ K}$	3	If you miss out the 1000, you will lose one mark.