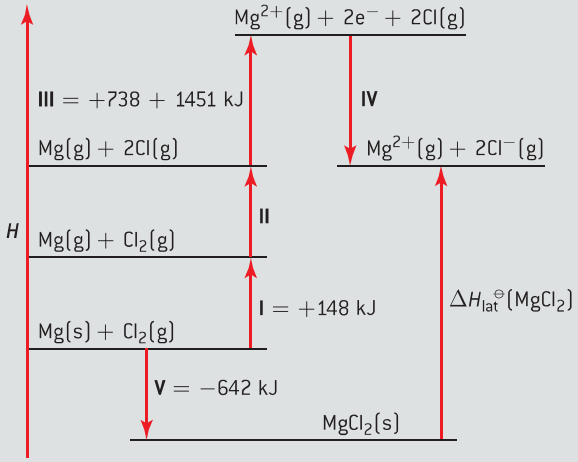
# Questions

**1** The lattice enthalpy of magnesium chloride can be calculated from the Born–Haber cycle shown in figure 6.




▲ Figure 6

a) Identify the enthalpy changes labelled by **I** and **V** in the cycle. [2]

b) Use the ionization energies given in the cycle above and further data from the *Data booklet* to calculate a value for the lattice enthalpy of magnesium chloride. [4]

c) The theoretically calculated value for the lattice enthalpy of magnesium chloride is +2326 kJ. Explain the difference between the theoretically calculated value and the experimental value. [2]

d) The experimental lattice enthalpy of magnesium oxide is given in section 18 of the *Data booklet*. Explain why magnesium oxide has a higher lattice enthalpy than magnesium chloride. [2]

**IB, November 2010**

**2** The lattice enthalpy values for lithium fluoride and calcium fluoride are shown below.

LiF(s) $\Delta H^{\ominus} = +1022 \text{ kJ mol}^{-1}$
$CaF_2(s)$ $\Delta H^{\ominus} = +2602 \text{ kJ mol}^{-1}$

Which of the following statements help(s) to explain why the value for lithium fluoride is less than that for calcium fluoride?

I) The ionic radius of lithium is less than that of calcium.

II) The ionic charge of lithium is less than that of calcium.

A. I only
B. II only
C. I and II
D. Neither I nor II [1]

**IB, May 2004**

**3** Which reaction occurs with the largest increase in entropy?

A. $Pb(NO_3)_2(s) + 2KI(s) \rightarrow PbI_2(s) + 2KNO_3(s)$
B. $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
C. $3H_2(g) + N_2(g) \rightarrow 2NH_3(g)$
D. $H_2(g) + I_2(g) \rightarrow 2HI(g)$ [1]

**IB, May 2004**

**4** The $\Delta H^{\ominus}$ and $\Delta S^{\ominus}$ values for a certain reaction are both positive. Which statement is correct about the spontaneity of this reaction at different temperatures?

A. It will be spontaneous at all temperatures.
B. It will be spontaneous at high temperatures but not at low temperatures.
C. It will be spontaneous at low temperatures but not at high temperatures.
D. It will not be spontaneous at any temperature. [1]

**IB, May 2004**

**5** The following reaction is spontaneous only at temperatures above 850° C.

$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

Which combination is correct for this reaction at 1000 °C?

| | $\Delta G$ | $\Delta H$ | $\Delta S$ |
|---|---|---|---|
| A. | − | − | − |
| B. | + | + | + |
| C. | − | + | + |
| D. | + | − | − |

[1]

**IB, May 2007**

**6** Explain in terms of $\Delta G^{\ominus}$, why a reaction for which both $\Delta H^{\ominus}$ and $\Delta S^{\ominus}$ values are positive can sometimes be spontaneous and sometimes not. [4]

**IB, May 2004**

**7** Throughout this question, use relevant information from the *Data booklet*.

a) Define the term *standard enthalpy change of formation* and illustrate your answer with an equation, including state symbols, for the formation of nitric acid. [4]

b) Propyne undergoes complete combustion as follows:

$$C_3H_4(g) + 4O_2(g) \rightarrow 3CO_2(g) + 2H_2O(l)$$

Calculate the enthalpy change of this reaction, given the following additional values: [4]

$\Delta H_f^{\ominus}$ of $CO_2(g) = -394$ kJ mol$^{-1}$

$\Delta H_f^{\ominus}$ of $H_2O(l) = -286$ kJ mol$^{-1}$

c) Predict and explain whether the value of $\Delta S^{\ominus}$ for the reaction in part (b) would be negative, close to zero, or positive. [3]

**IB, May 2005**

## End of topic questions (page 373)

**1. a)** **I:** atomization/sublimation (of Mg)/$\Delta H^{\ominus}_{\text{atomization}}(\text{Mg})/\Delta H^{\ominus}_{\text{sublimation}}(\text{Mg})$;

**V:** enthalpy change of formation of $(MgCl_2)/\Delta H^{\ominus}_{\text{formation}}(MgCl_2)$;

**b)** Energy value for **II**: +243;

Energy value for **III**: 738 + 1451 = 2189;

Energy value for **IV**: 2 × (−349);

$\Delta H^{\ominus}_{\text{lat}}(MgCl_2) = 642 + 148 + 243 + 2189 = (+)2252$ KJ

**c)** theoretical value assumes ionic model; experimental value greater due to (additional) covalent character;

**d)** oxide greater charge; oxide smaller radius;

**2.** B

**3.** B

**4.** B

**5.** C

**6.** a reaction is spontaneous when $\Delta G^{\ominus}$ is negative and non-spontaneous when $\Delta G^{\ominus}$ is positive; at high T, $\Delta G^{\ominus}$ is negative (because) $T\Delta S^{\ominus}$ is greater than $\Delta H^{\ominus}$; at low T, $\Delta G^{\ominus}$ is positive because $T\Delta S^{\ominus}$ is smaller than $\Delta H^{\ominus}$;

**7. a)** the enthalpy/energy/heat change for the formation of one mole of a compound/substance from its elements in their standard states/under standard conditions/at 298 K and 1 atm;

$\frac{1}{2}H_2(g) + \frac{1}{2}N_2(g) + 1\frac{1}{2}O_2(g) \rightarrow HNO_3(1)$

**b)** $\Delta H_r = \sum \Delta H_f^{\ominus}$ (products) $- \sum \Delta H_f^{\ominus}$ (reactants)/suitable cycle

$= 3\times(-394) + 2\times(-286) - 185 = -1939$ kJ

**c)** negative; decrease in disorder/increase in order; 5 mol of gas → 3 mol of gas/reduction in number of gas moles.