Q1 (a) (i) What is meant by the term *lattice energy*?

(ii) Write an equation to represent the lattice energy of MgO.

(b) The apparatus shown in the diagram can be used to measure the enthalpy change of formation of magnesium oxide, (MgO).

List the measurements you would need to make using this apparatus in order to calculate enthalpy change of formation of magnesium oxide (MgO).

(c) Use the following data, together with appropriate data from the *Data Booklet*, to calculate a value of enthalpy change of formation of (MgO).

- Lattice energy of MgO(s) = –3791 kJ mol\(^{-1}\)
- Enthalpy change of atomisation of Mg = +148 kJ mol\(^{-1}\)
- Electron affinity of the oxygen atom = –141 kJ mol\(^{-1}\)
- Electron affinity of the oxygen anion, O\(^-\) = +798 kJ mol\(^{-1}\)
Q2 The following table lists some enthalpy changes for magnesium and strontium compounds.

<table>
<thead>
<tr>
<th>enthalpy change</th>
<th>value for magnesium /kJ mol(^{-1})</th>
<th>value for strontium /kJ mol(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>lattice enthalpy of (M(OH)_2)</td>
<td>-2993</td>
<td>-2467</td>
</tr>
<tr>
<td>enthalpy change of (M^{2+}(g))</td>
<td>-1890</td>
<td>-1414</td>
</tr>
<tr>
<td>enthalpy change of (OH^-(g))</td>
<td>-550</td>
<td>-550</td>
</tr>
</tbody>
</table>

(i) Use the above data to calculate values of \(\Delta H_{\text{solution}}\) for Mg(OH)_2 and for Sr(OH)_2.

\[
\text{Mg(OH)_2} ........................................................................................................................................
\]

\[
\text{Sr(OH)_2} ....................................................................................................................................
\]

(ii) Use your results in (i) to suggest whether Sr(OH)_2 is more or less soluble in water than is Mg(OH)_2. State any assumptions you make.

(iii) Suggest whether Sr(OH)_2 would be more or less soluble in hot water than in cold. Explain your reasoning.

(June 2010 P42)

Q3 The major ore of barium is barytes, BaSO_4. This is very unreactive, and so other barium compounds are usually made from the sulfide, BaS. This is obtained by heating the crushed ore with carbon, and extracting the BaS with water.

\[
\text{BaSO}_4(s) + 4\text{C}(s) \rightarrow \text{BaS}(s) + 4\text{CO}(g)
\]

When 250 g of ore was heated in the absence of air with an excess of carbon, it was found that the CO produced took up a volume of 140 dm\(^3\) at 450 K and 1 atm.

(i) Calculate the number of moles of CO produced.

\[
\text{(i)} \text{ Calculate the number of moles of } \text{BaSO}_4 \text{ in the } 250 \text{ g sample of the ore.}
\]

\[
\text{(iii)} \text{ Calculate the percentage by mass of } \text{BaSO}_4 \text{ in the ore.}
\]
Use the following data and data from the *Data Booklet* to construct a Born-Haber cycle and calculate the lattice energy of BaS.

<table>
<thead>
<tr>
<th>Process</th>
<th>Energy (kJ mol(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard enthalpy change of formation of BaS(s)</td>
<td>-460</td>
</tr>
<tr>
<td>Standard enthalpy change of atomisation of Ba(s)</td>
<td>+180</td>
</tr>
<tr>
<td>Standard enthalpy change of atomisation of S(s)</td>
<td>+279</td>
</tr>
<tr>
<td>Electron affinity of the sulfur atom</td>
<td>-200</td>
</tr>
<tr>
<td>Electron affinity of the S(^{−}) ion</td>
<td>+640</td>
</tr>
</tbody>
</table>

Q4 One of the reasons the melting point of magnesium chloride is quite high is because it has a fairly high lattice energy.

(a) (i) Explain the term *lattice energy*.

(ii) Write a balanced equation including state symbols to represent the lattice energy of magnesium chloride.

(b) Suggest, with an explanation in each case, how the lattice energy of magnesium chloride might compare with that of

(i) sodium chloride, NaCl,

(ii) calcium chloride, CaCl\(_2\).
(c) Use the following data to calculate a value for the lattice energy of sodium chloride.

\[
\begin{align*}
\Delta H_f (\text{NaCl}) &= -411 \text{ kJ mol}^{-1} \\
\Delta H_{\text{f}} (\text{Na}) &= 107 \text{ kJ mol}^{-1} \\
\Delta H_{\text{f}} (\text{Cl}) &= 122 \text{ kJ mol}^{-1} \\
\text{first ionisation energy of Na} &= 494 \text{ kJ mol}^{-1} \\
\text{electron affinity of Cl} &= -349 \text{ kJ mol}^{-1}
\end{align*}
\]

(June 2004)

Q5 (a) Write an equation to represent the lattice energy of sodium oxide, Na₂O.

(b) The Born-Haber cycle shown may be used to calculate the lattice energy of sodium oxide.

(i) In the spaces below, identify the species A and B in the cycle, including the appropriate state symbols.

species A ........................................ species B ........................................

(ii) Identify the enthalpy changes labelled by the numbers 1 to 4 in the cycle.

1 .................................................................

2 .................................................................

3 .................................................................

4 .................................................................

ZAHID IQBAL WARRAICH 0333-4200541
Q6 (i) Write a chemical equation representing the lattice energy of AgBr.

(ii) Use the following data to calculate a value for the lattice energy of AgBr(s).

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>First ionisation energy of silver</td>
<td>+731 kJ mol⁻¹</td>
</tr>
<tr>
<td>Electron affinity of bromine</td>
<td>−325 kJ mol⁻¹</td>
</tr>
<tr>
<td>Enthalpy change of atomisation of silver</td>
<td>+285 kJ mol⁻¹</td>
</tr>
<tr>
<td>Enthalpy change of atomisation of bromine</td>
<td>+112 kJ mol⁻¹</td>
</tr>
<tr>
<td>Enthalpy change of formation of AgBr(s)</td>
<td>−100 kJ mol⁻¹</td>
</tr>
</tbody>
</table>

(iii) How might the lattice energy of AgCl compare to that of AgBr? Explain your answer.

Q6 (a) (i) What is meant by the term enthalpy change of hydration?

(ii) Write an equation that represents the hydration of the Mg²⁺ ion.

(iii) Suggest a reason why enthalpy change of hydration of the Mg²⁺ ion is greater than enthalpy change of hydration of the Ca²⁺ ion.
(iv) Suggest why it is impossible to determine the enthalpy change of hydration of the oxide ion, $O_2^-$.

The enthalpy change of solution for $\text{MgCl}_2$, enthalpy change of solution ($\text{MgCl}_2(\text{s})$), is represented by the following equation.

$$\text{MgCl}_2(\text{s}) + \text{aq} \rightarrow \text{Mg}^{2+}(\text{aq}) + 2\text{Cl}^-(\text{aq})$$

Describe the simple apparatus you could use, and the measurements you would make, in order to determine a value for enthalpy change of solution of ($\text{MgCl}_2(\text{s})$) in the laboratory.

(c) The table below lists data relevant to the formation of $\text{MgCl}_2(\text{aq})$.

<table>
<thead>
<tr>
<th>Enthalpy Change</th>
<th>Value / kJ mol$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta H_f^\circ(\text{MgCl}_2(\text{s}))$</td>
<td>$-641$</td>
</tr>
<tr>
<td>$\Delta H_f^\circ(\text{MgCl}_2(\text{aq}))$</td>
<td>$-801$</td>
</tr>
<tr>
<td>Lattice energy of $\text{MgCl}_2(\text{s})$</td>
<td>$-2526$</td>
</tr>
<tr>
<td>$\Delta H_{\text{hyd}}^\circ(\text{Mg}^{2+}(\text{g}))$</td>
<td>$-1890$</td>
</tr>
</tbody>
</table>

By constructing relevant thermochemical cycles, use the above data to calculate a value for

(i) $\Delta H_{\text{f2d}}^\circ(\text{MgCl}_2(\text{s}))$,

(ii) $\Delta H_{\text{hyd}}^\circ(\text{Cl}^-(\text{g}))$.  

(June 2012 P42)