Calculate and plot an Ellingham diagram for the formation of MO(s) and CO(g) from their elements in the temperature range 300–2 000 K. Use this plot to determine the temperature at which carbon (itself being oxidized to gaseous carbon monoxide) will reduce MO(s) to the metal M. Carefully explain any assumptions that you have made in reaching your answer.

Question 3

This question carries 27 per cent of the marks for this assignment, and tests Learning Outcomes 1, 9, 22, 23, 25 and 26 of Book 4.

The alkali metals form a series of hydroxides of formula type MOH. The standard enthalpy change for the process

$$\tfrac{1}{2}O_2(g) + \tfrac{1}{2}H_2(g) + e^-(g) = OH^-(g) \qquad (2)$$

is called the standard enthalpy of formation of the gaseous hydroxide ion, $\Delta H_f^\ominus(OH^-, g)$. It has been determined experimentally to be $-144\ kJ\ mol^{-1}$ at 298.15 K.

(a) (*13 marks*) Draw a labelled Born–Haber cycle for potassium hydroxide, KOH(s), in which $\Delta H_f^\ominus(OH^-, g)$, and its formation reaction appears. Calculate a value for the lattice energy of potassium hydroxide, L(KOH, s) at 298.15 K. Any other data that you need should be taken from the S205 *Data Book*.

(b) (*8 marks*) In Table 14.1 of the S205 *Data Book*, we have only quoted ionic radii for monatomic ions. Use the KOH lattice energy that you calculated in part (a), and the simple Kapustinskii equation (Equation 20.11 on p. 136 of Book 4) to estimate an ionic radius for the hydroxide ion, which contains two atoms. Show your working.

(c) (*6 marks*) According to your calculated radius, which halide ion does the hydroxide ion most resemble in size? Discuss briefly whether your result seems reasonable.

$W = z^i$

$i(i-1)z^{i-2}(1-z^2) + 2iz^i + \left(n(n+1) - \frac{m^2}{1-z^2}\right)z^i$

$z^i((1-i)i - 2i + n(n+$

$M^+_{(g)}$ O^{2-} H^+

$|$ $|-E_2(O)$ $|$

$M^+_{(g)} + O^-$ H^+

$\uparrow$ $\uparrow -E_1(O)$ $I(H)$

$M_{(g)}$ O H

$\uparrow$ $\uparrow \frac{1}{2}D(O-O)$ $\uparrow \frac{1}{2}D(H-H)$

$M_{(s)}$ $\frac{1}{2}O_2$ $\frac{1}{2}H_2$ $\Delta^\ominus H_f(MOH)$

$L(MOH)$

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