Chapter 10 – Answers to questions (for in-chapter questions)

1. a. Mg \(2,8,2\), Ca \(2,8,8,2\)
   
   b. Mg \(1s^2, 2s^22p^6, 3s^2\), Ca \(1s^2, 2s^22p^6, 3s^23p^6, 4s^2\)

2. The ‘effective nuclear charge’ on all Group I metals is +1 and that on all Group II metals is +2. So, for metals in the same period, acting on very similar electron structures, the effective nuclear charge (pulling in the electrons) is twice as large for the Group II metal compared with the Group I metal. Therefore, the atomic radius of the Group II metal is smaller.

3. a. With an inner shell of only 2 electrons and a very small atomic radius, the attraction of the nuclear charge for outer delocalised electrons is much stronger in Be than in other Group II metals. So, the effective bond between atoms is stronger in Be, leading to a higher melting point and boiling point.
   
   b. The effective nuclear charge of Group I metals is only +1 whereas that of Group II metals is +2. So, Group I metals have an even weaker attraction between the nucleus and outer electrons than Group II metals. Therefore, the interatomic forces in Group I metals are weaker resulting in lower melting points.

4. When Group II metals act as reducing agents, they lose electrons. But, Be is a weaker reducing agent (losing electrons less readily) because its very small atomic radius results in a stronger attraction between the nucleus and outer electrons than in other Group II metals.

5. The magnesium ribbon is usually shiny, relatively free of any oxide coating and with a larger surface area to volume ratio than pieces of calcium which normally have an obvious oxide layer.

6. a. 
   
   b. (outer shell electrons only)

7. The \(Be^{2+}\) ion is extremely small and the \(O^{2-}\) ion is very small. This results in very strong interionic forces in \(Be^{2+}O^{2-}\) which forms a coherent barrier to any further reaction when Be is heated in oxygen.

8. a. Small pieces of Sr will react rapidly with cold water producing a stream of hydrogen bubbles plus an alkaline solution of strontium hydroxide and a milky precipitate of the same solid.
   
   b. \(Sr(s) + 2H_2O(l) \rightarrow Sr(OH)_2(aq) + H_2(g)\)

9. Barium oxide reacts vigorously and exothermically when drops of water are added to it. The mixture fizzes as barium hydroxide is produced. If more water is added, the barium hydroxide dissolves to form an alkaline solution.
10  a  \[ \text{MgO(s)} + \text{H}_2\text{SO}_4(aq) \rightarrow \text{MgSO}_4(aq) + \text{H}_2\text{O(l)} \]

b  \[ \text{Ba(OH)}_2(s) + 2\text{HCl(aq)} \rightarrow \text{BaCl}_2(aq) + 2\text{H}_2\text{O(l)} \]

c  \[ \text{Sr(OH)}_2(aq) + \text{CO}_2(g) \rightarrow \text{SrCO}_3(s) + \text{H}_2\text{O(l)} \]

11  Since limestone (calcium carbonate) decomposes at about 900 °C, the presence of limestone throughout the world suggests that, since its formation, the temperature of the rocks in which limestone occurs has not risen to 900 °C.

12  The equation for the decomposition is:

\[ \text{Ba(NO}_3\text{)}_2(s) \rightarrow \text{BaO(s)} + 2\text{NO}_2(g) + \frac{1}{2}\text{O}_2(g) \]

Rel. mol. mass \(\text{Ba(NO}_3\text{)}_2\) = 261.3

Rel. mol. mass \(\text{BaO}\) = 153.3

\[ \therefore 261.3 \text{ g Ba(NO}_3\text{)}_2 \text{ leaves } 153.3 \text{ g of BaO} \]

\[ \therefore 13 \text{ g Ba(NO}_3\text{)}_2 \text{ leaves } \frac{153.3}{261.3} \times 13 \text{ g BaO} = 7.6 \text{ g BaO} \]

13  a and c

14  a  endothermic,  b  exothermic,  c  exothermic

15  a  \[ \text{Ca(OH)}_2(aq) + \text{Na}_2\text{CO}_3(aq) \rightarrow \text{CaCO}_3(s) + 2\text{NaOH(aq)} \]

b  \[ 2\text{Ca(OH)}_2(aq) + \text{2Cl}_2(aq) \rightarrow \text{CaCl}_2(aq) + \text{Ca(ClO)}_2(aq) + 2\text{H}_2\text{O(l)} \]

c  \[ \text{CaCO}_3(s) + \text{Na}_2\text{CO}_3(s) + 2\text{SiO}_2(s) \rightarrow \text{CaSiO}_3(s) + \text{Na}_2\text{SiO}_3(s) + 2\text{CO}_2(g) \]

16  a  In order to compare more easily the amounts dissolving (in terms of formulae masses).

b  Because the \(\text{CrO}_4^{2-}\) ion is even larger than the \(\text{SO}_4^{2-}\) ion which means that \(r_-\) is even greater than \(r_+\). As a result, the lattice energies vary even less from MgCrO\(_4\) to BaCrO\(_4\) and the variation in solubility of these compounds is dictated even more by the hydration energies of their cations. As \(\Delta H_{\text{hyd}}\) of the cations becomes less exothermic from Mg\(^{2+}\) to Ba\(^{2+}\), the chromates decline in solubility even faster than the sulfates.

c  The \(\text{CO}_3^{2-}\) ion is much smaller than either the \(\text{SO}_4^{2-}\) ion or the \(\text{CrO}_4^{2-}\) ion. So, the relative sizes of \(r_+\) and \(r_-\) are closer in carbonates and this means that lattice energies must be taken into account, as well as hydration energies of both the anion and cation, in considering the relative solubilities of Group II carbonates.