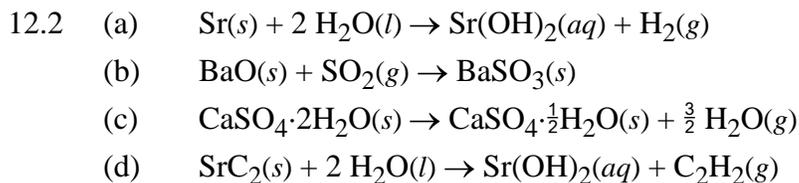


Chapter 12

THE GROUP 2 ELEMENTS: THE ALKALINE EARTH METALS

Exercises



12.4 (a) Magnesium; (b) barium.

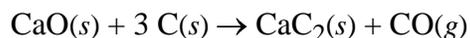
12.6 The lattice energies for compounds of divalent alkaline earth metals with dinegative anions (that is, the electrostatic attraction) will be much greater than with the mononegative anions. On the other hand, the hydration enthalpy of three ions (with mononegative anions) will be greater than that for the two ions with divalent anions. Thus the salts with dinegative ions have a greater energy penalty with the greater lattice energy and recoup less with the lower hydration enthalpy, resulting in a lower solubility.

12.8 The higher the charge density, the more strongly the polar water molecules will be attracted toward the cation. Magnesium has the highest charge density of the group (with the exception of beryllium) and hence will be highly hydrated.

12.10 Magnesium forms a wide range of compounds containing covalent bonds, for example, the Grignard reagents. We can explain this behavior in terms of its higher charge density than that of the other alkaline earth metals (except beryllium), giving it a greater tendency to form covalent bonds.

12.12 Limestone and shales.

12.14 The calcium oxide is heated with carbon at high temperatures in an electric furnace to give calcium carbide:



This is, in turn, heated in an electric furnace with nitrogen gas to give calcium cyanamide:



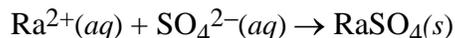
12.16 (a) $\text{CaMg}(\text{CO}_3)_2$; (b) CaCO_3 ; (c) $\text{CaSO}_4 \cdot 2 \text{H}_2\text{O}$.

12.18 The major cause of the exothermicity of the dissolving of anhydrous calcium chloride is the hydration of the high-charge-density calcium ion. The hexahydrate already contains the hydrated ion, so this step is missing from the enthalpy cycle.

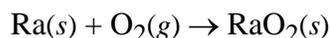
12.20 The compounds of the metal should be ionic and colorless (except with a colored anion), and with the lowest charge density of the group, they are unlikely to be hydrated. Radium metal should react vigorously with water to form very soluble radium hydroxide:



Radium sulfate should be extremely insoluble:



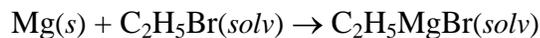
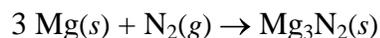
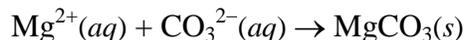
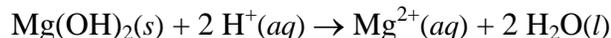
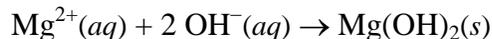
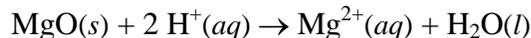
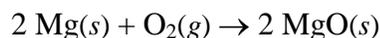
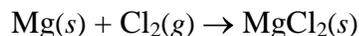
On heating, radium should react rapidly with dioxygen to form radium dioxide(-2):



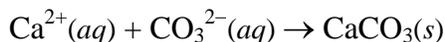
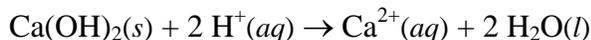
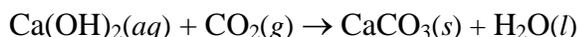
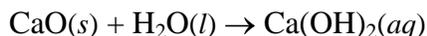
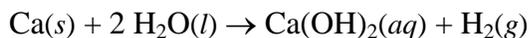
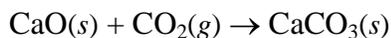
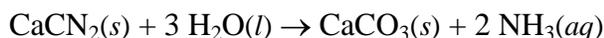
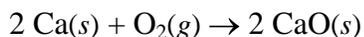
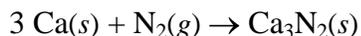
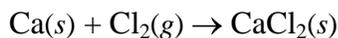
plus other reactions common to the alkaline earth metals.

12.22 Calcium hydroxide phosphate, $\text{Ca}_5(\text{OH})(\text{PO}_4)_3$.

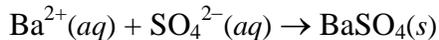
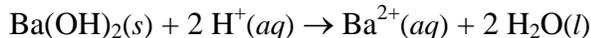
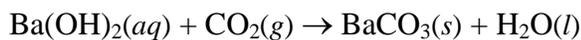
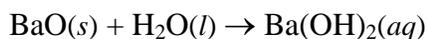
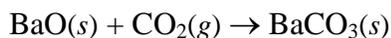
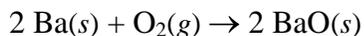
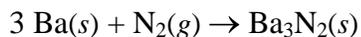
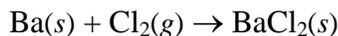
12.24 Magnesium:



Calcium:



Barium:



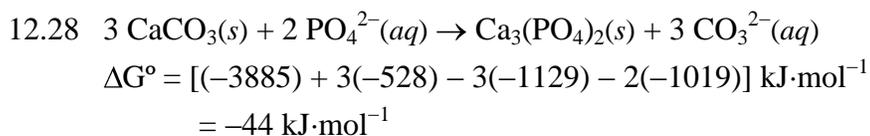
Beyond the Basics

12.26 Using the Born-Landé equation:

$$-2991 \text{ kJ} \cdot \text{mol}^{-1} = -\frac{(6.02 \times 10^{23} \text{ mol}^{-1}) \times 1.748 \times 2 \times 2 \times (1.602 \times 10^{-19} \text{ C})^2}{4 \times 3.142 \times (8.854 \times 10^{-12} \text{ C}^2 \cdot \text{J}^{-1} \cdot \text{mol}^{-1})(r_+ + r_-)} \left(1 - \frac{1}{9}\right)$$

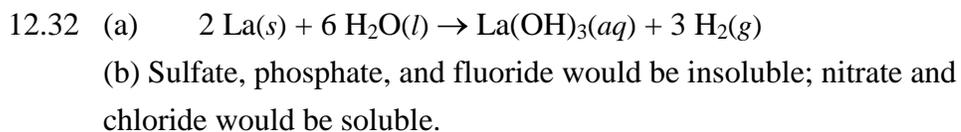
$$r_+ + r_- = 2.88 \times 10^{-10} \text{ m} = 288 \text{ pm}$$

$$r_- = 288 \text{ pm} - 114 \text{ pm} = 174 \text{ pm}$$



That is, the formation of solid calcium phosphate is thermodynamically preferred to calcium carbonate. All (common) nitrates are soluble.

12.30 Magnesium oxide, because it would have a much higher lattice energy as a result of the 2+/2- ion charge combination compared with the 2+/1- combination in magnesium fluoride.



12.34 Possibly four large iodine atoms cannot fit around the tiny beryllium atom.