

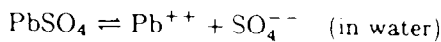
precipitate out until the product of the remaining ion concentrations attains the standard value. If the product is less than the standard value, the solution is not saturated.

**Table 7.2**  
Approximate Solubility Products

substance	12°F	15°C	18°C	25°C
Al(OH) <sub>3</sub>		4 EE-13	1.1 EE-15	3.7 EE-15
CaCO <sub>3</sub>		0.99 EE-8		0.87 EE-8
CaF <sub>2</sub>			3.4 EE-11	4.0 EE-11
Fe(OH) <sub>3</sub>			1.1 EE-36	
Mg(OH) <sub>2</sub>			1.2 EE-11	1 EE-11
MgCO <sub>3</sub>	2.6 EE-5			1 EE-5
BaCO <sub>3</sub>		7 EE-9		8.1 EE-9
BaSO <sub>4</sub>			0.87 EE-10	1.1 EE-10
CaSO <sub>4</sub>	2 EE-4			
Fe(OH) <sub>2</sub>			1.6 EE-14	8 EE-6
MnCO <sub>3</sub>				1.8 EE-11
Mn(OH) <sub>2</sub>			4 EE-14	
MgF <sub>2</sub>			7.1 EE-9	6.6 EE-9

*Example 7.12*

What is the solubility product of lead sulfate (PbSO<sub>4</sub>) if its solubility is 38 mg/l?



The molecular weight of PbSO<sub>4</sub> is 207.19 + 32.06 + (4)(16) = 303.25

The number of moles of PbSO<sub>4</sub> in a liter of saturated solution is

$$0.038/303.25 = 1.25 \text{ EE } -4$$

This is also the number of moles of Pb<sup>++</sup> and SO<sub>4</sub><sup>--</sup> that will form in the solution. Therefore,

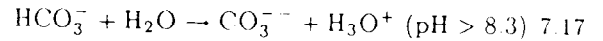
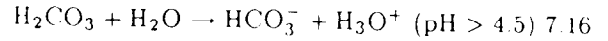
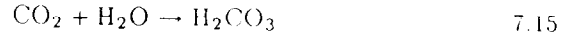
$$K_{sp} = [\text{Pb}^{++}][\text{SO}_4^{--}] = (1.25 \text{ EE } -4)^2 = 1.56 \text{ EE } -8$$

The method used in example 7.12 to find the solubility product works well with chromates (CrO<sub>4</sub><sup>--</sup>), halides (F<sup>-</sup>, Cl<sup>-</sup>, Br<sup>-</sup>, I<sup>-</sup>), sulfates (SO<sub>4</sub><sup>--</sup>), and iodates (IO<sub>3</sub><sup>-</sup>). However, sulfides (S<sup>--</sup>), carbonates (CO<sub>3</sub><sup>--</sup>), phosphates (PO<sub>4</sub><sup>--</sup>), and the salts of transition elements (such as iron) hydrolyze and must be treated differently.

## 4 QUALITIES OF SUPPLY WATER

### A. ACIDITY AND ALKALINITY

Acidity is a measure of acids in solution. Acidity in surface water is caused by formation of *carbonic acid* (H<sub>2</sub>CO<sub>3</sub>) from carbon dioxide in the air.<sup>1</sup>



Measurement of acidity is done by titration with a standard basic measuring solution. Acidity in water is typically given in terms of the CaCO<sub>3</sub> equivalent that would neutralize the acid.

$$\begin{aligned} &\text{acidity (mg/l of CaCO}_3\text{)} \\ &= \frac{(\text{vol. titrant})(\text{titrant normality})(50.000)}{(\text{vol. sample})} \quad 7.18 \end{aligned}$$

Alkalinity is a measure of the amount of negative ions in the water. Specifically, OH<sup>-</sup>, CO<sub>3</sub><sup>--</sup>, and HCO<sub>3</sub><sup>-</sup> all contribute to alkalinity.<sup>2</sup> The measure of alkalinity is the sum of concentrations of each of the substances measured as CaCO<sub>3</sub>.

*Example 7.13*

Water from a city well is analyzed and is found to carry 20 mg/l as substance of HCO<sub>3</sub><sup>-</sup> and 40 mg/l as substance of CO<sub>3</sub><sup>--</sup>. What is the alkalinity of this water?

From appendix A, the factors converting HCO<sub>3</sub><sup>-</sup> and CO<sub>3</sub><sup>--</sup> ions to CaCO<sub>3</sub> equivalents are 0.82 and 1.67 respectively.

$$\begin{aligned} \text{alkalinity} &= (0.82)(20) + (1.67)(40) \\ &= 83.2 \text{ mg/l as CaCO}_3 \end{aligned}$$

Alkalinity can also be found by using an acidic titrant.

$$\begin{aligned} &\text{alkalinity (mg/l of CaCO}_3\text{)} \\ &= \frac{(\text{vol. titrant})(\text{titrant normality})(50.000)}{(\text{vol. sample})} \quad 7.19 \end{aligned}$$

Alkalinity and acidity of a titrated sample is determined from color changes in indicators added to the titrant. Table 7.3 lists indicators that are commonly used.

<sup>1</sup> Carbonic acid is very aggressive and must be neutralized to eliminate the cause of water pipe corrosion. If the pH of water is greater than 4.5, carbonic acid ionizes to form bicarbonate (equation 7.16). If the pH is greater than 8.3, carbonate ions form which cause water hardness by combining with calcium (See equation 7.17).

<sup>2</sup> Other radicals, such as NO<sub>3</sub><sup>-</sup>, also contribute to alkalinity, but their presence is rare. If detected, they should be included in the calculation of alkalinity.