Example:

Given the following equation, how many grams of $PbCO_3$ will dissolve when 1.00 L of 1.00 M H^+ is added to 5.00 g of $PbCO_3$?

$$PbCO_3(s) + 2H^+(aq) \rightarrow Pb^{2+}(aq) + H_2O(l) + CO_2(g)$$

1. Calculate # moles (H^+) added

$$\#\text{moles}(H^+) = 1.00\,L \cdot 1.00\,M = 1\text{ mol }(H^+)$$

2. Calculate # moles of $PbCO_3$ that is dissolving

$$\#\text{moles}(PbCO_3)_{\text{dissolved}} = \#\text{moles}(H^+) \cdot \frac{1\text{ mol}(PbCO_3)}{2\text{ mol}(H^+)}$$

$$= 1.00\text{ mol} \cdot \frac{1\text{ mol}}{2\text{ mol}}$$

$$= 0.500\text{ mol}$$

3. Calculate the mass $PbCO_3$ dissolved

$$\text{mass}(PbCO_3)_{\text{dissolved}} = 0.500\text{ mol} \cdot \frac{267.2\text{ g}}{1\text{ mol}}$$

$$= 134\text{ g}$$

A solution of Ag^+ and Hg^{2+} ions. The addition of 0.100 L of 1.22 M NaI is just enough to precipitate all of the ions as AgI and HgI_2. The total mass of the precipitate is 28.1 g. Find the mass of AgI in the precipitate.

Plan:

moles (NaI) → moles (I^-) → AgI and HgI_2

1. # moles NaI $= 0.100\,L \cdot 1.22\,M = 0.122\,M$

   # moles I^- $= 0.122\,M \cdot \dfrac{1\,mol\,(I^-)}{1\,mol\,(NaI)}$

   $= 0.122\,M$

2. Let x be the moles of AgI and y be the moles of HgI_2

$$x + 2y = 0.122\,mol\,(I^-)$$

$$\Rightarrow y = 0.061\,mol - 0.5x$$

3. Total mass precipitate = mass (AgI) + mass (HgI_2)

total mass = $x\,mol\,(AgI) \cdot M_w(AgI) + y\,mol\,(HgI_2) \cdot M_w(HgI_2)$

$$28.1\,g = \left(x\,mol\,(AgI) \cdot \frac{234.77\,g}{1\,mol}\right) + \left(y\,mol\,HgI_2 \cdot \frac{454.4\,g}{1\,mol}\right)$$

4. Substitute "y"

$$28.1\,g = 234.77\,g \cdot x + (0.061 - 0.5x)\,454.4\,g$$

$$28.1\,g = 234.77\,g \cdot x + 27.72\,g - 227.2\,x$$

$$7.575\,x = 0.38$$

$$x = 0.0502$$

moles (AgI) = 0.0502 mol

$\Rightarrow$ mass (Ag) $= 11.8\,g$

Toxicities of heavy metals

Table 1 The MCL standards for the most hazardous heavy metals (Babel and Kurniawan, 2003).

Heavy metal	Toxicities
Arsenic	Skin manifestations, visceral cancers, vascular disease
Cadmium	Kidney damage, renal disorder, human carcinogen
Chromium	Headache, diarrhea, nausea, vomiting, carcinogenic
Copper	Liver damage, Wilson disease, insomnia
Nickel	Dermatitis, nausea, chronic asthma, coughing, human carcinogen
Zinc	Depression, lethargy, neurological signs and increased thirst
Lead	Damage the fetal brain, diseases of the kidneys, circulatory system, and nervous system
Mercury	Rheumatoid arthritis, and diseases of the kidneys, circulatory system, and nervous system

Heavy metal precipitation

Table 1
Heavy metal removal using chemical precipitation.

Species	Initial metal conc.	Precipitant	Optimum pH	Removal efficiency (%)	Ref.
Zn^{2+}	32 mg/L	CaO	9–10	99–99.3	Ghosh et al., in press
Cu^{2+}, Zn^{2+}, Cr^{3+}, Pb^{2+}	100 mg/L	CaO	7–11	99.37–99.6	Chen et al., 2009b
Cu^{2+}, Zn^{2+}, Pb^{2+}	0.018, 1.34, 2.3 mM	H_2S	3.0	100, >94, >92	Alvarez et al., 2007
Cr^{3+}	5363 mg/L	CaO and MgO	8.0	>99	Guo et al., 2006
Hg^{2+}	65.6, 188 μg/L	1,3-benzenediamidoethanethiolate	4.7 and 6.4	>99.9	Blue et al., 2008
CuEDTA	25, 50,100 mg/L	1,3,5-hexahydrotriazinedithiocarbamate	3.0	99.0, 99.3, 99.6	Fu et al., 2007

Hydroxide precipitation:

$$M^{2+}(aq) + 2OH^-(aq) \longrightarrow M(OH)_2$$
$$M^{3+}(aq) + 3OH^-(aq) \longrightarrow M(OH)_3$$

Lime:

$$CaO(s) + H_2O(l) \rightleftharpoons Ca(OH)_2(aq)$$

Alternative:

Sulfide precipitation

$$M^{2+}(aq) + H_2S(g) \longrightarrow MS(s) + 2H^+(aq)$$

Hydroxyapatite

tooth enamel : $Ca_{10}(PO_4)_6(OH)_2$

Tooth decay : bacteria produce acids when acting on sugar and other carbohydrates

$$Ca_{10}(PO_4)_6(OH)_2 + 8H^+(aq) \longrightarrow 10\,Ca^{2+}(aq) + 6\,HPO_4^{2-}(aq) + 2H_2O\,\ell$$

Add Fluoride : $\rightarrow$ $Ca_{10}(PO_4)_6F_2$

Coca Cola

Phosphoric acid → reacts with Ca^{2+} in the intestine ⇒
less Ca^{2+} available for HA production

Vitamin C : suppresses production of osteoclasts (bone destroying cells)
and promote production of osteoblasts (bone producing cells)