Recitation, Week 7, CHM 1045, Fall 2020 – SOLUTIONS

1. In the previous homework set we considered potential applications of nanoparticles based on calcium carbonate, $CaCO_3(s)$. Cancer cells are more acidic than noncancerous tissue. Because carbonate is the anion of a weak acid, carbonate compounds are basic. Nanoparticles tend to accumulate in tumors, suggesting that nanoparticles based on calcium carbonate might be used to treat cancer.

A. One way to determine the amount of calcium carbonate in a sample is to react it with a strong acid, such hydrobromic acid, HBr(aq), according to the following chemical equation.

$$2HBr(aq) + CaCO_3(s) \rightarrow H_2CO_3(aq) + CaBr_2(aq)$$

A sample of $CaCO_3$ nanoparticles was reacted with HBr(aq) as shown above. It took 267 mL of 0.114 M HBr(aq) to react with all of the calcium carbonate. How many grams of $CaCO_3$ were contained in the sample? (The molar mass of $CaCO_3$ is 100.09 g/mol.)

Let's start with the "known quantity": 267 mL of HBr(aq).

$$267\ \text{mL HBr}(aq) \times \frac{1\ \text{L}}{1000\ \text{mL}} \times \frac{0.114\ \text{mol HBr}}{1\ \text{L HBr}(aq)} \times \frac{1\ \text{mol CaCO}_3}{2\ \text{mol HBr}} \times \frac{100.09\ \text{g CaCO}_3}{1\ \text{mol CaCO}_3}$$

$$= \boxed{1.52\ \text{g CaCO}_3}$$

B. The chemical equations above is a formula equation. Write the net ionic equation for this reaction.

FE: $2HBr(aq) + CaCO_3(s) \rightarrow H_2CO_3(aq) + CaBr_2(aq)$

IE: $2H^+ + \cancel{2Br^-} + CaCO_3(s) \rightarrow H_2CO_3 + Ca^{2+} + \cancel{2Br^-}$ (H_2CO_3 is a weak acid)

NIE: $2H^+(aq) + CaCO_3(s) \rightarrow H_2CO_3(aq) + Ca^{2+}(aq)$

2. Write balanced formula equations (FE) and net ionic equations (NIE) for the following reactions.

A. $CuCl_2(aq) + Pb(s) \rightarrow$

$Cu^{2+}(aq) + 2Cl^-(aq) + Pb(s) \rightarrow$

If one of the reactants is a metallic element, so if a reaction occurs, it must be a redox reaction where the metal is oxidized. Use the activity series to determine if the reaction is favored. Oxidation of copper is below oxidation of lead,

$$Pb \rightarrow Pb^{2+} + 2e^-$$

$$Cu \rightarrow Cu^{2+} + 2e^-$$

so oxidation of copper is less favored and Pb will "give" its electrons to Cu^{2+} to form Cu and Pb^{2+}.

Reverse the "half reaction" for copper because Cu^{2+} is reduced, and add the two equations to cancel electrons.

$Cu^{2+} + 2e^- \rightarrow Cu$
$Pb \rightarrow Pb^{2+} + 2e^-$

$Cu^{2+} + \cancel{2e^-} + Pb \rightarrow Cu + Pb^{2+} + \cancel{2e^-}$

NIE: $Cu^{2+}(aq) + Pb(aq) \rightarrow Cu(aq) + Pb^{2+}(aq)$

Add the "spectator" ions to get the formula equation.

ME: $CuCl_2(aq) + Pb(s) \rightarrow Cu(s) + PbCl_2(s)$

For acid-base and precipitation reactions, ionize soluble ionic compounds and strong acids, switch cations and ions, etc...

B. $K_2SO_4(aq) + CaCl_2(aq) \rightarrow$

FE: $K_2SO_4(aq) + CaCl_2(aq) \rightarrow 2KCl(aq) + CaSO_4(s)$

IE: $2K^+ + SO_4^{2-} + Ca^{2+} + 2Cl^- \rightarrow 2K^+ + 2Cl^- + Ca^{2+} + SO_4^{2-} \rightarrow 2K^+ + 2Cl^- + CaSO_4(s)$

NIE: $SO_4^{2-}(aq) + Ca^{2+}(aq) \rightarrow CaSO_4(s)$

C. $KF(aq) + HI(aq) \rightarrow$

FE: $KF(aq) + HI(aq) \rightarrow KI(aq) + HF(aq)$

IE: $K^+ + F^- + H^+ + I^- \rightarrow K^+ + I^- + H^+ + F^- \rightarrow K^+ + I^- + HF$

HF is a weak acid => mostly unionized

NIE: $F^-(aq) + H^+(aq) \rightarrow HF(aq)$

3. It was suggested that the lead in old plumbing* could be sealed by running a solution of $Cu^{2+}(aq)$ through the pipes. How would this help? Write a chemical equation to support your answer.

*The solder used to join the pipes contained lead, and a torch was used to "sweat" the joints between pieces of pipe.

Lead will reduce the Cu^{2+} ions to form copper metal, (in principle) coating the lead. Of course, there are other issues that must be addressed, including the rate of the reaction and the integrity of the copper coating. See Problem 2.A for the chemical equation assuming $CuCl_2(aq)$ was used.

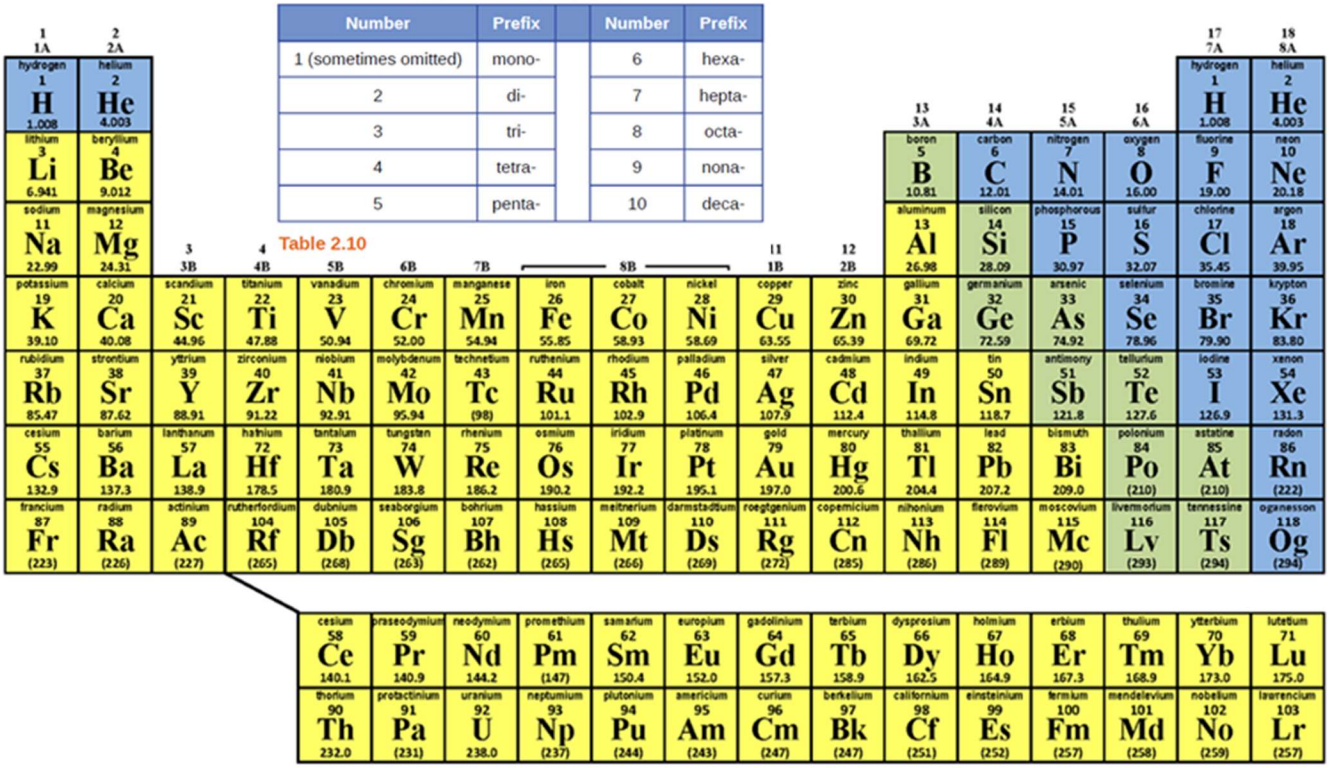
4. Name the following compounds.

$H_2S(g)$	dihydrogen sulfide
$H_2S(aq)$	hydrosulfuric acid
SrH_2	strontium hydride
$H_2SO_3(aq)$	sulfurous acid
$Sr(HSO_3)$	strontium hydrogen sulfite
$CuCl_2 \cdot 6H_2O$	copper(II) chloride hexahydrate

Nomenclature Prefixes

Number	Prefix	Number	Prefix
1 (sometimes omitted)	mono-	6	hexa-
2	di-	7	hepta-
3	tri-	8	octa-
4	tetra-	9	nona-
5	penta-	10	deca-

Table 2.10



Common Polyatomic Ions			
ammonium	NH_4^+	mercury(I)	Hg_2^{2+}
acetate	$C_2H_3O_2^-$	azide	N_3^-
cyanide	CN^-	hydroxide	OH^-
arsenate	ArO_3^-	bromate	BrO_3^-
carbonate	CO_3^{2-}	chlorate	ClO_3^-
chromate	CrO_4^{2-}	dichromate	$Cr_2O_7^{2-}$
iodate	IO_3^-	manganate	MnO_3^-
nitrate	NO_3^-	phosphate	PO_4^{3-}
sulfate	SO_4^{2-}		

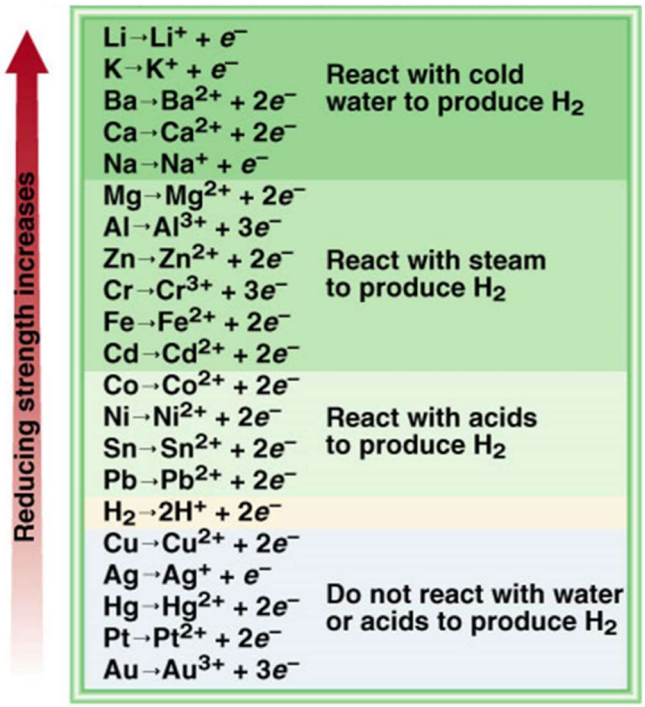


TABLE 4.2 Solubility Rules for Common Ionic Compounds in Water at 25°C

Soluble Compounds	Insoluble Exceptions
Compounds containing alkali metal ions (Li^+, Na^+, K^+, Rb^+, Cs^+) and the ammonium ion (NH_4^+)	
Nitrates (NO_3^-), bicarbonates (HCO_3^-), and chlorates (ClO_3^-)	
Halides (Cl^-, Br^-, I^-)	Halides of Ag^+, Hg_2^{2+}, and Pb^{2+}
Sulfates (SO_4^{2-})	Sulfates of Ag^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, Hg_2^{2+}, and Pb^{2+}
Insoluble Compounds	**Soluble Exceptions**
Carbonates (CO_3^{2-}), phosphates (PO_4^{3-}), chromates (CrO_4^{2-}), sulfides (S^{2-})	Compounds containing alkali metal ions and the ammonium ion
Hydroxides (OH^-)	Compounds containing alkali metal ions and the Ba^{2+} ion