

## CH 221 Practice Problem Set #4

This is a **practice problem set** and not the actual graded problem set that you will turn in for credit.  
Answers to each problem can be found at the end of this assignment.

Covering: **Chapter Four and Chapter Guide Four**

Important Tables and/or Constants: **Solubility Table** (in the "Net Ionics" lab or here: <https://mhchem.org/sol>)- Use the Net Ionics solubility table when answering questions about solubility in CH 221)

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- Balance the following equations:
  - $\text{Cr(s)} + \text{O}_2\text{(g)} \rightarrow \text{Cr}_2\text{O}_3\text{(s)}$
  - $\text{Cu}_2\text{S(s)} + \text{O}_2\text{(g)} \rightarrow \text{Cu(s)} + \text{SO}_2\text{(g)}$
  - $\text{C}_6\text{H}_5\text{CH}_3\text{(l)} + \text{O}_2\text{(g)} \rightarrow \text{H}_2\text{O(l)} + \text{CO}_2\text{(g)}$
- Balance the following equations and name each reactant and product:
  - $\text{Fe}_2\text{O}_3\text{(s)} + \text{Mg(s)} \rightarrow \text{MgO(s)} + \text{Fe(s)}$
  - $\text{AlCl}_3\text{(s)} + \text{NaOH(aq)} \rightarrow \text{Al(OH)}_3\text{(s)} + \text{NaCl(aq)}$
  - $\text{NaNO}_3\text{(s)} + \text{H}_2\text{SO}_4\text{(l)} \rightarrow \text{Na}_2\text{SO}_4\text{(s)} + \text{HNO}_3\text{(l)}$
  - $\text{NiCO}_3\text{(s)} + \text{HNO}_3\text{(aq)} \rightarrow \text{Ni(NO}_3)_2\text{(aq)} + \text{CO}_2\text{(g)} + \text{H}_2\text{O(l)}$
- Like many metals, aluminum reacts with a halogen to give a metal halide.  
 $2 \text{Al(s)} + 3 \text{Br}_2\text{(l)} \rightarrow \text{Al}_2\text{Br}_6\text{(s)}$   
What mass of  $\text{Br}_2$ , in grams, is required for complete reaction with 2.56 g of Al? What mass of white, solid  $\text{Al}_2\text{Br}_6$  is expected?
- Aluminum chloride,  $\text{AlCl}_3$ , is made by treating scrap aluminum with chlorine.  
 $2 \text{Al(s)} + 3 \text{Cl}_2\text{(g)} \rightarrow 2 \text{AlCl}_3\text{(s)}$   
If you begin with 2.70 g of Al and 4.05 g of  $\text{Cl}_2$ ,
  - Which reactant is limiting?
  - What mass of  $\text{AlCl}_3$  can be produced?
  - What mass of the excess reactant remains when the reaction is completed?
- The deep blue compound  $\text{Cu(NH}_3)_4\text{SO}_4$  is made by the reaction of copper(II) sulfate and ammonia:  $\text{CuSO}_4\text{(aq)} + 4 \text{NH}_3\text{(aq)} \rightarrow \text{Cu(NH}_3)_4\text{SO}_4\text{(aq)}$ 
  - If you use 10.0 g of  $\text{CuSO}_4$  and excess  $\text{NH}_3$ , what is the theoretical yield of  $\text{Cu(NH}_3)_4\text{SO}_4$ ?
  - If you isolate 12.6 g of  $\text{Cu(NH}_3)_4\text{SO}_4$ , what is the percent yield of  $\text{Cu(NH}_3)_4\text{SO}_4$ ?
- A sample of limestone and other soil materials is heated, and the limestone decomposes to give calcium oxide and carbon dioxide:  $\text{CaCO}_3\text{(s)} \rightarrow \text{CaO(s)} + \text{CO}_2\text{(g)}$   
A 1.506 g sample of limestone-containing material gives 0.558 g of  $\text{CO}_2$ , in addition to  $\text{CaO}$ , after being heated at a high temperature. What is the mass percent of  $\text{CaCO}_3$  in the original sample?
- Styrene, the building block of polystyrene, consists of only C and H. If 0.438 g of styrene is burned in oxygen and produces 1.481 g of  $\text{CO}_2$  and 0.303 g of  $\text{H}_2\text{O}$ , what is the empirical formula of styrene?
- Nickel forms a compound with carbon monoxide,  $\text{Ni}_x\text{(CO)}_y$ . To determine its formula, you carefully heat a 0.0973 g sample in air to convert the nickel to 0.0426 g of  $\text{NiO}$  and the CO to 0.100 g of  $\text{CO}_2$ . What is the empirical formula of  $\text{Ni}_x\text{(CO)}_y$ ?

9. Menthol, from oil of mint, has a characteristic odor. The compound contains only C, H, and O. If 95.6 mg of menthol burns completely in O<sub>2</sub>, and gives 269 mg of CO<sub>2</sub> and 110 mg of H<sub>2</sub>O, what is the empirical formula of menthol?
10. An unknown compound has the formula C<sub>x</sub>H<sub>y</sub>O<sub>z</sub>. You burn 0.0956 g of the compound and isolate 0.1356 g of CO<sub>2</sub> and 0.0833 g of H<sub>2</sub>O. What is the empirical formula of the compound? If the molar mass is 62.1 g/mol, what is the molecular formula?
11. Which compound or compounds in each of the following groups is (are) expected to be soluble in water?
- CuO, CuCl<sub>2</sub>, FeCO<sub>3</sub>
  - AgI, Ag<sub>3</sub>PO<sub>4</sub>, AgNO<sub>3</sub>
  - K<sub>2</sub>CO<sub>3</sub>, KI, KMnO<sub>4</sub>
12. The following compounds are water-soluble. What ions are produced by each compound in aqueous solution?
- KOH
  - LiNO<sub>3</sub>
  - K<sub>2</sub>SO<sub>4</sub>
  - (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>
13. Decide whether each of the following is water-soluble. If soluble, tell what ions are produced.
- Na<sub>2</sub>CO<sub>3</sub>
  - NiS
  - CuSO<sub>4</sub>
  - BaBr<sub>2</sub>
14. Predict the products of each precipitation reaction. Balance the completed equation, and then write the net ionic equation.
- $\text{NiCl}_2(\text{aq}) + (\text{NH}_4)_2\text{S}(\text{aq}) \rightarrow$
  - $\text{Mn}(\text{NO}_3)_2(\text{aq}) + \text{Na}_3\text{PO}_4(\text{aq}) \rightarrow$
15. Balance the following equations, and then write the net ionic equation.
- $(\text{NH}_4)_2\text{CO}_3(\text{aq}) + \text{Cu}(\text{NO}_3)_2(\text{aq}) \rightarrow \text{CuCO}_3(\text{s}) + \text{NH}_4\text{NO}_3(\text{aq})$
  - $\text{Pb}(\text{OH})_2(\text{s}) + \text{HCl}(\text{aq}) \rightarrow \text{PbCl}_2(\text{s}) + \text{H}_2\text{O}(\text{l})$
  - $\text{BaCO}_3(\text{s}) + \text{HCl}(\text{aq}) \rightarrow \text{BaCl}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$

## Answers to the Practice Problem Set:

### 1. Answers:

- $4 \text{Cr(s)} + 3 \text{O}_2\text{(g)} \rightarrow 2 \text{Cr}_2\text{O}_3\text{(s)}$
- $\text{Cu}_2\text{S(s)} + \text{O}_2\text{(g)} \rightarrow 2 \text{Cu(s)} + \text{SO}_2\text{(g)}$
- $\text{C}_6\text{H}_5\text{CH}_3\text{(l)} + 9 \text{O}_2\text{(g)} \rightarrow 4 \text{H}_2\text{O(l)} + 7 \text{CO}_2\text{(g)}$

### 2. Answers:

- $\text{Fe}_2\text{O}_3\text{(s)} + 3 \text{Mg(s)} \rightarrow 3 \text{MgO(s)} + 2 \text{Fe(s)}$   
iron(III) oxide, magnesium, magnesium oxide, iron
- $\text{AlCl}_3\text{(s)} + 3 \text{NaOH(aq)} \rightarrow \text{Al(OH)}_3\text{(s)} + 3 \text{NaCl(aq)}$   
aluminum chloride, sodium hydroxide, aluminum hydroxide, sodium chloride
- $2 \text{NaNO}_3\text{(s)} + \text{H}_2\text{SO}_4\text{(l)} \rightarrow \text{Na}_2\text{SO}_4\text{(s)} + 2 \text{HNO}_3\text{(l)}$   
sodium nitrate, hydrogen sulfate (sulfuric acid), sodium sulfate, hydrogen nitrate (nitric acid)
- $\text{NiCO}_3\text{(s)} + 2 \text{HNO}_3\text{(aq)} \rightarrow \text{Ni(NO}_3)_2\text{(aq)} + \text{CO}_2\text{(g)} + \text{H}_2\text{O(l)}$   
nickel(II) carbonate, hydrogen nitrate (nitric acid), nickel(II) nitrate, carbon dioxide, water

3. 22.7 g Br<sub>2</sub>; 25.3 g Al<sub>2</sub>Br<sub>6</sub>

4. a. Cl<sub>2</sub> b. 5.09 g c. 1.67 g Al

5. a. 14.3 g b. 88.3%

6. 84.3%

7. CH

8. Ni(CO)<sub>4</sub>

9. C<sub>10</sub>H<sub>19</sub>O

10. EF = CH<sub>3</sub>O, MF = C<sub>2</sub>H<sub>6</sub>O<sub>2</sub>

11. a. CuCl<sub>2</sub> b. AgNO<sub>3</sub> c. all three compounds

12. a. K<sup>+</sup> and OH<sup>-</sup> ions b. Li<sup>+</sup> and NO<sub>3</sub><sup>-</sup> ions c. K<sup>+</sup> and SO<sub>4</sub><sup>2-</sup> ions d. NH<sub>4</sub><sup>+</sup> and SO<sub>4</sub><sup>2-</sup> ions

13. a. soluble, Na<sup>+</sup> and CO<sub>3</sub><sup>2-</sup> ions b. insoluble c. soluble, Cu<sup>2+</sup> and SO<sub>4</sub><sup>2-</sup> ions d. soluble, Ba<sup>2+</sup> and Br<sup>-</sup> ions

### 14. Answers:

- $\text{NiCl}_2\text{(aq)} + (\text{NH}_4)_2\text{S(aq)} \rightarrow \text{NiS(s)} + 2 \text{NH}_4\text{Cl(aq)}$   
 $\text{Ni}^{2+}\text{(aq)} + \text{S}^{2-}\text{(aq)} \rightarrow \text{NiS(s)}$
- $3 \text{Mn(NO}_3)_2\text{(aq)} + 2 \text{Na}_3\text{PO}_4\text{(aq)} \rightarrow \text{Mn}_3\text{(PO}_4)_2\text{(s)} + 6 \text{NaNO}_3\text{(aq)}$   
 $3 \text{Mn}^{2+}\text{(aq)} + 2 \text{PO}_4^{3-}\text{(aq)} \rightarrow \text{Mn}_3\text{(PO}_4)_2\text{(s)}$

### 15. Answers:

- $(\text{NH}_4)_2\text{CO}_3\text{(aq)} + \text{Cu(NO}_3)_2 \rightarrow \text{CuCO}_3\text{(s)} + 2 \text{NH}_4\text{NO}_3\text{(aq)}$   
 $\text{CO}_3^{2-}\text{(aq)} + \text{Cu}^{2+}\text{(aq)} \rightarrow \text{CuCO}_3\text{(s)}$
- $\text{Pb(OH)}_2\text{(s)} + 2 \text{HCl(aq)} \rightarrow \text{PbCl}_2\text{(s)} + 2 \text{H}_2\text{O(l)}$   
 $\text{Pb(OH)}_2\text{(s)} + 2 \text{H}^+\text{(aq)} + 2 \text{Cl}^-\text{(aq)} \rightarrow \text{PbCl}_2\text{(s)} + 2 \text{H}_2\text{O(l)}$
- $\text{BaCO}_3\text{(s)} + 2 \text{HCl(aq)} \rightarrow \text{BaCl}_2\text{(aq)} + \text{H}_2\text{O(l)} + \text{CO}_2\text{(g)}$   
 $\text{BaCO}_3\text{(s)} + 2 \text{H}^+\text{(aq)} \rightarrow \text{Ba}^{2+}\text{(aq)} + \text{H}_2\text{O(l)} + \text{CO}_2\text{(g)}$