

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)

- 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 Br_2 , in grams, is required for complete reaction with 2.56 g of Al? What mass of white, solid Al_2Br_6 is expected?
- Aluminum chloride, 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 Cl_2 ,
 - Which reactant is limiting?
 - What mass of 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 CuSO_4 and excess 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 CO_2 , in addition to CaO , after being heated at a high temperature. What is the mass percent of 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 CO_2 and 0.303 g of H_2O , 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 NiO and the CO to 0.100 g of 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 O₂, and gives 269 mg of CO₂ and 110 mg of H₂O, what is the empirical formula of menthol?
10. An unknown compound has the formula C_xH_yO_z. You burn 0.0956 g of the compound and isolate 0.1356 g of CO₂ and 0.0833 g of H₂O. 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, CuCl₂, FeCO₃
 - AgI, Ag₃PO₄, AgNO₃
 - K₂CO₃, KI, KMnO₄
12. The following compounds are water-soluble. What ions are produced by each compound in aqueous solution?
- KOH
 - LiNO₃
 - K₂SO₄
 - (NH₄)₂SO₄
13. Decide whether each of the following is water-soluble. If soluble, tell what ions are produced.
- Na₂CO₃
 - NiS
 - CuSO₄
 - BaBr₂
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 Br₂; 25.3 g Al₂Br₆

4. a. Cl₂ 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)₄

9. C₁₀H₁₉O

10. EF = CH₃O, MF = C₂H₆O₂

11. a. CuCl₂ b. AgNO₃ c. all three compounds

12. a. K⁺ and OH⁻ ions b. Li⁺ and NO₃⁻ ions c. K⁺ and SO₄²⁻ ions d. NH₄⁺ and SO₄²⁻ ions

13. a. soluble, Na⁺ and CO₃²⁻ ions b. insoluble c. soluble, Cu²⁺ and SO₄²⁻ ions d. soluble, Ba²⁺ and Br⁻ 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:

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