

1. Calculate the molarity and osmolarity of a solution containing 6.8 g of sodium phosphate dissolved into 4.3 L of water. (5 pts)

$$\text{Molarity} = \frac{6.8\text{g} \times \frac{\text{mol}}{164\text{g}}}{4.3\text{L}} = 9.64 \times 10^{-3}\text{ M}$$



$$\text{Osmolarity} = 4 \times 9.64 \times 10^{-3} = 0.0386 \text{ osmol}$$

2. Fill in the missing information in the following table: (12 pts)

| Symbol | Protons | Neutrons | Electrons | Charge |
|-----------------------|---------|----------|-----------|--------|
| $^{39}\text{K}^+$ | 19 | 20 | 18 | +1 |
| $^{16}\text{O}^{2-}$ | 8 | 8 | 10 | -2 |
| ^{20}Ne | 10 | 10 | 10 | 0 |
| $^{56}\text{Fe}^{n+}$ | 26 | 30 | 23 | +3 |

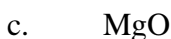
3. Name the following compounds: (8 pts)



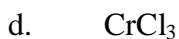
Copper(I) Carbonate



Potassium Iodide



Magnesium Oxide



Chromium(III) Chloride

4. An element has three naturally occurring isotopes with the following masses and abundances:

| Isotopic Mass (amu) | Fractional Abundance |
|---------------------|----------------------|
| 38.964 | 0.9326 |
| 39.964 | 0.0001 |
| 40.962 | 0.0673 |

What is the atomic weight of this element? (6pts)

$$\text{Atomic Weight} = (38.964)(0.9326) + (39.964)(0.0001) + (40.962)(0.0673) = 39.10 \text{ Amu}$$

5. Write the Lewis dot structures for each of the following elements. (9pts)

a. N



b. B



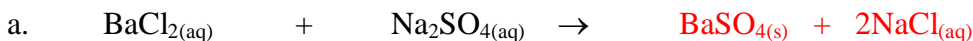
c. C



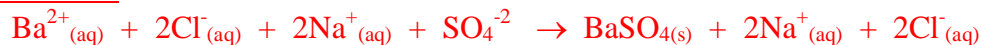
| Soluble | Except | Insoluble | Except |
|-------------------------------------------------------|---------------------------------------------------------------|--------------------|----------------------------|
| $\text{Na}^+, \text{K}^+, \text{Li}^+, \text{NH}_4^+$ | None | CO_3^{2-} | Group 1A, NH_4^+ |
| NO_3^- | None | PO_4^{3-} | Group 1A, NH_4^+ |
| $\text{Cl}^-, \text{Br}^-, \text{I}^-$ | $\text{Ag}^+, \text{Pb}^{2+}$ | S^{2-} | Group 1A, NH_4^+ |
| SO_4^{2-} | $\text{Ca}^{2+}, \text{Ag}^+, \text{Pb}^{2+}, \text{Ba}^{2+}$ | OH^- | Group 1A, Ca^{2+} |

6. Write the balance molecular equation, complete ionic equation, and net ionic equation for each of the following aqueous metathesis reactions. If no reaction occurs, just write NR after the arrow: (18 pts)

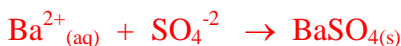
Molecular



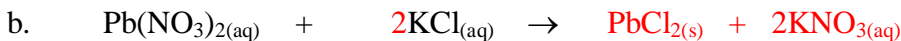
Complete Ionic



Net Ionic



Molecular



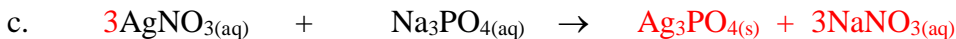
Complete Ionic



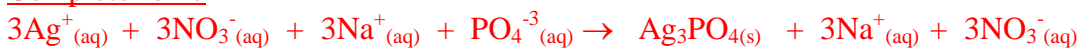
Net Ionic



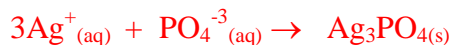
Molecular



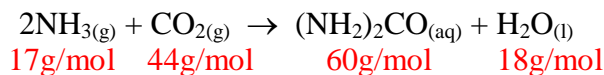
Complete Ionic



Net Ionic



7. Urea, $(\text{NH}_2)_2\text{CO}$, is prepared by reacting ammonia with carbon dioxide:



If 637.2 g of NH_3 are treated with 1142 g of CO_2 , which is the limiting reagent? How many grams of urea will be produced? How many grams of the excess reagent will be left over? (12pts)

$$637.2 \text{ g NH}_3 \times \frac{\text{mol}}{17\text{g}} \times \frac{1 \text{ mol urea}}{2 \text{ mol NH}_3} = 18.74 \text{ mol urea}$$

$$1142 \text{ g CO}_2 \times \frac{\text{mol}}{44\text{g}} \times \frac{1 \text{ mol urea}}{1 \text{ mol CO}_2} = 25.95 \text{ mol urea}$$

NH_3 is the limiting reagent.

$$18.74 \text{ mol urea} \times \frac{60\text{g}}{\text{mol}} = 1124.4 \text{ g urea}$$

CO_2 is in excess.

$$25.95 \text{ mol} - 18.74 \text{ mol} = 7.21 \text{ mol of CO}_2 \text{ in excess}$$

$$7.21 \text{ mol CO}_2 \times \frac{44\text{g}}{\text{mol}} = 317.2 \text{ g CO}_2 \text{ left over}$$

8. Caffeine, a stimulant found in coffee, tea, and chocolate, contains 49.48% carbon, 5.15% hydrogen, 28.87% nitrogen, and 16.49% oxygen by mass and has a molar mass of 194 g/mol. Determine the empirical and molecular formula of caffeine. (10 pts)

Assume a 100 g sample.

$$49.48 \text{ g C} \times \frac{\text{mol}}{12.01\text{g}} = 4.12 \text{ mol} \div 1.03 \text{ mol} = 4$$

$$5.15 \text{ g H} \times \frac{\text{mol}}{1.01\text{g}} = 5.10 \text{ mol} \div 1.03 \text{ mol} = 5$$

$$28.87 \text{ g N} \times \frac{\text{mol}}{14.01\text{g}} = 2.06 \text{ mol} \div 1.03 \text{ mol} = 2$$

$$16.49 \text{ g O} \times \frac{\text{mol}}{15.99\text{g}} = 1.03 \text{ mol} \div 1.03 = 1$$

Empirical Formula

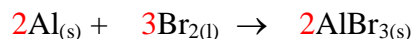
$\text{C}_4\text{H}_5\text{N}_2\text{O}$ 97g/mol

$$\frac{\text{molecular mass}}{\text{empirical mass}} = \frac{194}{94} = 2$$

Molecular Formula

$\text{C}_8\text{H}_{10}\text{N}_4\text{O}_2$

9. Aluminum burns in bromine, producing aluminum bromide:



When 10.0 g of aluminum was reacted with an excess of bromine, 79.8 g of aluminum bromide was isolated. Calculate the theoretical yield and the percent yield of this reaction. (10pts)

$$10.0 \text{ g} \times \frac{\text{mol}}{27 \text{ g}} \times \frac{2 \text{ mol AlBr}_3}{2 \text{ mol Al}} \times \frac{267 \text{ g}}{\text{mol}} = 98.9 \text{ g AlBr}_3 \quad \text{Theoretical Yield}$$

$$\% \text{ Yield} = \frac{\text{actual}}{\text{theoretical}} \times 100 = \frac{79.8 \text{ g}}{98.9 \text{ g}} \times 100 = 80.7 \%$$

10. A 25.0 mL sample of sulfuric acid, H_2SO_4 , required 43.25 mL of a 0.198 M NaOH solution for neutralization. What is the concentration of the sulfuric acid solution? Write out the balance molecular equation for this reaction. (10 pts)



Diprotic acid

$$M_a = \frac{M_b V_b}{2V_a} = \frac{(0.198\text{M})(43.25\text{mL})}{2(25.0\text{mL})} = 0.171 \text{ M sulfuric acid}$$

11. Extra Credit. Hydrogen has two stable isotopes, ^1H and ^2H , and sulfur has four stable isotopes, ^{32}S , ^{33}S , ^{34}S , and ^{36}S . How many peaks would you observe in the mass spectrum of the positive ion of hydrogen sulfide, H_2S^+ ? Assume no decomposition of the ion into smaller fragments. (5 pts)

| <u>For</u> | <u>Possible Masses</u> | | | | | | |
|------------------------|------------------------|----|----|----|----|----|----|
| $^1\text{H}^1\text{H}$ | 34 | 35 | 36 | __ | 38 | | |
| $^2\text{H}^2\text{H}$ | | | 36 | 37 | 38 | __ | 40 |
| $^1\text{H}^2\text{H}$ | | | 35 | 36 | 37 | __ | 39 |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

7 peaks