Name: ____________________________ Date: ____________________

1. What is the molecular weight of $HC_2H_3O_2$ — 1. **60.05 g mol**

   $H = 4 \times 1.0079 = 4.0316$
   $C = 2 \times 12.01 = 24.02$
   $O = 2 \times 15.999 = 31.998$
   $4.0316 + 24.02 + 31.998 = 60.0496 \therefore 60.05$

2. What is the molecular weight of $Al(C_2H_3O_2)_3$ — 2. **204.081 g/mol**

   $Al = 1\ (26.95)$
   $C = 6\ (12.011)$
   $O = 6\ (15.9954)$
   $H = 9\ (1.0079)$ MW = 204.081 g/mol

3. What is the molecular weight of $Sc_2(C_2O_4)_3$ — 3. **353.98 g/mol**

   $Sc = 2(44.96)$
   $C = 6(12.011)$
   $O = 12\ (15.9954)$
   MW = 353.98 g/mol

4. What is the molarity of a solution made from 25.0 grams of $Mg(OH)_2$ dissolved in 175.0 mL of water? — 4. **2.45 M $Mg(OH)_2$**

   $$\frac{25.0\,\text{g}}{175.0\,\text{mL}} \times \frac{1\,\text{mol}}{58.33\,\text{g}} \times \frac{1\,\text{mL}}{0.001\,\text{L}}$$

5. How many grams of HCl are required to make 105.0 mL of 2.75 M HCl? — 5. **10.5 g HCl**

   $$\frac{105.0\,\text{mL}}{} \times \frac{0.001\,\text{L}}{1\,\text{mL}} \times \frac{2.75\,\text{mol}}{1\,\text{L}} \times \frac{36.46\,\text{g}}{1\,\text{mol}}$$

6. Given the reaction: $2\ NaOH(aq) + 1\ H_2SO_4(aq) \longrightarrow 1\ Na_2SO_4(aq) + 2\ H_2O(l)$ how many grams of $Na_2SO_4$ can be produced from 25.0 grams of NaOH. — 6. **44.4 g $Na_2SO_4$**

   $$\frac{25.0\,\text{g NaOH}}{} \times \frac{1\,\text{mol NaOH}}{40\,\text{g NaOH}} \times \frac{1\,\text{mol Na}_2\text{SO}_4}{2\,\text{mol NaOH}} \times \frac{142.05\,\text{g Na}_2\text{SO}_4}{1\,\text{mol Na}_2\text{SO}_4}$$

7. What is the molarity of a solution made from 25.0 grams of NaOH dissolved in 350.0 mL of water? — 7. **1.79 M NaOH**

   $$\frac{25.0\,\text{g NaOH}}{350.0\,\text{mL Sln}} \times \frac{1\,\text{mol NaOH}}{40.00\,\text{g NaOH}} \times \frac{1{,}000\,\text{mL}}{1\,\text{L}} = 1.79\,\text{M NaOH}$$

8. How many grams of NaOH are required to make 250.0 mL of 1.25 M NaOH? — 8. **12.5 g NaOH**

   $$\frac{250.0\,\text{mL sln}}{} \times \frac{1\,\text{L}}{1{,}000\,\text{mL}} \times \frac{1.25\,\text{mol NaOH}}{1\,\text{L sln}} \times \frac{40.00\,\text{g NaOH}}{1\,\text{mol NaOH}} = 12.5\,\text{g NaOH}$$

9. 27.5 mL of 0.35M NaOH is how many grams of NaOH? — 9. **0.39 g NaOH**

   $$\frac{27.5\,\text{mL sln}}{} \times \frac{1\,\text{L}}{1{,}000\,\text{mL}} \times \frac{0.35\,\text{mol NaOH}}{1\,\text{L sln}} \times \frac{40.00\,\text{g NaOH}}{1\,\text{mol NaOH}} = .39\,\text{g NaOH}$$

10. Jay performed a titration and noted that 225.0 mL of 0.85 M NaOH completely neutralized 175 mL of $H_2SO_4$. What is the Molarity of the $H_2SO_4$ solution? (Hint: $2NaOH(aq) + H_2SO_4(aq) \longrightarrow 2HOH(l) + Na_2SO_4(aq) + \text{heat}$. — 10. **.55 M $H_2SO_4$**

   $$\frac{225.0\,\text{mL NaOH}}{175.0\,\text{mL H}_2\text{SO}_4} \times \frac{1\,\text{L NaOH}}{1{,}000\,\text{mL NaOH}} \times \frac{.85\,\text{mol NaOH}}{1\,\text{L of Sln}} \times \frac{1\,\text{mol H}_2\text{SO}_4}{2\,\text{mol NaOH}} \times \frac{1{,}000\,\text{mL H}_2\text{SO}_4}{1\,\text{L of sln}} = .55\,\text{M H}_2\text{SO}_4$$

11. Jay performed a titration and noted that 15.0 mL of 8.0 M NaOH completely neutralized an unknown volume of 6.5 M $H_2SO_4$. What is the volume (in mL) of the $H_2SO_4$ solution? (Hint: $2NaOH(aq) + H_2SO_4(aq) \longrightarrow 2HOH(l) + Na_2SO_4(aq) + heat$.

11. **9.2 mL $H_2SO_4$**

$$\frac{150.0\,\text{mL NaOH}}{} \times \frac{1\,\text{L NaOH}}{1,000\,\text{mL NaOH}} \times \frac{8.0\,\text{mol}}{1\,\text{L of Sln}} \times \frac{1\,\text{mol}\,H_2SO_4}{2\,\text{mol NaOH}} \times \frac{1\,\text{L of Sln}}{6.5\,\text{mol}\,H_2SO_4} \times \frac{1,000\,\text{mL}}{1\,\text{L of Sln}} = 9.2\,\text{mL}\,H_2SO_4$$

12. How many grams of HCl are required to make 750.0 mL of 3.000 M HCl?

12. **82.04 g HCl**

$$\frac{750.0\,\text{mL}}{} \times \frac{0.001\,\text{L}}{1\,\text{mL}} \times \frac{3.000\,\text{mol}}{1\,\text{L}} \times \frac{36.46\,\text{g}}{1\,\text{mol}}$$

13. What is the molarity of a solution made from 15.0 grams of $AgNO_3$ dissolved in 275.0 mL of water?

13. **0.321 M $AgNO_3$**

$$\frac{15.0\,\text{g}}{275.0\,\text{mL}} \times \frac{1\,\text{mol}}{169.88\,\text{g}} \times \frac{1\,\text{mL}}{0.001\,\text{L}}$$

14. Answer the following questions about the given the reaction:
$2\ H_3PO_4(aq) + 3\ Mg(OH)_2(aq) \longrightarrow 1\ Mg_3(PO_4)_2(aq) + 6\ H_2O(l) + 12.0kJ$

(a) How many grams of $Mg_3(PO_4)_2$ can be produced from 125.0 grams of $Mg(OH)_2$. 14(a) **187.8 g $Mg(OH)_2$**

$$\frac{125.0\,\text{g}\,Mg(OH)_2}{} \times \frac{1\,\text{mol}\,Mg(OH)_2}{58.33\,\text{g}\,Mg(OH)_2} \times \frac{1\,\text{mol}\,Mg_3(PO_4)_2}{3\,\text{mol}\,Mg(OH)_2} \times \frac{262.87\,\text{g}\,Mg_3(PO_4)_2}{1\,\text{mol}\,Mg_3(PO_4)_2}$$

(b) How many grams of $H_3PO_4$ are required to react with 11.0 grams of $Mg(OH)_2$. 14(b) **12.3 g $H_3PO_4$**

$$\frac{11.0\,\text{g}\,Mg(OH)_2}{} \times \frac{1\,\text{mol}\,Mg(OH)_2}{58.33\,\text{g}\,Mg(OH)_2} \times \frac{2\,\text{mol}\,H_3PO_4}{3\,\text{mol}\,Mg(OH)_2} \times \frac{97.99\,\text{g}\,H_3PO_4}{1\,\text{mol}\,H_3PO_4}$$

15. Bob performed a titration and noted that 75.0 mL of 0.65 M $Mg(OH)_2$ completely neutralized 250.0 mL of HCl. What is the Molarity of the HCl solution?
Hint: $1\ Mg(OH)_2(aq) + 2\ HCl(aq) \longrightarrow 2\ HOH(l) + MgCl_2(aq)$.

15. **0.39 M HCl**

$$\frac{75\,\text{mL}\,Mg(OH)_2}{250.\,\text{mL HCl}} \times \frac{0.001\,\text{L}}{1\,\text{mL}} \times \frac{0.65\,\text{mol}\,Mg(OH)_2}{1\,\text{L}} \times \frac{2\,\text{mol HCl}}{1\,\text{mol}\,Mg(OH)_2} \times \frac{1\,\text{mL}}{0.001\,\text{L}}$$

16. How many mL of 0.55 M NaOH are required to neutralize 195.0 mL of 1.87 M $H_2SO_4$?
Hint: $1\ H_2SO_4(aq) + 2\ NaOH(aq) \longrightarrow 2\ HOH(l) + 1\ Na_2SO_4(aq)$.

16. **1300 mL NaOH**

$$\frac{195.0\,\text{mL}\,H_2SO_4}{} \times \frac{0.001\,\text{L}}{1\,\text{mL}} \times \frac{1.87\,\text{mol}\,H_2SO_4}{1\,\text{L}} \times \frac{2\,\text{mol NaOH}}{1\,\text{mol}\,H_2SO_4} \times \frac{1\,\text{L}}{0.55\,\text{mol NaOH}} \times \frac{1\,\text{mL}}{0.001\,\text{L}}$$

17. Todd performed a titration and noted that 115.0 mL of 0.85 M $Mg(OH)_2$ completely neutralized 135.0 mL of $H_3PO_4$. What is the Molarity of the $H_3PO_4$ solution?
Hint: $3\ Mg(OH)_2(aq) + 2H_3PO_4(aq) \longrightarrow 6\ HOH(l) + Mg_3(PO_4)_2(s)$.

17. **0.48 M $H_3PO_4$**

$$\frac{1150\,\text{mL}\,Mg(OH)_2}{135\,\text{mL}\,H_3PO_4} \times \frac{0.001\,\text{L}}{1\,\text{mL}} \times \frac{0.85\,\text{mol}\,Mg(OH)_2}{1\,\text{L}} \times \frac{2\,\text{mol}\,H_3PO_4}{3\,\text{mol}\,Mg(OH)_2} \times \frac{1\,\text{mL}}{0.001\,\text{L}}$$

18. How many mL of 3.25 M $Mg(OH)_2$ are required to neutralize 240.0 mL of 1.25 M $H_3PO_4$?
Hint: $3\ Mg(OH)_2(aq) + 2\ H_3PO_4(aq) \longrightarrow 6\ HOH(l) + Mg_3(PO_4)_2(s)$.

18. **138 mL $Mg(OH)_2$**

$$\frac{240.0\,\text{mL}\,H_3PO_4}{} \times \frac{0.001\,\text{L}}{1\,\text{mL}} \times \frac{1.25\,\text{mol}\,H_3PO_4}{1\,\text{L}} \times \frac{3\,\text{mol}\,Mg(OH)_2}{2\,\text{mol}\,H_3PO_4} \times \frac{1\,\text{L}}{3.25\,\text{mol}\,Mg(OH)_2} \times \frac{1\,\text{mL}}{0.001\,\text{L}}$$

19. Jay is baking apple pies using the following recipe: 3 Apples + 2 cups sugar + 5 teaspoons Cinnamon + 4 cups Flour $\longrightarrow$ 2.5 apple pies. In my cupboard I have the following: 24 apples, 10 cups of Sugar, 30 teaspoons of Cinnamon and 25 cups of Flour. Answer the following questions:

    (a) What is the limiting ingredient? 19(a) **Sugar**

    (b) Amount of Apples left: 19(b) **9 apples**

    (c) Amount of Sugar left: 19(c) **0**

    (d) Amount of Cinnamon left: 19(d) **5 teaspoons**

    (e) Amount of Flour left: 19(e) **5 cups**

    (f) Number of pies made: 19(f) **12.5 pies**

Find the LR:

$$\frac{24\text{ apples}}{} \times \frac{2.5\text{ pies}}{3\text{ apples}} = 20\text{ pies}$$
$$\frac{10\text{ cups Sugar}}{} \times \frac{2.5\text{ pies}}{2\text{cups Sugar}} = 12.5\text{ pies}$$
$$\frac{30\text{ teaspoons Cinnamon}}{} \times \frac{2.5\text{ pies}}{5\text{ teaspoons Cinnamon}} = 15\text{ pies}$$
$$\frac{25\text{ cups Flour}}{} \times \frac{2.5\text{ pies}}{4\text{ cups Flour}} = 15.6\text{ pies}$$

Sugar produces the least number of pies therefore is the limiting ingredient.

Calculating ER Left Over:

$$\frac{10\text{ cups Sugar}}{} \times \frac{3\text{ apples}}{2\text{ cups Sugar}} = 15\text{ apples used (24-15=9 left)}$$
$$\frac{10\text{ cups Sugar}}{} \times \frac{5\text{ teaspoons Cinnamon}}{2\text{ cups Sugar}} = 25\text{ teaspoons Cinnamon used (30-25=5 left)}$$
$$\frac{10\text{ cups Sugar}}{} \times \frac{4\text{ cups Flour}}{2\text{ cups Sugar}} = 20\text{ cups Flour used (25-20=5 left)}$$

20. Given the reaction: $3\,Mg(OH)_2(aq) + 2\,H_3PO_4(aq) \longrightarrow Mg_3(PO_4)_2(aq) + 6\,HOH + 543\,kJ$
25.0 g of $Mg(OH)_2$ was reacted with 50.0 g of $H_3PO_4$. MW: $Mg(OH)_2$ = 58.3258 g/mol, $H_3PO_4$ = 97.9937 g/mol, $Mg_3(PO_4)_2$ = 262.87 g/mol, and HOH = 18.0158 g/mol.

    (a) What was the limiting reactant? 20(a) **$Mg(OH)_2$**

    (b) Moles $Mg(OH)_2$ left: 20(b) **0 mol**

    (c) Moles $H_3PO_4$ left: 20(c) **0.224 mol**

    (d) Moles $Mg_3(PO_4)_2$ left: 20(d) **0.143 mol**

    (e) Moles HOH left: 20(e) **0.857 mol**

    (f) Is the reaction Endothermic or Exothermic? 20(f) **Exothermic**

(g) How much heat is consumed/produced in the reaction? 20(g) **77.6 kJ produced**

$$\frac{25.0\,\text{g Mg(OH)}_2}{} \times \frac{1\,\text{mol Mg(OH)}_2}{58.3258\,\text{g Mg(OH)}_2} \times \frac{1\,\text{mol Mg}_3(\text{PO}_4)_2}{3\,\text{mol Mg(OH)}_2} = 0.143\,\text{mol Mg}_3(\text{PO}_4)_2$$

$$\frac{50.0\,\text{g H}_3\text{PO}_4}{} \times \frac{1\,\text{mol H}_3\text{PO}_4}{97.9937\,\text{g H}_3\text{PO}_4} \times \frac{1\,\text{mol Mg}_3(\text{PO}_4)_2}{2\,\text{mol H}_3\text{PO}_4} = 0.255\,\text{mol Mg}_3(\text{PO}_4)_2$$

$$\frac{25.0\,\text{g Mg(OH)}_2}{} \times \frac{1\,\text{mol Mg(OH)}_2}{58.3258\,\text{g Mg(OH)}_2} \times \frac{2\,\text{mol H}_3\text{PO}_4}{3\,\text{mol Mg(OH)}_2} = 0.286\,\text{mol H}_3\text{PO}_4$$

$$\frac{50.0\,\text{g H}_3\text{PO}_4}{} \times \frac{1\,\text{mol H}_3\text{PO}_4}{97.9937\,\text{g H}_3\text{PO}_4} = 0.510\,\text{mol H}_3\text{PO}_4$$

initial - final $= 0.224\,\text{mol H}_3\text{PO}_4$

$$\frac{25.0\,\text{g Mg(OH)}_2}{} \times \frac{1\,\text{mol Mg(OH)}_2}{58.3258\,\text{g Mg(OH)}_2} \times \frac{6\,\text{mol HOH}}{3\,\text{mol Mg(OH)}_2} = 0.857\,\text{mol HOH}$$

$$\frac{25.0\,\text{g Mg(OH)}_2}{} \times \frac{1\,\text{mol Mg(OH)}_2}{58.3258\,\text{g Mg(OH)}_2} \times \frac{543\,\text{kJ}}{3\,\text{mol Mg(OH)}_2} = 77.6\,\text{kJ released}$$

21. Given the reaction: $2\,\text{Al(OH)}_3() + 3\,\text{H}_2\text{SO}_4(\text{aq}) \longrightarrow \text{Al}_2(\text{SO}_4)_3(\text{s}) + 6\,\text{HOH} + 115\text{kJ}$
35.75 g of $\text{Al(OH)}_2$ was reacted with 40.25 g of $\text{H}_2\text{SO}_4$.
MW: $\text{Al(OH)}_3$ = 77.97 g/mol, $\text{H}_2\text{SO}_4$ = 98.09 g/mol, $\text{Al}_2(\text{SO}_4)_3$ = 342.11 g/mol, and $\text{H}_2\text{O}$ = 18.02 g/mol.

(a) What was the limiting reactant? 21(a) **$\text{H}_2\text{SO}_4$**

(b) Moles $\text{H}_2\text{SO}_4$ left: 21(b) **0 mol**

(c) Moles $\text{Al(OH)}_3$ left: 21(c) **0.1849 mol**

(d) Moles $\text{Al}_2(\text{SO}_4)_3$ left: 21(d) **0.4103 mol**

(e) Moles $\text{H}_2\text{O}$ left: 21(e) **0.8207 mol**

(f) Is the reaction Endothermic or Exothermic? 21(f) **Exothermic**

(g) How much heat is consumed/produced in the reaction? 21(g) **15.73 kJ**

$$\frac{35.75\,\text{g Al(OH)}_3}{} \times \frac{1\,\text{mol Al(OH)}_3}{77.97\,\text{g Al(OH)}_3} \times \frac{6\,\text{mol H}_2\text{O}}{2\,\text{mol Al(OH)}_3} = 1.376\,\text{mol H}_2\text{O}$$

$$\frac{40.25\,\text{g H}_2\text{SO}_4}{} \times \frac{1\,\text{mol H}_2\text{SO}_4}{98.09\,\text{g H}_2\text{SO}_4} \times \frac{6\,\text{mol H}_2\text{O}}{3\,\text{mol H}_2\text{SO}_4} = 0.8207\,\text{mol H}_2\text{O}$$

$$\frac{35.75\,\text{g Al(OH)}_3}{} \times \frac{1\,\text{mol Al(OH)}_3}{77.97\,\text{g Al(OH)}_3} = 0.4585\,\text{mol Al(OH)}_3$$

$$\frac{40.25\,\text{g H}_2\text{SO}_4}{} \times \frac{1\,\text{mol H}_2\text{SO}_4}{98.09\,\text{g H}_2\text{SO}_4} \times \frac{2\,\text{mol Al(OH)}_3}{3\,\text{mol H}_2\text{SO}_4} = 0.2736\,\text{mol Al(OH)}_3$$

initial - final $= 0.1849\,\text{mol Al(OH)}_3$

$$\frac{40.25\,\text{g H}_2\text{SO}_4}{} \times \frac{1\,\text{mol H}_2\text{SO}_4}{98.09\,\text{g H}_2\text{SO}_4} \times \frac{1\,\text{mol Al}_2(\text{SO}_4)_3}{1\,\text{mol H}_2\text{SO}_4} = 0.4103\,\text{mol Al}_2(\text{SO}_4)_3$$

$$\frac{40.25\,\text{g H}_2\text{SO}_4}{} \times \frac{1\,\text{mol H}_2\text{SO}_4}{98.09\,\text{g H}_2\text{SO}_4} \times \frac{115\,\text{kJ}}{3\,\text{mol H}_2\text{SO}_4} = 15.73\,\text{kJ produced}$$

22. Given the reaction: $2\,\text{C}_2\text{H}_6 + 7\,\text{O}_2 \longrightarrow 4\,\text{CO}_2 + 6\,\text{H}_2\text{O} + 75\,\text{kJ}$
22.25 g of $\text{C}_2\text{H}_6$ was reacted with 22.05 g of $\text{O}_2$.
MW: $\text{C}_2\text{H}_6$ = 30.07 g/mol, $\text{O}_2$ = 32.00 g/mol, $\text{CO}_2$ = 44.01 g/mol, and $\text{H}_2\text{O}$ = 18.02 g/mol.

(a) What was the limiting reactant? 22(a) **$O_2$**

(b) Moles $O_2$ left: 22(b) **0 mol**

(c) Moles $C_2H_6$ left: 22(c) **0.543 mol**

(d) Moles $CO_2$ left: 22(d) **0.394 mol**

(e) Moles $H_2O$ left: 22(e) **0.591 mol**

(f) Is the reaction Endothermic or Exothermic? 22(f) **Exothermic**

(g) How much heat is consumed/produced in the reaction? 22(g) **7.39 kJ**

$$\frac{22.25\,\text{g}\,C_2H_6}{} \times \frac{1\,\text{mol}\,C_2H_6}{30.07\,\text{g}\,C_2H_6} \times \frac{4\,\text{mol}\,CO_2}{2\,\text{mol}\,C_2H_6} = 1.48\,\text{mol}\,CO_2$$

$$\frac{22.05\,\text{g}\,O_2}{} \times \frac{1\,\text{mol}\,O_2}{32.00\,\text{g}\,O_2} \times \frac{4\,\text{mol}\,CO_2}{7\,\text{mol}\,O_2} = 0.394\,\text{mol}\,CO_2$$

$$\frac{22.25\,\text{g}\,C_2H_6}{} \times \frac{1\,\text{mol}\,C_2H_6}{30.07\,\text{g}\,C_2H_6} = 0.740\,\text{mol}\,C_2H_6$$

$$\frac{22.05\,\text{g}\,O_2}{} \times \frac{1\,\text{mol}\,O_2}{32.00\,\text{g}\,O_2} = 0.690\,\text{mol}\,O_2$$

$$\frac{.690\,\text{mol}\,O_2}{} \times \frac{2\,\text{mol}\,C_2H_6}{7\,\text{mol}\,O_2} = 0.197\,\text{mol}\,C_2H_6$$

initial - final $= 0.543\,\text{mol}\,C_2H_6$

$$\frac{.690\,\text{mol}\,O_2}{} \times \frac{6\,\text{mol}\,H_2O}{7\,\text{mol}\,O_2} = 0.591\,\text{mol}\,H_2O$$

$$\frac{.690\,\text{mol}\,O_2}{} \times \frac{75\,\text{kJ}}{7\,\text{mol}\,O_2} = 7.39\,\text{kJ produced}$$

23. Answer the following questions about the reaction below. Clearly label and show work in the space provided below, or on a separate sheet of paper.
Hint: $1\ Al(NO_3)_3(aq) + 3\ NaI(aq) + 75.0\text{kJ} \longrightarrow 3\ NaNO_3(aq) + 1\ AlI_3(s)$.

(a) What is the limiting reagent if you start with 15.0 grams of NaI and 10.0 grams of $Al(NO_3)_3$? 23(a) **NaI**

(b) What is the theoretical yield of $AlI_3$ in grams? 23(b) **13.6 g $AlI_3$**

(c) How many grams of the excess reagent will be left over? 23(c) **2.9 g**

(d) What is the percent yield if you performed the reaction in lab and produced 12.50 grams of $AlI_3$? 23(d) **91.9%**

(e) Is the reaction exothermic or endothermic? 23(e) **Endothermic**

(f) How much energy (in Joules) is consumed/produced in the reaction? 23(f) $2.50 \times 10^3$ **or** 2.50 **kJ**

Find the LR:
$$\frac{15.0\,\text{g NaI}}{} \times \frac{1\,\text{mol NaI}}{149.9\,\text{g}} \times \frac{1\,\text{mol AlI}_3}{3\,\text{mol NaI}} \times \frac{407.68\,\text{g AlI}_3}{1\,\text{mol AlI}_3} = 13.6\,\text{g AlI}_3$$
$$\frac{10.0\,\text{g Al(NO}_3)_3}{} \times \frac{1\,\text{mol Al(NO}_3)_3}{212.98\,\text{g Al(NO}_3)_3} \times \frac{1\,\text{mol AlI}_3}{1\,\text{mol Al(NO}_3)_3} \times \frac{407.86\,\text{g AlI}_3}{1\,\text{mol AlI}_3} = 19.15\,\text{g AlI}_3$$
The LR is therefore $Al(NO_3)_3$ and we produce 10.4 g $AlI_3$

ER used:
$$\frac{15.0\,\text{g NaI}}{} \times \frac{1\,\text{mol NaI}}{149.9\,\text{g NaI}} \times \frac{1\,\text{mol Al(NO}_3)_3}{3\,\text{mol NaI}} \times \frac{212.98\,\text{g Al(NO}_3)_3}{1\,\text{mol Al(NO}_3)_3} = 10.4\,\text{g Al(NO}_3)_3$$ used, therefore Start (10.0) - Used (7.1) = 2.9 g $Al(NO_3)_3$ Leftover

The Percent Yield is: $\frac{12.5}{13.6} \times 100 = 91.9\ \%$

Finding the Energy produced:
$$\frac{15.0\,\text{g NaI}}{} \times \frac{1\,\text{mol NaI}}{149.9\,\text{g NaI}} \times \frac{75.0\,\text{kJ}}{3\,\text{mol NaI}} \times \frac{1000\,\text{J}}{1\,\text{kJ}} = 2.50 \times 10^3\,\text{J or } 2.50\,\text{kJ}$$

24. Answer the following questions about the reaction below. Clearly label and show work in the space provided below, or on a separate sheet of paper.
Hint: $3\ Mg(OH)_2(aq) + 2\ H_3PO_4(aq) \longrightarrow 6\ HOH(l) + 1\ Mg_3(PO_4)_2(s) + 320.\ kJ.$

(a) What is the limiting reagent if you start with 25.0 grams of $Mg(OH)_2$ and 25.0 grams of $H_3PO_4$? 24(a) **$H_3PO_4$**

(b) What is the theoretical yield in grams of $Mg_3(PO_4)_2$ in grams? 24(b) **33.5 g $Mg_3(PO_4)_2$**

(c) How many grams of the excess reagent will be left over? 24(c) **2.7 g $H_3PO_4$**

(d) What is the percent yield if you performed the reaction and produced 12.50 grams of $Mg_3(PO_4)_2$? 24(d) **37.3 %**

(e) Is the reaction exothermic or endothermic? 24(e) **Exothermic**

(f) How much energy (in Joules) is consumed/produced in the reaction? 24(f) $4.08 \times 10^4$ **or** $40,800J$

Find the LR:
$$\frac{25.0\,\text{g Mg(OH)}_2}{} \times \frac{1\,\text{mol Mg(OH)}_2}{58.33\,\text{g}} \times \frac{1\,\text{mol Mg}_3(\text{PO}_4)_2}{3\,\text{mol Mg(OH)}_2} \times \frac{262.87\,\text{g}}{1\,\text{mol}} = 37.6\,\text{g Mg}_3(\text{PO}_4)_2$$
$$\frac{25.0\,\text{g H}_3\text{PO}_4}{} \times \frac{1\,\text{mol H}_3\text{PO}_4}{97.99\,\text{g H}_3\text{PO}_4} \times \frac{1\,\text{mol Mg}_3(\text{PO}_4)_2}{2\,\text{mol H}_3\text{PO}_4} \times \frac{262.87\,\text{g}}{1\,\text{mol}} = 33.5\,\text{g Mg}_3(\text{PO}_4)_2$$
The LR is therefore $H_3PO_4$ and we produce 33.5 g $Mg_3(PO_4)_2$

ER used: $\frac{25.0\,\text{g H}_3\text{PO}_4}{} \times \frac{1\,\text{mol H}_3\text{PO}_4}{97.99\,\text{g H}_3\text{PO}_4} \times \frac{3\,\text{mol Mg(OH)}_2}{2\,\text{mol H}_3\text{PO}_4} \times \frac{58.33\,\text{g Mg(OH)}_2}{1\,\text{mol}} = 22.3\,\text{g Mg(OH)}_2$ used, therefore Start (25.0) - Used (22.3) = 2.7 g $H_3PO_4$ Leftover

The Percent Yield is: $\frac{12.5}{33.5} \times 100 = 37.3\ \%$

Finding the Energy produced:

$$\frac{25.0\,\mathrm{g\,H_3PO_4}}{} \times \frac{1\,\mathrm{mol\,H_3PO_4}}{97.99\,\mathrm{g\,H_3PO_4}} \times \frac{320\,\mathrm{kJ}}{2\,\mathrm{mol\,H_3PO_4}} \times \frac{1000\,\mathrm{J}}{1\,\mathrm{kJ}} == 40820 = 4.08 \times 10^4 \text{ or } 40,800\,\mathrm{J} =$$

25. Given the reaction: $H_2SO_4(aq) + 2\,NaOH(aq) \longrightarrow Na_2SO_4(aq) + 2\,H_2O + 784\,kJ$
34.7 g of $H_2SO_4$ was reacted with 75.0 g of NaOH. MW: $H_2SO_4$ = 98.09 g/mol, NaOH = 40.00 g/mol, $Na_2SO_4$ = 142.05 g/mol, and $H_2O$ = 18.02 g/mol.

(a) What was the limiting reactant? 25(a) **$H_2SO_4$**

(b) Grams $H_2SO_4$ left: 25(b) **0 g**

(c) Grams NaOH left: 25(c) **46.7 g**

(d) Grams $Na_2SO_4$ left: 25(d) **50.25 g**

(e) Grams $H_2O$ left: 25(e) **12.75 g**

(f) Is the reaction Endothermic or Exothermic? 25(f) **Exothermic**

(g) How much heat is consumed/produced in the reaction? 25(g) **277.3 kJ produced**

$$\frac{34.7\,\mathrm{g\,H_2SO_4}}{} \times \frac{1\,\mathrm{mol\,H_2SO_4}}{98.09\,\mathrm{g\,H_2SO_4}} \times \frac{2\,\mathrm{mol\,H_2O}}{1\,\mathrm{mol\,H_2SO_4}} \times \frac{18.02\,\mathrm{g\,H_2O}}{1\,\mathrm{mol\,H_2O}} = 12.75\,\mathrm{g\,H_2O}$$

$$\frac{75.0\,\mathrm{g\,NaOH}}{} \times \frac{1\,\mathrm{mol\,NaOH}}{40.00\,\mathrm{g\,NaOH}} \times \frac{2\,\mathrm{mol\,H_2O}}{2\,\mathrm{mol\,NaOH}} \times \frac{18.02\,\mathrm{g\,H_2O}}{1\,\mathrm{mol\,H_2O}} = 33.79\,\mathrm{g\,H_2O}$$

$$\frac{34.7\,\mathrm{g\,H_2SO_4}}{} \times \frac{1\,\mathrm{mol\,H_2SO_4}}{98.09\,\mathrm{g\,H_2SO_4}} \times \frac{2\,\mathrm{mol\,NaOH}}{1\,\mathrm{mol\,H_2SO_4}} \times \frac{40.00\,\mathrm{g\,NaOH}}{1\,\mathrm{mol\,NaOH}} = 28.30\,\mathrm{g\,NaOH}$$

initial - final $= 46.7\,\mathrm{g\,NaOH}$

$$\frac{34.7\,\mathrm{g\,H_2SO_4}}{} \times \frac{1\,\mathrm{mol\,H_2SO_4}}{98.09\,\mathrm{g\,H_2SO_4}} \times \frac{1\,\mathrm{mol\,Na_2SO_4}}{1\,\mathrm{mol\,H_2SO_4}} \times \frac{142.05\,\mathrm{g\,Na_2SO_4}}{1\,\mathrm{mol\,Na_2SO_4}} = 50.25\,\mathrm{g\,Na_2SO_4}$$

$$\frac{34.7\,\mathrm{g\,H_2SO_4}}{} \times \frac{1\,\mathrm{mol\,H_2SO_4}}{98.09\,\mathrm{g\,H_2SO_4}} \times \frac{784\,\mathrm{kJ}}{1\,\mathrm{mol\,H_2SO_4}} = 277.3\,\mathrm{kJ}\text{ released}$$

26. Answer the following questions about the reaction of Sodium Iodide with Barium Chloride to produce Sodium Chloride and Barium Chloride. (Clearly label and show work in the space provided below.)
$2NaI + BaCl_2 + 200kJ \longrightarrow 2NaCl + BaI_2(s)$

(a) What is the limiting reagent if you start with 50.0 grams of NaI and 35.0 grams of $BaCl_2$? 26(a) **NaI**

(b) What is the theoretical yield in grams of $BaI_2$ in grams? 26(b) **65.2 g $BaI_2$**

(c) How many grams of the excess reagent will be left over? 26(c) **.30 g $BaCl_2$**

(d) What is the percent yield if you performed the reaction and produced 15.0 grams of $BaI_2$? 26(d) **23%**

(e) Is the reaction exothermic or endothermic? 26(e) **Endothermic**

(f) How much energy is consumed/produced in the reaction? 26(f) **33.4 kJ**

$$\frac{50.0\,\mathrm{g\,NaI}}{} \times \frac{1\,\mathrm{mol\,NaI}}{149.9\,\mathrm{g\,NaI}} \times \frac{1\,\mathrm{mol\,BaI_2}}{2\,\mathrm{mol\,NaI}} \times \frac{391.15\,\mathrm{g\,BaI_2}}{1\,\mathrm{mol\,BaI_2}} = 65.2\,\mathrm{g\,BaI_2}$$

$$\frac{35.0\,\text{g BaCl}_2}{} \times \frac{1\,\text{mol BaCl}_2}{208.2\,\text{g BaCl}_2} \times \frac{1\,\text{mol BaI}_2}{1\,\text{mol BaCl}_2} \times \frac{391.15\,\text{g BaI}_2}{1\,\text{mol BaI}_2} = 65.8\,\text{g BaI}_2$$

$$\frac{50.0\,\text{g NaI}}{} \times \frac{1\,\text{mol NaI}}{149.9\,\text{g NaI}} \times \frac{1\,\text{mol BaCl}_2}{2\,\text{mol NaI}} \times \frac{208.2\,\text{g BaCl}_2}{1\,\text{mol BaCl}_2} = 34.7\,\text{g BaCl}_2$$

initial - final $= .30\,\text{g BaCl}_2$

$$\frac{15.0}{65.2} \times 100 = 23\%$$

$$\frac{50.0\,\text{g NaI}}{} \times \frac{1\,\text{mol NaI}}{149.9\,\text{g NaI}} \times \frac{200\,\text{kJ}}{2\,\text{mol NaI}} = 33.4\,\text{kJ consumed}$$