Stoichiometry Review

YOU MUST SHOW ALL WORK AND YOUR ANSWERS MUST INCLUDE THE PROPER NUMBER OF SIG FIGS AND COMPLETE UNITS IN ORDER TO RECEIVE CREDIT FOR THE PROBLEM.

BALANCE THE FOLLOWING EQUATIONS TO USE IN QUESTIONS 5 – 14:

1. 4 Al + 3 O_2 → 2 Al_2O_3
2. ____ Cu + 2 $AgNO_3$ → 2 Ag + ____ $Cu(NO_3)_2$
3. ____ Zn + 2 HCl → ____ $ZnCl_2$ + ____ H_2
4. 2 Fe + 3 Cl_2 → 2 $FeCl_3$

PERFORM THE FOLLOWING STOICHIOMETRIC CALCULATIONS:

5. Zinc reacts with hydrochloric acid to produce zinc chloride and hydrogen. How many moles of HCl are required to produce 7.50 moles of $ZnCl_2$?

$$7.50\ \text{mol}\ ZnCl_2 \left| \frac{2\ \text{mol}\ HCl}{1\ \text{mol}\ ZnCl_2} \right. = 15.0\ \text{mol}\ HCl$$

6. Copper metal reacts with silver nitrate to form silver and copper(II) nitrate. How many grams of copper are required to form 250 g of silver?

$$250\ \text{g}\ Ag \left| \frac{1\ \text{mol}\ Ag}{107.868\ \text{g}\ Ag} \right| \frac{1\ \text{mol}\ Cu}{2\ \text{mol}\ Ag} \left| \frac{63.546\ \text{g}\ Cu}{1\ \text{mol}\ Cu} \right. = 74\ \text{g}\ Cu$$

7. When aluminum is burned in excess oxygen, aluminum oxide is produced. How many grams of oxygen are required to produce 0.75 moles of Al_2O_3?

$$0.75\ \text{mol}\ Al_2O_3 \left| \frac{3\ \text{mol}\ O_2}{2\ \text{mol}\ Al_2O_3} \right| \frac{31.998\ \text{g}\ O_2}{1\ \text{mol}\ O_2} = 36\ \text{g}\ O_2$$

8. How many grams of iron(III) chloride are produced when 15.3 g of iron react with excess chlorine gas?

$$15.3\ \text{g}\ Fe \left| \frac{1\ \text{mol}\ Fe}{55.845\ \text{g}\ Fe} \right| \frac{2\ \text{mol}\ FeCl_3}{2\ \text{mol}\ Fe} \left| \frac{162.204\ \text{g}\ FeCl_3}{1\ \text{mol}\ FeCl_3} \right. = 44.4\ \text{g}\ FeCl_3$$

9. Copper metal reacts with silver nitrate to form silver and copper(II) nitrate. How many moles of silver will be produced from 3.65 moles of silver nitrate?

$$3.65\ \text{mol}\ AgNO_3 \left| \frac{2\ \text{mol}\ Ag}{2\ \text{mol}\ AgNO_3} \right. = 3.65\ \text{mol}\ Ag$$

10. How many grams of iron are needed to react with 31.0 L of chlorine gas at STP to produce iron(III) chloride?

$$31.0\,L\,Cl_2 \left|\frac{1\,mol\,Cl_2}{22.4\,L\,Cl_2}\right|\frac{2\,mol\,Fe}{3\,mol\,Cl_2}\left|\frac{55.845\,g\,Fe}{1\,mol\,Fe}\right| = 51.5\,g\,Fe$$

11. When 9.34 g of zinc react with excess hydrochloric acid how many grams of zinc chloride will be produced?

$$9.34\,g\,Zn \left|\frac{1\,mol\,Zn}{65.38\,g\,Zn}\right|\frac{1\,mol\,ZnCl_2}{1\,mol\,Zn}\left|\frac{136.286\,g\,ZnCl_2}{1\,mol\,ZnCl_2}\right| = 19.5\,g\,ZnCl_2$$

12. How many liters of oxygen gas at STP are required to react with 65.3 g of aluminum in the production of aluminum oxide?

$$65.3\,g\,Al \left|\frac{1\,mol\,Al}{26.982\,g\,Al}\right|\frac{3\,mol\,O_2}{4\,mol\,Al}\left|\frac{22.4\,L\,O_2}{1\,mol\,O_2}\right| = 40.7\,L\,O_2$$

13. Zinc metal reacts with chromium(III) nitrate in a single replacement reaction. How many grams of zinc are required to react with 42.5 g $Cr(NO_3)_3$? First, write a balanced equation.

$$42.5\,g\,Cr(NO_3)_3 \left|\frac{1\,mol\,Cr(NO_3)_3}{238.008\,g\,Cr(NO_3)_3}\right|\frac{3\,mol\,Zn}{2\,mol\,Cr(NO_3)_3}\left|\frac{65.38\,g\,Zn}{1\,mol\,Zn}\right| =$$

$$2Cr(NO_3)_3\,(aq) + 3Zn\,(s) \longrightarrow 3Zn(NO_3)_2\,(aq) + 2Cr\,(s)$$

PERFORM THE FOLLOWING LIMITING REACTANT PROBLEMS:

14. When 16.3 g of magnesium and 4.52 g of oxygen gas react, how many grams of magnesium oxide will be formed? Identify the limiting and excess reactants. Determine how much excess remains.

ER LR

$$2\,Mg + O_2 \rightarrow 2\,MgO$$

$$16.3\,g\,Mg \left|\frac{1\,mol\,Mg}{24.305\,g\,Mg}\right|\frac{2\,mol\,MgO}{2\,mol\,Mg}\left|\frac{40.304\,g\,MgO}{1\,mol\,MgO}\right| = 27.0\,g\,MgO$$

$$4.52\,g\,O_2 \left|\frac{1\,mol\,O_2}{31.998\,g\,O_2}\right|\frac{2\,mol\,MgO}{1\,mol\,O_2}\left|\frac{40.304\,g\,MgO}{1\,mol\,MgO}\right| = \boxed{11.4\,g\,MgO}$$

$11.4\ g\ MgO \left|\frac{1\ mol\ MgO}{40.304\ g\ MgO}\right|\frac{2\ mol\ Mg}{2\ mol\ MgO}\left|\frac{24.305\ g\ Mg}{1\ mol\ Mg}\right| = 6.87\ g\ Mg$ used

$16.3\ g - 6.87\ g = 9.43\ g$

15. If 25.3 g of aluminum reacts with 25.3 g of copper(II) sulfate, how many grams of copper are formed? Identify the limiting and excess reactants in this single replacement reaction. Determine how much excess remains.

ER LR

$2\ Al + 3\ CuSO_4 \rightarrow 3\ Cu + Al_2(SO_4)_3$

$25.3\ g\ Al \left|\frac{1\ mol\ Al}{26.982\ g\ Al}\right|\frac{3\ mol\ Cu}{2\ mol\ Al}\left|\frac{63.546\ g\ Cu}{1\ mol\ Cu}\right| = 89.4\ g\ Cu$

$25.3\ g\ CuSO_4 \left|\frac{1\ mol\ CuSO_4}{159.608\ g\ CuSO_4}\right|\frac{3\ mol\ Cu}{3\ mol\ CuSO_4}\left|\frac{63.546\ g\ Cu}{1\ mol\ Cu}\right| = 10.1\ g\ Cu$

$10.1\ g\ Cu \left|\frac{1\ mol\ Cu}{63.546\ g\ Cu}\right|\frac{2\ mol\ Al}{3\ mol\ Cu}\left|\frac{26.982\ g\ Al}{1\ mol\ Al}\right| = 2.86\ g\ Al$ used

$25.3\ g - 2.86\ g = 22.4\ g$ remain

16. Identify the limiting and excess reactants when 1.00 g of zinc reacts with .0375 moles $Pb(NO_3)_2$. How many grams of lead are formed in this single replacement reaction?

LR ER

$Zn + Pb(NO_3)_2 \rightarrow Pb + Zn(NO_3)_2$

$1.00\ g\ Zn \left|\frac{1\ mol\ Zn}{65.38\ g\ Zn}\right|\frac{1\ mol\ Pb}{1\ mol\ Zn}\left|\frac{207.2\ g\ Pb}{1\ mol\ Pb}\right| = 3.17\ g\ Pb$

$.0375\ mol\ Pb(NO_3)_2 \left|\frac{1\ mol\ Pb}{1\ mol\ Pb(NO_3)_2}\right|\frac{207.2\ g\ Pb}{1\ mol\ Pb} = 7.77\ g\ Pb$

$3.17\ g\ Pb \left|\frac{1\ mol\ Pb}{207.2\ g\ Pb}\right|\frac{1\ mol\ Pb(NO_3)_2}{1\ mol\ Pb} = .0153\ mol\ Pb(NO_3)_2$ used

$.0375\ mol - .0153\ mol = .0222\ mol$ remain

17. If 24.5 g of iron are placed in 0.25 moles HCl, how many grams of $FeCl_2$ are obtained? Identify the limiting and excess reactants in this single replacement reaction.

ER LR

$Fe + 2\ HCl \rightarrow FeCl_2 + H_2$

$24.5\ g\ Fe \left|\frac{1\ mol\ Fe}{55.845\ g\ Fe}\right|\frac{1\ mol\ FeCl_2}{1\ mol\ Fe}\left|\frac{126.75\ g\ FeCl_2}{1\ mol\ FeCl_2}\right| = 55.6\ g\ FeCl_2$

$0.25\ mol\ HCl \left|\frac{1\ mol\ FeCl_2}{2\ mol\ HCl}\right|\frac{126.75\ g\ FeCl_2}{1\ mol\ FeCl_2} = 16\ g\ FeCl_2$

PERFORM THE FOLLOWING PERCENT YIELD CALCULATIONS:

18. If 12.5 g of copper react with excess chlorine gas, then 25.4 g of copper(II) chloride are produced. Find the theoretical and percent yields.

$$Cu + Cl_2 \rightarrow CuCl_2$$

$$12.5\text{ g Cu} \left| \frac{1\text{ mol Cu}}{63.546\text{ g Cu}} \right| \frac{1\text{ mol CuCl}_2}{1\text{ mol Cu}} \left| \frac{134.452\text{ g CuCl}_2}{1\text{ mol CuCl}_2} \right| = 26.4\text{ g CuCl}_2$$

$$\%\text{ Yield} = \frac{\text{actual}}{\text{theo}} \times 100 = \frac{25.4\text{ g}}{26.4\text{ g}} \times 100 = 96.2\%$$

19. If 6.57 g of iron react with an excess of hydrochloric acid, HCl, then 11.2 g of iron(II) chloride are obtained in addition to hydrogen gas. Find the theoretical and percent yields.

$$Fe + 2\,HCl \rightarrow FeCl_2 + H_2$$

$$6.57\text{ g Fe} \left| \frac{1\text{ mol Fe}}{55.845\text{ g Fe}} \right| \frac{1\text{ mol FeCl}_2}{1\text{ mol Fe}} \left| \frac{126.751\text{ g FeCl}_2}{1\text{ mol FeCl}_2} \right| = 14.9\text{ g FeCl}_2$$

$$\%\text{ Yield} = \frac{11.2\text{ g}}{14.9\text{ g}} \times 100 = 75.2\%$$

20. If 5.45 g of potassium chlorate are decomposed to form potassium chloride, 1.75 g of oxygen gas are also given off. Find the theoretical and percent yields.

$$2\,KClO_3 \rightarrow 2\,KCl + 3\,O_2$$

$$5.45\text{ g KClO}_3 \left| \frac{1\text{ mol KClO}_3}{122.548\text{ g KClO}_3} \right| \frac{3\text{ mol O}_2}{2\text{ mol KClO}_3} \left| \frac{31.998\text{ g O}_2}{1\text{ mol O}_2} \right| = 2.13\text{ g O}_2$$

$$\%\text{ Yield} = \frac{1.75\text{ g}}{2.13\text{ g}} \times 100 = 82.1\%$$