Chapter 8

CHEM V20 Worksheet

1. Benzene, C_6H_6, is a known carcinogen that burns in air according to the following equation:

$$2C_6H_6 + 15O_2 \rightarrow 12CO_2 + 5H_2O$$

a) What is the mol ratio of O_2 to C_6H_6?

$O_2 : C_6H_6$

$\boxed{15 : 2}$

$$\boxed{\frac{2\ C_6H_6}{15\ O_2}}$$

b) How many mols of O_2 are required to react with 1.3 mol of C_6H_6?

$$1.3\ \text{mol}\ \cancel{C_6H_6} \times \frac{15\ O_2}{2\ \cancel{C_6H_6}} = \boxed{9.75\ \text{mol}\ O_2}$$

c) How mols of H_2O can be produced with 53.3 mol of C_6H_6?

$$53.3\ \text{mol}\ C_6H_6 \times \frac{5\ H_2O}{2\ C_6H_6} = \boxed{133.25\ \text{mol}\ H_2O}$$

2. The balanced equation for the decomposition of TNT, $C_7H_5(NO_2)_3$, is

$$\underline{2}C_7H_5(NO_2)_3 \rightarrow 7C + 7CO + 3N_2 + \underline{5}H_2O$$

a) What is the mol ratio of C and CO?

$$7:7 = C : CO$$

b) How many mols of H_2O would form if 2.32 mol of $C_7H_5(NO_2)_3$ reacts?

$$2.32 \text{ mol } C_7H_5(NO_2)_3 \times \frac{5 \quad H_2O}{2 \quad C_7H_5(NO_2)_3} = \boxed{5.8 \text{ mol } H_2O}$$

c) How many mols of $C_7H_5(NO_2)_3$ are required to produce 0.0424 mol of CO?

$$0.0424 \text{ mol } CO \times \frac{2 \quad C_7H_5(NO_2)_3}{7 \quad CO} = \boxed{0.0121 \text{ mol } C_7H_5(NO_2)_3}$$

3. When active metals such as ~~sodium are exposed to air, they quickly~~ form a coating of metal oxide. The balanced equation for ~~the reaction of sodium metal with oxygen gas~~ is:

$$4\ \cancel{Na}\overset{Al}{} + O_2 \rightarrow 2Al_2O_3$$

Suppose a sheet of pure aluminum gains 0.0900 g of mass when exposed to air. Assume that this gain can be attributed to its reaction with oxygen. What mass of O_2 reacted with the Al?

Q: mass of O_2 based on 0.0900g Al

$$0.0900g\ Al \times \frac{\overset{\textcircled{1}}{1}\ mol}{26.98\ g} \times \frac{\overset{\textcircled{2}}{3}\ O_2}{4\ Al} \times \frac{\overset{\textcircled{3}}{32.00}\ g}{1\ mol} = \boxed{\underline{0.801}\ g\ O_2}$$

$$4\ Al + 3O_2 \rightarrow 2\ Al_2O_3$$

g	0.09 g ↓	③ ? ↑	
mol	① →	②	

mol → mol

4. Diiodine pentoxide is used in respirators to remove carbon monoxide from air:

$$I_2O_{5(s)} + 5\ CO_{(g)} \rightarrow I_{2(s)} + 5\ CO_{2(g)}$$

a) What mass of carbon monoxide could be removed from air by a respirator that contains 50.0 g of diiodine pentoxide?

$$50.0\text{ g } I_2O_5 \times \frac{1\text{ mol}}{333.81\text{ g}} \times \frac{5\ CO}{1\ I_2O_5} \times \frac{28.01\text{ g}}{1\text{ mol}}$$

$$= \boxed{20.98\text{ g } CO}$$

5. For each of the following unbalanced equations, balance the equation and then determine how many grams of the second reactant would be required to react completely with 0.600 g of the first reactant.

a) $\underline{2}\,Cr_{(s)} + \underline{3}\,Cl_{2(g)} \rightarrow \underline{2}\,CrCl_{3(s)}$

0.6 g ?g

↓ ↑

mol → mol

$$0.6\,g\ Cr \times \frac{1\ mol}{52.00\ g} = 0.01154\ mol\ Cr$$

$$0.01154\ mol\ Cr \times \frac{3\ Cl_2}{2\ Cr} = 0.0173\ mol\ Cl_2$$

$$0.0173\ mol\ Cl_2 \times \frac{70.90\ g}{1\ mol} = \boxed{1.23\ g\ Cl_2}$$

b) $\underline{\ \ }\,C_5H_{12(g)} + \underline{8}\,O_{2(g)} \rightarrow \underline{5}\,CO_{2(g)} + \underline{6}\,H_2O_{(g)}$

0.6 g ?

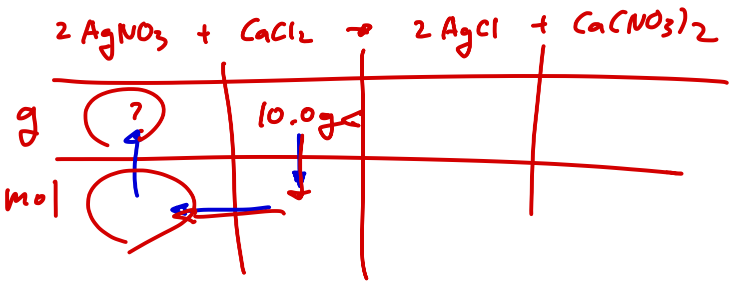
$$0.6\,g\ C_5H_{12} \times \frac{1\ mol}{72.15\ g} \times \frac{8\ O_2}{1\ C_5H_{12}} \times \frac{32.00\ g}{1\ mol} = \boxed{2.13\ g\ O_2}$$

6. When silver nitrate is added to an aqueous solution of calcium chloride, a precipitation reaction occurs that removes the chloride ions from solution.

$$2\ \text{AgNO}_{3(s)} + \text{CaCl}_{2(aq)} \rightarrow 2\ \text{AgCl}_{(s)} + \text{Ca(NO}_3)_{2(aq)}$$

mass (g)

a) If a solution contains 10.0 g CaCl_2, what mass of AgNO_3 should be added to remove all of the chloride ions from solution?



$$10.0\,\cancel{\text{g}}\ \cancel{\text{CaCl}_2} \times \frac{1\ \text{mol}}{110.98\ \cancel{\text{g}}} \times \frac{2\ \text{AgNO}_3}{1\ \cancel{\text{CaCl}_2}} \times \frac{169.87\ \text{g}}{1\ \cancel{\text{mol}}}$$

$$= 30.61\ \text{g AgNO}_3$$

b) When enough AgNO_3 is added so that all 10.0 g of CaCl_2 react, what mass of the AgCl precipitate should form?

$$10.0\text{g CaCl}_2 \times \frac{1\ \text{mol}}{110.98\ \text{g}} \times \frac{2\ \text{AgCl}}{1\ \text{CaCl}_2} \times \frac{143.32\ \text{g}}{1\ \text{mol}} = \boxed{25.83\ \text{g AgCl}}$$

8. The balanced equation for the reaction of phosphorus and oxygen gas to form tetraphosphorus decoxide is: What is the limiting reactant when each of the following sets of quantities of reactants is mixed?

P

by running out first

$$P_{4(g)} + 5\,O_{2(g)} \rightarrow P_4O_{10(s)}$$

a) 0.50 mol P_4 and 5.0 mol O_2 LR

$$0.50\ \text{mol}\ \boxed{P_4} \times \frac{1\ P_4O_{10}}{1\ P_4} = \underline{0.5}\ \text{~~5~~ smaller.}$$

$$5.0\ \text{mol}\ O_2 \times \frac{1\ P_4O_{10}}{5\ O_2} = \cancel{1.0}$$

b) 0.20 mol P_4 and 1.0 mol O_2

$$0.2\ \boxed{P_4} \times \frac{1\ P_4O_{10}}{1\ P_4} = 0.2$$

$$1.0\ \boxed{O_2} \times \frac{1\ P_4O_{10}}{5\ O_2} = 0.2$$

) same.

LR

c) 0.25 mol P_4 and 0.75 mol O_2

$$0.25\ P \times \frac{1\ P_4O_{10}}{1\ P} = 0.25$$

$$0.75\ \boxed{O_2} \times \frac{1\ P_4O_{10}}{5\ O_2} = \boxed{0.15}$$

LR

9. The balanced equation for the reaction of aluminum metal and chlorine gas is Assume that 0.40 g of Al is mixed with 0.60 g of Cl_2.

$$2\,Al_{(s)} + 3\,Cl_{2(g)} \rightarrow 2AlCl_{3(s)}$$

a) What is the limiting reactant?

X $0.40g\ Al \times \frac{1\ mol}{26.98\ g} \times \frac{2\ AlCl_3}{2\ Al}$ 0.0148 X

$0.60\ g\ \boxed{Cl_2} \times \frac{1\ mol}{70.90\ g} \times \frac{2\ AlCl_3}{3\ Cl_2}$ 0.0056 = smaller.

LR

b) What is the maximum amount of $AlCl_3$, in grams, that can be produced?

$$0.60g\ Cl_2 \times \frac{1\ mol}{70.90\ g} \times \frac{2\ AlCl_3}{3\ Cl_2} \times \frac{133.34\ g}{1\ mol}$$

$$= \boxed{0.752\ g\ AlCl_3}$$

10. Certain drain cleaners are a mixture of sodium hydroxide and powdered aluminum. When dissolved in water, the sodium hydroxide reacts with the aluminum and the water to produce hydrogen gas. The sodium hydroxide helps dissolve grease, and the hydrogen gas provides a mixing and scrubbing action. What mass of hydrogen gas would be formed from a reaction of 2.48g Al and 4.75g NaOH in water?

$$2Al_{(s)} + 2\ NaOH_{(aq)} + 6\ H_2O_{(l)} \rightarrow 2\ NaAl(OH)_{4(aq)} + 3\ H_{2(g)}$$

2.48g	4.75g			$\boxed{0.2786g}$
0.0919	0.1188		X	0.1379 mol

Smaller

$\times \frac{2.02\ g}{1\ mol}$

$$2.48\ g\ Al \times \frac{1\ mol}{26.98\ g} = 0.0919\ mol \times \frac{3\ H_2}{2\ Al} = 0.1379)$$

Smaller.

$$4.75\ g\ NaOH \times \frac{mol}{40.00\ g} = 0.1188\ mol \times \frac{3\ H_2}{2\ NaOH} = 0.\cancel{1782}$$

11. A 5.0-g sample of greenish-yellow Cl_2 gas is added to a 10.0-g sample of gray potassium metal to form a white solid in a sealed container.

a) Write a balanced equation for the combination reaction that should occur.

$$Cl_2 + 2K \rightarrow 2KCl$$

$$\begin{array}{ccc} & LR & \\ A & + 2B & \rightarrow C \\ 10 & 10 & \\ -5 & -10 & \\ \hline 5 & 0 & \\ \text{excess} & & \end{array}$$

b) Identify the limiting reactant.

$$5g\ Cl_2 \times \frac{1\ mol}{70.90\ g} \times \frac{2\ KCl}{1\ Cl_2} = \boxed{0.141\ mol\ KCl}$$

smaller.

$$10g\ K \times \frac{1\ mol}{39.10\ g} \times \frac{2\ KCl}{2\ K} = 0.256$$

c) Predict the appearance of the substances left in the reaction container once the reaction is complete.

d) Calculate the mass of product that should form.

$$0.141\ mol\ KCl \times \frac{74.55\ g}{1\ mol} = \boxed{10.5g\ KCl}$$

e) What mass of excess reactant should be mixed with the product after the reaction is complete?

12. A student was synthesizing aspirin in the laboratory. Using the amount of limiting reactant, she calculated the mass of aspirin that should form as 8.95 g. When she weighed her aspirin product on the balance, its mass was 7.44 g.

→ experimental.

a) What is the actual yield of aspirin?

$$\%\text{Yield} = \frac{A}{T} \times 100$$

7.44g

→ calculated.

b) What is the theoretical yield of aspirin?

8.95g

c) Calculate the percent yield for this synthesis.

$$\frac{7.44}{8.95} \times 100 = \boxed{83.13\ \%}$$

13. The combination reaction of sodium metal and chlorine gas to form sodium chloride is represented by the following balanced equation:

$$2\,Na_{(s)} + Cl_{2(g)} \rightarrow 2\,NaCl_{(s)}$$

Na

If 5.00 g of sodium metal reacts completely with excess chlorine gas, and 11.5 g NaCl is actually obtained, what is the percent yield of sodium chloride?

AY.

g → mol → mol → g

$$\frac{A_{NaCl}}{T_{NaCl}} \times 100 = \%$$

$\frac{10.2}{x} = 0.92$

$\frac{10.2}{0.92} = x = 11.09$

14. The combination reaction of sodium metal and nitrogen gas to form sodium nitride is represented by the following balanced equation:

$$6\ Na_{(s)} + N_{2(g)} \rightarrow 2Na_3N_{(s)}$$

If 0.30 mol of Na is mixed with 0.60 mol of N2, and $\underline{\text{0.092 mol of Na3N}}$ is obtained, what is the percent yield for the reaction?

Actual Yield

$$6\ Na + N_2 \rightarrow 2\ Na_3N$$

0.3 0.6

Smaller.

Theo. Yield.

$$\left(0.3\ mol\ Na \times \frac{2\ Na_3N}{6\ Na}\right) = \underline{0.1\ mol\ Na_3N}$$

$$\frac{0.092}{0.1} \times 100 = \boxed{92\%}$$

$$0.6\ mol\ N_2 \times \frac{2\ Na_3N}{1\ N_2} = \cancel{1.2\ mol\ Na_3N}$$

15. The decomposition reaction of calcium carbonate is represented by the following balanced equation:

$$CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$$

After a 15.8-g sample of calcium carbonate was heated in an open container to cause decomposition, the mass of the remaining solid was determined to be ~~9.10~~ 8.10g g. The student is unsure if the reaction is complete, so the solid could contain unreacted $CaCO_3$.

experimental number.

$$\% \text{ Yield.} = \frac{\boxed{A}}{\boxed{T}} \times 100$$

$$CaCO_3 \rightarrow CaO + CO_2$$

15.8 g ①↓ mol $\xrightarrow{②}$ mol ③↑ g ← Theo. Yield.

$$\underbrace{15.8\,g\ CaCO_3 \times \frac{1\ mol}{100.09\,g} = 0.1579\ mol\ CaCO_3}_{①} \underbrace{\times \frac{1\ CaO}{1\ CaCO_3} = 0.1579\ mol\ CaO}_{②} \underbrace{\times \frac{56.08\ g}{1\ mol} = 8.86\,g\ CaO}_{③}$$

Theo. amount.

Ca 40.08 x 1
C 12.01 x 1
O 16.00 x 3

Ca 40.08 x 1
O 16.00 x 1

$$= \frac{8.10\,g}{8.86\,g} \times 100 = \boxed{91.42\%}$$