KEY

CHMG.141.02

With Dr. Bailey

# Stoichiometry/Review

W15

A. Zinc reacts with acids to produce $H_2$ gas.

Have 10.0 g of Zn

**$Zn(s) + 2\,HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$**

1. What is the theoretical yield (g) of $H_2$ gas?

$10.0\,g\,Zn \times \frac{1\,mol\,Zn}{65.39\,g} = 0.153\,mol_{Zn}$

$0.153\,mol_{Zn} \times \frac{1\,mol\,H_2}{1\,mol\,Zn} \times \frac{2.02\,g\,H_2}{1\,mol\,H_2} = \boxed{0.309\,g\,H_2}$

2. How many liters of $H_2$ at 1.15 atm and 30.0 °C are produced by reaction of 10.0 g Zn?

$P \cdot V = n \cdot R \cdot T$ $\quad 0.153\,mol_{Zn} = 0.153\,mol\,H_2$

$K = 30.0\,^{\circ}C + 273.15 = 303.15\,K$

$V = \frac{n \cdot R \cdot T}{P} = \frac{0.153\,mol_{H_2} \times 0.0821\,\frac{L \cdot atm}{mol \cdot K} \times 303.15\,K}{1.15\,atm} = \boxed{3.31\,L_{H_2}}$

3. How many liters of $H_2$ at STP are produced by reaction of 10.0 g Zn?

$0.153\,mol_{H_2} \times \frac{22.4\,L}{1\,mol} = \boxed{3.43\,L_{H_2}}$

4. What <u>volume</u> of 2.50 M HCl is needed to convert the Zn completely?

$Zn(s) + 2\,HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

10.0g 2.50M

V = ?

$0.153\,mol_{Zn} \times \frac{2\,mol\,HCl}{1\,mol_{Zn}} = 0.306\,mol\,HCl$

$M = \frac{\#\,mol}{V(L)}$ $\quad V = \frac{\#\,mol}{M} = \frac{0.306\,mol\,HCl}{2.50\,mol/L} =$

$= \boxed{0.122\,L = 122\,mL}$

5. What molarity of $ZnCl_2$ formed?

$0.153 \text{ mol Zn} \times \frac{1 \text{ mol } ZnCl_2}{1 \text{ mol Zn}} = 0.153 \text{ mol } ZnCl_2$

$M_{ZnCl_2} = \frac{0.153 \text{ mol } ZnCl_2}{0.122 \text{ L}} = \boxed{1.25 \frac{\text{mol}}{\text{L}}}$ $\quad V = 0.122 \text{ L}$

6. How many molecules of HCl participate in the reaction? How many Cl atoms?

$0.306 \text{ mol HCl} \times \frac{6.022 \times 10^{23} \text{ molec.}}{1 \text{ mol}} = \boxed{1.84 \times 10^{23} \text{ molecules HCl}}$

$1.84 \times 10^{23} \text{ molec. HCl} \times \frac{1 \text{ atom Cl}}{1 \text{ molec. HCl}} = \boxed{1.84 \times 10^{23} \text{ atoms Cl}}$

7. $Zn(s) + 2\,HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$ $\Delta H = -125$ kJ

- Is this reaction exothermic or endothermic? $\boxed{\text{exothermic, heat = product}}$
- Calculate the amount of heat transferred when 10.0 g solid zinc reacts?

$0.153 \text{ mol Zn} \times \frac{125 \text{ kJ}}{1 \text{ mol Zn}} = \boxed{19.1 \text{ kJ}}$

B. Titration of 20.0 mL of an unknown sulfuric acid acid solution required 18.45 mL of 0.100 M NaOH to reach equivalence.

1. Write the balanced equation.

$H_2SO_4(aq) + 2\,NaOH(aq) \rightarrow Na_2SO_4(aq) + 2\,H_2O(l)$

$V_A = 20.0 \text{ mL}$, $M = ?$ $\quad V_B = 18.45 \text{ mL}$, $M = 0.100$

2. What is the concentration of the sulfuric acid?

$\#\text{ mol}_B = M_B \times V_B = 0.100 \frac{\text{mol}}{\text{L}} \times \left(18.45 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}}\right) = 0.00185 \text{ mol}_B$

$0.00185 \text{ mol B} \times \frac{1 \text{ mol } H_2SO_4}{2 \text{ mol B}} = 0.000923 \text{ mol}_A$

$M = \frac{0.000923 \text{ mol}}{20.0 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}}} = \boxed{0.0462 \frac{\text{mol}}{\text{L}}}$

3. Calculate the pH of the sulfuric acid solution.

$H_2SO_4(aq) \rightarrow 2\,H^+(aq) + SO_4^{-2}(aq)$

$[H^+] = 2\,[H_2SO_4] = 2 \times 0.0462\,M = 0.0923\,M_{(H^+)}$

$pH = -\log(0.0923) =$

**Part C**

1. 10.00 of hydrogen and 10.00 of oxygen mixed in the previously evacuated 500 mL flask at 500 K. After the reaction has reached completion, what would be the pressure in the flask?

a) Write the balanced equation.

$$2\,H_2(g) + O_2(g) \rightarrow 2\,H_2O(g)$$

b) What is the theoretical yield of water (in moles, in g)? Tip: this is limiting reactants problem

$$10.0\,g\,H_2 \times \frac{1\,mol\,H_2}{2.016\,g\,H_2} = 4.96\,mol\,H_2 \times \frac{2\,mol\,H_2O}{2\,mol\,H_2} = 4.96\,mol\,H_2O$$

$$10.0\,g\,O_2 \times \frac{1\,mol\,O_2}{32.0\,g\,O_2} = 0.3125\,mol\,O_2 \times \frac{2\,mol\,H_2O}{1\,mol\,O_2} = 0.625\,mol\,H_2O$$

So, $O_2$ is limiting reactant

$$0.625\,mol\,H_2O \times \frac{18.02\,g\,H_2O}{1\,mol\,H_2O} = 11.3\,g\,H_2O$$

c) Build the table: $H_2(g) + O_2(g) \longrightarrow 2\,H_2O$

| Number of moles | $H_2$ | $O_2$ | $H_2O$ |
|---|---|---|---|
| Initial | 4.96 | 0.3125 | 0 |
| Change | $-2(0.3125)$ | $-0.3125$ | $+0.625$ |
| After the reaction has reached completion | 4.335 | 0 | 0.625 |

d) What total moles of gas is at completion?

$$N_{total} = 4.335 + 0.625 = 4.96\,mol$$

e) What would be the pressure in the flask?

$$P \cdot V = n \cdot R \cdot T \qquad P = \frac{n \cdot R \cdot T}{V} = \frac{4.96\,mol \times 0.0821\,\frac{L\,atm}{mol \cdot K} \times 500\,K}{0.500\,L} =$$

$$= 407\,atm$$

# Mole Conversions to Mass, Volume, Molecules, and Molarity