

KEY

Stoichiometry/Review

W/5

A. Zinc reacts with acids to produce H₂ gas.

Have 10.0 g of Zn

1. What is the theoretical yield (g) of H₂ gas?

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

$$0.153 \text{ mol Zn} \times \frac{1 \text{ mol H}_2}{1 \text{ mol Zn}} \times \frac{2.02 \text{ g H}_2}{1 \text{ mol H}_2} = \boxed{0.309 \text{ g H}_2}$$

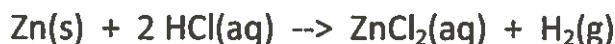
2. How many liters of H₂ at 1.15 atm and 30.0 °C are produced by reaction of 10.0 g Zn?

$$K = 30.0^\circ\text{C} + 273.15 = 303.15 \text{ K} \quad P \cdot V = n \cdot R \cdot T \quad 0.153 \text{ mol Zn} = 0.153 \text{ mol H}_2$$

$$V = \frac{n \cdot R \cdot T}{P} = \frac{0.153 \text{ mol H}_2 \times 0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \times 303.15 \text{ K}}{1.15 \text{ atm}} = \boxed{3.31 \text{ L H}_2}$$

3. How many liters of H₂ at STP are produced by reaction of 10.0 g Zn?

$$0.153 \text{ mol H}_2 \times \frac{22.4 \text{ L}}{1 \text{ mol}} = \boxed{3.43 \text{ L H}_2}$$

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

10.0g 2.50M

V = ?

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

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

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

5. What molarity of ZnCl_2 formed?

$$M_{\text{ZnCl}_2} = \frac{0.153 \text{ mol ZnCl}_2}{0.122 \text{ L}} = 1.25 \frac{\text{mol}}{\text{L}}$$

$$0.153 \frac{\text{mol}}{\text{Zn}} \times \frac{1 \text{ mol ZnCl}_2}{1 \text{ mol Zn}} = 0.153 \text{ mol ZnCl}_2$$

$$V = 0.122 \text{ L}$$

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

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

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

7. $\text{Zn(s)} + 2 \text{HCl(aq)} \rightarrow \text{ZnCl}_2\text{(aq)} + \text{H}_2\text{(g)}$ $\Delta H = -125 \text{ kJ}$

• Is this reaction exothermic or endothermic?

exothermic
heat = product

• Calculate the amount of heat transferred when 10.0 g solid zinc reacts?

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

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

1. Write the balanced equation.



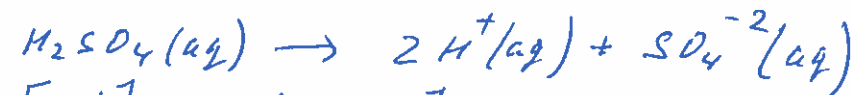
2. What is the concentration of the sulfuric acid?

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

$$0.00185 \text{ mol}_B \times \frac{1 \text{ mol H}_2\text{SO}_4}{2 \text{ mol}_B} = 0.000923 \text{ mol}_A$$

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

3. Calculate the pH of the sulfuric acid solution.



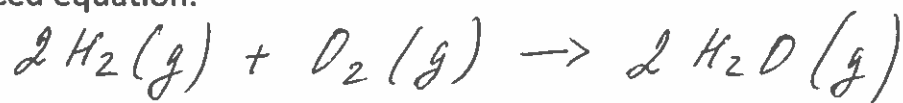
$$[\text{H}^+] = 2 [\text{H}_2\text{SO}_4] = 2 \times 0.0462 \text{ M} = 0.0923 \text{ M}_{(\text{H}^+)}$$

$$\text{pH} = -\log(0.0923) =$$

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.



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

$$10.0\text{ g H}_2 \times \frac{1\text{ mol H}_2}{2.016\text{ g H}_2} = 4.96\text{ mol H}_2 \times \frac{2\text{ mol H}_2\text{O}}{2\text{ mol H}_2} = 4.96\text{ mol H}_2\text{O}$$

$$10.0\text{ g O}_2 \times \frac{1\text{ mol O}_2}{32.0\text{ g O}_2} = 0.3125\text{ mol O}_2 \times \frac{2\text{ mol H}_2\text{O}}{1\text{ mol O}_2} = 0.625\text{ mol H}_2\text{O}$$

So, O₂ is limiting reactant

$$0.625\text{ mol H}_2\text{O} \times \frac{18.02\text{ g H}_2\text{O}}{1\text{ mol H}_2\text{O}} = 11.3\text{ g H}_2\text{O}$$

- c) Build the table:

$$\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}$$

Number of moles	H ₂	O ₂	H ₂ O
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?

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

- e) What would be the pressure in the flask?

$$P \cdot V = n \cdot R \cdot T \quad P = \frac{n \cdot R \cdot T}{V} = \frac{4.96\text{ mol} \times 0.0821 \frac{\text{L atm}}{\text{mol} \cdot \text{K}} \times 500\text{ K}}{0.500\text{ L}} = 4107\text{ atm}$$

Mole Conversions to Mass, Volume, Molecules, and Molarity

