# Lab Session 12, Experiment 11: Valence, the Combining Capacity of Elements and Molecules

One molar mass of an element or compound that produces or reacts with 1.008 grams of

The apparatus should be set up as shown in Figure 12.1. Make sure the bottom of the thistle tube almost touches the bottom of the Erlenmeyer flask. You may be instructed to use the end sink rather than a metal or plastic trough. Be sure that all fittings are tight. This includes the fittings of the rubber stopper in the Erlenmeyer flask, the glass tube through the stopper, and the rubber tubing to the glass tube. (The latter may require a hose clamp or wire winding.)

1. Record the exact mass of the magnesium as entry (a) in the data table.
2. Remove the two-hole stopper from the Erlenmeyer flask and add enough water the cover the bottom of the thistle tube. If the magnesium is ribbon, form it into a ball or tight coil, and place it in the flask. Reinsert the rubber stopper tightly.
3. Add 10 mL of 6M hydrochloric acid solution by pouring it into the thistle tube. Put a rubber stopper in the top of the thistle tube to avoid back-splashing acid or escape of hydrogen gas.
4. After the reaction is complete, allow a few minutes for the flask to cool. Be sure to keep the end of the rubber tubing above the water level in the Florence flask. The gas collected ($H_2$ and water vapor) must be at the same pressure as the barometric pressure. To equalize pressures, remove the gas delivery tube and raise or lower the Florence flask so that the water levels in the trough (or end sink) and in the Florence flask are equal. (You may have to tilt the flask to equalize levels. Be careful that the mouth of the Florence flask stays below the water level in the trough.) Cover the Florence flask opening with a watch glass, invert the Florence flask and place it on the desktop.
5. Using a graduated cylinder, measure the volume of water that must be added to the Florence flask to fill it. It will be assumed that this is the volume of the gas collected. It should be recorded as item (e) in the data table.
6. Measure the temperature of the water in the trough with your thermometer and record it as item (b) below. It will be assumed that this is the temperature of the collected gas.
7. Record the barometric pressure as item (c) below. This is the total pressure of the hydrogen and water vapor.

| | |
|---|---|
| (a) Mass of magnesium | g |
| (b) Temperature of water in trough | ºC |
| (c) Barometric pressure | Torr |

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## 11B Exercise: Converting Data to the Correct Units

1. Calculate the Pressure P = ____________atm

$$\text{Pressure [atm]} = \frac{\text{Barometric Pressure} - \text{Vapor Pressure of } H_2O}{760 \text{ Torr/atm}}$$

2. Calculate the Volume V = ___________ L

Volume in L = Volume in mL ÷ 1000

3. Calculate the Temperature T = ___________K

Absolute temperature in Kelvins = $^{o}C$ + 273.15

4. Calculate the mass of hydrogen Mass = ___________g

Calculating the grams of hydrogen produced using the ideal gas law:

PV = Mass of hydrogen produced ÷ molar mass of hydrogen × 0.08206 (R) × T

Rearranged:

$$\text{Mass in grams of hydrogen produced} = \frac{P \times V \times \text{Molar Mass of } H_2}{0.08206\ (R) \times T}$$

5. From the generalized balanced equation: Mg + x HCl → $MgCl_x$ + ½ x $H_2$, we can calculate how many grams of hydrogen should be produced from the number of grams of magnesium reacted, as follows:

$$g_{\text{ hydrogen}} = (g_{\text{ Mg}})\left(\frac{1\,\text{mole Mg}}{24.305\,\text{g Mg}}\right)\left(\frac{(x/2)\,\text{moles } H_2}{1\,\text{mole Mg}}\right)\left(\frac{2.016\,\text{g } H_2}{1\,\text{mole } H_2}\right) = \frac{x}{24.11}.$$

Rearrangement yields the following ratio.

$$\frac{g_{\text{hydrogen}}}{g_{\text{Mg}}} = \frac{x}{24.11}\text{. Thus, } x = \left(\frac{g_{\text{hydrogen}}}{g_{\text{Mg}}}\right)(24.11)\text{. } x = \left(\frac{\_\_\_\_\_\_\_\_\_\_ g_{H_2}}{\_\_\_\_\_\_\_\_\_\_ g_{\text{Mg}}}\right)(24.11) = \_\_\_\_\_\_\_ .$$

$$\%\text{ error} = \frac{|x - 2|}{2} \text{ X } 100 = \_\_\_\_\_\_\_\_\%$$

Give a balanced equation for the reaction of magnesium with hydrochloric acid:

______________________________________________________________________

6. Verification that HCl is th

## *Report Form 11: The Combining Capacity of Elements and Molecules*

Name____________________________________

Partner_____________________Section #_____

### 11A Experiment

| | |
|---|---|
| (a) Mass of magnesium | g |
| (b) Temperature of water in trough | º C |
| (c) Barometric pressure | Torr |
| (d) Vapor pressure of water at the temperature recorded in (b) | Torr |
| (e) Volume of gas collected = Volume of $H_2O$ added | mL |

### 11B Exercise: Converting Data to the Correct Units

1. Calculate the Pressure P = ________atm
2. Calculate the Volume V = __________L
3. Calculate the Temperature T = __________K
4. Calculate the Mass of hydrogen Mass = __________g
5. $x = \left(\frac{\_\_\_\_\_\_\_\_\ g_{H_2}}{\_\_\_\_\_\_\_\_\ g_{Mg}}\right)(24.11) =$ ________ . % error = ________.

   Give a balanced equation for the reaction of magnesium with hydrochloric acid:

   ______________________________________________________________________

6. Verification that HCl is the excess reagent by completing the following calculations:

________ moles HCl added – ________ moles HCl needed = ________ moles of HCl unreacted

### 11C Alternate Calculations

1. Moles of $H_2$ = ______________mol.
2. Moles of Mg = ______________mol.
3. Mole ratio of $H_2$ to Mg = ______________.
4. $x_{exp} = 2 \times$ ratio = ______________.
5. % error = ______________%.

### 11D Exercise: Nomenclature

| | |
|---|---|
| calcium sulfide | Iron (II) chloride |

sodium sulfate