Chem 108: Lab

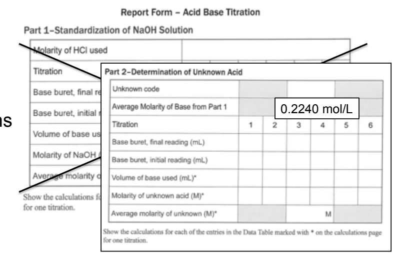
Week 15

Sign in
Pick up Papers
Choose 2-3 partners for today's experiments

Chem 108: Lab

Due Today:
Acid-Base Titration
Complete Individual Report form pp.94-96.

Include clear calculations with units.


Name: ____________
Section: ________

Report Form – Acid Base Titration

Part 1–Standardization of NaOH Solution

Molarity of HCl used
Titration
Base buret, final re…
Base buret, initial …
Volume of base us…
Molarity of NaOH …
Average molarity o…

Show the calculations fo… for one titration.

Part 2–Determination of Unknown Acid

Unknown code						
Average Molarity of Base from Part 1			0.2240 mol/L			
Titration	1	2	3	4	5	6
Base buret, final reading (mL)						
Base buret, initial reading (mL)						
Volume of base used (mL)*						
Molarity of unknown acid (M)*						
Average molarity of unknown (M)*				M		

Show the calculations for each of the entries in the Data Table marked with * on the calculations page for one titration.

Unkown Acid Neutralization

Net Ionic Equation/ Calculation

$$H^{+}_{(aq)} + OH^{-}_{(aq)} \longrightarrow H_2O_{(l)}$$

acid base water

25.00 mL of $M_{H+\,aq}$= ? (unknown acid solution) was titrated with a sodium hydroxide solution, M_{OH-}= ? 0.2162 M. It required 24.20 mL as an average of three trials which were within +/- 0.20 mL to reach a faint pink color.

$$?M_{H+} = [M_{OH-} \times V_{OH-} / V_{H+}]\,[?\, mol_{H+} / ?\, mol_{OH-}]$$

$$= \frac{0.2162\ mol_{OH-} \times 0.02420\ L_{OH-} \times 1\ mol_{H+}}{L_{OH-} \times 0.02500\ L_{H+} \times 1\ mol_{OH-}} = 0.2093\ M_{H+}$$

Two Experiments (Goup Based)

Selected Partner(s): Group of 3-4.

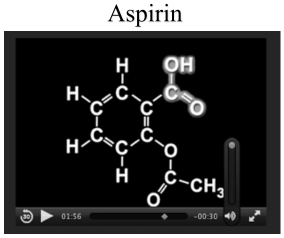
1. Synthesis of Aspirin (Part A ONLY)
   Lab Manual Instructions pg. 88; Report pg. 90 ONLY

   After the class completes filtering & storing the synthesized aspirin, then the second experiment can be started.

   (Do help other Groups.)

2. Gas Stoichiometry
   Lab Manual Instructions pp. 53-56; Report pp. 58-60

Experiment 1: Synthesis of an NSAID (Non-steroid anti-inflammatory drug) Aspirin



$C_9H_8O_4$

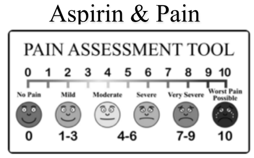
http://chemconnections.org/general/movies/Representations.MOV

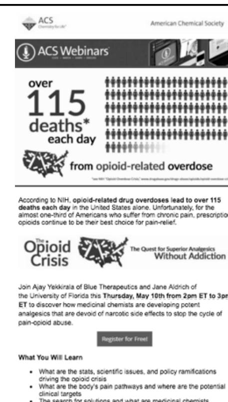
NSAIDs are used primarily to treat inflammation, mild to moderate pain, and fever.

Synthesis of Aspirin (an NSAID)

Used primarily to treat inflammation, mild to moderate pain, and fever.

Aspirin & Pain

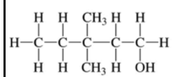




Representing Organic Molecules

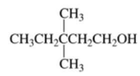
Common Formulas & Drawings

Molecular formula: $C_7H_{16}O$ **Empirical Formula:** $C_7H_{16}O$

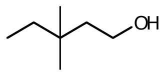


Condensed Structure:

$CH_3CH_2C(CH_3)_2CH_2CH_2OH$ or

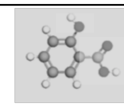


Bond-Line Structure:

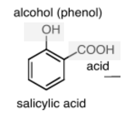


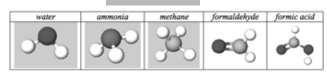
REACTANT: Salicylic Acid

Common Functional Groups



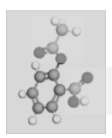
Name	General Formula
Alcohols	R–OH
Ethers	R–O–R′
Amines	$R–NH_2$
Carboxylic Acids	R-C(=O)-OH



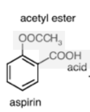


PRODUCT: Acetyl salicylic acid (aspirin)

Common Functional Groups



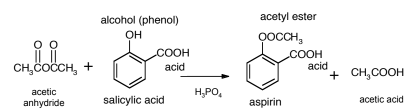
Name	General Formula
Aldehydes	R-C(=O)-H
Ketones	R-C(=O)-R'
Carboxylic Acids	R-C(=O)-OH
Esters	R-C(=O)-OR'
Amides	R-C(=O)-N(R")R'



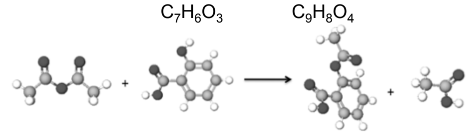
Group of 3-4.

Synthesis of Aspirin

Part A pg.88 - ONLY

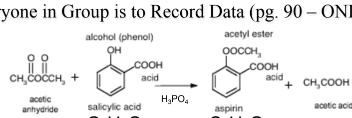


$C_7H_6O_3$ $C_9H_8O_4$



Synthesis of Aspirin

Everyone in Group is to Record Data (pg. 90 – ONLY)



$C_7H_6O_3$ $C_9H_8O_4$

1. **Get equipment from stockroom with your group.**
2. **Follow instructions in lab manual pg.88 carefully. Be mindful of your safety. WEAR eye protection.**
3. **Store in lab drawer as instructed in Part A.3 of the instructions of the lab procedure.**
4. **Part A-4. Next Week**

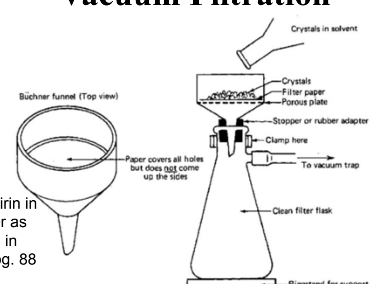
Equipment

From the stockroom:
- Beaker clamp
- filter flask
- Büchner funnel
- ice bath – in lab

From the common drawer:
- ring stand and ring
- wire gauze
- Bunsen burner

From your drawer:
- 125 mL Erlenmeyer flask
- large beaker

Vacuum Filtration

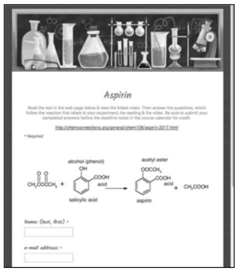


Store aspirin in lab drawer as instructed in Part A.3 pg. 88 of the instructions of the lab procedure.

https://www.youtube.com/watch?v=uJO_frXdNsU

Completed Report Form & On-line Post Lab Due next week.

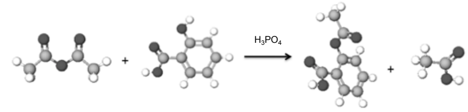
http://chemconnections.org/general/chem108/Aspirin%20Guide.html



Store filtered crude aspirin in lab drawer and weigh next week.

NEXT WEEK: Calculate % Yield.

TODAY: *Calculate Theoretical Yield*



grams (Salicylic Acid) ⟶ grams (Aspirin)

Using your mass of salicylic acid from page 90.

Moles / Molar Mass / Stoichiometry

$C_9H_8O_4$ MW = 180.15

? grams (SA)	1 mol (SA)	1 mol A	grams (A) (Molecular Weight A)	= ? (A)
	grams (SA) (Molecular Weight SA)	1 mol SA	1 mol (A)	

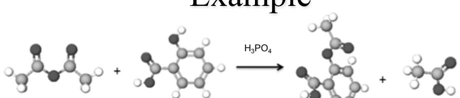
"Gatekeeper"

$C_7H_6O_3$ MW = 138.12

??? aspirin

Show clearly labeled calculation with units & correct s.f ; Have pg. 90 signed before leaving lab.

Example



grams (Salicylic Acid) ⟶ grams (Aspirin)

Moles / Molar Mass / Stoichiometry

$C_9H_8O_4$ MW = 180.15

5.0 grams (SA)	1 mol (SA)	1 mol A	grams (A) (Molecular Weight A)	= ? (A)
	grams (SA) (Molecular Weight SA)	1 mol SA	1 mol (A)	

"Gatekeeper"

$C_7H_6O_3$ MW = 138.12

6.5 g aspirin

Experiment 2:

Gas Stoichiometry

http://chemconnections.org/general/chem108/Magnesium-Zinc-wo.1.mov

Experimentally Determining Moles of Hydrogen

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

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

Using Partial Pressures
the Ideal Gas Law & Stoichiometry
Dr. Ron Rusay

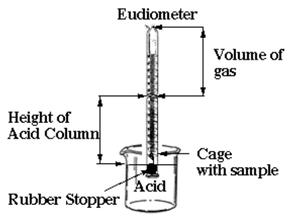
- Refer to the Procedure section pp. 53-57. The following slides correspond to the instructions in the procedure.

Equipment

From the stockroom:
- 100 mL eudiometer
- buret clamp
- digital thermometer
- meter stick

From common equipment shelves:
- ring stand

From your drawer:
- large beaker (at least 400 mL)
- wash bottle



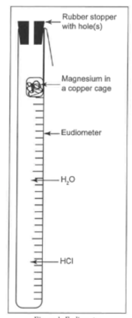
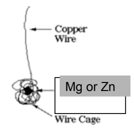
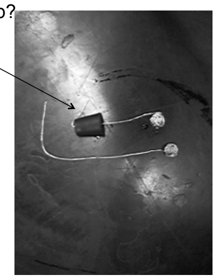


Figure 1–Eudiometer

What is wrong with this set up?





$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

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

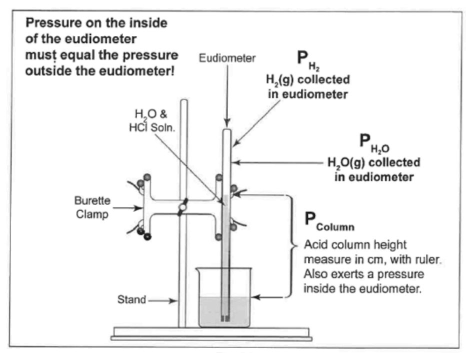
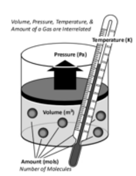


Figure 2

- Refer to the Gas Stoichiometry Report Form, pg. 58-59
- Experimental data is to be obtained for the reaction of a known mass of magnesium metal:

  $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$
- The volume of hydrogen, pressure and temperature determined and recorded.
- Moles of hydrogen is calculated using Ideal Gas Law calculations, then calculating mass of the starting magnesium from the number of moles of hydrogen.



Background

Ideal Gas Law

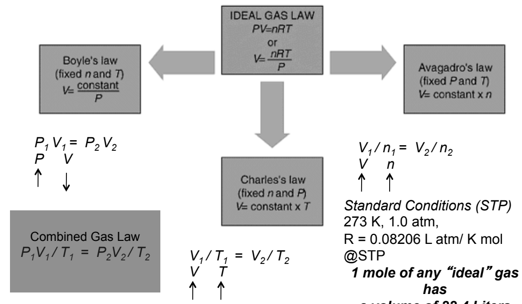
PV = n RT

- **R = "proportionality" constant**
  = 0.08206 L atm K^{-1} mol^{-1}
- **P = pressure of gas in atm**
- **V = volume of gas in liters**
- **n = moles of gas**
- **T = temperature of gas in Kelvin**

Standard Conditions Temperature, Pressure & Moles

- "STP"
- For 1 mole of a gas at STP:
- P = 1 atmosphere
- T = 0°C (273.15 K)
- The molar volume of an ideal gas is ***22.42*** liters at STP

Isobaric process: pressure constant
Isochoric process: volume constant
Isothermal process: temperature constant



Standard Conditions (STP)
273 K, 1.0 atm,
R = 0.08206 L atm/ K mol
@STP
1 mole of any "ideal" gas has a volume of 22.4 Liters.

Hydrogen & the Ideal Gas Law

$n_{H_2(g)} = PV / RT$

- **n = moles $H_2(g)$**
- **P $H_2(g)$ = pressure of H_2(g) in atm (mm Hg → atm)**
- **V = experimental volume (mL→ L)**
- **T = experimental temperature (°C → K)**

$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

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

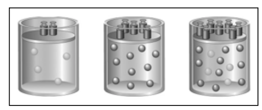
Total Pressure:

Sum of the Partial Pressures

- For a mixture of gases, the total pressure is the sum of the pressures of each gas in the mixture.

$P_{Total} = P_1 + P_2 + P_3 + ...$

$P_{Total} \propto n_{Total}$



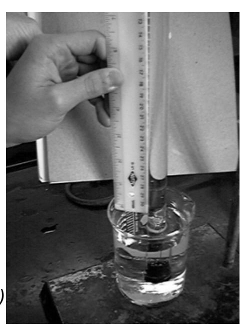
$n_{Total} = n_1 + n_2 + n_3 + ...$

•**P $H_2(g)$ = P Total** (barometric) - **P H_2O (g) [*TABLE*] - P HCl (g)**

P HCl (g) =

HCl Height (mm) ÷ 12.95

Density Hg is 12.95 times > density HCl(aq)



0.772 mm Hg/cm of acid solution

P HCl (g) =

HCl Height (mm) x 0.0772

Density Hg is 12.95 times > density HCl(aq)

Ideal Gas Law:

Moles / Avogadro's Law

$n_{H_2(g)} = PV / RT$

- **n = moles $H_2(g)$**
- **P $H_2(g)$ = pressure of H_2(g) in atm (mm Hg → atm)**
- **P $H_2(g)$ = P Total** (barometric) - **P H_2O (g) [*TABLE*] - P HCl (g)**
- **V = experimental volume (mL→ L)**
- **T = experimental temperature (°C → K)**
- **R = 0.082057338** L atm $K^{-1} mol^{-1}$ **(constant)**

$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$
$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

- Refer to Report Form Part I pg. 58: (Example uses Zinc.)

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

Mole Calculations:
- Stoichiometry Calculation
- Ideal Gas Law Calculations
- Comparison (% Error)
- Everyone in the Group is to complete Part I and Part II pp. 58-60

Stoichiometry

Moles Hydrogen / Mass of Zinc

(Part I: Zinc Calculation)

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

$\text{mol}_{\,H_2(g)} = \text{mol}_{\,Zn(s)}$

$\text{mass (g)}_{\,Zn(s)} = \text{mol } Zn(s) \times \text{Molar Mass}_{\,Zn(s)}$

Zinc Example Calculation

- Complete Report Form pg. 58 Part I:

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

Mole Calculations:
- Stoichiometry Calculation
- Ideal Gas Law Calculations
- Comparison (% Error)

Report Form – Gas Stoichiometry

Part I – Sample Data for Mass of Zinc

Chemical Reaction		
DATA COLLECTED		
Volume of hydrogen collected*	81.5 mL	L
Temperature of hydrogen*	22.0 °C	K
Barometric pressure*	29.98 in Hg	mm Hg
Height of solution in eudiometer from benchtop		19.2 cm
Height of solution in beaker from benchtop		10.0 cm
CALCULATIONS AND RESULTS		
Difference in liquid levels of solution in eudiometer and beaker*		
Aqueous vapor pressure at temperature of hydrogen		mm Hg
Pressure caused by acid column:* (Difference in cm)*(0.772 mm Hg/cm)		mm Hg
Pressure of hydrogen alone*	mm Hg	atm
Moles of hydrogen*		moles
Moles of zinc*		moles
Mass of zinc (calculated)*		g

Show the calculations for each of the entries in the Data Table marked with * on the calculations page.

Question: If the mass of zinc used was 0.21 g, what is the percent error for your calculated mass of zinc? Show your work below.

Moles : Ideal Gas Law

(Part I: Zinc Calculation Example)

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

$n_{\,H_2(g)} = PV / RT$

- **n = moles $H_2(g)$**
- **$P_{\,H_2(g)}$ = pressure of $H_2(g)$ in atm (mm Hg → atm)**
- **$P_{\,H_2(g)}$ = P Total (barometric) - $P_{\,H_2O\,(g)}$ [*TABLE*] - $P_{\,HCl\,(g)}$**
- **V = experimental volume (mL → L)**
- **T = experimental temperature (°C → K)**

R = **0.082057338** L atm K^{-1} mol^{-1}

Moles : Ideal Gas Law

(Part I: Zinc Calculation Example)

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

$n_{\,H_2(g)} = PV / RT$

V = experimental volume (mL → L)

R = **0.082057338** L atm K^{-1} mol^{-1}

Report Form – Gas Stoichiometry

Part I – Sample Data for Mass of Zinc

Chemical Reaction		
DATA COLLECTED		
Volume of hydrogen collected*	81.5 mL	L
Temperature of hydrogen*	22.0 °C	K
Barometric pressure*	29.98 in Hg	mm Hg
Height of solution in eudiometer from benchtop		19.2 cm
Height of solution in beaker from benchtop		10.0 cm
CALCULATIONS AND RESULTS		
Difference in liquid levels of solution in eudiometer and beaker*		
Aqueous vapor pressure at temperature of hydrogen		mm Hg
Pressure caused by acid column:* (Difference in cm)*(0.772 mm Hg/cm)		mm Hg
Pressure of hydrogen alone*	mm Hg	atm
Moles of hydrogen*		moles
Moles of zinc*		moles
Mass of zinc (calculated)*		g

Show the calculations for each of the entries in the Data Table marked with * on the calculations page.

Question: If the mass of zinc used was 0.21 g, what is the percent error for your calculated mass of zinc? Show your work below.

Moles : Ideal Gas Law

(Part I: Zinc Calculation Example)

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

$n_{\,H_2(g)} = PV / RT$

V = experimental volume (mL → L)

T = experimental temperature (°C → K)

R = **0.082057338** L atm K^{-1} mol^{-1}

Report Form – Gas Stoichiometry

Part I – Sample Data for Mass of Zinc

Chemical Reaction		
DATA COLLECTED		
Volume of hydrogen collected*	81.5 mL	L
Temperature of hydrogen*	22.0 °C	K
Barometric pressure*	29.98 in Hg	mm Hg
Height of solution in eudiometer from benchtop		19.2 cm
Height of solution in beaker from benchtop		10.0 cm
CALCULATIONS AND RESULTS		
Difference in liquid levels of solution in eudiometer and beaker*		
Aqueous vapor pressure at temperature of hydrogen		mm Hg
Pressure caused by acid column:* (Difference in cm)*(0.772 mm Hg/cm)		mm Hg
Pressure of hydrogen alone*	mm Hg	atm
Moles of hydrogen*		moles
Moles of zinc*		moles
Mass of zinc (calculated)*		g

Show the calculations for each of the entries in the Data Table marked with * on the calculations page.

Question: If the mass of zinc used was 0.21 g, what is the percent error for your calculated mass of zinc? Show your work below.

Moles : Ideal Gas Law

(Part I: Zinc Calculation Example)

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

$n_{H_2(g)} = PV / RT$

V = experimental volume (mL → L)

T = experimental temperature (°C → K)

P $_{H_2(g)}$ = pressure of H_2(g) in atm (mm $_{Hg}$ → atm)

P $_{H_2(g)}$ = P Total (barometric) - P H_2O (g) [*TABLE*] - P HCl (g)

R = 0.082057338 L atm K^{-1} mol^{-1}


Report Form – Gas Stoichiometry

Part I – Sample Data for Mass of Zinc

Chemical Reaction		
DATA COLLECTED		
Volume of hydrogen collected*	81.5 mL	L
Temperature of hydrogen*	22.0 °C	K
Barometric pressure*	29.98 in Hg	mm Hg
Height of solution in eudiometer from benchtop		19.2 cm
Height of solution in beaker from benchtop		10.0 cm
CALCULATIONS AND RESULTS		
Difference in liquid levels of solution in eudiometer and beaker*		
Aqueous vapor pressure at temperature of hydrogen		mm Hg
Pressure caused by acid column:* (Difference in cm)*(0.772 mm Hg/cm)		mm Hg
Pressure of hydrogen alone*	mm Hg	atm
Moles of hydrogen*		moles
Moles of zinc*		moles
Mass of zinc (calculated)*		g

Show the calculations for each of the entries in the Data Table marked with * on the calculations page.

Question: If the mass of zinc used was 0.21 g, what is the percent error for your calculated mass of zinc? Show your work below.

Moles : Ideal Gas Law

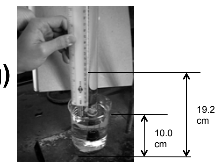
Part I: Hydrogen Calculation, (*Refer to Form's Data*)

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

$n_{H_2(g)} = PV / RT$

- **n = moles $_{H_2(g)}$**
- **P $_{H_2(g)}$ = pressure of H_2(g) in atm (mm $_{Hg}$ → atm)**
- **P $_{H_2(g)}$ = 29.98 inches Hg (barometric) - 19.8 mm Hg H_2O (g) [*TABLE*] - P HCl (g)**

P HCl (g)



R = 0.082057338 L atm K^{-1} mol^{-1}

•**P $_{H_2(g)}$ = P Total (barometric) - P H_2O (g) [*TABLE*] - P HCl (g)**

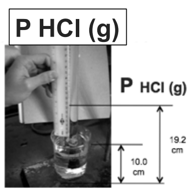
P HCl (g) =

19.2 cm Hg - 10.0 cm Hg = 92 mm HCl

HCl Height (mm) ÷ 12.95

= 7.10 mm Hg

Density Hg is 12.95 times > density HCl(aq)



0.772 mm Hg/cm of acid solution

P HCl (g) =

19.2 cm Hg - 10.0 cm Hg = 92 mm HCl

HCl Height (mm) x 0.0772

= 7.10 mm Hg

Density Hg is 12.95 times > density HCl(aq)

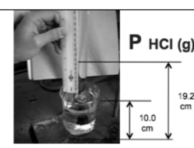
P H_2(g) = 761.5 mm Hg (barometric)

- 19.8 mm Hg H_2O (g) - 7.1 mm Hg HCl (g)

= 734.6 mm Hg

= 734.6 mm Hg / 760.0 mm Hg / 1.000 atm

= 0.9666 atm



Moles : Ideal Gas Law

(Part I: Hydrogen Calculation)

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

$n_{H_2(g)} = PV / RT$

- **n = moles $_{H_2(g)}$**
- **P $_{H_2(g)}$ = 0.9666 atm**
- **V = 0.0815 L**
- **T = 295.1 K**

R = 0.08206 L atm K^{-1} mol^{-1}

n **H_2(g) =** 0.00325 **moles $_{H_2(g)}$** = 0.00325 **moles $_{Zn(s)}$**

% Error

Theoretical Mass Zinc vs. Experimental

(Part I: Calculation)

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

mass (g) $_{Zn(s)}$ = mol Zn(s) x Molar Mass $_{Zn(s)}$

= 0.00325 moles $_{Zn(s)}$ x 65.37 g/mol **$_{Zn(s)}$**

% Error = $\frac{\text{experimental grams}_{Zn(s)} - \text{theoretical grams}_{Zn(s)}}{\text{theoretical grams}_{Zn(s)}} \times 100$

= $\frac{0.213\text{ g} - 0.21\text{ g}}{0.21\text{ g}} \times 100$

= 1.4 %

Bring completed Report Forms to Dr. R. to get Mg(s) sample(s).

(Part II) Magnesium

$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

Mole Calculations:

- Stoichiometry Calculation
- Ideal Gas Law Calculations
- Comparison (% Error)

Get equipment from stockroom and complete data acquisition for Part II.

Have individual Report Forms checked before leaving lab today.

Name: __________

Section: ______

Part II – Mass of Magnesium

Chemical Reaction		
DATA COLLECTED		
Unknown number		
Volume of hydrogen collected*	mL	L
Temperature of hydrogen*	°C	K
Barometric pressure*	inches Hg	mm Hg
Height of solution in eudiometer from benchtop		cm
Height of solution in beaker from benchtop		cm
CALCULATIONS AND RESULTS		
Difference in liquid levels of solution in eudiometer and beaker*		cm Acid Solution
Aqueous vapor pressure at temperature of hydrogen		mm Hg
Pressure caused by acid column:* (Difference in cm) * (0.772 mmHg/cm)		mm Hg
Pressure of hydrogen alone*	mm Hg	atm
Moles of hydrogen*		moles
Moles of magnesium*		moles
Mass of magnesium*		g

Show the calculations for each of the entries in the Data Table marked with * on the calculations page.