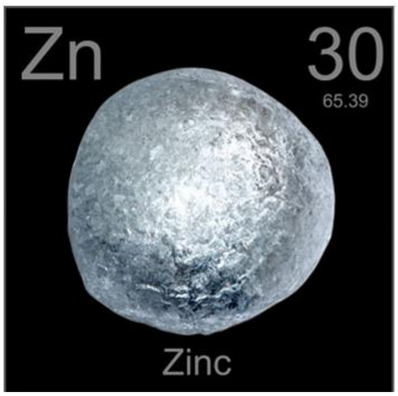
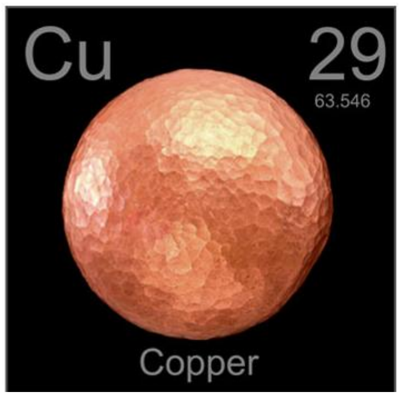
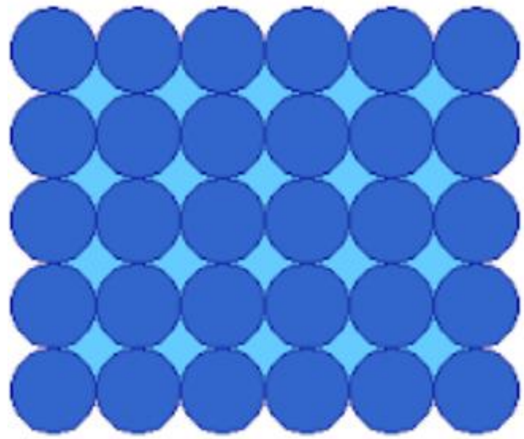
CEAC 103
GENERAL CHEMISTRY

Experiment 6

Determination of The Atomic Weight of a Metal







Purpose: To determine atomic weight of a metal by measuring the volume of the hydrogen gas liberated from the reaction of the oxidation of a metal with an acid.

MATERIALS:

A piece of metal	Beaker	Erlenmeyer flask
Florence flask	Filter paper	Hydrochloric acid (HCl)

THEORY:

A metal which is a good reducing agent will react with hydrochloric acid, liberating hydrogen gas and forming a salt.

$M(solid) + nH^{+} (aqueous) \text{---} > M^{n+} (aqueous) + n/2\ H_2 (gas)$

In this exercise, a weighed sample of metal will be completely dissolved in HCI solution, and the volume of hydrogen liberated will be determined from the volume of water that it displaces. From this data the atomic weight of the metal will be calculated.

After the determination of the atomic weight of the metal, the assistant will tell the student the name of the metal and its theoretical atomic weight. The student then can calculate the percent error in this determination. For the reaction given above the valence of the metal is taken as n+.

A mole is defined as the amount of a substance that contains the same number of chemical units as the number of atoms in exactly 12.0000 g of ${}^{12}_{6}C$

1 mol ${}^{12}_{6}C$ atoms = 12.0000 g ${}^{12}_{6}C$

A mole of atoms, therefore, consists of Avagadro's number of atoms and has a mass in grams numerically equal to the atomic weight of the element, shortly.

$$\text{number of moles of an atom} = \frac{\text{weight}}{\text{Atomic Weight}}$$

$$\text{number of moles of a molecule} = \frac{\text{weight}}{\text{Molecular Weight}}$$

Before doing this experiment, it will be necessary for the student to review his knowledge about the ideal gas equation.

Ideal Gas Equation:

The behavior of an ideal gas is expressed by the well-known equation given below.

$PV = nRT$ Ideal Gas Equation

In order to use this equation correctly the student should use the following units.

P(pressure)	atm
V(volume)	liter
n(number of moles)	moles
T(temperature)	$K = {}^oC + 273$
R(universal gas constant)	0.082 L. atm/mole.K

EXAMPLE 1:

Standard conditions are defined as 0^oC and 1 atm for temperature and pressure, respectively. Using ideal gas equation, calculate the volume which is occupied by one mole of an ideal gas under the standard conditions (STP).

SOLUTION:

$T = 0^oC$

$T = 0^oC + 273.15 = 273.15\ K$

$PV = nRT \quad V = nRT/P$

$V = (1\ mole)(0.082\ L.atm.mole^{-1}K^{-1})(273\ K) / 1\ atm$

$V = 22.4\ L/mole$

EXAMPLE 2:

In a reaction, 334 mL of H_2 gas is liberated at a pressure of 674 mm Hg and a temperature of 17^oC. Calculate the number of moles of H_2 gas liberated.

SOLUTION:

760 mm Hg = 1 atm

P = (674 mm Hg) (1 atm /760mm Hg) = 0.887 atm

T = 17^{o}C + 273 = 290 K

V = 0.334 L

R = 0.082 L.atm.mole^{-1}K^{-1}

$$n = \frac{PV}{RT} = \frac{0887 \text{ x } 0334}{0.082 \text{ x } 290} = 0.012 \text{ moles of } H_2$$

EXAMPLE 3:

0.26 g of an unknown metal is liberating 0.004 moles of H_2 gas. Find the atomic weight of this metal. If the valence of this metal is 2+. Using a periodic table find the name of this metal.

SOLUTION:

0.004 moles of H_2 contains 0.008 moles of H

For n = 2.2 moles of H^+ liberate 1 mole of metal

number of moles of metal = (0.008 moles H)(1 mole metal/2 moles H^+) = 0.004 moles of metal

$$\text{number of moles} = \frac{\text{weight}}{\text{Atomic Weight}} \longrightarrow \text{At. Wt} = \frac{\text{weight}}{\text{number of moles}} = \frac{0.26}{0.004} = 65.0 \text{ g/mole}$$

Closest value to this experimental atomic wt. value is 65.39, thus the metal is predicted to be Zinc.

PROCEDURE:

1. Fill a large Florence flask with water.
2. Pour about 40 mL of dilute HCI into a 125 mL Erlenmeyer flask in such a way that none of the acid comes in contact with the neck of the flask.
3. Set up the apparatus as shown in the figure, and fill the tube between the Florence flask and the beaker with water.
4. Weigh out about 0.3 g of your metal to the nearest 0.010 g. Record this weight.
5. Place the sample in a small bag made from a piece of filter paper; if your sample consists of one or two pieces of metal this may not be necessary.
6. Tie the bag of piece of metal with a piece of thread and suspend it a few centimetres below from the top of the flask, providing that it does not come into contact with the acid solution. You may drop it into the solution as well. THE SYSTEM MUST BE AIRTIGHT. To check for leaks, do the following (8-12).
7. Put some water in the beaker. Keeping the tube between the Florence flask and the beaker filled with water, end of the tube must be placed under the surface of water in the beaker.
8. Raise the beaker until the water surfaces in Florence flask and beaker are at the same level.
9. Close the end of the tube with your fingers and empty the beaker.
10. After the beaker is replaced open the tube. A few drops of water should run from the tube into the beaker, then the flow should cease.
11. A steady strewn or dripping indicates the presence of a leak, which must be eliminated before you proceed further.
12. When the system is shown to be airtight, tilt the Erlenmeyer flask until the acid solution comes in contact with the metal.
13. You will see the hydrogen gas is being produced near the metal, and some water will pour into the beaker. Keep the end of the tube under the surface of water in the beaker. If the reaction is too slow, you may heat the acid solution gently by using the wire gauze, **WAIT** THE PERMISSION OF YOUR ASSISTANT
14. If the reaction becomes too vigorous, it may be stopped by returning the flask to an upright position.
15. After the metal has completely dissolved, completely allow the system to come to room temperature

16. Equalize the water levels in the beaker and Florence flask.
17. Measure the volume of the water in the beaker with a graduated cylinder, record it.
18. This volume of the water displaced will be taken as the volume of hydrogen gas liberated.
19. Record the room temperature, convert the unit into K.
20. Record the vapor pressure of water, P_{H_2O} at this temperature
21. Record the atmospheric pressure, P_{atm}.
22. Calculate the partial pressure of H_2 gas, P_{H_2} , in the flask; express it in the units of atm.
23. Calculate the number of moles of H_2.
24. Calculate the number of moles of H.
25. Ask your assistant the valence of the metal
26. What is the number of moles of metal?
27. Calculate the atomic weight of metal.
28. Ask your **assistant the name of the metal.**
29. Ask your assistant the exact atomic weight of the metal.
30. Calculate the percent error for the experimental atomic weight of the metal.

DATA SHEET

Determination of The Atomic Weight of a Metal

Student's Name :

Laboratory Section/Group Number :

Assistant's name and signature : Date:

<u>DATA</u>

1. Weight of the metal (W) =…………………g

2. Volume of the water displaced (V_{H_2O}) =…………………mL

3. Volume of H_2 gas produced ($V_{H_2} = V_{H_2O}$) =…………………L

4. Temperature $T_{room} = T_{H_2}$ =…………………^oC

5. Vapor pressure of H_2O at T = P_{H_2O} =…………………mm Hg

6. Atmospheric pressure= Patm =…………………mm Hg

7. Partial pressure of H_2 gas $P_{H_2} = P_{atm} - P_{H_2O}$ =…………………mm Hg

8. Number of moles of H_2 $n_{H_2} = \frac{P_{H_2}V_{H_2}}{RT_{H_2}}$ =………………….

9. Number of moles of H (n_H) =………………….

10. Valence of the metal =………………….

11. Number of moles of metal =………………….

12. Atomic Wt $= \frac{\text{Weight}}{number\ of\ moles\ of\ metal}$ = …………………. g/mol

13. Name of the metal =………………….

14. Percent error for experimental Atomic Weight =………………….