**EXPERIMENT 5**

**PHYSICAL AND CHEMICAL PROPERTIES OF GASES**

**Introduction**

Gas is one of the states in which a matter can exist. Most properties of gases are independent from its content. Several physical properties of gases include:

1. **Compressibility**: gases can be compressed and expanded according to the size and shape of its container.
2. **Gases** are 1000 times **less dense** than solids and liquids.
3. **Gas expands** when heated.
4. **Gas dissolves** in other gas in various proportions.

The properties of gases are measured by four main parameters: pressure (P), volume (V), the amount of gas particles in mole (n) and temperature (T). During the 18th century, these properties are formulated into ideal gas laws. These laws are:

1. Boyle’s Law – the volume of a gas is inversely proportional to its pressure, mathematically written as:

$$P \~ \frac{1}{V} ; P\_{1}V\_{1}=P\_{2}V\_{2} (at constant n and T)$$

1. Charles’ Law – the volume of gas is directly proportional to its temperature, mathematically written as:

$$V \~ T ; \frac{V\_{1}}{T\_{1}}=\frac{V\_{2}}{T\_{2}} (at constant n and P)$$

When V is plotted against T, a linear graph will be produced. When the line is extrapolated until the volume reaches 0, it will intersect the axis at T= -273,15 oC, setting the value as absolute zero temperature. Based on this calculation, the scale for absolute temperature is defined as Kelvin temperature scale, with 0 K = -273,15 oC and 273K = 0 oC. For all calculations using gas laws, the temperature must be stated in kelvins.

1. **Avogadro’s Law** – equal volumes of gases, at the same temperature and pressure, have the same number of molecules. It can be written as the equation:

$$\frac{V\_{1}}{n\_{1}}=\frac{V\_{2}}{n\_{2}}$$

1. **Gay-Lussac’s Law** – the pressure of a gas is directly proportional to its temperature, mathematically written as:

$$P \~ T ; \frac{P\_{1}}{T\_{1}}=\frac{P\_{2}}{T\_{2}} (at constant n and V)$$

The combination of all the gas laws produces the Ideal Gas Law, which is formulated as the following equation:

$$PV=nRT$$

with R being the universal gas constant; R=8.314 JK-1mol-1 or R=0.08206 L.atm.mol-1.K-1

The Ideal Gas Law is commonly used to calculate properties of gases. Most real gases behave like ideal gas in low pressure and concentration. It is also necessary to define molar gas volume, $V\_{m}$, which is the volume of 1 mole of gas at a certain temperature. It may be calculated using the Ideal Gas Law at various pressure and temperature.

**Materials and Equipments**

Materials: Solid Zn, Mg, Al, HCl 6M, methylene blue, ice, CH3COOH, NH3, universal pH indicator and demineralized water.

Equipments: standard glass equipments, volume determination equipment set, microscale chemistry set, plastic glass, etc.

**Method**

1. **Determination of An Unknown Metal’s Relative Atomic Mass and Molar Volume of Hydrogen**
2. Weigh approximately 0,2 gram of a powdered unknown metal (write down the exact measurement), then put the powder into flask 3 (the reactor).
3. Fill flask 2 with tap water up to the bottom part of the flask’s neck.
4. Empty both tubing mounted on flask-2’s cork by using a hand-pump (tubing B and one half of tubing A), then assemble the set according to the diagram. Make sure the corks are tightly fitted.
5. Measure 25 mL of 6 M HCl solution, then pour it through the funnel on flask 3. The funnel is bounded to a squeeze-tap, therefore in order to let the acid solution flow down, the tap must be pressed. Let all the solution drop down.
6. Rinse the measuring cylinder and the funnel using a known amount of demineralized water, let it flow into the reactor. The exact volume of water used must be known.
7. During the experiment and reaction takes place, water will flow from flask 2 to glass 1. Wait until the reaction between HCl and the metal completely finished and no more water flows into glass 1.
8. Measure the temperature of water in glass 1, then measure its volume using measuring cylinders.
9. Measure room temperature and pressure using a digital barometer and thermometer (provided by the lab staff’s bench)
10. Calculate the relative atomic mass of the metal used based on acquired data.
11. **Temperature Impact on Gas Volume**
12. Prepare plastic pipette and microplate.
13. Fill one of the well on the microplate with water (choose the larger well). Add 2-3 drops of methylene blue.
14. Place the bulb of the plastic pipette into a plastic measuring cup (as indicated at the figure below).
15. Insert the open end of the plastic pipette to the water-filled well.
16. Hold the open end under the water surface.
17. Fill the plastic measuring glass with ice cube, then let the bulb touch the ice cube. Observe the water level changes inside the tube.
18. Remove all ice cubes from the cup. Let the air temperature inside the bulb reach room temperature.
19. Fill the plastic measuring cup with some hot water.
20. Dip the bulb into the hot water. Observe the water level changes inside the tube.

1. **Gas Diffusion**
2. Choose one line of small wells in the microplate in your microscale chemistry set.
3. Add one drop of universal indicator into every well in the line except the first and the last wells.
4. Put 10 drops of water into each well containing universal indicator, or until the well is completely full.
5. Put 10 drops of vinegar into one of the empty well within the row (either the first or the last hole).
6. Put 10 drops of ammonia into the other empty well within the row.
7. **Immediately** cover the microplate using the plastic tray provided.
8. **After 5 minutes,** lift the tray and observe the color changes of the universal indicator solution .