Lab Session 11, Experiment 10: Determination of the Molar Mass of Oxygen

The molar mass (sometimes called the gram molar mass, or the molecular weight) of a gaseous compound can be calculated if the following are known: the mass, volume, temperature, and pressure of the gas. In this experiment, the molar mass of oxygen will be determined. Potassium chlorate will be decomposed to produce oxygen. The mass of oxygen generated will equal the difference between the mass of $KClO_3$ before decomposition and the mass of the residue after decomposition. The volume of the oxygen will be the volume of water displaced from a bottle initially filled with water. The total gaseous pressure ($P_{oxygen} + P_{water}$) will be assumed to be barometric pressure. The temperature of the oxygen will be assumed to be the same as that of the water displaced.

10A Experiment

Record all measurements in the data table provided.

1. Fill $KClO_3$ into your large test tube to a depth of 2-3 cm. Add a small quantity of MnO_2 and weigh the test tube with contents.
2. Mix well. Mount the test tube as shown in Figure 11.1. *Note*: All connections must be tight. This includes glass tubes through stoppers, stoppers in vessels, and rubber tubing connections to glass tubes. The latter may require a hose clamp or wire winding.

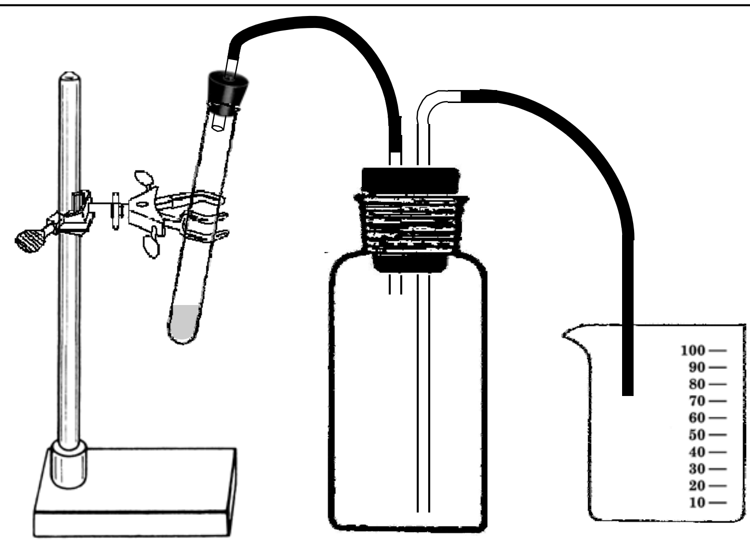

Figure 11.1

3. Before heat is applied to the test tube, the assembly must be checked to make sure that water will not be transferred from the bottle to the beaker by siphoning. Proceed with this check as follows. Remove the test tube from the assembly by removing the rubber stopper from it. Insert the glass tube extending from the stopper into the opening of a rubber bulb that you get from the stockroom. Squeeze the rubber bulb gently to fill the delivery tube between the bottle and the beaker with water. While the delivery tube is filled, close a pinch-clamp over the connecting rubber tubing between the test tube and the bottle. Empty the beaker; a small quantity of water will be transferred to the beaker when filling the delivery tube. Put the large test tube back in place. Remove the pinch-clamp and observe for siphoning. If water flows into the beaker, there is a leak around the stopper that must be corrected before proceeding. If there is no evidence of siphoning, proceed to the next step.

4. Apply heat from your burner, slowly at first, to begin the decomposition of the chlorate. After a little more than half the water in the bottle has been transferred to the beaker, discontinue the heating.
5. Allow the test tube to cool to room temperature, then place a pinch-clamp over the rubber tube. Remove and weigh the test tube. Measure the volume and temperature of the water in the beaker, which is equivalent to the volume and temperature of oxygen generated.
6. Obtain the vapor pressure of water from the table below and calculate the pressure of dry oxygen. You will have to convert the vapor pressure of water from Torr to atm. [1 atm = 760 Torr]

Vapor Pressure of Water

ºC	Torr	ºC	Torr	ºC	Torr	ºC	Torr	ºC	Torr	ºC	Torr
18.0	15.477	20.0	17.535	22.0	19.827	24.0	22.377	26.0	25.209	28.0	28.349
18.2	15.673	20.2	17.753	22.2	20.070	24.2	22.648	26.2	25.509	28.2	28.680
18.4	15.871	20.4	17.974	22.4	20.316	24.4	22.922	26.4	25.812	28.4	29.015
18.6	16.071	20.6	18.197	22.6	20.565	24.6	23.198	26.6	26.117	28.6	29.354
18.8	16.272	20.8	18.422	22.8	20.815	24.8	23.476	26.8	26.426	28.8	29.697
19.0	16.477	21.0	18.650	23.0	21.068	25.0	23.756	27.0	26.739	29.0	30.043
19.2	16.685	21.2	18.880	23.2	21.324	25.2	24.039	27.2	27.055	29.2	30.392
19.4	16.894	21.4	19.113	23.4	21.583	25.4	24.326	27.4	27.374	29.4	30.745
19.6	17.105	21.6	19.349	23.6	21.845	25.6	24.617	27.6	27.696	29.6	31.102
19.8	17.319	21.8	19.587	23.8	22.110	25.8	24.912	27.8	28.021	29.8	31.461

7. Use the ideal gas law to calculate the gram-molar mass of oxygen. See the review of the ideal gas law in the table below.

Review of the Ideal Gas Law

$PV = nRT$	$M = (\text{mass} \times RT) \div PV$
$PV = (\text{mass} \div M) \times RT$	where M is g/mol of gas
$PVM = \text{mass} \times RT$	$R = 0.08206$ L atm mol^{-1} K^{-1}

(a) Mass of test tube and contents before heating	g	
(b) Mass of test tube and contents after heating	g	
(c) Mass of oxygen in flask [(a)–(b)]	g	
(d) Volume of water transferred = Volume of O_2	mL	L
(e) Temperature of water = Temperature of O_2	ºC	K
(f) Barometric pressure = P_{atm}	Torr	atm
(g) Vapor pressure of water	Torr	atm
(h) Pressure of dry oxygen [(f)–(g)]	Torr	atm
(i) Molar mass of oxygen	g/mol	
(j) % error = [(|(i) – 32.00| / 32.00) x 100]	%	

10B Exercise

1. Why is it necessary to allow the test tube to cool before it is removed for weighing?

   ____

2. Why must the water delivery tube extend nearly to the bottom of the flask?

   ____

3. When water flow ceases, what can be assumed as the relationship between barometric pressure (P_{atm}) and the pressure inside the flask (P_{oxygen} + P_{water})?

   ____

4. Is it necessary to decompose all the chlorate?

   ____

Report Form 10: Determination of the Molar Mass of Oxygen

Name____________________________________

Partner_____________________Section #_____

10A Experiment

(a) Mass of test tube and contents before heating	g	
(b) Mass of test tube and contents after heating	g	
(c) Mass of oxygen in flask [(a)–(b)]	g	
(d) Volume of water transferred = Volume of O_2	mL	L
(e) Temperature of water = Temperature of O_2	ºC	K
(f) Barometric pressure = P_{atm}	Torr	atm
(g) Vapor pressure of water	Torr	atm
(h) Pressure of dry oxygen [(f)–(g)]	Torr	atm
(i) Molar mass of oxygen	g/mol	
(j) % error = [(|(i) – 32.00| / 32.00) x 100]	%	

10B Exercise

1. Why is it necessary to allow the test tube to cool before it is removed for weighing?

____

2. Why must the glass water delivery tube extend nearly to the bottom of the bottle?

____

3. When water flow ceases, what can be assumed as the relationship between barometric pressure (P_{atm}) and the pressure inside the flask (P_{oxygen} + P_{water})?

____

4. Is it necessary to decompose all the chlorate?

____