Determination of the Molar Mass of Butane

Purpose: to determine the molar mass of butane by collecting a volume of gas by the downward displacement of water.

Apparatus:

- 1000 mL graduated cylinder
- thermometer
- electronic balance
- barometer

Materials:

- butane (in canister)

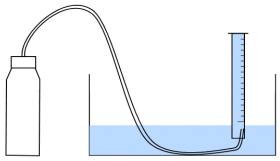
Procedure:

1. Carefully determine and record the mass of a butane canister. Don't get it wet!!!

2. Fill a sink with water. Fill a 1000 mL graduated cylinder with water and invert in the sink.

3. Take the temperature of the water and record this value.

4. Using the delivery tube add approximately 850 mL of butane to the inverted graduated cylinder. Don't get the canister wet!!



5. Determine the mass of butane cylinder a second time and record the value. You may need to repeat steps 1,4 and 5 to get a "good" reading.

6. Raise or lower the graduated cylinder such that the level of water inside the cylinder and the level of water in the sink is the same. Accurately record the volume of the butane. Remember that you are reading the cylinder upside down.

7. Find and record the atmospheric pressure.

Observations:

Mass of Butane Canister Before Sample (g)	
Mass of Butane Canister After Sample (g)	
Volume of Butane Collected (mL)	
Water Temperature (°C)	
Atmospheric Pressure (kPa)	

Concluding Questions:

1. Determine the mass of butane that was collected using a three line calculation.

2. Determine the actual pressure of butane in the cylinder. To do this you must consider the contribution of $H_2O(g)$ that was pickup up by the butane as it bubbled through the water. Dalton's law of partial pressures is used for this.

$$P_T = P_1 + P_2 + P_3 + \text{etc}$$

P_T is the total pressure and P_1, P_2 etc. are the partial pressures of each gas in the sample. In our atmosphere we would use:

$$P_T = P_{N_2} + P_{O_2} + P_{Ar} + P_{CO_2}$$

For this experiment we would use:

$$P_T = P_{C_4H_{10}} + P_{H_2O}$$

The partial pressure of water can be determined from a vapour pressure table which can be found attached to the back of this lab. The vapour pressure is dependent on temperature. Use the water temperature to determine the partial pressure of water. Use the atmospheric pressure for the total pressure. Solve for the partial pressure of butane. This answer is what you will use in the next question.

3. Using your answer from #2 for pressure, the volume of butane gas that you have collect and the temperature for the water (should be the same as the temperature of the butane gas), perform an ideal gas law calculation to determine the amount of butane gas collected. Be sure to follow all of the details when performing this calculation. Consult your notes!

4. Now using your answer from #1 (mass of butane in your sample) and your answer from #3 (amount of butane in your sample), create a ratio of g/mol and use this to determine the mass of one mole of butane (use the units of g/mol). Don't make this harder than it is!!!

$$\frac{\text{mass butane collected in g}}{\text{amount butane collected in mol}} = \frac{\text{molar mass in g}}{\text{1 mol}}$$

5. Now using the chemical formula of butane (C_4H_{10}), determine what the molar mass really should be.

6. Perform a %error calculation using your answers from #4 and #5 and the formula:

$$\%\ \text{error} = \frac{|\text{exper. value - actual value}|}{\text{actual value}} \times 100\%$$

Saturation Vapor Pressure Over Water

C	0 kPa	0.1 kPa	0.2 kPa	0.3 kPa	0.4 kPa	0.5 kPa	0.6 kPa	0.7 kPa	0.8 kPa	0.9 kPa
0	0.611	0.615	0.620	0.624	0.629	0.634	0.638	0.643	0.647	0.652
1	0.657	0.662	0.666	0.671	0.676	0.681	0.686	0.691	0.696	0.701
2	0.706	0.711	0.716	0.721	0.726	0.731	0.737	0.742	0.747	0.752
3	0.758	0.763	0.769	0.774	0.780	0.758	0.791	0.796	0.802	0.807
4	0.813	0.819	0.825	0.831	0.836	0.842	0.848	0.854	0.860	0.866
5	0.872	0.878	0.884	0.891	0.879	0.903	0.909	0.916	0.922	0.929
6	0.935	0.941	0.948	0.955	0.961	0.968	0.974	0.981	0.988	0.995
7	1.002	1.009	1.015	1.022	1.029	1.037	1.044	1.051	1.058	1.065
8	1.073	1.080	1.087	1.095	1.102	1.110	1.117	1.125	1.132	1.140
9	1.148	1.156	1.163	1.171	1.179	1.187	1.195	1.203	1.211	1.219
10	1.228	1.236	1.244	1.253	1.261	1.269	1.278	1.286	1.295	1.304
11	1.312	1.321	1.330	1.339	1.348	1.357	1.366	1.375	1.384	1.393
12	1.402	1.412	1.421	1.430	1.440	1.449	1.459	1.468	1.478	1.488
13	1.497	1.507	1.517	1.527	1.537	1.547	1.557	1.567	1.578	1.588
14	1.598	1.609	1.619	1.630	1.640	1.651	1.662	1.672	1.683	1.694
15	1.705	1.716	1.727	1.738	1.749	1.761	1.772	1.783	1.795	1.806
16	1.818	1.830	1.841	1.853	1.865	1.877	1.889	1.901	1.913	1.925
17	1.938	1.950	1.962	1.975	1.987	2.000	2.012	2.025	2.038	2.051
18	2.064	2.077	2.090	2.103	2.116	2.130	2.143	2.157	2.170	2.184
19	2.197	2.211	2.225	2.239	2.253	2.267	2.281	2.295	2.309	2.324
20	2.338	2.353	2.367	2.382	2.397	2.412	2.427	2.442	2.457	2.472
21	2.487	2.502	2.518	2.533	2.549	2.565	2.580	2.596	2.612	2.628
22	2.644	2.660	2.677	2.693	2.709	2.726	2.743	2.759	2.776	2.793
23	2.810	2.827	2.844	2.861	2.879	2.896	2.914	2.931	2.949	2.967
24	2.985	3.002	3.021	3.039	3.057	3.075	3.094	3.112	3.131	3.150
25	3.169	3.188	3.207	3.226	3.245	3.264	3.284	3.303	3.323	3.343
26	3.362	3.382	3.402	3.423	3.443	3.463	3.484	3.504	3.525	3.546
27	3.567	3.588	3.609	3.630	3.651	3.673	3.694	3.716	3.738	3.759
28	3.781	3.804	3.826	3.848	3.870	3.893	3.916	3.938	3.961	3.984
29	4.007	4.031	4.054	4.078	4.101	4.125	4.149	4.173	4.197	4.221
30	4.245	4.270	4.294	4.319	4.344	4.369	4.394	4.419	4.444	4.469
31	4.495	4.521	4.547	4.572	4.599	4.625	4.651	4.677	4.704	4.731
32	4.758	4.785	4.812	4.839	4.866	4.894	4.921	4.949	4.977	5.005
33	5.033	5.062	5.090	5.119	5.147	5.176	5.205	5.235	5.264	5.293
34	5.323	5.353	5.382	5.412	5.443	5.473	5.503	5.534	5.565	5.596
35	5.627	5.658	5.689	5.721	5.752	5.784	5.816	5.848	5.880	5.913
36	5.945	5.978	6.011	6.044	6.077	6.111	6.144	6.178	6.212	6.246
37	6.280	6.314	6.348	6.383	6.418	6.453	6.488	6.523	6.559	6.594
38	6.630	6.666	6.702	6.738	6.775	6.812	6.848	6.885	6.922	6.960
39	6.997	7.035	7.073	7.111	7.149	7.187	7.226	7.265	7.304	7.343
40	7.382	7.421	7.461	7.501	7.541	7.581	7.621	7.662	7.703	7.744
41	7.785	7.826	7.867	7.909	7.951	7.993	8.035	8.078	8.120	8.163
42	8.206	8.249	8.293	8.336	8.380	8.424	8.469	8.513	8.558	8.602
43	8.647	8.693	8.738	8.784	8.829	8.875	8.922	8.968	9.015	9.062
44	9.109	9.156	9.204	9.251	9.299	9.347	9.396	9.444	9.493	9.542
45	9.591	9.641	9.690	9.740	9.790	9.840	9.891	9.942	9.993	10.044
46	10.095	10.147	10.199	10.241	10.303	10.356	10.409	10.462	10.515	10.569
47	10.622	10.676	10.730	10.785	10.840	10.894	10.950	11.005	11.061	11.116
48	11.173	11.229	11.286	11.342	11.399	11.457	11.514	11.572	11.630	11.689
49	11.747	11.806	11.865	11.924	11.984	12.044	12.104	12.164	12.225	12.286
50	12.347	12.408	12.470	12.532	12.594	12.657	12.719	12.782	12.846	12.909