Section 16B – Gas Laws

Boyle's Law

Answer the following questions:
1. A sample of gas has an initial volume of 2.5 L and a pressure of 2.0 atm. What is the final pressure if the volume is compressed to 1.5 L?
2. A sample of gas has a pressure of 550 mmHg with a volume of 1.75 L. What is the volume if the gas is exposed to external pressure equal to air pressure?
3. A sample of gas in a balloon has a volume of 5.0 L at sea level, what is the volume of the balloon when it is released and reached a height of 20000 ft. when air pressure is 365 mmHg?
4. A sample of gas in a 5.0 L balloon at sea level is pulled underwater to a depth of 200 ft. where the water pressure is about 4500 mmHg, what is the new volume of the balloon?
5. A balloon containing 25.0 g of neon gas has a pressure of 0.75 atm in a compressible container. What is the pressure if the container is compressed to a third of its original volume?

Charles's Law

Answer the following questions:
1. Your sweetheart gives you a balloon on Valentine's Day. Inside where it is 25°C the balloon has a volume of 6.5 L. When you go outside and the temperature drops to 0°C, what is the new volume of the balloon?
2. The initial temperature of a sample of gas is 150°C with an unknown volume. When the temperature lowers to 100°C the volume is 10.0 L, what is the original volume of the gas?
3. A balloon has a volume of 4.25 L at -10°C, at what temperature with balloon have a volume of 8.50 L?
4. A compressible piston has a volume of 3.5 L at 30°C, at what tempered with the gas have a volume of 1.65 L?
5. A sample of carbon dioxide has a volume of 1.0 L, what is the volume when the temperature is increased by 1.5×?

Gay-Lussac Law

1. The pressure inside a balloon at 10°C is 1.2 atm, what is the pressure when the temperature is raised to 100°C ?
2. What is the difference in air pressure from your kitchen (22°C) and your freezer (-3°C), assume pressure in the kitchen is the pressure at sea level.
3. Propane is stored in tanks with a pressure threshold of 200 psi (1psi = 0.068 atm) at what temperature will the tank explode if the pressure inside is 100 psi at 28°C?
4. A solid container has a sample of nitrogen with a pressure of 120 mmHg at 50°C, at what temperature will the pressure be 3052 mmHg?
5. A solid steel box has a sample of CO_2 at a pressure of 1000 mmHg at 15°C, what is the pressure at 250°C?

Combined Gas Law

1. A balloon contains a sample of dinitrogen monoxide at a temperature of 25°C, volume of 5.0L and a pressure of 1.0 atm. At what temperature will the volume be 7.5 L and the pressure be 0.80 atm?
2. A piston in a car has a volume of 50 mL at a temperature of 0°C (car is off) with a pressure of 0.9 atm. When the car is on the temperature of the air in the piston is now 250°C with a pressure of 1.1 atm, what is the volume of the cylinder?
3. A small cylinder of CO_2 is under a pressure of 1000 psi at 25°C and a volume of 11 L. The gas is released into your chemistry class room, the pressure is now 14.7 psi and the temperature is now 15°C, what is the volume of the gas?
4. The pressure surrounding a balloon is 1.0 atm at 30°C. The balloon has a volume of 4.5 L, at what temperature will the balloon expand to a volume of 8.5 L with a pressure of 1.5 atm?
5. A sample of helium gas has a volume of 1.05×10^3 L at a temperature of 500°C and a pressure of 1.00 atm. What will the pressure be if the helium is cooled to 100°C and the volume is reduced to 10.5 L?

Ideal Gas Law

1. A 3.0 mole sample of steam has a volume of 5.0 L at a temperature of 25°C, what is the pressure of the gas?
2. What mass of carbon dioxide will have a volume of 3.2 L at 120°C with a pressure of 5.0 atm?
3. The average house in Grosse Pointe uses 5500 L of methane *A DAY!!!!!!!!* What mass of methane is needed at your home if the temperature of methane is 20°C with a pressure of 1.0 atm?
4. Using the above equation and assuming there are 4000 homes in Grosse Pointe Woods, what mass of methane is used *EACH DAY*?
5. At what temperature will a 20.5 g sample of steam have a volume of 50.0 L and a pressure of 700 mmHg?
6. What is the density of dinitrogen monoxide in at 2.5 atm with a temperature 15°C?
7. A greenhouse gas is composed of chlorine and oxygen. It has a density of 7.71 g/L at 36°C and 2.88 atm, identify the gas.

1) A sample of nitrogen gas has a volume of 3.5 L at a pressure of 2.5 atm. What is the pressure if the volume is increased to 5.0 L?

2) A sample of argon has a volume of 5.0 L at a temperature of 25°C. What is the volume if the temperature is lowered to −3°C?

3) A sample of carbon dioxide has a pressure of 3.15 atm at 14°C. What has the temperature been changed to if the pressure of the gas is reduced to 1.15 atm?

4) 35.4 g of nitrogen gas has a volume of 25.0 L. What is the volume if 13.5 g of nitrogen is added?

5) A sample of sulfur dioxide has a volume of 16.7 L at 35°C and a pressure of 1.25 atm. What is the pressure if the volume is increased to 24.9 L and the temperature is increased to 75°C?

6) A 45.6 g sample of ethane has a pressure of 1.25 atm and a temperature of 40°C. What is the volume?

7) At STP what volume does a 78.0g sample of xenon take up?

8) Calculate the density of CO_2 at 35°C and 2.25 atm.

9) A sample of argon has a volume of 2.58 L with a pressure of 1.48 atm. The volume is increased and the new pressure is 0.45 atm, what is the new volume?

10) A sample of methane has a volume of 10.0 L at 0°C in the winter, what is the temperature if the new volume is 9.0 L?

11) A balloon containing ethane has a pressure of 0.92 atm at a temperature of 25°C. What is the new pressure if the temperature is raised to 37°C?

12) A 128 g sample of nitrogen trifluoride has a volume of 5.6 L, what mass of nitrogen trifluoride has a volume of 12.5 L?

13) A sample of ammonia has a volume of 7.5 L @ 45°C and a pressure of 0.50 atm. At what temperature will the volume become 9.4 L and the pressure will be 2.15 atm?

14) What mass of water vapor has a pressure of 1.48 atm in a 10 L container @ 17°C?

15) At STP what mass of methanol has a volume of 88.8 L?

16) Calculate the density of hydrogen sulfide at 2.0°C and a1.85 atm.

Demonstrations

Boyle's Law

1) Obtain a pipet
2) Fill with water until bulb and a little of the line is full.
3) Get clamp from teacher and clamp the end of the pipet.
4) Gently depress the pipet bulb and record what you see.

Charles's Law

Procedure

1) Use a thoroughly dried 125 mL Erlenmeyer flask for this experiment. If it is not dry, rinse the flask with a small amount of acetone or ethanol and place it upside-down on a paper towel to dry.

2) Fit the flask with a one-hole rubber stopper inserted with a short piece of dry glass tubing. Add rubber tubing to the end of the glass tube and assemble the apparatus as shown on the board, using the125 mL flask and a 400 mL beaker. Be sure that the stopper fits tightly in the flask, the glass tubing fits tightly in the rubber stopper, and the rubber tubing fits tightly on the glass tubing. Leave a 1 cm gap between the bottom of the flask and the beaker.

3) Pour water into the beaker until as much of the flask is covered as possible.

4) Using a Bunsen burner, heat the water in the beaker until it boils and then continue to heat for 5 minutes. At this point determine the temperature of the water. Read the thermometer while its bulb is immersed in the water and record the reading as entry (c) in the data table below. Make sure the thermometer does not touch the beaker.

5) After the water in the beaker has been boiling for about 5 minutes, place a clamp on the rubber tubing. While the water is still boiling, close the clamp in order to make the flask airtight. Turn off the Bunsen burner by closing the gas valve at its base, then turn off the gas at the bench.

6) Loosen the ring stand clamp, remove the flask from the beaker, and immerse it in a water bath stopper end down. It should be cooled upside-down in the sink for about 5 minutes, with the stopper and tubing completely immersed in water throughout this period. At the end of this time, loosen the screw clamp while the end of the tube is completely submerged and let water be forced into the flask.

7) Holding the rubber tubing closed with your fingers, remove the flask from the sink, and determine the volume of the water in the flask by pouring it into a 100 mL graduated cylinder. Record this volume as entry (a) in the data table.

8) Determine the temperature of the water in the sink and record it as entry (d) in the data table. Your instructor may opt to prepare ice/water baths in the end sinks, in which case the temperature should be close to 0°C. You should measure it with your thermometer and record it anyway.

9) To determine the volume of gas (air) used in the beginning, it is necessary to accurately determine the volume of the Erlenmeyer flask. *Completely* fill the flask

with water and place the rubber stopper (and tubing) in its previous position. Remove the stopper and measure the volume of the water in the flask with a 100 mL graduated cylinder. Record this volume as entry (b) in the data table.
(a) Volume of water forced into the flask mL

Volume of water forced into the flask	(a)
Initial volume of the air (measured volume of the flask/stopper)	(b)
Initial temperature of the air (temperature of the hot water)	(c)
Final temperature of the air (temperature of the water in the sink)	(d)
Final volume of the air [(b)–(a)] (measured volume of the flask minus the volume of water forced into the flask)	(e)

To summarize, a given volume of air was taken at the temperature of boiling water. The air was cooled, causing it to contract. The new volume was determined experimentally.

Checking your results
The accuracy of the experimental determination of the final volume (entry (e) in the data table) can be checked by calculating this volume with Charles' Law. Change the temperature reading into the absolute (Kelvin) scale and enter your data into the following formula:
Initial V (mL) × Final T (K) = Final V (mL) × Initial T(K)

Avogadro's Principle
Avogadro's Law relates the number of moles of gas to the volume of the gas. We are going to add moles of gas to a container through a chemical means.

Procedure

1) Obtain a small balloon and Erlenmeyer flask.
2) Mass out 0.5 g of zinc powder and using a funnel add the zinc to the balloon.
3) In the Erlenmeyer flask add approximately 15.0 mL of 1.0 M HCl
4) Attach the balloon to the top of the Erlenmeyer flask. ***Be sure to not dump ANY of zinc into the flask!!!!!!!!!!***
5) Once the balloon is securely attached, invert the balloon dumping out as much of the zinc powder as possible. Hold the balloon onto the Erlenmeyer flask, we have a plan for the gas that we are creating.
6) Once the reaction has come to a stop remove the balloon and tie it off.
7) Dump solution down the drain and wash out the flask.