Pre-AP Chemistry – Unit 7, Gas Behavior

Objective 1: Students will understand the Kinetic Molecular Theory (KMT) for gases and use it to explain the following relationships: Boyle's Law, Charles' Law, Gay-Lussac's Law, and Avogadro's Law. [GL.16.C.1, GL.17.C.1]

Objective 2: Students will apply the combined gas law, ideal gas law, and Dalton's law to calculate the effects of pressure (P), temperature (T), volume (V), and number of moles (n) on a gas system and will apply the moles determined to stoichiometric calculations at non-standard conditions. [GL.16.C.2, GL.17.C.1, GL.18.C.1, S.12.C.3, S.12.C.4]

Objective 1

1. Define the following terms: kinetic energy, kinetic theory, gas pressure, vacuum, atmospheric pressure, barometer, pascal (Pa), standard atmosphere (atm), compressibility, diffusion, effusion, Boyle's law, Charles', Law, Gay-Lussac's law, Avogadro's law, Graham's law.

2. (a) State and explain Boyle's law using the kinetic theory of gases. (b) Determine the final pressure of a fixed quantity of gas originally at a 1.5 atm of pressure in a 2.5L container at 256K if the container is compressed to 0.75L but the temperature remains 256K. (c) What volume will the air in a 355mL bag initially at a temperature of 300K and a pressure of 315kPa occupy if the pressure is reduced to 50kPa while the temperature remains the same?

3. (a) State and explain Charles's law using the kinetic theory of gases. (b) Determine the volume of a fixed quantity of air originally at 485K in a fixed pressure container with a volume of 4789mL if the temperature is reduced to 200K. (c) Determine the temperature reached if 45.0L of nitrogen gas in a balloon (constant pressure) at 298K is compressed to 12L.

4. (a) State and explain Gay-Lussac's law using the kinetic theory of gases. (b) Determine the new pressure of a gas originally at 25°C and a pressure of 7.5atm if the temperature is changed to 100°C and the volume is unchanged. (c) At what temperature, in °C, will the pressure of a gas originally at 845K and 6.3atm reach a pressure of 1000kPa assuming the volume remains the same?

5. (a) State and explain Avogadro's law using the kinetic theory of gases. (b) How would the addition of 5 moles of an ideal gas to a system under constant temperature and pressure affect the volume if there were originally 10 moles of gas occupying a volume of 4500mL in an expandable container?

Objective 2

1. Define the following terms: combined gas law, ideal gas constant, ideal gas law, partial pressure, and Dalton's law of partial pressures.

2. Use the combined gas law to determine the changes in a system in the following scenarios.
   (a) Determine the final pressure of a gas initially at 35°C in a 5.2L container with a pressure of 3.5atm if the container is compressed to half its original size and is heated to 400K.
   (b) A certain car tire has a volume of 50L with a pressure of 300kPa at a temperature of 23°C before a road trip. At the end of the trip the temperature has risen to 315K and the pressure has changed to 3.9atm. What volume does the air in the tire now occupy?

(c) A certain explosive device has an initial volume of 2000L. If the device is detonated over land the pressure prior to explosion reaches 800 atm. After the explosion the gas returns to ambient pressure (101.3kPa) and temperature (292K). In the process the gas expands to occupy a volume of 10^5 L. What was the temperature, in degrees Celsius, inside the bomb case at the instant of explosion?

3. Use the ideal gas law to determine the changes in a system in the following scenarios.
   (a) Determine the number of moles of gas in a 6.8L container with a pressure of 5.2atm that has a temperature of 600K.
   (b) At what pressure would the volume of an expandable container at a temperature of 50°C with 85g of nitrogen gas reach 100L?
   (c) Find the temperature of a gas system constrained to a volume of 1758mL if the pressure is measured as 85kPa. The system contains 5.0mol of gas.
   (d) Find the mass of sulfur dioxide gas (SO_2) present in a 180L drum at a temperature of 40°C and a pressure of 300kPa.

4. (a) State and explain the idea behind Dalton's law of partial pressures. (b) A mixture of gases (0.477mol He, 0.280mol Ne, and 0.110mol Ar) is placed in a 7.00L vessel at 25°C. Find the partial pressure of each gas and the total pressure in the container. (c) If the total pressure in a sealed 15.0L flask containing 45.2g Xe, 12.5g O_2 and some hydrogen gas is 210kPa at 300K then what is the partial pressure of the hydrogen gas ($P_{hydrogen}$)?

5. The following reaction is carried out in an expandable container under a constant pressure of 600kPa and the final temperature is determined to be 180°C. Determine the volume of CO gas produced when 100g of oxygen reacts with an excess of carbon.

   $2\ C(s) + O_2\ (g) \rightarrow 2\ CO\ (g)$

6. A certain gas system is constructed so that sulfur dichloride gas (SCl_2) can be combined with oxygen gas (O_2) to produce $SOCl_2$, according to the reaction below. A reactor is charged with 100g SCl_2 and 25g of O_2.

   $2\ SCl_2\ (l) + O_2\ (g) \rightarrow 2\ SOCl_2\ (g)$

   (a) If the system is initially in a reactor with a fixed volume of 100L with a pressure of 4.6atm, and a temperature of 500K then which is the limiting reactant? (b) What is the theoretical yield of $SOCl_2$? (c) If the temperature after the reaction has changed to 655K, then what pressure in the reactor at that point is due to $SOCl_2$?

7. Determine the volume of I_2 gas produced from the following reaction given that the reaction occurs in an environment with a temperature of 600°C and the pressure after the reaction was determined to be 2.2atm and there are 200g of GaI_3 present in the beginning.

   $GaI_3\ (s) \rightarrow Ga\ (s) + I_2\ (g)$