Gas Problems – All Kinds

1. The largest balloon in the Macy's Thanksgiving Day parade is Clifford, the Big Red Dog. When fully inflated, Clifford holds 42,000 cubic feet of helium at a temperature of 4.0 °C and a pressure of 755.8 mmHg. How many grams of helium are required to inflate the balloon? What is the density of the helium in the balloon? 2.1×10^5 g He .175 g/L

2. A refrigeration tank holding 5.00 L of Freon gas ($C_2Cl_2F_4$) at 25.0°C and 3.00 atm pressure developed a leak. When the leak was discovered and repaired, the tank had lost 76.0 grams of gas. What was the pressure of the gas remaining in the tank at 25 °C? P = .822 atm

3. One of the methods for estimating the temperature of the center of the sun is based on the ideal gas law. If the center is assumed to consist of gases whose average molar mass is 2.0, and if the density and pressure are 1.4×10^3 kg/m^3 and 1.3×10^9 atm, respectively, calculate the temperature.
T = 2.3×10^7 K

4. A gas is composed of 30.4% N and 69.6% O. Its density is 11.1 g/L at -20 °C and 2.50 atm. What are the empirical and molecular formulas of the gas?
Empirical NO_2 Molecular N_2O_4

5. An organic compound had the following analysis: C, 55.8 % by mass; H, 7.03% by mass; O, 37.2% by mass. A 1.500 gram sample of the compound was vaporized and was found to occupy 530. cm^3 at 100.0 °C and 740.0 torr. What is the molecular formula of the compound? $C_4H_6O_2$

6. Oxygen gas, generated by the reaction $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$ is collected over water at 27.0°C in a 2.00 L vessel at a pressure of 760 torr. (The vapor pressure of water at 27.0°C is 26.0 torr.) How many moles of $KClO_3$ were consumed in the reaction? .0541 moles $KClO_3$

7. A 1.00 g sample of SF_x has a volume of 416 mL at 745 mmHg and 75.0°C. What is the value of x?
x = 2

8. In an effusion apparatus, H_2 is found to effuse at the rate of 5.9 mL/s. Another gas in the same apparatus effuses at the rate of 0.55 mL/s. What is the molecular weight of the gas?

240 g/mol

9. Calculate the volume of carbon dioxide at 30.0°C and 0.925 atm produced from 1.446 g of $Sc_2(CO_3)_3$ by the following reaction:

$$Sc_2(CO_3)_3\,(s) + 6HCl\,(aq) \rightarrow 3H_2O\,(l) + ScCl_3\,(aq) + 3CO_2\,(g)$$

V = .432 L CO_2

10. Mixtures of helium and oxygen are used in scuba tanks to help prevent "the bends." For a particular dive, 46 L of He at 25.0°C and 1.0 atm and 12 L of O_2 at 25.0°C and 1.0 atm were pumped into a tank with a volume of 5.0 L. Calculate the partial pressure of each gas and the total pressure in the tank at 25.0°C.

P_T = 11.6 atm

11. Which of the following is the ordering of average kinetic energies of H_2O at 800 K, He at 600 K and N_2 at 400 K? Explain your choice.

a. $He = N_2 = H_2O$
b. $He > H_2O > N_2$
c. $H_2O > He > N_2$
d. $N_2 > H_2O > He$
e. $He > N_2 > H_2O$

$KE = \frac{3}{2}RT$ (↑ ↑)

12. Which of the following is the ordering of the average velocities of He, N_2, and H_2O at 600 K? Explain your choice.

a. $He = N_2 = H_2O$
b. $He > H_2O > N_2$
c. $H_2O > He > N_2$
d. $N_2 > H_2O > He$
e. $He > N_2 > H_2O$

$KE = \frac{1}{2}mv^2$ (↓ ↑)

The Kinetic Molecular Theory and Gases

1. Which of the following is not an assumption of the kinetic molecular theory of a gas?

   A. Gases are made up of tiny particles in constant, chaotic motion.
   B. Gas particles are very small compared to the average distance between the particles.
   C. Gas particles collide with the walls of their container in elastic collisions.
   D. The average velocity of the gas particles is directly proportional to the absolute temperature.
   E. All of the above are correct.

2-4. Consider three 1 L flasks at STP. Flask A contains NH_3 gas, flask B contains NO_2 gas, and flask C contains N_2 gas.

2. Which contains the largest number of molecules?

   A. flask A
   B. flask B
   C. flask C
   D. all are the same
   E. none

3. In which flask are the molecules least polar and therefore most ideal in behavior?

   A. flask A
   B. flask B
   C. flask C
   D. all are the same
   E. none

4. In which flask do the molecules have the highest average kinetic energy?

   A. flask A
   B. flask B
   C. flask C
   D. all are the same
   E. none

5. Which conditions of P, T, and *n*, respectively, are most ideal?

   A. high P, high T, high *n*
   B. low P, low T, low *n*
   C. high P, low T, high *n*
   D. low P, high T, high *n*
   E. low P, high T, low *n*

6. In which of the following is it impossible to predict whether the pressure of a gas will increase, decrease, or stay the same?

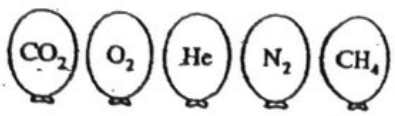
   A. A gas sample is heated.
   B. A gas sample is heated, and the volume is increased.
   C. A gas sample is cooled, and some gas is withdrawn.
   D. Additional gas is added to a sample of gas.
   E. A gas sample is cooled, and the volume is increased.

7. Calculate the density of bromine at STP.

7.10 g/L

8. What volume will 150.0 g of NO_2 occupy at 750 mmHg and 30.0 C?

82.2 L



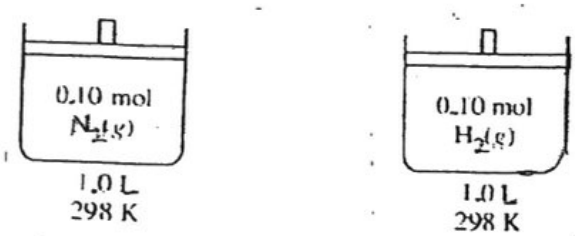
9. Represented above are five identical balloons, each filled to the same volume at 25 C and1.0 atm pressure with the pure gases indicated.

A. Which balloon contains the greatest mass of gas? Explain.

B. Compare the average kinetic energies of the gas molecules in the balloons. Explain.

C. Which balloon contains the gas that would be expected to deviate most from the behavior of an ideal gas? Explain.

D. Twelve hours after being filled, all the balloons have decreased in size. Predict which balloon will be the smallest. Explain the reasoning.



10. Consider two containers of volume 1.0 L at 298 K, as shown above. One container holds 0.10 mole N_2 (g) and the other holds 0.10 mole H_2 (g). The average KE of the N_2 molecules is 6.2×10^{-21} J. Assume that the N_2 and the H_2 exhibit ideal behavior.

A. Is the pressure in the container holding the H_2 less than, greater than, or equal to the pressure in the container holding the N_2? Justify your answer.

B. What is the average KE of the H_2 molecules?

C. The molecules of which gas, N_2 or H_2, have the greater average speed? Justify your answer.

D. What change could be made that would decrease the average KE of the N_2 molecules in the container?

E. If the volume of the container holding the H_2 was decreased to 0.50 L at 298 K, what would be the change in each of the following variables? In each case, justify your answer.

(i) The pressure within the container

(ii) The average speed of the H_2 molecules

SOME MORE GAS LAW PROBLEMS!

1. A 100 ml flask containing nitrogen, N_2, at a pressure of 160.0 mmHg is emptied into a 100.0 ml flask of carbon dioxide, CO_2. The combined pressure of the two gases is 300.0 mmHg. What was the original pressure of the CO_2? $P_{CO_2} = 140\ mmHg$

2. An air-filled balloon has a volume of 225 L at 0.94 atm and 25°C. Soon after, the pressure changes to 0.99 atm and the temperature changes to 0°C. What is the new volume of the balloon? $V_2 = 2.0 \times 10^2\ L$

3. A discarded spray paint can contains only a small volume of the propellant gas at a pressure of 34,470 Pa. The volume of the can is 473.18 mL. If the can is run over by the garbage truck and flattened to a volume of 13.16 mL, what is the pressure in Pa assuming the can does not leak? $P_2 = 1.239 \times 10^6\ kPa$

4. A tank of compressed CO_2 has a temperature of 23.6°C and a volume of 31.4 L. The CO_2 is completely transferred into a smaller tank that has a volume of 25.0 L. Assuming none of the CO_2 escapes during the transfer, what is the temperature of the CO_2 in the smaller tank if the temperature is lowered to achieve the same pressure as in the larger tank? $T_2 = 236\ K\ (-37°C)$

5. What is the density of a gas at STP if its density is 1.75 g/dm^3 at 110 kPa and 45.0°C? $d_2 = 1.88\ g/L$

6. A storage tank contains 120.0 liters of oxygen at 147°C and 6.0 atmospheres. Find the mass of the gas in the tank. $mass = 668\ g$

7. A cylinder contains nitrogen gas and a small amount of water at 25°C. The total pressure is 600.0 mm. What is the pressure due to the nitrogen gas? If the volume is cut in half, what is the pressure of the water vapor, pressure of the nitrogen, and the total pressure? $P_T = 1176\ mmHg$

8. A particular tank can safely hold gas up to a pressure of 36.2 atm. When the tank contains 36.0 g of N_2 at 25 C, the exerts a pressure of 12.7 atm. What is the highest temperature to which the gas sample can be heated safely? $T_{max} = 849\ K = 576°C$

9. Uranium isotopes have been separated by taking advantage of the different rates of effusion of the two isotopic forms of UF_6. One form contains uranium of atomic weight 238, and the other of atomic weight 235. What are the relative rates of effusion of these two molecules?

Mixtures of Gases

1. A mixture of gases consists of 3.00 moles of helium, 4.00 moles of argon, and 1.00 moles of neon. The total pressure of the mixture is 1200.0 torr.
   A. Calculate the mole fraction of each gas in the mixture.
   B. Calculate the partial pressure of each gas in the mixture.

2. A mixture of three gases consists of a number of moles fluorine and an equal number of moles of Xe and H_2, each of which is double the moles of F_2. The total pressure of the mixture is 1000.0 torr. What is the partial pressure of the fluorine gas?

   $P_{F_2} = 200$ torr

3. What will be the total pressure in a 2.50 L container at 25°C if it contains 0.016 moles of CO_2 and .035 moles of CH_4?

   $P_T = .50$ atm

4. A gas sample contains 0.1 moles of oxygen and 0.4 moles of nitrogen. If the sample is at standard temperature and pressure, what is the partial pressure of the nitrogen?

   $P_{N_2} = .8$ atm

5. A gaseous mixture of oxygen and nitrogen as maintained at a constant temperature. Which of the following MUST be true regarding the two gases?

   A. Their average kinetic energies will be the same.
   B. Their average molecular speeds will be the same.
   C. Their partial pressures will be the same.
   D. Their total masses will be the same.
   E. Their densities will be the same.

6. $2\ N_2O_5(s) \rightarrow 4\ NO(g) + O_2(g)$

A 2.00 L evacuated flask has a .200 mole sample of $N_2O_5(s)$ sealed inside it. The flask is heated to decompose the solid and cooled to 300K. The $N_2O_5(s)$ is completely decomposed according to the balanced equation above. What is the final total pressure of the gases in the flask?

$P_T = 6$ atm

FRQs – from the College Board

1. A rigid 5.00 L cylinder contains 24.5 g of $N_2(g)$ and 28.0 g of $O_2(g)$.

(a) Calculate the total pressure, in atm, of the gas mixture in the cylinder at 298 K. 8.56 atm

(b) The temperature of the gas mixture in the cylinder is decreased to 280 K. Calculate each of the following.

(i) The mole fraction of $N_2(g)$ in the cylinder .499

(ii) The partial pressure, in atm, of $N_2(g)$ in the cylinder 4.27 atm

(c) If the cylinder develops a pinhole-sized leak and some of the gaseous mixture escapes, would the ratio $\frac{\text{moles of } N_2(g)}{\text{moles of } O_2(g)}$ in the cylinder increase, decrease, or remain the same? Justify your answer.

A different rigid 5.00 L cylinder contains 0.176 mol of $NO(g)$ at 298 K. A 0.176 mol sample of $O_2(g)$ is added to the cylinder, where a reaction occurs to produce $NO_2(g)$.

(d) Write the balanced equation for the reaction.

(e) Calculate the total pressure, in atm, in the cylinder at 298 K after the reaction is complete. 1.29 atm

2. A rigid 8.20 L flask contains a mixture of 2.50 moles of H_2, 0.500 mole of O_2, and sufficient Ar so that the partial pressure of Ar in the flask is 2.00 atm. The temperature is 127°C.

(a) Calculate the total pressure in the flask. 14.00 atm

(b) Calculate the mole fraction of H_2 in the flask. .714

(c) Calculate the density (in g L^{-1}) of the mixture in the flask. 5.01 g/L

The mixture in the flask is ignited by a spark, and the reaction represented below occurs until one of the reactants is entirely consumed.

$$2\,H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$

(d) Give the mole fraction of all species present in the flask at the end of the reaction. .143

$$2\,H_2O_2(aq) \rightarrow 2\,H_2O(l) + O_2(g)$$

3. The mass of an aqueous solution of H_2O_2 is 6.951 g. The H_2O_2 in the solution decomposes completely according to the reaction represented above. The $O_2(g)$ produced is collected in an inverted graduated tube over water at 23.4°C and has a volume of 182.4 mL when the water levels inside and outside of the tube are the same. The atmospheric pressure in the lab is 762.6 torr, and the equilibrium vapor pressure of water at 23.4°C is 21.6 torr.

(a) Calculate the partial pressure, in torr, of $O_2(g)$ in the gas-collection tube. 741.0 torr

(b) Calculate the number of moles of $O_2(g)$ produced in the reaction. .00732 moles O_2

(c) Calculate the mass, in grams, of H_2O_2 that decomposed. .498 g H_2O_2

(d) Calculate the percent of H_2O_2, by mass, in the original 6.951 g aqueous sample. 7.16%

(e) Write the oxidation number of the oxygen atoms in H_2O_2 and the oxidation number of the oxygen atoms in O_2 in the appropriate cells in the table below.

Substance	Oxidation Number of Oxygen Atoms
H_2O_2	
O_2	

(f) Write the balanced oxidation half-reaction for the reaction.