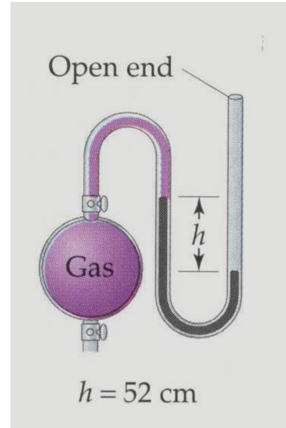
REVIEW QUESTIONS
Chapter 5

1. Determine the pressure of the gas (in mmHg) in the diagram below, given atmospheric pressure= 0.975 atm.



$$P_{atm} = 0.975\ \cancel{atm} \times \frac{760\ mmHg}{1\ \cancel{atm}} = 741\ mmHg$$

$$h = 52\ \cancel{cmHg} \times \frac{10\ mmHg}{1\ \cancel{cmHg}} = 520\ mmHg$$

$$P_{gas} = P_{atm} - h = 741\ mmHg - 520\ mmHg = 221\ mmHg$$

2. A sample of oxygen gas has a volume of 26.7 L at 752 mmHg and 20°C. What is the volume of this gas at 1.30 atm and 20°C?

$$V_2 = V_1 \times \frac{P_1}{P_2} = 26.7\ L \times \frac{752\ mmHg}{1.30\ \cancel{atm} \times \frac{760\ mmHg}{1\ \cancel{atm}}} = 20.3\ L$$

3. A 35.8 L cylinder of Argon gas is connected to and transferred into an evacuated 1875-L tank at constant temperature. If the final pressure in the tank is 721 mmHg, what must have been the original pressure (in atm) in the cylinder?

$$P_1 = P_2 \times \frac{V_2}{V_1} = \left(721\ \cancel{mmHg} \times \frac{1\ atm}{760\ \cancel{mmHg}}\right) \times \frac{1875\ L}{35.8\ L} = 49.7\ atm$$

4. A sample of gas has a volume of 4.25 L at 25.6°C and 748 mmHg. What will be the volume of this gas at 26.8°C and 742 mmHg?

$$V_2 = V_1 \times \frac{P_1}{P_2} \times \frac{T_2}{T_1} = 4.25\ L \times \frac{748\ mmHg}{742\ mmHg} \times \frac{299.8\ K}{298.6\ K} = 4.30\ L$$

5. What is the percent change in the volume of a fixed amount of gas at a fixed pressure if the temperature is increased from 1.00°C to 2.00°C? Is this the same percentage increase as produced by a temperature change from 10.00°C to 20.00°C? Explain.

From 1.00°C to 2.00°C

$$V_2 = V_1 \times \frac{T_2}{T_1} = 1.0000 \text{ L} \times \frac{275 \text{ K}}{274 \text{ K}} = 1.0036 \text{ L}$$

$$\% \text{ change} = \frac{0.0036 \text{ L}}{1.0000 \text{ L}} \times 100 = 0.36\%$$

From 10.00°C to 20.00°C

$$V_2 = V_1 \times \frac{T_2}{T_1} = 1.0000 \text{ L} \times \frac{293 \text{ K}}{283 \text{ K}} = 1.0353 \text{ L}$$

$$\% \text{ change} = \frac{0.0353 \text{ L}}{1.0000 \text{ L}} \times 100 = 3.53\%$$

Even though both temperatures are doubled, the percentage change of 10-20 degrees is much greater than the change of 1-2 degrees because volume is proportional to the absolute temperature and not the Celsius temperature.

6. A 34.0-L cylinder contains 305 g of oxygen gas at 22°C. How many grams of gas must be released to reduce the pressure in the cylinder to 1.15 atm if the temperature remains constant?

Mass of gas present at 1.15 atm

$$n = \frac{PV}{RT} = \frac{(1.15 \cancel{\text{ atm}})(34.0 \cancel{\text{ L}})}{(0.0821 \frac{\cancel{\text{L atm}}}{\text{mol} \cancel{\text{ K}}})(295 \cancel{\text{ K}})} = 1.6\underline{1}4 \text{ mol}$$

$$\text{mass of oxygen} = 1.6\underline{1}4 \cancel{\text{ mol}} \times \frac{32.0 \text{ g}}{1 \cancel{\text{ mol}}} = 51.6 \text{ g}$$

Mass of gas that must be removed

305 g – 51.6 g = 253 g

7. At STP, 0.280 L of a gas weighs 0.400 g. Calculate the molar mass of this gas.

$$\text{moles of gas} = 0.280\ \cancel{L} \times \frac{1\ \text{mol}}{22.4\ \cancel{L}} = 0.0125\ \text{mol}$$

$$\text{molar mass} = \frac{0.400\ \text{g}}{0.0125\ \text{mol}} = 32.0\ \text{g/mol}$$

8. Calculate the density of HBr gas in g/L at 733 mmHg and 46°C.

Assume 1 mole of gas

mass = 80.9 g/mol

$$\text{volume} = \frac{nRT}{P} = \frac{(1.00\ \cancel{mol})(0.0821\ \frac{L\ \cancel{atm}}{\cancel{mol}\ \cancel{K}})(319\ \cancel{K})}{733\ \cancel{mmHg} \times \frac{1\ \cancel{atm}}{760\ \cancel{mmHg}}} = 27.\underline{1}5\ \text{L}$$

$$\text{density} = \frac{\text{mass}}{\text{volume}} = \frac{80.9\ \text{g}}{27.\underline{1}5\ \text{L}} = 2.98\ \text{g/L}$$

9. A mixture of 4.00 g of hydrogen and 10.0 g of helium are in a 4.30-L flask at 0°C. What is the total pressure of the container and the partial pressures of each gas?

$$\text{mol } H_2 = 4.00\ \cancel{g} \times \frac{1\ \text{mol}}{2.00\ \cancel{g}} = 2.00\ \text{mol}$$

$$\text{mol He} = 10.0\ \cancel{g} \times \frac{1\ \text{mol}}{4.00\ \cancel{g}} = 2.50\ \text{mol}$$

Total mol = 2.00 + 2.50 = 4.50 mol

$$P_{Total} = \frac{nRT}{V} = \frac{(4.50\ \cancel{mol})(0.0821\ \frac{\cancel{L}\ atm}{\cancel{mol}\ \cancel{K}})(273\ \cancel{K})}{4.30\ \cancel{L}} = 23.5\ \text{atm}$$

$$X_{H_2} = \frac{2.00\ \text{mol}}{4.50\ \text{mol}} = 0.444 \qquad X_{He} = \frac{2.50\ \text{mol}}{4.50\ \text{mol}} = 0.556$$

$$P_{H_2} = X_{H_2} P_{Tot} = (0.444)(23.5\ \text{atm}) = 10.4\ \text{atm}$$

$$P_{He} = X_{He} P_{Tot} = (0.556)(23.5\ \text{atm}) = 13.1\ \text{atm}$$

10. Life rafts and weather balloons can be inflated by the reaction shown below:

$$CaH_2\ (s)\ +\ 2\ H_2O\ (l)\ \rightarrow\ Ca(OH)_2\ (aq)\ +\ 2\ H_2\ (g)$$

How many grams of CaH_2 are needed to produce 10.0 L of hydrogen gas at 740 mmHg and 23°C?

$$n_{H_2} = \frac{PV}{RT} = \frac{(740\ \cancel{mmHg}\ x\ \frac{1\ \cancel{atm}}{760\ \cancel{mmHg}})(10.0\ \cancel{L})}{(0.0821\frac{\cancel{L\ atm}}{mol\ \cancel{K}})(296\ \cancel{K})} = 0.401\ mol$$

$$0.401\ \cancel{mol\ H_2}\ x\ \frac{1\ \cancel{mol}\ CaH_2}{2\ \cancel{mol\ H_2}}\ x\ \frac{42.1\ g}{1\ \cancel{mol}} = 8.44\ g\ CaH_2$$

11. Nitroglycerin, an explosive compound, decomposes according to the equation below:

$$4\ C_3H_5(NO_3)_3\ (s)\ \rightarrow\ 12\ CO_2\ (g) + 10\ H_2O\ (g) + 6\ N_2\ (g) + O_2\ (g)$$

Calculate the total volume of gases produced at 1.2 atm and 26°C when 260 g of nitroglycerine is decomposed.

$$260\ \cancel{g}\ \cancel{NG}\ x\ \frac{1\ \cancel{mol}}{227.1\ \cancel{g}}\ x\ \frac{29\ mol\ gas}{4\ \cancel{mol\ NG}} = 8.30\ mol\ gas$$

$$V = \frac{nRT}{P} = \frac{(8.30\ \cancel{mol})(0.0821\frac{L\ \cancel{atm}}{\cancel{mol\ K}})(299\ \cancel{K})}{1.2\ \cancel{atm}} = 170\ L$$

12. A 1.65-g sample of Al is reacted with excess HCl and the hydrogen produced is collected over water at 25°C at a barometric pressure of 744 mmHg. What volume of hydrogen gas is produced in this reaction? (Vapor pressure of water at 25°C is 23.8 mmHg)

$$2\ Al\ (s) + 6\ HCl\ (aq)\ \rightarrow\ 2\ AlCl_3\ (aq)\ + 3\ H_2\ (g)$$

$$P_{H_2} = P_{atm} - P_{H_2O} = 744\ mmHg - 23.8\ mmHg = 72\underline{0}.2\ mmHg$$

$$1.65\ \cancel{g\ Al}\ x\ \frac{1\ \cancel{mol}}{27.0\ \cancel{g}}\ x\ \frac{3\ mol\ H_2}{2\ \cancel{mol\ Al}} = 0.0917\ mol\ H_2$$

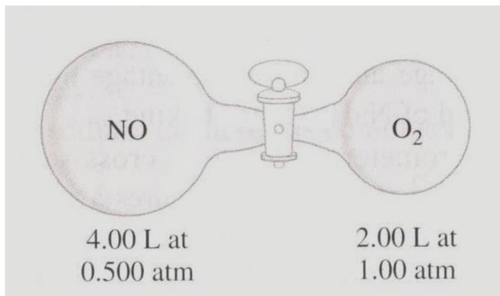
$$V = \frac{nRT}{P} = \frac{(0.0917\ \cancel{mol})(0.0821\frac{L\ \cancel{atm}}{\cancel{mol\ K}})(298\ \cancel{K})}{72\underline{0}.2\ \cancel{mmHg}\ x\ \frac{1\ atm}{760\ \cancel{mmHg}}} = 2.37\ L$$

CHALLENGE QUESTION

Nitric oxide reacts with oxygen gas as shown below:

$$2\ NO\ (g)\ +\ O_2\ (g)\ \rightarrow\ 2\ NO_2\ (g)$$

Initially NO and O_2 are separated as shown in the diagram below. When the valve is opened the reaction quickly goes to completion. Determine the identity of the gases that remain at the end of the reaction and their partial pressure. Assume temperature remains at 25°C.



Since the system is at constant temperature, the moles of gas is proportional to the product of pressure and volume as shown below:

PV = n ~~RT~~ at constant temp. PV α n

Before reaction

mol NO α (4.00 L)(0.500 atm) = 2.00

mol O_2 α (2.00 L)(1.00 atm) = 2.00

	2 NO	+ O_2	⟶ 2 NO_2
Initial	2.00	2.00	0
React	2.00	1.00	2.00
End	0	1.00	2.00

At end of reaction, total volume is 6.00 L. Therefore,

$$P_{O_2}\ \alpha\ \frac{mol}{V} = \frac{1.00}{6.00} = 0.167\ atm$$

$$P_{NO_2}\ \alpha\ \frac{mol}{V} = \frac{2.00}{6.00} = 0.333\ atm$$