

Guide to Chapter 9. Gases

Answers in green and red.

We will spend three lecture days on this chapter.

- ❖ Day 1. Pressure, barometers, STP, manometers, Charles Law, Boyles Law, Avogadro's Law, Combined Gas Law, Type 1 and Type 2 calculations.
- ❖ Day 2. Stoichiometry calculations (density, molar mass), mole fraction, Dalton's Law of partial pressure, kinetic theory of gases, Graham's Law effusion/diffusion.
- ❖ Day 3. Gas molecular velocity, average kinetic energy, real gases, chemistry in the atmosphere.

Read the introductory paragraph to Chapter 9.

Read Section 9.1 Gases and Gas Pressure.

Learning Objective 1: Understand the concept of pressure and its relationship to force. Be able to convert between the different units of pressure (Pa, kPa, MPa, atm, mmHg, torr). Understand how a manometer and a barometer work.

Learning Objective 2: Know the definition of STP. Know the standard molar volume (22.4 L)

Do Problems 1 - 4 at the end of the section.

Do the following end-of-chapter problems: 30, 36, 38, 40

Problem Club Question A. (a) Convert 158 mmHg to units of atmospheres. (b) Convert 0.795 atm to torr.

Answer: (a) 0.208 atm (b) 604 torr

Problem Club Question B. A simple open-ended manometer contains a sample of krypton gas. The level of Hg in the vertical portion of the manometer column open to the air is 4.7 cm higher than in the vertical portion connected to the flask. If the external pressure is 770 mmHg, what is the pressure of the krypton sample?

Answer: 817 mmHg

Problem Club Question C. An open-end manometer containing a sample of gas in the bulb and open to an external pressure of 790 mmHg. If the level of mercury in the arm connected to the bulb is 14.5 cm higher than the level of mercury in the arm open to the atmosphere, what is the pressure inside the bulb?

Answer: 645 mmHg

Read Section 9.2 The Gas Laws and Section 9.3 The Ideal Gas Law.

Learning Objective 3: Solve problems involving the ideal gas law, $PV=nRT$: (Type I). You are given three of the variables P, V, n, T, and asked to calculate the fourth.

Learning Objective 4: Solve Type II problems (in which there has been a change in the system). The proper equation is $P_1V_1/n_1T_1 = P_fV_f/n_fT_f$

- Solve problems involving Boyle's Law.
- Solve problems involving Charles's Law.
- Solve problems involving Gay-Lussac's Law.
- Solve problems involving Avogadro's principle

Do Problem 5 at the end of Section 2 and Problems 6 – 10 at the end of Section 3.

Do the following end-of-chapter problems: 44, 46, 48, 50, 52, 54

Problem Club Question D. A 10-L gas cylinder contains 380-g of nitrogen. What pressure is exerted by the N_2 at 25 °C?

Answer: 33 atm

Problem Club Question E. (a) The pressure of a 5.00-L sample of xenon gas is 725 mmHg. Assuming that the temperature and moles of Xe remain unchanged, calculate the new pressure when the volume becomes 8.75-L; (b) What gas law applies to this problem?

Answer: (a) 414 mmHg (b) Boyles

Problem Club Question F. How many moles of air are there in a 125-mL Erlenmeyer flask if the pressure is 755 torr and the temperature is 20 °C?

Answer: 0.00516 mol

Problem Club Question G. An open flask contains 0.200 mol of air at 745 mmHg and 25 °C. How many moles are present in the flask when the pressure is 1.10 atm and the temperature is 33 °C

Answer: 0.230 mol

Problem Club Question H. (a) A gas sample is originally at STP. To what temperature must this gas be changed in order to triple its volume? (b) What gas law applies to this problem?

Answer: (a) 819 K (b) Charles

Problem Club Question I. A tire is inflated to a gauge pressure of 28.0 psi at 67 °F. After several hours of driving the pressure reads 34 psi. What is the temperature of the gas in the tire now?

Answer: 179.8 °F

Problem Club Question J. At what temperature would 4.00 g nitrogen gas occupy 5.00 L at 795.0 mmHg?

Answer: 446 K

Problem Club Question K. Suppose a sample of argon occupies 550 mL at 300 K and 2.5 atm pressure. What is the volume of the gas at STP?

Answer: 1250 mL

Problem Club Question L. (ACS-Style) Answer: B

Problem Club Question M. (ACS-Style) Answer: 450 L

Problem Club Question N. (ACS-Style) Answer: 1.67 atm

Problem Club Question O. (ACS-Style) Answer: 3.47 L?

Problem Club Question P. (ACS-Style) Answer: 0.0094 mol

Read Section 9.4 Stoichiometry relationships with gases.

Learning Objective 5: Use the modified ideal gas law (where n has been substituted with m/MM) This gives the relationships. Use these equations to solve problems regarding molecular mass or the density of a gas.

$$PV = mRT/MM \text{ or } MM = mRT/PV$$

$$P \cdot MM = dRT, (d = \text{density} = m/V)$$

Do Problems 11 – 13 at the end of the section.

Do the following end-of-chapter problems: 56, 58, 60, 62, 64, 66, 68, 70

Problem Club Question Q. Calculate the density (g/L) of Cl₂ gas at STP

Answer: 3.17 g/L

Problem Club Question R. The atmosphere of Venus is known to consist of mostly CO₂. The surface temperature is 460 °C and the pressure is 75 atm. Calculate the density of carbon dioxide at the surface of Venus.

Answer: 55 g/L

Problem Club Question S. Calculate the density of: (a) argon at STP; and (b) nitrogen at 25 °C and 770 mmHg

Answer: (a) 1.78 g/L (b) 1.16 g/L

Problem Club Question T. A liquid of unknown identity is vaporized at 85 °C in a flask with a volume of 644 mL at 710 mmHg. The mass of the vapor is 2.771-g. What is the density and molar mass of the unknown?

Answer: density = 4.30 g/L and molar mass = 135 g/mol

Problem Club Question U. A gas has a density of 4.55 g/L at STP. What is its MM?

Answer: 102 g/mol

Problem Club Question V. What is the MM of a gas with a density of 2.99 g/L at 25 °C and 744 mmHg? Derive the needed formula starting with $PV = nRT$ and show your work.

Answer: 74.7 g/mol

Problem Club Question W. What is the density of carbon dioxide at STP? Derive the needed formula starting with $PV = nRT$ and show your work.

Answer: 1.96 g/L

Problem Club Question X. (ACS-Style) Answer: C

Problem Club Question Y. (ACS-Style) Answer: B

Problem Club Question Z. (ACS-Style) Answer: D

Problem Club Question AA. (ACS-Style) Answer: A

Problem Club Question BB. (ACS-Style) Answer: C

Problem Club Question CC. (ACS-Style) Answer: B

Read Section 9.5 Partial Pressure and Dalton's Law.

Learning Objective 6: Understand Dalton's Law of Partial Pressure.

Learning Objective 7: Compute the pressure of a gas collected over water.

Do Problems 14 - 17 at the end of the section.

Do the following end-of-chapter problems: 72, 74, 76, 78

Problem Club Question DD. A gaseous mixture contains 5.78 g of xenon and 2.15 g of neon. (a) What is the mole fraction of each gas? (b) What is the partial pressure of each gas inside of a 75-L flask at 85 °C? (c) What is the total pressure?

Answer: A gaseous mixture contains 5.78 g of xenon and 2.15 g of neon. (a) $X_{Xe} = 0.292$ and $X_{Ne} = 0.707$ (b) $P_{Xe} = 0.0172$ atm and $P_{Ne} = 0.0418$ (c) total pressure = 0.059 atm

Problem Club Question EE. (ACS-Style) Answer: B

Read Section 9.6. Kinetic-Molecular Theory of Gases, and 9.7. Graham's Law: Diffusion and Effusion of Gases

Learning Objective 8: Understand the major results of the Kinetic-Molecular Theory of Gases, specifically as it relates to the velocity of gas molecules.

Learning Objective 9: Be able to perform Graham's Law calculations for effusion/diffusion..

Do Problems 18 and 19 at the end of the Section 6 and 20 and 21 at the end of Section 7.

Do the following end-of-chapter problems: 32, 84, 86, 88, 90

Problem Club Question FF. An unknown gas effuses 4 times faster than oxygen. What is its MM? Could it be neon or hydrogen?

Answer: MM = 2.0 g/mol -possibly hydrogen

Problem Club Question GG. CH₄S and C₄H₁₀S both smell bad. If both are spilled together in the corner of a room, which gas would you smell first? What is the ratio of their rates of diffusion?

Answer: CH₄S would be smelled first. Ratio of diffusion rates = [rate of CH₄S/rate of C₄H₁₀S] = 1.37

Problem Club Question HH. What is the ratio of the rate of effusion of the most abundant gas, nitrogen, to that of the most dense gas known, UF₆?

Answer: 3.54:1.00

Problem Club Question II. It takes 32.0 s for ammonia to effuse down a capillary tube. How long will it take hydrogen chloride to effuse down an identical capillary tube at the same conditions of temperature and pressure?

Answer: 46.8 s

Problem Club Question JJ. A gas thought to be HF, HCl, HBr, or HI is allowed to effuse along a Graham's Law tube where it will react with ammonia effusing from the other end. If ammonia is found to effuse just over twice as fast (2.17 times as fast to be exact), which was the acid gas?

Answer: HBr

Problem Club Question KK. Calculate the average speed of (a) a chlorine molecule at 25 °C; (b) an argon atom at -25 °C.

Answer: (a) 324 m/s (b) 393 m/s

Problem Club Question LL. Calculate the relative rates of effusion for CH₄(g) and SF₆(g), $u_{\text{CH}_4}/u_{\text{SF}_6}$

Answer: 3.02:1

Problem Club Question MM. (ACS-Style) Answer: D

Problem Club Question NN. (ACS-Style) Answer: A

Problem Club Question OO. (ACS-Style) Answer: A

Read Section 9.8. The Behavior of Real Gases

Learning Objective 10: Understand why real gases deviate from ideal behavior. State the conditions under which real gases most nearly exhibit ideal behavior.

Problem Club Question PP. A sample of methane gas, CH₄, is at 50 °C and 20 atm. Would you expect it to behave more ideally or less ideally if (a) the pressure were reduced to 1 atm? (b) the temperature were reduced to -50 °C?

Answer: (a) more (b) less

Problem Club Question QQ. (ACS-Style) Answer: B

Problem Club Question RR. (ACS-Style) Answer: D

(A) high pressure and high temperature.

Read Section 9.9. The Earth's Atmosphere.

Problem Club Question SS. True/False

T F Nitrogen is the main component of the atmosphere.

T F Carbon dioxide would not exist in the atmosphere if it were not for society-made factors such as electricity generation.

T F Internal combustion engines are associated with nitrogen-oxide pollutants.

T F Coal-fired power plants are associated with sulfur-oxide pollutants.

T F Photochemical smog is another phrase for acid rain

T F Limestone reacts with acid rain producing CO₂.

Answer: T F T T F T