Name ______________________________ Date ______________

Gases

Before You Read

Review Vocabulary

Define *the following terms.*

density — mass (m) per unit of volume (V)

stoichiometry — the study of quantitative relationships between amounts of reactants used and products formed by a chemical reaction

kinetic-molecular theory — a description of the properties of gases in terms of energy, size, and motion of particles

Chapter 9 — **Balance** *the following equation.*

__2__ Fe + __3__ H_2SO_4 ⟶ $Fe_2(SO_4)_3$ + __3__ H_2

Chapter 11 — **Show** *the mole ratios for the following reaction.*

$N_2 + 3H_2 \longrightarrow 2NH_3$

1. **a.** mole ratio of N to H_2

$$\frac{1 \text{ mol N}}{3 \text{ mol } H_2}$$

2. **b.** mole ratio of NH_3 to H_2

$$\frac{2 \text{ mol } NH_3}{3 \text{ mol } H_2}$$

Chapter 12 — **Explain** *how gas particles exert pressure.*

Gas particles exert pressure when they collide with the walls of their container.

Name ______________________ Date ____________

Gases

Section 1 The Gas Laws

Main Idea — **Details**

Scan *Section 1 of your text. Use the checklist below as a guide.*

- Read all section titles.
- Read all boldfaced words.
- Read all tables and graphs.
- Look at all pictures and read the captions.
- Think about what you already know about this subject.

Write *three facts you discovered about the gas laws.*

1. **Accept all reasonable responses.**
2. ______________________
3. ______________________

New Vocabulary

Use your text to define each term.

Boyle's law	**states that the volume of a given amount of gas held at a constant temperature varies inversely with the pressure**
absolute zero	**the lowest possible temperature; zero kelvin**
Charles's law	**states that the volume of a given mass of gas is directly proportional to its kelvin temperature at constant pressure**
Gay-Lussac's law	**states that the pressure of a given mass of gas varies directly with the kelvin temperature when the volume remains constant**
combined gas law	**states the relationship among pressure, volume, and temperature of a fixed gas amount**

Name ______________________ Date ____________

Main Idea — **Details**

Boyle's Law

Use with Example Problem 1, page 443.

Solve *Read Example Problem 1 in your text.*

You Try It

Problem

Helium gas in a balloon is compressed from 4.0 L to 2.5 L at constant temperature. The gas's pressure at 4.0 L is 210 kPa. Determine the pressure at 2.5 L.

1. Analyze the Problem

Known:

V_1 = **4.0 L**

V_2 = **2.5 L**

P_1 = **210 kPa**

Unknown:

P_2 = **? kPa**

Use the equation for Boyle's law to solve for P_2.

2. Solve for the Unknown

Write the equation for Boyle's law: $P_1V_1 = P_2V_2$

To solve for P_2, divide both sides by V_2. $P_2 = \frac{P_1(V_1)}{(V_2)}$

Substitute the known values. $P_2 = \frac{210\text{kPa}\ (4.0\ \text{L})}{2.5\ \text{L}}$

Solve for P_2. P_2 = **340 kPa**

3. Evaluate the Answer

When the volume is **decreased**, the pressure is **increased**. The answer is in **kPa**, a unit of pressure.

Name ______________________ Date ______________

Section 1 The Gas Laws (continued)

Main Idea — **Details**

Charles's Law

Use with Example Problem 2, page 446.

Summarize *Fill in the blanks to help you take notes while you read Example Problem 2.*

Problem

A gas sample at 40.0°C occupies a volume of 2.32 L. Assuming the pressure is constant, if the temperature is raised to 75.0°C, what will the volume be?

1. **Analyze the Problem**

   Known:

   T_1 = **40.0°C**

   V_1 = **2.32 L**

   T_2 = **75.0°C**

   Unknown:

   V_2 = **? L**

   Use Charles's law and the known values for T_1, V_1, and T_2 to solve for V_2.

2. **Solve for the Unknown**

   Convert the T_1 and T_2 Celsius temperatures to kelvin:

   T_1 = 273 + 40.0°C = **313** K T_2 = 273 + 75.0°C = **348** K

   Write the equation for Charles's law:

   $$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

   To solve for V_2, multiply both sides by T_2:

   $$V_2 = \frac{V_1 T_2}{T_1}$$

   Substitute known values:

   $$V_2 = \frac{2.32\ \text{L}\ (348\ \text{K})}{(313\ \text{K})}$$

   Solve for V_2.

   V_2 = **2.58 L**

3. **Evaluate the Answer**

   When temperature in kelvin increases by a small amount, the volume **increases** by a small amount. The answer is in **liters**, a unit for volume.

Main Idea — **Details**

Gay-Lussac's Law

Use with Example Problem 3, page 448.

Solve *Read Example Problem 3 in your text.*

You Try It

Problem

The pressure of a gas stored in a refrigerated container is 4.0 atm at 22.0°C. Determine the gas pressure in the tank if the temperature is lowered to 0.0°C.

1. **Analyze the Problem**

Known:

P_1 = 4.0 atm

T_1 = **22.0°C**

T_2 = **0.0°C**

Unknown:

P_2 = ? **atm**

Use Gay-Lussac's law and the known values for T_1, V_1, and T_2 to solve for V_2.

2. **Solve for the Unknown**

Convert the T_1 and T_2 Celsius figures to kelvin.

T_1 = **273** + 22.0°C = **295** K

T_2 = 273 + **0.0** °C = **273** K

Write the equation for Gay-Lussac's law.

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

To solve for P_2, multiply both sides by T_2.

$$P_2 = \frac{P_1(T_2)}{(T_1)}$$

Substitute known values.

$$P_2 = 4.0 \text{ atm} \frac{(273 \text{ K})}{(295 \text{ K})}$$

Solve for P_2.

P_2 = 3.7 atm

3. **Evaluate the Answer**

The temperature **decreased** and the pressure **decreased**.

Name ______________________ Date ______________

Main Idea — **Details**

The Combined Gas Law

Use with page 449.

Describe *the combined gas law.*

a single law that includes all of the variables affecting the behavior of gases—pressure, volume, and temperature

Write *the combined gas law equation.*

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Pressure is inversely proportional to **volume** and directly proportional to **temperature**. Volume also is **directly proportional** to temperature.

Use with Example Problem 4, page 450.

Solve *Read Example Problem 4 in your text.*

You Try It

Problem

A gas at 100.0 kPa and 30.0°C has an initial volume of 1.00 L. Determine the temperature that could support the gas at 200.0 kPa and a volume of 0.50 L.

1. **Analyze the Problem**

   Known:

   P_1 = **100.0 kPa**

   P_2 = **200.0 kPa**

   T_1 = **30.0°C**

   V_1 = **1.00 L**

   V_2 = **0.50 L**

   Unknown:

   T_2 = ? °C

   Remember that volume increases as temperature increases, and volume is inversely proportional to pressure.

2. **Solve for the Unknown**

   Convert the T_1 Celsius temperature to kelvin.

   T_1 = **273** + 30.0°C = **303** K

Name _______________________________________ Date ______________

Section 1 The Gas Laws (continued)

Main Idea — **Details**

Write the combined gas law equation.

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

To solve for T_2, multiply both sides of the equation by T_2.

$$\frac{T_2P_1V_1}{T_1} = P_2V_2$$

Multiply both sides of the equation by T_1.

$$T_2 P_1 V_1 = \underline{P_2V_2T_1}$$

Divide both sides of the equation by $P_1 V_1$.

$$T_2 = \frac{P_2V_2T_1}{P_1V_1}$$

Substitute known values.

$$T_2 = \frac{200.0\text{ kPa} \times 0.50\text{L} \times 303\text{ K}}{100.0\text{ kPa} \times 1.00\text{ L}}$$

Solve for T_2.

$$T_2 = 303\text{ K} - 273\text{ K} = 30.0°\text{C}$$

3. Evaluate the Answer

As pressure **increased** and volume **decreased** in proportional amounts, the temperature remained constant.

Name ______________________ Date ____________

Gases

Section 2 The Ideal Gas Law

Main Idea | **Details**

Skim *Section 2 of your text. Write three questions that come to mind from reading the headings and the illustration captions.*

1. **Accept all reasonable responses.**
2. ______________________
3. ______________________

New Vocabulary

Use your text to define each term.

Avogadro's principle — **states that equal volumes of gases at the same temperature and pressure contain equal numbers of particles**

molar volume — **the volume that one mole of gas occupies at 0.00°C and 1.00 atm pressure**

standard temperature and pressure (STP) — **the conditions of 0.00°C temperature and 1.00 atm pressure**

ideal gas constant (R) — **an experimentally determined constant; the value of R depends on the units used for pressure**

ideal gas law — **describes the physical behavior of an ideal gas in terms of the pressure, volume, temperature, and number of moles of gas present**

Main Idea | **Details**

Avogadro's principle

Use with pages 452–453.

Explain *Avogadro's principle by completing the paragraph below.*

Avogadro's principle states that **equal volumes of gases at the same temperature and pressure contain equal numbers of particles**.

The **molar** volume for a gas is the volume that one mole occupies at **1.00 atm** of pressure and a temperature of **0.00°C**.

Convert the following volumes of a gas at STP to moles by using 22.4 L/mol as the conversion factor.

$$2.50\ L \times \frac{1\ mol}{22.4\ L} = \mathbf{0.112\ mol}$$

$$7.34\ L \times \frac{1\ mol}{22.4\ L} = \mathbf{0.328\ mol}$$

$$4.7\ L \times \frac{1\ mol}{22.4\ L} = \mathbf{0.21\ mol}$$

Name ______________________ Date ____________

Section 2 The Ideal Gas Law (continued)

Main Idea | **Details**

The Ideal Gas Law

Use with pages 454–455.

Analyze *the ideal gas law.*

The equation is written **PV** = **nRT**

P represents **pressure**

V represents **volume**

n represents the number of **moles** of gas present

R represents the **ideal gas constant**

T represents temperature

The ideal gas law states that **the volume of a gas varies directly with the number of moles of the gas and its kelvin temperature and varies inversely with its pressure**. The value of R depends on the units used for **pressure**.

Real Versus Ideal Gases

Use with pages 457–459.

Describe *the properties of an ideal gas.*

An ideal gas is one whose particles take up no space and have no intermolecular attractive forces.

Describe *the properties of a real gas.*

Real gas particles have some volume and are subject to intermolecular forces.

Name ______________________________ Date ______________

Section 2 The Ideal Gas Law (continued)

Main Idea | **Details**

The Ideal Gas Law

Use with Example Problem 6, page 455.

Summarize *Fill in the blanks to help you take notes while you read Example Problem 6.*

Problem

Calculate the number of moles of a gas contained in a 3.0-L vessel at 3.00×10^2 K with a pressure of 1.50 atm.

1. **Analyze the Problem**

Known:

$V =$ **3.0 L**

$T =$ **3.00×10^2 K**

$P =$ **1.50 atm**

$R = 0.0821 \frac{L \cdot atm}{mol \cdot K}$

Unknown:

$n = ?$ mol

Use the known values to find the value of n.

2. **Solve for the Unknown**

Write the ideal gas law equation.

$$PV = nRT$$

To solve for n, divide both sides by RT.

$$n = \frac{PV}{RT}$$

Substitute known values into the equation.

$$n = \frac{(1.50\ atm)(3.0\ L)}{\left(0.0821\frac{L \cdot atm}{mol \cdot K}\right)(3.00 \times 10^2\ K)}$$

Solve for n.

$$n = \frac{(1.50\ \cancel{atm})(3.0\ \cancel{L})}{\left(0.0821\frac{\cancel{L} \cdot \cancel{atm}}{\cancel{mol} \cdot \cancel{K}}\right)(3.00 \times 10^2\ \cancel{K})}$$

$n =$ **0.18 mol**

3. **Evaluate the Answer**

The answer agrees with the prediction that the number of moles will be **less than** one mole. The unit in the answer is the **mole**.

Name ______________________ Date ______________

Gases

Section 3 Gas Stoichiometry

Main Idea — **Details**

Scan *Section 3 of your text. Use the checklist below as a guide.*

- Read all section titles.
- Read all boldfaced words.
- Read all tables and graphs.
- Look at all pictures and read the captions.
- Think about what you already know about this subject.

Write *three facts you discovered about gas stoichiometry.*

1. **Accept all reasonable responses.**
2. ______________________
3. ______________________

Academic Vocabulary

Define the following terms.

ratio **the relationship in quantity between two things**

Name ______________________ Date ____________

Section 3 Gas Stoichiometry (continued)

Main Idea | **Details**

Stoichiometry and Volume–Volume Problems

Use with page 460.

Indicate *the moles and volume for the reaction below. Use Figure 10 as a reference.*

$2C_4H_{10}(g)$	+	$13O_2(g)$	$\longrightarrow$	$8CO_2(g)$	+	$10H_2O(g)$
2 moles		**13** moles		**8** moles		**10** moles
2 volumes		**13** volumes		**8** volumes		**10** volumes

The coefficients in the balanced equation represent **molar** amounts and relative **volumes**.

Volume–Volume Problems

Use with Example Problem 7, page 461.

Summarize *Fill in the blanks to help you take notes while you read Example Problem 7.*

Problem

Determine the volume of oxygen gas needed for the complete combustion of 4.00 L of propane gas (C_3H_8).

1. **Analyze the Problem**

   Known: V of C_3H_8 = **4.00 L**

   Unknown: V of O_2 = ? L

   Use the known volume of 4.00 L to find the volume needed for the combustion.

2. **Solve for the Unknown**

   Write the balanced equation for the combustion of C_3H_8.

   $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$

   Write the volume ratio.

   $$\frac{5 \text{ volumes of } O_2}{1 \text{ volume of } C_3H_8}$$

   Multiply the known volume of propane by the volume ratio to find the volume of O_2.

   $$4.00\text{ L } C_3H_8 \times \frac{5 \text{ volumes } O_2}{1 \text{ volume } C_3H_8} = 20.0\text{ L } O_2$$

3. **Evaluate the Answer**

   The coefficients of the reactants show that the quantity of **oxygen** consumed is greater than the amount of propane. The unit of the answer is the **liter**, a unit of volume.

Name ______________________________ Date ______________

Gases Chapter Wrap-Up

After reading the chapter, review what you have learned. Match each of the gas laws with its equation.

4	Ideal gas law	1.	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$
3	Gay-Lussac's law	2.	$P_1V_1 = P_2V_2$
1	Charles's law	3.	$\frac{P_1}{T_1} = \frac{P_2}{T_2}$
5	Combined gas law	4.	$PV = nRT$
2	Boyle's law	5.	$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Review

Use this checklist to help you study.

- ☐ Study your Science Notebook for this chapter.
- ☐ Study the vocabulary words and scientific definitions.
- ☐ Review daily homework assignments.
- ☐ Reread the chapter and review the tables, graphs, and illustrations.
- ☐ Answer the Section Review questions at the end of each section.
- ☐ Look over the Study Guide at the end of the chapter.

Real-World Connection

Explain why the volume of a balloon increases as you blow into it instead of bursting immediately from the added pressure.

As the amount of gas increases, the volume increases. As the volume increases, the pressure remains the same.