Name _____ Date _____ Class _____

CHAPTER 14 STUDY GUIDE FOR CONTENT MASTERY

Gases

Section 14.1 The Gas Laws

In your textbook, read about the basic concepts of the three gas laws.

Use each of the terms below to complete the passage. Each term may be used more than once.

pressure	temperature	volume

Boyle's law relates **(1)** Pressure and **(2)** Volume if **(3)** temp and amount of gas are held constant. Charles's law relates **(4)** temp and **(5)** Volume if **(6)** pressure and amount of gas are held constant. Gay-Lussac's law relates **(7)** Pressure and **(8)** temp if **(9)** Volume and amount of gas are held constant.

In your textbook, read about the effects of changing conditions on a sample of gas.

For each question below, write *increases*, *decreases*, or *stays the same*.

Increases **10.** The room temperature increases from 20°C to 24°C. What happens to the pressure inside a cylinder of oxygen contained in the room?

Same Vol **11.** What happens to the pressure of the gas in an inflated expandable balloon if the temperature is increased?

Increases **12.** An aerosol can of air freshener is sprayed into a room. What happens to the pressure of the gas if its temperature stays constant?

Increases **13.** The volume of air in human lungs increases before it is exhaled. What happens to the temperature of the air in the lungs to cause this change, assuming pressure stays constant?

Decreases **14.** A leftover hamburger patty is sealed in a plastic bag and placed in the refrigerator. What happens to the volume of the air in the bag?

Increases **15.** What happens to the pressure of a gas in a lightbulb a few minutes after the light is turned on?

Section 14.2 The Combined Gas Law and Avogadro's Principle

In your textbook, read about the combined gas law.

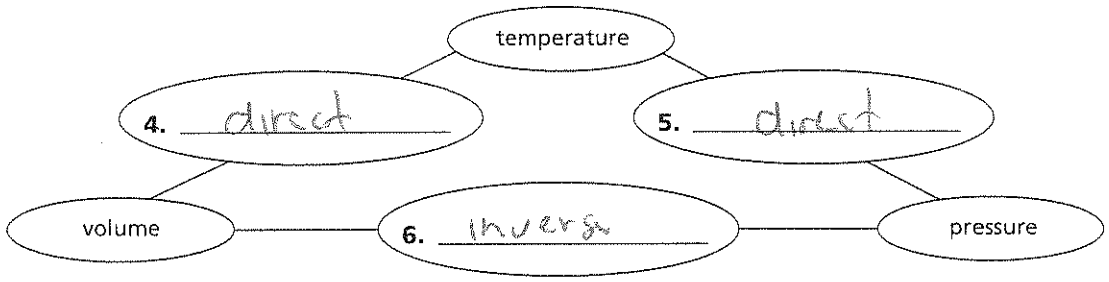
Fill in the following table. State what gas law is derived from the combined gas law when the variable listed in the first column stays constant and the variables in the second column change.

Derivations from the Combined Gas Law

Stays constant	Change	Becomes this law
Volume	Temperature, pressure	1. $P_1/T_1 = P_2/T_2$ Gay-Lussac's
Temperature	Pressure, volume	2. $P_1V_1 = P_2V_2$ Boyle's
Pressure	Temperature, volume	3. $V/T = V'/T'$ Charles's

In your textbook, read about the relationships among temperature, pressure, and volume of a sample of gas.

Fill in the blanks between the variables in the following concept map to show whether the variables are directly or inversely proportional to each other. Write *direct* or *inverse* between the variables.



In your textbook, read about the combined gas law and Avogadro's principle.

Circle the letter of the choice that best completes the statement or answers the question.

7. The variable that stays constant when using the combined gas law is
   (a.) amount of gas. **b.** pressure. **c.** temperature. **d.** volume.

8. The equation for the combined gas law can be used instead of which of the following equations?
   a. Boyle's law **b.** Charles's law **c.** Gay-Lussac's law (d.) all of these

9. Which of the following expresses Avogadro's principle?
   (a.) Equal volumes of gases at the same temperature and pressure contain equal numbers of particles.
   Or (b.) One mole of any gas will occupy a certain volume at STP.
   c. STP stands for standard temperature and pressure.
   d. The molar volume of a gas is the volume that one mole occupies at STP.

Section 14.2 *continued*

Answer the following questions.

10. What is standard temperature and pressure (STP)?

1 atm, 760 mmHg, 14.7 psi, 273 k

11. What is the molar volume of a gas equal to at STP?

22.4 L

In your textbook, read about how to solve problems using the combined gas law and Avogadro's principle.

Store

Each problem below needs more information to determine the answer. List as many letters as are needed to solve the problem.

a. molar volume of the gas
b. molar mass of the gas
c. temperature of the gas
d. pressure of the gas
e. volume of the gas
f. No further information is needed.

a b F **12.** What volume will 1.0 g N_2 gas occupy at STP?

a F **13.** What volume will 2.4 mol He occupy at STP?

d F **14.** A gas sample occupies 3.7 L at 4.0 atm and 25°C. What volume will the sample occupy at 27°C?

e c F **15.** A sample of carbon dioxide is at 273 K and 244 kPa. What will its volume be at 400 kPa? T_1 P_1 V_2

C **16.** A sample of oxygen occupies 10.0 L at 4.00 atm pressure. At what temperature will the pressure equal 3.00 atm if the final volume is 8.00 L? P_2 V_1 P_1

f **17.** At what pressure will a sample of gas occupy 5.0 L at 25°C if it occupies 3.2 L at 1.3 atm pressure and 20°C? T_2 P_2 V_2

a b **18.** How many grams of helium are in a 2-L balloon at STP?

f **19.** One mole of hydrogen gas occupies 22.4 L. What volume will the sample occupy if the temperature is 290 K and the pressure is 2.0 atm?

Section 14.3 The Ideal Gas Law

In your textbook, read about the ideal gas law.

Answer the following questions.

1. Why is the mathematical relationship among the amount, volume, temperature, and pressure of a gas sample called the ideal gas law?

   $P \times V = n \times R \times T$

2. Define the ideal gas constant, R.

   conversion factor to equalize values for gases when dealing w/ diff pressures

3. In Table 14-1 in your textbook, why does R have different numerical values?

4. What variable is considered in the ideal gas law that is not considered in the combined gas law?

   changing amount of gases

In your textbook, read about real versus ideal gases.

For each statement below, write *true* or *false*.

F 5. An ideal gas is one whose particles take up space.

F 6. At low temperatures, ideal gases liquefy.

F 7. In the real world, gases consisting of small molecules are the only gases that are truly ideal.

T 8. Most gases behave like ideal gases at many temperatures and pressures.

T 9. No intermolecular attractive forces exist in an ideal gas.

T 10. Nonpolar gas molecules behave more like ideal gases than do gas molecules that are polar.

T 11. Real gases deviate most from ideal gas behavior at high pressures and low temperatures.

T 12. The smaller the gas molecule, the more the gas behaves like an ideal gas.

Section 14.3 *continued*

In your textbook, read about applying the ideal gas law.

Rearrange the ideal gas law, $PV = nRT$, to solve for each of the following variables. Write your answers in the table.

Rearranging the Ideal Gas Law Equation

Variable to Find	Rearranged Ideal Gas Law Equation
n	**13.** PV/RT
P	**14.** nRT/V
T	**15.** PV/nR
V	**16.** $= nRT/P$

In your textbook, read about using the ideal gas law to solve for molar mass, mass, or density.

Use the following terms below to complete the statements. Each term may be used more than once.

mass	molar mass	volume

The number of moles of a gas is equal to the **(17)** mass divided by the **(18)** molar mass.

Density is defined as **(19)** mass per unit **(20)** volume.

To solve for M in the equation $M = \frac{mRT}{PV}$, the **(21)** mass and the **(22)** volume of the gas must be known.

According to the equation $D = \frac{MP}{RT}$, the **(23)** molar of the gas must be known when calculating density.

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Practice Problems for Gas Laws and Their Variables, and Gas Stoichiometry

Multiple Choice

Identify the letter of the choice that best completes the statement or answers the question.

A 1. For the reaction $N_2 + 3H_2 \rightarrow 2NH_3$, how many moles of nitrogen are required to produce 18 mol of ammonia?
   a. 9.0 mol
   b. 18 mol
   c. 27 mol
   d. 36 mol

B 2. What happens to the volume of a gas during compression?
   a. The volume increases.
   b. The volume decreases.
   c. The volume remains constant.
   d. It is impossible to tell because all gases are different.

A 3. All of the following equations are statements of the ideal gas law except
   a. $P = nRTV$
   b. $\frac{PV}{T} = nR$
   c. $\frac{P}{n} = \frac{RT}{v}$
   d. $R = \frac{PV}{nT}$

A 4. According to the kinetic-molecular theory, particles of matter
   a. are in constant motion.
   b. have different shapes.
   c. have different colors.
   d. are always fluid.

C 5. According to the kinetic-molecular theory, gases condense into liquids because of
   a. gravity.
   b. atmospheric pressure.
   c. forces between molecules.
   d. elastic collisions.

d 6. The kinetic-molecular theory explains the behavior of
   a. gases only.
   b. solids and liquids.
   c. liquids and gases.
   d. solids, liquids, and gases.

A 7. A pressure of 745 mm Hg equals
   a. 745 torr.
   b. 1 torr.
   c. 1 pascal.
   d. 745 pascal.

C 8. Convert the pressure 0.75 atm to mm Hg.
   a. 101.325 mm Hg
   b. 430 mm Hg
   c. 570 mm Hg
   d. 760 mm Hg

A 9. If the height of mercury in a barometer at 0°C is less than 760 mm Hg, then
   a. the atmospheric pressure is less than standard atmospheric pressure.
   b. the atmospheric pressure is greater than standard atmospheric pressure.
   c. the atmospheric pressure is equal to standard atmospheric pressure.
   d. the atmospheric pressure cannot be determined.

B 10. To observe the effects of changing pressure on the volume of a gas, factors that must be kept constant are the gas's temperature and
   a. density.
   b. quantity.
   c. elasticity.
   d. All of the above

C 11. If the temperature of a fixed quantity of gas decreases and the pressure remains unchanged,
a. its volume increases.
b. its volume is unchanged.
c. its volume decreases.
d. its density decreases.

B 12. The gas pressure inside a container decreases when
a. the number of gas molecules is increased.
b. the number of gas molecules is decreased.
c. the temperature is increased.
d. the number of molecules is increased and the temperature is increased.

C 13. The volume of a gas is 400.0 mL when the pressure is 1.00 atm. At the same temperature, what is the pressure at which the volume of the gas is 2.0 L?
a. 0.5 atm
b. 5.0 atm
c. 0.20 atm
d. 800 atm

D 14. The pressure of a sample of helium is 2.0 atm in a 200-mL container. If the container is compressed to 10 mL without changing the temperature, what is the new pressure?
a. 200 atm
b. 0.10 atm
c. 100 atm
d. 40. atm

C 15. A sample of gas collected at 750. mm Hg occupies 250. mL. At constant temperature, what pressure does the gas exert if the volume increases to 300. mL?
a. 50. mm Hg
b. 550. mm Hg
c. 625. mm Hg
d. 900. mm Hg

A 16. The volume of a gas is 93 mL when the temperature is 91°C. If the temperature is reduced to 0°C without changing the pressure, what is the new volume of the gas?
a. 70 mL
b. 100 mL
c. 120 mL
d. 273 mL

D 17. If a gas occupies 950.0 mL at standard temperature, what volume does it occupy at 25.00°C if the pressure remains constant?
a. 870.0 mL
b. 966.0 mL
c. 1000.0 mL
d. 1037 mL

B 18. On a cold winter morning when the temperature is –13°C, the air pressure in an automobile tire is 1.5 atm. If the volume does not change, what is the pressure after the tire has warmed to 15°C?
a. –1.5 atm
b. 1.7 atm
c. 3.0 atm
d. 19.5 atm

D 19. If V, P, and T represent the original volume, pressure, and temperature in the correct units, and V', P', and T' represent the new conditions, what is the combined gas law?
a. $\frac{PV}{T'} = \frac{P'V'}{T}$
b. $\frac{PV'}{T} = \frac{P'V}{T'}$
c. $\frac{P'V}{T} = \frac{PV'}{T'}$
d. $\frac{PV}{T} = \frac{P'V'}{T'}$

D 20. The volume of a sample of oxygen is 300.0 mL when the pressure is 1 atm and the temperature is 27.0°C. At what temperature is the volume 1.00 L and the pressure 0.500 atm?
a. 22.0°C
b. 45.0°C
c. 0.50 K
d. 227°C

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B 33. In the reaction $N_2(g) + 2O_2(g) \rightarrow 2NO_2(g)$, what is the volume ratio of N_2 to NO_2?
a. 1:1
b. 1:2
c. 2:1
d. 2:5

B 34. In the reaction $H_2(g) + Cl_2(g) \rightarrow 2HCl$, what is the volume ratio of Cl_2 to HCl?
a. 1:1
b. 1:2
c. 2:1
d. 2:2

D 35. When hydrogen burns, water vapor is produced. The equation is $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$. If 12 L of oxygen are consumed, what volume of water vapor is produced?
a. 1 L
b. 2 L
c. 12 L
d. 24 L

A 36. What is the number of moles of H_2 produced when 23 g of sodium react with water according to the equation $2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$?
a. 0.50 mol
b. 1 mol
c. 2 mol
d. 4 mol

Problem

Element	Symbol	Atomic mass
Bromine	Br	79.904
Calcium	Ca	40.078
Carbon	C	12.011
Chlorine	Cl	35.4527
Cobalt	Co	58.933 20
Copper	Cu	63.546
Fluorine	F	18.998 4032
Hydrogen	H	1.007 94
Iodine	I	126.904
Iron	Fe	55.847
Lead	Pb	207.2
Magnesium	Mg	24.3050
Mercury	Hg	200.59
Nitrogen	N	14.006 74
Oxygen	O	15.9994
Potassium	K	39.0983
Sodium	Na	22.989 768
Sulfur	S	32.066

37. What mass in grams of water is produced if 33.6 liters of oxygen at STP reacts with excess hydrogen according to the chemical equation $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$?

54 g

$\frac{33.6\ L}{22.4\ L/mol} = 1.5\ moles$

$2H_2 + O_2 \rightarrow 2H_2O$

$1.5\ moles \rightarrow 3\ moles \rightarrow 3 \times 18\ g/mole = 54\ g$

C 21. At 0.500 atm and 15.0°C a sample of gas occupies 120. L. What volume does it occupy at 0.250 atm and 10.0°C?
a. 60 L
b. 111 L
c. 236 L
d. 480 L

A 22. In the equation $C + O_2(g) \rightarrow CO_2(g)$, one volume of O_2 yields how many volumes of CO_2?
a. 1
b. 2
c. 3
d. 4

C 23. Equal volumes of diatomic gases under the same conditions of temperature and pressure contain the same number of
a. protons.
b. ions.
c. molecules.
d. Dalton's "ultimate particles."

B 24. At constant temperature and pressure, gas volume is directly proportional to the
a. molar mass of the gas.
b. number of moles of gas.
c. density of the gas at STP.
d. rate of diffusion.

A 25. The standard molar volume of a gas at STP is
a. 22.4 L.
b. g/22.4 L.
c. g-mol wt/22.4 L.
d. 1 L.

C 26. What is the volume occupied by 1 mol of oxygen at STP?
a. 11.2 L
b. 16.0 L
c. 22.4 L
d. 32.0 L

C 27. What is the volume occupied by 1 mol of water vapor at STP?
a. 11.2 L
b. 18.0 L
c. 22.4 L
d. 33.6 L

D 28. A 1.00 L sample of a gas has a mass of 1.92 g at STP. What is the molar mass of the gas?
a. 1.92 g/mol
b. 19.2 g/mol
c. 22.4 g/mol
d. 43.0 g/mol

C 29. Which is a common unit for the ideal gas constant R?
a. L·atm
b. mol·K
c. $\frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}$
d. $\frac{\text{atm}}{\text{K}}$

C 30. Calculate the approximate temperature of a 0.50 mol sample of gas at 750 mm Hg and a volume of 12 L.
a. –7°C
b. 11°C
c. 15°C
d. 288°C

C 31. What is the approximate volume of gas in a 1.50 mol sample that exerts a pressure of 0.922 atm and has a temperature of 10.0°C?
a. 13 L
b. 14.2 L
c. 37.8 L
d. 378 L

B 32. The ratios of the volumes of the gaseous reactants and products in a chemical reaction at constant temperature and pressure can be determined from the
a. formulas.
b. coefficients in the balanced equation.
c. subscripts in the balanced equation.
d. gas constant.

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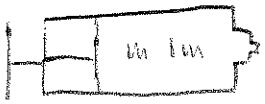
Gasses and their properties. The variables that change as a result of other varibles once equilibrium is reached. All answers are for each situation fter it comes to rest. Rember to check your work!



Fill in the following table with one of these terms: *increases, decreases, stays the same.* Assume the amount of gas is constant.

1.

Volume	Pressure	Temperature
increases	stays the same	~~decreases~~ inc

~~24~~ = Total points

2.

Volume	Pressure	Temperature
increases	decreases	stays the same

3.

Volume	Pressure	Temperature
stays the same	increases	increases

4.

Volume	Pressure	Temperature
decreases	increases	stays the same

5.

Volume	Pressure	Temperature
increases	stays the same	increases

6.

Volume	Pressure	Temperature
stays the same	increased	increases

7.

Volume	Pressure	Temperature
decreases	stays the same	decreased

Fill in the following table with one of these terms: *increases, decreases, stays the same.* Assume the amount of gas is constant.

8.

Volume	Pressure	Temperature
decreases	increases	stays the same

9.

Volume	Pressure	Temperature
stays the same	decreases	increases

10.

Volume	Pressure	Temperature
stays the same	increase	decreases

11.

Volume	Pressure	Temperature
decrease	stays the same	decreases

12. Which equation shows the ideal gas law?

[A] $\frac{P_1}{T_1} = \frac{P_2}{T_2}$ at constant volume

[B] $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

[C] $P_1V_1 = P_2V_2$, at constant temperature

[D] $PV = nRT$

[E] $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ at constant pressure

13. Based on the combined gas law, at constant volume, doubling the kelvin temperature would have what effect on pressure? P x 2

Each of the following examples gives a change in volume, temperature, amount, or pressure of a gas sample. Indicate whether the other variable mentioned would increase or decrease as a result. If a variable is not mentioned, assume it is constant.

14. Additional gas is added to a soccer ball. The pressure ↑.

15. An inflated balloon is placed in a refrigerator. The volume ↓.

Each of the following examples gives a change in volume, temperature, amount, or pressure of a gas sample. Indicate whether the other variable mentioned would increase or decrease as a result. If a variable is not mentioned, assume it is constant.

16. A piston in an engine compresses the gas into a smaller volume. The pressure ↑.

17. Compressed air in scuba tanks cools off as a diver swims at deeper levels. The pressure in the tanks ↓.

18. The volume of an inflated balloon increases when the amount of gas in the balloon ↑.

19. A person sits on an air mattress. The pressure ↑.

20. Consider the ideal gas law and the ideal gas constant. What information do you need in order to determine the volume of the gas if you know the pressure, the temperature, and the ideal gas constant?

    [A] the density of the gas
    [B] the percentage composition of the gas
    [C] the number of moles of the gas
    [D] the molecular mass of the gas

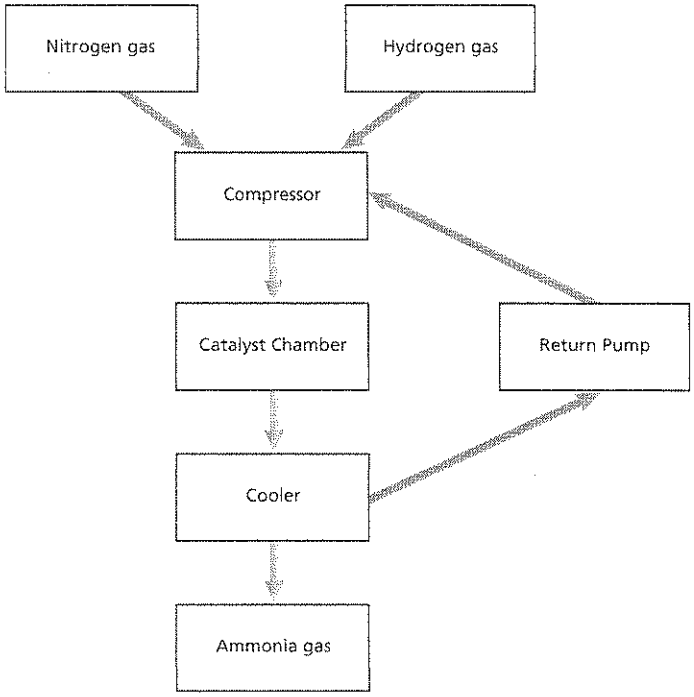
21. Explain why R can have different numerical values.

Diff units of pressure

2pts

22. Elemental nitrogen (N_2) makes up approximately 79 percent of the air. Nitrogen is essential to life, but plants cannot use it in its elemental form. In nature, lightning and bacteria in the soil and roots of certain plants convert atmospheric nitrogen into nitrogen-containing compounds that plants can use. However, due to the amount of agricultural crops planted, natural methods of converting atmospheric nitrogen do not provide all the nitrogen compounds needed by the growing plants. For this reason, chemical fertilizers are sprayed over the soil, supplying nitrogen compounds.

Ammonia (NH_3) gas is a component in the manufacturing of fertilizers. One method used to prepare the ammonia is called the Haber process. Fritz Haber first developed this process, which produces ammonia from elemental nitrogen and hydrogen gases. The following diagram summarizes the Haber process.



Use what you know about gases and the Haber process to answer the following questions. Show your work.

2 pts

Heated nitrogen and hydrogen gases are reduced in volume in the compressor. What effect do these changes in temperature and volume have on the pressure of the gases?

Both increase the pressure

☆ extra credit: write the equation for the reaction above:

$3H_2 + N_2 \rightarrow 2NH_3$