

Chapter 5:

Gases

CHAPTER 6 QUESTIONS**MULTIPLE-CHOICE QUESTIONS**Questions 1–5

- (A) H_2
(B) He
(C) O_2
(D) N_2
(E) CO_2
1. This is the most plentiful gas in the earth's atmosphere.
 2. A 1 mole sample of this gas occupying 1 liter will have the greatest density.
 3. At a given temperature, this gas will have the greatest rate of effusion.
 4. The molecules of this nonpolar gas contain polar bonds.
 5. The molecules of this gas contain triple bonds.
 6. The temperature of a sample of an ideal gas confined in a 2.0 L container was raised from 27°C to 77°C . If the initial pressure of the gas was 1200 mmHg, what was the final pressure of the gas?
(A) 300 mmHg
(B) 600 mmHg
(C) 1400 mmHg
(D) 2400 mmHg
(E) 3600 mmHg
 7. A sealed container contains 0.20 moles of oxygen gas and 0.10 moles of hydrogen gas. If the temperature is 25°C throughout the container, which of the following is true?
(A) The partial pressures of the two gases are the same.
(B) The average kinetic energy of the two gases are the same.
(C) The molecular masses of the two gases are the same.
(D) The total masses of the two gases are the same.
(E) The average molecular speeds of the two gases are the same.
 8. A gas sample contains 0.1 mole of oxygen and 0.4 moles of nitrogen. If the sample is at standard temperature and pressure, what is the partial pressure due to nitrogen?
(A) 0.1 atm
(B) 0.2 atm
(C) 0.5 atm
(D) 0.8 atm
(E) 1.0 atm

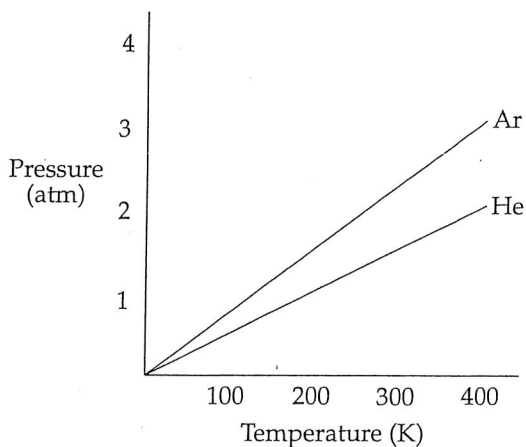
9. A mixture of gases contains 1.5 moles of oxygen, 3.0 moles of nitrogen, and 0.5 moles of water vapor. If the total pressure is 700 mmHg, what is the partial pressure of the nitrogen gas?
- (A) 70 mmHg
(B) 210 mmHg
(C) 280 mmHg
(D) 350 mmHg
(E) 420 mmHg
10. A mixture of helium and neon gases has a total pressure of 1.2 atm. If the mixture contains twice as many moles of helium as neon, what is the partial pressure due to neon?
- (A) 0.2 atm
(B) 0.3 atm
(C) 0.4 atm
(D) 0.8 atm
(E) 0.9 atm
11. Nitrogen gas was collected over water at 25°C. If the vapor pressure of water at 25°C is 23 mmHg, and the total pressure in the container is measured at 781 mmHg, what is the partial pressure of the nitrogen gas?
- (A) 23 mmHg
(B) 46 mmHg
(C) 551 mmHg
(D) 735 mmHg
(E) 758 mmHg
12. When 4.0 moles of oxygen are confined in a 24-liter vessel at 176°C, the pressure is 6.0 atm. If the oxygen is allowed to expand isothermally until it occupies 36 liters, what will be the new pressure?
- (A) 2 atm
(B) 3 atm
(C) 4 atm
(D) 8 atm
(E) 9 atm
13. A gas sample is confined in a 5-liter container. Which of the following will occur if the temperature of the container is increased?
- I. The kinetic energy of the gas will increase.
II. The pressure of the gas will increase.
III. The density of the gas will increase.
- (A) I only
(B) II only
(C) I and II only
(D) I and III only
(E) I, II, and III
14. A 22.0 gram sample of an unknown gas occupies 11.2 liters at standard temperature and pressure. Which of the following could be the identity of the gas?
- (A) CO_2
(B) SO_3
(C) O_2
(D) N_2
(E) He
15. A gaseous mixture at a constant temperature contains O_2 , CO_2 , and He. Which of the following lists the three gases in order of increasing average molecular speeds?
- (A) O_2 , CO_2 , He
(B) O_2 , He, CO_2
(C) He, CO_2 , O_2
(D) He, O_2 , CO_2
(E) CO_2 , O_2 , He
16. Which of the following conditions would be most likely to cause the ideal gas laws to fail?
- I. High pressure
II. High temperature
III. Large volume
- (A) I only
(B) II only
(C) I and II only
(D) I and III only
(E) II and III only

23. An ideal gas fills a balloon at a temperature of 27°C and 1 atm pressure. By what factor will the volume of the balloon change if the gas in the balloon is heated to 127°C at constant pressure?
- (A) $\frac{27}{127}$
(B) $\frac{3}{4}$
(C) $\frac{4}{3}$
(D) $\frac{2}{1}$
(E) $\frac{127}{27}$
24. A gas sample with a mass of 10 grams occupies 6.0 liters and exerts a pressure of 2.0 atm at a temperature of 26°C. Which of the following expressions is equal to the molecular mass of the gas? The gas constant, R , is 0.08 (L-atm)/(mol-K).
- (A) $\frac{(10)(0.08)(299)}{(2.0)(6.0)}$ g/mol
(B) $\frac{(299)(0.08)}{(10)(2.0)(6.0)}$ g/mol
(C) $\frac{(2.0)(6.0)(299)}{(10)(0.08)}$ g/mol
(D) $\frac{(10)(2.0)(6.0)}{(299)(0.08)}$ g/mol
(E) $\frac{(2.0)(6.0)}{(10)(299)(0.08)}$ g/mol
25. Which of the following assumptions is (are) valid based on kinetic molecular theory?
- I. Gas molecules have negligible volume.
II. Gas molecules exert no attractive forces on one another.
III. The temperature of a gas is directly proportional to its kinetic energy.
- (A) I only
(B) III only
(C) I and III only
(D) II and III only
(E) I, II, and III

17. Which of the following expressions is equal to the density of helium gas at standard temperature and pressure?
- (A) $\frac{1}{22.4} \text{ g/L}$
 (B) $\frac{2}{22.4} \text{ g/L}$
 (C) $\frac{1}{4} \text{ g/L}$
 (D) $\frac{4}{22.4} \text{ g/L}$
 (E) $\frac{4}{4} \text{ g/L}$
18. An ideal gas is contained in a 5.0 liter chamber at a temperature of 37°C. If the gas exerts a pressure of 2.0 atm on the walls of the chamber, which of the following expressions is equal to the number of moles of the gas? The gas constant, R , is 0.08 (L-atm)/(mol-K).
- (A) $\frac{(2.0)(5.0)}{(0.08)(37)} \text{ moles}$
 (B) $\frac{(2.0)(0.08)}{(5.0)(37)} \text{ moles}$
 (C) $\frac{(2.0)(0.08)}{(5.0)(310)} \text{ moles}$
 (D) $\frac{(2.0)(310)}{(0.08)(5.0)} \text{ moles}$
 (E) $\frac{(2.0)(5.0)}{(0.08)(310)} \text{ moles}$
19. Which of the following gases would be expected to have a rate of effusion that is three times as large as that of H_2 ?
- (A) O_2
 (B) N_2
 (C) He
 (D) H_2O
 (E) CO_2
20. A gaseous mixture of oxygen and nitrogen is 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.
21. Nitrogen gas was collected over water at a temperature of 40°C, and the pressure of the sample was measured at 796 mmHg. If the vapor pressure of water at 40°C is 55 mmHg, what is the partial pressure of the nitrogen gas?
- (A) 55 mmHg
 (B) 741 mmHg
 (C) 756 mmHg
 (D) 796 mmHg
 (E) 851 mmHg
22. A balloon occupies a volume of 1.0 liter when it contains 0.16 grams of helium at 37°C and 1 atm pressure. If helium is added to the balloon until it contains 0.80 grams while pressure and temperature are kept constant, what will be the new volume of the balloon?
- (A) 0.50 liters
 (B) 1.0 liters
 (C) 2.0 liters
 (D) 4.0 liters
 (E) 5.0 liters

PROBLEMS

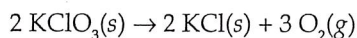
1.



The graph above shows the changes in pressure with changing temperature of gas samples of helium and argon confined in a closed 2-liter vessel.

- What is the total pressure of the two gases in the container at a temperature of 200 K?
- How many moles of helium are contained in the vessel?
- How many molecules of helium are contained in the vessel?
- What is the ratio of the average speeds of the helium atoms to the average speeds of the argon atoms?
- If the volume of the container were reduced to 1 liter at a constant temperature of 300 K, what would be the new pressure of the helium gas?

2.



The reaction above took place and 1.45 liters of oxygen gas were collected over water at a temperature of 29°C and a pressure of 755 millimeters of mercury. The vapor pressure of water at 29°C is 30.0 millimeters of mercury.

- What is the partial pressure of the oxygen gas collected?
- How many moles of oxygen gas were collected?
- What would be the dry volume of the oxygen gas at a pressure of 760 millimeters of mercury and a temperature of 273 K?
- What was the mass of the KClO_3 consumed in the reaction?

ESSAYS

3. Equal molar quantities of two gases, O_2 and H_2O , are confined in a closed vessel at constant temperature.
- (a) Which gas, if any, has the greater partial pressure?
 - (b) Which gas, if any, has the greater density?
 - (c) Which gas, if any, has the greater concentration?
 - (d) Which gas, if any, has the greater average kinetic energy?
 - (e) Which gas, if any, will show the greater deviation from ideal behavior?
 - (f) Which gas, if any, has the greater average molecular speed?
4. Use your knowledge of chemical principles and kinetic-molecular theory to explain the following statements.
- (a) A lit candle placed in a sealed jar will not burn for very long.
 - (b) A glass of water left out in air can completely vaporize, although the temperature never comes close to the boiling point of water.
 - (c) The volume of a gas-filled balloon placed underwater at a constant temperature will decrease as its depth below the surface of the water is increased.
 - (d) As the temperature of a gas is decreased, the measured pressure of the gas becomes less than the pressure predicted by the ideal gas law.

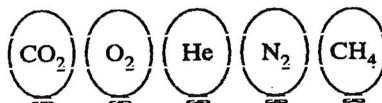
CHAPTER 6 ANSWERS AND EXPLANATIONS

MULTIPLE-CHOICE QUESTIONS

- 1. D Nitrogen gas makes up about 78 percent of the gas in the earth's atmosphere.
- 2. E Density is a measure of grams per liter. CO_2 has the greatest molecular mass (44), so 1 mole of CO_2 will have the most mass in 1 liter and, therefore, the greatest density.
- 3. A According to Graham's law, the lighter the gas, the greater the rate of effusion. H_2 is the lightest gas (MW = 2), so it will have the greatest rate of effusion.
- 4. E CO_2 is the only gas listed that has bonds between atoms of differing electronegativity. The carbon-oxygen bonds in CO_2 are polar, although the linear geometry of the molecule makes the molecule nonpolar overall.
- 5. D N_2 is the only gas listed whose atoms are held together in a triple bond.

12 • Gases and Their Properties

AP QUESTION



Represented above are five identical balloons, each filled to the same volume at 25°C and 1.0 atmosphere 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 your reasoning.

Root-Mean-Square Velocity Problems

- 1) What is the RMS velocity for water vapor at 300⁰ C? $R = 8.314 \text{ kg}\cdot\text{m}^3/\text{s}^2\cdot\text{K}\cdot\text{mol}$).

966 m/sec
- 2) What is the RMS velocity for hydrogen gas at 30⁰ C?

1943 m/sec
- 3) Compare the answers from problems 1 and 2. Are they surprising to you in any way? Explain.
- 4) Why do gas molecules tend to move more quickly at high temperatures than at low temperatures?
- 5) If gas molecules move so quickly (on the order of 1 kilometer per second), how come it takes so long to smell a jar of pickles when it's opened across the room?

12 • Gases and Their Properties

PRACTICE TEST

- A pressure of 745 mmHg corresponds to ____ kPa.
a) 55.89 kPa c) 99.3 kPa
b) 0.980 kPa d) 745 kPa
- Liquid nitrogen has a boiling point of -196°C this corresponds to...
a) -469 K c) 153 K
b) 77 K d) 469 K
- 1.20 atm is the same pressure as:
a) 1.2 mmHg d) 850 mmHg
b) 760 mmHg e) 358 mmHg
c) 912 mmHg
- For an ideal gas, which pair of variables are inversely proportional to each other (if all other factors remain constant)?
a) P, V c) V, T
b) P, T d) n, P
- A real gas would act most ideal at
a) 1.0 atm and 273 K
b) 10 atm and 546 K
c) 10 atm and 273 K
d) 0.5 atm and 546 K
e) 0.5 atm and 273 K
- One mole of hydrogen, H_2 , occupies 61.2 L at
a) 100°C and 1.00 atm
b) 200°C and 1.00 atm
c) 0°C and 0.500 atm
d) 50°C and 0.500 atm
e) 100°C and $.500\text{ atm}$
- A 31.0 mL sample of gas is collected at a temperature of 37°C and pressure of 720 mmHg . What is its volume at 17°C and 580 mmHg .
a) 23 mL d) 41 mL
b) 27 mL e) 58 mL
c) 36 mL
- The coldest possible temperature of a gas is:
a) 0°C b) 273 K c) -273 K d) -273°C
- The pressure of 4.0 L of an ideal gas in a flexible container is decreased to one-third of its original pressure and its absolute temperature is decreased by one-half. The volume then is
a) 1.0 L b) 4.0 L c) 6.0 L d) 8.0 L e) 24 L
- A given mass of gas in a rigid container is heated from 100°C to 300°C . Which of the following best describes what will happen to the pressure of the gas? The pressure will...
a) decrease by a factor of three.
b) increase by a factor of three.
c) increase by a factor less than three.
d) decrease by a factor greater than three.
- What is the pressure exerted by some nitrogen gas collected in a tube filled with water on a day when the room temperature is 18.0°C and the room pressure is 750.0 mmHg ? [The partial pressure of water at 18°C is 15.5 mmHg .]
a) 15.5 mmHg d) 760.0 mmHg
b) 750.0 mmHg e) 732.0 mmHg
c) 734.5 mmHg

12. As the average kinetic energy of the molecules of a sample increases, the temperature of the sample
- decreases
 - increases
 - remains the same
13. If a gas that is confined in a rigid container is heated, the pressure of the gas will...
- increase
 - decrease
 - remain the same
14. A mixture of gases at 810 kPa pressure contains:
 3.0 moles of oxygen gas,
 2.0 moles of helium gas, and
 4.0 moles of carbon dioxide gas.
 What is the partial pressure of helium gas, P_{He} .
- 405 kPa
 - 1620 kPa
 - 810 kPa
 - 81.0 kPa
 - 180 kPa
15. If a gas has a pressure of 2.0 atm, which one of the following equations will express its pressure after...
- the number of moles has been increased to three times the original amount,
 - the absolute temperature (K) has been reduced to half, and
 - the volume has been tripled?
- $P_2 = 2.0 \text{ atm} \times \frac{1}{3} \times \frac{2}{1} \times \frac{4}{1}$
 - $P_2 = 2.0 \text{ atm} \times \frac{3}{1} \times \frac{1}{2} \times \frac{1}{3}$
 - $P_2 = 2.0 \text{ atm} \times \frac{3}{1} \times \frac{2}{1} \times \frac{1}{3}$
 - $P_2 = 2.0 \text{ atm} \times \frac{1}{3} \times \frac{1}{4} \times \frac{3}{1}$
16. A sample of gas occupies 30.0 L at 0.800 atm and 298 K. How many moles of gas are in the sample?
- 22.4
 - 0.981
 - 1.02
 - 2.23
 - none of these
17. When ammonium nitrite undergoes decomposition, only gases are produced according to the equation:
 $\text{NH}_4\text{NO}_2(\text{s}) \rightarrow \text{N}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$
 What is the total volume of gases produced at 819K and 1.00 atm pressure when 128 g of ammonium nitrite undergoes the above decomposition reaction?

18. At STP, it was found that 1.12 L of a gas had a mass of 2.78 g. Its molar mass is
- 2.78 g/mol
 - 27.8 g/mol
 - 55.6 g/mol
 - 111 g/mol
19. A mixture of gases, nitrogen, oxygen, and carbon dioxide at 27 °C and 0.50 atmospheres pressure occupied a volume of 492 mL. How many moles of gas are there in this sample?
- 0.010
 - 1/9
 - 7.6
 - 10
20. At a given temperature, gaseous ammonia molecules (NH_3) have a velocity that is ____ gaseous sulfur dioxide molecules (SO_2).
- greater than
 - less than
 - equal to
 - more inf. needed
21. The ratio of the average velocities of $\text{SO}_2(\text{g})$ to $\text{CH}_4(\text{g})$ at 300 K is
- 1:4
 - 1:2
 - 4:1
 - 2:1
22. A sealed flask contains 1 molecule of hydrogen for every 3 molecules of helium at 20 °C. If the total pressure is 400 kPa, the partial pressure of the hydrogen is...
- 100 kPa
 - 200 kPa
 - 300 kPa
 - 400 kPa

23. A given mass of a gas occupies 5.00 L at 65 °C and 480 mmHg. What is the volume of the gas at 630 mmHg and 85 °C?
- a) $5.00 \times \frac{65}{85} \times \frac{480}{630}$
- b) $5.00 \times \frac{338}{358} \times \frac{480}{630}$
- c) $5.00 \times \frac{358}{338} \times \frac{480}{630}$
- d) $5.00 \times \frac{358}{338} \times \frac{630}{480}$
- e) $5.00 \times \frac{338}{358} \times \frac{630}{480}$
24. Which statement best explains why a confined gas exerts pressure?
- a) the molecules are in random motion
- b) the molecules travel in straight lines
- c) the molecules attract each other
- d) the molecules collide with the container walls
25. CH₄ gas and O₂ gas are together in a container. Which statement correctly describes the **velocities** of the two molecules.
- a) The two molecules have the **same** average velocity.
- b) The CH₄ is moving **twice** as fast as the O₂.
- c) The CH₄ is moving **faster**, but **not twice as fast** as the O₂.
- d) The O₂ is moving **faster** than the CH₄.

0705

Name: _____ Class: _____ Date: _____

GAS LAWS WORKSHEET (⁶⁶66 points)

Show all work and formulas. Circle your final answer with units. Convert all Temperatures to Kelvin (3pts each)

1. A gas occupies 3.5L at 2.5 mm Hg pressure. What is the volume at 10 mm Hg at the same temperature?

2. A constant volume of oxygen is heated from 100°C to 185°C. The initial pressure is 4.1 atm. What is the final pressure?

3. A sample of 25 L of NH_3 gas at 10°C is heated at constant pressure until it fills a volume of 50L. What is the new temperature in K?

4. A certain quantity of argon gas is under 16 torr pressure at 253K in a 12L vessel. How many moles of argon are present?

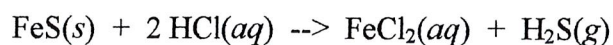
5. An unknown gas weighs 34 g and occupies 6.7L at 2 atm and 245K. What is its molecular weight?

6. An ideal gas occupies 400ml at 270 mm Hg and 65°C. If the pressure is changed to 1.4 atm and the temperature is increased to 100°C, what is the new volume?
7. What is the volume of 23 g of neon gas at 1°C and a pressure of 2 atm?
8. If 11 moles of HCl gas occupies 15L at 300°C, what is the pressure in torr?
9. The pressure is 6.5 atm, 2.3 mole of Br₂ gas occupies 9.3 L . What is the temperature in °C?
10. A 600mL balloon is filled with helium at 700mm Hg barometric pressure. The balloon is released and climbs to an altitude where the barometric pressure is 400mm Hg. What will the volume of the balloon be if, during the ascent, the temperature drops from 24 to 5°C?

11. In an autoclave, a constant amount of steam is generated at a constant volume. Under 1.00 atm pressure the steam temperature is 100°C. What pressure setting should be used to obtain a 165°C steam temperature for the sterilization of surgical instruments?

12. A quantity of gas exerts a pressure of 98.6 kPa at a temperature of 22°C. If the volume remains unchanged, what pressure will it exert at -8°C?

13. Iron (II) sulfide reacts with hydrochloric acid as follows:



What volume of H₂S, measured at 30°C and 95.1 kPa, will be produced when 132 g of FeS reacts?

14. For a mole of ideal gas, sketch graphs of

- P vs. V at constant T.
- P vs. T at constant V.
- V vs. T at constant P.

15. If I have 5.6 liters of gas in a piston at a pressure of 1.5 atm and compress the gas until its volume is 4.8 L, what will the new pressure inside the piston be?

16. If I have 45 liters of helium in a balloon at 25°C and increase the temperature of the balloon to 55°C , what will the new volume of the balloon be?

17. How many moles of gas does it take to occupy 120 liters at a pressure of 2.3 atmospheres and a temperature of 340 K?

18. If I initially have 4.0 L of a gas at a pressure of 1.1 atm, what will the volume be if I increase the pressure to 3.4 atm?

19. If a gas B effuses four times as fast as gas A. What is the ratio of the molar masses (A/B).

20. What volume of oxygen could be prepared at 750 torr and 123 °C from 63.7 g of KClO_3 . According to the following equation.



21. Determine the molar mass of a gas if a 4.23 g sample of the gas occupies 4.00 L at 27 °C and a pressure of 715 torr.