Chapter 14

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

____ 11. Why is a gas easier to compress than a liquid or a solid?
- a. Its volume increases more under pressure than an equal volume of liquid does.
- b. Its volume increases more under pressure than an equal volume of solid does.
- c. The space between gas particles is much less than the space between liquid or solid particles.
- d. The volume of a gas’s particles is small compared to the overall volume of the gas.

____ 12. Why does the pressure inside a container of gas increase if more gas is added to the container?
- a. There is an increase in the number of collisions between particles and the walls of the container.
- b. There is an increase in the temperature of the gas.
- c. There is a decrease in the volume of the gas.
- d. There is an increase in the force of the collisions between the particles and the walls of the container.

____ 13. How does the gas propellant move when an aerosol can is used?
- a. from a region of high pressure to a region of lower pressure
- b. from a region of high pressure to a region of equally high pressure
- c. from a region of low pressure to a region of higher pressure
- d. from a region of low pressure to a region of equally low pressure

____ 14. If the volume of a container of gas is reduced, what will happen to the pressure inside the container?
- a. The pressure will increase.
- b. The pressure will not change.
- c. The pressure will decrease.
- d. The pressure depends on the type of gas.

____ 15. If a balloon is squeezed, what happens to the pressure of the gas inside the balloon?
- a. It increases.
- b. It stays the same.
- c. It decreases.
- d. The pressure depends on the type of gas in the balloon.

____ 16. What happens to the temperature of a gas when it is compressed?
- a. The temperature increases.
- b. The temperature does not change.
- c. The temperature decreases.
- d. The temperature becomes unpredictable.

____ 17. As the temperature of the gas in a balloon decreases, which of the following occurs?
- a. The volume of the balloon increases.
- b. The average kinetic energy of the gas decreases.
- c. The gas pressure inside the balloon increases.
- d. all of the above

____ 18. What happens to the pressure of a gas inside a container if the temperature of the gas decreases?
- a. The pressure increases.
- c. The pressure decreases.
- b. The pressure does not change.
- d. The pressure cannot be predicted.

____ 19. If 4 moles of gas are added to a container that already holds 1 mole of gas, how will the pressure change inside the container?

a. The pressure will be five times higher.
b. The pressure will double.
c. The pressure will be four times higher.
d. The pressure will not change.

____ 20. Why does air escape from a tire when the tire valve is opened?
a. The pressure outside the tire is lower than the pressure inside the tire.
b. The pressure outside the tire is greater than the pressure inside the tire.
c. The temperature is higher outside the tire than inside the tire.
d. There are more particles of air outside the tire than inside the tire.

____ 21. Which of these changes would NOT cause an increase in the pressure of a contained gas?
a. The volume of the container is increased.
b. More of the gas is added to the container.
c. The temperature is increased.
d. The average kinetic energy of the gas in increased.

____ 22. When the Kelvin temperature of an enclosed gas doubles, the particles of the gas ____.
a. move faster
b. strike the walls of the container with less force
c. decrease in average kinetic energy
d. decrease in volume

____ 23. The volume of a gas is doubled while the temperature is held constant. How does the gas pressure change?
a. It is reduced by one half.
b. It does not change.
c. It is doubled.
d. It varies depending on the type of gas.

____ 24. The volume of a gas is reduced from 4 L to 0.5 L while the temperature is held constant. How does the gas pressure change?
a. It increases by a factor of four.
b. It decreases by a factor of eight.
c. It increases by a factor of eight.
d. It increases by a factor of two.

____ 25. Boyle's law states that ____.
a. the volume of a gas varies inversely with pressure
b. the volume of a gas varies directly with pressure
c. the temperature of a gas varies inversely with pressure
d. the temperature of a gas varies directly with pressure

____ 26. When the temperature and number of particles of a gas are constant, which of the following is also constant?
a. the sum of the pressure and volume
b. the difference of the pressure and volume
c. the product of the pressure and volume
d. the ratio of the pressure and volume

____ 27. Charles's law states that ____.
a. the pressure of a gas is inversely proportional to its temperature in kelvins
b. the volume of a gas is directly proportional to its temperature in kelvins
c. the pressure of a gas is directly proportional to its temperature in kelvins
d. the volume of a gas is inversely proportional to its temperature in kelvins

____ 28. If a balloon is heated, what happens to the volume of the air in the balloon if the pressure is constant?
a. It increases.
b. It stays the same.
c. It decreases.
d. The change cannot be predicted.

____ 29. When the pressure and number of particles of a gas are constant, which of the following is also constant?
a. the sum of the volume and temperature in kelvins
b. the difference of the volume and temperature in kelvins

c. the product of the volume and temperature in kelvins
d. the ratio of the volume and temperature in kelvins

____ 30. If a balloon is heated, what happens to the pressure of the air inside the balloon if the volume remains constant?
a. It increases.
b. It stays the same.
c. It decreases.
d. The change cannot be predicted.

____ 31. When the volume and number of particles of a gas are constant, which of the following is also constant?
a. the sum of the pressure and temperature in kelvins
b. the difference of the pressure and temperature in kelvins
c. the product of the pressure and temperature in kelvins
d. the ratio of the pressure and temperature in kelvins

____ 32. As the temperature of a fixed volume of a gas increases, the pressure will ____.
a. vary inversely
b. decrease
c. not change
d. increase

____ 33. If a sealed syringe is plunged into cold water, in which direction will the syringe piston slide?
a. in
b. out
c. No movement will occur.
d. The direction cannot be predicted.

____ 34. What happens when a piston is used to decrease the volume of a contained gas?
a. Fewer gas particles exert a force on the piston.
b. The piston’s pressure on the gas becomes greater than the pressure exerted by the gas on the piston.
c. Gas particles become compressed.
d. Gas particles leak out of the container.

____ 35. A gas occupies a volume of 2.4 L at 14.1 kPa. What volume will the gas occupy at 84.6 kPa?
a. 497 L
b. 2.5 L
c. 14 L
d. 0.40 L

____ 36. If a sealed syringe is heated, in which direction will the syringe plunger move?
a. out
b. in
c. The plunger will not move.
d. The direction cannot be predicted.

____ 37. A sample of gas occupies 17 mL at –112°C. What volume does the sample occupy at 70°C?
a. 10.6 mL
b. 27 mL
c. 36mL
d. 8.0mL

____ 38. In general, for a gas at a constant volume, ____.
a. the pressure of the gas is inversely proportional to its temperature in kelvins
b. the volume of the gas is inversely proportional to its temperature in kelvins
c. the volume of the gas is directly proportional to its temperature in kelvins
d. the pressure of the gas is directly proportional to its temperature in kelvins

____ 39. The combined gas law relates which of the following?
a. pressure and volume only
b. temperature and pressure only
c. volume and temperature only
d. temperature, pressure, and volume

____ 40. If a balloon containing 3000 L of gas at 39°C and 99 kPa rises to an altitude where the pressure is 45.5 kPa and the temperature is 16°C, the volume of the balloon under these new conditions would be calculated using the following conversion factor ratios: ____.
a. $3000 \text{ L} \times \frac{99}{45.5} \times \frac{16}{39}$
b. $3000 \text{ L} \times \frac{312}{289} \times \frac{45.5}{99}$
c. $3000 \text{ L} \times \frac{289}{312} \times \frac{99}{45.5}$
d. $3000 \text{ L} \times \frac{39}{16} \times \frac{45.5}{99}$

____ 41. What does the ideal gas law allow a scientist to calculate that the other gas laws do not?

a. number of moles
b. pressure
c. volume
d. temperature

____ 42. At a certain temperature and pressure, 0.20 mol of carbon dioxide has a volume of 3.1 L. A 3.1-L sample of hydrogen at the same temperature and pressure ____.
a. has the same mass
b. contains the same number of atoms
c. has a higher density
d. contains the same number of molecules

____ 43. How is the ideal gas law usually written?
a. $\frac{PV}{nT} = R$
b. $\frac{PV}{T} = nR$
c. $PV = nRT$
d. $P = \frac{nRT}{V}$

____ 44. Which law can be used to calculate the number of moles of a contained gas?
a. Boyle’s law
b. combined gas law
c. ideal gas law
d. Charles’s law

____ 45. Which of the following is constant for 1 mole of any ideal gas?
a. PVT
b. $\frac{PV}{T}$
c. $\frac{PT}{V}$
d. $\frac{VT}{P}$

____ 46. At high pressures, how does the volume of a real gas compare with the volume of an ideal gas under the same conditions?
a. It is much greater.
b. It is much less.
c. There is no difference.
d. It depends on the type of gas.

____ 47. At low temperatures and pressures, how does the volume of a real gas compare with the volume of an ideal gas under the same conditions?
a. It is greater.
b. It is less.
c. There is no difference.
d. It depends on the type of gas.

____ 48. An ideal gas CANNOT be ____.
a. condensed
b. cooled
c. heated
d. compressed

____ 49. Under what conditions of temperature and pressure is the behavior of real gases most like that of ideal gases?
a. low temperature and low pressure
b. low temperature and high pressure
c. high temperature and low pressure
d. high temperature and high pressure

____ 50. If the atmospheric pressure on Mt. Everest is one-third the atmospheric pressure at sea level, the partial pressure of oxygen on Everest is ____.
a. one-sixth its pressure at sea level
b. one-third its pressure at sea level
c. one-half its pressure at sea level
d. equal to its pressure at sea level

____ 51. What happens to the partial pressure of oxygen in a sample of air if the temperature is increased?
a. It increases.
b. It stays the same.
c. It decreases.
d. The change cannot be determined.

____ 52. If oxygen is removed from a sample of air as iron rusts, what happens to the partial pressure of oxygen in the air?
a. It increases.
b. It stays the same.
c. It decreases.
d. The change cannot be determined.

____ 53. If oxygen is removed from a sample of air as iron rusts, what happens to the total pressure of the air?

a. It increases.
b. It stays the same.
c. It decreases.
d. The change cannot be determined.

____ 54. A breathing mixture used by deep-sea divers contains helium, oxygen, and carbon dioxide. What is the partial pressure of oxygen at 101.4 kPa if P_{He} = 82.5 kPa and P_{CO_2} = 0.4 kPa?

a. 82.9 kPa
b. 19.3 kPa
c. 18.5 kPa
d. 101.0 kPa

____ 55. When a container is filled with 3.00 moles of H_2, 2.00 moles of O_2, and 1.00 mole of N_2, the pressure in the container is 768 kPa. What is the partial pressure of O_2?

a. 256 kPa
b. 128 kPa
c. 128 kPa
d. 192 kPa

____ 56. A box with a volume of 22.4 L contains 1.0 mol of nitrogen and 2.0 mol of hydrogen at 0 °C. Which of the following statements is true?

a. The total pressure in the box is 101 kPa.
b. The partial pressures of N_2 and H_2 are equal.
c. The total pressure is 202 kPa
d. The partial pressure of N_2 is 101 kPa.

____ 57. If the volume of a container of air is reduced by one-half, what happens to the partial pressure of oxygen within the container?

a. It is reduced by one-half.
b. It does not change.
c. It is doubled.
d. It is reduced by one-fourth.

____ 58. The tendency of molecules to move toward areas of lower concentration is called ____.

a. suffusion
b. suspension
c. effusion
d. diffusion

____ 59. Which of the following gases will effuse the most rapidly?

a. bromine
b. chlorine
c. ammonia
d. hydrogen

____ 60. Which of the following atoms would have the greatest velocity if each atom had the same kinetic energy?

a. bromine
b. chlorine
c. ammonia
d. hydrogen

____ 61. Which of the following gases is the best choice for inflating a balloon that must remain inflated for a long period of time?

a. argon
b. oxygen
c. hydrogen
d. neon

Short Answer

62. The volume of a gas is 250 mL at 340.0 kPa pressure. What will the volume be when the pressure is reduced to 50.0 kPa, assuming the temperature remains constant?

63. A balloon filled with helium has a volume of 30.0 L at a pressure of 100 kPa and a temperature of 15.0 °C. What will the volume of the balloon be if the temperature is increased to 80.0 °C and the pressure remains constant?

64. A gas has a volume of 590 mL at a temperature of –55.0 °C. What volume will the gas occupy at 30.0 °C?

65. A rigid container of O_2 has a pressure of 340 kPa at a temperature of 713 K. What is the pressure at 273 K?

66. A 10-g mass of krypton occupies 15.0 L at a pressure of 210 kPa. Find the volume of the krypton when the pressure is increased to 790 kPa.

67. A gas has a pressure of 710 kPa at 227 °C. What will its pressure be at 27 °C, if the volume does not change?

68. A gas occupies a volume of 140 mL at 35.0 °C and 97 kPa. What is the volume of the gas at STP?

69. A gas storage tank has a volume of 3.5×10^5 m^3 when the temperature is 27 °C and the pressure is 101 kPa. What is the new volume of the tank if the temperature drops to –10 °C and the pressure drops to 95 kPa?

70. How many moles of N_2 are in a flask with a volume of 250 mL at a pressure of 300.0 kPa and a temperature of 300.0 K?

71. The gaseous product of a reaction is collected in a 25.0-L container at 27 °C. The pressure in the container is 300.0 kPa and the gas has a mass of 96.0 g. How many moles of the gas are in the container?

72. What is the pressure exerted by 32 g of O_2 in a 22.0-L container at 30.0 °C?

73. A mixture of gases at a total pressure of 95 kPa contains N_2, CO_2, and O_2. The partial pressure of the CO_2 is 24 kPa and the partial pressure of the N_2 is 48 kPa. What is the partial pressure of the O_2?

74. Use Graham's law to calculate how much faster fluorine gas, F_2, will effuse than chlorine gas, Cl_2, will. The molar mass of F_2 = 38.0; the molar mass of Cl_2 = 70.9.

Essay

75. How does the air pressure in a balloon change when the balloon is squeezed? Explain why this change occurs.

76. How does the pressure of an enclosed gas in a rigid container change when the gas is heated? Explain why this change occurs.

77. Explain how pumping air into a bicycle tire increases the pressure within the tire.

78. What are some of the differences between a real gas and an ideal gas?

79. What is Dalton's law of partial pressures? Explain how this law relates to the fact that mountain climbers must carry tanks of oxygen when scaling high peaks.

80. Explain why the rates of diffusion and effusion, for any particular gas at constant temperature, are proportional to the square root of the molar mass of the gas.

SHORT ANSWER

62. ANS:

$$V_2 = V_1 \times \frac{P_1}{P_2} = 250 \text{ mL} \times \frac{340.0 \text{ kPa}}{50.0 \text{ kPa}} = 1700 \text{ mL}$$

DIF: L2 REF: p. 419 OBJ: 14.2.1

63. ANS:

$$V_2 = V_1 \times \frac{T_2}{T_1} = 30.0 \text{ L} \times \frac{353 \text{ K}}{288 \text{ K}} = 34.3 \text{ L}$$

DIF: L2 REF: p. 421 OBJ: 14.2.1

64. ANS:

$T_1 = –55\,°\text{C} + 273 = 218 \text{ K}$

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

$$V_2 = V_1 \times \frac{T_2}{T_1} = 590 \text{ mL} \times \frac{303 \text{ K}}{218 \text{ K}} = 820 \text{ mL}$$

DIF: L2 REF: p. 421 OBJ: 14.2.1

65. ANS:

$$P_2 = P_1 \times \frac{T_2}{T_1} = 340 \text{ kPa} \times \frac{273 \text{ K}}{713 \text{ K}} = 140 \text{ kPa}$$

DIF: L2 REF: p. 421 OBJ: 14.2.1

66. ANS:

$P_1 \times V_1 = P_2 \times V_2$

$210 \text{ kPa} \times 15.0 \text{ L} = 790 \text{ kPa} \times V_2$

$$\frac{210 \text{ kPa} \times 15.0 \text{ L}}{790 \text{ kPa}} = V_2$$

$V_2 = 4.0 \text{ L}$

DIF: L3 REF: p. 419 OBJ: 14.2.1

67. ANS:

$227\,°\text{C} + 273 = 500 \text{ K}$

$27\,°\text{C} + 273 = 300 \text{ K}$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}\ ;\ \frac{710 \text{ kPa}}{500 \text{ K}} = \frac{P_2}{300 \text{ K}}$$

$$710 \text{ kPa} \times \frac{300 \text{ K}}{500 \text{ K}} = P_2$$

$P_2 = 470 \text{ kPa}$

DIF: L3 REF: p. 421 OBJ: 14.2.1

68. ANS:

T_1 = 35.0 °C + 273 = 308 K

T_2 = 0.0 °C + 273 = 273 K

$$V_2 = P_1 \times V_1 \times \frac{T_2}{T_1 \times P_2}$$

$$V_2 = 97\text{ kPa} \times 140\text{ mL} \times \frac{273\text{ K}}{308\text{ K} \times 101\text{ kPa}} = 120\text{ mL}$$

DIF: L3 REF: p. 424 OBJ: 14.2.2

69. ANS:

T_1 = 27 °C + 273 = 300 K; P_1 = 101 kPa

T_2 = –10 °C + 273 = 263 K; P_2 = 95 kPa

$$V_2 = P_1 \times V_1 \times \frac{T_2}{T_1 \times P_2} = (101\text{ kP}) \times (3.5 \times 10^5\text{ m}^3) \times \frac{263\text{ K}}{300\text{ K} \times 95\text{ kPa}}$$

$V_2 = 3.26 \times 10^5\text{ m}^3$

DIF: L3 REF: p. 424 OBJ: 14.2.2

70. ANS:

$$250\text{ mL} \times \frac{1\text{ L}}{1000\text{ mL}} = 0.25\text{ L}$$

$$n = P\frac{PV}{RT} = \frac{300.0\text{ kPa} \times 0.25\text{ L}}{8.31\text{ (L}\cdot\text{kPa)/(K}\cdot\text{mol)} \times 300.0\text{ K}} = 0.030\text{ mol}$$

DIF: L2 REF: p. 427 OBJ: 14.3.1

71. ANS:

$$n = \frac{PV}{RT} = \frac{300.0\text{ kPa} \times 25\text{ L}}{8.31\text{ (L}\cdot\text{kPa)/(K}\cdot\text{mol)} \times 300\text{ K}} = 3.0\text{ mol}$$

DIF: L2 REF: p. 427 OBJ: 14.3.1

72. ANS:

$$32\text{ g } O_2 \times \frac{1\text{ mol } O_2}{32\text{ g } O_2} = 1\text{ mol } O_2$$

$$P = \frac{nRT}{V} = \frac{1.0\text{ mol} \times 8.31\text{ (L}\cdot\text{kPa)/(K}\cdot\text{mol)} \times 303\text{ K}}{22.0\text{ L}} = 110\text{ kPa}$$

DIF: L2 REF: p. 427 OBJ: 14.3.1

73. ANS:

$P_{O_2} = P_{total} - (P_{CO_2} + P_{N_2})$ = 95 kPa – (48 kPa + 24 kP) = 23 kPa

DIF: L2 REF: p. 434 OBJ: 14.4.1

74. ANS:

$\text{Rate}_{F_2} / \text{Rate}_{Cl_2} = \sqrt{(70.9 / 38.0)} = 1.4$

DIF: L2 REF: p. 436 OBJ: 14.4.2

ESSAY

75. ANS:
The air pressure increases. Squeezing reduces the enclosed volume of the balloon without changing the number of particles in the balloon. Consequently, the number of collisions between the particles and the balloon increases.

DIF: L3 REF: p. 416 OBJ: 14.1.2

76. ANS:
The pressure increases when the gas is heated because increasing the temperature of the gas increases the average kinetic energy of the particles in the gas. With an increase in average kinetic energy, there will be an increase in the number of collisions between the particles and the container walls. In addition, because the particles are moving faster, on average, the collisions will occur with greater force. Both factors, the increased frequency of collision and the increased force of the collisions, contribute to the increase in pressure.

DIF: L3 REF: p. 417 OBJ: 14.1.2

77. ANS:
Adding air increases the number of gas particles in the tire. Collisions of particles with the inside walls of the tire cause the pressure that is exerted by the enclosed gas. Therefore, increasing the number of air particles increases the number of collisions, which in turn increases the pressure within the tire.

DIF: L3 REF: p. 415 OBJ: 14.2.1

78. ANS:
An ideal gas is one that follows the gas laws at all conditions of pressure and temperature. The behavior of a real gas deviates from the behavior of an ideal gas, particularly at low temperatures and high pressures. Also, kinetic theory assumes that the particles of an ideal gas have no volume and are not attracted to each other. This is not true for real gases. Real gases can be liquefied and sometimes solidified by cooling and applying pressure, but ideal gases cannot.

DIF: L3 REF: p. 428 OBJ: 14.3.2

79. ANS:
Dalton's law of partial pressures states that, at constant volume and temperature, the total pressure exerted by a mixture of gases is equal to the sum of the partial pressures of the individual gases in the mixture. Mountain climbers carry oxygen tanks because at high altitudes, the total air pressure is much lower than it is at sea level and the partial pressure of oxygen in the air is correspondingly lower, also. This low partial pressure of oxygen is not sufficient to support respiration.

DIF: L3 REF: p. 433 OBJ: 14.4.1

80. ANS:
At constant temperature, particles all have the same average kinetic energy. The formula for kinetic energy is $KE = 1/2\ mv^2$. At constant temperature, the KE is constant and the velocity is proportional to the square root of $1/m$. Because the diffusion and effusion rates are directly proportional to the velocity at which a particle is moving, these rates are also proportional to the square root of $1/m$. So the more mass a particle has, the more slowly it will diffuse or effuse.

DIF: L3 REF: p. 435 OBJ: 14.4.2