8.E: Gases (Exercises)

Exercises (Pressure)

Define pressure. What causes it?

2. Define and relate three units of pressure.

3. If a force of 16.7 N is pressed against an area of 2.44 m^2 , what is the pressure in pascals?

4. If a force of 2,546 N is pressed against an area of 0.0332 m^2 , what is the pressure in pascals?

5. Explain why the original definition of atmosphere did not work well.

6. What units of pressure are equal to each other?

7. How many atmospheres are in 889 mmHg?

8. How many atmospheres are in 223 torr?

9. How many torr are in 2.443 atm?

10. How many millimeters of mercury are in 0.334 atm?

11. How many millimeters of mercury are in 334 torr?

12. How many torr are in 0.777 mmHg?

13. How many pascals are there in 1 torr?

14. A pressure of 0.887 atm equals how many pascals?

Answers

1. Pressure is force per unit area. It is caused by gas particles hitting the walls of its container.

3. 6.84 Pa

5. Because the atmospheric pressure at sea level is variable, it is not a consistent unit of pressure.

7. 1.17 atm

9. 1,857 torr

11. 334 mmHg

13. 133 Pa

Exercises (Gas Laws)

1. Define gas law. What restrictions are there on the units that can be used for the physical properties?

2. What unit of temperature must be used for gas laws?

3. Boyle's law relates the _____ of a gas inversely with the _____ of that gas.

4. Charles's law relates the _____ of a gas directly with the _____ of that gas.

5. What properties must be held constant when applying Boyle's law?

6. What properties must be held constant when applying Charles's law?

7. A gas has an initial pressure of 1.445 atm and an initial volume of 1.009 L. What is its new pressure if volume is changed to 0.556 L? Assume temperature and amount are held constant.

8. A gas has an initial pressure of 633 torr and an initial volume of 87.3 mL. What is its new pressure if volume is changed to 45.0 mL? Assume temperature and amount are held constant.

9. A gas has an initial pressure of 4.33 atm and an initial volume of 5.88 L. What is its new volume if pressure is changed to 0.506 atm? Assume temperature and amount are held constant.

10. A gas has an initial pressure of 87.0 torr and an initial volume of 28.5 mL. What is its new volume if pressure is changed to 206 torr? Assume temperature and amount are held constant.

11. A gas has an initial volume of 638 mL and an initial pressure of 779 torr. What is its final volume in liters if its pressure is changed to 0.335 atm? Assume temperature and amount are held constant.

12. A gas has an initial volume of 0.966 L and an initial pressure of 3.07 atm. What is its final pressure in torr if its volume is changed to 3,450 mL? Assume temperature and amount are held constant.

13. A gas has an initial volume of 67.5 mL and an initial temperature of 315 K. What is its new volume if temperature is changed to 244 K? Assume pressure and amount are held constant.

14. A gas has an initial volume of 2.033 L and an initial temperature of 89.3 K. What is its volume if temperature is changed to 184 K? Assume pressure and amount are held constant.

15. A gas has an initial volume of 655 mL and an initial temperature of 295 K. What is its new temperature if volume is changed to 577 mL? Assume pressure and amount are held constant.

16. A gas has an initial volume of 14.98 L and an initial temperature of 238 K. What is its new temperature if volume is changed to 12.33 L? Assume pressure and amount are held constant.

17. A gas has an initial volume of 685 mL and an initial temperature of 29°C. What is its new temperature if volume is changed to 1.006 L? Assume pressure and amount are held constant.

18. A gas has an initial volume of 3.08 L and an initial temperature of −73°C. What is its new volume if temperature is changed to 104°C? Assume pressure and amount are held constant.

Answers

1. A gas law is a simple mathematical formula that allows one to predict the physical properties of a gas. The units of changing properties (volume, pressure, etc.) must be the same.

3. pressure; volume

5. amount of gas and temperature

7. 2.62 atm

9. 50.3 L

11. 1.95 L

13. 52.3 mL

15. 260 K

17. 444 K, or 171°C

Exercises (Other Gas Laws)

1. State Gay-Lussac’s law.

2. State Avogadro’s law.

3. Use Gay-Lussac’s law to determine the final pressure of a gas whose initial pressure is 602 torr, initial temperature is 356 K, and final temperature is 277 K. Assume volume and amount are held constant.

4. Use Gay-Lussac’s law to determine the final temperature of a gas whose initial pressure is 1.88 atm, initial temperature is 76.3 K, and final pressure is 6.29 atm. Assume volume and amount are held constant.

5. If 3.45 × 1022 atoms of Ar have a volume of 1.55 L at a certain temperature and pressure, what volume do 6.00 × 1023 atoms of Ar have at the same temperature and pressure?

6. If 5.55 × 1022 atoms of He occupy a volume of 2.06 L at 0°C at 1.00 atm pressure, what volume do 2.08 × 1023 atoms of He occupy under the same conditions?

7. Use Avogadro’s law to determine the final volume of a gas whose initial volume is 6.72 L, initial amount is 3.88 mol, and final amount is 6.10 mol. Assume pressure and temperature are held constant.

8. Use Avogadro's law to determine the final amount of a gas whose initial volume is 885 mL, initial amount is 0.552 mol, and final volume is 1,477 mL. Assume pressure and temperature are held constant.

9. Use the combined gas law to complete this table. Assume that the amount remains constant in all cases.

V_i =	Pl =	Tl =	V_2 =	P_2 =	t_2 =
56.9 mL	334 torr	266 K		722 torr	334 K
0.976 L	2.33 atm	443 K	1.223 L		355 K
3.66 L	889 torr	23°C	2.19 L	739 torr	

10. Use the combined gas law to complete this table. Assume that the amount remains constant in all cases.

V_i =	Pl =	Tl =	V_2 =	P_2 =	t_2 =
56.7 mL	1.07 atm	-34°C		998 torr	375 K
3.49 L	338 torr	45°C	1,236 mL		392 K

11. A gas starts at the conditions 78.9 mL, 3.008 atm, and 56°C. Its conditions change to 35.6 mL and 2.55 atm. What is its final temperature?

12. The initial conditions of a sample of gas are 319 K, 3.087 L, and 591 torr. What is its final pressure if volume is changed to 2.222 L and temperature is changed to 299 K?

13. A gas starts with initial pressure of 7.11 atm, initial temperature of 66°C, and initial volume of 90.7 mL. If its conditions change to 33°C and 14.33 atm, what is its final volume?

14. A sample of gas doubles its pressure and doubles its absolute temperature. By what amount does the volume change?

Answer

The pressure of a gas is proportional to its absolute temperature.

3. 468 torr

5. 27.0 L

7. 10.6 L

9.

Vi =	Pl =	Tl =	V_2 =	P_2 =	*T2* =
56.9 mL	334 torr	266 K	33.1 mL	722 torr	334 K
0.976 L	2.33 atm	443 K	1.223 L	1.49 atm	355 K
3.66 L	889 torr	23°C	2.19 L	739 torr	147 K, or -126°C

11. 126 K, or −147°C

13. 40.6 mL

Exercises (The Ideal Gas Law and Some Applications)

1. What is the ideal gas law? What is the significance of R?

2. Why does R have different numerical values (see Table 6.1 "Values of the Ideal Gas Law Constant ")?

3. A sample of gas has a volume of 3.91 L, a temperature of 305 K, and a pressure of 2.09 atm. How many moles of gas are present?

4. A 3.88 mol sample of gas has a temperature of 28°C and a pressure of 885 torr. What is its volume?

5. A 0.0555 mol sample of Kr has a temperature of 188°C and a volume of 0.577 L. What pressure does it have?

6. If 1.000 mol of gas has a volume of 5.00 L and a pressure of 5.00 atm, what is its temperature?

7. A sample of 7.55 g of He has a volume of 5,520 mL and a temperature of 123°C. What is its pressure in torr?

8. A sample of 87.4 g of Cl_2 has a temperature of −22°C and a pressure of 993 torr. What is its volume in milliliters?

9. A sample of Ne has a pressure of 0.772 atm and a volume of 18.95 L. If its temperature is 295 K, what mass is present in the sample?

10. A mercury lamp contains 0.0055 g of Hg vapor in a volume of 15.0 mL. If the operating temperature is 2,800 K, what is the pressure of the mercury vapor?

11. Oxygen is a product of the decomposition of mercury(II) oxide: $2HgO(s) \rightarrow 2Hg(\ell) + O_2(g)$ What volume of O_2 is formed from the decomposition of 3.009 g of HgO if the gas has a pressure of 744 torr and a temperature of 122°C?

12. Lithium oxide is used to absorb carbon dioxide: $Li_2O(s) + CO_2(g) \rightarrow Li_2CO_3(s)$ What volume of CO_2 can 6.77 g of Li_2O absorb if the CO_2 pressure is $3.5 \times 10{-}4$ atm and the temperature is 295 K?

13. What is the volume of 17.88 mol of Ar at STP?

14. How many moles are present in 334 L of H_2 at STP?

15. How many liters, at STP, of CO2 are produced from 100.0 g of C_8H_{18}, the approximate formula of gasoline?

$$2C_8H_{18}(\ell) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(\ell)$$

16. How many liters, at STP, of O_2 are required to burn 3.77 g of butane from a disposable lighter?

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(\ell)$$

17. What is the density of each gas at STP? a. He b. Ne c. Ar d. Kr

18. What is the density of each gas at STP? a. H_2 b. O_2 c. N_2

19. What is the density of SF_6 at 335 K and 788 torr?

20. What is the density of He at −200°C and 33.9 torr?

Answers

1. The ideal gas law is PV = nRT. R is the ideal gas law constant, which relates the other four variables.

3. 0.327 mol

5. 3.64 atm

7. 8,440 torr

9. 12.2 g

11. 0.230 L

13. 401 L

15. 157 L

17.

a. 0.179 g/L
b. 0.901 g/L
c. 1.78 g/L
d. 3.74 g/L

19. 5.51 g/L

Exercises (Gas Mixtures)

1. What is the total pressure of a gas mixture containing these partial pressures: $P_{N2} = 0.78$ atm, $P_{H2} = 0.33$ atm, and $P_{O2} = 1.59$ atm?

2. What is the total pressure of a gas mixture containing these partial pressures: $P_{Ne} = 312$ torr, $P_{He} = 799$ torr, and $P_{Ar} = 831$ torr?

3. In a gas mixture of He and Ne, the total pressure is 335 torr and the partial pressure of He is 0.228 atm. What is the partial pressure of Ne ?

4. In a gas mixture of O_2 and N_2, the total pressure is 2.66 atm and the partial pressure of O_2 is 888 torr. What is the partial pressure of N_2 ?

5. A 3.55 L container has a mixture of 56.7 g of Ar and 33.9 g of He at 33°C. What are the partial pressures of the gases and the total pressure inside the container?

6. A 772 mL container has a mixture of 2.99 g of H_2 and 44.2 g of Xe at 388 K. What are the partial pressures of the gases and the total pressure inside the container?

7. A sample of O_2 is collected over water in a 5.00 L container at 20°C. If the total pressure is 688 torr, how many moles of O_2 are collected?

8. A sample of H_2 is collected over water in a 3.55 L container at 50°C. If the total pressure is 445 torr, how many moles of H_2 are collected?

9. A sample of CO is collected over water in a 25.00 L container at 5°C. If the total pressure is 0.11 atm, how many moles of CO are collected?

10. A sample of NO_2 is collected over water in a 775 mL container at 25°C. If the total pressure is 0.990 atm, how many moles of NO_2 are collected?

11. A sample of NO is collected over water in a 75.0 mL container at 25°C. If the total pressure is 0.495 atm, how many grams of NO are collected?

12. A sample of ClO_2 is collected over water in a 0.800 L container at 15°C. If the total pressure is 1.002 atm, how many grams of ClO_2 are collected?

13. Determine the mole fractions of each component when 44.5 g of He is mixed with 8.83 g of H_2.

14. Determine the mole fractions of each component when 9.33 g of SO_2 is mixed with 13.29 g of SO_3.

15. In a container, 4.56 atm of F_2 is combined with 2.66 atm of Cl_2. What are the mole fractions of each component?

16. In a container, 77.3 atm of SiF_4 are mixed with 33.9 atm of O_2. What are the mole fractions of each component?

Answers

1. $2.70\ \text{atm}$

3. 162 torr, or $0.213\ \text{atm}$

5. $P_{\text{Ar}} = 10.0\ \text{atm}; P_{\text{He}} = 59.9\ \text{atm}; P_{\text{tot}} = 69.9\ \text{atm}$

7. $0.183\ \text{mol}$

9. $0.113\ \text{mol}$

11. $0.0440\ \text{g}$

13. $\chi\text{He} = 0.718; \chi_{\text{H}}2 = 0.282$

15. $\chi^{\text{F2}} = 0.632; \chi\chi_{\text{Cl}} = 0.368$

Additional Exercises

1. What is the pressure in pascals if a force of 4.88kN is pressed against an area of $235\ \text{cm}^2$?

2. What is the pressure in pascals if a force of $3.44 \times 10^4\text{MN}$ is pressed against an area of $1.09\ \text{km}^2$?

3. What is the final temperature of a gas whose initial conditions are $667\ \text{mL}, 822\ \text{torr}$, and 67°C and whose final volume and pressure are $1.334\ \text{L}$ and $2.98\ \text{atm}$, respectively? Assume the amount remains constant.

4. What is the final pressure of a gas whose initial conditions are $1.407\ \text{L}, 2.06\ \text{atm}$, and -67°C and whose final volume and temperature are $608\ \text{mL}$ and $449\ \text{K}$, respectively? Assume the amount remains constant.

5. Propose a combined gas law that relates volume, pressure, and amount at constant temperature.

6. Propose a combined gas law that relates amount, pressure, and temperature at constant volume.

7. A sample of 6.022×10^{23} particles of gas has a volume of $22.4\ \text{L}$ at 0°C and a pressure of 1.000 atm. Although it may seem silly to contemplate, what volume would 1 particle of gas occupy?

8. One mole of liquid N_2 has a volume of $34.65\ \text{mL}$ at -196°C. At that temperature, $1\ \text{mol}$ of N_2 gas has a volume of $6.318\ \text{L}$ if the pressure is $1.000\ \text{atm}$. What pressure is needed to compress the N_2 gas to $34.65\ \text{mL}$?

9. Use two values of R to determine the ratio between an atmosphere and a torr. Does the number make sense?

10. Use two values of R to determine how many joules are in a liter·atmosphere.

11. At an altitude of $40\ \text{km}$ above the earth's surface, the atmospheric pressure is 5.00 torr, and the surrounding temperature is -20°C. If a weather balloon is filled with $1.000\ \text{mol}$ of He at 760 torr and 22°C, what is its
    a. initial volume before ascent?
    b. final volume when it reaches $40\ \text{km}$ in altitude? (Assume the pressure of the gas equals the surrounding pressure.)

12. If a balloon is filled with $1.000\ \text{mol}$ of He at 760 torr and 22°C, what is its

    a. initial volume before ascent?
    b. final volume if it descends to the bottom of the Mariana Trench, where the surrounding temperature is 1.4°C and the pressure is $1,060\ \text{atm}$?

13. Air, a mixture of mostly N_2 and O_2, can be approximated as having a molar mass of $28.8\ \text{g/mol}$ What is the density of air at 1.00 atm and 22°C ? (This is approximately sea level.)

14. Air, a mixture of mostly N_2 and O_2, can be approximated as having a molar mass of $28.8\ \text{g/mol}$ What is the density of air at 0.26 atm and -26°C ? (This is approximately the atmospheric condition at the summit of Mount Everest.)

15. On the surface of Venus, the atmospheric pressure is $91.8\ \text{atm}$, and the temperature is 460°C. What is the density of CO_2 under these conditions? (The Venusian atmosphere is composed largely of CO_2.)

16. On the surface of Mars, the atmospheric pressure is 4.50 torr, and the temperature is -87°C. What is the density of CO_2 under these conditions? (The Martian atmosphere, similar to its Venusian counterpart, is composed largely of CO_2.)

17. HNO_3 reacts with iron metal according to

$$\mathrm{Fe(s) + 2HNO_3(aq) \rightarrow Fe(NO_3)_2(aq) + H_2(\,g)} \tag{8.E.1}$$

In a reaction vessel, $23.8\ \mathrm{g}$ of Fe are reacted but only $446\ \mathrm{mL}$ of $\mathrm{H_2}$ are collected over water at $25^\circ\mathrm{C}$ and a pressure of 733 torr. What is the percent yield of the reaction?

18. $\mathrm{NaHCO_3}$ is decomposed by heat according to

$$\mathrm{2NaHCO_3(\,s) \rightarrow Na_2CO_3(\,s) + H_2O(\ell) + CO_2(\,g)} \tag{8.E.2}$$

If you start with $100.0\ \mathrm{g}$ of $\mathrm{NaHCO_3}$ and collect $10.06\ \mathrm{L}$ of $\mathrm{CO_2}$ over water at $20^\circ\mathrm{C}$ and $0.977\ \mathrm{atm}$, what is the percent yield of the decomposition reaction?

ANSWERS

1. $208,000\ \mathrm{Pa}$

3. $1,874\ \mathrm{K}$

5. $\frac{P_1V_1}{n_1} = \frac{P_2V_2}{n_2}$

7. $7.3.72 \times 10^{-23}\ \mathrm{L}$

9. $1\ \mathrm{atm} = 760$ torr

11. a. $24.2\ \mathrm{L}$
    b. $3155\ \mathrm{L}$

13. $1.19\ \mathrm{g/L}$

15. $67.2\ \mathrm{g/L}$

17. 3.99%