8.E: Gases (Exercises)

Ch 8.1 -8.5

1. Explain the differences between the microscopic and the macroscopic properties of matter. Is the boiling point of a compound a microscopic or macroscopic property? molecular mass? Why?
2. How do the microscopic properties of matter influence the macroscopic properties? Can you relate molecular mass to boiling point? Why or why not?
3. For a substance that has gas, liquid, and solid phases, arrange these phases in order of increasing density.
   a. strength of intermolecular interactions.
   b. compressibility.
   c. molecular motion.
   d. order in the arrangement of the molecules or atoms.
4. Which elements of the periodic table exist as gases at room temperature and pressure? Of these, which are diatomic molecules and which are monatomic? Which elements are liquids at room temperature and pressure? Which portion of the periodic table contains elements whose binary hydrides are most likely gases at room temperature?
5. A 1.00 mol sample of gas at 25°C and 1.0 atm has an initial volume of 22.4 L. Calculate the results of each change, assuming all the other conditions remain constant.
   a. The pressure is changed to 85.7 mmHg. How many milliliters does the gas occupy?
   b. The volume is reduced to 275 mL. What is the pressure in millimeters of mercury?
   c. The pressure is increased to 25.3 atm. What is the temperature in degrees Celsius?
   d. The sample is heated to 30°C. What is the volume in liters?
   e. The sample is compressed to 1255 mL, and the pressure is increased to 2555 torr. What is the temperature of the gas in kelvins?
6. A 1.00 mol sample of gas is at 300 K and 4.11 atm. What is the volume of the gas under these conditions? The sample is compressed to 6.0 atm at constant temperature, giving a volume of 3.99 L. Is this result consistent with Boyle's law?
7. A 8.60 L tank of nitrogen gas at a pressure of 455 mmHg is connected to an empty tank with a volume of 5.35 L. What is the final pressure in the system after the valve connecting the two tanks is opened? Assume that the temperature is constant.
8. At constant temperature, what pressure in atmospheres is needed to compress 14.2 L of gas initially at 25.2 atm to a volume of 12.4 L? What pressure is needed to compress 27.8 L of gas to 20.6 L under similar conditions?
9. One method for preparing hydrogen gas is to pass HCl gas over hot aluminum; the other product of the reaction is $AlCl_3$. If you wanted to use this reaction to fill a balloon with a volume of 28,500 L at sea level and a temperature of 78°F, what mass of aluminum would you need? What volume of HCl at STP would you need?
10. An 3.50 g sample of acetylene is burned in excess oxygen according to the following reaction:

    $$2\ C_2H_2(g) + 5\ O_2(g) \rightarrow 4\ CO_2(g) + 2\ H_2O(l)$$

    At STP, what volume of $CO_2(g)$ is produced?

11. Calculate the density of ethylene (C_2H_4) under each set of conditions.
    a. 7.8 g at 0.89 atm and 26°C
    b. 6.3 mol at 102.6 kPa and 38°C
    c. 9.8 g at 3.1 atm and −45°C
12. At 140°C, the pressure of a diatomic gas in a 3.0 L flask is 635 kPa. The mass of the gas is 88.7 g. What is the most likely identity of the gas?
13. What volume must a balloon have to hold 6.20 kg of H_2 for an ascent from sea level to an elevation of 20,320 ft, where the temperature is −37°C and the pressure is 369 mmHg?
14. What must be the volume of a balloon that can hold 313.0 g of helium gas and ascend from sea level to an elevation of 1.5 km, where the temperature is 10.0°C and the pressure is 635.4 mmHg?
15. A typical automobile tire is inflated to a pressure of 28.0 lb/in.^{2} Assume that the tire is inflated when the air temperature is 20°C; the car is then driven at high speeds, which increases the temperature of the tire to 43°C. What is the pressure in the tire? If the volume of the tire had increased by 8% at the higher temperature, what would the pressure be?

16. The average respiratory rate for adult humans is 20 breaths per minute. If each breath has a volume of 310 mL of air at 20°C and 0.997 atm, how many moles of air does a person inhale each day? If the density of air is 1.19 kg/m^3, what is the average molecular mass of air?
17. Kerosene has a self-ignition temperature of 255°C. It is a common accelerant used by arsonists, but its presence is easily detected in fire debris by a variety of methods. If a 1.0 L glass bottle containing a mixture of air and kerosene vapor at an initial pressure of 1 atm and an initial temperature of 23°C is pressurized, at what pressure would the kerosene vapor ignite?

Answers

1.
2.
3.
4.
5.
    a. 1.99×10^5 mL
    b. 6.19×10^4 mmHg
    c. 7270°C
    d. 22.8 L
    e. 51.4 K
6.
7. 281 mmHg
8.
9. 20.9 kg Al, 5.20×10^4 L HCl
10.
11. a. 1.0 g/L
    b. 1.1 g/L
    c. 4.6 g/L
12.
13.
14. 2174 L

Additional Exercises

1. What is the pressure in pascals if a force of 4.88 kN is pressed against an area of 235 cm^2?
2. What is the pressure in pascals if a force of 3.44×10^4 MN is pressed against an area of 1.09 km^2?
3. What is the final temperature of a gas whose initial conditions are 667 mL, 822 torr, and 67°C and whose final volume and pressure are 1.334 L and 2.98 atm, respectively? Assume the amount remains constant.
4. What is the final pressure of a gas whose initial conditions are 1.407 L, 2.06 atm, and −67°C and whose final volume and temperature are 608 mL and 449 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 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 mL at −196°C. At that temperature, 1 mol of N_2 gas has a volume of 6.318 L if the pressure is 1.000 atm. What pressure is needed to compress the N_2 gas to 34.65 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 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 mol of He at 760 torr and 22°C, what is its
    a. initial volume before ascent?
    b. final volume when it reaches 40 km in altitude? (Assume the pressure of the gas equals the surrounding pressure.)
12. If a balloon is filled with 1.000 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 atm?

13. Air, a mixture of mostly N_2 and O_2, can be approximated as having a molar mass of 28.8 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 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 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

$$Fe(s) + 2HNO_3(aq) \rightarrow Fe(NO_3)_2(aq) + H_2(g)$$

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

18. $NaHCO_3$ is decomposed by heat according to

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(\ell) + CO_2(g)$$

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

? Answers

1. 208,000 Pa
2.
3. 1,874 K
4.
5. $$\frac{P_1V_1}{n_1} = \frac{P_2V_2}{n_2}$$
6.
7. 3.72×10^{-23} L
8.
9. 1 atm = 760 torr
10.
11.
    1. 24.2 L
    2. 3155 L
12.
13. 1.19 g/L
14.
15. 67.2 g/L
16.
17. 3.99%