***Chemistry***

**9: Gases**

**9.5: The Kinetic-Molecular Theory**

91. Can the speed of a given molecule in a gas double at constant temperature? Explain your answer.

Solution

Yes. At any given instant, there are a range of values of molecular speeds in a sample of gas. Any single molecule can speed up or slow down as it collides with other molecules. The average velocity of all the molecules is constant at constant temperature.

93. The distribution of molecular velocities in a sample of helium is shown in Figure 9.34. If the sample is cooled, will the distribution of velocities look more like that of H2 or of H2O? Explain your answer.

Solution

H2O. Cooling slows the velocities of the He atoms, causing them to behave as though they were heavier.

95. A 1‑L sample of CO initially at STP is heated to 546 K, and its volume is increased to 2 L.

(a) What effect do these changes have on the number of collisions of the molecules of the gas per unit area of the container wall?

(b) What is the effect on the average kinetic energy of the molecules?

(c) What is the effect on the root mean square speed of the molecules?

Solution

Both the temperature and the volume are doubled for this gas (*n* constant), so *P* remains constant. (a) The number of collisions per unit area of the container wall is constant. (b) The average kinetic energy doubles; it is proportional to temperature. (c) The root mean square speed increases to  times its initial value; *u*rms is proportional to .

97. Answer the following questions:

(a) Is the pressure of the gas in the hot air balloon shown at the opening of this chapter greater than, less than, or equal to that of the atmosphere outside the balloon?

(b) Is the density of the gas in the hot air balloon shown at the opening of this chapter greater than, less than, or equal to that of the atmosphere outside the balloon?

(c) At a pressure of 1 atm and a temperature of 20 °C, dry air has a density of 1.2256 g/L. What is the (average) molar mass of dry air?

(d) The average temperature of the gas in a hot air balloon is 1.30 × 102 °F. Calculate its density, assuming the molar mass equals that of dry air.

(e) The lifting capacity of a hot air balloon is equal to the difference in the mass of the cool air displaced by the balloon and the mass of the gas in the balloon. What is the difference in the mass of 1.00 L of the cool air in part (c) and the hot air in part (d)?

(f) An average balloon has a diameter of 60 feet and a volume of 1.1  105 ft3. What is the lifting power of such a balloon? If the weight of the balloon and its rigging is 500 pounds, what is its capacity for carrying passengers and cargo?

(g) A balloon carries 40.0 gallons of liquid propane (density 0.5005 g/L). What volume of CO2 and H2O gas is produced by the combustion of this propane?

(h) A balloon flight can last about 90 minutes. If all of the fuel is burned during this time, what is the approximate rate of heat loss (in kJ/min) from the hot air in the bag during the flight?

Solution

(a) equal, because the balloon is free to expand until the pressures are equalized; (b) less than the density outside; (c) assume three-place accuracy throughout unless greater accuracy is stated:

;

(d) convert the temperature to °C; then use the ideal gas law:



;

(e) 1.2256 g/L – 1.09966 g/L = 0.129 g/L; (f) calculate the volume in liters, multiply the volume by the density difference to find the lifting capacity of the balloon, subtract the weight of the balloon after converting to pounds:



3.11  106 L  0.129 g/L = 4.01  105 g

= 884 lb; 884 lb – 500 lb = 384 lb

net lifting capacity = 384 lb; (g) First, find the mass of propane contained in 40.0 gal. Then calculate the moles of CO2(*g*) and H2O(*g*) produced from the balanced equation.



151.4 L  0.5005 g L–1 = 75.8g

Molar mass of propane = 3(12.011) + 8(1.00794) = 36.033 + 8.064 = 44.097 g mol–1



The reaction is 

For each 1.72 mol propane, there are 3  1.72 mol = 5.15 mol of CO2 and 4  1.72 mol = 6.88 mol H2O. The total volume at STP = 22.4 L  12.04 = 270 L; (h) The total heat released is determined from the heat of combustion of the propane. Using the equation in part (g),



Since there is 1.72 mol propane, 1.72  2043.96 kJ mol–1 = 3.52  103 kJ is used for heating. This heat is used over 90 minutes, so  is released.

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