AP Physics

The Mole, Molecular Mass, and Ideal Gas Laws Practice

Name: KEY

1. A mass of 135 g of an element is known to contain 3.01×10^{23} atoms.
   a. How many moles of the element are present?

   b. What is the element? _____

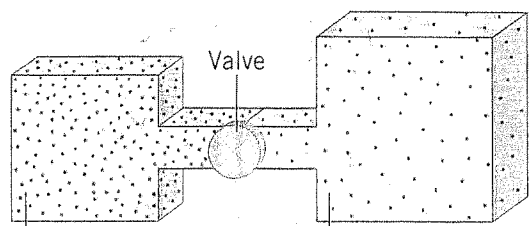
2. A cylindrical glass of water (H_2O) has a radius of 4.5 cm and a height of 12 cm. The density of water is 1 g/cm^3.
   a. How many moles of water molecules are in the glass?

   b. How many water molecules are in the glass?

   c. How many hydrogen atoms are in the glass? _____

3. In a portable oxygen system, the oxygen (O_2) is contained in a cylinder whose volume is 0.0028 m^3. A full cylinder has an absolute pressure of 1.5×10^7 Pa when the temperature is 296 K. Find the mass of the oxygen in the cylinder.

8. The drawing shows two thermally insulated tanks. They are connected by a valve that is initially closed. Each tank contains neon gas at the pressure, temperature, and volume indicated. When the valve is opened, the contents of the two tanks mix and the pressure becomes constant throughout.



$n_1 = 547$ mol $n_2 = 240.7$ mol

$n_3 = 787.7$ mol

$PV = nKT$, $n = \frac{PV}{RT}$

547 ~~532~~ mol

   a. What is the final temperature? Ignore any change in the temperature of the tanks themselves. (Hint: The heat gained by the gas in one tank is equal to that lost by the other.)

$n_1 C \Delta T_1 + n_2 C \Delta T_2 = 0$

$547(T_3 - 220) + 241(T_3 - 580) = 0$

$547T_3 - 120340 + 241T_3 - 139780 = 0$

$T_3 = 770$ K

   b. What is the final pressure?

$P_3 = \frac{n_3 R T_3}{V_3} = 277000$ Pa

6. On the sunlit surface of Venus, the atmospheric pressure is 9×10^6 Pa, and the temperature is 740 K. On the Earth's surface, the atmospheric pressure is 100,000 Pa, while the surface temperature can reach 320 K. These data imply that Venus has a "thicker" atmosphere at its surface than does the Earth, which means that the number of molecules per unit volume (N/V) is greater on the surface of Venus than on the Earth. Find the ratio $(N/V)_{Venus}/(N/V)_{Earth}$.

$PV = NkT$

$\frac{N}{V} = \frac{P}{kT}$

$\frac{(N/V)_V}{(N/V)_E} = \frac{(P/kT)_V}{(P/kT)_E} = \frac{(9 \times 10^6 / 740)}{(10^5 / 320)} = 38.9$

7. A tank contains 11 g of chlorine gas (Cl_2) at a temperature of 82 °C and an absolute pressure of 5.6×10^5 Pa. The mass per mole of Cl_2 gas is 70.9 g/mol

   a. Determine the volume of the tank.

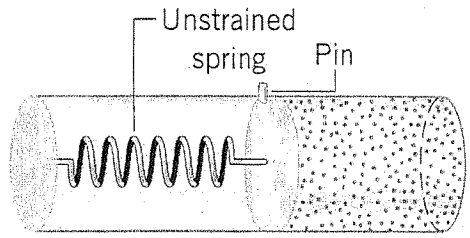
$\frac{11}{70.9} = 0.155\ mol$ $\quad PV = nRT$

$V = nRT/P = \frac{0.155(8.31)(355)}{5.6\times10^5} = 8.17\times10^{-4}\ m^3$

   b. Later, the temperature of the tank has dropped to 31 °C and, due to a leak, the pressure has dropped to 3.8×10^5 Pa. How many grams of chlorine have leaked out of the tank?

$n = \frac{PV}{RT} = \frac{(3.8\times10^5)(8.17\times10^{-4})}{8.31(304)} =$

9. A gas fills the right portion of a horizontal cylinder whose radius is 5 cm. The initial pressure of the gas is 1.01×10^5 Pa. A frictionless, movable piston separates the gas from the left portion of the cylinder that is evacuated and contains an ideal spring, as shown. The piston is initially held in place by a pin. The spring is initially unstrained, and the length of the gas-filled portion is 20 cm. When the pin is removed and the gas is allowed to expand, the length of the gas-filled chamber doubles. The initial and final temperatures are equal. Determine the spring constant of the spring.



$PV = nRT$

$P_1V_1 = P_2V_2 \qquad V_2 = 2V_1$

$P_1V_1 = P_2(2V_1)$

$P_2 = \frac{1}{2}P_1$

$A = \pi r^2 = 0.079$

$F = P_2A = kx$

$\frac{1}{2}P_1A = kx$

$k = \frac{\frac{1}{2}P_1A}{x} = \frac{\frac{1}{2}(1.01\times10^5)(0.079)}{0.2}$

$k = 1998\ N/m$