Answer on Question 58128, Physics, Molecular Physics | Thermodynamics

Question:

15. The average kinetic energy of the molecules of an ideal gas in a closed, rigid container is increased by a factor of 4. What happens to the pressure of the gas?

a) It remains constant

b) It increases by a factor of 2

c) It increases by a factor of 4

d) It increases by a factor of 8

Solution:

From the kinetic theory of gases we know, that the pressure of the gas on the walls of the closed, rigid container is given by the formula:

$$P = \frac{1}{3}\frac{N}{V}m\overline{v^2},$$

here, N is the number of the molecules of the gas, V is the volume of the closed container, m is the mass of the molecule, $\overline{v^2}$ is the root-mean-square speed of the molecules.

Since the average (translational) kinetic energy of the molecules of an ideal gas is $\frac{1}{2}m\overline{v^2}$, the previous formula becomes:

$$P = \frac{2}{3}\frac{N}{V}\frac{1}{2}m\overline{v^2} = \frac{2}{3}\frac{N}{V}KE_{avg}.$$

Let’s look at this formula. Since the container is closed, it means that the volume is constant. The number of molecules is constant too. So, if we increase the average (translational) kinetic energy KE_{avg} by a factor of 4, the pressure of the gas increases by a factor of 4. Therefore, the correct answer is c) It increases by a factor of 4.

Answer:

c) It increases by a factor of 4

16. At what temperature will the root-mean-square speed of oxygen molecules have the value of $640\ ms^{-1}$? 1 kilomole of oxygen has a mass of $32\ kg$.

a) 252.5℃

b) 332.3℃

c) 272.2℃

d) 373.2℃

Solution:

By the definition, the root mean square speed is given by the formula:

$$v_{rms} = \sqrt{\frac{3RT}{M}},$$

here, $R = 8.314\ \frac{J}{K \cdot mol}$ is the universal gas constant, T is the temperature (K), $M = 0.032\ \frac{kg}{mol}$ is the molar mass of oxygen molecule.

From this formula we can find the temperature of the oxygen gas:

$$T = \frac{v_{rms}^2 M}{3R} = \frac{(640\ ms^{-1})^2 \cdot 0.032\ \frac{kg}{mol}}{3 \cdot 8.314\ \frac{J}{K \cdot mol}} = 525.51\ K.$$

Let's convert Kelvin to Celsius:

$$T_{(℃)} = T_{(K)} - 273.15 = 525.51\ K - 273.15 = 252.36℃ \sim 252.5℃.$$

Answer:

a) 252.5℃