___ 1 A large balloon is being filled with He from gas cylinders. The temperature is 25.0°C and the pressure is 2.00 atmosphere. The volume of the inflated balloon is 2000. m^3. What was the volume of He in the cylinders if the gas was under a pressure of 130. atmospheres and at a temperature of 12.0°C when in the gas cylinders?

A) $29.4\,m^3$ B) $26.5\,m^3$ C) $14.7\,m^3$ D) $32.4\,m^3$ E) $58.9\,m^3$

Solution:

T, P, and V are 285. K, 130. atm, and V_i) initially, and are (298. K, 2.00 atm and 2000. m^3) in the balloon. Since the number of moles doesn't change, $\frac{P_iV_i}{T_i}$ must be the same as $\frac{P_fV_f}{T_f}$. That makes $V_i = \frac{(2.00)(2000.)(285.)}{(298.)(130.)} = 29.4 m^3$.

The correct answer is: A

___ 2 A cylinder contains oxygen gas at a temperature of $7°C$ and a pressure of 15 atm in a volume of 100 L. A fitted piston is lowered in the cylinder, decreasing the volume occupied by the gas to 80 L and raising the temperature to $40°C$. The gas pressure is now approximately

A) 17 atm B) 21 atm C) 8 atm D) 3 atm E) 75 atm

Solution:

Use $P_1V_1/T_1 = P_2V_2/T_2$ so that $P_2 = (P_1V_1/T_1)/(V_2/T_2) = 21$ atm.

The correct answer is: B

___ 3 A hailstorm causes an average pressure of 1.90 N/m^2 on the 190. m^2 flat roof of a house. The hailstones, each of mass 0.00800 kg, have an average velocity of 35.0 m/s perpendicular to the roof and rebound after hitting the roof with the same speed. How many hailstones hit the roof each second?

A) 322 B) 1418 C) 1289 D) 645 E) 1225

Solution:

The force is the rate of change of momentum. The momentum change of one object is $2mv$ so the total momentum change per second, which is the force, is $2mvn$ where n is the number that hit and bounce back in one second. The pressure is the force per unit area so $n = \frac{PA}{2mv} = 645$.

The correct answer is: D

___ 4 Five molecules of a gas have the following speeds: 200 km/s, 300 km/s, 400 km/s, 500 km/s, 600 km/s The rms speed for these molecules is

A) 400 km/s B) 419 km/s C) 424 km/s D) 388 km/s E) 410 km/s

Solution:

The mean square of these speeds is $[(200^2 + 300^2 + 400^2 + 500^2 + 600^2)/5](\text{km/s})^2 = 18 \times 10^4 (\text{km/s})^2$. The root mean square speed is the square root of that, which is $\sqrt{18} \times 10^2$ km/s = 424 km/s.

The correct answer is: C

___ 5 If the rms speed of oxygen molecules is 490 m/s at 0°C, the rms speed of oxygen molecules at 273°C is

A) 346. m/s B) 1960. m/s C) 693. m/s D) 980. m/s E) 490. m/s

Solution:

If the two rms speeds are v_1 and v_2 and the corresponding temperatures T_1 and T_2, we have $\frac{3}{2}kT_i = \frac{1}{2}mv_i^2$ for $i = 1, 2$. This implies that $v_2 = \sqrt{T_2/T_1}v_1 = \sqrt{546./273.} \times 490.\,\mathrm{m/s} = 693.\,\mathrm{m/s}$.

The correct answer is: C

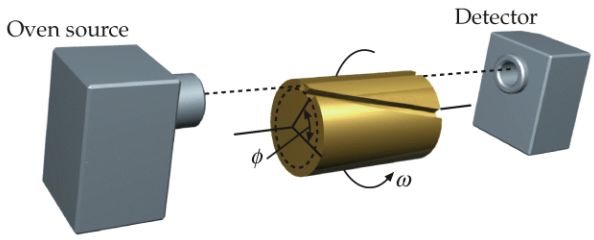

Figure 1: Problem 6

___ 6 A device used to measure the speed of molecules is shown above. When the cylinder is rotated at constant angular velocity only molecules that have the right speed will pass through the slanted slot and land on the detector. Derive an expression for the speed v in terms of the angular velocity ω, ϕ and L. L is the length of the cylinder and ϕ is the angle subtended by the slanted slot.

A) $v = \frac{\omega L}{4\phi}$ B) $v = \frac{2\pi\omega L}{\phi}$ C) $v = \frac{\omega L}{\phi}$

D) $v = \frac{\omega L}{2\pi\phi}$ E) $v = \frac{\omega L}{\pi\phi}$

Solution:

A molecule takes time $t = \frac{L}{v}$ to travel the length of the cylinder. In that time the cylinder turns through an angle of ωt radians. So $\phi = \omega t = \omega\frac{L}{v}$ which means that $v = \frac{\omega L}{\phi}$.

The correct answer is: C

1. A
2. B
3. D
4. C
5. C
6. C