PHY130

HW8_Help

1.

Solution or Explanation

Note: We are displaying rounded intermediate values for practical purposes. However, the calculations are made using the unrounded values.

(a) $T_C = T_K - 273.15 = 351 - 273.15 = 77.9°\text{C}$

(b) $T_F = \frac{9}{5}T_C + 32 = \frac{9}{5}(77.85) + 32 = 172°\text{F}$

2.

Solution or Explanation

(a) As the temperature drops by 25°C, the length of the pendulum changes by

$$\Delta L = \alpha L_0(\Delta T) = [19 \times 10^{-6}\ (°\text{C})^{-1}](1.6\ \text{m})(-25°\text{C})$$

or

$$\Delta L = -7.6 \times 10^{-4}\ \text{m} = -0.76\ \text{mm}.$$

Thus, the final length of the rod is $L = 1.6$ m − 0.76 mm = 1599.2 mm.

(b) From the expression for the period, $T = 2\pi\sqrt{L/g}$, we see that as the length decreases the period decreases. Thus, the pendulum will swing too rapidly and the clock will run fast.

4.

Solution or Explanation

(a) From the ideal gas law, $PV = nRT$, we find $P/T = nR/V$. Thus, if both n and V are constant as the gas is heated, the ratio P/T is constant, giving $P_f/T_f = P_i/T_i$, or

$$T_f = T_i\left(\frac{P_f}{P_i}\right) = (296\text{ K})\left(\frac{3P_i}{P_i}\right) = 888\text{ K} = 615°\text{C}.$$

(b) If both pressure and volume double as n is held constant, the ideal gas law gives

$$T_f = T_i\left(\frac{P_fV_f}{P_iV_i}\right) = T_i\left(\frac{(2P_i)(2V_i)}{P_iV_i}\right) = 4T_i = 4(296\text{ K}) = 1180\text{ K} = 911°\text{C}.$$

5.

Solution or Explanation

The initial and final absolute temperatures are

$$T_i = T_{C,\,i} + 273 = (24.5 + 273)\text{ K} = 298\text{ K and } T_f = T_{C,\,f} + 273 = (87.0 + 273)\text{ K} = 360\text{ K}.$$

The volume of the tank is assumed to be unchanged, or $V_f = V_i$. Also, two-thirds of the gas is withdrawn, so $n_f = n_i/3$. Thus, from the ideal gas law,

$$\frac{P_fV_f}{P_iV_i} = \frac{n_fRT_f}{n_iRT_i} \Rightarrow P_f = \left(\frac{n_f}{n_i}\right)\left(\frac{T_f}{T_i}\right)P_i = \left(\frac{1}{3}\right)\left(\frac{360\text{ K}}{298\text{ K}}\right)(10.9\text{ atm}) = 4.40\text{ atm}.$$

6.

Solution or Explanation

With n held constant, the ideal gas law gives

$$\frac{V_1}{V_2} = \left(\frac{P_2}{P_1}\right)\left(\frac{T_1}{T_2}\right) = \left(\frac{0.030\text{ atm}}{1.0\text{ atm}}\right)\left(\frac{305\text{ K}}{200\text{ K}}\right) = 4.58 \times 10^{-2}.$$

Since the volume of a sphere is $V = (4\pi/3)r^3$, $V_1/V_2 = (r_1/r_2)^3$.

Thus, $r_1 = \left(\frac{V_1}{V_2}\right)^{1/3} r_2 = (4.58 \times 10^{-2})^{1/3}(19\text{ m}) = 6.80\text{ m}.$

7.

Consult a periodic table to find that the molecular mass of butane (C_4H_{10}) is $M = 4M_C + 10M_H = 4(12.0 \text{ g/mol}) + 10(1.01 \text{ g/mol}) = 58.1$ g/mol = 0.0581 kg/mol. The rms speed of a butane molecule at 225 K is the following.

$$v_{rms} = \sqrt{v^2} = \sqrt{\frac{3RT}{M}}$$
$$= \sqrt{\frac{3(8.31 \text{ J/(mol}\cdot\text{K))}(225 \text{ K})}{0.0581 \text{ kg/mol}}}$$
$$= 311 \text{ m/s}$$

8.

Solution or Explanation

Note the values in this solution reflect those of the text book question, not the values you may have received for this question above.

One mole of any substance contains Avogadro's number of molecules and has a mass equal to the molar mass, M. Thus, the mass of a single molecule is $m = M/N_A$.

For helium, $M = 4.00 \text{ g/mol} = 4.00 \times 10^{-3}$ kg/mol, and the mass of a helium molecule is

$$m = \frac{4.00 \times 10^{-3} \text{ kg/mol}}{6.02 \times 10^{23} \text{ molecule/mol}}.$$

Since a helium molecule contains a single helium atom, the mass of a helium atom is

$$m_{atom} = 6.64 \times 10^{-27} \text{ kg}.$$

9.

Solution or Explanation

If $v_{rms} = v_{esc}$, we must have $v_{rms} = \sqrt{3k_BT/m} = v_{esc}$, where $k_B = 1.38 \times 10^{-23}$ J/K is Boltzmann's constant and m is the mass of a molecule (for carbon dioxide, $m = 7.30 \times 10^{-26}$ kg). Thus, the required absolute temperature is $T = mv_{esc}^2/3k_B$.

(a) To have $v_{rms} = v_{esc}$ on Earth where $v_{esc} = 1.12 \times 10^4$ m/s, the required temperature for the carbon dioxide gas is

$$T = \frac{(7.30 \times 10^{-26} \text{ kg})(1.12 \times 10^4 \text{ m/s})^2}{3(1.38 \times 10^{-23} \text{ J/K})} = 2.21 \times 10^5 \text{ K}.$$

(b) If $v_{rms} = v_{esc}$ on the Moon where $v_{esc} = 2.37 \times 10^3$ m/s, the temperature must be

$$T = \frac{(7.30 \times 10^{-26} \text{ kg})(2.37 \times 10^3 \text{ m/s})^2}{3(1.38 \times 10^{-23} \text{ J/K})} = 9900 \text{ K}.$$

10.

Solution or Explanation

(a) The initial absolute pressure in the tire is $P_1 = P_{atm} + P_{1,\ gauge} = 2.65$ atm, and the final absolute pressure is $P_2 = P_{atm} + P_{2,\ gauge} = 3.15$ atm.

The ideal gas law, with both n and V constant, gives

$$T_2 = \left(\frac{P_2}{P_1}\right)T_1 = \left(\frac{3.15 \text{ atm}}{2.65 \text{ atm}}\right)(300 \text{ K}) = 357 \text{ K}.$$

(b) When the quantity of gas varies, while volume and temperature are constant, the ideal gas law gives $\frac{n_3}{n_2} = \frac{P_3}{P_2}$. Thus, when air is released to lower the absolute pressure back to 2.65 atm, we have

$$\frac{n_3}{n_2} = \frac{2.65 \text{ atm}}{3.15 \text{ atm}} = 0.841.$$

At the end, we have 84.1% of the original mass of air remaining, or 15.9% of the original mass was released.