15-Phys-203

SUMMER 2003

Prof. R. A.. Serota
Quiz 1

Name _____

Formulae and constants:

$$Q = cm \triangle T$$

$$Q = Lm$$

$$\triangle E_{int} = Q - W$$

$$pV = nRT$$

$$E_{int} = \frac{3}{2} nRT \text{ (monoatomic ideal gas)}$$

1. How much heat must be absorbed by solid mercury of mass $m = 10$ g at 234 K to take it to a liquid state at 334 K? - The melting temperature of mercury is 234 K, the heat of fusion is 11.4 kJ/kg and the specific heat of liquid mercury is 140 J/kg·K.

   Solution

$$\begin{aligned} Q &= L_F m + cm\left(T_f - T_i\right) = \left[L_F + c\left(T_f - T_i\right)\right] m \\ &= \left[11.4 \times 10^3 + (140)\,(334 - 234)\right]\left(10^{-2}\right) = 254 \text{ J} \end{aligned}$$

2. A cylinder contains 5 L of helium at 300 K at 10 atm. The temperature is raised to 360 K and the pressure is reduced to 6 atm. What is the final volume of the gas in liters? - Assume that the gas is ideal.

   Solution

$$\frac{p_i V_i}{T_i} = \frac{p_f V_f}{T_f} = nR$$

$$V_f = V_i \frac{p_i}{p_f}\frac{T_f}{T_i} = 5\frac{10}{6}\frac{360}{300} = 10 \text{ L}$$

   Bonus question: What are the initial and final internal energies of the gas? - Helium is monatomic, 1 L $= 10^{-3}$ m^3, 1 atm $= 1.01 \times 10^5$ Pa

$$E_{int} = \frac{3}{2} nRT = \frac{3}{2} pV$$

$$E_{int,i} = \frac{3}{2}\left(1.01 \times 10^6\right)\left(5 \times 10^{-3}\right) = 7.5 \text{ kJ}$$

$$E_{int,f} = \frac{3}{2}\left(6 \times 1.01 \times 10^5\right)\left(10^{-2}\right) = 9 \text{ kJ}$$

   Could have also used

$$E_{int,f} = E_{int,i}\frac{T_f}{T_i} = (7.5)\left(\frac{360}{300}\right) = 9 \text{ kJ}$$

3. Consider that 100 J of work is done on a system and 50 J is extracted from the system as heat. In the sense of the first law of thermodynamics, what are the values (including algebraic signs) of W, Q, and $\triangle E_{int}$?

   Solution

   $W = -100$ J, $Q = -50$ J, and

$$\triangle E_{int} = Q - W = (-50 - (-100)) = 50 \text{ J}$$