Physics 10154 - Exam #5b

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work (or if some parts are incorrect) even if you get the right answer. Clearly indicate your answer with a circle or box and remember to include correct units and significant figures.

1. (25 pts) An ideal gas occupies a volume of 8.0 cm^3 at a temperature of 45°C and 1.5 atm.

a) Determine the number of moles of gas present.

b) If the pressure is increased to 3.5 atm and the temperature increased to 120°C and the number of moles is kept constant, what is the new volume of the gas?

a) $V = 8.0 \times 10^{-6}\ m^3$

$T = 45°C = 318\ K$

$P = 1.5\ atm = 151950\ Pa$

$$n = \frac{PV}{RT} = \frac{(151950)(8.0\times10^{-6})}{(8.31)(318)}$$

$$= \boxed{4.6 \times 10^{-4}\ moles}$$

b) $$\frac{V_2}{V_1} = \frac{\left(\frac{n_2}{n_1}\right)\left(\frac{R}{R}\right)\left(\frac{T_2}{T_1}\right)}{\left(\frac{P_2}{P_1}\right)} = \frac{(1)(1)\left(\frac{393}{318}\right)}{\left(\frac{3.5}{1.5}\right)} = 0.53$$

$$V_2 = 0.53 V_1 = \boxed{4.2 \times 10^{-6}\ m^3}$$

2. (25 pts) A styrofoam box contains 3.5 kg of ice at a temperature of 0°C. Over a period of 5.0 hours, the ice melts and remains at 0°C. The walls of the box are 2.0 cm thick, the surface area of the box is 0.15 square meters, and the outside temperature is 25°C. What is the thermal conductivity of the styrofoam?

The latent heat of fusion for water is 333,000 J/kg.

$\Delta Q = mL_f = 1165500 \text{ J}$

$\Delta t = 5 \text{ hrs} = 1800 \text{ s}$

$l = 0.020 \text{ m}$

$A = 0.15 \text{ m}^2$

$\Delta T = 25°C$

$$\frac{\Delta Q}{\Delta t} = \frac{k A \Delta T}{l}$$

$$\frac{1165500}{1800} = \frac{k(0.15)(25)}{0.020}$$

$64.75 = 187.5k$

$k = 0.35$

3. (25 pts) Gas changes from state A --> B --> C --> D

State A: P = 7.0 atm, V = 3.0 L 709100 Pa, 3×10^{-3} m^3
State B: P = 7.0 atm, V = 9.0 L 709100 Pa, 9×10^{-3} m^3
State C: P = 2.0 atm, V = 9.0 L 202600 Pa, 9×10^{-3} m^3
State D: P = 3.5 atm, V = 2.0 L 354550 Pa, 2×10^{-3} m^3

During this process, how much work is done by the gas?

$$W(A \to B) = (709100)(6\times10^{-3}) = 4254.6\ J$$

$$W(B \to C) = 0 \quad (\Delta V = 0)$$

$$W(C \to D) = \left(\frac{202600+354550}{2}\right)(-7\times10^{-3}) = -1950\ J$$

$$\boxed{W_{TOT} = 2300\ J}$$

4. (25 pts) A 770 gram mass is attached to a spring of strength k = 150 N/m. The mass oscillates back and forth with an amplitude of 38 cm.

How far (in cm) from its equilibrium position is the kinetic energy of the mass equal to the spring's potential energy?

We know $\frac{1}{2}mv^2 + \frac{1}{2}kx^2 = \frac{1}{2}kA^2$

and also $\frac{1}{2}mv^2 = \frac{1}{2}kx^2$

so substitute

$$\frac{1}{2}kx^2 + \frac{1}{2}kx^2 = \frac{1}{2}kA^2$$

$$2x^2 = A^2$$

$$x = \frac{A}{\sqrt{2}} = \boxed{0.27\,m}$$