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. (30 pts) The density of an ideal gas at a temperature 65° C and atmospheric pressure is 0.284 kg/m3. If the temperature falls to 25° C and the pressure increases to 2.5 atmospheres, keeping the number of molecules constant, what is the new density of the gas?

$N_1 = N_2$

$T_1 = 65°C = 338K$ $\quad T_2 = 298K$

$P_1 = 1.0\ atm$ $\quad P_2 = 2.5atm$

$$\frac{V_2}{V_1} = \frac{\left(\frac{N_2}{N_1}\right)\left(\frac{k}{k}\right)\left(\frac{T_2}{T_1}\right)}{\left(\frac{P_2}{P_1}\right)} = \frac{(1)(1)\left(\frac{298}{338}\right)}{\left(\frac{2.5}{1.0}\right)} = 0.353$$

$$\frac{\rho_2}{\rho_1} = \frac{\left(\frac{M_2}{M_1}\right)}{\left(\frac{V_2}{V_1}\right)} = \frac{(1)}{.353} = 2.84$$

$$\rho_2 = 2.84\,\rho_1 = \boxed{0.81\ kg/m^3}$$

2. (40 pts) 65 grams of steam at a temperature of 160° C is added to a 1.2 kg Aluminum container filled with 250 grams of water. Both pot and water are at an initial temperature of 22° C. Does all of the steam condense?

If yes, what is the final temperature of the system?
If no, how much steam condenses?

The specific heat of steam is 2010 J/kg-C.
The specific heat of water is 4186 J/kg-C.
The specific heat of aluminum is 900 J/kg-C.
The latent heat of vaporization for water is 2,260,000 J/kg.

ΔQ to condense steam:

$= (.065)(2010)(-60) - (.065)(2260000)$

$= -7839 \quad - 146900 \quad = -154739$

ΔQ to heat aluminum + water

$= (1.2)(900)(78) + (.250)(4186)(78)$

$= 84240 \quad + 81627 \quad = 165867$

Since ΔQ to condense steam is smaller, all steam condenses and T_F unknown but less than 100°C.

$\Delta Q_{steam} + \Delta Q_{Al} + \Delta Q_w = 0$

$-154739 + (.065)(4186)(T_F - 100) + (1.2)(900)(T_F - 22) + (.250)(4186)(T_F - 22)$

$-154739 + 272.09T_F - 27209 + 1080T_F - 23760 + 1046.5T_F - 23023 = 0$

$-228731 + 2398.59\,T_F = 0$

$T_F = \dfrac{228731}{2398.59} = 95°C$

3. (30 pts) A 250 gram mass is attached to a spring with spring constant k = 330 N/m. The spring is compressed 65 cm and then released from rest to oscillate on a frictionless, horizontal surface.

a) What is the maximum speed of the mass as it oscillates?

b) At what distance from the spring's equilibrium point is the kinetic energy of the system equal to its potential energy?

a) V_{max} occurs at $x = 0$

$$V = \sqrt{\frac{k}{m}A^2} = \sqrt{\frac{330}{.250}(.65)^2} = 24 \text{ m/s}$$

b) When does $\frac{1}{2}mv^2 = \frac{1}{2}kx^2$?

$$V^2 = \frac{k}{m}(A^2 - x^2)$$

$$\frac{1}{2}m\frac{k}{m}(A^2 - x^2) = \frac{1}{2}kx^2$$

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

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

$$x = \sqrt{\frac{1}{2}}A = .707A$$

$$= 0.46 m$$