Physics 10154 - Exam #5a

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) 8.0 moles of an ideal gas is held at a pressure of ~~[illegible]~~ 95 atmospheres in a 3.0 L container.

a) What is the temperature of the gas?

b) If the temperature of the gas in part a is doubled and 3.0 additional moles of gas are added, what is the new pressure of the gas in the container, in atmospheres?

a) $n_1 = 8.0$ moles

$P_1 = 95\ atm = 9.62 \times 10^6\ Pa$

$T_1 = ?$

$V_1 = 3.0 L = 3.0 \times 10^{-3} m^3$

$$T_1 = \frac{P_1 V_1}{n_1 R} = \frac{(9.62\times10^6)(3\times10^{-3})}{(8.0)(8.31)} = \boxed{430\ K}$$

b) T_2 doubled

$n_2 = 11.0$ moles

$$\frac{P_2}{P_1} = \frac{\left(\frac{n_2}{n_1}\right)\left(\frac{R}{R}\right)\left(\frac{T_2}{T_1}\right)}{\left(\frac{V_2}{V_1}\right)} = \frac{\left(\frac{11}{8}\right)(1)(2)}{(1)}$$

$$\frac{P_2}{P_1} = 2.75$$

$$P_2 = (2.75)(95) = \boxed{260\ atm}$$

2. (40 pts) 650 grams of ice at a temperature of -75° C is added to a 1.2 kg Aluminum pot filled with 250 grams of water. Both pot and water are at an initial temperature of 82° C. Does all of the ice melt?

If yes, what is the final temperature of the system?
If no, how much ice melts?

The specific heat of ice is 2090 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 fusion for water is 333,000 J/kg.

To melt ice:

$$\Delta Q = (.650)(2090)(75) + (.650)(333{,}000)$$

$$= 101887.5 + 216450 = 318337.5$$

To cool water + aluminum to 0°C:

$$\Delta Q = (1.2)(900)(-82) + (.250)(4186)(-82)$$

$$= -88560 - 85813 = -174373$$

Since ΔQ (melt ice) is larger, not all ice melts so $T_F = 0$ and we must find m_{ice}.

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

$$101887.5 + m_{ice}(333000) - 174373 = 0$$

$$m_{ice}(333000) = 72485.5$$

$$m_{ice} = 220 \text{ grams}$$

3. (30 pts) A 150 gram mass is attached to a spring with spring constant k = 330 N/m. The spring is compressed 75 cm and then released from rest to oscillate on a frictionless, horizontal surface.

a) What is the mechanical energy of this system?

b) At what distance from the spring's equilibrium point is the velocity of the mass equal to half its maximum velocity?

a) $E = \frac{1}{2}kA^2 = \frac{1}{2}(330)(.75)^2 = 92.8\ J$

or $93\ J$

b) $V_{max} = \sqrt{\frac{k}{m}A^2}$

Let $V = \frac{1}{2}\sqrt{\frac{k}{m}A^2}$

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

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

$\frac{1}{4}\frac{k}{m}A^2 = \frac{k}{m}(A^2 - x^2)$

$\frac{1}{4}A^2 = A^2 - x^2$

$x^2 = \frac{3}{4}A^2$

$x = \sqrt{\frac{3}{4}}A = 0.866A$

$x = (.866)(.75) = 0.65\ m$