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) A spherical balloon contains an ideal gas at an initial temperature of 15° C and an initial pressure of 3.5 atm. The initial radius of the balloon is 0.22 meters. Keeping the number of atoms constant, the gas inside the balloon is heated to 75° C and the pressure drops to 1.5 atmospheres.

What is the new radius of the balloon?

$P_1 V_1 = n_1 R T_1 \qquad n_1 = \frac{P_1 V_1}{R T_1}$

$P_1 = 3.5\,atm = 3.5 \times 10^5\,Pa$

$V_1 = \frac{4}{3}\pi r^3 = .0446\,m^3$

$R = 8.31$

$T = 288\,K$

$n_1 = \frac{(3.5\times10^5)(.0446)}{(8.31)(288)} = 6.52\text{ moles}$

$P_2 = 1.5\,atm = 1.5 \times 10^5\,Pa$

$T_2 = 348\,K$

$n_2 = n_1$

$V_2 = \frac{n_2 R T_2}{P_2} = \frac{(6.52)(8.31)(348)}{1.5\times10^5} = 0.126\,m^3$

$\frac{4}{3}\pi r_2^3 = .126 \qquad r_2^3 = .0300 \qquad \boxed{r_2 = .31\,m}$

2. (30 pts) 45 grams of steam at an initial temperature of 150° C is combined with 25 grams of ice at an initial temperature of 0° C.

What is the final temperature of this system when it reaches thermal equilibrium? If the final temperature is zero, determine how much of the ice melts. If the final temperature is 100° C, determine how much of the steam condenses.

The specific heat of steam is 2010 J/kg-C
The specific heat of ice is 2090 J/kg-C
The specific heat of water is 4186 J/kg-C

The latent heat of fusion for water is 333,000 J/kg.
The latent heat of vaporization for water is 2.26 x 10^6 J/kg.

To cool steam to 100°C:

$\Delta Q = (.045)(2010)(-50) = -4522$ J

To condense steam:

$\Delta Q = -(.045)(2.26\times10^6) = -101,700$ J

To melt ice:

$\Delta Q = (.025)(333,000) = 8325$

To heat water to 100°C

$\Delta Q = (.025)(4186)(100) = 10465$

Not enough energy to condense all steam, $T_F = 100°C$

$\Delta Q_{steam} + \Delta Q_{ice} = 0$

$-4522 - m_s(2.26\times10^6) + 8325 + 10465 = 0$

$m_s = \frac{14268}{2.26\times10^6} = .0063$

or **6.3 grams**

3. (40 pts) A 2.5 kg mass is attached to a k = 45 N/m horizontal spring on a frictionless surface.

a) What constant applied force is needed in order to stretch the spring so that the applied force and spring force are in equilibrium at a spring elongation of 72 cm?

b) Suppose the spring is stretched to this length and released from rest (the applied force vanishes), what will be the velocity of the mass when it passes back through the spring's equilibrium position?

c) Assume x = 0 at equilibrium and x = 72 cm or -72 cm at maximum elongation. At what value of x will the mass have a velocity equal to half of its maximum velocity?

a) $F_{spr} = F_{App}$

$kx = F_{App} = (45)(.72) = \boxed{32\ N}$

b) $V_{max} = V$ when $x = 0$

$V = \sqrt{\frac{k}{m}(A^2 - 0)} = \sqrt{\frac{45}{2.5}(.72)^2}$

$= \boxed{3.1\ m/s}$

c) $V = 1.53\ m/s$, $x = ?$

$2.33 = \frac{45}{2.5}(.72^2 - x^2)$

$0.1296 = .5184 - x^2$

$x^2 = 0.3888$ $\boxed{x = 0.62\ m}$