Physics 10154 - Exam #10A

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. (34 pts) Helium gas is kept in a container with a volume of 150 Liters and a pressure of 130 atmospheres. The helium tank is emptied by filling many balloons, each a sphere with a radius of 22 cm at a pressure of 1.2 atmospheres. The temperature inside and outside the tank is the same, and no Helium is lost in the transfer process.

To the nearest whole number, how many balloons can be filled?

$V_1 = 0.150\ m^3 \qquad V_2 = ?$

$P_1 = 130\ atm \qquad P_2 = 1.2\ atm$

$T_1 = T_2 \qquad N_1 = N_2$

$$\frac{V_2}{V_1} = \frac{\frac{N_2}{N_1}\frac{k}{k}\frac{T_2}{T_1}}{\frac{P_2}{P_1}} = \frac{\frac{1 \cdot 1 \cdot 1}{1.2}}{\frac{1}{130}} = 108.3$$

$$V_2 = 16.25\ m^3$$

$$V_{bal} = \frac{4}{3}\pi(.22)^3 = .0446\ m^3$$

$$N = \frac{16.25}{.0446} = \boxed{364}$$

2. (33 pts) 75 grams of ice at 0° C are added to a 2.5 kg iron pot with 150 grams of water already inside. The iron pot and the water are initially at a temperature of 35° C.

If the final temperature of the system is 0° C, determine how much of the ice melts with 2 SF.

If the final temperature of the system is greater than 0° C, determine the final temperature with 2 SF.

The specific heat of iron is 448 J/kg °C.
The specific heat of water is 4186 J/kg °C.
The specific heat of ice is 2090 J/kg °C.
The latent heat of fusion for ice is 333,000 J/kg.

For ice to melt: $\Delta Q = (.075)(333{,}000) = 24975\ J$

To cool iron: $\Delta Q = (2.5)(448)(-35) = -39200\ J$

To cool water: $\Delta Q = (.150)(4186)(-35) = -21976.5\ J$

Ice completely melts, $T_F > 0$

$$\Delta Q_{ice} + \Delta Q_{iron} + \Delta Q_{water} = 0$$

$$24975 + (.075)(4186)(T_F - 0) + (2.5)(448)(T_F - 35) + (.15)(4186)(T_F - 35) = 0$$

$$24975 + 313.95T_F + 1120T_F - 39200 + 627.9T_F - 21976.5 = 0$$

$$-36201.5 + 2061.85T_F = 0$$

$$T_F = \frac{36201.5}{2061.85} = \boxed{18^\circ C}$$

3. (33 pts) A 1.2-kg block is attached to a horizontal spring with spring constant 45 kg-s^2. The block oscillates on a frictionless surface and has a maximum speed of 5.5 m/s when it passes through the equilibrium point.

a) What is the amplitude of the oscillation?

b) What is the total mechanical energy of the system?

c) For what value of the displacement x is the kinetic energy equal to the potential energy?

a) At $x = 0$, $v = 5.5\ m/s$

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

$$0 + \frac{1}{2}(1.2)(5.5)^2 = \frac{1}{2}(45)A^2$$

$$18.15 = 22.5A^2$$

$$\boxed{A = 0.90\ m}$$

b) $E = \frac{1}{2}kA^2 = \frac{1}{2}(45)(.90)^2 = \boxed{18\ J}$

check $\frac{1}{2}(1.2)(5.5)^2 = 18\ J$

c) When $\frac{1}{2}mv^2 = \frac{1}{2}kx^2$, both $= \frac{1}{2}E = 9.075\ J$

$$\frac{1}{2}kx^2 = 9.075$$

$$x^2 = \frac{9.075}{22.5}$$

$$\boxed{x = 0.64\ m} \quad \text{or} \quad \frac{\sqrt{2}}{2}A \quad \text{or} \quad \frac{A}{\sqrt{2}}$$