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) An unknown quantity of gas is in a piston chamber at an initial pressure of 2.7 atm, initial volume of 1.5 Liters and initial temperature of 130° C. The gas expands to a new state with a final pressure of 1.4 atm and final temperature of 65° C.

a) What is the new volume of the gas, in Liters?
b) How much work is done by the gas during the expansion?

$N_1 = N_2$

$P_1 = 2.7\,atm \quad P_2 = 1.4\,atm$

$T_1 = 403\,K \quad T_2 = 338\,K$

$V_1 = 1.5\,L$

$$\frac{V_2}{V_1} = \frac{\left(\frac{N_2}{N_1}\right)\left(\frac{k}{k}\right)\left(\frac{T_2}{T_1}\right)}{\left(P_2/P_1\right)} = \frac{(1)(1)\left(\frac{338}{403}\right)}{\left(1.4/2.7\right)} = 1.62$$

$V_2 = 1.62\,V_1 = \boxed{2.4\,L}$

b) $W = P_{avg}\Delta V$

$= (2.05\,atm)(0.926\,L)$

$= (207665)(0.926 \times 10^{-3}) = \boxed{192\,J}$

or $190\,J$

2. (30 pts) A 750 gram mass is attached to a horizontal spring with a spring constant k = 150 N/m. The mass initially stretches the spring to a length of 27 cm and is released from rest.

a) Assuming the surface is frictionless, how fast is the mass moving at the spring's equilibrium point?

b) If x = 0 represents the equilibrium point, at what value of x is the mass moving with 75% of its maximum speed?

c) If the coefficient of kinetic friction between the mass and surface is 0.34, how fast is the mass moving at the spring's equilibrium point?

a) $E = \frac{1}{2}kA^2 = \frac{1}{2}(150)(.27)^2 = 5.4675\ J$

At eq $E = \frac{1}{2}mv^2$ $\quad 5.4675 = \frac{1}{2}(.750)v^2$

$v = 3.8\ m/s$

or $v = \sqrt{\frac{k}{m}A^2} = 3.8$

b) Let $v = 0.75\ V_{max}$

$\sqrt{\frac{k}{m}(A^2 - x^2)} = 0.75\sqrt{\frac{k}{m}A^2}$

$\frac{k}{m}(A^2 - x^2) = 0.5625\frac{k}{m}A^2$

$0.4375A^2 = x^2$

$x = 0.661A = 18\ cm$

c) $\Sigma W_F = W_{spr} + W_{KF} = \Delta K$ $\qquad W_{KF} = (\mu_k F_N)(\Delta s)\cos\theta$

$\frac{1}{2}kx^2 - \mu_k mgx = \frac{1}{2}mv^2 - 0$ $\qquad = \mu_k mgx(-1)$

$= -\mu_k mgx$

$5.4675 - (.34)(.750)(9.8)(.27) = \frac{1}{2}(.750)v^2$

$5.4675 - .6747 = .375v^2$

$4.793 = .375v^2$

$v = 3.6\ m/s$

3. (40 pts) A 2.5 kg aluminum pot is heated to an initial temperature of 380° C. 210 grams of water is poured into the pot with an initial temperature of 33° C.

Determine the final temperature of the system. If the final temperature is 100° C, then determine how many grams of water are converted into steam.

Q to cool pot to 100°C $= (2.5)(900)(-280) = -630{,}000 \text{ J}$

Q to heat water to 100°C $= (.210)(4186)(67) = 58{,}900 \text{ J}$

Q to boil water $= (.210)(2.26 \times 10^6) = 474{,}600 \text{ J}$

533,500

So, all water boils, $T_F > 100°C$

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

$$(2.5)(900)(T_F - 380) + 533{,}500 + (.210)(2010)(T_F - 100) = 0$$

$$2250\,T_F - 855{,}000 + 533{,}500 + 422.1\,T_F - 42210 = 0$$

$$2672\,T_F - 363710 = 0$$

$$T_F = \frac{363710}{2672} = 136°C$$