Physics 10154 - Exam #5d

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) 12.5 moles of gas occupy a volume of 2.00 Liters at a pressure of 1.00 atm (state A).

The volume of gas is shrunk to 0.500 L as the pressure steadily increases to 3.00 atm (state B).

The pressure is then reduced back to 1.00 atm keeping the volume constant (state C).

Finally, the gas returns to its initial state A.

How much work is done during the ABCA cycle (in Joules)?

What is the temperature of the gas at states A, B and C?

a) $W(A \to B) = \bar{P} \Delta V = (2.0\,atm)(-1.50\,L)$

$= (202600\,Pa)(-1.50 \times 10^{-3}\,m^3)$

$W(A \to B) = -304\,J$

$W(B \to C) = 0 \quad (\Delta V = 0)$

$W(C \to A) = (1.0\,atm)(1.50\,L)$

$= 152\,J$

$W_{TOT} = -152\,J$

b) $T_A = \dfrac{P_A V_A}{n_A R} = \dfrac{(1.00)(2.00)}{(12.5)(.0821)} = 1.9\,K$

$\dfrac{T_B}{T_A} = \dfrac{\left(\frac{P_B}{P_A}\right)\left(\frac{V_B}{V_A}\right)}{\left(\frac{n_B}{n_A}\right)\left(\frac{R}{R}\right)} = \dfrac{(3)\left(\frac{1}{4}\right)}{(1)(1)} = \dfrac{3}{4} \qquad T_B = 1.5\,K$

$\dfrac{T_C}{T_A} = \dfrac{(1)\left(\frac{1}{4}\right)}{(1)(1)} = \dfrac{1}{4} \qquad T_C = 0.49\,K$

2. (40 pts) 54 grams of water (c = 4186 J/kg-C) is at an initial temperature of 25°C. This water is poured onto a hot 5.2 kg iron skillet (c = 448 J/kg-C) at a temperature of 160°C. The specific heat of steam is 2010 J/kg-C and the latent heat of vaporization for water is 2.26×10^6 J/kg.

What is the final temperature of the system?

If the final temperature of the system is 100°C, determine how much water vaporizes.

Heat & vaporize water:

Heat water to 100°C $= (.054)(4186)(75) = 16953$ J

Vaporize water $= (.054)(2.26 \times 10^6) = 122040$ J

138993 J

Cool iron to 100°C: $(5.2)(448)(-60) = -139776$ J

Barely enough energy to convert all vapor to $T_F > 100$

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

$$138993 + (.054)(2010)(T_F - 100) + (5.2)(448)(T_F - 160) = 0$$

$$138993 + 108.54 T_F - 10854 + 2329.6 T_F - 372736 = 0$$

$$2438.14 T_F = 244597$$

$$T_F = 100.3°C$$

or $\boxed{100°C}$, all water vaporizes

3. (30 pts) A frictionless, horizontal spring (k = 140 N/m) has a 6.5 kg mass attached. The spring is stretched to a length of 26 cm from its equilibrium point and then released from rest.

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

b) What is the speed of the mass when it moves through the spring's equilibrium point?

c) If the mass is on a rough surface with a coefficient of kinetic friction equal to 0.16, what is the speed of the mass when it moves through the spring's equilibrium point the first time?

a) $E = \frac{1}{2}kA^2 = \boxed{4.7\ J}$

b) At eq $\frac{1}{2}mv^2 = E$

$$\frac{1}{2}(6.5)v^2 = 4.732\ J$$

$$\boxed{v = 1.2\ m/s}$$

c) $W_{spr} + W_{KF} = \Delta K$

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

$$4.732 - (.16)(6.5)(9.8)(.26) = \frac{1}{2}(6.5)v^2$$

$$4.732 - 2.65 = 3.25v^2$$

$$\boxed{v = 0.80\ m/s}$$