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. (25 pts) An ideal gas is in a sealed piston chamber so that the number of molecules cannot change, and the measured density of the gas is 0.233 kg/m³. The initial temperature of the gas is 120°C. The pressure of the gas increases by a factor of 2.4, and the temperature increases to 320°C. What is the new density of the gas?

$P_2 = 2.4 P_1$

$T_1 = 393 K$

$T_2 = 593 K$

$N_1 = N_2$

$$\frac{V_2}{V_1} = \frac{\left(\frac{N_2}{N_1}\right)\left(\frac{k}{k}\right)\left(\frac{T_2}{T_1}\right)}{\left(P_2/P_1\right)} = \frac{(1)(1)(593/393)}{2.4} = 0.629$$

$$\frac{\rho_2}{\rho_1} = \frac{\left(\frac{M_2}{M_1}\right)}{\left(\frac{V_2}{V_1}\right)} = \frac{1}{.629} = 1.59$$

$$\rho_2 = (1.59)(0.233) = \boxed{0.37 \text{ kg/m}^3}$$

2. (30 pts) 54 grams of water (c = 4186 J/kg-C) is at an initial temperature of 35°C. This water is poured onto a hot 1.5 kg iron skillet (c = 448 J/kg-C) at a temperature of 210°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 of the water vaporizes.

ΔQ to heat water to 100°C $= (0.054)(4186)(65) =$

$= 14693$ J

ΔQ to vaporize to steam at 100°C $= (.054)(2.26 \times 10^6)$

$= 122{,}040$ J

total 136733

ΔQ to cool iron to 100°C $= (1.5)(448)(-110)$

$= -73920$

so water heats to 100°C but not all vaporizes

$T_F = 100°C$, Find m_s, mass of water that turns into steam

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

$14693 + m_s(2.26 \times 10^6) - 73920 = 0$

$m_s(2.26 \times 10^6) = 59227$

$m_s = .026$ kg

3. (25 pts) An ideal gas undergoes the cyclic process as follows, as it moves from one state to another along a straight line on a PV diagram, in the sequence ABCA.

A: P = 2.00 atm, V = 35.0 L, U = 26500 J
B: P = 9.00 atm, V = 95.0 L, U = 77200 J
C: P = 2.00 atm, V = 95.0 L

a) Determine the work done by the gas during each of the three steps of this cycle, AB, BC and CA.

b) If 32200 J of heat leaves the gas during the BC step, what is the internal energy of the gas in state C?

c) Determine the heat added to the gas during the entire cycle.

a) $W(AB) = P_{Avg}\,\Delta V = (5.5\,atm)(60\,L)$

$= (557150\ Pa)(60\times10^{-3}\,m^3)$

$= 33400\ J$

$W(BC) = 0 \quad \Delta V = 0$

$W(CA) = (2.0)(-60)$

$= (202600)(-60\times10^{-3}) = -12200\ J$

b) $\Delta U(BC) = Q_{BC} - W_{BC}$

$U_C - U_B = -32200 - 0$

$U_C - 77200 = -32200 \Rightarrow U_C = 45000\ J$

c) $\Delta U_{TOT} = Q_{TOT} - W_{TOT}$

$0 = Q_T - W_T$

$Q_T = W(AB) + W(BC) + W(CA) = 21200\ J$

4. (20 pts) A frictionless, horizontal spring (k = 160 N/m) has a 4.5 kg mass attached. The spring is stretched to a maximum elongation of 33 cm from its equilibrium point and released from that point, initially at rest.

a) What is the natural oscillation period of the spring?
b) What is the mechanical energy of this system?
c) What is the speed of the mass when it moves through the equilibrium point?
d) At what value of x is the kinetic energy of the mass equal to the potential energy of the spring?

a) $T = 2\pi\sqrt{\frac{m}{k}} = 1.1\ s$ or $1.05\ s$

b) $E = \frac{1}{2}kA^2 = 8.7\ J$

c) At $x = 0$, $v = \sqrt{\frac{k}{m}A^2} = 2.0\ m/s$

d) When $\frac{1}{2}kx^2 = \frac{1}{2}\left(\frac{1}{2}kA^2\right)$

$x = \sqrt{\frac{1}{2}}A = .707A$

$= 0.23\ m$