# 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. (35 pts) 54 grams of water (c = 4186 J/kg-°C) is at an initial temperature of 25°C. The water is poured onto a hot 4.0 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 $2.26 \times 10^6$ J/kg.

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

To heat water to 100°C : $(.054)(4186)(75) = 16953$

To vaporize water : $(.054)(2.26 \times 10^6) = 122040$

138993 J

to cool iron to 100°C : $(4.0)(448)(-60) = -107520$ J

Enough Q to heat water to 100°C but not to vaporize all water, so $T_F = 100°C$

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

$$16953 + m_w(2.26 \times 10^6) - 107520 = 0$$

$$m_w(2.26 \times 10^6) = 90567$$

$$m_w = .040 \text{ kg or } 40 \text{ g}$$

2. (35 pts) 9.0 moles of gas occupies a volume of 2.00 Liters at a pressure of 3.00 atm (state A).

The volume of gas is shrunk to 0.800 L as the pressure steadily increases to 5.00 atm (state B).

The pressure is then reduced back to 3.00 atm keeping the volume constant at 0.800 L (state C). Finally, the gas returns to its initial state A.

a) If the internal energy of the gas at state A is 650 J and at state C is 820 J, how much heat is added to the gas as it moves from state A -> B -> C?

b) How much heat is added to the gas it is moves from C -> A?

a) $\Delta U(ABC) = 170$

$W_{by\,gas}(A \to B) = P_{Avg}\,\Delta V = (4.0\text{ atm})(-1.2L)$

$= (4.052\times10^5\text{ Pa})(-1.2\times10^{-3}\text{m}^3)$

$= -486\text{ J}$

$W_{by\,gas}(B \to C) = 0 \quad (\Delta V = 0)$

$\Delta U(ABC) = Q(ABC) - W_{by\,gas}(ABC)$

$170 = Q + 486$

$Q(ABC) = -316\text{ J}$

b) $\Delta U(CA) = -170 \quad (\text{since } \Delta U_{cycle} = 0)$

$W_{by\,gas}(CA) = (3.0\text{ atm})(+1.2L)$

$= (3.039\times10^5\text{ Pa})(1.2\times10^{-3}\text{m}^3)$

$= 365\text{ J}$

so $-170 = Q - 365$ $\quad Q(CA) = 195\text{ J}$

3. (30 pts) A spring (k = 540 N/m) has a 3.0 kg mass attached. The spring is stretched by some amount and released from rest, free to oscillate back and forth on a frictionless, horizontal surface. The velocity of the mass as it passes through equilibrium is 3.1 m/s.

a) What is the mechanical energy of the system?
b) What is the maximum distance the mass reaches from the spring's equilibrium point?
c) At what distance from the equilibrium point is the velocity of the mass equal to half its maximum speed?

$k = 540\ N/m$

$m = 3.0\ kg$

$V_{max} = 3.1\ m/s$

a) $E = \frac{1}{2}kx^2 + \frac{1}{2}mv^2$

At $x = 0$, $v = v_{max}$, so

$E = \frac{1}{2}mv_{max}^2 = 14.4\ J$

b) $14.415\ J = \frac{1}{2}kA^2$

$0.0534 = A^2 \Rightarrow A = 0.23\ m$

c) $v = \sqrt{\frac{k}{m}(A^2 - x^2)}$   $V_{max} = \sqrt{\frac{k}{m}A^2}$

so let $\sqrt{\frac{k}{m}(A^2 - x^2)} = \frac{1}{2}\sqrt{\frac{k}{m}A^2}$

$\frac{k}{m}(A^2 - x^2) = \frac{1}{4}\frac{k}{m}A^2$

$A^2 - x^2 = \frac{1}{4}A^2$

$\frac{3}{4}A^2 = x^2$

$x = \sqrt{\frac{3}{4}}A = 0.20\ m$