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) A tank contains 3.8 moles of Oxygen. The pressure in the tank changes from 32 atm to 12 atm while the temperature is lowered from 85°C to 15°C. How many moles are added to or withdrawn from the tank for this change to occur? Assume the volume of the tank does not change.

$n_1 = 3.8$ moles $\quad n_2 = ?$

$P_1 = 32$ atm $\quad P_2 = 12$ atm

$T_1 = 358$ K $\quad T_2 = 288$ K

$V_1 = V_2$

$$\frac{n_2}{n_1} = \frac{\left(\frac{P_2}{P_1}\right)\left(\frac{V_2}{V_1}\right)}{\left(\frac{R}{R}\right)\left(\frac{T_2}{T_1}\right)} = \frac{\left(\frac{12}{32}\right)\left(\frac{1}{1}\right)}{\left(\frac{1}{1}\right)\left(\frac{288}{358}\right)} = 0.466$$

$$n_2 = (0.466)(3.8) = 1.77 \text{ moles}$$

$$n_2 - n_1 = \boxed{2.0 \text{ moles removed}}$$

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 220°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.

$m_w = .054$ $\quad m_i = 5.2$

$c_w = 4186$ $\quad c_i = 448$

$T_w = 25°C$ $\quad T_i = 220°C$

Warming: Heat water to 100°C $Q = (.054)(4186)(75) \approx 16953$ J

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

138993 J

Cooling: Cool iron to 100°C $Q = (5.2)(448)(-120) = -279552$

$|Q|$ to cool iron $> |Q|$ to turn water to steam

so all water vaporizes and $T_F > 100°C$

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

$138993 + (.054)(2010)(T_F - 100) + (5.2)(448)(T_F - 220) = 0$

$138993 + 108.54 T_F - 10854 + 2329.6 T_F - 512512 = 0$

$2438.14 T_F = 384373$

$T_F = 158$ or $\boxed{160°C}$

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 natural oscillation period of this spring?

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

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

b) At what value of x is the speed equal to exactly half of its maximum possible speed?

a) $T = 2\pi\sqrt{\frac{m}{k}} = \boxed{1.4\ s}$

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

c) $\frac{1}{2}mv^2 = 4.7$

$v = \sqrt{\frac{2(4.7)}{m}} = \boxed{1.2\ m/s}$

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

$0.603^2 = \frac{140}{6.5}(.26^2 - x^2)$

$0.364 = 21.5(.0676 - x^2)$

$0.0169 = .0676 - x^2$

$x^2 = .05067$

$\boxed{x = 0.23\ m}$