Physics 10154 - Exam #5c

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) 2.0 moles of gas is in a piston chamber at an initial temperature of 25°C and pressure of 4.5 atmospheres. The pressure remains constant while the volume is increased by a factor of 2.5. Assume the amount of gas in the chamber remains constant.

a) What is the new temperature of the gas?

b) How much work is done by the gas during this process?

$n_1 = 2.0 \qquad n_2 = 2.0$

$P_1 = 4.5\ atm \qquad P_2 = 4.5\ atm = 455850\ Pa$

$\frac{V_2}{V_1} = 2.5$

$T_1 = 298 K$

$$\frac{T_2}{T_1} = \frac{\left(\frac{P_2}{P_1}\right)\left(\frac{V_2}{V_1}\right)}{\left(\frac{n_2}{n_1}\right)\left(\frac{k}{k}\right)} = 2.5$$

$\boxed{T_2 = 745 K}$ or $472°C$

b) $V_1 = \frac{n_1 R T_1}{P_1} = \frac{(2.0)(8.31)(298)}{455850\ Pa} = .01086\ m^3$

$V_2 = 2.5 V_1 = 0.02716\ m^3$

$W = P\Delta V = (455850)(.0163) = \boxed{7400\ J}$

or $nR\Delta T = (2.0)(8.31)(447) = 7400\ J$

2. (40 pts) 35 grams of ice (c = 2090 J/kg-C) at an initial temperature of -81°C is placed into a 74 gram aluminum container (c = 900 J/kg-C) which is filled with 64 grams of water (c = 4186 J/kg-C). Both container and water are at a temperature of 82°C. The latent heat of fusion for water is 333,000 J/kg.

Calculate the final temperature of the system.

If the final temperature is zero, calculate how much ice melts.

Melt ice:

warm ice to 0°C $= (.035)(2090)(81) = 5925\text{ J}$

melt ice $= (.035)(333000) = 11655\text{ J}$

17580 J

Cool Al + water:

cool Al to 0°C $= (.074)(900)(-82) = -5461\text{ J}$

cool water to 0°C $= (.064)(4186)(-82) = -21968\text{ J}$

-27429

$|Q|$ to cool Al + water $>$ $|Q|$ to warm + melt ice

so all ice melts, $T_F > 0$.

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

$$17580 + (.035)(4186)(T_F - 0) + (.064)(4186)(T_F - 82) + (.074)(900)(T_F - 82) = 0$$

$$17580 + 146.51\,T_F + 267.9\,T_F - 21968 + 66.6\,T_F - 5461 = 0$$

$$481.01\,T_F = 9849$$

$$\boxed{T_F = 20°C}$$

3. (30 pts) A pendulum made from aluminum (linear thermal expansion coefficient = 24.0 x 10-6) has a period of 4.40 seconds at a temperature of 20.0 °C. It is desired to increase the period of the pendulum to 4.55 seconds by changing the temperature of the aluminum.

By how many degrees C must the aluminum change to achieve this new period (indicate whether it has to get warmer or cooler)?

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$T^2 = \frac{4\pi^2 l}{g}$$

$$l_1 = \frac{gT^2}{4\pi^2} = \frac{(9.8)(4.4)^2}{4\pi^2} = 4.805866$$

$$l_2 = \frac{(9.8)(4.55)^2}{4\pi^2} = 5.13912$$

$$\Delta l = 0.33326$$

$$\Delta l = l_0 \alpha \Delta T$$

$$.33326 = 4.8059(24 \times 10^{-6})\Delta T$$

$$\boxed{\Delta T = 2890°C}$$