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. (35 pts) An ideal gas is held in a container at a temperature of 65°C in a 2.2 Liter volume at a pressure of 4.0 atm.

a) How many moles of gas are in the container?

b) If the number of moles is held constant and we increase the temperature to 140°C while decreasing the volume by half, what is the new pressure of the gas, in atm?

c) How much work is done by the gas during this change, in Joules?

$T_1 = 65°C = 338K$

$V_1 = 2.2L$

$P_1 = 4.0\,atm$

a) $n_1 = \frac{P_1 V_1}{R T_1}$

$= \frac{(4.0)(2.2)}{(.0821)(338)} = 0.317$

or 0.32 moles

b) $T_2 = 140°C = 413K$

$V_2 = \frac{1}{2} V_1$

$n_2 = n_1$

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

$= \frac{(1)(1)\left(\frac{413}{338}\right)}{0.5} = 2.44$

$P_2 = 2.44 P_1 = 9.775\,atm$ or $9.8\,atm$

$P_{Avg} = \frac{P_1 + P_2}{2} = 6.89\,atm$

$W_{by\,gas} = P_{Avg}\,\Delta V = (6.89\,atm)(-1.1\,L)$

$= (6.98 \times 10^5\,Pa)(-1.1 \times 10^{-3}\,m^3) = -770\,J$

2. (35 pts) 35 grams of ice (c = 2090 J/kg-°C) at an initial temperature of -81°C is placed into a 640 gram aluminum container (c = 900 J/kg-°C) at an initial temperature of 45°C. The latent heat of fusion for water is 333,000 J/kg. Also, the specific heat of water is 4186 J/kg-°C.

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

To heat ice to 0°C : $(.035)(2090)(81) = 5925\ J$

To melt ice : $(.035)(333,000) = 11655\ J$

$17580\ J$

To cool Al to 0°C : $(.640)(900)(-45) = -25920\ J$

So all ice melts, $T_F > 0$

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

$17580 + (.035)(4186)(T_F - 0) + (.640)(900)(T_F - 45) = 0$

$17580 + 146.51 T_F + 576 T_F - 25920 = 0$

$722.51 T_F = 8340$

$T_F = 12°C$

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) $\Delta U(ABC) = 170$

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

$= (4.052 \times 10^5\text{ Pa})(-1.2 \times 10^{-3}\text{ m}^3)$

$= -486\text{ J}$

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

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

$170 = Q + 486$

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

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

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

$= (3.039 \times 10^5\text{ Pa})(1.2 \times 10^{-3}\text{ m}^3)$

$= 365\text{ J}$

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