CHM 104 Team Problem ANSWERS

Chapter 11 (part 2)

#76 (Clausius-Clapeyron Equation)
Use the data below regarding Nitrogen's vapor pressure to determine the: Heat of Vaporization & the normal boiling point.

Temperature (K)	Vapor Press. (torr)
65	130.5
70	289.5
75	570.8
80	1028
85	1718

ANSWER:

1/T	ln P
0.0154	4.871
0.0143	5.668
0.0133	6.347
0.0125	6.935
0.0118	7.449

$y = -713.1x + 15.85$

so

$-713.1 = -\Delta H_{vap} / 8.314$ J/mol K

$\Delta H_{vap} = 5928.7$ J/mol does this make sense compare to water? (40.7 kJ/mol)

Now for the normal BP – when VP = 1atm or 760 torr

$(\ln 760) = -713.1\ (x) + 15.85$

$x = 0.0129\ K^{1-}$ → remember this is 1/T

$T = 77.5$ K → does this make sense? check the chart, check online

#145

The heat of combustion of CH_4 is 890.4 kJ/mol and the heat capacity of water is 75.2 J/mol K. What is the volume of methane (at 298K & 1.00atm) would be needed to convert 1.00L of water (at 298K) to water vapor at 373K?

ANSWER:

To find the volume of a gas use: $PV = nRT$

$V = (nRT) / P$

you know:

- $R = 0.08206$ L atm mol^{1-} K^{1-}
- P = 1atm
- T = 298 K
- n = ?? you don't know the amount of methane needed so...

The amount of methane depends on the amount of heat we will need.

Find the heat needed to convert 1.00L of water from 298K to 373K water vapor.
This will have 2 steps:

- Heat the liquid water from 298K (25^0C) to liquid water at 373K (100^0C)
- Heat the liquid water at 373 K to water vapor at 373K (boil the water)

Step 1: energy needed to heat the liquid to boiling point
$q = m_w C_s \Delta T$
we know the specific heat (C_s) in J $mol^{-1}K^{-1}$ so we need the water in moles

- 1.00L = 1000mL = 1000g (density of water is 1g/mL at 25^0C)
- 1000g (1mol / 18g) = 55.6 mol

$q = (55.6 \text{ mol}) (75.2 \text{ J mol}^{-1} \text{ K}^{1-}) (75\text{K})$ $\quad \Delta T = 373\text{K} – 298 \text{ K}$
q = 313,333 J = 313 kJ

Step 2: energy to boil the water (liquid to vapor)
$\Delta H_{vap} = 40.7$ kJ mol^{-1} (constant from the book)
55.6 mol (40.7kJ / 1mol) = 2263 kJ

Total energy needed: 313 kJ + 2263 kJ = 2576kJ

The Heat of combustion of methane = 890.4 kJ mol^{-1} so we can find the moles of methane needed...

- 2576 kJ (1mol / 890.4 kJ) = 2.89mol methane needed

Plug & chug into PV = nRT!
(1atm) V = (2.89mol)(0.0821 L atm $mol^{-1}K^{-1}$)(298K)
V = 70.7 L of methane