P. Chem I — Lecture 3 — 1/27/23

From HW 2 Problem 4b:

ideal gas adiabatic (reversible) given P_1, P_2, T_1 — what is T_2?

adiabatic → $q = 0$, insulate system

why not 5/2? ↑ you're given c_p — $\bar{C}_p - \bar{C}_v = R$

1^{st} law: $\Delta U = w = \frac{3}{2} nR\Delta T$

$C_v dT = dU \Leftarrow C_v = \left.\frac{\partial U}{\partial T}\right)_V$

What is T_f?

$w = w_{rev} = \frac{3}{2} nR\Delta T = -\int P dV$ — $PV = nRT$

$\frac{3}{2} nR dT = -P dV$ — how does P relate to volume? $P = \frac{nRT}{V}$

$\frac{3}{2} \cancel{nR} dT = -\frac{\cancel{nR}T}{V} dV$ *only real trick, put T with dT

$\frac{3}{2}\frac{dT}{T} = -\frac{dV}{V} \Rightarrow \frac{3}{2}\ln\left(\frac{T_2}{T_1}\right) = -\ln\left(\frac{V_2}{V_1}\right)$

$\frac{3}{2}\ln\left(\frac{T_2}{T_1}\right) = -\ln\left(\frac{\cancel{nR}T_1}{P_1} - \frac{P_2}{\cancel{nR}T_2}\right)$

$\frac{3}{2}\ln\left(\frac{T_2}{T_1}\right) = -\left(\ln\frac{T_2}{T_1} + \ln\frac{P_1}{P_2}\right)$

$\frac{5}{2}\ln\left(\frac{T_2}{T_1}\right) = -\ln\left(\frac{P_1}{P_2}\right)$

$\left(\frac{T_2}{T_1}\right) = -\frac{2}{5}\left(\frac{P_1}{P_2}\right)$

$\left(\frac{T_2}{T_1}\right) = \left(\frac{P_2}{P_1}\right)^{2/5}$

$T_2 = T_1\left(\frac{P_2}{P_1}\right)^{2/5}$

Last Class:

At constant P:

$$\Delta H = H_2 - H_1 = \int_{T_1}^{T_2} C_P \, dT$$

heat capacity of H_2O at 100°C? ∞

$T_1 = 90°C$ liquid $T_2 = 110°C$ vapor water

$$= \int_{90}^{100} C_{P,liq} \, dT + \int_{100}^{100} \infty \, dT \quad \int_{100}^{100} C_{p,vap} \, dT$$

$C_{P,liq}$: ~75 J/K·mol

$\int_{100}^{100} \infty \, dT$ → (sweat) → ΔH_{vap}

$C_{p,vap}$: 33.5 J/K·mol (more than double Cp liquid)

R = 8.31

33.2 J/K·mol

translational $\frac{3}{2}R$ + $\frac{3}{2}R$ rotational + R (Cp vs Cv) (because at constant pressure)

why is Cp liq more than double?
strong intermolecular forces of H_2O.