P. Chem 1 TA Session 2

3.) adiabatic ⇒ $q = 0$

$\Delta U = w$

$$\Delta U = \overset{0}{q} + w$$

$P = -P_{ext}$

$w = -P_{ext}\Delta V$

$\Delta U = nC_v\Delta T$

$$\Delta U = \tfrac{3}{2}nR\Delta T$$

where $C_v = \tfrac{3}{2}R$

$\Delta U = n\bar{C}_v\Delta T$

$\Delta U = C_v\Delta T$

ideal gas $PV = nRT$

$$V = \frac{nRT}{P}$$

$n\bar{C}_v = C_v$

$n\bar{C}_p = C_p$

Cv of diatomic gas

$$\Delta U = \tfrac{5}{2}nRT = -P_{ext}\Delta V$$

$$\Delta U = \tfrac{5}{2}nR\Delta T = -P_{ext}\,\Delta\left(\frac{nRT}{P}\right)$$

$$\Delta U = \frac{\tfrac{5}{2}\cancel{nR}\Delta T}{nR} = \frac{-\cancel{nR}P_{ext}}{nR}\left(\frac{\Delta T}{\Delta P}\right)$$

plug in
solve

$$\Delta U = \tfrac{5}{2}(T_f - T_1) = -P_{ext}\left(\frac{T_f}{P_f} - \frac{T_1}{P_1}\right)$$

$$(T_f - T_1)\cdot\left(\frac{1}{P_f} - \frac{1}{P_1}\right)$$

ΔT $\quad$ $\Delta\frac{1}{P}$

Problem #4

a) $\overset{\Delta T = 0}{\text{isothermal}}$: reversible

$PV = nRT$

$\bar{C}_p = \tfrac{5}{2}R$

boyles law : at $\Delta T = 0$,

$P_1V_1 = P_2V_2$

$$\frac{V_2}{V_1} = \frac{P_1}{P_2}$$

$w = -P_{ext}\Delta V$

$$P = \frac{nRT}{V}$$

$$w = -\int_1^2 P\,dV = -\int_1^2 \frac{nRT}{V}\,dV = -nRT\int_1^2 \frac{dV}{V}$$

$$w = -nRT\ln\left(\frac{V_2}{V_1}\right)$$

$$\int \frac{1}{x} = \ln[x] + C$$

$$P = \frac{nRT}{V}$$

b) $\overset{q=0}{\text{adiabatic}}$: reversible

$\Delta U = w$

$w = -P_{ext}\Delta V$

$\Delta U = n\bar{C}_v\,\Delta T$

$$n\bar{C}_v\Delta T = -P_{ext}\Delta V$$

$$n\bar{C}_v\Delta T = -\left(\frac{nRT}{V}\right)\Delta V$$

$$\frac{\cancel{n}\bar{C}_v\Delta T}{nT} = \frac{-\cancel{n}RT\left(\frac{\Delta V}{V}\right)}{nT}$$

$$\bar{C}_v\left(\frac{\Delta T}{T}\right) = -R\left(\frac{\Delta V}{V}\right)$$

what is $\bar{C}_v$?

$\bar{C}_p - \bar{C}_v = R$

$\tfrac{5}{2}R - \bar{C}_v = R$

$\tfrac{5}{2}R - R = \bar{C}_v$

$\bar{C}_v = \tfrac{3}{2}R$ ⟶

$$\bar{C}_v\int_{T_1}^{T_f}\left(\frac{\Delta T}{T}\right) = -R\int_{V_1}^{V_f}\left(\frac{\Delta V}{V}\right)$$

$$\frac{3}{2}\cancel{\ln}\left(\frac{T_2}{T_1}\right) = -\cancel{\ln}\left(\frac{V_2}{V_1}\right)$$

$$V = \frac{nRT}{P}$$

$$\left(\frac{T_2}{T_1}\right)^{3/2} = \left(\frac{V_1 = \frac{\cancel{nR}T_1}{P_1}}{V_2 = \frac{\cancel{nR}T_2}{P_2}}\right)$$

$$\frac{\left(\frac{T_2}{T_1}\right)^{3/2}}{\left(\frac{T_1}{T_2}\right)^{2/2}} = \frac{\left(\frac{T_1}{T_2}\right)\cdot\left(\frac{P_2}{P_1}\right)}{\left(\frac{T_1}{T_2}\right)^{2/2}}$$

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

once you have T_f, plug back into w

Problem 2

2b) $w = -P_{ext}(V_f - V_1)$

* $1\ L\cdot atm = 101.3\ J$
(work has to be in J)

2c) What is max work done by gas? (path A from notes)

$$w = -P_{ext}\Delta V = -\int_{V_1}^{V_f} P\,dV = \int_{V_1}^{V_f}\left(\frac{nRT}{V}\right)\Delta V = -nRT\ln\frac{V_f}{V_1}$$

$PV = nRT$

$P = \frac{nRT}{V}$

substitute since we don't know P, but we know V_f & V_1

$\Delta T = 0$

Please show your work, how you manipulate the equations is important.