Quiz 2.5 – Adiabatic Expansions

Name: Key

Question 1

An ideal diatomic gas at 25°C starts at a volume of 1.50 L and a pressure of 0.82 atm, and undergoes a reversible adiabatic compression to 0.325 L

$25°C \to 298.15\,K$

diatomic gas $\to C_V = \frac{5}{2}R$ and $C_P = \frac{7}{2}R$

- Find the final pressure after the compression

$\gamma = \frac{C_P}{C_V} = \frac{\frac{7}{2}R}{\frac{5}{2}R} = \frac{7}{5}$ $\quad p_iV_i^{\gamma} = p_2V_2^{\gamma}$ $\quad 0.82\,atm \cdot 1.50\,L^{\frac{7}{5}} = p_2 \cdot 0.325\,L^{\frac{7}{5}}$

$p_2 = 6.98\,atm$

- Find the final temperature after the compression

$c = \frac{C_V}{R} = \frac{\frac{5}{2}R}{R} = \frac{5}{2}$ $\quad V_iT_i^{c} = V_fT_f^{c}$ $\quad \cancel{0.82\,atm} \cdot 1.50\,L \cdot 298.15\,K^{\frac{5}{2}} = 0.325\,L \cdot T_f^{5/2}$

– use roots or logs to solve –

$T_f = 549.7\,K$

- Find the work (w_{sys}) for this process

$w = C_V\Delta T = \frac{5}{2} \cdot 8.314 \frac{J}{mol \cdot K} \cdot 0.05027\,moles \cdot (549.7\,K - 298.15\,K) = 263\,J$

$C_V \to C_{V,m} \cdot n$

Question 2

$n = \frac{pV}{RT} = \frac{\cancel{0.82\,atm \cdot 298.15\,K}\ 0.82\,atm \cdot 1.50\,L}{0.08206 \frac{L \cdot atm}{mol \cdot K} \cdot 298.15\,K} = 0.05027\,moles$

Reversible adiabatic changes involve work, no heat exchange, and are not isochoric, so why are able to use the equation $\Delta U = C_V\Delta T$ when analyzing adiabatic changes?

U is a state function, so we can analyze an alternate path. ~~Namely~~ Namely, an adiabatic path can be replaced by:

1) Isothermal expansion ($\Delta U = 0$)
2) Isochoric heating ($\Delta U = C_V\Delta T$)

Question 3

Reversible adiabatic changes involve no heat exchange, so why are the solutions to Question 1 different for monoatomic, diatomic, and non-linear polyatomic gases?

c and γ depend on C_V and C_P. Even though no heat is exchanged, work leads to a temperature change so heat capacities matter