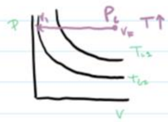
A1: To Perform reversible, constant pressure expansion



One can manipulate the surroundings by keeping the system sufficiently small such that the volume of gas in the surroundings is so large compared to the system that the system's expansion does not create an appreciable difference in the $P_{surroundings}$. (keep $dP_{surr} \approx 0$). Furthermore, the temperature of the system must be increased slowly to create infinitessimal imbalances between system and surroundings : $T_{sys} \approx T_{surr} + dT$ over time the small dT's sum to create an appreciable increase in the T_{sys} which results in an increase in volume @ P_{const} by ($PV\uparrow = nRT\uparrow$)

A2: It is possible. It could work by closing the system after initiating a slow chemical reaction within that gradually and uniformly increases the temperature of the system. This would utilize chemical work to increase the internal energy of the system rather than through heating. The increase in internal energy is transferred to the ideal gas particles as an increase in kinetic energy which increases its volume at constant pressure by the ideal gas law.

A3:

Fit obtained: $\boxed{\gamma = 1.671 \pm 0.005}$

γ for monoatomic gas $= 5/3$ or $1.66\overline{6}$

diatomic gas $= 7/5$ or 1.4

Thus the gas studied was likely $\boxed{\text{monoatomic}}$

A.4:

$$dU = dq + dw = -PdV = C_V\, dT$$

$$-\int \frac{nRT}{V} dV = \int C_V\, dT$$

$$-\int_{V_1}^{V} \frac{nR}{V} dV = \int_{T_1}^{T} \frac{C_V}{T} dT$$

$$-nR \ln\left(\frac{V}{V_1}\right) \cancel{+C} = C_V \ln\left(\frac{T}{T_1}\right) \cancel{+C}$$

$$\ln\left(\frac{V}{V_1}\right) = \frac{-C_V}{nR} \ln\left(\frac{T}{T_1}\right)$$

$$\ln\left(\frac{V}{V_1}\right) = \frac{-C_V}{C_P - C_V} \ln\left(\frac{T}{T_1}\right)$$

$$\ln\left(\frac{V}{V_1}\right) = \frac{1}{-\gamma+1} \ln\left(\frac{T}{T_1}\right)$$

$$(1-\gamma)\ln(V/V_1) = \ln(T/T_1)$$

$$\cancel{\ln}\left(\left(\frac{V}{V_1}\right)^{(1-\gamma)}\right) = \cancel{\ln}(T/T_1)$$

$$\left(\frac{V}{V_1}\right)^{1-\gamma} = \left(\frac{T}{T_1}\right)$$

$$\left(\frac{V}{V_1}\right)^{1-\gamma} = \left(\frac{\frac{PV}{\cancel{nR}}}{\frac{P_1V_1}{\cancel{nR}}}\right)$$

$$\left(\frac{V}{V_1}\right)^{1-\gamma}\left(\frac{V_1}{V}\right) = \frac{P}{P_1}$$

$$\left(\frac{V}{V_1}\right)^{\gamma}\left(\frac{V}{\cancel{V_1}}\right)\left(\frac{\cancel{V_1}}{\cancel{V}}\right) = \frac{P}{P_1}$$

$$\left(\frac{V_1}{V}\right)^{\gamma} = \frac{P}{P_1}$$

$$\frac{V_1^{\gamma}}{V^{\gamma}} = \frac{P}{P_1}$$

$$\frac{P_1V_1^{\gamma}}{V^{\gamma}} = P \qquad \text{let } \lambda = P_1V_1^{\gamma}$$

$$\boxed{\frac{\lambda}{V^{\gamma}} = P}$$

B3:

gas = CO_2

$T = 300K$

$n = 1\,mol$

$V_1 = 0.0005\,m^3$

$V_2 = 0.002\,m^3$

$a = 0.3687\ Pa\ m^6\ mol^{-2}$

$b = 4.62\times10^{-5}\ m^3\ mol^{-1}$

$$W = -\int_{V_1}^{V_F} P\,dV$$

$$= \int \frac{-nRT}{V-nb} + \frac{an^2}{V^2}\,dV$$

$$= -nRT\int \frac{1}{V-nb}\,dV + an^2\int \frac{1}{V^2}\,dV$$

$u = V-nb$

$du = 1\,dV$

$$-nRT\int \frac{1}{u}\,du + an^2\int V^{-2}\,dV$$

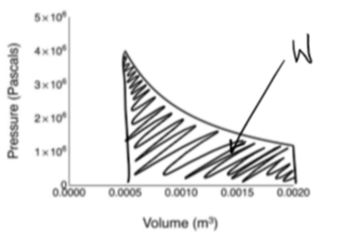
$$-nRT\ln(V-nb)\Big|_{V_1}^{V_F} + \frac{an^2 V^{-1}}{-1}\Big|_{V_1}^{V_F} = -nRT\ln(V_F-nb) + nRT\ln(V_1-nb) + \frac{-an^2}{V_F} + \frac{an^2}{V_1}$$

$$nRT\left[\ln(V_1-nb) - \ln(V_F-nb)\right]$$

$$W = nRT\ln\left(\frac{V_1-nb}{V_F-nb}\right) + an^2\left(\frac{1}{V_1} - \frac{1}{V_F}\right)$$

$$[W] = \cancel{mol}\cdot\frac{m^3\cdot Pa}{\cancel{K}\cdot\cancel{mol}}\cdot\cancel{K} + \frac{Pa\cdot m^{6}}{\cancel{mol^2}}\cancel{mol^2}\cdot\left(\frac{1}{\cancel{m^3}}\right)$$

$$= Pa\cdot m^3 = J$$



$$W = 1\times 8.3145\times 300\times\ln\left(\frac{0.0005 - 1\times4.62\times10^{-5}}{0.002 - 1\times4.62\times10^{-5}}\right) + 0.3687\times1^2\left(\frac{1}{0.0005} - \frac{1}{0.002}\right)$$

$$\boxed{W = -3088.4\ J}$$

B4:

$$U = \frac{3}{2}nRT - \frac{an^2}{V}$$

$V_1 = 0.0005$

$V_F = 0.002$

$$\Delta U = \left(\frac{3}{2}nRT - \frac{an^2}{V_F}\right) + \left[-\frac{3}{2}nRT + \frac{an^2}{V_1}\right]$$

$$\Delta U = \frac{-an^2}{V_F} + \frac{an^2}{V_1} = \frac{an^2}{V_1} - \frac{an^2}{V_F} = an^2\left(\frac{1}{V_1} - \frac{1}{V_F}\right)$$

$$= 0.3687\cdot\left(\frac{1}{0.0005} - \frac{1}{0.002}\right)$$

$$\Delta U\ \boxed{= 553.05\ J}$$

Expansion: $V_F > V_1$
thus, ΔU always > 0
and internal energy increases

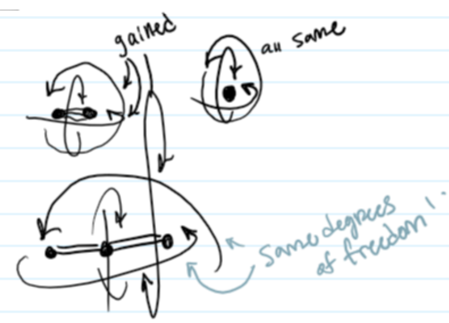
B5:

$$\Delta U = 553.05 = q + w = q - 3088.4\ J$$

$$\boxed{q = 3641.4\ J}$$

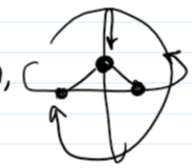
C1:

	C_p	C_v	$C_p - C_v$
Monoatomic:	$5/2\ nR$	$3/2\ nR$	nR
Diatomic:	$7/2\ nR$	$5/2\ nR$	nR
(Bent) Triatomic:	$8/2\ nR$	$6/2\ nR$	nR
Linear Triatomic:	$7/2\ nR$?	$5/2\ nR$	nR



Because a linear triatomic molecule has the same degrees of freedom as a diatomic molecule kinetic energy is stored in the same modes of rotation and thus the C_p is the same. $\therefore$ $\boxed{C_p = \frac{7}{2}nR}$

C2: C_P for H_2O as the bent triatomic molecule gains an additional mode of freedom
Since moving from monoatomic to diatomic gains two degrees of freedom, and increases by $\frac{2}{2}$ adding one additional degree of freedom must increase the C_P by $\frac{1}{2}$



$$\boxed{\therefore C_{P,H_2O} = \frac{8}{2}nR}$$

$n = \frac{1000}{MM}$

$mol = \#\cancel{kg} \frac{1\ mol}{MM\ \cancel{g}} \times \frac{1000\cancel{g}}{1\cancel{kg}}$

$\frac{nRT}{V}$

C3: $C_{P,CO_2} = 0.846 \frac{kJ}{kg\cdot K}$

$C_{P,H_2O} = 1.864 \frac{kJ}{kg\cdot K}$

$$\frac{8}{2}nR = [mol \times \frac{Pa\cdot m^3}{mol\cdot K}]$$

$$\frac{8}{2}R = \frac{\cancel{Pa\,m^3}}{\cancel{mol}\ K} \times \frac{1}{\frac{\cancel{g}}{\cancel{mol}}} \times \frac{1000\cancel{g}}{kg} \times \frac{1\ kJ}{1000\cancel{J}}$$

$$\frac{8}{2} \times R \times \frac{1}{MM} \times \cancel{1000} \times \frac{1}{\cancel{1000}}$$

$$\frac{8}{2} \times 8.3145 \times \frac{1}{18.02} \times \cancel{1000} \times \frac{1}{\cancel{1000}}$$

The bent molecules fit the predicted heat capacity well

$\boxed{\text{Predicted } C_{P,H_2O} = 1.8456}$

Predicted $C_{P,CO_2} = \frac{7}{2} \times R \times \frac{1}{MM_{CO_2}} = \boxed{0.6612 \frac{kJ}{kg\,K}}$

$= \frac{7}{2} \times 8.3145 \times \frac{1}{44.01} =$

The predicted triatomic linear heat capacity is an underestimate of the true value.