$\boxed{40{\cdot}05\ \text{kJ}}$

Thursday, September 16, 2021 10:04 AM

specific → ≡ per unit mass

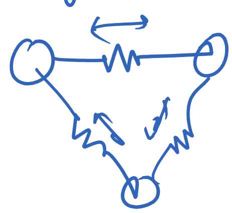
Mono-atomic gas

U = molecular kinetic energy $= \frac{3}{2}RT$

| Equipartition of energy → z y x $\frac{1}{2}R + \frac{1}{2}R$

$U_{\text{Diatomic gas}} = \frac{3}{2}RT + 1\,RT = \frac{5}{2}RT$

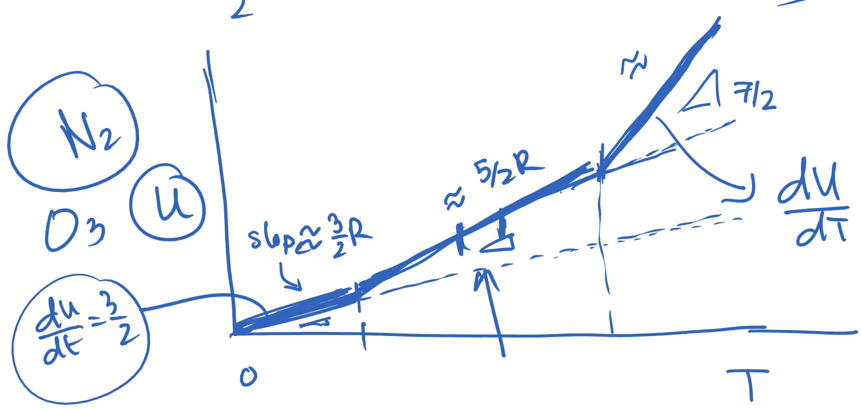
Triatomic gas



Vib. Potential energy
Vib kinetic "

$U_{\text{Triatomic}} = \frac{3}{2}RT + 1\,RT + \frac{1}{2}RT + \frac{1}{2}RT$
$= 7/2\ RT$

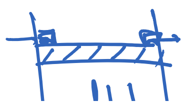
$U = 3/2\ RT$ for Mono atomic
$= \frac{5}{2}\ RT$ " diatomic
$= \frac{7}{2}\ RT$ " triatomic



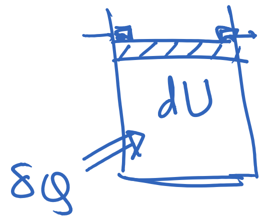
$\frac{dU}{dT} = 7/2$

$\boxed{\frac{dU}{dT} = \frac{5}{2}R}$

$\boxed{\frac{dU}{dt} = \text{Specific Heat}}$



$\delta Q - \delta W = dU$ 1st Law



$$\delta Q - \cancel{\delta W} = dU \quad \text{1st Law}$$

Vol = const

$$\delta Q = dU$$

total internal energy (kJ)

$$C_v = \frac{1}{m}\frac{\delta Q}{dT} = \frac{1}{m}\frac{dU}{dT} = \frac{1}{m}\frac{d(mu)}{dT}$$

sp. internal energy (kJ/K)

$$= \frac{m}{m}\left(\frac{du}{dT}\right)$$

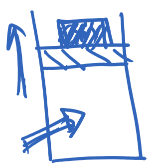
Sp. Heat at const. vol.

$$C_v = \frac{du}{dT}$$

or $\underline{du = C_v\, dT}$

Constant Pressure Process

$\int p\,dV$



$$\delta Q - \delta W = dU$$

$$\Rightarrow \quad \delta Q - p\,dV = dU$$

$$\delta Q = p\,dV + dU \qquad \text{since } p = \text{Const.}$$

$$= d(pV) + dU$$

$$= d(mRT) + d(mu)$$

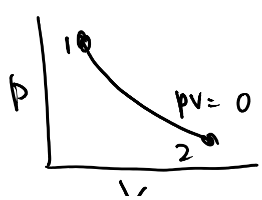
$$\delta Q = m\left[R\,dT + C_v\,dT\right]$$

$$C_p = \frac{1}{m}\frac{\delta Q}{dT} = \frac{1}{\cancel{m}}\frac{\cancel{m}\left[R\,dT + C_v\,dT\right]}{dT} = (R + C_v)$$

$$\Rightarrow \boxed{(C_p - C_v) = R}$$

$$\boxed{(\text{Sp. Heat})_{\text{adiabatic}} = 0 \longrightarrow \quad \delta Q - \delta W = dU}$$

$$(\text{Sp. Heat})_{\text{isoth.}} \neq \qquad \delta Q - \delta W = dU \longrightarrow T$$



$$\delta Q - \delta W = 0$$

$$\int \delta Q = \int \delta W$$

$$Q = \left(P_1 V_1 \ln \frac{V_2}{V_1}\right)$$

$\int \delta q - \int \delta w$

$$\rightarrow \boxed{q = \left(p_1 v_1 \ln \frac{V_2}{V_1}\right)}$$

$$C_{\text{iso thermal process}} = \frac{1}{m}\left(\frac{\delta q}{\delta T \nearrow}\right) \Longrightarrow \infty$$

Specific Heat for a polytropic process

$$pV^n = C$$

$$W_{poly} = \frac{p_1V_1 - p_2V_2}{n-1} = \frac{mR(T_1 - T_2)}{(n-1)}$$

$$q - W = \Delta U$$

$$\boxed{\begin{aligned}\Delta U &= U_2 - U_1 \\ &= m C_v (T_2 - T_1)\end{aligned}}$$

$$C_p - C_v = R$$

$$C_p/C_v - 1 = R/C_v$$

$$\text{or } (\gamma - 1) = R/C_v$$

$$\Rightarrow \boxed{R = C_v(\gamma - 1)}$$

$$q_{pa} = W + \Delta U$$

$$= \frac{mR(T_1 - T_2)}{n-1} + m C_v (T_2 - T_1)$$

$$= m C_v \frac{\gamma - 1}{n-1}(T_1 - T_2) + m C_v (T_2 - T_1)$$

$$= m C_v (T_2 - T_1)\left[1 - \frac{\gamma - 1}{n-1}\right]$$

$$= m C_v (T_2 - T_1) \frac{n - \cancel{1} - \gamma + \cancel{1}}{n-1}$$

$$\boxed{Q = m C_v (T_2 - T_1)\left(\frac{n-\gamma}{n-1}\right)}$$

$$C_n = \frac{1}{m}\frac{Q}{\Delta T} = \frac{1}{\cancel{m}} \frac{1}{\cancel{(T_2 - T_1)}} \cancel{m} C_v \cancel{(T_2 - T_1)} \left(\frac{n-\gamma}{n-1}\right)$$

$$\boxed{C_n = C_v\left(\frac{n-\gamma}{n-1}\right)}$$

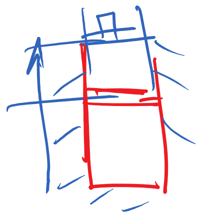
$$\boxed{pV^\gamma = C}$$

If $n = \gamma$, $C_n = 0 \Rightarrow$ Adiabatic process

2 kg of air expands adiabatically from 10 bar & 600 K to 1 bar. Find final temp. & work done

$m = 2\,kg$

Work done



$m = 2\,kg$

$p_1 = 1000\ kPa$ | $p_2 = 1\,bar \Rightarrow 100$

$T_1 = 600\ K$ | $T_2 =$

$600\ K \rightarrow 310.8\ K$

Take $\gamma_{air} = 1.4$

$$W = \frac{mR(T_1 - T_2)}{(\underset{\gamma}{n} - 1)} = \frac{mR(T_1 - T_2)}{(\gamma - 1)}$$

$$\boxed{\frac{T_2}{T_1} = \left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}} = \left(\frac{V_1}{V_2}\right)^{n-1}}$$

$$T_2 = T_1 \left(\frac{1}{10}\right)^{\frac{0.4}{1.4}}$$

$$= 310.8\ K$$

Work is done at the expense of internal energy