1) a) 1 mole of water = 18 gram. $\longrightarrow$ # of moles in our body = $\frac{80\text{ Kg}}{18\text{ gram}} \sim$

Weight of our body = 80 Kg

$\sim \frac{80\text{ Kg}}{20\text{ gram}} = 4\times 10^{3}$ mole $\rightarrow$ # of water molecules in our body =

$4\times10^{3} \times 6.23\times10^{23} \sim 25\times10^{26}$. $=: N_0$

b) Area of the planet Earth $\sim 4\pi R^{2} \sim 4\pi\times(6700\times10^{3})^{2} \sim$

$12\times(6.7)^{3}\times10^{10}\ m^{2} \simeq 500\times10^{10}\ m^{2}$

Area of oceans $\sim \frac{3}{4}\times$ Area of earth $\sim 400\times10^{10}\ m^{2}$

Average depth of Oceans $\sim (100-1000)\ m \rightarrow$

Volume of Oceans $\sim 4\times10^{14} - 4\times10^{15} \longrightarrow$ Rounding $10^{14-15}\ m^{3}$

Volume of a droplet $\sim$ O $\sim 10\ mm^{3} \sim 10\times10^{-9}\ m^{3} = 10^{-8}\ m^{3}$

$\rightarrow$ # droplets of water in the ocean $\sim 10^{22-23} =: N_1$

$\rightarrow$ $\boxed{N_0 \gtrsim 10^{5-6}\ N_1}$

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2) $\left(P + \frac{a}{v^2}\right)(v - b) = RT$

We want $\left(\frac{\partial v}{\partial T}\right)_P$.

$$\rightarrow \left(dp - \frac{2a}{v^3}dv\right)(v-b) + \left(P + \frac{a}{v^2}\right)(dv) = RdT$$

we set $dp = 0 \rightarrow$ $$dv\left[P + \frac{a}{v^2} - \frac{2a}{v^3}(v-b)\right] = RdT$$

$$\rightarrow dv\left[P - \frac{a}{v^2} + \frac{2ab}{v^3}\right] = RdT \rightarrow$$

$$\left(\frac{\partial v}{\partial T}\right)_p = \frac{R}{P - \frac{a}{v^2} + \frac{2ab}{v^3}}$$ inserting P from the

equation of stat $\rightarrow$ $$\boxed{\left(\frac{\partial v}{\partial T}\right)_p = \frac{R}{\frac{RT}{v-b} - \frac{2a}{v^2} + \frac{2ab}{v^3}}}.$$

---

problem 3: we have $\left(P + \frac{a}{v^2}\right)(v-b) = RT \rightarrow$

$(A) :=$ ~~یکای کمیت~~ A ~~مرو~~ $m =$ متر $Kg =$ ~~کیلوگرم~~ , $s =$ ثانیه $\rightarrow$

$$(b) = m^3 \qquad (a) = m^6 \times (p) = m^6 \times \frac{(F)}{m^2}$$

$$(F) = Kg \times m \times s^{-2} \rightarrow (a) = m^4 \times Kg \times m \times s^{-2} = Kg \times m^3 \times s^{-2}.$$

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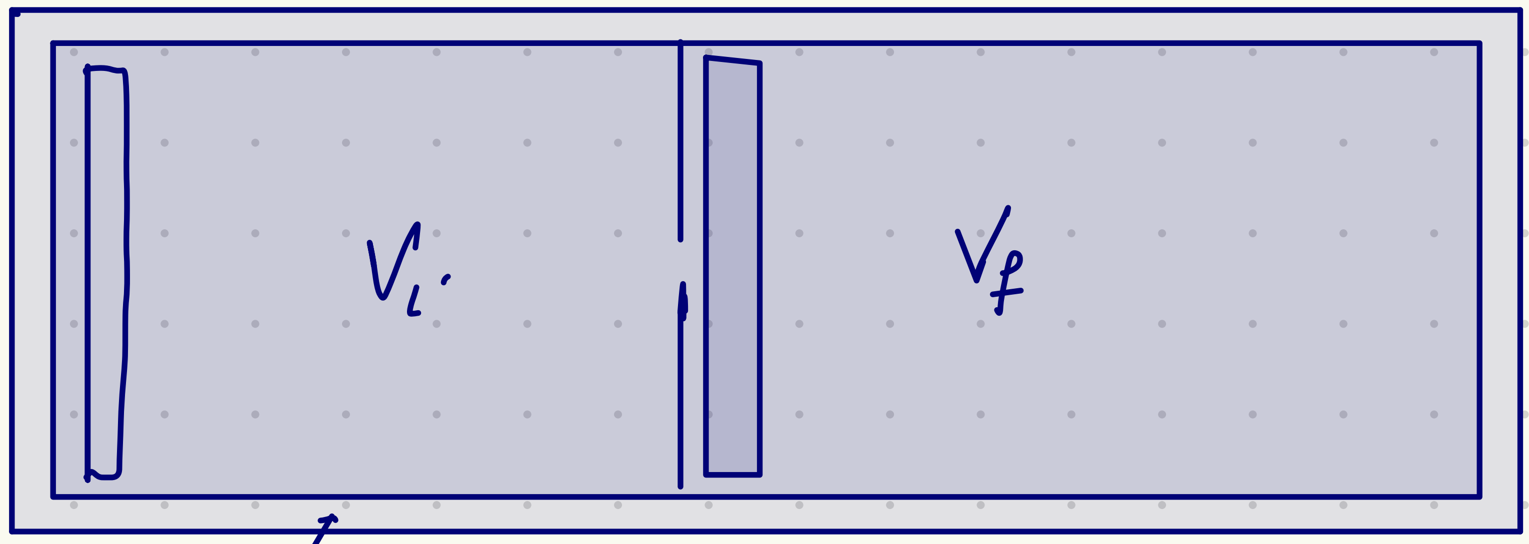
problem 4:



دیواره‌ی بی‌دررو.

First law for the gas on the left: $0 - U_i = Q_i + P_i V_i$ ①

پیستون سمت چپ روی گاز سمت چپ کار انجام داده است.

Second law for the gas on the right:

$U_f - 0 = Q_f - P_f V_f$ ②

گاز سمت راست روی پیستون سمت راست کار انجام داده است.

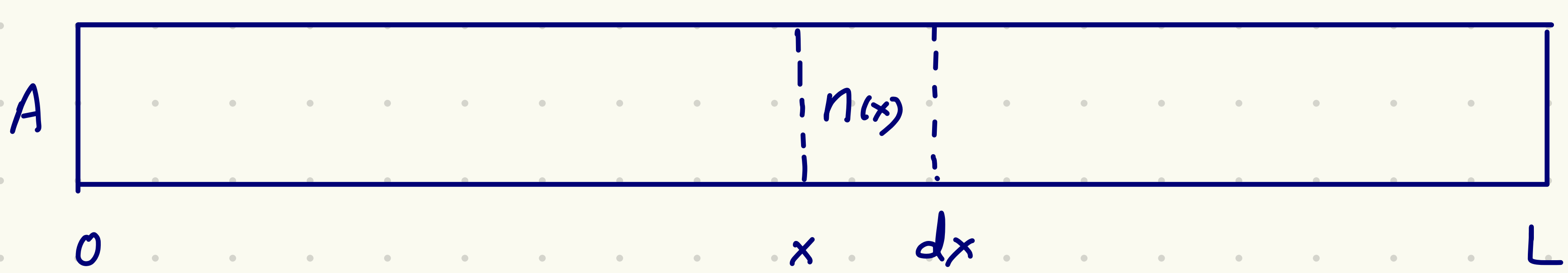
Adiabatic walls $\rightarrow$ $Q_i + Q_f = 0$.

① + ② $\longrightarrow$ $-U_i + U_f = P_i V_i - P_f V_f$ $\longrightarrow$ $U_f + P_f V_f = U_i + P_i V_i$

---

problem 5.

سطح مقطع



$n(x) =$ تعداد ذرات درون بازه‌ی x, $x+dx$ ①

$\nu(x) =$ تعداد ذرات در واحد حجم ②

①, ② $\longrightarrow$ $n(x) = \nu(x) A dx$.

Equation of state for the gas inside x & $x+dx$:

$$PV = nRT \longrightarrow P(A\,dx) = n(x)\,R\,T(x) = (\nu(x)\,A\,dx)\,R\,T(x)$$

$\rightarrow$ Eliminating $A\,dx$ from both sides $\longrightarrow$ $P = \nu(x)\,R\,T(x)$

$$\rightarrow \quad \nu(x) = \frac{P}{R\,T(x)} = \frac{P}{R\left[T_0 + \frac{T_L - T_0}{L}x\right]}$$

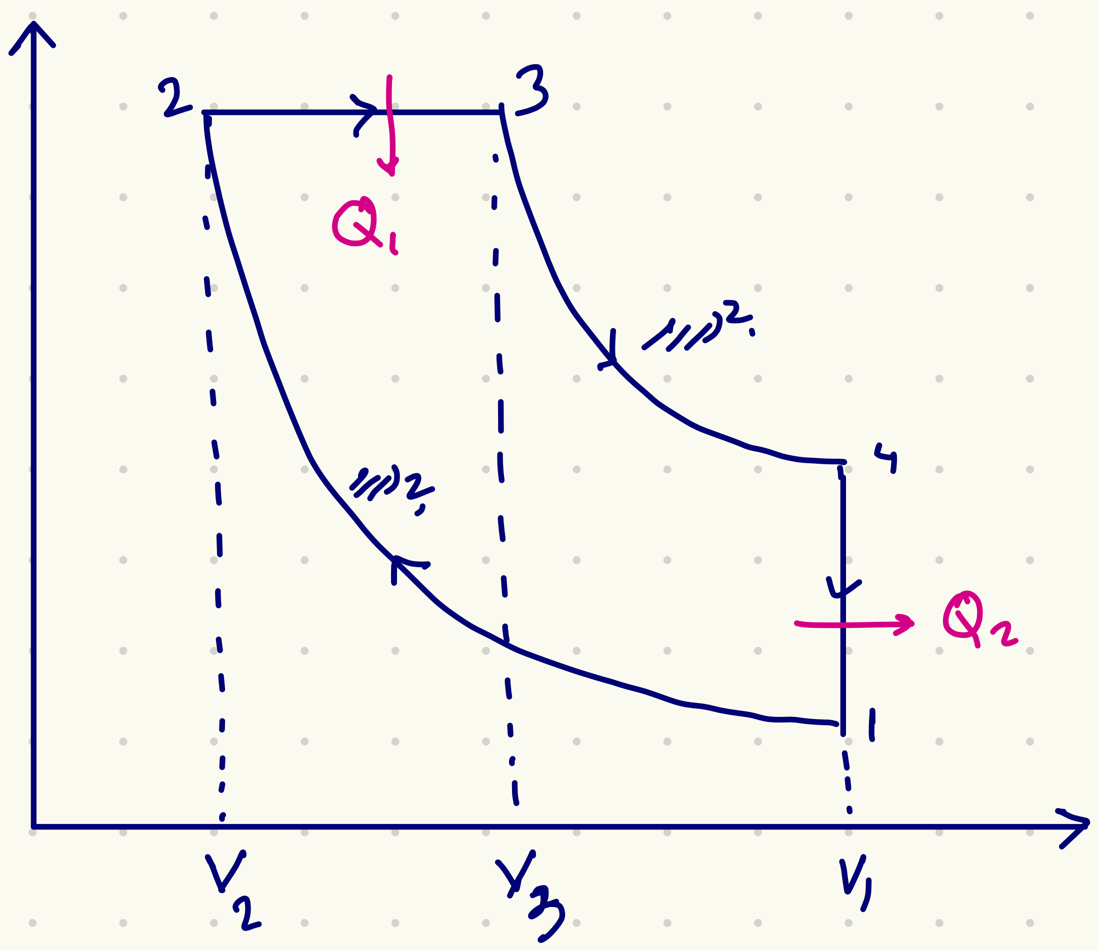
n = total number of moles $= \int_0^L \nu(x)\,A\,dx \longrightarrow$

$$n = \frac{AP}{R}\int_0^L \frac{dx}{T_0 + \frac{T_L - T_0}{L}x} = \frac{AP}{R}\,\frac{L}{T_L - T_0}\,\ln\left(\frac{T_L}{T_0}\right)$$

Since $AL = V \longrightarrow$ $$\boxed{PV = \frac{nR(T_L - T_0)}{\ln(T_L/T_0)}}$$

---

problem 6.



$$Q_H = C_p(T_3 - T_2)$$
$$Q_L = C_v(T_4 - T_1) \longrightarrow \eta = 1 - \frac{Q_L}{Q_H} = 1 - \frac{C_v}{C_p}\,\frac{T_4 - T_1}{T_3 - T_2}$$

$$\rightarrow \eta = 1 - \frac{1}{\gamma}\,\frac{T_4 - T_1}{T_3 - T_2} \qquad (1)$$

Since $1 \to 2$ is adiabatic $\longrightarrow$ $T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$ (2)

Since $3 \to 4$ is adiabatic $\longrightarrow$ $T_4 V_1^{\gamma-1} = T_3 V_3^{\gamma-1}$ (3)

Equation of state in $2 \to 3$: $\frac{T_3}{V_3} = \frac{T_2}{V_2}$. (4)

So in (1) we first express T_1 & T_4 (using 2 & 3) in terms of T_2 & T_3

$$\rightarrow \eta = 1 - \frac{1}{\gamma}\,\frac{\left(\frac{V_3}{V_1}\right)^{\gamma-1} T_3 - \left(\frac{V_2}{V_1}\right)^{\gamma-1} T_2}{T_3 - T_2}$$

$\longrightarrow$ چون V_2, V_3 متناسب با T_2, T_3 هستند و هر دو در مخرج و صورت قرار دارند

پس به جای T_2, T_3 ، V_2, V_3 قرار دادیم. $\longleftarrow$

Using (4) $\rightarrow$

$$\eta = 1 - \frac{1}{\gamma}\,\frac{\left(\frac{V_3}{V_1}\right)^{\gamma-1} V_3 - \left(\frac{V_2}{V_1}\right)^{\gamma-1} V_2}{V_3 - V_2}$$

با تقسیم صورت و مخرج بر V_1 و استفاده از تعاریف $\leftarrow r_c = \frac{V_1}{V_2}$, $r_E = \frac{V_1}{V_3}$

$$\eta = 1 - \frac{1}{\gamma}\,\frac{\left(\frac{1}{r_E}\right)^{\gamma-1} - \left(\frac{1}{r_c}\right)^{\gamma-1}}{\frac{1}{r_E} - \frac{1}{r_c}}$$