

4ο Κεφάλαιο. Νόμοι θερίαν - Κινητική Θεωρία. Απαντήσεις

A. Ερωτήσεις κλειστών τύπων.

4.1 α-Σ, β-Σ, γ-Σ, δ-Λ Σωστές οι α, β, γ

4.2 $A(P, V, T) \rightarrow B(P', V, T')$ $T' = T + \frac{300}{100}T = 4T$, $P' = 6P \Rightarrow P' = 4P$

Σωστή η (β)

4.3 $T_1 = 273 + \theta_1 = 273 + 17 = 290K$, $P_2 = 2P_1 \Rightarrow T_2 = 2T_1 = 2 \cdot 290K = 580K$

$T_2 = 273 + \theta_2 \Rightarrow 580 = 273 + \theta_2 \Rightarrow \theta_2 = 307^\circ C$ Σωστή η (δ)

4.4 α-Λ, β-Σ, γ-Λ, δ-Λ Σωστή η (β)

4.5. α. $\rho_2 = \frac{\rho_1}{3} \Rightarrow \frac{m_2}{V_2} = \frac{m_1}{3V_1} \Rightarrow \frac{m_2}{V_2} = \frac{m_1}{3V_1} \Rightarrow V_2 = 3V_1 \Rightarrow V_2 > V_1$, α-λίστος

β. $p = 6P \Rightarrow \frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow \frac{V_1}{T_1} = \frac{3V_1}{T_2} \Rightarrow T_2 = 3T_1$ β-λίστος

γ. $p = 6P$ γ-λίστος

δ. $\Delta V = V_2 - V_1 = 3V_1 - V_1 = 2V_1$, $\pi\% = \frac{\Delta V}{V_1} 100\% = \frac{2V_1}{V_1} 100\% = 200\%$ δ-λίστος

4.6 α. $pV = nRT$... δυνατότητα να γινεί η σχέση να εξαρτάται από το είδος του αερίου

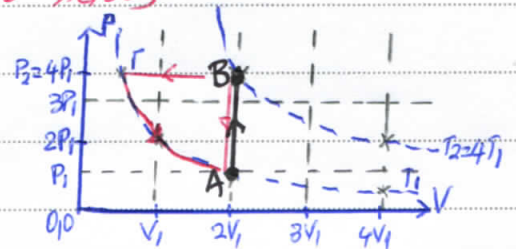
β. $pV = 6P \Rightarrow V' = \frac{V}{2}$ β-λίστος

γ. $pV = nRT \Rightarrow p = \frac{nR}{V} T \Rightarrow p = \frac{nR}{V} T \xrightarrow{T=6P} p = 6P \cdot e$, γ-λίστος

δ. $p = 6P$, $\frac{V}{T} = 6P \Rightarrow V' = 2V \Rightarrow T' = 2T$ δ-λίστος

4.7. α-λίστος β-λίστος $\rightarrow \eta_{BA}$

$\eta_{B \rightarrow A}$
δ-λίστος δ-λίστος

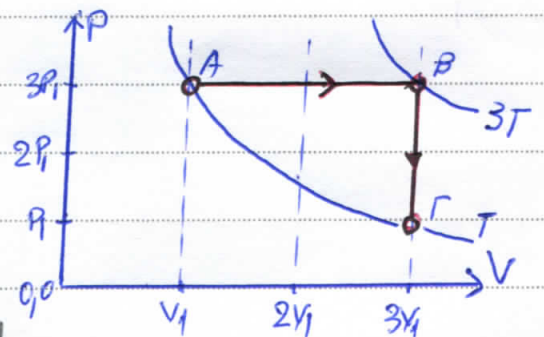


4.8 α. $P_A V_A = P_B V_B$ α-λίστος

β. $V_B = 3V_A$ β-λίστος

γ. - λίστος

δ. - λίστος



4.9 α-λίστος. Δεν γράφει σταθερή η ποσότητα

β. $P_B V = 2n \cdot R \cdot 2T \Rightarrow P_B = 4P_A$ β-λίστος

γ. $P_A V = nRT$ λίστος

δ. $\frac{P_A V_A}{T_A} = 2R$, $\frac{P_B V_B}{T_B} = 2nR$... δ-λίστος

$A(P, V, T, n) \rightarrow A'(P, V, T, 2n)$
 $\downarrow$
 $B(P, V, 2T, 2n)$

4.10. Ήπειρδη στο δοχείο έχει ομοιογενή στρώση - αν δεχθείς
αρχή αερίων - η πίεση που ασκεί είναι ίση με
αυτή της ατμόσφαιρας, $p = p_{atm} = σταθερή$. (προσέχουμε η
φυσική δεν είναι ιδιότητα γιατί γεννιέται η ποσότητα)

α- Αξία του νόμου της διατήρησης α- λάθος

β- σωστό

γ- λάθος

δ- σωστό

4.11. $A(p, V, T, e, v_{rms}, K) \xrightarrow{\text{ισοβαρής}} B(p', V', T', e', v'_{rms}, K')$

α. $A: v_{rms} = \sqrt{\frac{3RT}{M_r}}$, $B: v'_{rms} = \sqrt{\frac{3RT'}{M_r}}$ $v'_{rms} = 2v_{rms} \Rightarrow \sqrt{\frac{3RT'}{M_r}} = 2\sqrt{\frac{3RT}{M_r}} \Rightarrow T' = 4T$ α- λάθος

β. $p = σταθ$, $\frac{V}{T} = σταθ \Rightarrow V' = 4V$ β- λάθος

γ. $e = \frac{m_{O_2}}{V_B} = \frac{m_{O_2}}{4V_A} = \frac{e_A}{4} \Rightarrow e' = \frac{e}{4}$ γ- σωστό

δ. $K = \frac{3}{2}KT \Rightarrow \gamma$ - σωστό

4.12

α. $pV = nRT \Rightarrow p = \frac{m_{O_2}}{V M_r} RT \Rightarrow p = \frac{e}{M_r} RT \xrightarrow{T=σταθ} p = σταθ \cdot e$ (p, e σταθερά) α- σωστό

β. Στην ισόχωρη $e = \frac{m_{O_2}}{V} = σταθερή$, β- σωστό

γ. $p = \frac{e}{M_r} RT \Rightarrow eT = \frac{p M_r}{R} \xrightarrow{p=σταθ} eT = σταθ$ γ- λάθος (e, T δυνηστικά ανάλογα)

δ. $p = \frac{1}{3} e v_{rms}^2 \Rightarrow e v_{rms}^2 = 3p \xrightarrow{p=σταθ} e v_{rms}^2 = σταθ$ δ- σωστό

4.13. Ισοβαρής $pV = σταθ$, $T = σταθ$, $V' = 4V$, $p' = \frac{p}{4}$, $e = σταθ \cdot p$, $e' = \frac{e}{4}$, $v_{rms} = σταθερή$,
α- λάθος β- λάθος γ- σωστό δ- σωστό
 $E = σταθερή$

4.14. $\bar{v}_A^2 = 2\bar{v}_B^2$: $v_{rms,A} = \sqrt{\bar{v}_A^2}$, $v_{rms,B} = \sqrt{\bar{v}_B^2}$ $\Rightarrow v_{rms,A}^2 = 2v_{rms,B}^2 \Rightarrow \frac{3RT_A}{M_r} = 2\frac{3RT_B}{M_r}$
 $\hookrightarrow v_{rms,A}^2 = \bar{v}_A^2$ $\hookrightarrow v_{rms,B}^2 = \bar{v}_B^2$ $\Rightarrow T_A = 2T_B$

α- λάθος

β- λάθος

γ- σωστό

δ- σωστό

Ισοβαρής $p_A = 2p_B$

Ισοβαρής $V_A = 2V_B$

4.15. α-λόθος β-λόθος γ-λόθος δ-λόθος
 $\delta. K_{\text{ολ}} = N\bar{K} = nN_A \frac{3}{2} \frac{R}{N_A} T = \frac{3}{2} nRT$ δ-σωστό

4.16 α-λόθος β-λόθος γ-λόθος δ-λόθος
 $\delta. \bar{K} = \frac{3}{2} kT = \frac{3}{2} \frac{RT}{N_A} = \frac{3}{2} \frac{nRT}{nN_A} = \frac{3}{2} \frac{PV}{nN_A} \xrightarrow{P=\text{const}} \Rightarrow \bar{K} \propto V$ γ-σωστό δ-λόθος

4.17 α-λόθος. Γιατί είναι $p, \bar{u}^2$ ανάλογα στην ιδόθεση της κεφαλής
 πράγμα η πυκνότητα ρ να είναι $\propto \frac{1}{V}$... υασι
 παν δεν ισχύει

β-σωστό Από την $P = \frac{1}{3} \rho \bar{u}^2$ εφόσον $\rho \propto \frac{1}{V}$ και $\bar{u}^2 \propto T$, $P \propto \frac{T}{V}$
 γ-σωστό δ-σωστό $K_{\text{ολ}} = N\bar{K} = nN_A \frac{3}{2} \frac{R}{N_A} T = \frac{3}{2} nRT = \frac{3}{2} pV$

4.18 $A(p, V, T, n) \rightarrow B(p', V, T, 2n)$

α. $p = \frac{nRT}{V}$, $p' = \frac{2nRT}{V}$ άρα $p' = 2p$ α-σωστό

β. $\bar{K} = \frac{3}{2} kT$ ίδια β-λόθος

γ. $K_{\text{ολ}} = \dots = \frac{3}{2} pV$, $K_{\text{ολ},A} = \frac{3}{2} pV$, $K_{\text{ολ},B} = \frac{3}{2} 2pV = 2K_{\text{ολ},A}$ γ-σωστό

δ. $\bar{u}_{\text{ΕΝ}} = \sqrt{\frac{3RT}{M_r}}$ δ-σωστό

ε. $c = \frac{m_{\text{ολ}}}{V} = \frac{nM_r}{V}$, $c_A = \frac{n_A M_r}{V}$, $c_B = \frac{2n_A M_r}{V} = 2c_A$ ε-λόθος

B. Ερωτήσεις και ασκήσεις

4.19

$$\alpha) P_2 = \frac{n_2 R T_2}{V} \quad P_1 = \frac{n_1 R T_1}{V}$$

$$P_2 > P_1 \Rightarrow \frac{n_2 R T_2}{V} > \frac{n_1 R T_1}{V} \Rightarrow n_2 T_2 > n_1 T_1$$

$$n_A T_A = 2 n_B \cdot \frac{T_B}{3} = \frac{2}{3} n_B T_B \Rightarrow n_B T_B = \frac{3}{2} n_A T_A \Rightarrow n_B T_B > n_A T_A$$

↳ Εξωτερική Πρόσθεση

$$\alpha \rightarrow [2 \rightarrow B \quad 1 \rightarrow A]$$

$$\beta) \left. \begin{array}{l} P_A V = n_A R T_A \\ P_B V = n_B R T_B \end{array} \right\} \frac{P_B}{P_A} = \frac{n_A R T_A}{n_B R T_B} \Rightarrow \frac{P_B}{P_A} = \frac{\frac{2}{3} n_B T_B}{n_B T_B} = \frac{2}{3} \Rightarrow P_B = \frac{2}{3} P_A$$

$$\eta) P_A = \frac{3}{2} P_B \Rightarrow P_A = \frac{3}{2} \cdot 4 \text{ atm} \Rightarrow P_A = 6 \text{ atm}$$

Από αω om η σελ m β.3

4.20

$$[\varphi_1 > \varphi_2 \Rightarrow \varepsilon \varphi_1 > \varepsilon \varphi_2 \Rightarrow \frac{P_1}{T} > \frac{P_2}{T} \Rightarrow P_1 > P_2]$$

$$\Rightarrow \frac{n_1 R T}{V_1} > \frac{n_2 R T}{V_2} \Rightarrow \frac{n_1}{V_1} > \frac{n_2}{V_2} \xrightarrow{n_1 = n_2} V_2 > V_1$$

$$\alpha \rightarrow A \quad \beta \rightarrow B$$

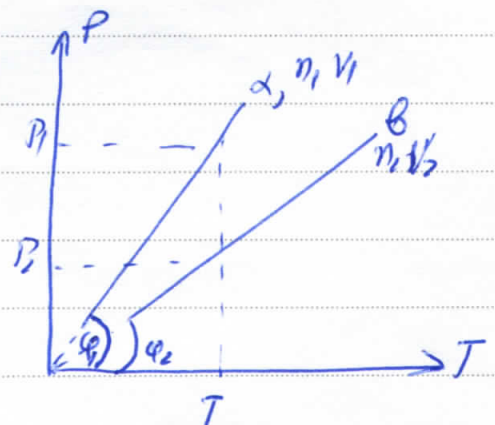
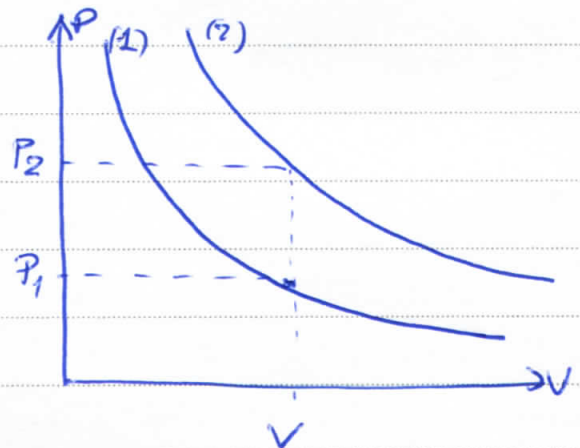
$$\varepsilon \varphi = \frac{P}{T} = \frac{\frac{n R T}{V}}{T} = \frac{n R}{V} \Rightarrow \varepsilon \varphi = \frac{n R}{V}$$

$$\varphi_1 > \varphi_2 \Rightarrow \varepsilon \varphi_1 > \varepsilon \varphi_2 \Rightarrow \frac{n R}{V_1} > \frac{n R}{V_2} \Rightarrow V_2 > V_1$$

ως αω m αω αω

$$\alpha \rightarrow A$$

$$\beta \rightarrow B$$



4.24 γέωχηρη μεταβολή $\frac{P}{T} = \text{const} = \frac{nR}{V}$

1^ο στάδιο $\frac{P}{T} = \frac{nR}{V_1} = 1000 \text{ SI}$

2^ο στάδιο $\frac{P}{T} = \frac{nR}{V_2} = \frac{nR}{2V_1} = \frac{nR}{4V_1} = \frac{1000}{4} = 250$

$\Rightarrow P = 250 T \text{ (SI)}$ Άρα σωστή η (α)

4.25 γέωθετη μεταβολή

1^η ποσότητα: $PV = 450 = nRT \text{ (SI)}$

2^η ποσότητα: $PV = n_2 RT_2 = 1,5n_1 R \cdot \frac{T_1}{3} = \frac{n_1 RT_1}{2} = \frac{450}{2} = 225 \text{ SI}$

$\Rightarrow PV = 225 \text{ (SI)}$ Άρα σωστή η (β)

4.26 γέωχηρη μεταβολή

$(P_1 = 2,8 \text{ atm}, T_1 = 273 + 17 = 290 \text{ K}) \Rightarrow (P_2 = ?, T_2 = 273 + 51 = 324 \text{ K})$

$\frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow P_2 = \frac{P_1}{T_1} T_2 \Rightarrow P_2 = \frac{2,8 \text{ atm}}{290 \text{ K}} \cdot 324 \text{ K} \Rightarrow P_2 = 3,24 \text{ atm}$

Άρα σωστή η (α)

4.27 γέωθετη μεταβολή

$(V_1 = 2,8 \text{ L}, T_1 = 273 + 7 = 280 \text{ K}) \Rightarrow (V_2 = ?, T_2 = 273 + 127 = 400 \text{ K})$

$\frac{V_2}{T_2} = \frac{V_1}{T_1} \Rightarrow V_2 = \frac{V_1}{T_1} T_2 \Rightarrow V_2 = \frac{2,8 \text{ L}}{280 \text{ K}} \cdot 400 \text{ K} \Rightarrow V_2 = 4 \text{ L}$

$\Delta V = V_2 - V_1 = 1,2 \text{ L}$

Άρα σωστή η σχέση (α)

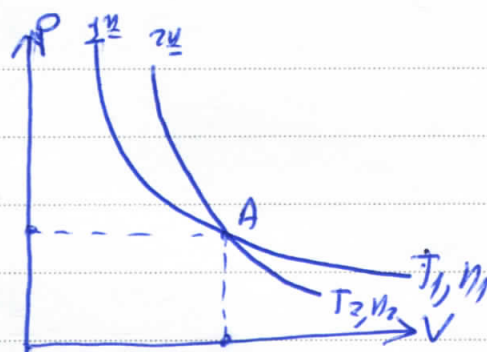
4.28 γράψτε ότι οι δύο γασόμενοι
τον σταθερό τένομα
στο A

Για τον γασόμενο (1) ισχύει

$$P_1 V_1 = n_1 R T_1 \xrightarrow{A} P_A V_A = n_1 R T_1$$

Για τον γασόμενο (2) ισχύει

$$P_2 V_2 = n_2 R T_2 \xrightarrow{A} P_A V_A = n_2 R T_2$$



$$\dots n_1 R T_1 = n_2 R T_2 \Rightarrow n_1 T_1 = n_2 T_2$$

Κάθε γασόμενος περιγράφεται από την $PV = nRT$ άρα
η διαφορετικότητα των γασόμενων καθορίζεται από
το πηλίκο nT .

Γδω ότως $n_1 T_1 = n_2 T_2$ έχω αποδείξει ότι οι δύο γασόμενοι

4.29. $v_{\text{RMS}} = \sqrt{\frac{3RT}{M_r}} \Rightarrow v_{\text{RMS}}^2 = \frac{3RT}{M_r}$

$$v_{1,\text{RMS}}^2 = \frac{3RT_1}{M_r}$$

$$v_{2,\text{RMS}}^2 = \frac{3RT_2}{M_r}$$

$$v_{2,\text{RMS}} = 2v_{1,\text{RMS}} \Rightarrow v_{2,\text{RMS}}^2 = 4v_{1,\text{RMS}}^2$$

$$\Rightarrow \frac{3RT_2}{M_r} = 4 \frac{3RT_1}{M_r} \Rightarrow T_2 = 4T_1 \Rightarrow T_2 = 4(273 + 17) = 4 \cdot 290 \Rightarrow$$

$$T_2 = 1160 \text{ K} \Rightarrow 273 + \theta_2 = 1160 \Rightarrow \theta_2 = 887 \text{ }^\circ\text{C}$$

Απόσπασμα η' (α)

4.30 α) γόναρες φέρωλας
 σε δόχεια γάλα θάλλω

$$\epsilon\phi\varphi = \frac{P}{T} = \frac{nR}{V}$$

$$\epsilon\phi\varphi_B > \epsilon\phi\varphi_A \Rightarrow \frac{n_{B,R}}{V} > \frac{n_{A,R}}{V}$$

$$\Rightarrow n_B > n_A \Rightarrow \frac{m_{B,R}}{M_{R,B}} > \frac{m_{A,R}}{M_{R,A}}$$

$$\Rightarrow M_{R,A} > M_{R,B}$$

$$Μο'φα κορνω = m = \frac{m_{R,B}}{N} = \frac{n M_{R,B}}{n N_A} = \frac{M_{R,B}}{N_A} \quad \left. \vphantom{\frac{m_{R,B}}{N}} \right\} \Rightarrow \frac{M_{R,A}}{N_A} = \frac{M_{R,B}}{N_A}$$

$$\Rightarrow m_{\text{κορνω}, A} > m_{\text{κορνω}, B} \quad \text{Άρα α-βωστή}$$

β) $v_{\text{EN}} = \sqrt{\frac{3RT}{M_R}}$

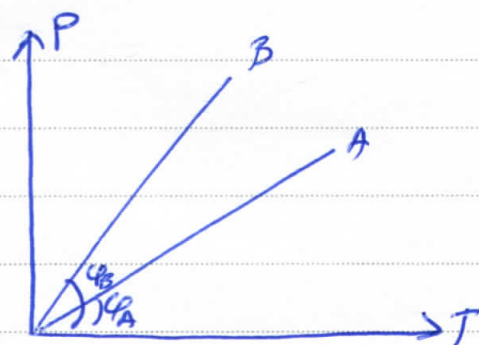
$$\left. \begin{aligned} v_{\text{EN},A} &= \sqrt{\frac{3RT}{M_{R,A}}} \\ v_{\text{EN},B} &= \sqrt{\frac{3RT}{M_{R,B}}} \end{aligned} \right\} \frac{v_{\text{EN},A}}{v_{\text{EN},B}} = \sqrt{\frac{M_{R,B}}{M_{R,A}}} < 1 \Rightarrow v_{\text{EN},A} < v_{\text{EN},B}$$

Άρα β-γάλας

γ) $P = \frac{1}{3} \rho v_{\text{EN}}^2 = \frac{1}{3} \frac{m_{R,B}}{V} v_{\text{EN}}^2$

$\frac{m_{R,B}}{V}$ ίδιο και για τα δύο θέρια

Άρα στο ίδιο πίεση έχουμε ίδιο v_{EN}
 γ-γάλας



4.31 γ ιδιότητα γενική $\frac{V}{T} = \frac{nR}{P} \Rightarrow V = nR \frac{V}{P} \Rightarrow T = \frac{V}{6n\alpha\theta}$

$$v_{\text{rms}}^2 = \frac{3RT}{M_r} \Rightarrow v_{\text{rms}}^2 = \frac{3R}{M_r} \cdot \frac{V}{6n\alpha\theta} \neq v_{\text{rms}}^2 = 6n\alpha\theta V \Rightarrow V = 6n\alpha\theta \cdot v_{\text{rms}}^2$$

Άρα αμεν $n(\alpha)$

$$\left. \begin{array}{l} v_{\text{rms}}^2 = \frac{3RT}{M_r} \\ V = \frac{nRT}{P} \end{array} \right\} \frac{v_{\text{rms}}^2}{V} = \frac{3P}{nM_r} = \frac{3P}{m_g} = 6n\alpha\theta \Rightarrow \underline{V = 6n\alpha\theta v_{\text{rms}}^2}$$

Πιο εύκολα $P = \frac{1}{3} \rho v_{\text{rms}}^2 = \frac{1}{3} \frac{m_g}{V} v_{\text{rms}}^2 \Rightarrow V = \frac{m_g}{3P} v_{\text{rms}}^2 \Rightarrow V = 6n\alpha\theta v_{\text{rms}}^2$
 $L = \frac{m_g}{3P}$

$$\left. \begin{array}{l} \bar{K} = \frac{3}{2} kT = \frac{3}{2} \frac{R}{N_A} T \\ V = \frac{nRT}{P} \end{array} \right\} \frac{\bar{K}}{V} = \frac{\frac{3}{2} \frac{RT}{N_A}}{\frac{nRT}{P}} = \frac{3}{2} \frac{P}{n \cdot N_A} = \frac{3}{2} \frac{P}{m_g} = 6n\alpha\theta$$

$\Rightarrow \bar{K} = 6n\alpha\theta V$ γ ιδιότητα γενική $n(\alpha)$

Άρα γ ιδιότητα οι (α) και (β)

4.32. γ ιδιότητα γενική $V = 6n\alpha\theta$

$$\left. \begin{array}{l} \bar{K} = \frac{3}{2} \frac{R}{N_A} T \\ P = \frac{nRT}{V} \end{array} \right\} \frac{\bar{K}}{P} = \frac{3}{2} \frac{V}{nN_A} = \frac{3}{2} \frac{V}{m_g} = 6n\alpha\theta \Rightarrow \bar{K} = 6n\alpha\theta P$$

$$P = \frac{1}{3} \rho v_{\text{rms}}^2 \Rightarrow P = \frac{1}{3} \frac{m_g}{V} v_{\text{rms}}^2 \Rightarrow P = 6n\alpha\theta v_{\text{rms}}^2$$

$L = 6n\alpha\theta P$ γ ιδιότητα γενική $n(\alpha)$

Άρα αμεν $n(\alpha)$ α, β

4.33 Υπόθεση γειώσης

$$1^{\circ} \text{ Σχέση: } P = \frac{1}{3} \rho v_{\text{EN}}^2 = \frac{1}{3} \frac{m_{\text{H}}}{V} v_{\text{EN}}^2 \Rightarrow P = 0,5 v_{\text{EN}}^2 \text{ (SI)} \quad \frac{m_{\text{H}}}{3V} = 0,5 \text{ (SI)}$$

$$2^{\circ} \text{ Σχέση: } P = \frac{1}{3} \rho' v_{\text{EN}}^2 = \frac{1}{3} \frac{3m_{\text{H}}}{2V} v_{\text{EN}}^2 = \frac{3}{2} \frac{m_{\text{H}}}{3V} v_{\text{EN}}^2 = \frac{3}{2} 0,5 v_{\text{EN}}^2 = 0,75 v_{\text{EN}}^2$$

$$\Rightarrow P = 0,75 v_{\text{EN}}^2 \text{ (SI)}$$

Άρα βωστή η σχέση (8)

4.34 Υπόθεση $\bar{K} = 6 \cdot 10^{-26} \cdot p$ (SI)

$$\begin{aligned} \text{δοτίζεται} \quad \left. \begin{aligned} \bar{K} &= \frac{3}{2} \frac{R}{N_A} T \\ \frac{P}{T} &= \text{const} = \frac{nR}{V} \Rightarrow P = \frac{nR}{V} T \end{aligned} \right\} \frac{\bar{K}}{P} &= \frac{\frac{3}{2} \frac{R}{N_A}}{\frac{nR}{V}} = \frac{3}{2} \frac{V}{nN_A} = \frac{3}{2} \frac{V}{N} \\ \frac{3}{2} \frac{V}{N} &= 6 \cdot 10^{-26} \text{ (SI)} \end{aligned}$$

$$\text{Ποιεί} \quad \frac{\bar{K}}{P} = \frac{3}{2} \frac{2V}{N} = 2 \cdot \frac{3}{2} \frac{V}{N} = 2 \cdot 6 \cdot 10^{-26} = 12 \cdot 10^{-26}$$

$$\text{Άρα } \bar{K} = 12 \cdot 10^{-26} \cdot p \text{ (SI)}$$

Σωστή η (α)

Υπόθεση

$$4.35 \quad \left. \begin{aligned} \bar{K} &= \frac{3}{2} \frac{R}{N_A} T \\ V &= \frac{nR}{P} T \end{aligned} \right\} \Rightarrow \frac{\bar{K}}{V} = \frac{\frac{3}{2} \frac{P}{nN_A}}{\frac{nR}{P} T} = \frac{3}{2} \frac{P}{N} = \text{const} \Rightarrow \bar{K} = \text{const} \cdot V$$

$$\Rightarrow \bar{K} = \text{const} \cdot A \cdot y \Rightarrow \bar{K} = \text{const} \cdot y$$

α - βωστή

$$\begin{aligned} \text{β)} \quad \left. \begin{aligned} v_{\text{EN}}^2 &= \frac{3PT}{Mr} \\ V &= \frac{nR}{P} T \end{aligned} \right\} \Rightarrow \frac{v_{\text{EN}}^2}{V} = \frac{3P}{nMr} \Rightarrow \frac{v_{\text{EN}}^2}{V} = \frac{3P}{M_{\text{O}_2}} = \text{const} \\ \Rightarrow v_{\text{EN}}^2 &= \text{const} \cdot A \cdot y \Rightarrow \\ v_{\text{EN}}^2 &= \text{const} \cdot y \end{aligned}$$

Άρα β - βωστή

$$b) \quad V = 6 \text{ m/s} \quad T \Rightarrow Ay = 6 \text{ m/s}^2 T \Rightarrow T = \frac{A}{6 \text{ m/s}^2} Y \Rightarrow T = 6 \text{ m/s}^2 Y$$

Арақ ж-сұрақ

$$c) \quad P = 6 \text{ m/s}^2 \quad \text{Арақ ж-сұрақ}$$

Αερίδες και πρобиήματα

4.36

$$m_{\text{gas}} = 48 = 4 \cdot 10^3 \text{ kg} \quad V = 8L = 8 \cdot 10^{-3} \text{ m}^3$$

$$c = \frac{m_{\text{gas}}}{V} = \frac{48}{8L} = 0,5 \text{ g/L}$$

Γενικά: $pV = \text{const}$ $c = \text{const}$

$$a) \quad \frac{c_{\text{max}}}{p_{\text{max}}} = \frac{c}{p} \Rightarrow \frac{0,5}{p_{\text{max}}} = \frac{1,6}{8,4} \Rightarrow p_{\text{max}} = 2,625 \text{ atm}$$

e)	$p (\text{atm})$	$V (L)$	$c (\text{g/L})$
A	2,625	8L	0,5 g/L
B	3,5	6,4L	0,625 g/L
Γ	3,2	5,0L	0,8 g/L
Δ	4,0	4,0L	1,0 g/L
E	5,0	3,2L	1,25 g/L
Z	6,4	2,5L	1,6 g/L

$$4.37 \quad A = 0,04 \text{ m}^2 \quad h = 32 \text{ cm} \quad B = 200 \text{ N}$$

$$d) \quad P_{\text{atm}} = P_{\text{atm}} + \frac{B}{A} = 10^5 \frac{\text{N}}{\text{m}^2} + \frac{200 \text{ N}}{0,04 \text{ m}^2}$$

$$\Rightarrow P_{\text{atm}} = 10^5 \frac{\text{N}}{\text{m}^2} + 50 \cdot 10^2 = 100 \cdot 10^3 + 5 \cdot 10^3$$

$$\Rightarrow P_{\text{atm}} = 105 \cdot 10^3 \Rightarrow P_{\text{atm}} = 1,05 \cdot 10^5 \text{ N/m}^2$$

$$V_1 = A h$$

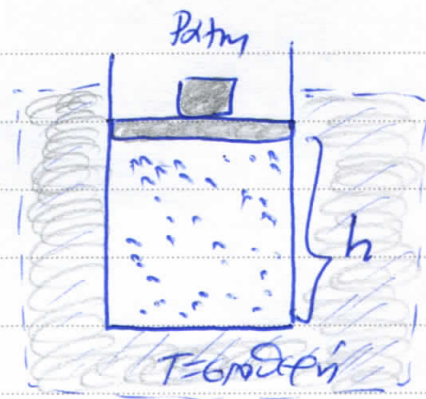
e) 1000 g/cm³

$$f) \quad \dots \quad P_2 = 0, \quad V_2 = A(h - \Delta y)$$

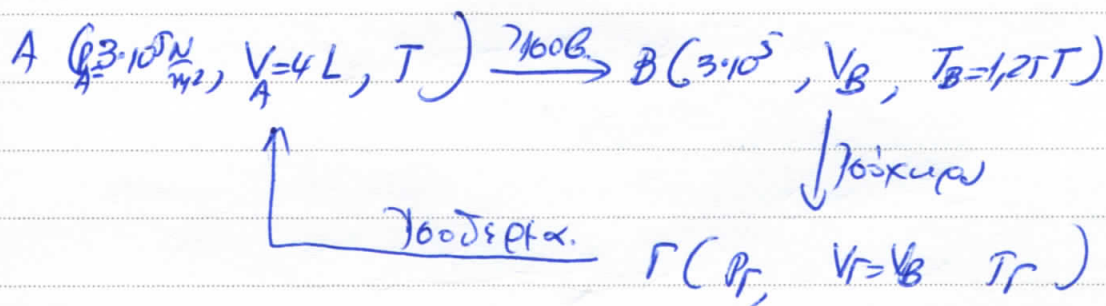
$$P_1 V_1 = P_2 V_2 \Rightarrow P_1 A h = P_2 A (h - \Delta y) \Rightarrow P_2 = P_1 \frac{h}{h - \Delta y} \Rightarrow P_2 = 1,05 \cdot 10^5 \frac{\text{N}}{\text{m}^2} \cdot \frac{32 \text{ cm}}{30 \text{ cm}}$$

$$\Rightarrow P_2 = 1,12 \cdot 10^5 \text{ N/m}^2$$

$$g) \quad P_2 = P_{\text{atm}} + \frac{B'}{A} \Rightarrow (P_2 - P_{\text{atm}}) A = B' \Rightarrow B' = 0,12 \cdot 10^5 \cdot 0,04 \Rightarrow B' = 480 \text{ N}$$



4.38 $m_2 = 98g$ $M_r = 28 \text{ g/mole} \Rightarrow n = \frac{m_2}{M_r} = \frac{98g}{28 \text{ g/mole}} = 3.5 \text{ mole}$



AB: $\frac{V}{T} = \text{const} \Rightarrow \frac{V_A}{T_A} = \frac{V_B}{T_B} \Rightarrow \frac{4 \text{ L}}{T} = \frac{V_B}{1.25T} \Rightarrow V_B = 5 \text{ L}$

B Γ : 100°C isobar $V_r = V_B \Rightarrow V_r = 5 \text{ L}$

A Γ : 100°C isobar $P_A V_A = P_r V_r \Rightarrow P_r = \frac{P_A V_A}{V_r}$

$\Rightarrow P_r = \frac{3 \cdot 10^5 \text{ N/m}^2 \cdot 4 \text{ L}}{5 \text{ L}} \Rightarrow P_r = 2.4 \cdot 10^5 \text{ N/m}^2$

B Γ : $\frac{P}{T} = \text{const} \Rightarrow \frac{P_B}{T_B} = \frac{P_r}{T_r} \Rightarrow \frac{3 \cdot 10^5}{1.25T} = \frac{2.4 \cdot 10^5}{T_r} \Rightarrow T_r = T$

$\hookrightarrow$ Δεν κεραυδεται AT 100°C isobar $T_r = T_A = T$

$P_A V_A = n R T \Rightarrow T = \frac{P_A V_A}{n R} \Rightarrow T = \frac{3 \cdot 10^5 \text{ N/m}^2 \cdot 4 \cdot 10^{-3} \text{ m}^3}{0.4 \text{ mole} \cdot \frac{25 \text{ J/mole}}{3 \text{ mol K}}} \Rightarrow T = 360 \text{ K}$

$T_A = 360 \text{ K}$

$T_B = 360 \cdot 1.25 = 450 \text{ K}$

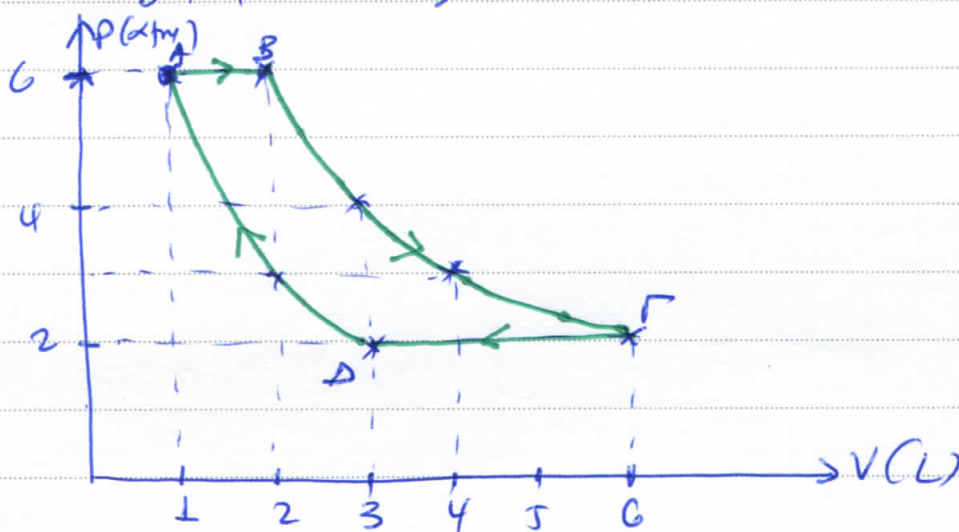
$T_r = T_A = 360 \text{ K}$

	P	V	T
A	$3 \cdot 10^5 \text{ N/m}^2$	4 L	360 K
B	$3 \cdot 10^5 \text{ N/m}^2$	5 L	450 K
Γ	$2.4 \cdot 10^5 \text{ N/m}^2$	5 L	360 K

4039

- $A (P_A = 6 \text{ atm}, V_A = 1 \text{ L}, T_A = 300 \text{ K})$
 $B (P_B = 6 \text{ atm}, V_B = 2 \text{ L}, T_B = 600 \text{ K})$
 $\Gamma (P_\Gamma = 2 \text{ atm}, V_\Gamma = 6 \text{ L}, T_\Gamma = 600 \text{ K})$
 $\Delta (P_\Delta = 2 \text{ atm}, V_\Delta = 3 \text{ L}, T_\Delta = 300 \text{ K})$
 $A (P_A = 6 \text{ atm}, V_A = 1 \text{ L}, T_A = 300 \text{ K})$
- $\left. \begin{matrix} A \\ B \end{matrix} \right\} 1600 \text{ J}$
 $\left. \begin{matrix} \Gamma \\ \Delta \end{matrix} \right\} 1600 \text{ J}$
 $\left. \begin{matrix} \Delta \\ A \end{matrix} \right\} 1600 \text{ J}$

	P	V	T
A	6 atm	1 L	300 K
B	6 atm	2 L	600 K
Γ	2 atm	6 L	600 K
Δ	2 atm	3 L	300 K

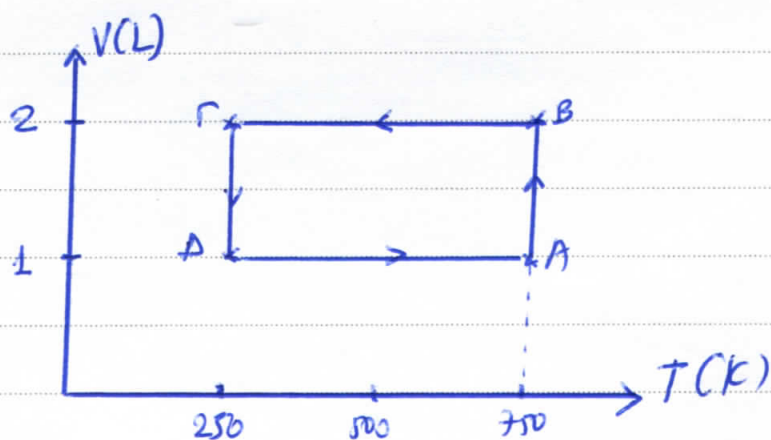
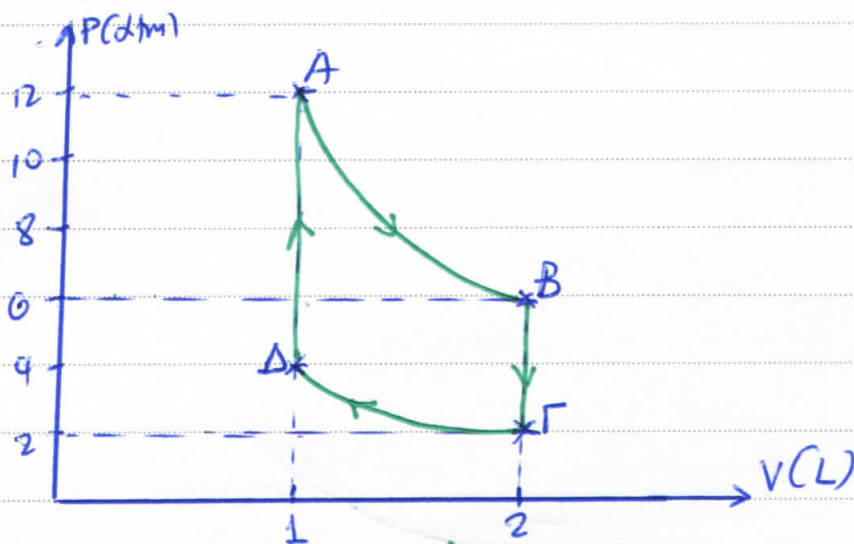


4.40 A (12 atm, 1L, 700K) } 1600 J/mol
 B (6 atm, 2L, 700K) }

Γ (2 atm, 2L, 250K) } 700 J/mol
 Δ (4 atm, 1L, 250K) }

Δ (4 atm, 1L, 250K) } 1600 J/mol

A (12 atm, 1L, 700K) } 700 J/mol

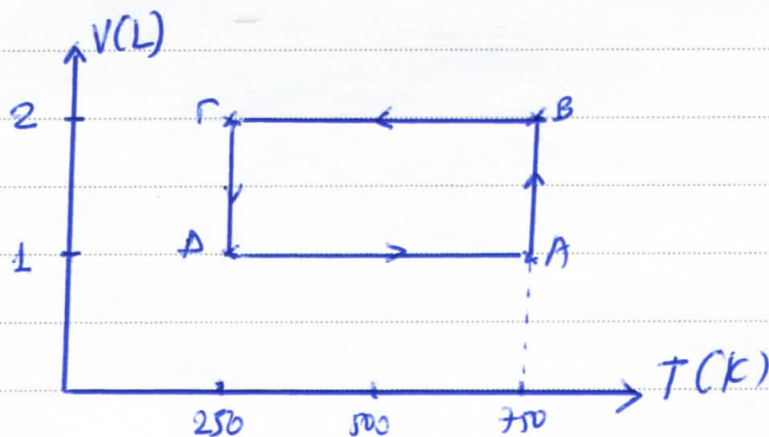
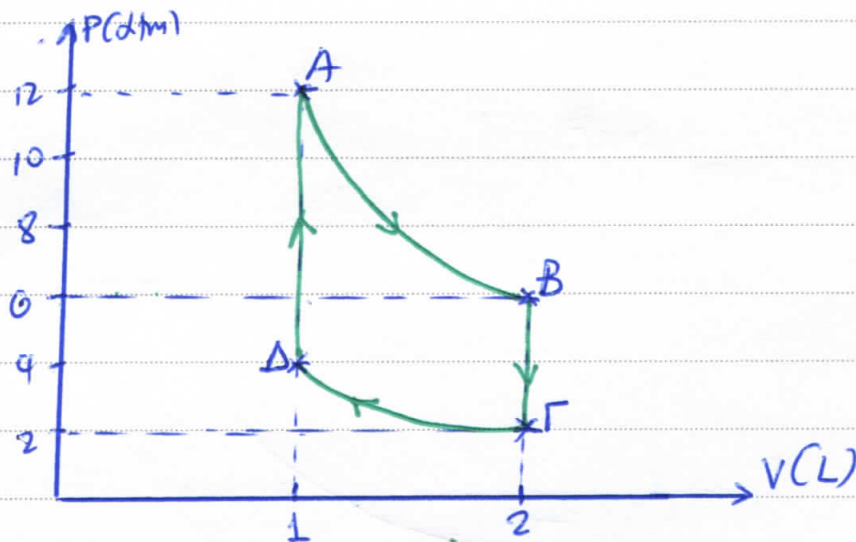


4.40 A (12 atm, 1L, 700K) } 1600 J
 B (6 atm, 2L, 700K) }

Γ (2 atm, 2L, 250K) } 700 J

Δ (4 atm, 1L, 250K) } 1600 J

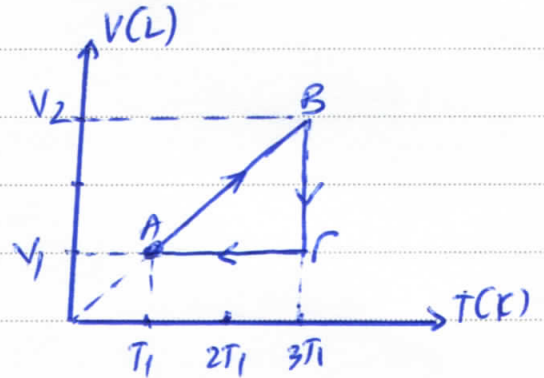
A (12 atm, 1L, 700K) } 700 J



4.41

$$T_B = 900K \Rightarrow 3T_1 = 900K \Rightarrow T_1 = 300K$$

- d) AB: V, T αντιστοίχα $\Rightarrow \frac{V}{T} = \text{const}$
 $\rightarrow$ Ισοβαρής διεύθυνση
 ΒΓ: Ισοβαρής συμπίεση
 ΓΑ: Ισοχωρή ψύξη



- α) A ($P_A = 2,4 \text{ atm}$, $V_A = V_1 = 1,5L$, $T_A = T_1 = 300K$) } 700 βαρ
 B ($P_B = 2,4 \text{ atm}$, $V_B = 3V_1 = 4,5L$, $T_B = 3T_1 = 900K$) }
 Γ ($P_\Gamma = 7,2 \text{ atm}$, $V_\Gamma = V_1 = 1,5L$, $T_\Gamma = T_B = 900K$) } 700 βαρ
 $P_\Gamma V_\Gamma = P_B V_B \Rightarrow P_\Gamma \cdot 1,5 = 2,4 \cdot 4,5 \Rightarrow P_\Gamma = 7,2 \text{ atm}$

4.42 A. (2 atm , V_1 , $300K$)

$$P_A V_A = nRT_A \Rightarrow V_A = \frac{nRT_A}{P_A} = \frac{0,4 \text{ mole} \cdot \frac{8,314 \text{ J}}{\text{mole} \cdot K} \cdot 300K}{2 \cdot 10^5 \text{ N/m}^2} = 5 \cdot 10^{-3} \text{ m}^3 = 5L$$

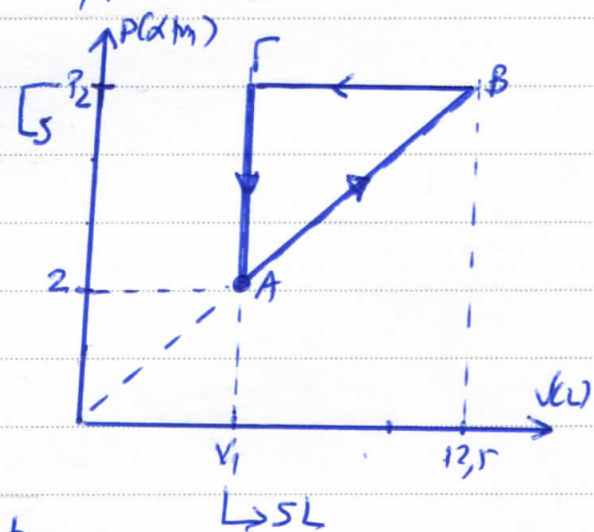
$$\Rightarrow V_A = 500 \cdot 10^{-6} \text{ m}^3 = 5 \cdot 10^{-3} \text{ m}^3 = 5L$$

A (2 atm , $5L$, $300K$.)

AB: Ισοβαρής διεύθυνση
 $P = \text{const}$ $\Rightarrow \frac{P_B}{P_A} = \frac{V_A}{V_B}$

$$\frac{P_B}{2} = \frac{5}{12,5} \Rightarrow P_B = \frac{2}{5} = 0,4 \text{ atm}$$

$$\frac{P_A V_A}{T_A} = \frac{P_B V_B}{T_B} \Rightarrow \frac{2 \text{ atm} \cdot 5L}{300K} = \frac{0,4 \text{ atm} \cdot 12,5L}{T_B} \Rightarrow T_B = 187,5K$$



$$BF : \gamma_{\text{όμοιοι}} \quad \frac{V}{T} = \text{const} \Rightarrow \frac{V_B}{T_B} = \frac{V_r}{T_r} \Rightarrow \frac{135L}{1875K} = \frac{5L}{T_r} \Rightarrow T_r = 700K$$

ΓΑ : $\gamma_{\text{όμοιοι}}$

$$\begin{aligned} \text{B.) } A & (P_A = 2 \text{ atm}, V_A = 5L, T_A = 300K) \\ B & (P_B = 5 \text{ atm}, V_B = 135L, T_B = 1875K) \\ \Gamma & (P_r = 5 \text{ atm}, V_r = 5L, T_r = 700K) \end{aligned}$$

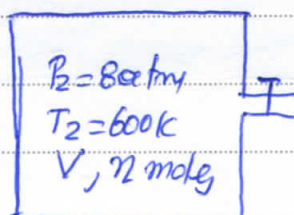
4.43

α) Αφαιρέστε ένα ποσό θερμότητας

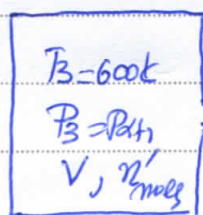
$$\left. \begin{aligned} P_1 &= 4 \text{ atm} & T_1 &= 273 + 27 = 300K \\ B &=? & T_2 &= 273 + 327 = 600K \end{aligned} \right\} \frac{P_2}{P_1} = \frac{T_2}{T_1} \Rightarrow P_2 = \frac{P_1}{T_1} \cdot T_2 \Rightarrow$$

$$\Rightarrow P_2 = \frac{4 \text{ atm} \cdot 600K}{300K} \Rightarrow P_2 = 8 \text{ atm}$$

β.)



$$P_2 V = n R T_2$$



$$P_3 V = n' R T_3$$

$$\begin{aligned} P_3 &= P_{atm} \\ V &= V_A \\ P_A &= P_{atm} \end{aligned}$$

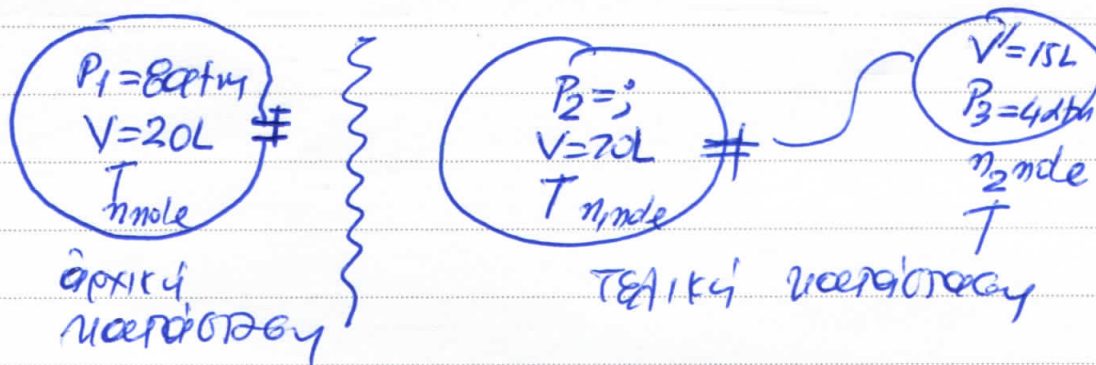
$$\begin{aligned} \text{Επειδή } P_3 &= P_{atm} \Rightarrow P_3 = P_{atm} \\ \Rightarrow P_3 &= 1 \text{ atm} \end{aligned}$$

$$\delta) \frac{P_3 V}{P_2 V} = \frac{n' R T_3}{n R T_2} \Rightarrow \frac{P_3}{P_2} = \frac{n'}{n} \Rightarrow n' = n \frac{P_3}{P_2} \Rightarrow$$

$$\Rightarrow \frac{m'}{M_r} = \frac{m}{M_r} \frac{P_3}{P_2} \Rightarrow m' = m \frac{P_3}{P_2} \Rightarrow m' = 12g \frac{1 \text{ atm}}{8 \text{ atm}} \Rightarrow m' = 1.5g$$

Άρα η γάζα που έφυγε προς το περιβάλλον είναι $\Delta m = 10.5g$

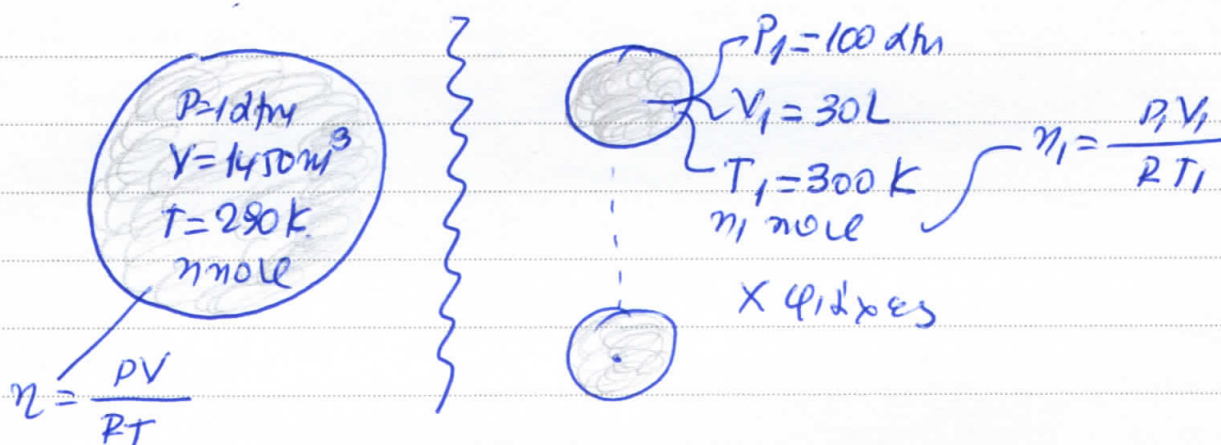
4.44



$$\eta = \eta_1 + \eta_2 \Rightarrow \frac{P_1 V}{RT} = \frac{P_2 V}{RT} + \frac{P_3 V'}{RT} \Rightarrow P_1 V = P_2 V + P_3 V'$$

$$\Rightarrow P_2 = P_1 - P_3 \frac{V'}{V} \Rightarrow P_2 = 8 \text{ atm} - 4 \text{ atm} \cdot \frac{15 \text{ L}}{20 \text{ L}} \Rightarrow P_2 = 5 \text{ atm}$$

4.45



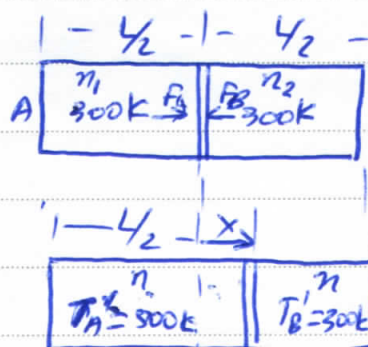
$$\eta = X \eta_1 \Rightarrow \frac{PV}{RT} = X \frac{P_1 V_1}{R T_1} \Rightarrow X = \frac{P V \cdot T_1}{P_1 V_1 T}$$

$$\Rightarrow X = \frac{1 \text{ atm} \cdot 1450 \text{ m}^3 \cdot 300 \text{ K}}{100 \text{ atm} \cdot 30 \cdot 10^{-3} \text{ m}^3 \cdot 290 \text{ K}} \Rightarrow X = 500 \text{ moles}$$

4.46 For a piston $\Sigma F_x = 0 \Rightarrow F_A = F_B \Rightarrow P_A A = P_B A$
 $\Rightarrow P_A = P_B \Rightarrow \frac{n_1 R T_A}{A \cdot \frac{1}{2}} = \frac{n_2 R T_B}{A \cdot \frac{1}{2}} \Rightarrow n_1 = n_2 = n$

For a piston $\Sigma F_x = 0 \Rightarrow F_A' = F_B' \Rightarrow P_A' A = P_B' A$
 $\Rightarrow \frac{n R T_A'}{V_A'} = \frac{n R T_B'}{V_B'} \Rightarrow \frac{T_A'}{A(\frac{1}{2} + x)} = \frac{T_B'}{A(\frac{1}{2} - x)} \Rightarrow$

$$\Rightarrow \frac{500}{20 + x} = \frac{300}{20 - x} \Rightarrow 5(20 - x) = 3(20 + x) \Rightarrow 100 - 5x = 60 + 3x \Rightarrow 40 = 8x \Rightarrow x = 5 \text{ cm}$$

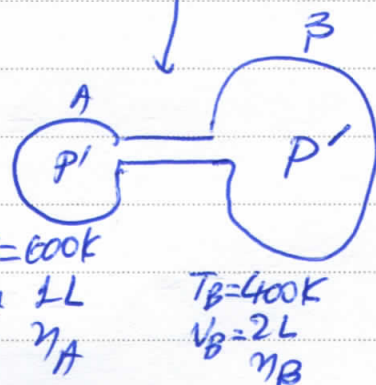
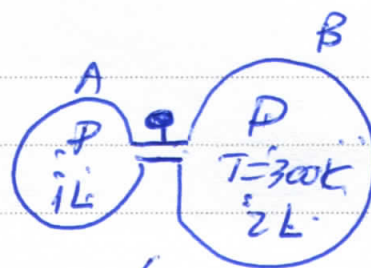


4.47

$$a) P_0(V_A + V_B) = nRT$$

$$\Rightarrow P = \frac{nRT}{V_A + V_B} = \frac{0,9 \text{ mole} \cdot \frac{25}{3} \frac{\text{J}}{\text{mol} \cdot \text{K}} \cdot 300 \text{ K}}{3 \cdot 10^{-3}}$$

$$\Rightarrow P = 7,5 \cdot 10^5 \text{ N/m}^2 = 7,5 \text{ atm}$$



$$b) n_A + n_B = n$$

$$\frac{P' \cdot V_A}{R T_A} + \frac{P' \cdot V_B}{R T_B} = \frac{P \cdot (V_A + V_B)}{R T}$$

$$\Rightarrow P' \left[\frac{V_A}{T_A} + \frac{V_B}{T_B} \right] = P \frac{V_A + V_B}{T} \Rightarrow P' \frac{V_A T_B + V_B T_A}{T_A T_B} = P \frac{V_A + V_B}{T}$$

$$\Rightarrow P' = P \frac{V_A + V_B}{T} \cdot \frac{T_A T_B}{V_A T_B + V_B T_A} = 7,5 \text{ atm} \cdot \frac{3 \text{ L}}{300 \text{ K}} \cdot \frac{600 \text{ K} \cdot 400 \text{ K}}{1 \text{ L} \cdot 400 \text{ K} + 2 \text{ L} \cdot 600 \text{ K}}$$

$$\Rightarrow P' = 7,5 \text{ atm} \cdot \frac{3 \cdot 2 \cdot 400}{1600} \Rightarrow P' = 11,25 \text{ atm} = 11,25 \cdot 10^5 \text{ N/m}^2$$

$$c) n_A = \frac{P' \cdot V_A}{R T_A} = \frac{11,25 \cdot 10^5 \cdot 10^{-3}}{\frac{25}{3} \cdot 600} \Rightarrow n_A = 0,225 \text{ mole}$$

$$n_B = \frac{P' \cdot V_B}{R T_B} = \frac{11,25 \cdot 10^5 \cdot 2 \cdot 10^{-3}}{\frac{25}{3} \cdot 400} \Rightarrow n_B = 0,675 \text{ mole}$$

4.48

а) $e = 6 \text{ рад} \cdot \text{с}$ e, p заданы в условии

$$P_0 = P \Delta t = 1 \text{ дж}$$

в)

$$\frac{e_0}{P_0} = \frac{e}{P} \Rightarrow e_0 = e \frac{P_0}{P}$$

$$\begin{array}{|l} e_0 = ? \\ P_0 = ? \\ T = ? \end{array} \quad \left| \begin{array}{l} P_{\text{из}} \\ \square \end{array} \right.$$

$$\Rightarrow e_0 = 0,818 \frac{\text{д}}{\text{с}} \cdot \frac{1 \text{ дж}}{0,675 \text{ дж}}$$

$$\begin{array}{|l} e = 0,818 \text{ д/с} \\ P = 0,675 \text{ дж/с} \\ T = ? \end{array} \quad \left| \begin{array}{l} \square \\ \rightarrow \end{array} \right.$$

$$\Rightarrow e_0 = 1,218 \text{ д/с}$$

$$г) P_0 V_0 = \eta R T \Rightarrow P_0 = \frac{\eta R}{V_0} T \Rightarrow P_0 = \frac{e_0}{V_0} T \Rightarrow T = \frac{P_0 V_0}{e_0 R}$$

$$\Rightarrow T = \frac{10^5 \cdot 79 \cdot 10^{-3}}{1,2 \cdot \frac{25}{3}} \Rightarrow T = 290 \text{ К}$$

$$д) v_{\text{ср}} = \sqrt{\frac{3 P T}{M R}} \Rightarrow v_{\text{ср}} = \sqrt{\frac{3 \cdot \frac{25}{3} \cdot 290}{28 \cdot 10^{-3}}} \Rightarrow v_{\text{ср}} = 500 \text{ м/с}$$

4.49 а) $e = 6 \text{ рад} \cdot \text{с}$ $\Rightarrow$ заданы e и ΔT

$$в) \Delta \theta = 100^\circ \text{ К} = 100 \text{ К} \Rightarrow \Delta P = \dots \text{ адфна, } 25 \text{ К}$$

$$A(P_1, V_1, T_1) \rightarrow B(P_2 = P_1 + \frac{25}{100} P_1 = 1,25 P_1, V_1, T_2 = T_1 + 100 \text{ К})$$

$$\frac{P_2}{T_2} = \frac{P_1}{T_1} = \frac{P_2 - P_1}{T_2 - T_1} = \frac{1,25 P_1}{\Delta T} \Rightarrow \frac{P_1}{T_1} = \frac{1,25 P_1}{\Delta T} \Rightarrow \frac{1}{T_1} = \frac{1,25}{\Delta T}$$

$$\Rightarrow 1,25 T_1 = \Delta T \Rightarrow T_1 = \frac{\Delta T}{1,25} \Rightarrow T_1 = \frac{100 \text{ К}}{1,25} \Rightarrow T_1 = 80 \text{ К}$$

$$T_2 = 180 \text{ К}$$

4.50

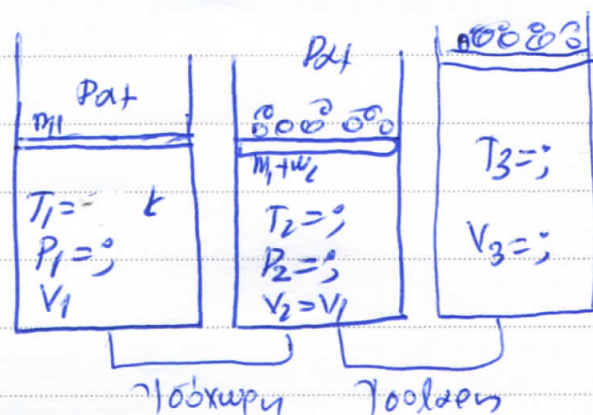
a) γόορυπν 4ετq λογí

$$T_1 = 273 + \dots = \dots$$

$$P_1 = P_{at} + \frac{m_1 g}{A} = 10^5 + \frac{120}{120 \cdot 10^{-4}} = 1,1 \cdot 10^5 \text{ N/m}^2$$

ΜΕΤΑ $T_2 = ?$

$$P_2 = P_{at} + \frac{36 \cdot 10}{12 \cdot 10^{-3}} = 10^5 + \frac{360}{120 \cdot 10^{-4}} = 1,3 \cdot 10^5 \text{ N/m}^2$$



$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow T_2 = P_2 \frac{T_1}{P_1} = \frac{1,3 \cdot 10^5}{1,1 \cdot 10^5} \cdot 275 \text{ K} \Rightarrow T_2 = 325 \text{ K}$$

b) γοοlαερν

$$[P_2 = 1,3 \cdot 10^5 \text{ N/m}^2, T_2 = 325 \text{ K}]$$

↓ γοοlαερν

$$[P_3 = 1,3 \cdot 10^5 \text{ N/m}^2, V_3, T_3 = 273 + 11^\circ = 380 \text{ K}]$$

$$\frac{V_2}{T_2} = \frac{V_3}{T_3} = \frac{V_3 - V_2}{T_3 - T_2} = \frac{\Delta V}{\Delta T} \Rightarrow \frac{V_2}{T_2} = \frac{\Delta V}{\Delta T}$$

$$\Rightarrow \frac{\Delta V}{V_2} = \frac{\Delta T}{T_2} = \frac{380 - 325}{325} = 0,2$$

$$\Rightarrow \eta \% = \frac{\Delta V}{V_2} 100 \% = 20 \%$$

4.51

α. Επειδή το βυθόστο

αυξάνεται με την ταχύτητα

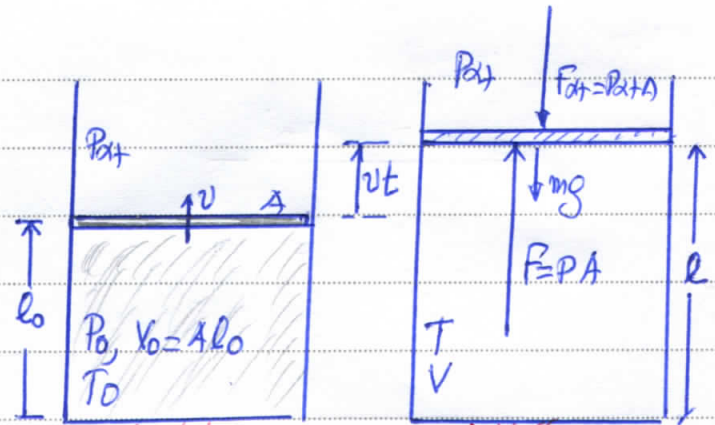
ταχύτητα $v = 2 \cdot 10^3 \text{ m/s}$

$$\Sigma F_y = 0 \Rightarrow F - P_{at} - mg = 0$$

$$\Rightarrow PA = P_{at} + mg$$

$$\Rightarrow P = P_{at} + \frac{mg}{A} = 6100 \text{ Pa} \quad (1)$$

Από την κατάσταση είναι γνωστός

και $P = P_{atmos} = P_0 = 1,1 \cdot 10^5 \text{ N/m}^2 = 1,1 \text{ atm}$ 

$$A = 10^{-2} \text{ m}^2, \quad v = 2 \frac{\text{m}}{\text{s}} = 2 \cdot 10^{-3} \frac{\text{m}}{\text{s}}$$

$$h_0 = 0,15 \text{ m}, \quad T_0 = 300 \text{ K}$$

$$T_0 = 1,1 \cdot 10^5 \text{ N/m}^2 = 1,1 \text{ atm}$$

$$\text{β. (1)} \Rightarrow P - P_{at} = \frac{mg}{A} \Rightarrow m = \frac{(P - P_{at})A}{g} \xrightarrow{\text{SI}} m = \frac{(1,1 \cdot 10^5 - 10^5) \frac{\text{N}}{\text{m}^2} \cdot 10^{-2} \text{ m}^2}{10 \text{ m/s}^2}$$

$$\Rightarrow m = \frac{0,1 \cdot 10^5 \cdot 10^{-2}}{10} \text{ kg} \Rightarrow m = 10 \text{ kg}$$

$$\gamma. \quad \frac{V}{T} = \text{const} \Rightarrow \frac{V}{T} = \frac{V_0}{T_0} \Rightarrow \frac{V}{T} = \frac{A h_0}{T_0} = \frac{10^{-2} \text{ m}^2 \cdot 0,15 \text{ m}}{300 \text{ K}} = \frac{15 \cdot 10^{-4}}{3 \cdot 10^2} = 5 \cdot 10^{-6} \text{ (SI)}$$

$$\Rightarrow V = 5 \cdot 10^{-6} \cdot T \text{ (SI)}$$

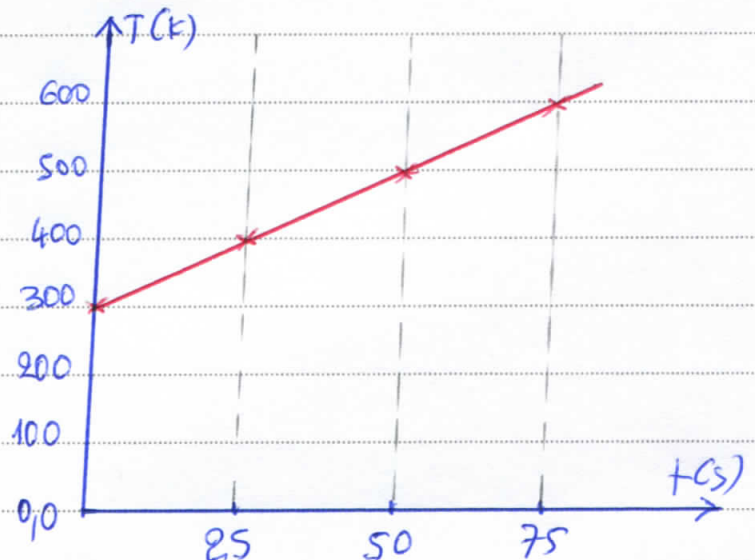
$$\delta. \quad V = 5 \cdot 10^{-6} \cdot T \Rightarrow A(h_0 + vt) = 5 \cdot 10^{-6} \cdot T \xrightarrow{\text{SI}} 10^{-2} (0,15 + 2 \cdot 10^{-3} t) = 5 \cdot 10^{-6} T$$

$$\Rightarrow 15 \cdot 10^{-4} + 2 \cdot 10^{-5} t = 5 \cdot 10^{-6} T$$

$$\Rightarrow T = \frac{15 \cdot 10^{-4}}{5 \cdot 10^{-6}} + \frac{2 \cdot 10^{-5}}{5 \cdot 10^{-6}} t$$

$$\Rightarrow T = 300 + 4t \text{ (SI)}$$

t(s)	0	25	50	75
T(K)	300	400	500	600



4.53

a) $\frac{\Delta P}{\Delta T} = 0,005 \frac{\text{atm}}{\text{K}}$ Υόλωση σε σχέση

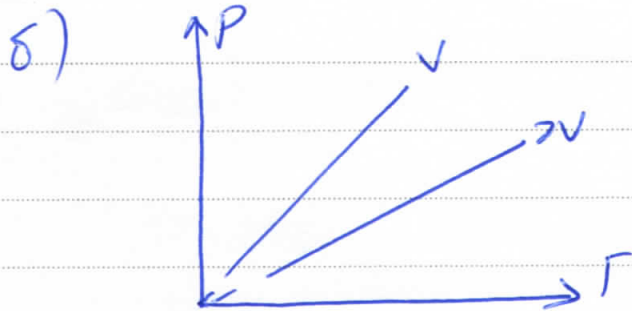
$$\frac{P_0}{T_0} = \frac{P}{T} = \frac{\Delta P}{\Delta T} \Rightarrow \frac{P}{T} = 0,005 \cdot \frac{10^5 \text{ N/m}^2}{\text{K}} = 5 \cdot 10^2 \text{ SI} \Rightarrow \frac{P}{T} = 500 \text{ (SI)}$$

e) $\frac{P}{T} = 500 = \frac{1,8 \cdot 10^5}{T} = 500 \Rightarrow \frac{1,8 \cdot 10^5}{500} = T \Rightarrow T = 360 \text{ K}$

$$\pm 273 + \theta = 360 \Rightarrow \theta = 87^\circ \text{C}$$

δ) $\frac{P}{T} = 0,005 = \frac{nR}{V} = 500 \text{ (σε K)} \quad \text{(σε K)}$

σε θερμοκρασία 2V $\frac{P}{T} = \frac{nR}{2V} = \frac{500}{2} = 250 \Rightarrow \frac{P}{T} = 250 \text{ (SI)}$



4.54

Μόνο πω λω πω σιγα σιγα

θερμότητας ή γερμίας

Είχατε 1/6000000 Τεταδομή

α) Από την αρχική κατάσταση

στο σύστημα $\Sigma F_y = 0 \Rightarrow$

$$\Rightarrow F_{\text{αερίων}} - F_{\text{ατ}} - mg = 0$$

$$\Rightarrow P_0 A - P_{\text{ατ}} A - mg = 0 \Rightarrow P_0 = P_{\text{ατ}} + \frac{mg}{A} \Rightarrow P_0 = 10^5 \text{ N/m}^2 + \frac{18 \cdot 10^{-2} \text{ kg} \cdot 9.8 \text{ m/s}^2}{5 \cdot 10^{-3} \text{ m}^2} \Rightarrow P_0 = 1,0218 \cdot 10^5 \text{ N/m}^2$$

$$\Rightarrow P_0 = 1,02 \text{ atm}$$

$$\beta) P_0 V_0 = n R T \Rightarrow T = \frac{P_0 \cdot A \cdot h}{n R} = \frac{1,0218 \cdot 10^5 \text{ N/m}^2 \cdot 5 \cdot 10^{-3} \text{ m}^2 \cdot 0,95 \text{ m}}{0,102 \text{ mol} \cdot \frac{25}{3} \frac{\text{J}}{\text{mol K}}} \Rightarrow T = 300 \text{ K}$$

$$\delta) pV = P_0 V_0 \Rightarrow p = \frac{P_0 V_0}{V} = \frac{P_0 \cdot A \cdot h}{A(h-y)} \Rightarrow p = P_0 \frac{h}{h-y} = 1,0218 \cdot 10^5 \frac{\text{N}}{\text{m}^2} \cdot \frac{0,95 \text{ m}}{0,40 \text{ m}}$$

$$\Rightarrow p = 1,275 \cdot 10^5 \text{ N/m}^2 \text{ ή } p = 1,275 \text{ atm}$$

δ.) Σε ποια κατάσταση πω λω πω - έχει μετατοπιστεί κατά y - και δεδομένου ότι η κατάσταση πω λω πω $V = 0$ - άρα $\Sigma F_y = 0$ έχουμε

$$\Sigma F_y = 0 \Rightarrow F + F_{\text{ατ}} - F_{\text{αερίων}} - mg = 0 \Rightarrow F + P_{\text{ατ}} A - p A + mg$$

$$\Rightarrow F = p A - P_{\text{ατ}} A - mg \quad (1)$$

$$\text{Boyle: } pV = P_0 V_0 \Rightarrow p \cdot A(h-y) = P_0 A h \Rightarrow p = \frac{P_0 h}{h-y} \quad (2)$$

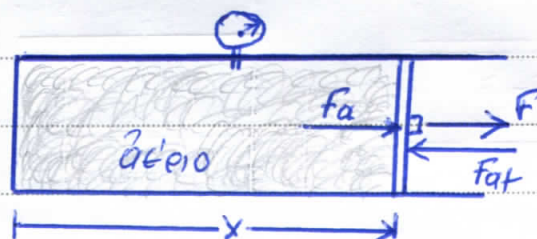
$$\text{Από (1) και (2) παίρνουμε } F = \frac{P_0 h}{h-y} A - P_{\text{ατ}} A - mg \xrightarrow{\text{SI}}$$

$$F = \frac{1,0218 \cdot 10^5 \cdot 0,5 \cdot 5 \cdot 10^{-3}}{0,5 - y} - 10^5 \cdot 5 \cdot 10^{-3} - 1 \cdot 10 \Rightarrow F = \frac{255}{0,5 - y} - 510 \text{ (SI)}$$

$$\Rightarrow F = \frac{510 y}{0,5 - y} \text{ (SI)}$$

4.55

- α) Από τον πίνακα παρατηρούμε
 ότι $pV = pAx = (p/x) \cdot A = 600 \cdot A = 600\theta$
 αν ορίζουμε ότι η θερμοκρασία
 είναι σταθερή



- Για $x = 0,3 \text{ m}$: $F = pA \stackrel{\text{SI}}{\Rightarrow} 400 = 9,80 \cdot 10^5 \cdot A \Rightarrow A = 5 \cdot 10^{-3} \text{ m}^2$
 β). $pV = 600\theta = 2,40 \cdot 10^5 \cdot 5 \cdot 10^{-3} \cdot 0,10 = 120 \Rightarrow pV = 120 \text{ SI}$

$p (\text{N/m}^2)$	$240 \cdot 10^5$	$1,20 \cdot 10^5$	$0,80 \cdot 10^5$	$0,6 \cdot 10^5$
$V (\text{m}^3)$	$5 \cdot 10^{-4}$	$10 \cdot 10^{-4}$	$15 \cdot 10^{-4}$	$20 \cdot 10^{-4}$

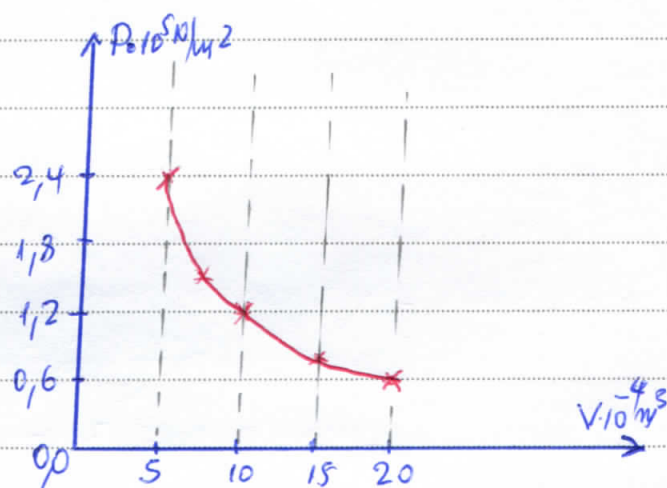
- γ. $pV = 120 \text{ (SI)} \Rightarrow nRT = 120 \text{ (SI)}$
 $\stackrel{\text{SI}}{\Rightarrow} 0,04 \cdot \frac{25}{3} \cdot T = 120 \Rightarrow T = 360 \text{ K}$

- δ. $F_a = pA \stackrel{\text{SI}}{\Rightarrow} F_a = \frac{120}{V} \cdot A$

$$\Rightarrow F_a = \frac{120}{Ax} \cdot A \Rightarrow F_a = \frac{120}{x} \text{ (SI)}$$

- ε. $\Sigma F_x = 0 \Rightarrow F + F_a - F_{at} = 0$
 $F_{at} = p_{at} \cdot A = 10^5 \cdot 5 \cdot 10^{-3} = 500 \text{ N} \quad \left. \vphantom{\begin{matrix} \Sigma F_x = 0 \\ F_{at} = 500 \text{ N} \end{matrix}} \right\} \Rightarrow F + \frac{120}{x} - 500 = 0 \Rightarrow$

$$\Rightarrow F = 500 - \frac{120}{x} \text{ (SI)}$$

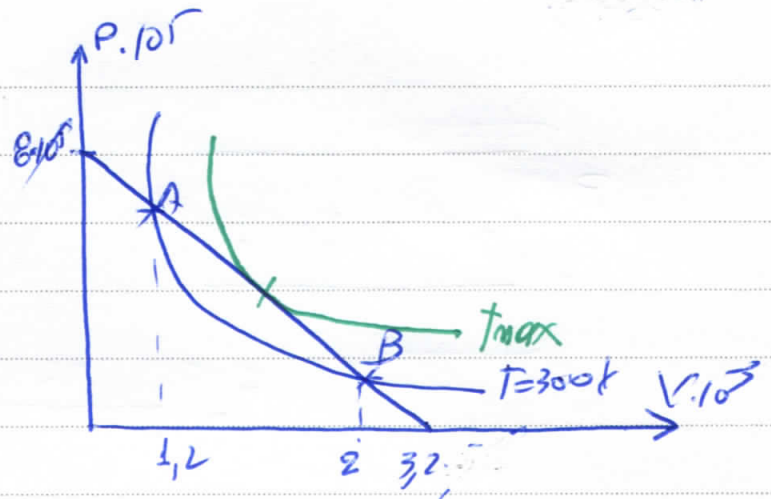


4.56

$$d) \quad P = 8 \cdot 10^5 - 2,5 \cdot 10^8 V$$

$$0 = 8 \cdot 10^5 - 2,5 \cdot 10^8 V \Rightarrow$$

$$V = \frac{8 \cdot 10^5}{2,5 \cdot 10^8} \Rightarrow V = 3,2 \cdot 10^{-3}$$



$$e) \quad PV = nRT \Rightarrow (8 \cdot 10^5 - 2,5 \cdot 10^8 V) V = \frac{2}{R} \cdot 300$$

$$8 \cdot 10^5 V - 2,5 \cdot 10^8 V^2 = 600$$

$$\Rightarrow +2,5 \cdot 10^8 V^2 - 8 \cdot 10^5 V + 600 = 0$$

$$\Delta = 64 \cdot 10^{10} - 4 \cdot 2,5 \cdot 10^8 \cdot 600$$

$$\Delta = 64 \cdot 10^{10} - 60 \cdot 10^{10} = 4 \cdot 10^{10}$$

$$\sqrt{\Delta} = 2 \cdot 10^5$$

$$V = \frac{8 \cdot 10^5 \pm 2 \cdot 10^5}{2 \cdot 2,5 \cdot 10^8} \Rightarrow \begin{cases} \frac{10 \cdot 10^5}{5 \cdot 10^8} = 2 \cdot 10^{-3} \\ \frac{6 \cdot 10^5}{5 \cdot 10^8} = 1,2 \cdot 10^{-3} \end{cases}$$

$$P = 8 \cdot 10^5 - 2,5 \cdot 10^8 \cdot 2 \cdot 10^{-3} = 8 \cdot 10^5 - 5 \cdot 10^5 = 3 \cdot 10^5$$

$$P = 8 \cdot 10^5 - 2,5 \cdot 10^8 \cdot 1,2 \cdot 10^{-3} = 8 \cdot 10^5 - 3 \cdot 10^5 = 5 \cdot 10^5$$

$$A. (P = 5 \cdot 10^5 \text{ N/m}^2, V = 1,2 \cdot 10^{-3} \text{ m}^3)$$

$$B. (P = 3 \cdot 10^5 \text{ N/m}^2, V = 2 \cdot 10^{-3} \text{ m}^3)$$

$$f) \quad 8 \cdot 10^5 V - 2,5 \cdot 10^8 V^2 = 2T \Rightarrow 2,5 \cdot 10^8 V^2 - 8 \cdot 10^5 V + 2T = 0$$

$$\Delta \geq 0 \Rightarrow 64 \cdot 10^{10} - 4 \cdot 2,5 \cdot 10^8 \cdot 2T \geq 0 \Rightarrow -10^8 T \geq -32 \cdot 10^{10}$$

$$\Rightarrow T \leq 320 \text{ K} \quad (=) \quad \underline{T_{\max} = 320 \text{ K}}$$

$$g) \quad 2,5 \cdot 10^8 V^2 - 8 \cdot 10^5 V + 640 = 0 \quad \text{or} \quad V^2 - 32 \cdot 10^{-4} V + 2,56 \cdot 10^{-8} = 0$$

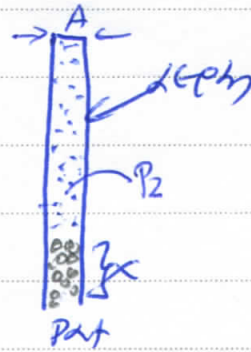
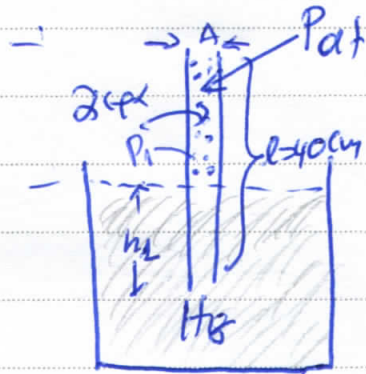
$$(V - 16 \cdot 10^{-4})^2 = 0 \Rightarrow V = 16 \cdot 10^{-4} \quad \text{or} \quad \underline{\underline{V = 1,6 \cdot 10^{-3} \text{ m}^3}}$$

$$P = 8 \cdot 10^5 - 2,5 \cdot 10^8 \cdot 1,6 \cdot 10^{-3} \Rightarrow \underline{\underline{P = 4 \cdot 10^5 \text{ N/m}^2}}$$

4.57

$$l = 40 \text{ cm}$$

$$h_1 = 24.25 \text{ cm}$$



$$\begin{aligned} \text{Left side: } P_1 &= P_{at} \\ V_1 &= A(l - h_1) \end{aligned}$$

$$V_2 = A(l - x)$$

$$P_{at} = x \rho_l g + P_2 \Rightarrow P_2 = P_{at} - x \rho_l g$$

$$P_1 V_1 = P_2 V_2 \Rightarrow P_{at} \cdot A(l - h_1) = (P_{at} - x \rho_l g) \cdot A(l - x)$$

$$\begin{aligned} \Rightarrow 76 \text{ cmHg} \cdot (40 - 24.25) \text{ cm} &= (76 - x) \text{ cmHg} \cdot (40 - x) \text{ cm} \\ 76 \cdot 15.75 &= (76 - x)(40 - x) \\ 1197 &= 3040 - 116x + x^2 \end{aligned}$$

$$\Rightarrow x^2 - 116x + 1843 = 0$$

$$\Delta = 116^2 - 4 \cdot 1843$$

$$\sqrt{\Delta} = 78$$

$$x = \frac{116 \pm 78}{2} \Rightarrow \begin{cases} 19 \text{ cm} \\ 97 \text{ cm} \end{cases}$$

$$\text{Since } x = 19 \text{ cm}$$

$$\begin{aligned} P_1 V_1 &= 76 \text{ cmHg} \cdot A \cdot 15.75 \text{ cm} = 1197 A \\ P_2 V_2 &= (76 - 19) \text{ cmHg} \cdot A \cdot 21 \text{ cm} = 1197 A \end{aligned} \quad \checkmark$$

4.58

29 -

α) Αρχική κατάσταση θέρμης

 $V_1 = A h_1$ (όγκος), η/εγκ P_1

$$P_1 = P_{at} \Rightarrow 65 \text{ cm Hg} + P_1 = P_{at}$$

$$\Rightarrow 65 \text{ cm Hg} + P_1 = 77 \text{ cm Hg}$$

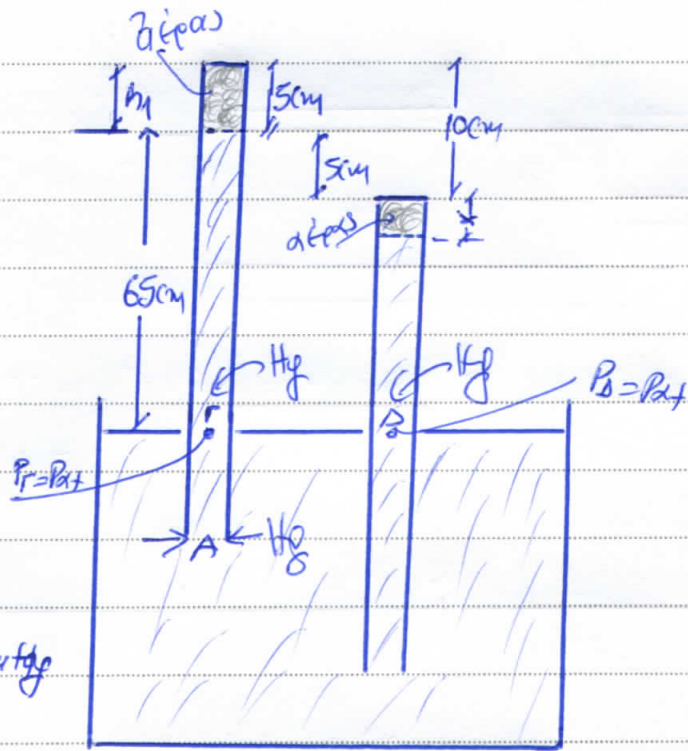
$$\Rightarrow P_1 = 12 \text{ cm Hg}$$

Τελική κατάσταση θέρμης

όγκος $V_2 = A x$, η/εγκ P_2

$$P_2 = P_{at} \Rightarrow (60 - x) \text{ cm Hg} + P_2 = 77 \text{ cm Hg}$$

$$\Rightarrow P_2 = (17 + x) \text{ cm Hg}$$



$$P_1 V_1 = P_2 V_2 \Rightarrow A h_1 \cdot 12 \text{ cm Hg} = A x \cdot (17 + x) \text{ cm Hg} \Rightarrow 5 \cdot 12 = x (17 + x)$$

$$\Rightarrow 60 = 17x + x^2 \Rightarrow x^2 + 17x - 60 = 0 \quad \dots \text{ γε' κόβει θετική λύση}$$

$$x = 3 \text{ cm}$$

$$\beta) P_1 V_1 = n R T \Rightarrow P_1 = \frac{n R}{V_1 M_r} P T \Rightarrow P_1 = C \frac{P T}{M_r}$$

$$\Rightarrow C = \frac{P_1 M_r}{P T} \Rightarrow C = \frac{12 \text{ cm Hg} \cdot 29 \cdot 10^3 \text{ kg/mole}}{\frac{25}{3} \frac{\text{Joule}}{\text{mole}} \cdot 290 \text{ K}}$$

$$\Rightarrow C = \frac{12 \cdot 10^{-2} \text{ m} \cdot 13,6 \cdot 10^3 \text{ kg/m}^3 \cdot 29 \cdot 10^3 \text{ kg/mole}}{\frac{25}{3} \frac{\text{Joule}}{\text{mole}} \cdot 290 \text{ K}} \Rightarrow C = 0,19584 \text{ kg/m}^3$$

4.59

$$m_{\text{O}_2} = 1,2 \text{ g}$$

$$\rho = 0,38 \text{ kg/m}^3$$

$$v_{\text{O}_2} = 2000 \text{ m/s}$$

$$\alpha) p = \frac{1}{3} \rho v_{\text{O}_2}^2 = \frac{1}{3} \cdot 0,38 \cdot \frac{10^3 \text{ kg}}{10^3 \text{ m}^3} \cdot 4 \cdot 10^6 \text{ m}^2/\text{s}^2$$

-30-

$$\Rightarrow p = 4 \cdot 10^5 \text{ N/m}^2$$

$$\text{в) } \bar{K} = \frac{1}{2} m v_{\text{O}_2}^2 = \frac{1}{2} \frac{m_{\text{O}_2}}{N} v_{\text{O}_2}^2 = \frac{1}{2} \frac{m_{\text{O}_2}}{n N_A} v_{\text{O}_2}^2 = \frac{1}{2} \frac{n \cdot M_{\text{O}_2}}{n N_A} v_{\text{O}_2}^2$$

Lyofa voew

$$\Rightarrow \bar{K} = \frac{1}{2} \frac{M_{\text{O}_2}}{N_A} v_{\text{O}_2}^2 = \frac{1}{2} \cdot \frac{4 \cdot 10^{-3}}{6 \cdot 10^{23}} \cdot 4 \cdot 10^6 \Rightarrow \bar{K} = \frac{4}{3} \cdot 10^{-20} \text{ Joule}$$

н

$$\bar{K} = \frac{3}{2} k T = \frac{3}{2} \frac{R}{N_A} T = \frac{3}{2} \frac{pV}{n N_A} = \frac{3}{2} \frac{p \cdot m_{\text{O}_2}}{n N_A} = \frac{3}{2} \frac{p \cdot M_{\text{O}_2}}{n N_A}$$

$$\Rightarrow \bar{K} = \frac{3}{2} \frac{p \cdot M_{\text{O}_2}}{n N_A} = \frac{3}{2} \cdot \frac{4 \cdot 10^5 \cdot 4 \cdot 10^{-3}}{93 \cdot 6 \cdot 10^{23}} = \frac{16}{12} \cdot 10^{-20} \text{ Joule}$$

$$\text{д) } \bar{K} = \frac{3}{2} \frac{R}{N_A} T \Rightarrow T = \frac{2 \bar{K} N_A}{3 R} = \frac{2 \cdot \frac{4}{3} \cdot 10^{-20} \cdot 6 \cdot 10^{23}}{3 \cdot \frac{8,31}{3}} =$$

$$\underline{T = 640 \text{ K}}$$

$$pV = nRT \Rightarrow T = \frac{pV}{nR} = \frac{p \cdot m_{\text{O}_2}}{nR} = \frac{p \cdot M_{\text{O}_2}}{n R}$$

$$= \frac{p \cdot M_{\text{O}_2}}{n R} = \frac{4 \cdot 10^5 \cdot 4 \cdot 10^{-3}}{\frac{2 \cdot 93}{3}} \Rightarrow T = 640 \text{ K}$$

4.60 a) $P = \frac{1}{2} e v_{\text{eff}}^2 \Rightarrow v_{\text{eff}} = \sqrt{\frac{2P}{e}} = \sqrt{\frac{3 \cdot 4 \cdot 10^5}{0.3}} = 2 \cdot 10^3 \text{ m/s} \Rightarrow \underline{v_{\text{eff}} = 2000 \text{ m/s}}$

b) $\bar{K} = \frac{1}{2} m v_{\text{eff}}^2$
 $m_{\text{gr}} = e V = 0.3 \frac{\text{kg}}{\text{m}^3} \cdot 4 \cdot 10^3 \text{ m}^3 = 1.2 \cdot 10^3 \text{ kg}$
 $m = \frac{m_{\text{gr}}}{N} = \frac{1.2 \cdot 10^3}{1.2 \cdot 10^{23}} \Rightarrow m = 10^{-20} \text{ kg/4000}$
 $\Rightarrow \bar{K} = \frac{1}{2} \cdot 10^{-20} \cdot 4 \cdot 10^6$
 $\Rightarrow \underline{\bar{K} = 2 \cdot 10^{-7} \text{ J/m}^3}$

г) $K_{\text{gr}} = N \bar{K} = 1.2 \cdot 10^{23} \cdot 2 \cdot 10^{-7} = 2.4 \cdot 10^3 \text{ J}$
 $K_{\text{gr}} = n N_A \cdot \frac{3}{2} \frac{R}{N_A} T = \frac{3}{2} P V = \frac{3}{2} \cdot 4 \cdot 10^5 \cdot 4 \cdot 10^3 = 2.4 \cdot 10^3 \text{ J} = 2.4 \cdot 10^3 \text{ J}$

~~д) $m = 10^{-26} \text{ kg/4000}$~~

е) $V = 6 \text{ л} \Rightarrow 600 \text{ см}^3$ $v_{\text{eff}} = 2000 \text{ м/с}$ $\bar{K} = \frac{3}{2} k T$
 $P \rightarrow 4P$ $Q \rightarrow 4Q$ $T \rightarrow 4T$
 K, T удваиваются $\bar{K}' = 4 \bar{K} = 4 \cdot 2 \cdot 10^{-7} \text{ J} = 8 \cdot 10^{-7} \text{ J}$

$v_{\text{eff}} = \sqrt{\frac{3P}{M}} \leadsto v'_{\text{eff}} = \sqrt{\frac{3 \cdot 4P}{M}} = 2 v_{\text{eff}} \Rightarrow v'_{\text{eff}} = 4000 \text{ м/с}$

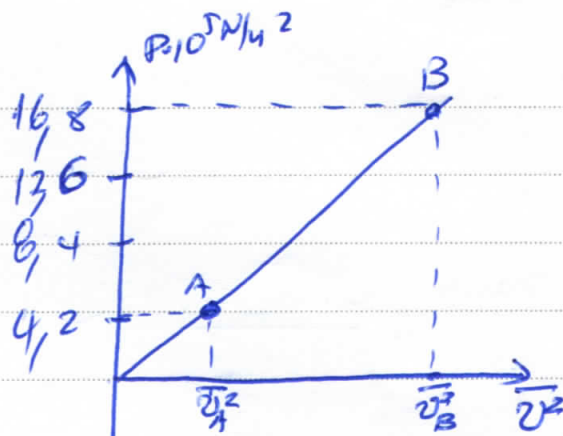
4-63

α) παρατηρούμε ότι η
υπόψη αερίων είναι

$$e\phi = \frac{P}{\bar{v}^2} = \frac{\frac{1}{2}e\bar{v}^2}{\bar{v}^2} = \frac{e}{2} = 6 \text{ kcal}$$

≠ 0 παρατηρούμε

τοίχους με αέριο



β) $\rho = \frac{m_{\text{air}}}{V} = \frac{n \cdot M_r}{n \cdot V_{\text{mole}}} = \frac{10 \cdot 10^{-3} \text{ kg/mole}}{224 \cdot 10^{-3} \text{ m}^3/\text{mole}} \Rightarrow \rho = \frac{100}{224} \text{ kg/mole} = \frac{25}{56} \text{ kg/m}^3$

γ) A: $P = \frac{1}{2} e \bar{v}_{\text{EN},A}^2 \Rightarrow \bar{v}_{\text{EN},A} = \sqrt{\frac{2P}{e}} = \sqrt{\frac{3 \cdot 4.2 \cdot 10^5}{\frac{25}{56}}}$

$$\Rightarrow \bar{v}_{\text{EN},A} = \sqrt{\frac{3 \cdot 4.2 \cdot 5.6 \cdot 10^6}{25}} = \frac{8.4 \cdot 10^3}{5} = 1680 \text{ m/s}$$

$P_B = 4P_A$
 $T_B = 4T_A$

$\bar{v}_{\text{EN},B} = \sqrt{2} \bar{v}_{\text{EN},A} \Rightarrow \bar{v}_{\text{EN},B} = 3360 \text{ m/s}$

δ $\frac{P}{T} = 6 \text{ kcal} = \frac{nR}{V} = \frac{nR}{n \cdot V_{\text{mole}}} = \frac{25}{224 \cdot 10^{-3}} = \frac{25 \cdot 10^3}{672}$

$P = \frac{25 \cdot 10^4}{672} \cdot T \text{ SF} \Rightarrow P = \frac{250000}{672} \cdot T \text{ (SF)}$

ε) $\frac{\bar{v}_{\text{EN}}^2}{4} = \frac{3RT_A}{M_r} \Rightarrow T_A = \frac{\bar{v}_{\text{EN}}^2 \cdot M_r}{3R} = \frac{1680^2 \cdot 10 \cdot 10^{-3}}{3 \cdot 25} \Rightarrow T_A = 1128,96 \text{ K}$
 $T_B = 4.515,84 \text{ K}$

$P = \frac{250000}{672} T \Rightarrow T = \frac{672P}{250000}$

$T_A = \frac{672 \cdot 4.2 \cdot 10^5}{25 \cdot 10^3} \Rightarrow T_A = 1128,96 \text{ K} \dots$

9)

$$V = \frac{0,72 \cdot 10^{-3}}{3 \cdot 1,2 \cdot 10^5} \bar{v}^2 \Rightarrow \underline{V = 2 \cdot 10^{-9} \bar{v}^2 \text{ (SI)}}$$

$$\Rightarrow V = 138 \cdot 10^{-4} \text{ m}^3 \quad \therefore V = 138 \text{ L}$$

$$d) \quad \overline{K}_A = \frac{1}{2} m \overline{U_{\text{eff}}^2} = \overline{K} = \frac{1}{2} m \cdot \frac{V}{2 \cdot 10^5} \approx \overline{F} = 6 \text{ mG} \cdot V.$$

$$\partial \rho / \partial t + \nabla \cdot \vec{E} = 0$$

देखिए $\vec{E} = 6000 \cdot \vec{V}$
 तब $\vec{E}' = 6000 \cdot \vec{V}' \Rightarrow 1,25 \vec{E} = 6000 \cdot \vec{V}'$

$$\frac{1,25 E}{K} = \frac{6000 V}{400 V} \rightarrow V = 325 V$$

$$\rightarrow V' = 1,75 \cdot 1,78 L \Rightarrow V' = 1,6 L.$$

$$\Delta V' = V' - V = 1,6L - 1,28L \Rightarrow \underline{\Delta V' = 0,32L}$$

4.65

-35-

$$a) \rho = \frac{m}{V} = \frac{n M_r}{V} = \frac{95 \cdot 4 \cdot 10^{-3}}{5 \cdot 10^{-3}} = 0,4 \text{ g/cm}^3$$

$$P = \frac{1}{3} \rho v_{\text{ср}}^2 \Rightarrow v_{\text{ср}} = \sqrt{\frac{3P}{\rho}} = \sqrt{\frac{3 \cdot 3 \cdot 10^5}{0,4}} = \sqrt{\frac{9 \cdot 10^5}{4 \cdot 10^{-1}}} = \frac{3}{2} \cdot 10^3 = \underline{\underline{v_{\text{ср}} = 1500 \text{ m/s}}}$$

$$b) v_{\text{ср}}' = 1000 + \frac{20}{100} 1500 = 1800 \text{ m/s}$$

$$\left. \begin{aligned} v_{\text{ср}} &= \sqrt{\frac{3RT}{M_r}} \\ v_{\text{ср}}' &= \sqrt{\frac{3RT'}{M_r}} \end{aligned} \right\} \frac{v_{\text{ср}}}{v_{\text{ср}}'} = \sqrt{\frac{T}{T'}} \Rightarrow \frac{T'}{T} = \frac{1800^2}{1500^2} = \left(\frac{6}{5}\right)^2 = \frac{36}{25} = 1,44$$

$$\frac{K'}{K} = \frac{\frac{3}{2} k T'}{\frac{3}{2} k T} = 1,44 \Rightarrow K' = 1,44 K \quad \Delta K = 0,44 K$$

$$\eta \% = \frac{\Delta K}{K} 100\% \Rightarrow \eta \% = 44\%$$

$$\eta \text{ не равно } \frac{K'}{K} = \frac{\frac{1}{2} m v_{\text{ср}}'^2}{\frac{1}{2} m v_{\text{ср}}^2} = \left(\frac{v_{\text{ср}}'}{v_{\text{ср}}}\right)^2 = \dots$$

$$c) P = \frac{1}{3} \rho v_{\text{ср}}^2 = \frac{1}{3} \cdot 0,4 \cdot 1800^2 = 4,32 \cdot 10^5 \text{ N/m}^2$$

$$\text{по условию} \Rightarrow \underline{\underline{P = 4,32 \cdot 10^5 \text{ N/m}^2}}$$

и следовательно

$$\rho = 0,4 \text{ г/см}^3$$

4.66

$$a) P = P_{\text{ext}} + \frac{mg}{A} = 10 \frac{\text{SN}}{\text{m}^2} + \frac{10}{2 \cdot 10^{-3}} = 10 \cdot 10^4 + 0.5 \cdot 10^6 = 10.5 \cdot 10^4 = 1.05 \cdot 10^5 \text{ N/m}^2$$

$$P = 1.05 \cdot 10^5 \text{ N/m}^2 \quad \text{m} \quad \underline{P = 1.05 \text{ atm}}$$

$$b) \bar{K} = \frac{3}{2} kT = \frac{3}{2} k \cdot \frac{PV}{nR} = \frac{3}{2} \frac{P}{N_A} \frac{P \cdot AY}{N_A R} = \frac{3}{2} \frac{P \cdot AY}{N}$$

$$\Rightarrow \bar{K} = \frac{3}{2} \frac{1.05 \cdot 10^5 \cdot 2 \cdot 10^{-3} \cdot 2 \cdot 10^{-1}}{6 \cdot 10^{21}} \Rightarrow \underline{\bar{K} = 1.05 \cdot 10^{-20} \text{ J}}$$

$$c) T = \frac{2\bar{K}}{3k} = \frac{2 \cdot 1.05 \cdot 10^{-20}}{3 \cdot \frac{25}{18} \cdot 10^{-23}} \Rightarrow \underline{T = 504 \text{ K}}$$

$$d) \text{Változatlan } \rightarrow P = P_{\text{ext}} + \frac{mg}{A} = 1.05 \cdot 10^5 \text{ N/m}^2$$

$v_{\text{ext}} \rightarrow v_{\text{int}} = 0$

$$e) \frac{V'}{V} = \frac{T'}{T} \Rightarrow \frac{AY'}{AY} = \frac{T'}{T} \Rightarrow T' = \frac{Y'}{Y} \cdot T = \frac{0.8}{0.2} T$$

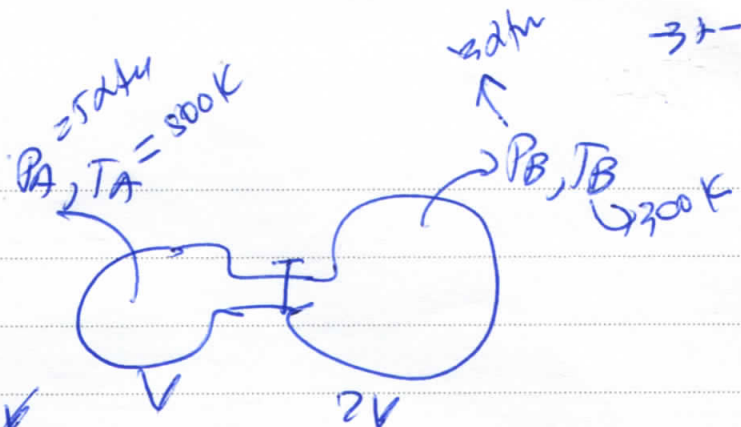
$$\Rightarrow T' = 4T$$

$$\bar{K}' = \frac{3}{2} kT' = \frac{3}{2} k \cdot 4T = 4K = 4 \cdot 1.05 \cdot 10^{-20} \text{ J}$$

$$\Rightarrow \underline{\bar{K}' = 4.2 \cdot 10^{-20} \text{ J}}$$

$$f) \frac{v_{\text{ext}}}{v_{\text{int}}} = \sqrt{\frac{T'}{T}} = 2 \Rightarrow \frac{v_{\text{ext}}}{v_{\text{int}}} = 2$$

4.67



a) $n_A + n_B = n_{\text{tot}} \Rightarrow \frac{P_A V}{RT_A} + \frac{P_B V}{RT_B} = \frac{P_3 V}{RT}$

$$\frac{P_A}{T_A} + \frac{2P_B}{T_B} = \frac{3P}{T} \Rightarrow \frac{5 \cdot 10^5}{500} + \frac{2 \cdot 3 \cdot 10^5}{300} = \frac{3 \cdot 3,6 \cdot 10^5}{T}$$

$$\Rightarrow 0,01 + 0,02 = \frac{3 \cdot 3,6}{T} \Rightarrow T = \frac{3 \cdot 3,6}{0,03}$$

$$\Rightarrow T = 360 \text{ K}$$

$$\bar{K} = \frac{3}{2} \frac{P}{n_A} T = \frac{3}{2} \frac{25}{6 \cdot 10^{23}} \cdot 360 = \frac{25 \cdot 360}{12} \cdot 10^{-23}$$

$$\Rightarrow \bar{K} = 750 \cdot 10^{-23} \text{ J} \Rightarrow \bar{K} = 7,5 \cdot 10^{-21} \text{ J}$$

b) $v_{\text{eff}} = \sqrt{\frac{3PT}{M_r}} = \sqrt{\frac{3 \cdot \frac{25}{3} \cdot 360}{4 \cdot 10^{-3}}} = \sqrt{\frac{25 \cdot 360 \cdot 10^4}{4}} = 5 \cdot 6 \cdot 10^2$

$$\Rightarrow v_{\text{eff}} = 1500 \text{ m/s}$$

4.68

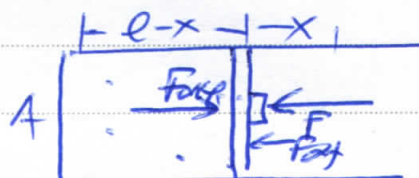
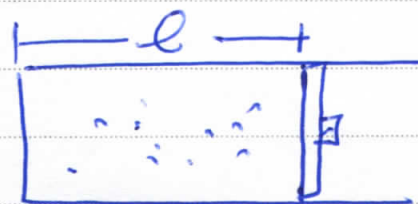
a) Αέρας που πορεύεται
 ενόσω $P = P_{at} = 10^5 \text{ N/m}^2$

$$\rho = \frac{m_0}{V_0} = \frac{m_0}{A \cdot l} = \frac{0,48 \cdot 10^{-3}}{10^{-3} \cdot 48 \cdot 10^{-2}}$$

$$\Rightarrow \rho = 0,3 \text{ kg/m}^3$$

$$P = \frac{1}{2} \rho v^2 = \frac{1}{2} \rho v^2 \Rightarrow v = \sqrt{\frac{2P}{\rho}}$$

$$\Rightarrow v = \sqrt{\frac{2 \cdot 10^5}{0,3}} \Rightarrow v = 10^3 \text{ m/s}$$



b)

$$PV = nRT \Rightarrow P \cdot A \cdot l = \frac{N}{N_A} RT \Rightarrow P \cdot A \cdot l = N k T$$

$$\Rightarrow T = \frac{P \cdot A \cdot l}{N k} = \frac{10^5 \cdot 10^{-3} \cdot 48 \cdot 10^{-2}}{1,08 \cdot 10^{22} \cdot \frac{25}{18} \cdot 10^{-23}} = \frac{48 \cdot 18}{25 \cdot 10^1}$$

$$\Rightarrow T = 320 \text{ K}$$

$$\gamma) P_0 V_0 = P \cdot V \Rightarrow P_0 A l = P \cdot A (l-x) \Rightarrow P = P_0 \frac{l}{l-x}$$

$$\Rightarrow P = 10^5 \frac{\text{N}}{\text{m}^2} \cdot \frac{48 \text{ cm}}{40 \text{ cm}} \Rightarrow P = 1,2 \cdot 10^5 \frac{\text{N}}{\text{m}^2}$$

$$\bar{E} = \frac{1}{2} \rho v^2 = \frac{1}{2} \rho v^2 = \frac{1}{2} \cdot \frac{25}{18} \cdot 10^{-23} \cdot 360 = 750 \cdot 10^{-23} \text{ J}$$

$$K_a = N \cdot \bar{E} = 1,08 \cdot 10^{22} \cdot 750 \cdot 10^{-23} = 81 \text{ J} \Rightarrow K_a = 81 \text{ J}$$

δ)

$$\Sigma F_x = 0 \Rightarrow F + F_{at} = F_{atc} \Rightarrow F + P_{at} A = P \cdot A$$

$$\Rightarrow F = P_0 \frac{l}{l-x} A - P_{at} A \Rightarrow F = 10^5 \frac{0,48 \cdot 10^{-3}}{0,48-x} - 10^5 \cdot 10^{-3}$$

$$F = \frac{48}{0,48 - x} - 100 \quad \text{SI} \quad \text{ou} \quad F = \frac{48 - 48 + 100x}{0,48 - x}$$

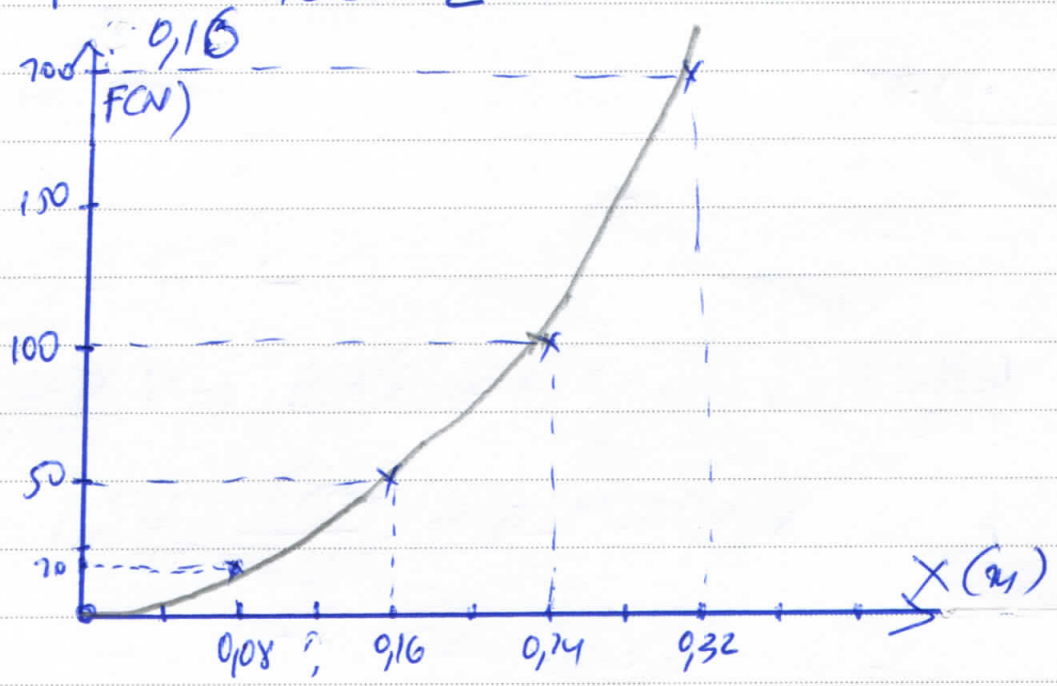
$$F = \frac{100x}{0,48 - x} \quad \text{SI}$$

$$\begin{aligned} x=0 & \quad F=0 \\ x=0,08 & \quad F = \frac{48}{0,40} - 100 = 20 \text{ N} \end{aligned}$$

$$x=0,16 \quad F = \frac{48}{0,32} - 100 = 50 \text{ N}$$

$$x=0,24 \quad F = \frac{48}{0,24} - 100 = 100 \text{ N}$$

$$x=0,32 \quad F = \frac{48}{0,16} - 100 = 200 \text{ N}$$



4.69

α) Υπολογισμός μεταβολών

$$\left. \begin{aligned} P &= 420 \cdot T \\ P &= \frac{nR}{V} \cdot T \end{aligned} \right\} \Rightarrow \frac{nR}{V} = 420 \text{ (SI)} \Rightarrow V = \frac{nR}{420} \text{ (SI)}$$

$$\bar{K} = \frac{3}{2} kT = \frac{3}{2} k \frac{PV}{nR} = \frac{3}{2} k \frac{P \cdot \frac{nR}{420}}{nR} \Rightarrow \bar{K} = \frac{3}{2} k \frac{1}{420} P$$

$$\Rightarrow \bar{K} = \frac{3}{2} \cdot 1.4 \cdot 10^{-23} \cdot \frac{1}{420} P \Rightarrow \bar{K} = 5 \cdot 10^{-26} P \quad \text{C' ε. δ}$$

$$\beta) K_{\text{ολ}} = N \cdot \bar{K} = N \cdot \frac{3}{2} kT \stackrel{\text{SI}}{=} 3 \cdot 10^{23} \cdot \frac{3}{2} \cdot 1.4 \cdot 10^{-23} \cdot 300 = 1890 \text{ J} \Rightarrow K_{\text{ολ}} = 1890 \text{ J}$$

$$\gamma) \frac{nR}{V} = 420 \Rightarrow \frac{N}{N_A} \frac{R}{V} = 420 \Rightarrow N \frac{R}{V} = 420 \text{ (SI)} \Rightarrow V = \frac{N \cdot R}{420}$$

$$\Rightarrow V = \frac{3 \cdot 10^{23} \cdot 1.4 \cdot 10^{-23}}{420} \Rightarrow V = 0.01 \text{ m}^3 \text{ ή } V = 10 \text{ L}$$

$$\delta) \frac{nR}{V'} = \frac{nR}{2V} = \frac{420}{2} = 210 \text{ (SI)}$$

$$\text{Άρα } P = \frac{nR}{V'} T \text{ ή } P = 210 T \text{ (SI)}$$

$$\bar{K} = \frac{3}{2} kT = \frac{3}{2} k \cdot \frac{PV'}{nR} = \frac{3}{2} k \cdot \frac{P}{nR} \cdot \frac{nR}{210} = \frac{3}{2} k \frac{1}{210} \cdot P$$

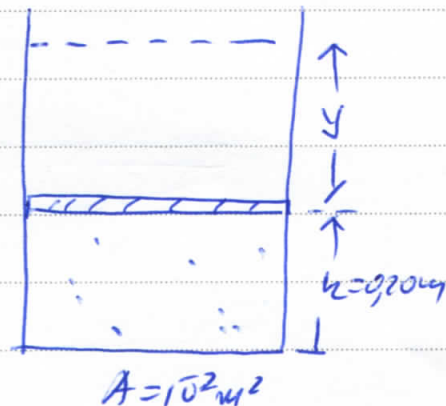
$$\Rightarrow \bar{K} = \frac{3}{2} \cdot 1.4 \cdot 10^{-23} \cdot \frac{1}{210} P \Rightarrow \bar{K} = 10 \cdot 10^{-26} P \text{ (SI)}$$

4.70

$$\alpha) P = P_{at} + \frac{\rho g h}{A} = 10^5 + \frac{20 \cdot 10}{10^{-2}} \Rightarrow P = 1,2 \cdot 10^5 \text{ N/m}^2$$

$$\rho V = n g \Rightarrow P T = \frac{\rho A h}{n g} = \frac{1,2 \cdot 10^5 \cdot 10^{-2} \cdot 0,2}{0,225}$$

$$\Rightarrow P T = \frac{0,24}{0,225} \cdot 10^3 \text{ SI}$$



$$v_{EN, Ne} = \sqrt{\frac{3 P T}{M_{g, Ne}}} = \sqrt{\frac{3}{20 \cdot 10^{-3}} \cdot \frac{0,24}{0,225} \cdot 10^3} = \sqrt{9,6 \cdot 10^6} \Rightarrow v_{EN, Ne} = 400 \text{ m/s}$$

$$v_{EN, He} = \sqrt{\frac{3 P T}{M_{g, He}}} = \sqrt{\frac{3}{4 \cdot 10^{-3}} \cdot \frac{0,24}{0,225} \cdot 10^3} = \sqrt{0,8 \cdot 10^6} = \sqrt{5 \cdot 0,16 \cdot 10^6} \Rightarrow v_{EN, He} = 896 \text{ m/s}$$

$$\frac{v_{EN, He}}{v_{EN, Ne}} = \sqrt{\frac{M_{g, He}}{M_{g, Ne}}} = \sqrt{5} = 2,24 \Rightarrow v_{EN, He} = 2,24 \cdot 400 = 896 \text{ m/s}$$

* 8)

$$\frac{V'}{V} = \frac{T'}{T} \Rightarrow \frac{A(h+y)}{A h} = \frac{T'}{T} = \frac{T'}{T} = \frac{45}{70} = 2,25$$

$$\frac{v'_{EN, Ne}}{v_{EN, Ne}} = \sqrt{\frac{T'}{T}} = \sqrt{2,25} = 1,5 \Rightarrow v'_{EN, Ne} = 1,5 \cdot 400 = v_{EN, Ne} = 600 \text{ m/s}$$

$$v'_{EN, He} = 1,5 \cdot 896 = v_{EN, He} = 1344 \text{ m/s}$$

$$8) K' = \frac{3}{2} K T', \quad K = \frac{3}{2} K T$$

$$\pi \% = \frac{\Delta K}{K} 100 \% = \frac{\frac{3}{2} K (T' - T)}{\frac{3}{2} K T} 100 \% = \frac{T' - T}{T} 100 \%$$

$$\Rightarrow \pi \% = \frac{125 T}{T} 100 \% \Rightarrow \pi \% = 125 \%$$

$$\begin{aligned} * 6) K_{gr} &= \frac{3}{2} K T N_1 + \frac{3}{2} K T N_2 = \frac{3}{2} K T (N_1 + N_2) = \frac{3}{2} \frac{P}{N_A} T (N_1 + N_2) = \frac{3}{2} P T \cdot n_2 = \frac{3}{2} P V \\ &= \frac{3}{2} P A \cdot h = \frac{3}{2} \cdot 1,2 \cdot 10^5 \text{ N/m}^2 \cdot 10^{-2} \text{ m}^2 \cdot 0,2 \text{ m} \Rightarrow K_{gr} = 360 \text{ J} \end{aligned}$$

Κεφάλαιο 5 - Η θερμοδυναμική των θερίων

Απαντήσεις -

A. Έρωτήσεις κλειστού τύπου

5.1 δ	5.2 δ	5.3 δ	5.4 δ
5.5 δ	5.6 δ	5.7 δ	5.8 δ
5.9 β, δ	5.10 δ, δ	5.11 β	5.12 β, δ
5.13 β	5.14 β	5.15 δ	5.16 β
5.17 β	5.18 δ	5.19 β	

B. Έρωτήσεις κατανομής

5.20 Για στοιχειώδη αδιαρροή ισοθερμή διεύθυνση έχουμε στοιχειώδη-αδιαρροή παραγωγή μηχανικών έργων $dW > 0$ βελάρος της εξωτερικής ενέργειας των θερίων, όρα αδιαρροή γέωση της εξωτερικής ενέργειας $dU < 0$... όρα αδιαρροή γέωση της θερμοκρασίας, κατά $dT < 0$. Τώρα στο λούτρο η θερμοκρασία είναι T και στο άπειρο $T-dT$ ούότε έχουμε εοή θερμότητας dQ μεταδιδόμενη θερμοκρασία, από $T-dT$ σε T και άναπλήρωση της εξωτερικής ενέργειας $dQ \rightarrow dU \rightarrow dW$. Τόση για παραγωγή έργου βελάρος της $U \rightarrow$ ώση για γέωση της $T \rightarrow$ εοή Q για άναπλήρωση U και T .

5.21. ΑΓισθιακή σύρρηση

5.22 για ισοθερμή διεύθυνση dQ

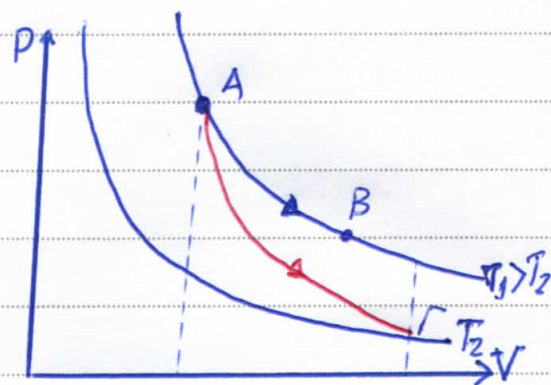
για μετατόπιση A , $Q_{AB} = \Delta U + W_{AB}$ $\Rightarrow \Delta U > 0$
 $\Rightarrow U = \text{σταθ}$ και $T = T_1$ σε όλη τη μετατόπιση AB

όρα για αδιαβατική διεύθυνση $dQ = 0$

ξεκινάει από το A και μετατοπίζει

σε για μετατόπιση Γ . $Q_{A\Gamma} = \Delta U_{A\Gamma} + W_{A\Gamma} \Rightarrow 0 = \Delta U_{A\Gamma} + W_{A\Gamma}$ $\Rightarrow$ $W_{A\Gamma} > 0 \Rightarrow \Delta U_{A\Gamma} < 0 \Rightarrow U_{\Gamma} < U_A \Rightarrow T_{\Gamma} < T_A$ δηλαδή η

τελική μετατόπιση Γ ανήκει σε χαμηλότερη θερμοκρασία από την αρχική μετατόπιση A .



5.23

AB ισόθερμη συμπίεση

$$W_{AB} = E_{\text{καρδίνης}} ABDEA = E_{ABDEA} > 0$$

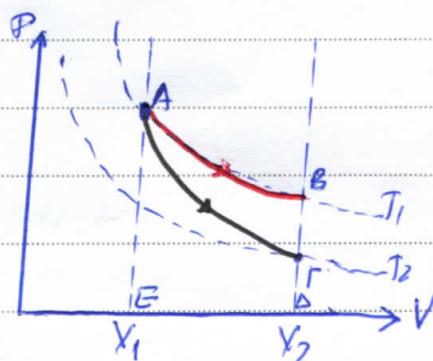
ΑΓ. αδιαβατική συμπίεση

$$W_{AG} = E_{AGDEA} > 0$$

Από το σχήμα φαίνεται ότι $E_{ABDEA} > E_{AGDEA}$

$$\Rightarrow W_{AB} > W_{AG} \Rightarrow W_{\text{ισόθερμη}} > W_{\text{αδιαβατική}}$$

Σωστή η (α)



5.24

$$W_1 > W_2 \quad \left. \begin{array}{l} \text{(*)} \\ \Delta U_1 = \Delta U_2 \end{array} \right\} +$$

$$\Delta U_1 = \Delta U_2$$

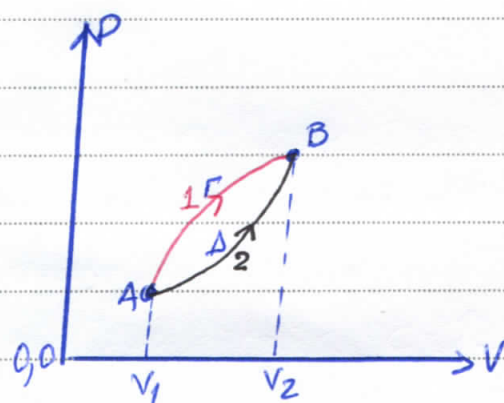
$$W_1 + \Delta U_1 > W_2 + \Delta U_2 \Rightarrow Q_1 > Q_2$$

$$\left. \begin{array}{l} \text{(*) } W_1 = W_{AB} \\ W_2 = W_{ADB} \end{array} \right\} \begin{array}{l} \text{Επειδή } E_{AFB} > E_{AAB} \\ \Rightarrow W_1 > W_2 \end{array}$$

Αρα

α. μεγαλύτερη ποσότητα θερμότητας έχει η (1)

β. μεγαλύτερη ποσότητα θερμότητας αποβάλλει η (1)



5.25

α. Η υδρογόνη βιοτεχνική βυσίρην

εν προκύπτει 1/2 mol υδρογόνου

$$\text{Είχα } \Delta U = \frac{3}{2} n R \Delta T = \frac{3}{2} n R (T_2 - T_1)$$

$$\left. \begin{array}{l} \Delta U_{AB} = \frac{3}{2} n R (T_2 - T_1) \\ \Delta U_{AG} = \frac{3}{2} n R (T_2 - T_1) \end{array} \right\} \Rightarrow \Delta U_{AB} = \Delta U_{AG}$$

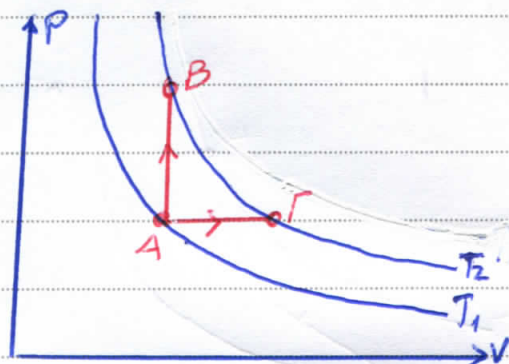
α - λάθος

$$\text{β. } W_{AB} = 0, W_{AG} > 0$$

β - λάθος

$$\left. \begin{array}{l} \Delta U_{AG} = \Delta U_{AB} \\ W_{AG} > W_{AB} \end{array} \right\} + \Rightarrow \Delta U_{AG} + W_{AG} > \Delta U_{AB} + W_{AB} \Rightarrow Q_{AG} > Q_{AB}$$

δ - σωστό



5.26

α. $\Delta U_{AB} = 0$, $\Delta U_{AG} > 0$ (αυξάνεται η T)

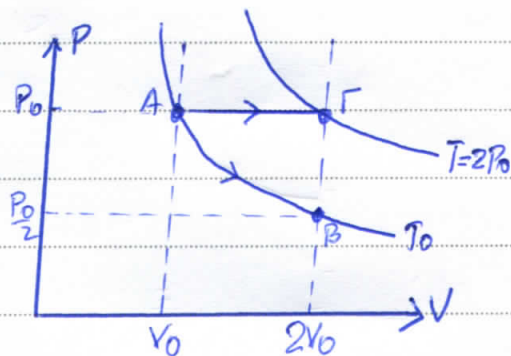
$\Delta U_{AG} > \Delta U_{AB}$ α-6ω6ρδ'

β. $W_{AG} > W_{AB}$ (μεγαλύτερο έργο, δυν P-V)

β-7δ8ω

γ. $\Delta U_{AG} + W_{AG} > \Delta U_{AB} + W_{AB} \Rightarrow Q_{AG} > Q_{AB}$

γ-6ω6ρδ'



5.27

α) Από τα αντίστοιχα έργο, δυν (P, V)

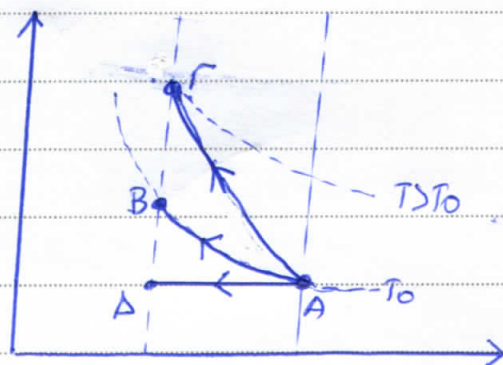
φαίνεται

$$|W_{AG}| > |W_{AB}| > |W_{AD}|$$

$$|W_{DAB}| > |W_{BAC}| > |W_{ADB}|$$

β) $\Delta U_{AD} < 0$, $\Delta U_{AB} > 0$, $\Delta U_{AG} > 0$

$$\underbrace{\Delta U_{AD} < \Delta U_{AB} < \Delta U_{AG}}_{\substack{\text{1606ρδς} \quad \text{700δ8ρδς} \quad \text{αυτάθωτικη} \\ \text{αλγεβρικός λγξ'}}$$



5.28

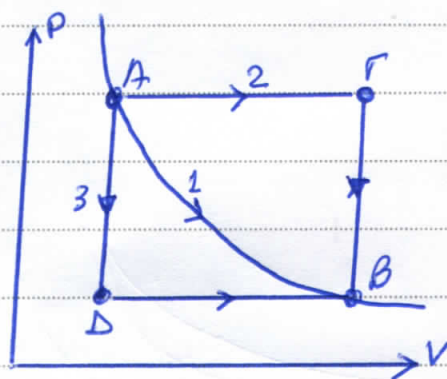
α) Από τα έργο, δυν φαίνεται

$$\delta\pi \quad W_2 > W_1 > W_3$$

$$\beta) \Delta U_2 = \Delta U_1 = \Delta U_3$$

$$\gamma) W_2 + \Delta U_2 > W_1 + \Delta U_1 > W_3 + \Delta U_3$$

$$\Rightarrow Q_2 > Q_1 > Q_3$$



5.29

a. $W_{ADB} > W_{AFB}$

α-2490

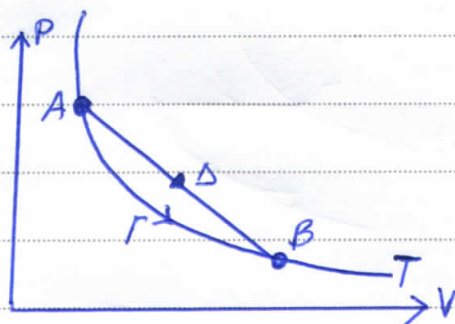
b. $\Delta U_{ADB} = \Delta U_{AFB} = 0$

β-20190

γ. $W_{ADB} + \Delta U_{ADB} > W_{AFB} + \Delta U_{AFB}$

$\Rightarrow Q_{ADB} > Q_{AFB}$

γ-6006N



5.30

$$W_{AB} = \frac{(12 \cdot 10^5 + 6 \cdot 10^5) \text{ N/m}^2}{2} (4 - 2) \cdot 10^{-3} \text{ m}^3$$

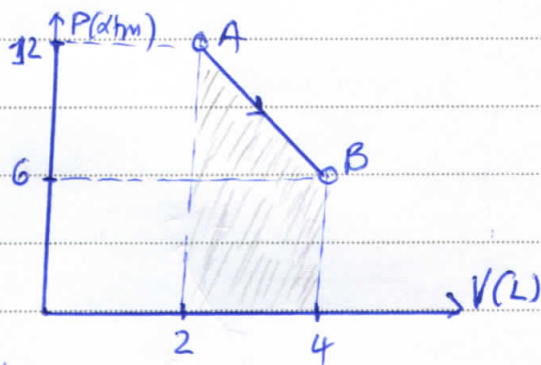
$\Rightarrow W_{AB} = 1800 \text{ J}$

$\Delta U_{AB} = 0 \dots P_A V_A = P_B V_B$, A, B ανήκουν

στην ίδια ισοθερμία

$Q_{AB} = \Delta U_{AB} + W_{AB} \Rightarrow Q_{AB} = 1800 \text{ J}$

Σωστή η (β)

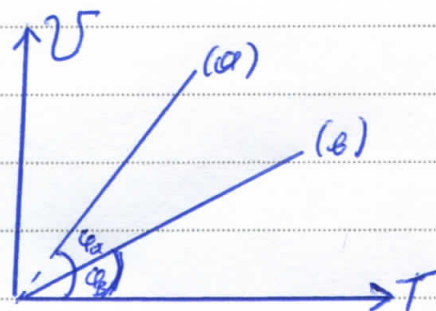


5.31. Ημιαίση της $U(T)$

Είκοις $\epsilon\phi\phi = \frac{U}{T} = \frac{\frac{3}{2} n R T}{T} = \frac{3}{2} n R$ (1)

Από το σχήμα $\phi_a > \phi_b$
 $\xrightarrow[\text{μονιμ}]{\text{οξεία}}$ $\epsilon\phi\phi_a > \epsilon\phi\phi_b \Rightarrow$

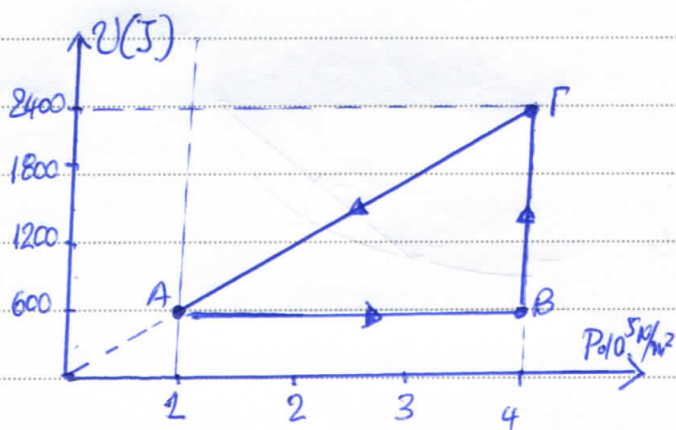
(1) $\Rightarrow \frac{3}{2} n_a R > \frac{3}{2} n_b R \Rightarrow n_a > n_b \Rightarrow \frac{N_a}{N_A} > \frac{N_b}{N_B} \Rightarrow N_a > N_b$ α-6006N



9.32

-5-

- α. AB: $V = \text{σταθερή}$, $\gamma \text{ ιδώσεως}$ $\Rightarrow$ $\text{ισοβαρής διεύρυνση}$
 ΒΓ: $P = \text{σταθερή}$, $\gamma \text{ ιδώσεως}$ $\Rightarrow$ ισοβαρής συμπίεση
 ΓΑ: $V, P \text{ ανάλογα} \Rightarrow (T, P) \text{ ανάλογα}$
 $\Rightarrow P \propto T \Rightarrow \gamma \text{ ιδώσεως}$ $\Rightarrow$ ισοχωρή ψύξη



- β. AB $\gamma \text{ ιδώσεως}$, ορθότε

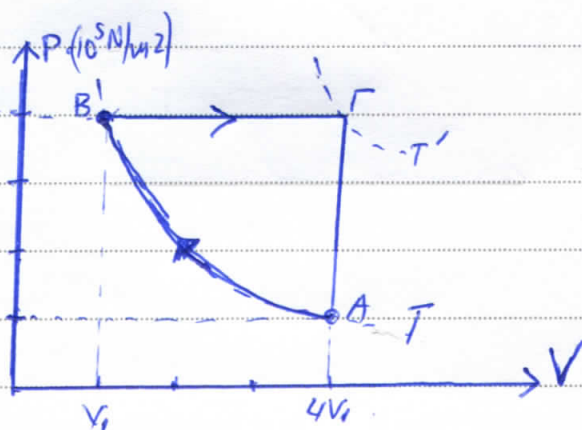
$$pV = \text{σταθ} = nRT \quad (1)$$

$$p_{AB} = \text{σταθερή} = 600 \text{ J} \Rightarrow$$

$$\Rightarrow \frac{3}{2} nRT = 600 \text{ (SI)} \Rightarrow nRT = 400 \text{ (SI)} \quad (2)$$

$$\xrightarrow{(1)} pV = 400 \text{ ή } p = \frac{400}{V} \text{ (SI)}$$

Σωστό η (α)



- γ. $W_{\text{ολ}} = W_{AB} + W_{B\Gamma} + W_{\Gamma A}$

$$W_{AB} = nRT \ln \frac{V_B}{V_A} = nRT \ln \frac{P_A}{P_B} = nRT \ln \frac{1 \cdot 10^5}{4 \cdot 10^5} = -2nRT \ln 2 \quad (2)$$

$$W_{AB} = -2 \cdot 400 \cdot 0,7 \Rightarrow W_{AB} = -560 \text{ J}$$

$$W_{B\Gamma} = P(V_{\Gamma} - V_B) = nRT' - nRT = nR\Delta T \quad (3)$$

$$\Delta U_{B\Gamma} = \frac{3}{2} nR\Delta T \Rightarrow U_{\Gamma} - U_B = \frac{3}{2} nR\Delta T \Rightarrow 2400 \text{ J} - 600 \text{ J} = \frac{3}{2} nR\Delta T$$

$$\Rightarrow nR\Delta T = 1200 \text{ J} \quad (4)$$

Από (3), (4) παίρνουμε $W_{B\Gamma} = 1200 \text{ J}$

$$W_{\Gamma A} = 0$$

$$\text{Άρα } W_{\text{ολ}} = -560 \text{ J} + 1200 \text{ J} + 0 \Rightarrow W_{\text{ολ}} = 640 \text{ J}$$

Σωστό η (δ)

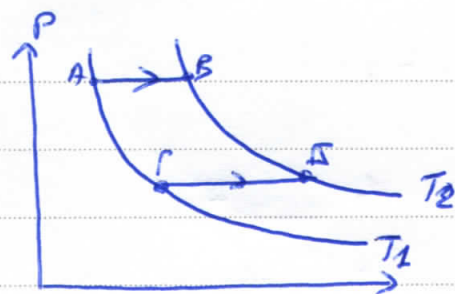
5.33

$$a) \Delta U_{AB} = \Delta U_{FD} \quad \text{Γη α εστρεφής } \Delta T \\ \alpha - \text{Geben}$$

$$b) W_{AB} = W_{FD} = p \Delta V = n R \Delta T \quad \alpha - \text{αδου}$$

$$c) \Delta U_{AB} + W_{AB} = \Delta U_{FD} + W_{FD}$$

$$\Rightarrow Q_{AB} = Q_{FD} \quad \alpha - \text{αδου}$$



5.34

$$a) \left. \begin{aligned} pV^\gamma &= 62000 \\ \frac{pV}{T} &= 62000 \end{aligned} \right\} T \cdot V^{\gamma-1} = 62000$$

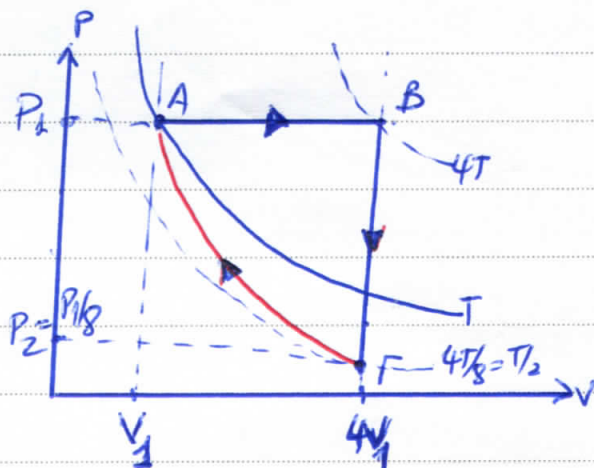
$$\Rightarrow T_A V_A^{\gamma-1} = T_F V_F^{\gamma-1}$$

$$\Rightarrow T \cdot V_1^{\gamma-1} = \frac{1}{2} \cdot (4V_1)^{\gamma-1}$$

$$\Rightarrow V_1^{\gamma-1} = \frac{2^{\gamma-2}}{2} \cdot V_1^{\gamma-1}$$

$$\Rightarrow V_1^{\gamma-1} = 2^{\gamma-3} \cdot V_1^{\gamma-1} \Rightarrow 2^0 = 2^{\gamma-3} \Rightarrow \gamma-3=0 \Rightarrow \gamma = \frac{5}{2} = 1.5$$

Άρα ααααα α α.3



$$b) \frac{P_B}{T_B} = \frac{P_F}{T_F} \Rightarrow \frac{P_1}{4T} = \frac{P_2}{\frac{4T}{8}} \Rightarrow P_1 = 8P_2 \Rightarrow P_2 = \frac{P_1}{8}$$

$$W_{AB} = P_1(4V_1 - V_1) = 3P_1V_1 = 3P_1V_1$$

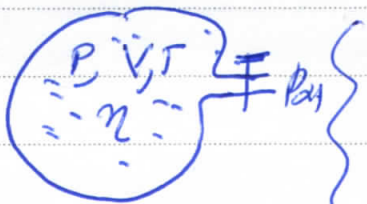
$$W_{FA} = \frac{P_1V_1 - P_2(4V_1)}{1-\gamma} = \frac{P_1V_1 - \frac{P_1}{8}(4V_1)}{1-1.5} = \frac{\frac{1}{2}P_1V_1}{-1/2} = -P_1V_1$$

$$\frac{W_1}{W_2} = \frac{3P_1V_1}{-P_1V_1} = -3 \Rightarrow W_2 = -\frac{W_1}{3}$$

Άρα ααααα α α.2

5.35

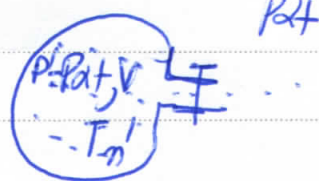
$P > P_{at}$



$$U = \frac{3}{2} n R T = \frac{3}{2} P V$$

$$P = P_{at} + \frac{150}{100} P_{at}$$

$$P = 2,5 P_{at}$$



$$n' < n$$

$$P' = P_{at}$$

$$U' = \frac{3}{2} P' V = \frac{3}{2} P_{at} V$$

$$\eta \% = \frac{\Delta U}{U} 100 \% = \frac{\frac{3}{2} P_{at} V - \frac{3}{2} 2,5 P_{at} V}{\frac{3}{2} \cdot 2,5 P_{at} V} 100 \%$$

$$\Rightarrow \eta \% = \frac{-\frac{4,5}{2} P_{at} V}{\frac{3,75}{2} P_{at} V} 100 = -\frac{4,5}{3,75} 100 \% = -60 \%$$

//

$$U = \frac{3}{2} P V = \frac{3}{2} 2,5 P_{at} V = \frac{7,5}{2} P_{at} V = 3,75 P_{at} V$$

$$U' = \frac{3}{2} P' V = \frac{3}{2} P_{at} V = 1,5 P_{at} V$$

$$\Delta U = -2,25 P_{at} V$$

$$\eta \% = \frac{-2,25 P_{at} V}{3,75 P_{at} V} 100 \% = -60 \% //$$

Ара ағары η (T).

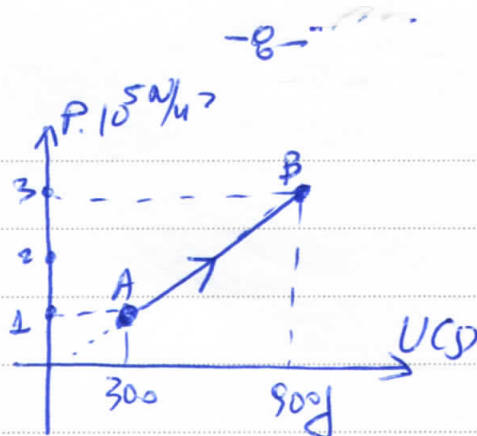
5.36

a) P, V σταθερά $\rightarrow P, T$ σταθερά
 ισόχωρη

b) $\Delta U_{AB} = 600 \text{ J}$
 $\frac{P}{V} = \text{const} \rightarrow V_B = 900 \text{ J}$

$Q_{AB} = \Delta U_{AB} + W_{AB} \Rightarrow Q_{AB} = 600 \text{ J}$ αποβλήν (6.1)

δ) $V_A = \frac{3}{2} n R T_A = \frac{3}{2} P_A V \Rightarrow 300 = \frac{3}{2} \cdot 10^5 \cdot V \Rightarrow V = 200 \cdot 10^{-5} \text{ m}^3$
 $\Rightarrow V = 2 \cdot 10^{-3} \text{ m}^3$ ή $V = 2 \text{ L}$ αποβλήν η δ.2



5.37 P, V σταθερά $\rightarrow P, T$ σταθερά

$Q_1 = Q_{AT} + Q_{TB} = \frac{3}{2} n R \Delta T_{AT} + \frac{5}{2} n R \Delta T_{TB}$

$Q_1 = \frac{3}{2} n R \cdot 2T + \frac{5}{2} n R \cdot 6T$

$Q_1 = 3nRT + 15nRT \Rightarrow Q_1 = 18nRT$

$\Delta U_1 = \frac{3}{2} n R \cdot 2T + \frac{3}{2} n R \cdot 6T = 12nRT$

$W_1 = n R \Delta T_{TB} = n R \cdot 6T = 6nRT$

$Q_1 = 18nRT = 1800 \Rightarrow nRT = 100$

$\left\{ \begin{array}{l} \Delta U_1 = 12nRT = 1200 \text{ J} \\ W_1 = 6nRT = 600 \text{ J} \end{array} \right.$

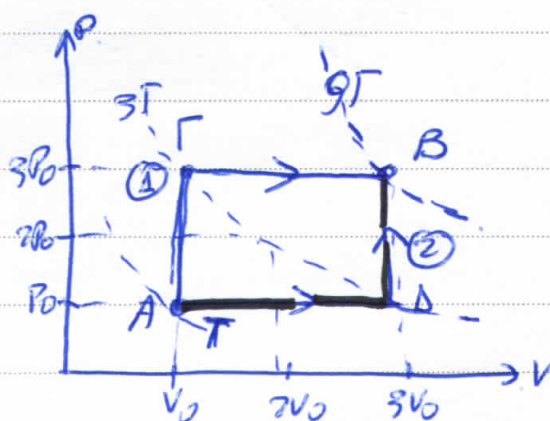
$\Delta U_2 = \frac{3}{2} n R \cdot 2T + \frac{3}{2} n R \cdot 6T \Rightarrow \Delta U_2 = 12nRT = 1200 \text{ J}$

$W_2 = n R \Delta T_{AD} = n R \cdot 2T = 2nRT = 200 \text{ J}$

$Q_2 = \Delta U_2 + W_2 = 1400 \text{ J}$

$Q_2 = \frac{5}{2} n R (2T - T) + \frac{3}{2} n R (9T - 3T) = \frac{5nRT}{2} + \frac{9nRT}{2} = \frac{14nRT}{2} = 14nRT = 1400 \text{ J}$

αποβλήν α-ε, β-ε, γ-α, δ-ε, ε-ε

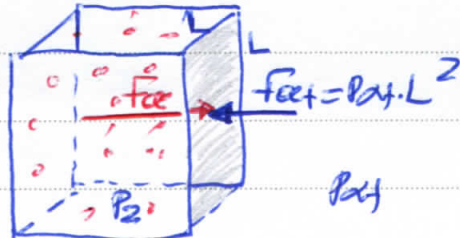


5.38

$$Q = \Delta U \Rightarrow 3U_1 = U_2 - U_1 \Rightarrow U_2 = 4U_1$$

$$2 \text{ particles} \rightarrow U_1, T, P_1 = P_{ext}$$

$$4 \text{ particles} \rightarrow 4U_1, 4T, P_2 = 4P_{ext}$$



$$\vec{F} = \vec{F}_{ext} + \vec{F}_{net}$$

$$\Delta F = F_{net} - F_{ext}$$

$$\Delta F = P_2 L^2 - P_1 L^2$$

$$\Delta F = 4P_1 L^2 - P_1 L^2$$

$$\Delta F = 3P_1 L^2$$

Answer 26 d

5.39

Process (1) A B C D A

$$Q_1 = \Delta U_1 + W_1 = W_1 = W_{AB} + W_{CD}$$

$$= nR(3T)(4) - nR(2T)(4)$$

$$= nRT(4)$$

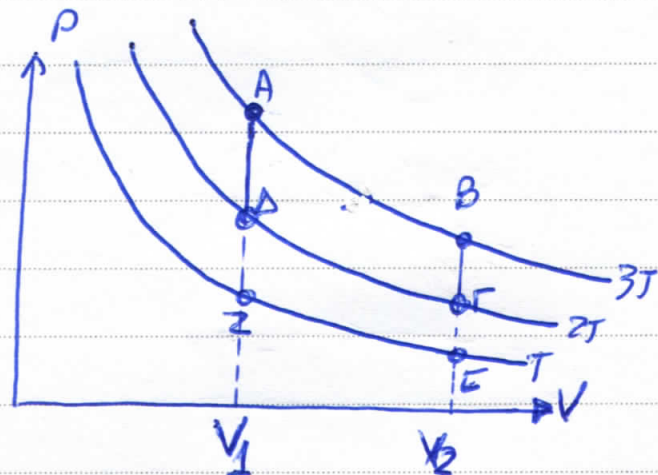
Process (2) D F E Z D

$$Q_2 = \Delta U_2 + W_2 = W_2 = W_{DF} + W_{EZ}$$

$$\Rightarrow Q_2 = nR(2T)(4) - nR(2T)(4)$$

$$\Rightarrow Q_1 = nRT(4)$$

Answer $Q_1 = Q_2$ same amount of heat (d)



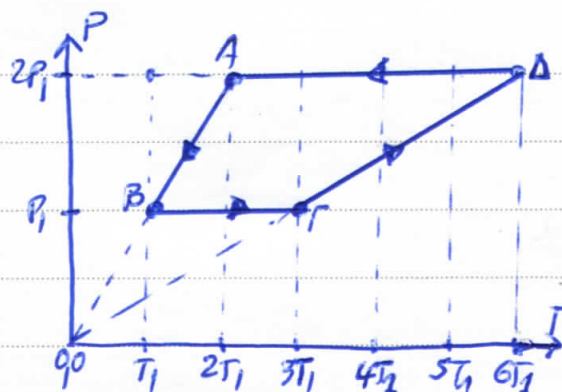
5.40

AB: 160 KPa, $T_A = 2T_B = 2T_1$, V_1

BC: 160 KPa, $V_1 \rightarrow 3V_1$

CD: 160 KPa, $3V_1$

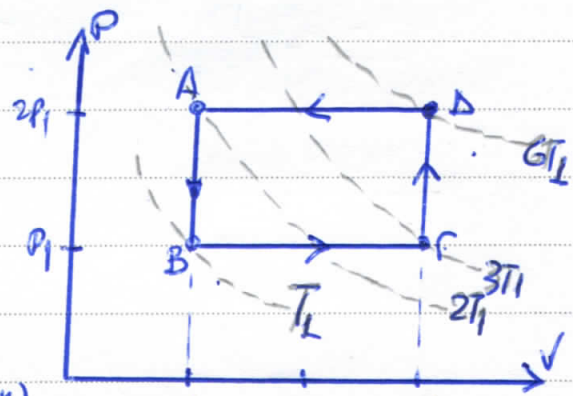
DA: 160 KPa, $3V_1 \rightarrow V_1$



$$W = -E = -(2P_1 - P_1) \cdot (3V_1 - V_1)$$

$$\Rightarrow W = -2P_1 V_1$$

$$\text{Значит } \eta (\%)$$



5.41

a) AB: 160 KPa

AC: 160 KPa

b) AB: $PV = \text{const}$

$$P_A V_A = P_B V_B$$

$$8 \cdot 2 \text{ атм} \cdot L = 2 \text{ атм} \cdot V_B$$

$$\Rightarrow V_B = 8L \quad \text{б-60616}$$

$$\dots \text{и для } V_C = 8L$$

$$\gamma) P_A V_A^\gamma = P_C V_C^\gamma \Rightarrow$$

$$8 \cdot 2^\gamma = 1 \cdot 8^\gamma \Rightarrow 2^{\gamma+3} = 2^{3\gamma}$$

$$\Rightarrow 2^{\gamma+3} = 2^{3\gamma} \quad \text{б) } 3+\gamma=3\gamma \Rightarrow 3=2\gamma \Rightarrow \gamma=1,5$$

$$\delta) \frac{P_A V_A}{T_A} = \frac{P_C V_C}{T_C} \Rightarrow \frac{8 \text{ атм} \cdot 2L}{500 \text{ K}} = \frac{1 \text{ атм} \cdot 8L}{T_C} \Rightarrow T_C = 250 \text{ K}$$

$$\text{б-60616}$$

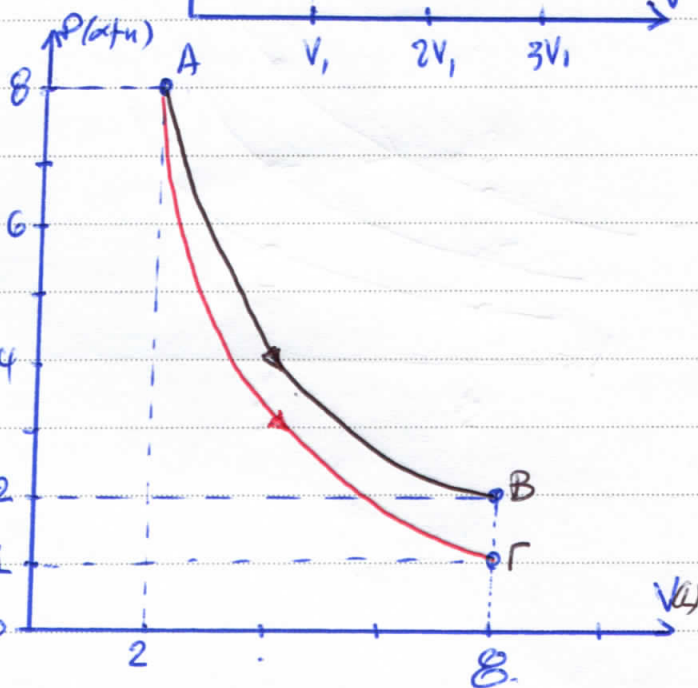
$$\text{б-7200}$$

$$\epsilon) W_{AB} = nRT \ln 4 = 2nRT \ln 2 = 2P_A V_A \ln 2 = 2 \cdot 8 \cdot 2 \ln 2 \text{ атм} \cdot L = 32 \ln 2 \text{ атм} \cdot L$$

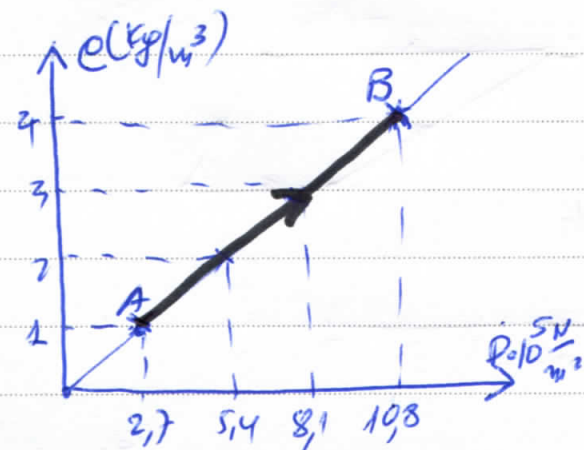
$$W_{AC} = \frac{P_C V_C - P_A V_A}{1 - \gamma} = \frac{1 \cdot 8 - 8 \cdot 2}{1 - 1,5} = \frac{-8}{-0,5} = -16 \text{ атм} \cdot L$$

$$\eta = \frac{32 \ln 2}{16} \Rightarrow \eta = 2 \ln 2$$

$$\text{б-7200}$$



5.42 $m = 6 \text{ kg} = 6 \cdot 10^3 \text{ g}$
 $\rho = 6 \text{ kg} \cdot \text{m}^{-3}$ ρ απόλυτα
 ομογενής υμενότητα



α. $P = \frac{1}{3} \rho v_{\text{rms}}^2$
 $v_{\text{rms}} = 6 \text{ m/s}$ να υποθέσουμε
 πως AB

$v_{\text{rms}} = 6 \text{ m/s}$ $v_{\text{rms}} = \sqrt{\frac{3P}{\rho}} = \sqrt{\frac{3 \cdot 2,7 \cdot 10^5}{6}} \Rightarrow v_{\text{rms}} = \sqrt{81 \cdot 10^4} \Rightarrow v_{\text{rms}} = 900 \text{ m/s}$
 η αλλαγή στην υμενότητα είναι 2 φορές μεγαλύτερη

β. $U = \frac{3}{2} nRT = \frac{3}{2} PV = \frac{3}{2} P \frac{m}{\rho} = \frac{3}{2} \frac{P}{\rho} m$

$\hookrightarrow \frac{P}{\rho} = 6 \text{ m/s}$ να υποθέσουμε

$\Rightarrow U = \frac{3}{2} \frac{2,7 \cdot 10^5}{6} \cdot 6 \cdot 10^3 \Rightarrow U = 2430 \text{ J}$ $\rho = 6 \text{ kg/m}^3$

γ. [η αλλαγή ... η P δεν είναι ανάλογη με T]

$PV = \rho RT = nRT = P_A V_A = P_A \frac{m}{\rho_A} = \frac{P_A}{\rho_A} m = \frac{2,7 \cdot 10^5}{6} \cdot 6 \cdot 10^3$

$\Rightarrow PV = 1620 \text{ (SI)} \Rightarrow P = \frac{1620}{V} \text{ SI}$ $\rho = 6 \text{ kg/m}^3$

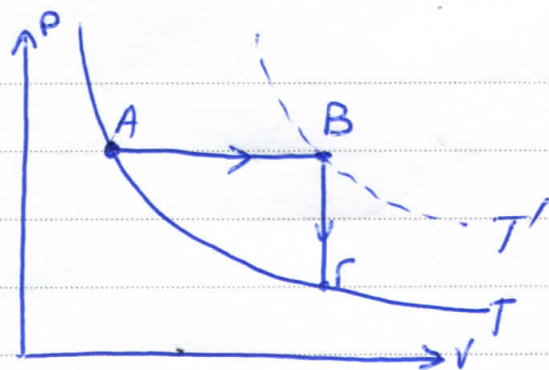
α-1, β-9, γ-9

Sol43

$$Q_{AB} = n C_p \Delta T$$

$$\Delta U_{AB} = n C_v \Delta T$$

$$Q_{B\Gamma} = n C_v \Delta T$$



$$Q_{B\Gamma} = n C_p \Delta T - n C_v \Delta T$$

$$Q_{B\Gamma} = n (C_p - C_v) \Delta T$$

$$Q_{AB} = n C_p \Delta T$$

$$Q_{AB} = \frac{370}{100} Q_{B\Gamma} \Rightarrow$$

$$\Rightarrow \text{[crossed out text]}$$

$$n C_p \Delta T = 3,5 n (C_p - C_v) \Delta T$$

$$\Rightarrow C_p = 3,5 C_p - 3,5 C_v \Rightarrow -2,5 C_p = -3,5 C_v$$

$$\Rightarrow \frac{C_p}{C_v} = \frac{3,5}{2,5} = \frac{7}{5} = 1,4 \Rightarrow \frac{C_p}{C_v} = 1,4 \Rightarrow \gamma = 1,4$$

δρα σωστό 70 (α)

Sol44

Ποσοστός γενελογί

$$\Delta U = n R \Delta T \Rightarrow \frac{\Delta U}{\Delta T} = n R \frac{\Delta T}{\Delta T}$$

$$\Rightarrow \frac{\Delta U}{\Delta T} = \frac{92}{P} R \cdot 0,1 = 0,02 \frac{J}{s} \Rightarrow \frac{\Delta U}{\Delta T} = 902 \frac{J}{s}$$

Αρα σωστό η (α)

Sol45

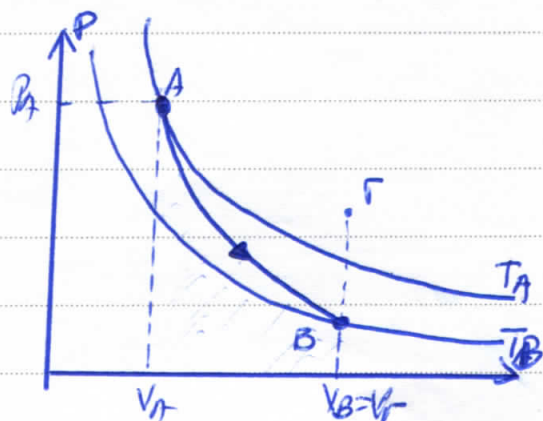
$$W_{AB} = -\Delta U_{AB} = -n \frac{3}{2} R (T_B - T_A)$$

$$Q_{B\Gamma} = \Delta U_{B\Gamma} = n \frac{3}{2} R (T_{\Gamma} - T_B)$$

$$Q_{B\Gamma} = W_{AB} \Rightarrow n \frac{3}{2} R (T_{\Gamma} - T_B) = n \frac{3}{2} R (T_A - T_B)$$

$$\Rightarrow T_{\Gamma} = T_A$$

Αρα σωστό η β



5.46

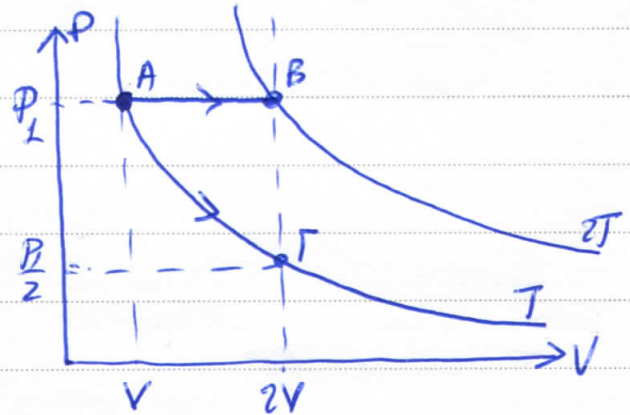
AB. e, T $\Rightarrow$ γ $\Rightarrow$ $\frac{e_B}{T_B} = \frac{e_A}{T_A}$ $\Rightarrow$ $\frac{e_B}{2} = \frac{e_A}{T_A}$ $\Rightarrow$ $T_B = 2T_A$, $V_B = 2V_A$
 AF e, P $\Rightarrow$ γ $\Rightarrow$ $\frac{e_F}{P_F} = \frac{e_A}{P_A}$ $\Rightarrow$ $\frac{e_F}{2} = \frac{e_A}{P_A}$ $\Rightarrow$ $P_F = \frac{P_A}{2}$, $V_F = 2V_A$

1^η μεταβολή

AB $e, T = \text{σταθ.}$
 γ $\Rightarrow$ $\frac{e_B}{T_B} = \frac{e_A}{T_A}$ $\Rightarrow$ $\frac{e_B}{2} = \frac{e_A}{T_A}$ $\Rightarrow$ $T_B = 2T_A$
 και $V_B = 2V_A$

2^η μεταβολή

AF $e, P = \text{σταθ.}$
 γ $\Rightarrow$ $\frac{e_F}{P_F} = \frac{e_A}{P_A}$ $\Rightarrow$ $\frac{e_F}{2} = \frac{e_A}{P_A}$ $\Rightarrow$ $P_F = \frac{P_A}{2}$, $V_F = 2V_A$



$$\dots V_B = V_F = 2V_A$$

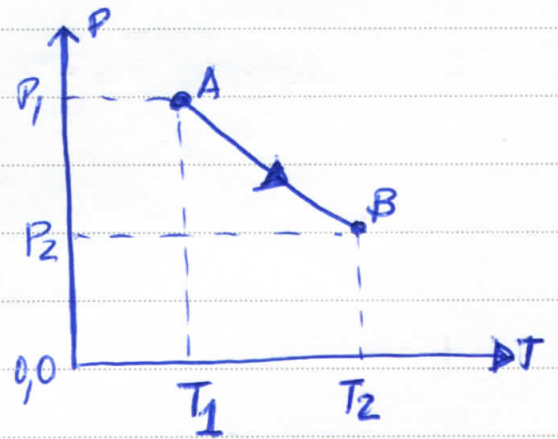
Από το σχήμα φαίνεται $W_{AB} > W_{AF}$
 $\Rightarrow$ Άρα σωστό ε δ (β)

5.47

a) $T_B > T_A \Rightarrow V_B > V_A$
 α -βλεπτο

b) $PV = nRT \Rightarrow V = \frac{nRT}{P}$

$\Rightarrow T \uparrow, P \downarrow \Rightarrow V$ αυξάνεται
 συνεπώς β-βλεπτο



c) $Q_{AB} = \Delta U_{AB} + W_{AB} > 0$ $\Rightarrow$ $\Delta U_{AB} > 0$ $\Rightarrow$ $W_{AB} > 0$ $\Rightarrow$ $Q_{AB} > 0$

5.48

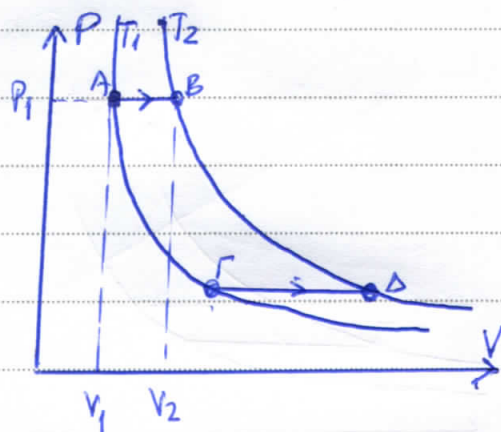
$$W = P \Delta V = p (V_{\text{fin}} - V_{\text{ex}}) = nR(T_2 - T_1)$$

$$\Rightarrow W = nR(T_2 - T_1)$$

$$W_{AB} = nR(T_B - T_A) = nR(T_2 - T_1)$$

$$W_{\Delta} = nR(T_D - T_C) = nR(T_2 - T_1) \quad \Rightarrow W_{AB} = W_{\Delta}$$

Σωστή η (β)



5.49

Ξέρω παρατηρούμε ότι

υπόλογιστη T_{∞} από

όπως οφθαλμίζει εφ' όσον

μεταβολή δόσης της υφάρ

πλην T μεταβάλλεται

Η αίσθηση $U(T)$ είναι

$$\epsilon_{\text{φ}} = \frac{U}{T} = \frac{\frac{3}{2} n R T}{T} = \frac{3}{2} n R = \frac{3}{2} \frac{N}{N_A} R$$

Από το σχήμα παρατηρούμε ότι $\epsilon_{\text{φ}A} > \epsilon_{\text{φ}B}$

$$\Rightarrow \frac{3}{2} \frac{N_A R}{N_A} > \frac{3}{2} \frac{N_B R}{N_B} \Rightarrow N_A > N_B$$

α. $N_A > N_B$... αλλά η υφάρξη μπορεί να είναι

ισόθετος αλλά όχι υφάρ

α-λίστος

β. $N_A > N_B$... αλλά η υφάρξη μπορεί να είναι ισόθετος

αλλά όχι υφάρ

β-λίστος

γ. Ξέρω T μεταβάλλεται η υφάρξη

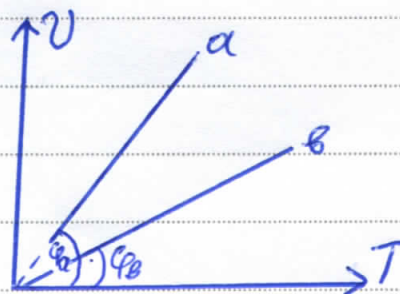
6/7 η δέν είναι ισόθετος

γ-λίστος

δ. Ξέρω δέν προσδιορίζεται το

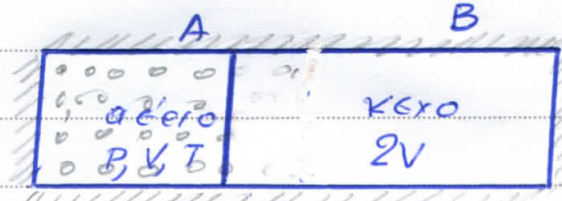
είδος της υφάρξης, αλλά $N_A > N_B$

δ-λίστος

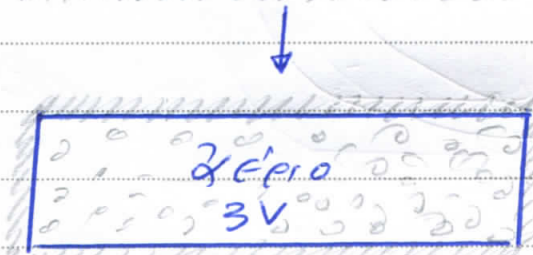


5.50

α. Η γεραλότη είναι
για αντίστροφη α-λυσή



β. Εάν έχουμε συμπίεση
άλλα ελαστική συμπίεση
χωρίς το δέριο να
παραμένει ίδιο... δεν υπάρχει βλάβη να διατηρηθεί
μείνει να μετασχηματιστεί... β-λυσή



γ. Υπάρχει θερμότητα $\Rightarrow Q=0$ δ-ερωτή
δ. $Q=\Delta U+W \Rightarrow 0=\Delta U+0 \Rightarrow \Delta U=0 \Rightarrow U=σταθερή$ δ-ερωτή

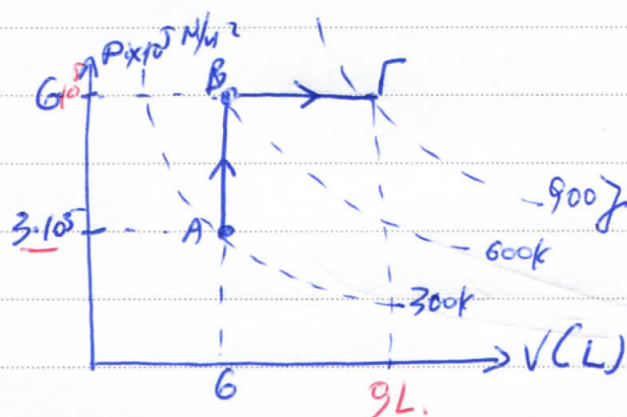
ε. Εάν μπορεί να έχουμε $Q=0$ αλλά η γεραλότη
δεν είναι αδιαβατική... η αδιαβατική γεραλότη
είναι αντίστροφη ε-λυσή

στ. Η γεραλότη δεν είναι γαστροπική
Η γαστροπική είναι αντίστροφη γεραλότη στ-λυσή

ζ. $U=σταθερή \Rightarrow \frac{3}{2}nRT=σταθερή \Rightarrow T=σταθερή$ (...και γαστροπική...)
 $\frac{PV}{T} = \frac{P'V}{T} \Rightarrow P' = \frac{P}{3}$ ζ-ερωτή

Γ! Αρνείται να απαντήσει
551) α.

	P	V	T
A	$3 \cdot 10^5$	6L	300K
B	$6 \cdot 10^5$	6L	600K
Γ	$6 \cdot 10^5$	9L	900K.



$$\left. \begin{aligned} Q_{AB} &= \frac{3}{2} nR (T_B - T_A) \\ Q_{B\Gamma} &= \frac{3}{2} nR (T_\Gamma - T_B) \end{aligned} \right\} \begin{aligned} Q_{AB} &= Q_{B\Gamma} \\ T_B - T_A &= T_\Gamma - T_B \Rightarrow T_\Gamma = 2T_B - T_A \Rightarrow T_\Gamma = 2 \cdot 600 - 300 \\ &\Rightarrow T_\Gamma = 900K \end{aligned}$$

$$\frac{V_B}{T_B} = \frac{V_\Gamma}{T_\Gamma} \Rightarrow \frac{6}{600} = \frac{V}{900} \Rightarrow \underline{V_\Gamma = 9L}$$

ο)

	Q	ΔU	W
AB	2700J	2700J	0
BΓ	4100J	2700J	1800J
ABΓ	7200	5400J	1800J

$$Q_{AB} = \frac{3}{2} nR (T_B - T_A) = \frac{3}{2} (P_B - P_A) V = \frac{3}{2} \cdot 3 \cdot 10^5 \cdot 6 \cdot 10^{-3} = 2700J$$

$$Q_{AB} = \Delta U_{AB} + W_{AB} = \Delta U_{AB} \Rightarrow \Delta U_{AB} = 2700J$$

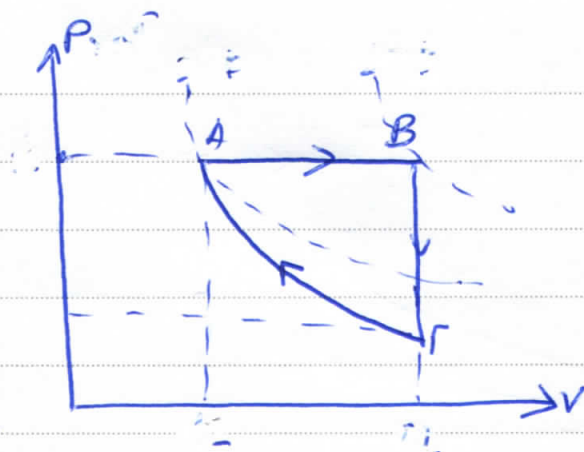
$$\Delta U_{B\Gamma} = \frac{3}{2} nR (T_\Gamma - T_B) = \frac{3}{2} P_B (V_\Gamma - V_B) = \frac{3}{2} \cdot 6 \cdot 10^5 \cdot (9 - 6) \cdot 10^{-3} = 2700J$$

$$W_{B\Gamma} = P (V_\Gamma - V_B) = 6 \cdot 10^5 \cdot (9 - 6) \cdot 10^{-3} = 1800J$$

$$Q_{B\Gamma} = \Delta U_{B\Gamma} + W_{B\Gamma} = 4100J$$

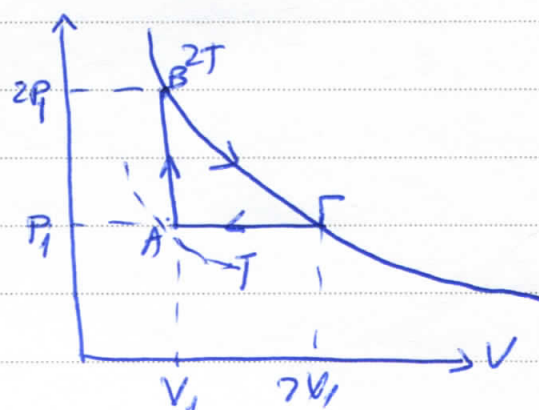
5.52

	Q	ΔU	W
AB	500J	300J	200J
BF	-394J	-394J	0
FA	0	+94J	-94J
ABFA	+106J	0	106J



5.53

	Q	ΔU	W
AB	+600J	+600J	0
BF	+560J	0	+560J
FA	-1000J	-600J	-400J
ABFA	+160J	0	+160J



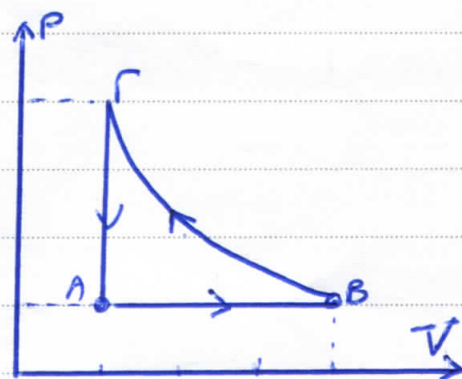
$$W_{FA} = P_1(V_1 - 7V_1) = -P_1 V_1 = -nRT = -400J \Rightarrow nRT = 400J$$

$$\Delta U_{FA} = \frac{3}{2} nR(T - 7T) = -\frac{3}{2} nRT = -\frac{3}{2} 400 = -600J$$

$$W_{BF} = nP_1 \Delta V = 2(nRT) \ln 7 = 2 \cdot 400 \cdot 0.97 = +560J$$

5.54

	Q	ΔU	W
AB	1000J	600J	400J
BF	-800J	0	-800J
FA	-600J	-600J	0
ABFA	-400J	0	-400J

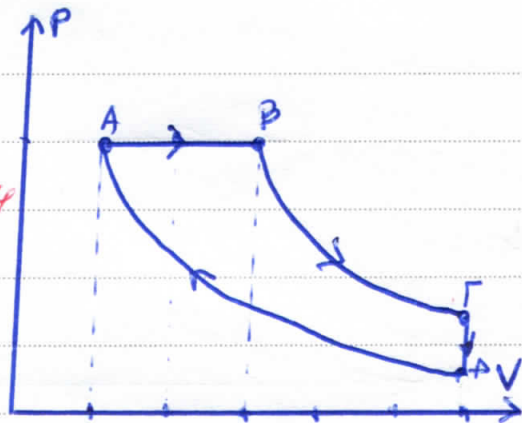


$$\left. \begin{array}{l} \Delta U_{AB} = \frac{3}{2} nR \Delta T \\ W_{AB} = nR \Delta T \\ Q_{AB} = \frac{5}{2} nR \Delta T \end{array} \right\} \frac{\Delta U_{AB}}{Q_{AB}} = \frac{3}{5} \Rightarrow \Delta U_{AB} = \frac{3}{5} 1000J = 600Joule$$

5.55

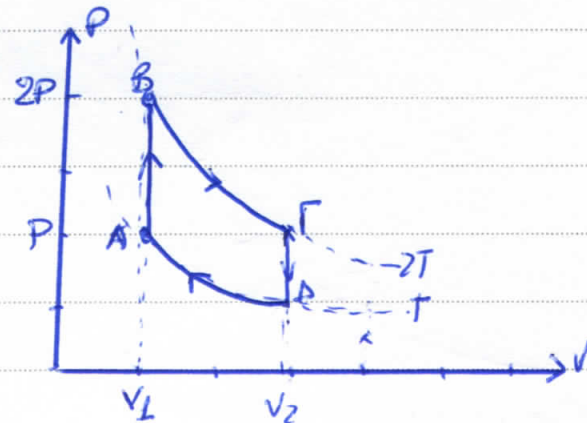
	Q	ΔU	W
AB	500 J	300 J	200 J*
BC	200 J	0	200 J
CA	-400 J	-400 J	0
DA	0	+100 J	-100 J
ABCA	+300 J	0	+300 J

* $\int P dV = 610.5 \text{ J}$



5.56

	Q	ΔU	W
AB	+300 J	+300 J	0
BC	+400 J	0	+400 J
CA	-300 J	-300 J	0
DA	-700 J	0	-700 J
ABCA	+700 J	0	+700 J



$$W_{BC} = nR2T \ln \frac{V_C}{V_B} = 2nRT \ln \frac{V_2}{V_1}$$

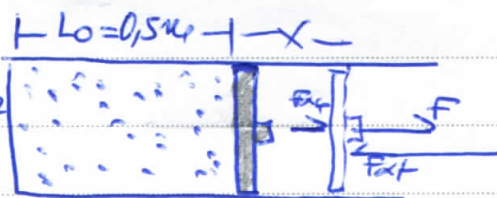
$$W_{DA} = nRT \ln \frac{V_D}{V_A} = nRT \ln \frac{V_1}{V_2} = -nRT \ln \frac{V_2}{V_1} = -\frac{W_{BC}}{2} = -\frac{400}{2} = -200 \text{ J}$$

$$\Delta U_{AB} = -\Delta U_{CA} \text{ or } \Delta U_{CA} = -\Delta U_{AB} = -300 \text{ J} \quad (\text{because of state ex. condition})$$

5.57 a) 000760848m

b) Approx $P_0 = P_{at} = 10^5 \text{ N/m}^2$

$$V_0 = A L_0 = 10^{-2} \cdot 0,5 = 5 \cdot 10^{-3} \text{ m}^3 \quad A = 10^{-2} \text{ m}^2$$



Total force $\Sigma F_x = 0 \Rightarrow F + F_{ext}/w = F_{at}$

$$\Rightarrow F + P A = P_{at} A \Rightarrow F = (P_{at} - P) A$$

process

$$\text{isobar } P$$

Boyle $P_0 V_0 = P V$

$$P_0 A L_0 = P A (L_0 + x)$$

$$P = P_0 \frac{L_0}{L_0 + x} = P_{at} \frac{L_0}{L_0 + x}$$

$$F = \left(P_{at} - P_{at} \frac{L_0}{L_0 + x} \right) A$$

$$\Rightarrow F = \frac{P_{at} L_0 + P_{at} x - P_{at} L_0}{L_0 + x} A \Rightarrow F = P_{at} \cdot \frac{x}{L_0 + x} A$$

$$\xrightarrow{SF} F = 10^5 \cdot \frac{x}{0,5 + x} \cdot 10^{-2} \text{ N} \quad \boxed{F = \frac{1000x}{0,5 + x} \text{ (SF)}}$$

c) Approx $P_0 = P_{at}$, $V_0 = A L_0$
isobar $P = 0$, $V = A L$

$$W = nRT \ln \frac{V}{V_0} = P_0 V_0 \ln \frac{A L}{A L_0} = 10^5 \text{ N/m}^2 \cdot 5 \cdot 10^{-3} \ln \frac{L}{0,5}$$

$$\Rightarrow W_{accin} = 500 \text{ J} \Rightarrow W_{accin} = 300 \text{ J}$$

$$Q = \Delta U + W \Rightarrow Q = 300 \text{ J}$$

$$\Delta K = W_{tot} \Rightarrow 0 = W_{F_{ext}} + W_F + W_{F_{at}}$$

$$W_{accin} = 300 \text{ J}$$

$$W_{F_{at}} = -F_{at} \cdot \Delta x = -P_{at} A \cdot \Delta x = -10^5 \cdot 10^{-2} \cdot 0,5 = -500 \text{ J}$$

$$\text{hex } 0 = +300 + W_F - 500 \Rightarrow \boxed{W_F = +200 \text{ J}}$$

5.58

$$a) P_0 = P_{at} + \frac{mg}{A} = 10^5 + \frac{20 \cdot 10}{10^{-2}} \Rightarrow P_0 = 1,2 \cdot 10^5 \text{ N/m}^2$$

$$b) pV = nRT = P_0 V_0 = P_0 A L_0$$

$$\Rightarrow pV = 1,2 \cdot 10^5 \text{ N/m}^2 \cdot 10^{-2} \text{ m}^2 \cdot 0,5 \Rightarrow pV = 600 \text{ (SI)}$$

$$d) T \text{ constant } \Rightarrow P \propto 1/V$$

$$pV = P_0 V_0 \Rightarrow P A (L_0 + y) = P_0 A L_0$$

$$\Rightarrow P = P_0 \frac{L_0}{L_0 + y}$$

$$\sum F_y = 0 \Rightarrow F_{at} + F - F_{at} - mg = 0$$

$$\Rightarrow F - F_{at} + mg - F_{at} = P_{at} A + mg - P A$$

$$\Rightarrow F = P_{at} A + mg - P_0 \frac{L_0}{L_0 + y} A \stackrel{SI}{\Rightarrow} F = 10^5 \cdot 10^{-2} + 20 \cdot 10 - 1,2 \cdot 10^5 \frac{0,5}{0,5 + y} 10^{-2}$$

$$\Rightarrow F = 1200 - \frac{600}{0,5 + y} \Rightarrow F = \frac{600 + 1200y - 600}{0,5 + y} \Rightarrow F = \frac{1200y}{0,5 + y} \text{ (SI)}$$

$$e) W_{exp} = nRT \ln \frac{A L}{A L_0} \Rightarrow W_{exp} = P_0 V_0 \ln 2 = 600 \ln 2 \Rightarrow W_{exp} = 420 \text{ J}$$

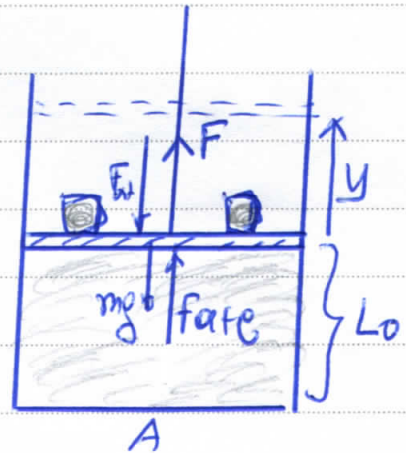
$$6T) \Delta K = W_{tot} \Rightarrow 0 = W_F + W_{exp} + W_{mg} + W_{at}$$

$$W_{exp} = 420 \text{ J}$$

$$W_{mg} = -mg \Delta y = -20 \cdot 10 \cdot 0,5 = -100 \text{ J}$$

$$W_{at} = -F_{at} \Delta y = -P_{at} A \Delta y = -10^5 \cdot 10^{-2} \cdot 0,5 = -500 \text{ J}$$

$$\Rightarrow 0 = W_F + 420 \text{ J} - 100 \text{ J} - 500 \text{ J} \Rightarrow W_F = +180 \text{ J}$$



5.59 100x ω p u φ ε τ α λ ο τ υ ρ = 250 T

$$V = 8L \quad T_1 = 300 K \quad P_1$$

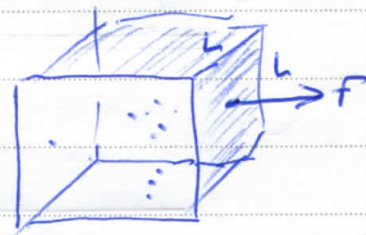
$$T_2 = 300 + \frac{400}{300} \cdot 300 \Rightarrow T_2 = 700 K \quad P_2$$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \Rightarrow P_2 = \frac{P_1}{T_1} \cdot T_2 = P_1 \cdot \frac{700}{300} \Rightarrow P_2 = \frac{7}{3} P_1$$

9) $V = L^3 \Rightarrow L = 2 \text{ m} \quad A = L^2 = 4 \text{ m}^2$

$$F = p \cdot A = 250 T \cdot A \Rightarrow F = 250 T \cdot 4$$

$$\Rightarrow \underline{F = 1000 T (SD)}$$



e)

$$\Delta U = \frac{3}{2} n R \Delta T = \frac{3}{2} n R (T_2 - T_1) = \frac{3}{2} (P_2 V - P_1 V)$$

$$\Rightarrow \Delta U = \frac{3}{2} (P_2 - P_1) V = \frac{3}{2} (250 T_2 - 250 T_1) V$$

$$\Rightarrow \Delta U = \frac{3}{2} 250 \cdot (T_2 - T_1) V = \frac{3}{2} 250 \cdot (700 - 300) \cdot 8$$

$$\Rightarrow \Delta U = 12 \cdot 10^5 J$$

$$Q = \Delta U + W \Rightarrow Q = \Delta U \Rightarrow \underline{Q = 12 \cdot 10^5 J}$$

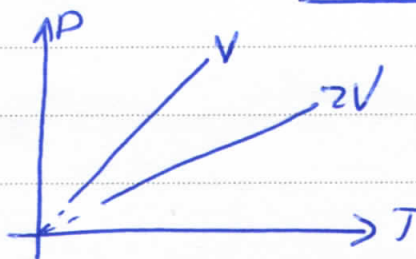
δ)

$$\frac{P}{T} = \frac{nR}{V}$$

$$\frac{P}{T} = \frac{nR}{V} = 250$$

$$\frac{P}{T} = \frac{nR}{2V} = \frac{1}{2} \frac{nR}{V} = \frac{1}{2} \cdot 250 = 125 \Rightarrow \underline{P = 125 T}$$

5) ε φ φ = $\frac{P}{T} = \frac{nR}{V}$
ε φ φ, V α ν τ ι ο ρ ρ ρ ρ ρ α λ ο τ υ ρ



$$f) Q = \Delta U = 0 = \frac{3}{2} (P_2 - P_1) V' = \frac{3}{2} \cdot (125T_2 - 125T_1) \Delta V$$

$$\Rightarrow Q = 3 \cdot 125 (700 - 300) \cdot 8 \Rightarrow Q = 12 \cdot 10^5 \text{ J}$$

5.60 $A = l \cdot l = 0,01 = 10^{-2} \text{ m}^2$

$$a) P = P_{at} + \frac{mg}{A} = 10^5 + \frac{5 \cdot 10}{10^{-2}} = 100 \cdot 10^3 + 5 \cdot 10^3 = 105 \cdot 10^3 = 1,05 \cdot 10^5 \text{ N/m}^2$$

$$e) |\Delta U| = mg \Delta Y = 5 \cdot 10 \Delta Y \Rightarrow 6 = 50 \Delta Y \Rightarrow \Delta Y = 0,12 \text{ m}$$

$$\Delta V = A \Delta Y = 10^{-2} \cdot 0,12 = 12 \cdot 10^{-4} \text{ m}^3$$

$$W = P \Delta V = 1,05 \cdot 10^5 \cdot 12 \cdot 10^{-4} \Rightarrow W = 126 \text{ J}$$

$$\Delta U = \frac{3}{2} n R \Delta T$$

$$W = P \Delta V = P (V_2 - V_1) = n R T_2 - n R T_1 = n R \Delta T \quad \}$$

$$\frac{\Delta U}{W} = \frac{3}{2} \Rightarrow \Delta U = \frac{3}{2} W \Rightarrow \Delta U = \frac{3}{2} \cdot 126 \Rightarrow \Delta U = 189 \text{ J}$$

$$g) Q = \Delta U + W \Rightarrow Q = 189 + 126 \Rightarrow Q = 315 \text{ Joule}$$

5.61 $A = l \cdot l = 0,01 \text{ m}^2 = 10^{-2} \text{ m}^2$

a) 1600 átomos

$$P = P_{at} + \frac{mg}{A} = 10^5 + \frac{80 \cdot 10}{10^{-2}} = 1010^5 + 8 \cdot 10^4$$

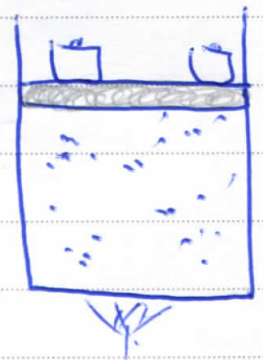
$$\Rightarrow P = 18 \cdot 10^4 \text{ m}^2 \quad P = 1,8 \cdot 10^5 \text{ N/m}^2$$

$$e) \left. \begin{array}{l} \Delta U = \frac{3}{2} n R \Delta T \\ W = P \Delta V = n R \Delta T \\ Q = \frac{5}{2} n R \Delta T \end{array} \right\} \frac{\Delta U}{Q} = \frac{3}{5} \Rightarrow \Delta U = \frac{3}{5} Q$$

$$\Delta U = 135 \text{ J}$$

$$g) W = 90 \text{ J} \Rightarrow W = P \Delta V = P A \Delta Y \Rightarrow \Delta Y = \frac{W}{P A}$$

$$\Rightarrow \Delta Y = \frac{90 \text{ J}}{1,8 \cdot 10^5 \cdot 10^{-2}} \Rightarrow \Delta Y = 50 \cdot 10^{-3} \text{ m} \Rightarrow \Delta Y = 0,05 \text{ m} \Rightarrow \Delta Y = 5 \text{ cm}$$



5.62

$$a) P = P_{at} + \frac{mg}{A} \Rightarrow mg = (P - P_{at})A \Rightarrow m = \frac{(P - P_{at})A}{g} = \frac{(1,08 \cdot 10^5 - 10^5) \cdot 10^{-2}}{10}$$

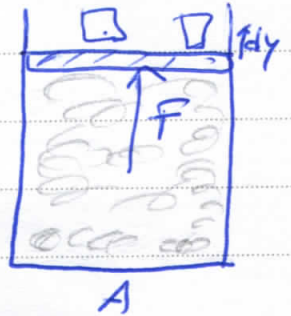
$$\Rightarrow m = \frac{9,08 \cdot 10^5 \cdot 10^{-2}}{10} \Rightarrow m = 8 \text{ kg}$$

b)

$$dW_{atm} = P dV = P A dy \Rightarrow \frac{dW_{atm}}{dt} = P A \frac{dy}{dt}$$

$$\Rightarrow P = P_{at} V \Rightarrow V = \frac{P}{P_{at}} = \frac{540 \cdot 10^3}{1,08 \cdot 10^5 \cdot 10^2}$$

$$\Rightarrow V = 500 \cdot 10^{-6} \text{ m}^3 \text{ s} \quad v = 5 \cdot 10^{-6} \text{ m/s} \quad v = 95 \text{ mm/s}$$



$$c) \left. \begin{array}{l} dU = \frac{3}{2} n R dT \\ dW = P dV = n R dT \end{array} \right\} \frac{dU}{dW} = \frac{3}{2} \Rightarrow dU = \frac{3}{2} dW$$

$$\Rightarrow \frac{dU}{dt} = \frac{3}{2} \frac{dW}{dt} \Rightarrow \frac{dU}{dt} = \frac{3}{2} P_{atm} v = \frac{3}{2} 540 \text{ mW} \Rightarrow \frac{dU}{dt} = 810 \text{ mW}$$

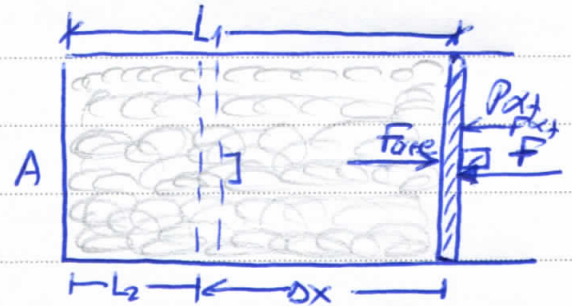
$$\Rightarrow \frac{dU}{dt} = 810 \frac{\text{mJ}}{\text{s}} \Rightarrow \frac{dW}{dt} = 540 \text{ J/s}$$

5.63 α) Θραύση γεραιών

β) Αρχικά $V_1 = A L_1$, $P_1 = P_{at} = 10^5 \text{ N/m}^2$

Τελικά $V_2 = A L_2$, $P_2 = ?$

$$P_2 V_2^\gamma = P_1 V_1^\gamma \Rightarrow P_2 A L_2^\gamma = P_1 A L_1^\gamma$$



$$\Rightarrow P_2 = P_1 \left(\frac{L_1}{L_2} \right)^\gamma = 10^5 \frac{\text{N}}{\text{m}^2} \left(\frac{1}{0,75} \right)^{5/2} = 10^5 (2)^{3/2} \Rightarrow P_2 = 8 \cdot 10^5 \text{ N/m}^2$$

$$\delta) W = \frac{P_2 V_2 - P_1 V_1}{1 - \gamma} = \frac{8 \cdot 10^5 \cdot 10^{-2} \cdot 0,25 - 10^5 \cdot 10^{-2} \cdot 1}{1 - 3/2} = \frac{1000 \text{ J}}{-0,5}$$

$$\Rightarrow W = -2000 \text{ J}$$

$$Q = \Delta U + W \Rightarrow 0 = \Delta U + W \Rightarrow \Delta U = +2000 \text{ J}$$

$$\delta) W_{at} = F_{at} \cdot dx = P_{at} \cdot A \cdot dx = 10^5 \frac{\text{N}}{\text{m}^2} \cdot 10^{-2} \cdot 0,75 \Rightarrow W_{at} = 750 \text{ Joule}$$

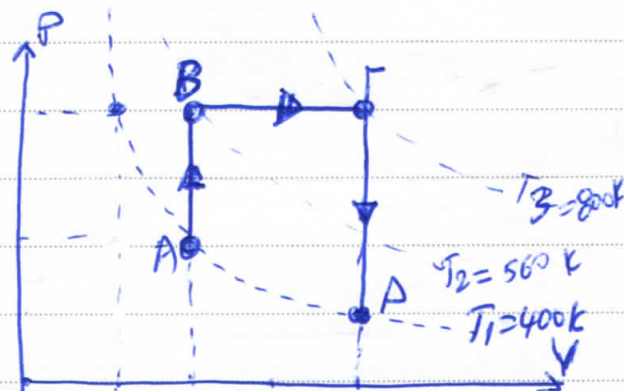
$$\Delta K = W_{at} + W_F + W_{at} \Rightarrow 0 = -2000 \text{ J} + W_F + 750 \text{ J}$$

$$\Rightarrow W_F = 1250 \text{ Joule}$$

$$\epsilon) \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \Leftrightarrow \frac{T_2}{T_1} = \frac{P_2 V_2}{P_1 V_1} = \frac{8 \cdot 10^5 \cdot 10^{-2} \cdot 0,25}{1 \cdot 10^5 \cdot 10^{-2} \cdot 1} = 2$$

$$\frac{v_{ex,2}}{v_{ex,1}} = \sqrt{\frac{T_2}{T_1}} = \sqrt{2} \Rightarrow \frac{v_{ex,2}}{v_{ex,1}} = \sqrt{2}$$

5.64 $n = 0,1 \text{ mole}$ $T_1 = 400 \text{ K}$ $Q_{AB} = 200 \text{ J}$
 $Q_{AB} = 200 \text{ J}$
 $Q_{CD} = -500 \text{ J}$



a) $\Delta U_{ABCD} = \Delta U_{AB} + \Delta U_{BC} + \Delta U_{CD}$ (1)
 $Q_{AB} = \Delta U_{AB} + W_{AB} \Rightarrow \Delta U_{AB} = 200 \text{ J}$
 $Q_{CD} = \Delta U_{CD} + W_{CD} \Rightarrow \Delta U_{CD} = -500 \text{ J}$

(1) $\Rightarrow 0 = 200 + \Delta U_{BC} - 500 \Rightarrow \Delta U_{BC} = 300 \text{ J}$

$\Delta U_{BC} = \frac{3}{2} n R \Delta T$
 $W_{BC} = P \Delta V = n A \Delta T$ } $\frac{\Delta U_{BC}}{W_{BC}} = \frac{3}{2} \Rightarrow W_{BC} = \frac{2}{3} \Delta U_{BC} \Rightarrow \underline{W_{BC} = 200 \text{ J}}$

$Q_{BC} = \Delta U_{BC} + W_{BC} \Rightarrow \underline{Q_{BC} = 500 \text{ J}}$

b) $\Delta U_{BC} = \frac{3}{2} n R \Delta T \Rightarrow 300 = \frac{3}{2} \cdot 0,1 \cdot \frac{25}{3} \cdot \Delta T_{BC} \Rightarrow \Delta T_{BC} = 240 \text{ K}$

$\Delta U_{AB} = \frac{3}{2} n R \Delta T \Rightarrow 200 = \frac{3}{2} \cdot 0,1 \cdot \frac{25}{3} \cdot \Delta T_{AB} \Rightarrow \Delta T_{AB} = 160 \text{ K}$

$T_B - T_A = 160 \Rightarrow T_B - 400 \text{ K} = 160 \text{ K} \Rightarrow \underline{T_B = 560 \text{ K}}$

$\Delta T_{BC} = 240 \text{ K} \Rightarrow T_C - T_B = 240 \text{ K} \Rightarrow \underline{T_C = T_B + 240 \text{ K} \Rightarrow T_C = 800 \text{ K}}$

c) $\frac{P_B}{T_B} = \frac{P_A}{T_A} = \frac{\Delta P}{\Delta T} \Rightarrow \Delta P = \frac{P_A}{T_A} \Delta T \Rightarrow \Delta P = P_A \frac{160}{400} \Rightarrow \Delta P_{AB} = 0,4 P_A$

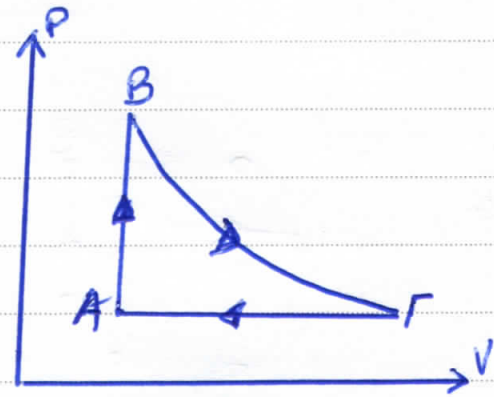
$\pi \% = \frac{\Delta P_{AB}}{P_A} 100 \% = 40 \%$

d) $\frac{V_C}{T_C} = \frac{V_B}{T_B} = \frac{\Delta V_{CB}}{\Delta T_{CB}} \Rightarrow \frac{V_B}{T_B} = \frac{\Delta V_{CB}}{\Delta T_{CB}} \Rightarrow \Delta V_{CB} = V_B \frac{\Delta T_{CB}}{T_B}$

$\Rightarrow \Delta V_{CB} = V_B \frac{240}{560} \Rightarrow \frac{\Delta V_{CB}}{V_B} = 0,428 \Rightarrow \pi \% = 42,8 \%$

5.65

	Q	ΔU	W
MB	4500J	4500J	0
BT	5600	0	5600J
TA	-7500J	-4500J	-3000J
ABTA	2600J	0	2600J



$$\left. \begin{aligned} \Delta U_{TA} &= \frac{3}{2} n R \Delta T \\ W_{TA} &= n R \Delta T \end{aligned} \right\} \frac{W_{TA}}{\Delta U_{TA}} = \frac{n R \Delta T}{\frac{3}{2} n R \Delta T} = \frac{2}{3} \Rightarrow W_{TA} = \frac{2}{3} \Delta U_{TA}$$

$$\Rightarrow W_{TA} = \frac{2}{3} (-4500 \text{ J})$$

$$\Rightarrow W_{TA} = -3000 \text{ Joule}$$

$$W_{ABTA} = W_{AB} + W_{BT} + W_{TA} \Rightarrow 2600 = 0 + W_{BT} - 3000 \Rightarrow W_{BT} = 5600 \text{ Joule}$$

5.66!!!

$$\alpha) Q_{AB} = \frac{3}{2} n R (T_B - T_A) = \frac{3}{2} [P_B V_B - P_A V_A]$$

$$\Rightarrow Q_{AB} = \frac{3}{2} (P_2 V_1 - P_1 V_1) \Rightarrow$$

$$Q_{AB} = \frac{3}{2} (P_2 - P_1) V_1 \Rightarrow P_2 - P_1 = \frac{2}{3} \frac{Q_{AB}}{V_1}$$

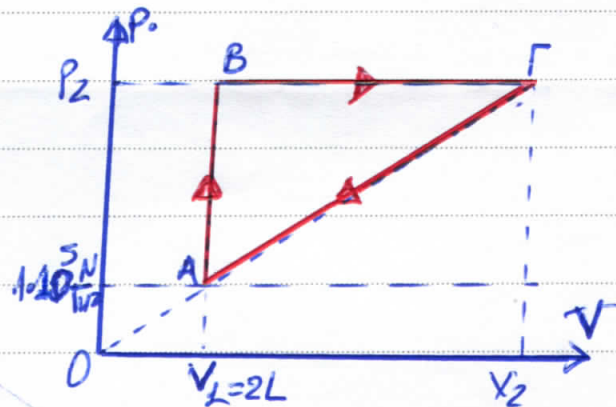
$$\Rightarrow P_2 - P_1 = \frac{2}{3} \cdot \frac{450}{2 \cdot 10^{-3}} \Rightarrow P_2 - P_1 = 1,5 \cdot 10^5 \text{ N/m}^2 \Rightarrow P_2 = 3,5 \cdot 10^5 \text{ N/m}^2$$

$$\frac{P_B}{T_B} = \frac{P_A}{T_A} \Rightarrow \frac{3,5 \cdot 10^5}{T_B} = \frac{1 \cdot 10^5}{T_A} \Rightarrow T_B = 3,5 T_A$$

$$\frac{P_2}{V_2} = \frac{P_1}{V_1} \Rightarrow \frac{3,5 \cdot 10^5}{V_2} = \frac{1 \cdot 10^5}{2L} \Rightarrow V_2 = 7L$$

$$\frac{V_T}{T_T} = \frac{V_B}{T_B} \Rightarrow \frac{5L}{1875} = \frac{2L}{T_B} \Rightarrow T_B = 750 \text{ K} \quad \text{K' } T_A = \frac{T_B}{3,5} \Rightarrow T_A = 300 \text{ K}$$

	P	V	T
A	$1 \cdot 10^5 \text{ N/m}^2$	2L	300K
B	$3,5 \cdot 10^5 \text{ N/m}^2$	2L	750K
T	$3,5 \cdot 10^5 \text{ N/m}^2$	5L	1875K



	P	V	T
A	$1 \cdot 10^5 \text{ N/m}^2$	2L	300K
B	$2,5 \cdot 10^5 \text{ N/m}^2$	2L	700K
F	$2,5 \cdot 10^5 \text{ N/m}^2$	5L	1875K

b)

	Q	ΔU	W
AB	450J	450J	0
BF	1875J	1125J	750J
FA	-2100	-1575J	-525J
ABFA	225	0	225J

$$\left. \begin{aligned} \Delta U_{AB} &= \frac{3}{2} n R \Delta T_{AB} \\ \Delta U_{BF} &= \frac{3}{2} n R \Delta T_{BF} \end{aligned} \right\} \Rightarrow \frac{\Delta U_{AB}}{\Delta U_{BF}} = \frac{T_B - T_A}{T_F - T_B} \Rightarrow \frac{450}{\Delta U_{BF}} = \frac{750 - 300}{1875 - 750} = \frac{450}{1125}$$

$$\Rightarrow \Delta U_{BF} = 1125 \text{ J}$$

$$\frac{W_{BF}}{\Delta U_{BF}} = \frac{n R \Delta T}{\frac{3}{2} n R \Delta T} = \frac{2}{3} \Rightarrow W_{BF} = \frac{2}{3} 1125 \Rightarrow W_{BF} = 750 \text{ J}$$

$$Q_{BF} = \Delta U_{BF} + W_{BF} \Rightarrow Q_{BF} = 1875 \text{ J}$$

$$|W_{FA}| = \frac{2,5 \cdot 10^5 + 1 \cdot 10^5}{2} \cdot 3 \cdot 10^{-3} = 525 \text{ J} \Rightarrow W_{FA} = -525 \text{ J}$$

5.67

$$a) P_A V_A^\gamma = P_B V_B^\gamma \Rightarrow 0,1 \cdot 10^5 \cdot 8^{5/3} = 3,2 \cdot 10^5 \cdot V_B^\gamma$$

$$\Rightarrow (2^3)^{5/3} = 32 V_B^{5/3} \Rightarrow V_B^{5/3} = 1$$

$$\Rightarrow V_B = 1 \text{ L}$$

$$\frac{P_A V_A}{T_A} = \frac{P_B V_B}{T_B} \Rightarrow \frac{0,1 \cdot 10^5 \cdot 8}{50 \text{ K}} = \frac{3,2 \cdot 10^5 \cdot 1}{T_B}$$

$$\Rightarrow T_B = 200 \text{ K}$$

$$\frac{V_\Gamma}{T_\Gamma} = \frac{V_B}{T_B} \Rightarrow \frac{8 \text{ L}}{T_\Gamma} = \frac{1 \text{ L}}{200 \text{ K}} \Rightarrow T_\Gamma = 1600 \text{ K}$$

$$\frac{U_{\text{EN},B}}{U_{\text{EN},A}} = \sqrt{\frac{T_B}{T_A}} = \sqrt{\frac{200}{500}} = \sqrt{2/5} \Rightarrow U_{\text{EN},B} = 2 U_{\text{EN},A} \Rightarrow U_{\text{EN},B} = 1100 \text{ mJ}$$

$$\frac{U_{\text{EN},\Gamma}}{U_{\text{EN},B}} = \sqrt{\frac{T_\Gamma}{T_B}} = \sqrt{\frac{1600}{200}} = \sqrt{8} = 2\sqrt{2} \Rightarrow U_{\text{EN},\Gamma} = 2\sqrt{2} \cdot 1100 \text{ mJ}, \text{ n } U_{\text{EN},\Gamma} = 2200\sqrt{2} \text{ mJ}$$

$$c) W_{AB} = \frac{P_B V_B - P_A V_A}{1 - \gamma} = \frac{3,2 \cdot 10^5 \cdot 1 \cdot 10^{-3} - 0,1 \cdot 10^5 \cdot 8 \cdot 10^{-3}}{1 - 5/3} = \frac{320 - 80}{-2/3}$$

$$\Rightarrow W_{AB} = -360 \text{ Joule} \quad \text{KM } \Delta U_{AB} = +360 \text{ J}$$

$$W_{B\Gamma} = P_2 (V_\Gamma - V_B) = 3,2 \cdot 10^5 \frac{\text{N}}{\text{m}^2} \cdot (8 - 1) \cdot 10^{-3} = 2240 \text{ J}$$

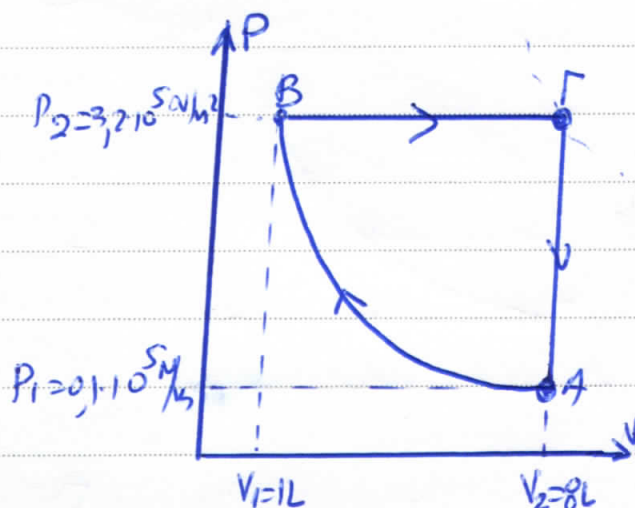
$$\frac{\Delta U_{B\Gamma}}{W_{B\Gamma}} = \frac{3/2 n R \Delta T}{n R \Delta T} = \frac{3}{2} \Rightarrow \Delta U_{B\Gamma} = \frac{3}{2} \cdot 2240 \Rightarrow \Delta U_{B\Gamma} = 3360 \text{ J}$$

$$Q_{B\Gamma} = \Delta U_{B\Gamma} + W_{B\Gamma} = 5600 \text{ J}$$

$$\Delta U_{\text{cycle}} = 0 \Rightarrow \Delta U_{AB} + \Delta U_{B\Gamma} + \Delta U_{\Gamma A} = 0 \Rightarrow +360 + 3360 + \Delta U_{\Gamma A} = 0$$

$$\Delta U_{\Gamma A} = -3000 \text{ J}$$

	Q	ΔU	W
AB	0	360 J	-360 J
B Γ	5600 J	3360 J	2240 J
ΓA	-3000 J	-3000	0
AB ΓA	+2600 J	+720 J	1880 J



5.68

a) AB: $eT = 6 \text{ mD}$ 760 kPa

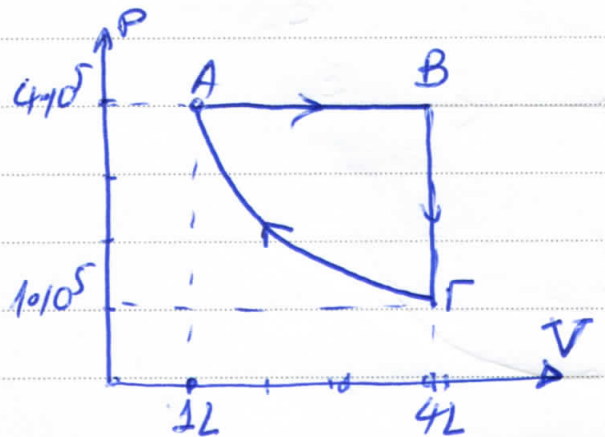
$$C_B = \frac{C_A}{4} \Rightarrow V_B = 4V_A = 4L$$

$$T_B = 4T_A = 1200 \text{ K}$$

BC: $eT = 6 \text{ mD}$ 760 kPa

CA: $eT = 6 \text{ mD}$ 760 kPa

$$P_A V_A = P_C V_C \Rightarrow P_C = 1 \cdot 10^5 \text{ N/m}^2$$



b)

$$\frac{V_{CN,B}}{V_{CN,A}} = \sqrt{\frac{T_B}{T_A}} = 2$$

$$\bar{K} = \frac{3}{2} kT$$

$$\bar{K}_B = 4 \bar{K}_A$$

	P	V	T	V_{CN}	$\bar{K}$	e
A	$4 \cdot 10^5 \text{ N/m}^2$	1L	300K	1370 m^3	$621 \cdot 10^{-23}$	0,6008/L
B	$4 \cdot 10^5 \text{ N/m}^2$	4L	1200K	2740 m^3	$2484 \cdot 10^{-23}$	0,1508/L
C	$1 \cdot 10^5 \text{ N/m}^2$	4L	300K	1370 m^3	$621 \cdot 10^{-23}$	0,6008/L

c)

$$W_{AB} = P \cdot (V_B - V_A) = 4 \cdot 10^5 \cdot (4 - 1) \cdot 10^{-3} = 1200 \text{ J}$$

$$\frac{\Delta U_{AB}}{W_{AB}} = \frac{3}{2} \Rightarrow \Delta U_{AB} = \frac{3}{2} W_{AB} = 1800 \text{ J}$$

$$Q_{AB} = 3000 \text{ J}$$

$$Q_{CA} = W_{CA} = nRT_C \ln \frac{V_C}{V_A} = P_C V_C (-\ln 4) = -2 P_C V_C \ln 2 = -1,4 P_C V_C$$

$$= -1,4 \cdot 4 \cdot 10^5 \cdot 1 \cdot 10^{-3} = -560 \text{ J}$$

	Q	ΔU	W
AB	3000 J	1800 J	1200 J
BC	-1800 J	-1800 J	0
CA	-560 J	0	-560 J
ABCA	640 J	0	640 J

5.69 AB 7000 J-ly gytone

$$a) W_{AB} = nRT \ln \frac{V_B}{V_A} = P_A V_A \ln \frac{V_B}{V_A}$$

$$\Rightarrow 140 = P_A \cdot 10^{-3} \ln 2$$

$$\Rightarrow 140 = P_A \cdot 10^{-3} \cdot 1,4$$

$$P_A = 100 \cdot 10^3 = 10^5 \text{ N/m}^2$$

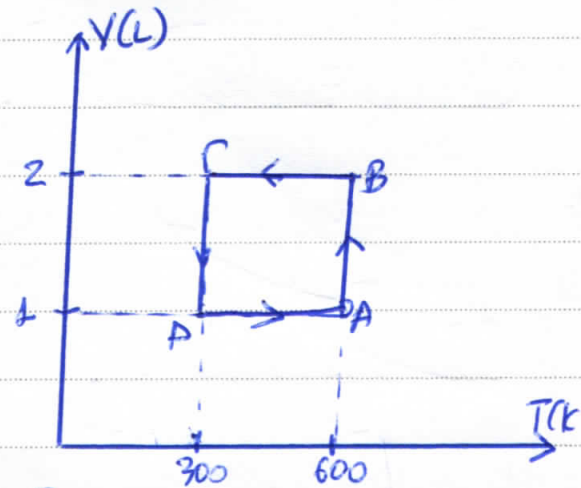
$$P_A = 1 \cdot 10^5 \text{ N/m}^2$$

AB 760 J-ly $P_A V_A = P_B V_B \Rightarrow 1 \cdot 10^5 \cdot 1 = P_B \cdot 2$

$$\Rightarrow P_B = 0,5 \cdot 10^5 \text{ N/m}^2$$

BC: 700 J-ly $\frac{P_C}{T_C} = \frac{P_B}{T_B} \Rightarrow \frac{P_C}{300} = \frac{0,5 \cdot 10^5}{600} \Rightarrow P_C = 0,25 \cdot 10^5 \text{ N/m}^2$

CD 760 J-ly gytone $P_C V_C = P_D V_D \Rightarrow 0,25 \cdot 10^5 \text{ N/m}^2 \cdot 2 \cdot 10^{-3} = P_D \cdot 1 \cdot 10^{-3}$
 $P_D = 0,50 \cdot 10^5 \text{ N/m}^2$



b)

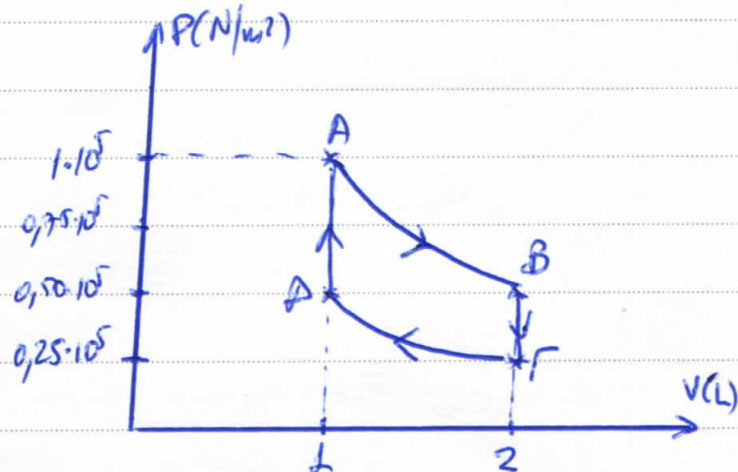
$$Q_{AB} = W_{AB} = nRT \ln 2 = P_A V_A \ln 2 = 140 \text{ J}$$

$$Q_{BC} = W_{BC} = nRT \ln \frac{1}{2} = -P_C V_C \ln 2 = -0,25 \cdot 10^5 \cdot 2 \cdot 10^{-3} \cdot 1,4 = -70 \text{ J}$$

$$\Delta U_{AB} = 0 \Rightarrow \Delta U_{BC} + \Delta U_{CD} + \Delta U_{DA} = 0$$

$$\Rightarrow \Delta U_{BC} = -\Delta U_{DA}$$

$$\Delta U_A = \frac{3}{2} nR \Delta T = \frac{3}{2} (P_A V_A - P_D V_D) = \frac{3}{2} (P_A - P_D) \cdot V_A = \frac{3}{2} (1 - 0,5) \cdot 10^5 \cdot 1 \cdot 10^{-3} = 75 \text{ J}$$



	Q	ΔU	W
AB	+140 J	0	+140 J
BC	-75 J	-75 J	0
CD	-70 J	0	-70 J
DA	+75 J	+75 J	0
ABCD	70 J	0	70 J

БГ: Үөдхүрү үйүм

Δ : Kostenpunkt aufsteigen

ΔΑ: Υοοχια, θέρφα

g) $\Delta A: \frac{P}{T} = 6 \text{ mD} \neq \frac{P_A}{T_A} = \frac{P_B}{T_B} \Rightarrow \frac{2 \cdot 10^5}{T_A} = \frac{1 \cdot 10^5}{300}$

$$\Rightarrow T_A = T_F = 600 \text{ K}$$

$$\text{Br: } \frac{P_B}{T_B} = \frac{P_r}{T_r} \Rightarrow \frac{2 \cdot 10^5}{T_B} = \frac{1 \cdot 10^5}{600} \Rightarrow T_B = 1200 \text{ K}$$

$$AB: \frac{V_A}{T_A} = \frac{V_B}{T_B} \Rightarrow \frac{V_A}{600} = \frac{V_B}{1200} \Rightarrow V_B = 2V_A$$

$$W_{AB} = P \cdot (V_B - V_A) \Rightarrow W_{AB} = P \cdot (7V_A - V_A) \Rightarrow V_A = \frac{W_{AB}}{P} = \frac{40 \text{ J}}{2 \cdot 10^5}$$

$$\Rightarrow V_A = 2 \cdot 10^{-3} \text{ m}^3 \text{ and } V_A = 2L \text{ and } V_B = 4L$$

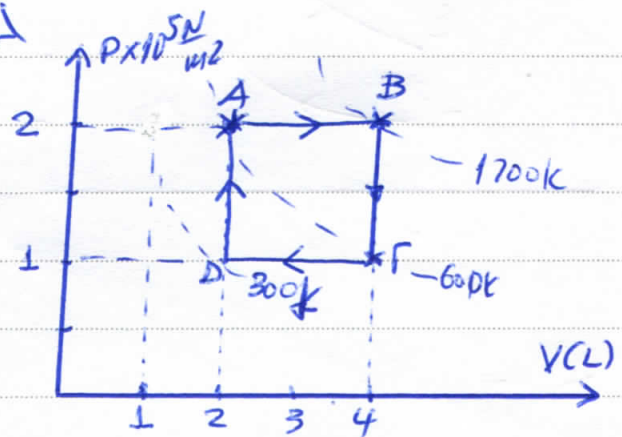
$$L_{\text{KOE}} V_D = \frac{1}{2} L \rightarrow X_T = 4L$$

$$\Delta r: \frac{V_A}{T_A} = \frac{V_r}{T_r} \quad \hookrightarrow \text{bei } V_D = 0$$

$$\hookrightarrow \frac{V_A}{300} = \frac{4L}{600} \Rightarrow V_A = 2L$$

d)

	P	V	T
A	$2 \cdot 10^5 \text{ N/m}^2$	2L	600K
B	$2 \cdot 10^5 \text{ N/m}^2$	4L	1200K
Γ	$1 \cdot 10^5 \text{ N/m}^2$	4L	600K
D	$1 \cdot 10^5 \text{ N/m}^2$	2L	300K



5) AB: $W_{AB} = 400\text{ J}$ $\Delta U_{AB} = \frac{3}{2} 400\text{ J} = 600\text{ J}$ $Q_{AB} = 1000\text{ J}$

$$r_D \quad W_D = P(K_B - K_T) = 1 \cdot 10^5 (9 - 4) \cdot 10^3 = -200 f, \quad \Delta U_D = \frac{3}{2} (-200) = -300 f$$

$$a_{T_1} = -500j$$

$$\Delta A: \Delta U_{\Delta A} = \frac{3}{2} n R \Delta T = \frac{3}{2} (P_A V_A - P_B V_B) = \frac{3}{2} V (P_A - P_B) = \frac{3}{2} \cdot 2 \cdot 10^{-3} \cdot 1 \cdot 10^5 \text{ N/m}^2$$

$$\Rightarrow \Delta U_{DA} = 300 \text{ J} \quad Q_{DA} = 300 \text{ J}$$

$$\Delta U_{Br} = \frac{3}{2} V (P_r - P_B) = \frac{3}{2} 4 \cdot 10^3 \cdot (-2) \cdot 10^5 = -600 \text{ J}$$

$$Q_{Br} = 0 = -600 \text{ J}$$

	Q	ΔU	W
AB	1000 J	600 J	400 J
Br	+600	-600	0
Ad	-500 J	-300 J	-200 J
dA	+900 J	+300 J	0
sum	1000 J	0	1000 J

5.71 A. ($4 \cdot 10^5 \frac{\text{N}}{\text{m}^2}$, 1 L)

$$Q_{Br} = \frac{3}{2} n R \Delta T_{Br} \Rightarrow -300 = \frac{3}{2} n R (-100)$$

$$\Rightarrow n R = 2 \text{ (SI)}$$

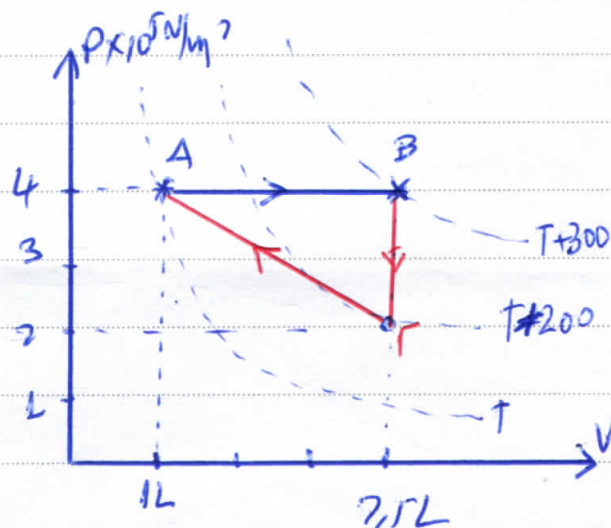
$$W_{AB} = n R \Delta T_{AB} = 2 \cdot 300 = 600 \text{ J}$$

$$\Delta U_{AB} = \frac{3}{2} W_{AB} = 900 \text{ J}$$

$$Q_{AB} = 1500 \text{ J}$$

$$W_{AB} = P (V_B - V_A) = 600 = 4 \cdot 10^5 \cdot [V_B - V_A]$$

$$V_B - V_A = 1.5 \cdot 10^{-3} \text{ m}^3 \text{ and } V_B = V_A + 1.5 \Rightarrow \underline{V_B = 2.5 \text{ L}}$$



$$\frac{V_A}{T_A} = \frac{V_B}{T_B} = \frac{V_B - V_A}{T_B - T_A} = \frac{\Delta V}{\Delta T} \Rightarrow \frac{1 \text{ L}}{T_A} = \frac{1.5 \text{ L}}{300} \Rightarrow T_A = 200 \text{ K}$$

$$T_B = 300 \text{ K}, T_C = 400 \text{ K}$$

$$\Delta U_{Br} = \frac{3}{2} n R \Delta T = \frac{3}{2} \cdot 2 \cdot (-100) = -300 \text{ J}, Q_{Br} = -300 \text{ J}$$

$$|W_{AB}| = \frac{4 \cdot 10^5 + 2 \cdot 10^5}{2} \cdot 1.5 \cdot 10^{-3} = 450 \text{ J} \text{ and } W_{AB} = -450 \text{ J}$$

$$\Delta U_{Ad} = 0 \Rightarrow 900 - 300 + \Delta U_{Ad} = 0 \Rightarrow \Delta U_{Ad} = -600 \text{ J}$$

$$Q_{Ad} = -1000 \text{ J}$$



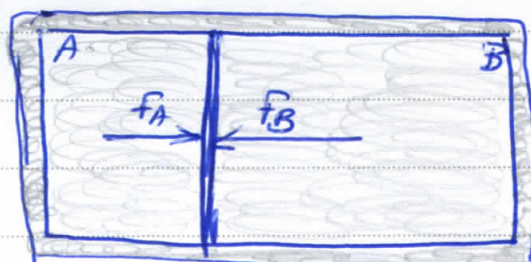
	Q	ΔU	W
AB	+1500J	+800J	+600J
BC	-800J	-300J	0
CA	-1050J	-600J	-450J
Sumo	+150J	0J	+150J

5.72

$$a) F_A = P_A A = 10^5 \frac{N}{m^2} \cdot 2 \cdot 10^{-2} = 2 \cdot 10^3 N$$

$$F_B = P_B A = 1,5 \cdot 10^5 \frac{N}{m^2} \cdot 2 \cdot 10^{-2} = 3 \cdot 10^3 N$$

$$SPR \text{ KNO} \quad \underline{SF = 10^5 N}$$



$$P_A = 10^5 \frac{N}{m^2}$$

$$V_A = 4L$$

$$T_A = 400K$$

$$P_B = 1,5 \cdot 10^5 \frac{N}{m^2}$$

$$V_B = 6L$$

$$T_B = 300K$$

b)

$$\left. \begin{aligned} n_A &= \frac{P_A V_A}{n T_A} \\ n_B &= \frac{P_B V_B}{n T_B} \end{aligned} \right\} \Rightarrow \frac{n_A}{n_B} = \frac{P_A V_A T_B}{P_B V_B T_A}$$

$$\Rightarrow \frac{n_A}{n_B} = \frac{10^5 \frac{N}{m^2} \cdot 4L \cdot 300K}{1,5 \cdot 10^5 \frac{N}{m^2} \cdot 6L \cdot 400K} = \frac{n_A}{n_B} = \frac{4 \cdot 3}{1,5 \cdot 6 \cdot 4} = \frac{3}{9} = \frac{1}{3} \Rightarrow \frac{n_A}{n_B} = \frac{1}{3}$$

$$c) \left. \begin{aligned} Q &= \Delta U + W \\ W &= 0 \\ Q &= 0 \end{aligned} \right\} \Rightarrow \Delta U = 0 \Rightarrow U_{Tei} = U_{oex} \Rightarrow \frac{3}{2} n_A R T = \frac{3}{2} n_A R T_A + \frac{3}{2} n_B R T_B$$

$$\hookrightarrow \frac{n_A}{n_B} = \frac{1}{3} \Rightarrow n_B = 3n_A$$

$$d) \Rightarrow (n_A + n_B) T = n_A T_A + n_B T_B \Rightarrow T = \frac{n_A T_A + n_B T_B}{n_A + n_B} \Rightarrow T = \frac{n_A T_A + 3n_A T_B}{n_A + 3n_A}$$

$$\Rightarrow T = \frac{n_A (T_A + 3T_B)}{4n_A} \Rightarrow T = \frac{400 + 3 \cdot 600}{4} \Rightarrow \underline{T = 550K}$$

$$e) P \cdot V = n R T \quad n_{tot} = n_A + n_B \Rightarrow \frac{P(V_A + V_B)}{T} = \frac{P_A V_A}{T_A} + \frac{P_B V_B}{T_B}$$

$$\Rightarrow P \cdot \frac{10L}{550K} = \frac{10^5 \cdot 4L}{400K} + \frac{1,5 \cdot 10^5 \cdot 6L}{300K} \Rightarrow P \cdot \frac{10}{550} = 10^5 (0,01 + 0,03)$$

$$\Rightarrow P = 2,2 \cdot 10^5 \frac{N}{m^2}$$

5.73.

Αρχική κατάσταση: Η/έγκυ
των αερίων είναι

$$P_1 = P_{at} + \frac{m_f}{A} + \frac{m_{Hg} \cdot g}{A} \quad (1)$$

$$m_{Hg} = V \cdot \rho_{Hg} = A h \rho_{Hg} \xrightarrow{SI}$$

$$m_{Hg} = 10^{-2} m^2 \cdot 0,5 m \cdot 13,6 \cdot 10^3 kg/m^3 \Rightarrow m_{Hg} = 68 kg$$

$$(1) \Rightarrow P_1 = 10 \frac{N}{m^2} + \frac{6 kg \cdot 10 m/s^2}{10^{-2} m^2} + \frac{68 kg \cdot 10 m/s^2}{10^{-2} m^2} \Rightarrow P_1 = 100 \cdot 10^3 \frac{N}{m^2} + 74 \cdot 10^3 \frac{N}{m^2}$$

$$\Rightarrow P_1 = 1,74 \cdot 10^5 N/m^2 \text{ ή } P_1 = 1,74 atm$$

$$\text{Αρχικός όγκος } V_1 = A h = 10^{-2} \cdot 0,5 = 5 \cdot 10^{-3} m^3$$

$$\text{Αρχική θερμοκρασία } T_1 = 273 + 23,8 = 296,8 K$$

Τελική κατάσταση αερίων όπου υπάρχει όγκος ο Hg

$$\text{Η/έγκυ αερίων } P_2 = P_{at} + \frac{m_f}{A} = 10 \frac{N}{m^2} + \frac{6 \cdot 10}{10^{-2}} = 100 \cdot 10^3 \frac{N}{m^2} + 6 \cdot 10^3 \frac{N}{m^2}$$

$$\Rightarrow P_2 = 106 \cdot 10^3 \frac{N}{m^2} \text{ ή } P_2 = 1,06 \cdot 10^5 \frac{N}{m^2} \text{ ή } P_2 = 1,06 atm$$

$$\text{Τελικός όγκος αερίων } V_2 = A \cdot H = A \cdot 2H = 10^{-2} m^2 \cdot 1 m = 10 \cdot 10^{-3} m^3$$

Η γυαλοπλάτη είναι στενική, είσαι ότι T_2 η τελική θερμοκρασία

$$\text{την αερίων έχουμε } \frac{P_2 V_2}{T_2} = \frac{P_1 V_1}{T_1} \Rightarrow T_2 = \frac{P_2 V_2}{P_1 V_1} \cdot T_1$$

$$\stackrel{SF}{\Rightarrow} T_2 = \frac{1,06 \cdot 10^5 \cdot 10 \cdot 10^{-3}}{1,74 \cdot 10^5 \cdot 5 \cdot 10^{-3}} \Rightarrow T_2 = 360,4 K \text{ ή } \theta_2 = 87,4^\circ C$$

Σε μια τυχαία θέση την το σύστημα έχει ανέλθει

$$\text{καθώς σχεδόν } \sum F_y = 0 \Rightarrow F - m_f g - m_{Hg} g - P_{at} A = 0$$

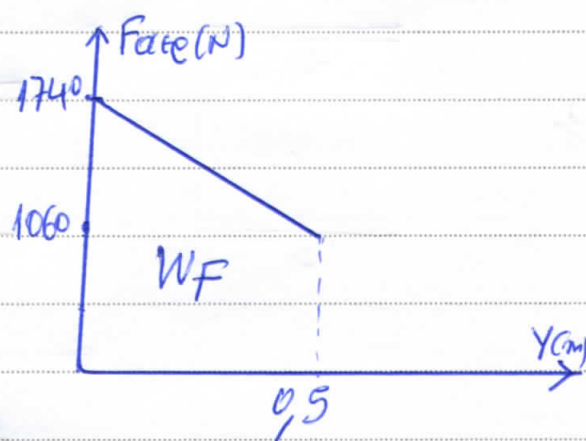
$$\Rightarrow F = m_f g + m_{Hg} g + P_{at} A = m_f g + A(h_f) \rho_{Hg} g + P_{at} A$$

$$\stackrel{SF}{\Rightarrow} F = 6 \cdot 10 + 10^2 (0,5 - y) \cdot 13,6 \cdot 10 + 10^5 \cdot 10^{-2} \Rightarrow$$

$$F = 60 + 1360 \cdot (0,5 - y) + 1000 \Rightarrow F = 1740 - 1360y \quad 0 \leq y \leq 0,5 \text{ m}$$

$$\text{Avg } W_F = \frac{1740 + 1060}{2} \cdot 0,5$$

$$\Rightarrow W_F = 700 \text{ J}$$



$$b) \Delta U = \frac{3}{2} n R \Delta T = \frac{3}{2} n R (T_2 - T_1)$$

$$\Rightarrow \Delta U = \frac{3}{2} [n R T_2 - n R T_1] = \frac{3}{2} [P_2 V_2 - P_1 V_1]$$

$$\Rightarrow \Delta U = \frac{3}{2} [1,06 \cdot 10^5 \cdot 10 \cdot 10^{-3} - 1,74 \cdot 10^5 \cdot 5 \cdot 10^{-3}] = \frac{3}{2} [1060 - 870]$$

$$\Rightarrow \Delta U = 285 \text{ Joule}$$

$$c) Q = \Delta U + W \Rightarrow Q = 700 \text{ J} + 285 \text{ J} \Rightarrow Q = 985 \text{ J}$$

$$d) T = 360,4 \text{ K} \Rightarrow \theta_2 = 87,4^\circ \text{C}$$

5.74

A. Αρχικά η πίεση και ό όγκος του αερίου είναι

$$P_1 = P_{at} + \frac{mg}{A} = 10^5 + \frac{10 \cdot 10}{10^{-2}} \Rightarrow P_1 = 1.1 \cdot 10^5 \text{ N/m}^2$$

$$V_1 = A \cdot \frac{h}{2} = 10^{-2} \cdot 0.5 \Rightarrow V_1 = 5 \cdot 10^{-3} \text{ m}^3$$

Γεγιναι η πίεση και ό όγκος έχουν τιμές

$$P_2 = P_{at} + \frac{mg}{A} + \frac{k \Delta l}{A} = 10^5 + \frac{10 \cdot 10}{10^{-2}} + \frac{200 \cdot 0.5}{10^{-2}} \Rightarrow P_2 = 1.2 \cdot 10^5 \text{ N/m}^2$$

$$V_2 = A h = 10^{-2} \cdot 1 \Rightarrow V_2 = 10 \cdot 10^{-3} \text{ m}^3$$

Εδώ έχω για γεγιναι γεωμετρική δεδομένη ποσότητα
Στοιχείο το (ε)

B. Σε σταθερά θερμοκρασία τον βελόνα η πίεση του αερίου

$$\text{είναι } P = \frac{mg}{A} + P_{at} + \frac{k \Delta l}{A} = \frac{10 \cdot 10}{10^{-2}} + 10^5 + \frac{200 \Delta l}{10^{-2}} \Rightarrow P = 1.1 \cdot 10^5 + 2 \cdot 10^5 \Delta l$$

... και η δύναμη που δίνει το αέριο στο βελόνα είναι

$$F_{\text{αερίου}} = P \cdot A = (1.1 \cdot 10^5 + 2 \cdot 10^5 \Delta l) \cdot 10^{-2} \Rightarrow F_{\text{αερίου}} = 1100 + 200 \Delta l \text{ (SI) } \text{ or } \Delta l \text{ σε m}$$

Γ.

$$W_{\text{αερίου}} = \text{Εμβαδόν του } F_{\text{αερίου}} (\Delta l)$$

$$\Rightarrow W_{\text{αερίου}} = \frac{1100 + 1700}{2} \cdot 0.5$$

$$\Rightarrow W_{\text{αερίου}} = 575 \text{ J}$$

$$\text{Σχόλιο: } W_{\text{ελατηρίου}} = -\frac{1}{2} k \Delta l_{\text{αρχ}}^2 - \frac{1}{2} k \Delta l_{\text{τελ}}^2 = -\frac{1}{2} k \Delta l_{\text{ε}}^2 = -\frac{1}{2} 200 \cdot 0.5^2 \Rightarrow$$

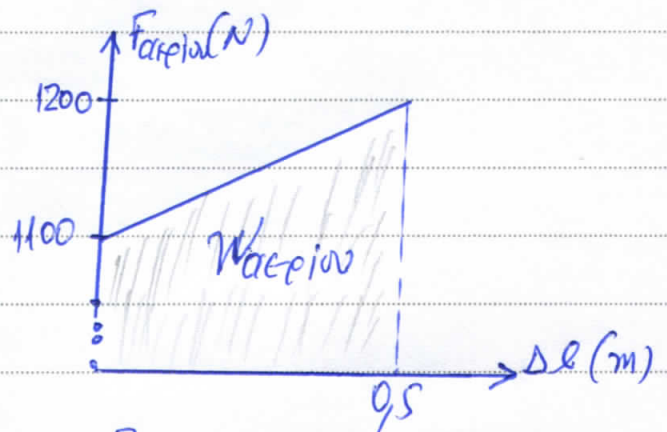
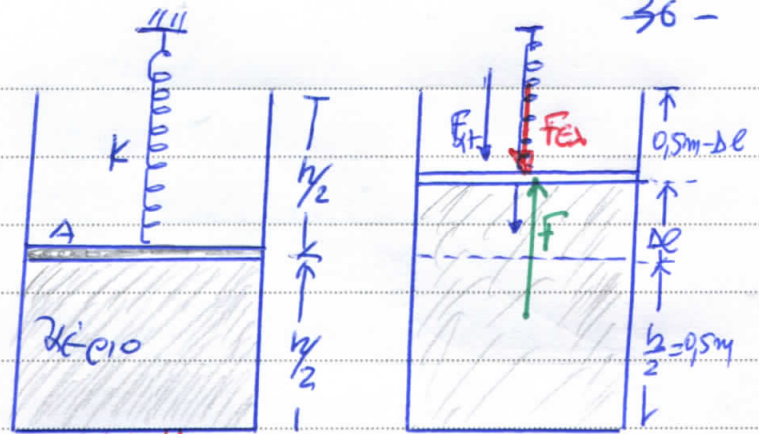
$$\Rightarrow W_{\text{ελατηρίου}} = -25 \text{ J}$$

$$W_{\text{at}} = -F_{\text{at}} \cdot \frac{h}{2} = -P_{\text{at}} \cdot A \cdot \frac{h}{2} = -10^5 \cdot 10^{-2} \cdot 0.5 \Rightarrow W_{\text{at}} = -500 \text{ J}$$

$$W_B = -mg \cdot \frac{h}{2} = -10 \cdot 10 \cdot 0.5 \Rightarrow W_B = -50 \text{ J}$$

$$\Delta K = W_{\text{αερίου}} + W_B + W_{\text{at}} + W_{\text{ελ}} = \dots = 0 \dots \text{αντιστοιχεί στο}$$

$$\frac{d}{dt} W = 0$$



... Το έργο των αερίων και διαφορετικές.

Στην ταχεία θέρμανση των βελόνων ($\approx 6 \text{ m/s}$)

$$\text{Όγκος αερίων } V = A \left(\frac{h}{2} + \Delta l \right) \xrightarrow{\text{SF}} V = 10^{-3} (0,5 + \Delta l) \Rightarrow 100V = 0,5 + \Delta l$$

$$\Rightarrow \Delta l = 100V - 0,5 \quad (\text{S.I})$$

$$\dots P_{\text{αερίων}} = 1,1 \cdot 10^5 + 0,2 \cdot 10^5 \Delta l \quad \left. \vphantom{P_{\text{αερίων}}} \right\} \Rightarrow P_{\text{αερίων}} = 1,1 \cdot 10^5 + 0,2 \cdot 10^5 (100V - 0,5) \Rightarrow$$

$$\Rightarrow P = 1,1 \cdot 10^5 + 20 \cdot 10^5 V - 0,1 \cdot 10^5 \Rightarrow P = 1,2 \cdot 10^5 + 2 \cdot 10^6 V \quad 5 \cdot 10^{-3} \leq V \leq 10 \cdot 10^{-3} \text{ (S.I.)}$$

Από το P-V βρίσκουμε το έργο

$$\text{των αερίων } W_{\text{αερίων}} = \frac{1,1 \cdot 10^5 + 1,2 \cdot 10^5 (10 - 5) \cdot 10^{-3}}{2}$$

$$\Rightarrow W_{\text{αερίων}} = 575 \text{ Joule}$$

Μεταβολή εσωτερικής ενέργειας

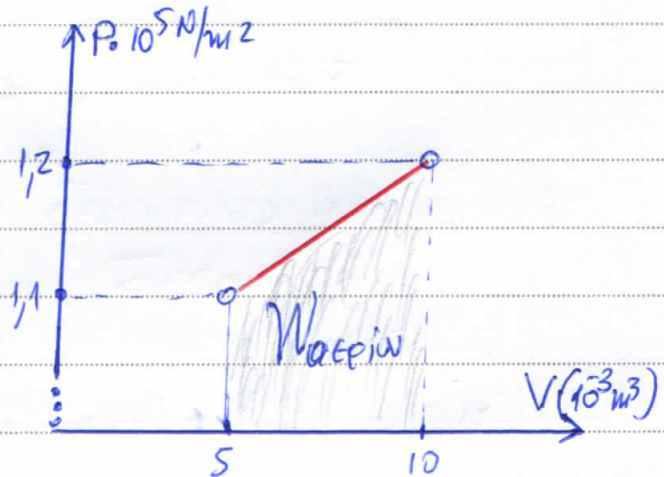
$$\Delta U = \frac{3}{2} n R \Delta T = \frac{3}{2} n R (T_{\text{αερίων}} - T_{\text{αρχ}})$$

$$\Rightarrow \Delta U = \frac{3}{2} (P_2 V_2 - P_1 V_1) = \frac{3}{2} \cdot (1,2 \cdot 10^5 \cdot 10 \cdot 10^{-3} - 1,1 \cdot 10^5 \cdot 5 \cdot 10^{-3})$$

$$\Rightarrow \Delta U = \frac{3}{2} (1200 - 550) \Rightarrow \Delta U = 975 \text{ Joule}$$

Προσφερόμενη θερμότητα

$$Q = \Delta U + W \Rightarrow Q = 975 \text{ J} + 575 \text{ J} \Rightarrow Q = 1550 \text{ J}$$



5.75

-38-

$$a) \frac{v_{en,A}}{v_{en,B}} = \sqrt{\frac{T_A}{T_B}} \Rightarrow \frac{v_{en,A}^2}{v_{en,B}^2} = \frac{T_A}{T_B} \Rightarrow \frac{2480^2}{(670\sqrt{2})^2} = \frac{T_A}{T_B} \Rightarrow T_B = 300K$$

$$\left(\frac{2480}{670} \right)^2 \frac{1}{2} = \frac{T_A}{T_B} = \frac{4^2}{2} = \frac{2400}{T_B}$$

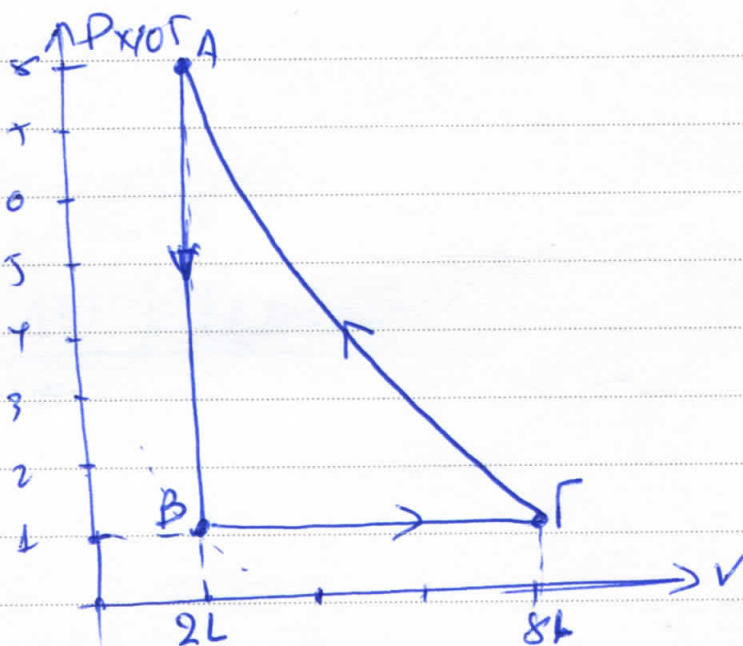
$$\frac{v_{en,\Gamma}}{v_{en,B}} = \sqrt{\frac{T_\Gamma}{T_B}} \Rightarrow \frac{v_{en,\Gamma}^2}{v_{en,B}^2} = \frac{T_\Gamma}{T_B} \Rightarrow \frac{(1740\sqrt{2})^2}{(670\sqrt{2})^2} = \frac{T_\Gamma}{300} \Rightarrow T_\Gamma = 1700K$$

$$\frac{P_A}{T_A} = \frac{P_B}{T_B} \Rightarrow \frac{8 \cdot 10^5}{2400} = \frac{P_B}{300}$$

$$P_B = 1 \cdot 10^5 \text{ N/m}^2$$

$$\frac{V_B}{T_B} = \frac{V_\Gamma}{T_\Gamma} \Rightarrow \frac{2L}{300} = \frac{V_\Gamma}{1700}$$

$$\Rightarrow V_\Gamma = 8L$$



	P	V	T
A	$8 \cdot 10^5$	$2L$	$2400K$
B	$1 \cdot 10^5$	$2L$	$300K$
Γ	$1 \cdot 10^5$	$8L$	$1700K$

$$b) P_A V_A^\gamma = P_\Gamma V_\Gamma^\gamma \Rightarrow 8 \cdot 10^5 \cdot 2^\gamma = 1 \cdot 10^5 \cdot 8^\gamma \Rightarrow 2^3 \cdot 2^\gamma = 2^{3\gamma} \Rightarrow 2^{3+\gamma} = 2^{3\gamma} \Rightarrow 3+\gamma = 3\gamma \Rightarrow \gamma = 2\gamma \Rightarrow \gamma = \frac{3}{2}$$

$$c) W_{B\Gamma} = P(V_\Gamma - V_B) = 10^5 \cdot 6 \cdot 10^{-3} = 600J$$

$$W_{\Gamma A} = \frac{P_A V_A - P_\Gamma V_\Gamma}{1 - \gamma} = \frac{8 \cdot 10^5 \cdot 2 \cdot 10^{-3} - 1 \cdot 10^5 \cdot 8 \cdot 10^{-3}}{1 - 3/2} = \frac{1600 - 800}{-0.5} = -1600J$$

$$\Delta U_{\Gamma A} = +1600J$$

$$\Delta U_{TA} = n C_V \Delta T = n C_V (T_A - T_r)$$

$$\Delta U_{Br} = n C_V \Delta T' = n C_V (T_r - T_B)$$

$$\frac{\Delta U_{TA}}{\Delta U_{Br}} = \frac{T_A - T_r}{T_r - T_B} \Rightarrow \frac{1600}{\Delta U_{Br}} = \frac{2400 - 1700}{1700 - 900} = \frac{1700}{900} = \frac{4}{3}$$

$$4 \Delta U_{Br} = 3 \cdot 1600 \Rightarrow \Delta U_{Br} = 1200 \text{ J}$$

$$Q_{Br} = \Delta U_{Br} + W_{Br} = 1800 \text{ J}$$

$$\Delta U_{AB} = 0 \Rightarrow \Delta U_{AB} + 1700 + 1600 = 0 \Rightarrow \Delta U_{AB} = -3300 \text{ J}$$

$$Q_{AB} = \Delta U_{AB} \Rightarrow Q_{AB} = -3300 \text{ J}$$

	Q	ΔU	W
AB	-3300	-3300	0
Br	1800	1700	600
TA	0	+1600	-1600
Σ	-1000 J	0	-1000 J

6η Εξότητα - Θεωρητικό Υπόμνημα Αποδείξεις

A. Ερωτήσεις κλειστού τύπου.

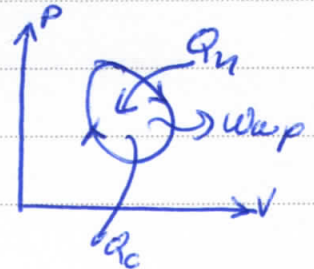
6.1 α-1, β-1, γ-ε, δ-1

6.2 α-1, β-1, γ-ε, δ-1

6.3 $Q_h - |Q_c| = W_{wp} \Rightarrow Q_h - W_{wp} = W_{wp}$

$\Rightarrow Q_h = 2W_{wp}$

$e = \frac{W_{wp}}{Q_h} = \frac{W_{wp}}{2W_{wp}} = \frac{1}{2} = 0,5, \quad e\% = 50\%$



Σωστή η (ε)

6.4 $Q_h - |Q_c| = W_{wp} \Rightarrow 5W_{wp} - |Q_c| = W_{wp} \Rightarrow 4W_{wp} = |Q_c|$

$Q_h = 5|W_{wp}|$

$\frac{|Q_c|}{Q_h} = \frac{4W_{wp}}{5|W_{wp}|} = 0,8 \Rightarrow 80\%$

Σωστή η (δ)

6.5 $e = \frac{W_{wp}}{Q_h}$ η $e = \frac{W_{wp}/t}{Q_h/t} \Rightarrow e = \frac{P_{wp}}{Q_h/t} \Rightarrow P_{wp} = e \frac{Q_h}{t}$

$\frac{Q_h}{t} = \frac{1800000 \text{ J}}{60 \text{ s}} = 3 \cdot 10^4 \text{ J/s} = 30 \cdot 10^3 \text{ J/s} = 30 \text{ kJ/s} = 30 \text{ kW}$

όρα $P_{wp} = e \frac{Q_h}{t} = 0,25 \cdot 30 \text{ kW} \Rightarrow P_{wp} = 7,5 \text{ kW}$

Απορ σωστή η (ε)

6.6 α-1, β-1, γ-ε, δ-1

6.7 α-1, β-1, γ-1, δ-ε

6.8 α-ε, β-1, γ-ε, δ-1

6.9 α-1, β-1, γ-ε, δ-ε

6.10 α-1, β-ε, γ-1, δ-ε

6.11 α-1, β-ε, γ-1, δ-1

(δ)

(δ)

$e = 1 - \frac{T_c}{T_h}$

(α, δ)

(γ, ε)

(β, σ)

(ε)

$$6.12 \quad e = 1 - \frac{T_c}{T_h} \Rightarrow 0,4 = 1 - \frac{T_c}{500} \text{ ή } \frac{T_c}{500} = 0,6 \text{ ή } T_c = 300\text{K} \text{ ή } \theta_c = 27^\circ\text{C}$$

Σωστό το (δ)

Β. Έρωτήσεις απαντήσεις

6.13 Αν η θερμοκή μηχανή ή τον μηχανή Carnot θα είχε απόδοση $e_c = 1 - \frac{T_c}{T_h} = 1 - \frac{300}{500} = 0,40$ ή $e\% = 40\%$
 Κάθε άλλη θερμοκή μηχανή που λειτουργεί μεταξύ των ίδιων θερμικών δεξαμενών έχει απόδοση $e\% < 40\%$.
 Τώρα που δίνεται $e\% = 48\% > 40\%$ προφανώς είναι λάθος
 στις φερόμενες ή υπολογισμούς Άρα λάθος

6.14 $e_c = 1 - \frac{T_c}{T_h} = 1 - \frac{300}{500} = 0,4$, άρα $e_{\max} = 0,4$ [Εν η θερμοκή μηχανή λειτουργήσει ως μηχανή Carnot ... Τώρα σε κάθε περίπτωση πρέπει $e\% < 40\%$]
 $Q_h - |Q_c| = W_{\text{usef}} \Rightarrow W_{\text{usef}} = 1200\text{J} - 700\text{J} = 500\text{J}$
 Η συντελεστή αδοχή της μηχανής γέτα δέδοται αυτα υπολογίζεται ως $e = \frac{W_{\text{usef}}}{Q_h} \Rightarrow e = \frac{500}{1200}$ ή $e = 0,416 > 0,4 = e_{\max}$
Άρα δεν είναι δυνατή η λειτουργία για τέτοια θερμοκή μηχανή.

6.15 Η μέγιστη απόδοση που μπορεί να έχει για τέτοια μηχανή είναι $e_{\max} = e_c = 1 - \frac{T_c}{T_h} = 1 - \frac{284}{420}$ ή $e_{\max} = 0,30$.

$$P_c = \frac{|Q_c|}{t} = \frac{15,6 \cdot 10^3 \text{J}}{60 \text{s}} = 0,26 \cdot 10^3 \text{W} \Rightarrow P_c = 26 \text{kW}$$

$$Q_h - |Q_c| = W_{\text{usef}} \Rightarrow \frac{Q_h}{t} - \frac{|Q_c|}{t} = \frac{W_{\text{usef}}}{t} \Rightarrow P_h - P_c = P_{\text{usef}} \Rightarrow P_h = P_c + P_{\text{usef}}$$

$$\Rightarrow P_h = 26 \text{kW} + 14 \text{kW} \Rightarrow P_h = 40 \text{kW}$$

$$e = \frac{W_{\text{usef}}}{Q_h} = \frac{W_{\text{usef}}/t}{Q_h/t} = \frac{P_{\text{usef}}}{P_h} \Rightarrow e = \frac{14,0 \text{kW}}{40 \text{kW}} \Rightarrow e = 0,35 > e_{\max} = 0,30$$

Άρα λάθος υπολογισμοί (β)

6.16
$$e_c = 1 - \frac{T_c}{T_h} = \frac{T_h - T_c}{T_h}$$

α.
$$e_{c,\alpha} = \frac{(T_h + 50) - T_c}{T_h + 50} = \frac{T_h - T_c + 50}{T_h + 50}$$

β.
$$e_{c,\beta} = \frac{T_h - (T_c - 50)}{T_h} = \frac{T_h - T_c + 50}{T_h}$$

γ.
$$e_{c,\gamma} = \frac{(T_h + 25) - (T_c - 25)}{T_h + 25} = \frac{T_h - T_c + 50}{T_h + 25}$$

... και στα τρία υφάσματα ο
αριθμητής είναι ίδιος, άρα μεγαλύτερος
εντεταστικός απόδοσης είναι αυτός
με τον μικρότερο παρονομαστή
άρα $e_{c,\beta} > e_{c,\gamma} > e_{c,\alpha}$
Σωστή η (β)

6.17 Η θερμική μηχανή αναφέρεται σε θερμοδυναμικό κύκλο...
επίσης ο 2ος θερμοδυναμικός νόμος αναφέρεται σε θερμική
μηχανή που διασφύζει κλειστό θερμοδυναμικό κύκλο...
Η 760 θερμότητα εισόδου δεν είναι κύκλος, άρα το ότι $Q_{\text{πρσ}} = W$
στην 760 θερμότητα δεν είναι αντίθετο με τον 2ο θερμοδυναμικό νόμο
Απάντηση: όχι δεν είναι αντίθετο... η 760 θερμότητα δεν είναι κύκλος.

6.18. Το Απορρό = Μονικό δεν είναι αντίθετο με τον 2ο θερμοδυναμικό νόμο
Αντίθετο θα ήταν αν γέγραφε Απορρό = Μονικό = Μονόθερμο.

6.19.
$$e = 0.40 = \frac{W_{\text{πρσ}}}{Q_h} = \frac{W_{\text{πρσ}}/t}{Q_h/t} = \frac{P_{\text{πρσ}}}{Q_h/t} \Rightarrow \frac{Q_h}{t} = \frac{P_{\text{πρσ}}}{e} \quad (1)$$

$$Q_h - |Q_c| = W_{\text{πρσ}} \Rightarrow \frac{Q_h}{t} - \frac{|Q_c|}{t} = \frac{W_{\text{πρσ}}}{t} \stackrel{(1)}{\Rightarrow} \frac{P_{\text{πρσ}}}{e} - \frac{|Q_c|}{t} = P_{\text{πρσ}} \quad (2)$$

$$\frac{|Q_c|}{t} = 3000 \frac{\text{J}}{\text{s}} = 30 \text{ kW} \stackrel{(2)}{\Rightarrow} \frac{P_{\text{πρσ}}}{0.4} - 30 \text{ kW} = P_{\text{πρσ}} \Rightarrow 1.5 P_{\text{πρσ}} = 30 \text{ kW}$$

$$\Rightarrow P_{\text{πρσ}} = 20 \text{ kW} \quad \text{Άρα σωστή η (β)}$$

6.20

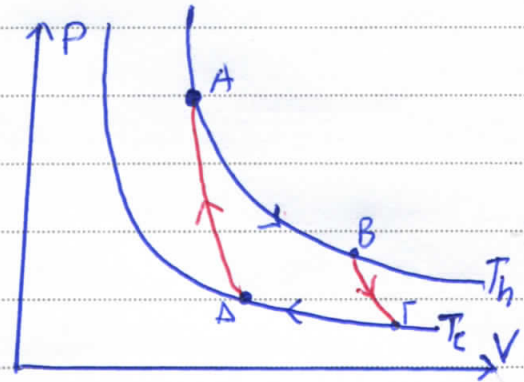
$$\alpha. \quad \left. \begin{aligned} W_{\text{net}} &= W_{AB} + W_{BC} + W_{CA} + W_{DA} \\ W_{BC} &= -W_{DA} \quad (\text{αντίθετες}) \end{aligned} \right\} \Rightarrow$$

$$W_{\text{net}} = W_{AB} - |W_{DA}| = W - 0,7W \Rightarrow$$

$$\Rightarrow W_{\text{net}} = 0,3W \quad \alpha - \text{απόδοσ}$$

$$\beta. \quad \frac{T_h}{T_c} = \frac{Q_h}{|Q_c|} = \frac{W_{AB}}{|W_{DA}|} = \frac{W}{0,7W} = \frac{10}{7}$$

$$\Rightarrow \frac{T_h}{T_c} = \frac{10}{7} \quad \beta - \text{απόδοσ}$$



$$\gamma. \quad e = \frac{W_{\text{net}}}{Q_h} = \frac{0,3W}{W} = 0,3 \Rightarrow e\% = 30\% \quad \gamma - \text{απόδοσ}$$

6.21 (βλ σχήμα της 6.20). $\Delta U_{BC} = -\Delta U_{DA}$ (1) (μεταβολές εσωτερικής ενέργειας μεταξὺ των ιδίων υποθερμικών)

$$Q_{BC} = \Delta U_{BC} + W_{BC} \Rightarrow W_{BC} = -\Delta U_{BC}$$

$$Q_{DA} = \Delta U_{DA} + W_{DA} \Rightarrow W_{DA} = -\Delta U_{DA}$$

$$\frac{W_{BC}}{W_{DA}} = \frac{-\Delta U_{BC}}{-\Delta U_{DA}} \xrightarrow{(1)} \frac{W_{BC}}{W_{DA}} = \frac{-\Delta U_{BC}}{\Delta U_{BC}} = -1 \Rightarrow W_{BC} = -W_{DA} \quad (\text{βλ 6.20-}\alpha)$$

$$\Rightarrow W_{BC} = |W_{DA}| \Rightarrow W_1 = |W_2| \quad \gamma - \text{απόδοσ}$$

$$6.22 \quad e_1 = \frac{W_1}{Q_h} = 0,3 \quad e_2 = \frac{W_2}{Q_h - |Q_c|} = 0,2$$

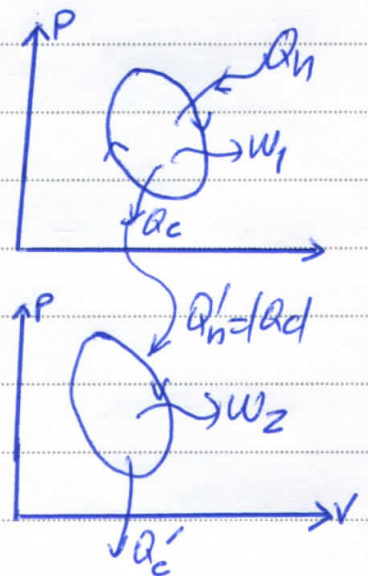
$$e = \frac{W_1 + W_2}{Q_h} = \frac{0,3Q_h + 0,2|Q_c|}{Q_h} \quad (1)$$

$$Q_h - |Q_c| = W_1 \Rightarrow Q_h - |Q_c| = 0,3Q_h \Rightarrow$$

$$\Rightarrow 0,7Q_h = |Q_c| \xrightarrow{(1)} e = \frac{0,3Q_h + 0,2 \cdot 0,7Q_h}{Q_h}$$

$$\Rightarrow e = 0,44 \quad \text{ή} \quad e\% = 44\%$$

Άρα αμετάβλητη η (γ)



6.23

$$Q_h = Q_{DA} + Q_{AB} = 300 \text{ J}$$

$$Q_{BF} = -Q_{AB} = -150 \text{ J}$$

$$Q_{AB} = nR2T \ln \frac{V_2}{V_1} = 2nRT \ln \frac{V_2}{V_1} \Rightarrow$$

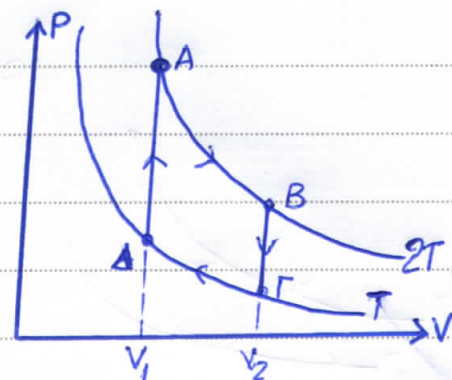
$$\Rightarrow 150 = 2nRT \ln \frac{V_2}{V_1} \Rightarrow nRT \ln \frac{V_2}{V_1} = 75 \text{ J} \quad (1)$$

$$Q_{FD} = nRT \ln \frac{V_1}{V_2} = -nRT \ln \frac{V_2}{V_1} = -75 \text{ J} \Rightarrow Q_{FD} = -75 \text{ J}$$

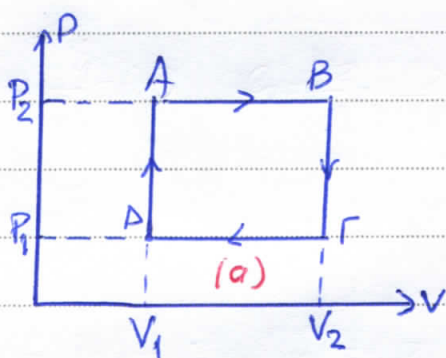
$$|Q_c| = |Q_{BF}| + |Q_{FD}| = 150 \text{ J} + 75 \text{ J} = 225 \text{ J}$$

$$Q_{\text{net}} = \Delta U_{\text{net}} + W_{\text{net}} \Rightarrow Q_h = |Q_c| = W_{\text{net}} \Rightarrow 300 \text{ J} - 225 \text{ J} = W_{\text{net}} \Rightarrow W_{\text{net}} = 75 \text{ J}$$

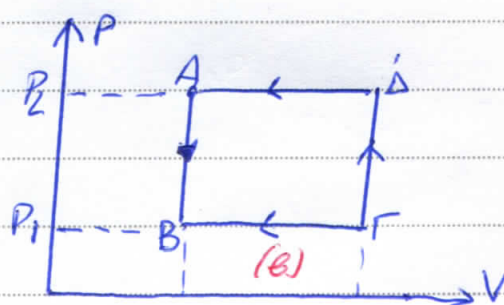
$$e = \frac{W_{\text{net}}}{Q_h} = \frac{75 \text{ J}}{300 \text{ J}} = 0,25 \text{ ή } e\% = 25\% \quad \text{Σωστό το (δ)}$$



6.24 . Κάνουμε τα δεδομένα διαγράμματα αθρο V-T και p-T
 σε διαγράμματα p-V. Οι κύκλοι σε p-V που να
 είναι κύκλοι θερμοκίνητων μηχανών πρέπει να είναι
 δεξιόστροφος (από διαγράμματα όμοια με αυτά των
 ερωτήσεων)



ΔΕΞΙΟΣΤΡΟΦΟΣ ΣΕ p-V
 ΚΥΚΛΟΣ ΤΩΝ ΥΠΟΛΕΙ
 ΠΑ ΕΙΝΑΙ ΚΥΚΛΟΣ
 ΘΕΡΜΟΚΙΝΗΤΗΣ
 ΜΗΧΑΝΗΣ



ΑΝΤΙΣΤΡΟΦΟΣ ΣΕ p-V
 ΚΥΚΛΟΣ ... ΔΕΝ ΥΠΟΛΕΙ
 ΝΑ ΕΙΝΑΙ ΚΥΚΛΟΣ ΘΕΡΜΟΚΙΝΗΤΗΣ
 ΜΗΧΑΝΗΣ
 Άρα σωστό το (α)

6.25 $\eta = 70\%$

$$e = 1 - \frac{T_C}{T_H} = 0,2 \Rightarrow \frac{T_C}{T_H} = 0,8 \Rightarrow T_C = 0,8 T_H$$

$$e = 1 - \frac{T_C'}{T_H} = 0,3 \Rightarrow \frac{T_C'}{T_H} = 0,7 \Rightarrow T_C' = 0,7 T_H$$

$$\eta = \frac{0,7 T_H - 0,8 T_H}{0,8 T_H} \cdot 100 = \frac{-0,1 T_H}{0,8 T_H} \cdot 100 = -12,5\%$$

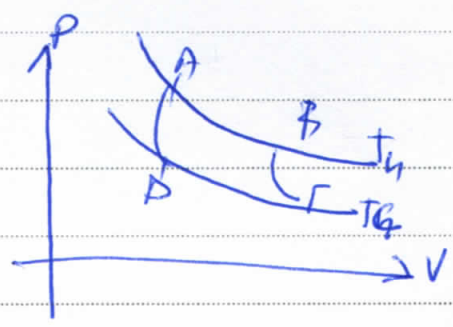
Συμπερασματικά (α)

6.26

$$|W_{AB}| = 0,75 W_{AB}$$

$$W_{AB} = W_{AB} - |W_{BA}| = 0,75 W_{AB}$$

$$W_{BA} = -W_{AB}$$



$$e = \frac{W_{net}}{Q_H} = \frac{0,75 W_{AB}}{W_{AB}} = 0,75 \quad \text{Από συνθήκη β}$$

6.27

$$T_H = 273 + 127 = 400 \text{ K}$$

$$T_C = 273 + 27 = 300 \text{ K}$$

$$e_c = 1 - \frac{T_C}{T_H} = \frac{T_H - T_C}{T_H} = \frac{100}{400} = 0,25$$

σταθερά μηχανής $e < e_c$ ή $e < 0,25$

$$\hookrightarrow e = \frac{P_{out}}{Q_{H/T}} < 0,25 \text{ ή } P_{out} < \frac{1}{4} \frac{Q_H}{t}$$

$$\Rightarrow P_{out} < \frac{1}{4} 2,6 \cdot 10^5 \text{ W ή } P_{out} < 6,5 \cdot 10^3 \text{ W}$$

$$\text{ή } P_{out} < 6,5 \text{ kW}$$

Συμπερασματικά (β)

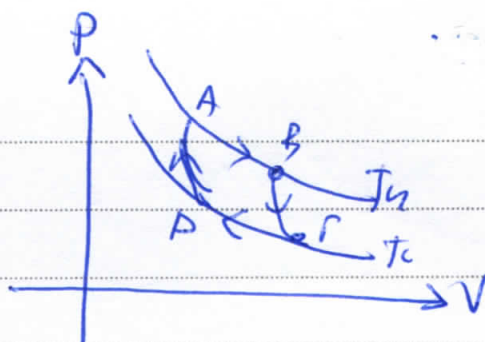
6.28

$$V_T = 0,6 V_B$$

$$\frac{3}{2} n R T_C = 0,6 \cdot \frac{3}{2} n R T_H \Rightarrow T_C = 0,6 T_H$$

$$e = 1 - \frac{T_C}{T_H} = 1 - \frac{0,6 T_H}{T_H} = 0,4 \Rightarrow e\% = 40\%$$

Subm $\eta(\alpha)$



6.29

$$W_{\text{exp}} = E = P_1 V_1$$

$$Q_h = Q_{AB} + Q_{BC}$$

$$Q_{AB} = \Delta U_{AB} = \frac{3}{2} n R \Delta T = \frac{3}{2} (2 P_1 V_1 - P_1 V_1) = \frac{3}{2} P_1 V_1$$

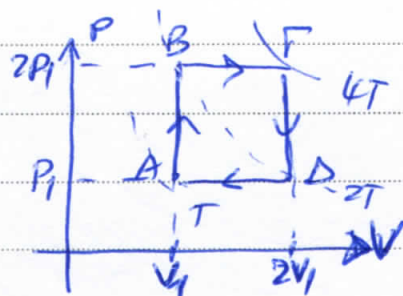
$$\Delta U_{BC} = \frac{3}{2} n R \Delta T = \frac{3}{2} (2 P_1 \cdot 2 V_1 - 2 P_1 V_1) = \frac{6}{2} P_1 V_1$$

$$W_{BC} = 2 P_1 (2 V_1 - V_1) = 2 P_1 V_1$$

$$Q_{BC} = \frac{5}{2} P_1 V_1 + 2 P_1 V_1 = \frac{10 P_1 V_1}{2}$$

$$Q_h = \frac{13}{2} P_1 V_1$$

Subm $\eta(\beta)$



$$e = \frac{W_{\text{exp}}}{Q_h} = \frac{P_1 V_1}{\frac{13}{2} P_1 V_1}$$

$$\Rightarrow e = \frac{2}{13}$$

6.30

$$Q_h = Q_{AB} + Q_{BC}$$

$$= \Delta U_{AB} + W_{BC}$$

$$= \frac{3}{2} n R \Delta T + n R T \ln 2$$

$$= \frac{3}{2} (2 P_1 V_1 - P_1 V_1) + 2 P_1 V_1 \cdot 0,7$$

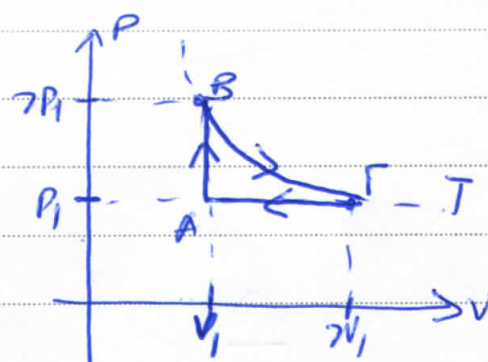
$$= 2,9 P_1 V_1$$

$$W_{\text{exp}} = W_{BC} + W_{CA} + W_{AB} = 2 P_1 V_1 \cdot 0,7 + P_1 (V_1 - 2 V_1)$$

$$\Rightarrow W_{\text{exp}} = 1,4 P_1 V_1 - P_1 V_1 = 0,4 P_1 V_1$$

$$e = \frac{W_{\text{exp}}}{Q_h} \Rightarrow e = \frac{0,4 P_1 V_1}{2,9 P_1 V_1} \Rightarrow e = \frac{4}{29}$$

Subm $\eta(\alpha)$



$$Q = 1 - \frac{T_c}{T_h} = \frac{T_h - T_c}{T_h} \quad (1)$$

$$e = 1 - \frac{T_c}{T_h} = \frac{T_h - T_c}{T_h} \quad (1)$$

$$e = 1 - \frac{T_c'}{T_h'} = 1 - \frac{T_c - \Delta T}{T_h - \Delta T} = \frac{T_h - \Delta T - T_c + \Delta T}{T_h - \Delta T} = \frac{T_h - T_c}{T_h - \Delta T} \quad (2)$$

1,2 $e' > e$ αειφοντορ
χρα σμεη η' (e)

$$d) e_1 = 1 - \frac{T_c}{T_{h1}} \quad e_2 = 1 - \frac{T_c}{T_{h2}} \quad T_{h1} > T_{h2} \Rightarrow \frac{T_c}{T_{h1}} < \frac{T_c}{T_{h2}}$$

$$\Rightarrow -\frac{T_c}{T_{h1}} > -\frac{T_c}{T_{h2}} \Rightarrow 1 - \frac{T_c}{T_{h1}} > 1 - \frac{T_c}{T_{h2}} \Rightarrow e_1 > e_2$$

а-бевх

e) $e_1 > e_2 \Rightarrow \frac{w_1}{\alpha_h} > \frac{w_2}{\alpha_h} \Rightarrow w_1 > w_2$ 8-1200

$$d) \quad \begin{array}{l} Q_n - |Q_{c1}| = W_1 \\ Q_n - |Q_{c2}| = W_2 \end{array} \xrightarrow{W_1 > W_2} Q_n - |Q_{c1}| > Q_n - |Q_{c2}|$$

$$\Rightarrow |Q_1| < |Q_2| \text{ or } |Q_2| > |Q_1|$$

த-தொ.

$$|Q_c| = 3W \quad Q_h - |Q_c| = W \Rightarrow Q_h - 3W = W \Rightarrow Q_h = 4W$$

$$Q = \frac{W}{Q_h} = \frac{W}{4W} = 0.25$$

$$e < e_{\max} \text{ if } e < 1 - \frac{T_c}{T_h} \text{ if } 0,25 < 1 - \frac{T_c}{T_h} \text{ if } \frac{T_c}{T_h} < 0,75$$

$$\frac{300}{T_h} < 0,75 \Rightarrow \frac{300}{T_h} < \frac{3}{4} \Rightarrow 400K < T_h \Rightarrow$$

$$400 \leq T_h > 400 \text{ K} \quad \text{in } 273 + \theta_c > 400$$

$$\theta_c > 127^\circ$$

Apakah benar n' (8)

Զոր ձեռն զգրաբանի
 ու լիարար օրում
 լուրջ լուրջ էր ու $\theta_H > 140^\circ$

$$6.34 \quad e_{\max} = e_c = 1 - \frac{T_c}{T_h} = 1 - \frac{273+7}{273+127} = 1 - \frac{280}{400} = \frac{120}{400} = 0,3$$

$$e < e_{\max} \text{ и } \frac{W_{\text{всп}}}{Q_h} < 0,30 \text{ и } \frac{Q_h - |Q_c|}{Q_h} < 0,3$$

$$\text{и } 1 - \frac{|Q_c|}{Q_h} < 0,3 \text{ и } -\frac{|Q_c|}{Q_h} < -0,7 \text{ и } \frac{|Q_c|}{Q_h} > 0,7$$

$$\text{и } \frac{|Q_c|}{500} > 0,7 \text{ и } |Q_c| > 350 \text{ J}$$

Итак условие выполнено при $|Q_c| = 380 \text{ J}$

Следовательно (8)

6.35

α) $P_A V_A^{5/3} = 16 \text{ (SI)}$

$16 \cdot 10^5 \cdot V_A^{5/3} = 16 \Rightarrow V_A^{5/3} = 10^{-5}$

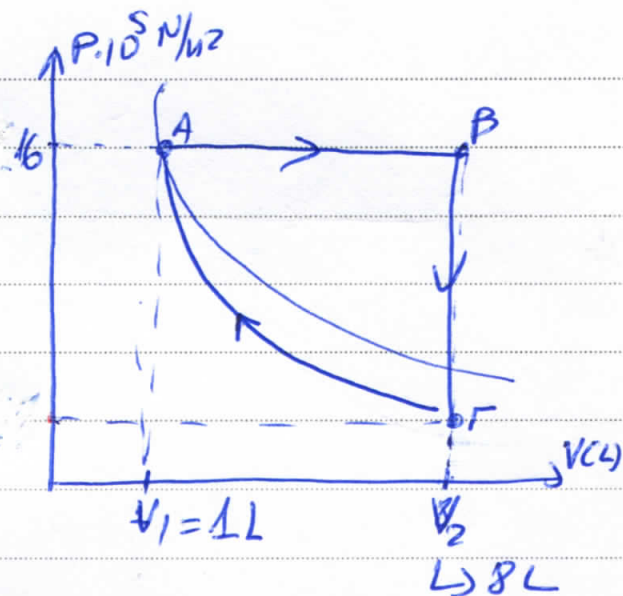
$\Rightarrow V_A = (10^{-5})^{3/5} \Rightarrow V_A = 10^{-3} \text{ m}^3$

$\Rightarrow V_A = 1 \text{ L}$

$P_r V_r^{5/3} = 16 \Rightarrow P_r (2 \cdot 10^{-3})^{5/3} = 16$

$\Rightarrow P_r (2^{5/3}) (10^{-3})^{5/3} = 16$

$P_r \cdot 32 \cdot 10^{-5} = 16 \Rightarrow P_r = 0,5 \cdot 10^5 \text{ N/m}^2$



β) $W_{\text{net}} = W_{AB} + W_{B\Gamma} + W_{\Gamma A}$

$W_{AB} = P(V_B - V_A) = 16 \cdot 10^5 \cdot (8 \cdot 10^{-3} - 1 \cdot 10^{-3}) = 11200 \text{ J}$

$W_{\Gamma A} = \frac{P_A V_A - P_r V_r}{1 - \gamma} = \frac{16 \cdot 10^5 \cdot 1 \cdot 10^{-3} - 0,5 \cdot 10^5 \cdot 8 \cdot 10^{-3}}{1 - 5/3} = \frac{1600 - 400}{-2/3} = -1800 \text{ J}$

$W_{\text{net}} = 11200 - 1800 = 9400 \text{ J}$

γ) $Q_{\text{net}} = Q_{AB} + Q_{B\Gamma} + Q_{\Gamma A} = Q_{AB} + Q_{B\Gamma}$

$\Delta U_{AB} = \frac{3}{2} n R \Delta T = \frac{3}{2} P(V_B - V_A) = \frac{3}{2} W_{AB} = \frac{3}{2} 11200 = 16800 \text{ J}$

$Q_{AB} = \Delta U_{AB} + W_{AB} = 28000 \text{ J}$

$Q_{B\Gamma} = \Delta U_{B\Gamma} = \frac{3}{2} n R \Delta T = \frac{3}{2} (P_r V_r - P_B V_B) = \frac{3}{2} (0,5 \cdot 10^5 - 16 \cdot 10^5) \cdot 8 \cdot 10^{-3}$
 $= \frac{3}{2} (-15,5 \cdot 10^5) \cdot 8 \cdot 10^{-3} = -18600 \text{ J}$

$Q_{\text{net}} = 28000 - 18600 = 9400 \text{ J} \Rightarrow Q_{\text{net}} = 9400 \text{ J}$

δ) $W_{\text{net}} = W_{\text{net}} = 9400 \text{ J} \quad Q_h = Q_{AB} = 28000 \text{ J}$

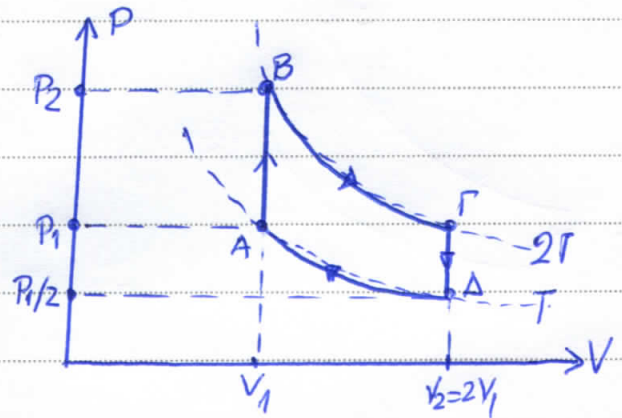
$e = \frac{W_{\text{net}}}{Q_h} = \frac{9400}{28000} \Rightarrow e = 0,3357 \Rightarrow e\% = 33,57\%$

6.36

$$AB: \frac{P_A}{T_A} = \frac{P_B}{T_B} \Rightarrow \frac{P_1}{T} = \frac{P_2}{2T} \Rightarrow P_2 = 2P_1$$

$$BF: P_B V_B = P_F V_F \Rightarrow P_2 V_1 = P_1 \cdot 2V_1 \Rightarrow P_F = P_1$$

$$\Delta A: P_A V_A = P_D V_D \Rightarrow P_1 V_1 = P_1 \cdot 2V_1 \Rightarrow P_D = \frac{P_1}{2}$$



$$a) Q_{AB} = \Delta U_{AB} = \frac{3}{2} nR \Delta T = \frac{3}{2} nRT \Rightarrow$$

$$\Rightarrow 900 = \frac{3}{2} nRT \Rightarrow nRT = 600 \text{ (SI)} \quad \text{and} \quad P_1 V_1 = 600 \text{ (SI)} \quad (1)$$

$$Q_h = Q_{AB} + Q_{BF}, \quad Q_{BF} = nR 2T \ln \frac{V_F}{V_B} = 2nRT \ln 2 \quad (2)$$

$$Q_{BF} = 2 \cdot 600 \cdot 0,7 \Rightarrow Q_{BF} = 840 \text{ J}$$

$$\text{Acc } Q_h = Q_{AB} + Q_{BF} = 900 \text{ J} + 840 \text{ J} \Rightarrow Q_h = 1740 \text{ J}$$

$$b) W_{BF} = nR 2T \ln 2 = 840 \text{ J}$$

$$W_{DA} = nRT \ln \frac{V_1}{2V_1} = -nRT \ln 2 \xrightarrow{(1)} W_{DA} = -600 \cdot 0,7 = -420 \text{ J}$$

$$W_{\text{net}} = W_{BF} + \cancel{W_{FD}} + W_{DA} + \cancel{W_{AB}} = W_{BF} + W_{DA} = 840 \text{ J} - 420 \text{ J} = 420 \text{ J}$$

$$\Rightarrow W_{\text{net}} = 420 \text{ J}$$

$$c) e = \frac{W_{\text{net}}}{Q_h} = \frac{420}{1740} \quad \text{and} \quad e = 0,2414 \quad \text{and} \quad e\% = 24,14\%$$

6.37 κύκλος Otto - θερμότητα

$$Q_h = Q_{AB} = n C_v (T_B - T_A)$$

$$Q_c = Q_{DA} = n C_v (T_D - T_r) \text{ ή } |Q_c| = n C_v (T_r - T_D)$$

$$e = \frac{W_{\text{net}}}{Q_h} = \frac{Q_h - |Q_c|}{Q_h} = 1 - \frac{|Q_c|}{Q_h} = 1 - \frac{T_r - T_D}{T_B - T_A} \quad (1)$$

$$pV^{\gamma} = \text{const} \Rightarrow \frac{nRT}{V} V^{\gamma} = \text{const} \Rightarrow T \cdot V^{\gamma-1} = \text{const}$$

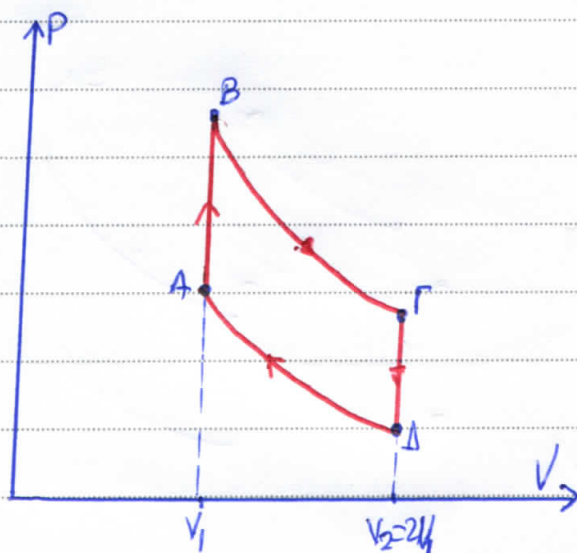
$$T_B \cdot V_1^{\gamma-1} = T_r \cdot V_2^{\gamma-1}$$

$$T_A \cdot V_1^{\gamma-1} = T_D \cdot V_2^{\gamma-1} \quad \left. \vphantom{\begin{matrix} T_B \cdot V_1^{\gamma-1} = T_r \cdot V_2^{\gamma-1} \\ T_A \cdot V_1^{\gamma-1} = T_D \cdot V_2^{\gamma-1} \end{matrix}} \right\} \Rightarrow (T_B - T_A) V_1^{\gamma-1} = (T_r - T_D) V_2^{\gamma-1} \Rightarrow$$

$$\Rightarrow \frac{T_r - T_D}{T_B - T_A} = \left(\frac{V_1}{V_2} \right)^{\gamma-1} \quad (2)$$

Από (1) και (2) παίρνουμε $e = 1 - \left(\frac{V_1}{V_2} \right)^{\gamma-1} \Rightarrow e = 1 - \left(\frac{1}{2} \right)^{1.5-1}$

$$\Rightarrow e = 1 - \left(\frac{1}{2} \right)^{0.5} \Rightarrow e = 1 - \frac{1}{\sqrt{2}} = 1 - \frac{1}{1.4} = \frac{0.4}{1.4} = \frac{2}{7} \text{ ή } e = 0.2857$$



6.38

$$a. \quad P_{\text{usef}} = \frac{W_{\text{usef}}}{T} \Rightarrow W_{\text{usef}} = P_{\text{usef}} \cdot T = 3010^3 \cdot 0,02$$

$$\Rightarrow W_{\text{usef}} = 600 \text{ Joule}$$

$$Q_h = Q_{rA} + Q_{AB}$$

$$W_{AB} = nRT_2 \ln 2 = P_1 V_1 \ln 2 = 0,7 P_1 V_1$$

$$W_{Br} = \frac{P_1}{2} (V_1 - V_2) = \frac{P_1}{2} (-V_1) = -0,5 P_1 V_1$$

$$W_{\text{usef}} = W_{AB} + W_{Br} = 0,7 P_1 V_1 - 0,5 P_1 V_1 = 0,2 P_1 V_1$$

$$\Rightarrow 600 \text{ J} = 0,2 P_1 V_1 \Rightarrow P_1 V_1 = 3000 \text{ J}$$

$$Q_{rA} = \Delta U_A = \frac{3}{2} n R \Delta T = \frac{3}{2} n R (T_2 - T_1) = \frac{3}{2} (P_1 - P_2) V_1 = \frac{3}{2} (P_1 - \frac{P_1}{2}) V_1 = \frac{3}{4} P_1 V_1 = \frac{3}{4} 3000 \text{ J}$$

$$\Rightarrow Q_{rA} = 2250 \text{ J}$$

$$Q_{AB} = W_{AB} = 0,7 P_1 V_1 = 0,7 \cdot 3000 \text{ J} = 2100 \text{ J}$$

$$Q_h = Q_{rA} + Q_{AB} = 2250 \text{ J} + 2100 \text{ J} = 4350 \text{ J}$$

$$W_{\text{usef}} = 600 \text{ J}$$

$$\left. \begin{array}{l} Q_h = 4350 \text{ J} \\ W_{\text{usef}} = 600 \text{ J} \end{array} \right\} e = \frac{W_{\text{usef}}}{Q_h} = \frac{600}{4350} \Rightarrow e = 0,138$$

$$\Rightarrow e\% = 13,8\%$$

$$b. \quad Q_{AB} = nRT_2 \ln 2 \Rightarrow 2100 = n \frac{25}{3} \cdot 600 \cdot 0,7 \Rightarrow n = 0,6 \text{ mole}$$

$$c. \quad Q_h - |Q_c| = W_{\text{usef}} \Rightarrow 4350 \text{ J} - |Q_c| = 600 \text{ J} \Rightarrow |Q_c| = 3750 \text{ J/K} \cdot \text{K} \cdot \text{h}$$

$$\Rightarrow \frac{|Q_c|}{t} = \frac{3750 \text{ J}}{0,02 \text{ s}} = 187500 \text{ J/s} \Rightarrow |Q_c| = 187500 \text{ J} \quad (5 \text{ I})$$

$$\text{Kost } \text{gas} \text{ } t = 1 \text{ h} = 3600 \text{ s} \Rightarrow |Q_c| = 187500 \cdot 3600 \Rightarrow |Q_c| = 675 \cdot 10^6 \text{ J}$$

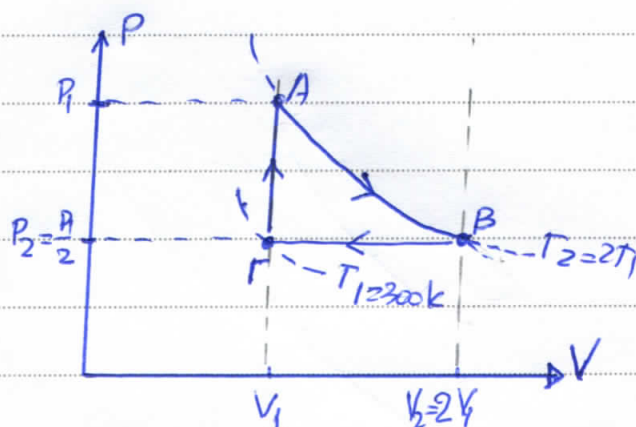
Από αυτή τη θερμοκρασία θα έχουμε θερμοκρασία

η mole υατάρ $\Delta \theta = 100^\circ \text{C}$ ή $\Delta T = 100 \text{ K}$

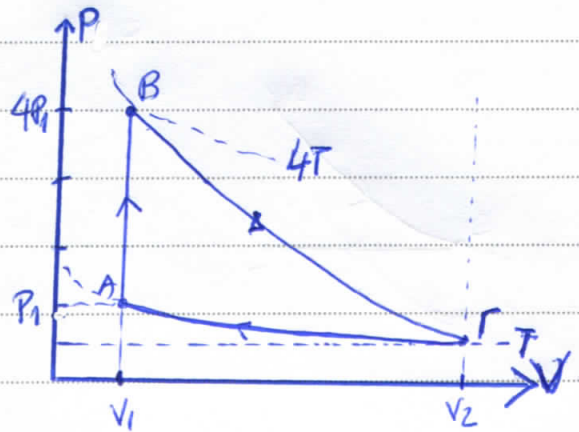
χρησιμοποιούμε το 40% $|Q_c| = 0,4 |Q_c| \Rightarrow |Q_c| = 270 \cdot 10^6 \text{ J}$

$$|Q_c| = \Delta U_{\text{100x}} + W_{\text{100x}} = \Delta U_{\text{100x}} = \frac{3}{2} n R \Delta T \Rightarrow n = \frac{2}{3} \frac{|Q_c|}{R \Delta T} = \frac{2}{3} \frac{270 \cdot 10^6 \text{ J}}{8,314 \cdot 100}$$

$$\Rightarrow n = 21,6 \cdot 10^4 \text{ mole}$$



6.39

a) A ($P_A = 4 \cdot 10^5 \text{ N/m}^2$, $V_A = 1 \text{ L}$, $T_A = 300 \text{ K}$)B ($P_B = 16 \cdot 10^5 \text{ N/m}^2$, $V_B = 1 \text{ L}$, $T_B = 1200 \text{ K}$)

$$\left. \begin{aligned} PV^{\gamma} &= \text{const} \\ \frac{P}{T} &= \text{const} \end{aligned} \right\} \Rightarrow T \cdot V^{\gamma-1} = \text{const}$$

$$\text{B} \rightarrow \text{C} \Rightarrow T_B V_B^{\gamma-1} = T_C V_C^{\gamma-1} \Rightarrow 4T \cdot V_1^{\gamma-1} = T \cdot V_2^{\gamma-1}$$

$$\Rightarrow \left(\frac{V_2}{V_1} \right)^{\gamma-1} = 4 \Rightarrow \left(\frac{V_2}{V_1} \right)^{\frac{5}{3}-1} = 2^2 \Rightarrow \left(\frac{V_2}{V_1} \right)^{\frac{2}{3}} = 2^2 \Rightarrow \left(\frac{V_2}{V_1} \right)^{\frac{1}{3}} = 2 \Rightarrow \frac{V_2}{V_1} = 8 \Rightarrow V_2 = 8V_1$$

$$\Rightarrow V_2 = 8 \text{ L}$$

$$P_C \cdot V_C = P_A V_A \Rightarrow P_C \cdot 8 = P_A \cdot 1 \Rightarrow P_C = \frac{P_A}{8} \Rightarrow P_C = 0,5 \cdot 10^5 \text{ N/m}^2$$

$$\text{b) } Q_h = Q_{AB} = \Delta U_{AB} = \frac{3}{2} n R \Delta T = \frac{3}{2} (4P_1 - P_1) V_1 = \frac{3}{2} 3P_1 V_1 = \frac{9}{2} P_1 V_1$$

$$\Rightarrow Q_h = 4,5 \cdot 4 \cdot 10^5 \cdot 10^{-3} \Rightarrow Q_h = 1800 \text{ J}$$

$$\text{c) } W_{\text{net}} = W_{AB} + W_{BC} + W_{CA} = W_{BC} + W_{CA}$$

$$W_{BC} = \frac{P_C V_C - P_B V_B}{1 - \gamma} = \frac{0,5 \cdot 10^5 \cdot 8 \cdot 10^{-3} - 16 \cdot 10^5 \cdot 10^{-3}}{1 - \frac{5}{3}} = \frac{400 - 1600}{-\frac{2}{3}} \Rightarrow W_{BC} = 1800 \text{ J}$$

$$W_{CA} = n R T_C \ln \frac{1}{8} = -3 n R T_C \ln 2 = -3 P_C V_C \ln 2 = -3 \cdot 4 \cdot 10^5 \cdot 10^{-3} \cdot 0,7$$

$$\Rightarrow W_{CA} = -840 \text{ J}$$

$$\text{Therefore } W_{\text{net}} = W_{BC} + W_{CA} = 1800 \text{ J} - 840 \text{ J} \Rightarrow W_{\text{net}} = 960 \text{ J}$$

$$\text{d) } e = \frac{W_{\text{net}}}{Q_h} = \frac{960}{1800} \Rightarrow e = 0,53 \Rightarrow e\% = 53\%$$

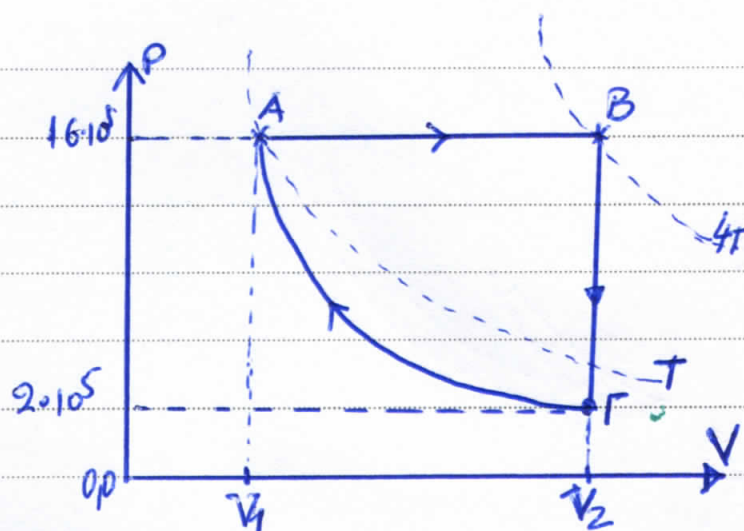
6.40

a. AB: $\frac{V}{T} = \text{const} \Rightarrow V_B = 4V_A = 4L$

ΓA: $PV^\delta = \text{const} \Rightarrow P_A V_A^\delta = P_r V_r^\delta \Rightarrow$

$$\Rightarrow 16 \cdot 10^5 \cdot 10^3 = 2 \cdot 10^5 \cdot 4^\delta \Rightarrow 8 = 2^{2\delta}$$

$$\Rightarrow 2^3 = 2^{2\delta} \Rightarrow 2\delta = 3 \Rightarrow \delta = 1,5$$



b. $W_{\text{exp}} = W_{AB} + W_{Br} + W_{rA}$

$$W_{\text{exp}} = W_{AB} + W_{rA} \quad (1)$$

$$W_{AB} = P(V_2 - V_1) = 16 \cdot 10^5 \cdot (4 - 1) \cdot 10^{-3} \Rightarrow W_{AB} = 4800 \text{ Joule}$$

$$W_{rA} = \frac{P_A V_A - P_r V_r}{1 - \delta} = \frac{16 \cdot 10^5 \cdot 1 \cdot 10^{-3} - 2 \cdot 10^5 \cdot 4 \cdot 10^{-3}}{1 - 1,5} \Rightarrow W_{rA} = \frac{1600 - 800}{-0,5}$$

$$\Rightarrow W_{rA} = -1600 \text{ J} \quad (1) \Rightarrow W_{\text{exp}} = 4800 - 1600 \Rightarrow \underline{W_{\text{exp}} = 3200 \text{ Joule}}$$

c) $\Delta U_{\text{cyc}} = \Delta U_{AB} + \Delta U_{Br} + \Delta U_{rA} \quad \left. \begin{array}{l} \Delta U_{rA} = -W_{rA} = +1600 \text{ J} \end{array} \right\} \Rightarrow \Delta U_{AB} = 9600 \text{ J}$

$$Q_h = Q_{AB} = \Delta U_{AB} + W_{AB} = 9600 \text{ J} + 4800 = 14400 \text{ J}$$

$$e = \frac{W_{\text{exp}}}{Q_h} = \frac{3200}{14400} \quad \text{et} \quad e = \frac{32}{144} \quad \text{et} \quad e = \frac{4}{18} \quad \text{et} \quad e = \frac{2}{9}$$

d) $f = \frac{N}{t} = \frac{1800}{60} = 30 \text{ Hz}$

$$P = \frac{W_{\text{exp}}}{T} = \frac{3200}{1/f} = 3200 \cdot 30 \quad \text{et} \quad P = 96 \text{ kW}$$

6.41

$$a) \frac{V_A}{T_A} = \frac{V_B}{T_B} \Rightarrow V_B = V_2 = 2L$$

$$b) \Delta U_{BA} = \Delta U_{BA} + \Delta U_{AB} = 0$$

$$\Rightarrow -3700 + \Delta U_{AB} = 0 \Rightarrow \Delta U_{AB} = 3700 \text{ J}$$

$$W_{AB} = P_A(V_B - V_A) = 36 \cdot 10^5 \cdot 1 \cdot 10^{-3} = 3600 \text{ J}$$

$$Q_h = Q_{AB} = \Delta U_{AB} + W_{AB} = 10800 \text{ J}$$

$$Q_h = 10800 \text{ J}$$

$$c) Q_C = Q_{CA} = nR T_0 \ln \frac{V_1}{V_3}$$

$$T \cdot V^{\gamma-1} = \text{const} \Rightarrow 2T_0 \cdot V_2^{\gamma-1} = T_0 \cdot V_3^{\gamma-1} \Rightarrow 2 \cdot 2^{1/2} = V_3^{1/2} \Rightarrow V_3 = 8L$$

$$\rightarrow Q_C = P_A V_1 \ln \frac{1}{8} = -3 P_A V_1 \ln 2 = 3 \cdot 36 \cdot 10^5 \cdot 10^{-3} \cdot 0.7$$

$$\Rightarrow Q_C = 7560 \text{ J} \text{ or } |Q_C| = 7560 \text{ Joule}$$

$$d) Q_h - |Q_C| = W_{\text{net}} \Rightarrow W_{\text{net}} = 3240 \text{ Joule}$$

$$e) \epsilon = \frac{W_{\text{net}}}{Q_h} = \frac{3240}{10800} = 0.3 \text{ or } 30\%$$

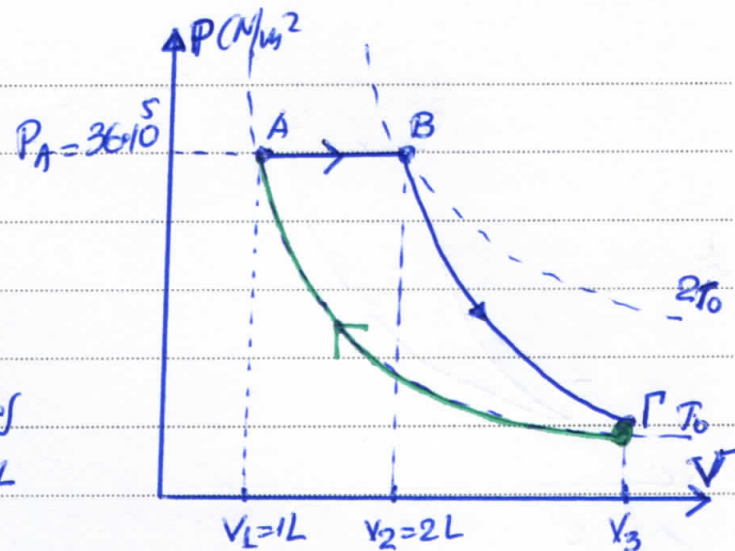
Answer

$$1. a) V_B = V_2 = 2L, V_C = V_3 = 8L$$

$$b) Q_h = 10800 \text{ Joule}$$

$$c) W_{\text{net}} = 3240 \text{ Joule}$$

$$d) \epsilon = 30\%$$



$$\alpha) \frac{T_B}{P_B} = \frac{T_A}{P_A} \Rightarrow \frac{2T_1}{P_2} = \frac{T_1}{P_1} \Rightarrow P_2 = 2P_1$$

$$Q_{AB} = 300 \text{ J} \Rightarrow \Delta U_{AB} = 300 \text{ J}$$

$$\Delta U_{AB} = \frac{3}{2} n R \Delta T = \frac{3}{2} n R (2T_1 - T_1)$$

$$\Delta U_{AB} = \frac{3}{2} n R T_1 \Rightarrow 300 = \frac{3}{2} n R T_1$$

$$\Rightarrow n R T_1 = 200 \text{ J of } P V = 200 \text{ Joule}$$

$$\Delta U_{BF} = \frac{3}{2} n R (4T_1 - 2T_1) = \frac{3}{2} n R 2T_1 = 3 n R T_1 = 600 \text{ J}$$

$$W_{BF} = P_2 (V_2 - V_1) = n R \cdot 4T_1 - n R 2T_1 = 2 n R T_1 = 400 \text{ J}$$

$$Q_{BF} = 1000 \text{ J}$$

$$Q_h = Q_{AB} + Q_{BF} \Rightarrow \boxed{Q_h = 1300 \text{ J}}$$

$$\beta) W_{\text{net}} = E = (P_2 - P_1)(V_2 - V_1) = (2P_1 - P_1)(2V_1 - V_1) = P V$$

$$\Rightarrow W_{\text{net}} = 200 \text{ J}$$

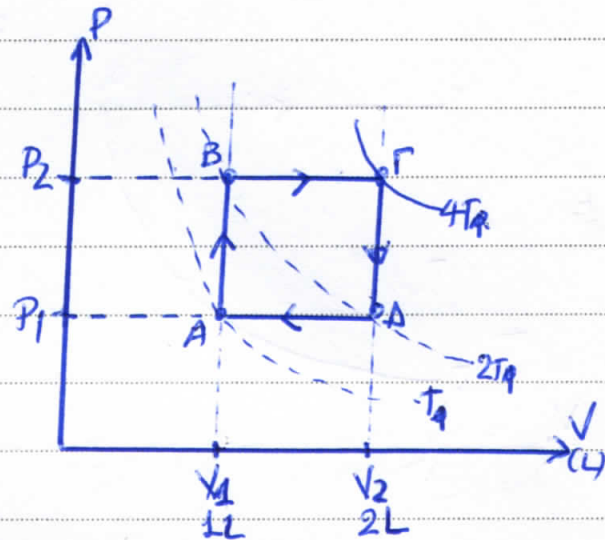
$$\gamma) Q_h - |Q_c| = W_{\text{net}} \Rightarrow |Q_c| = Q_h - W_{\text{net}} = 1100 \text{ J}$$

$$\Rightarrow Q_c = -1100 \text{ J}$$

$$\delta) e = \frac{W_{\text{net}}}{Q_h} = \frac{200}{1300} = \frac{2}{13}$$

$$\epsilon) P = \frac{W_{\text{net}}}{T} = W_{\text{net}} \cdot f = 200 \cdot 20 = 4000 \text{ W}$$

$$\Rightarrow P_{\text{pump}} = 4000 \text{ W}$$



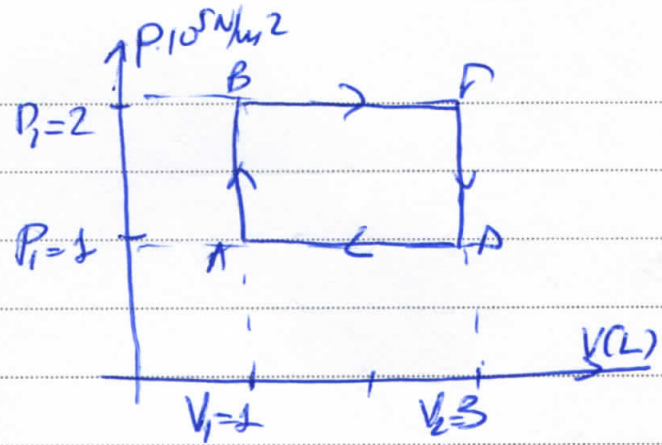
6.43

(2.1)

-20

$$a) W_{\text{comp}} = E = (P_2 - P_1)(V_1 - V_2)$$

$$\Rightarrow W_{\text{comp}} = 1.10^5 \frac{\text{N}}{\text{m}^2} (7 \cdot 10^3) = 200 \text{ J}$$



$$b) \Delta U_{AB} = \frac{3}{2} n R \Delta T = \frac{3}{2} (P_2 - P_1) V_1$$

$$= \frac{3}{2} (2 - 1) 10^5 \cdot 10^3 = 150 \text{ J}$$

$$Q_{AB} = 150 \text{ J}$$

$$\Delta U_{BD} = \frac{3}{2} n R \Delta T = \frac{3}{2} P_2 (V_2 - V_1) = \frac{3}{2} 2 \cdot 10^5 \cdot 2 \cdot 10^3 = 600 \text{ J}$$

$$W_{BD} = P_2 (V_2 - V_1) = 2 \cdot 10^5 \cdot 2 \cdot 10^3 = 400 \text{ J}$$

$$Q_{BD} = 100 \text{ J}$$

$$Q_h = Q_{AB} + Q_{BD} \Rightarrow Q_h = 1150 \text{ J}$$

$$c) e = \frac{W_{\text{comp}}}{Q_h} \Rightarrow e = \frac{200}{1150} \approx e = \frac{4}{23}$$

$$d) P = \frac{W_{\text{comp}}}{T} = W_{\text{comp}} \cdot f \Rightarrow f = \frac{P}{W_{\text{comp}}} = \frac{4000 \text{ W}}{200 \text{ J}} = 20 \text{ Hz}$$

$$N = f \cdot t = 20 \text{ Hz} \cdot 60 \text{ s} \Rightarrow N = 1200 \text{ kcal} / \text{min}$$

6.44

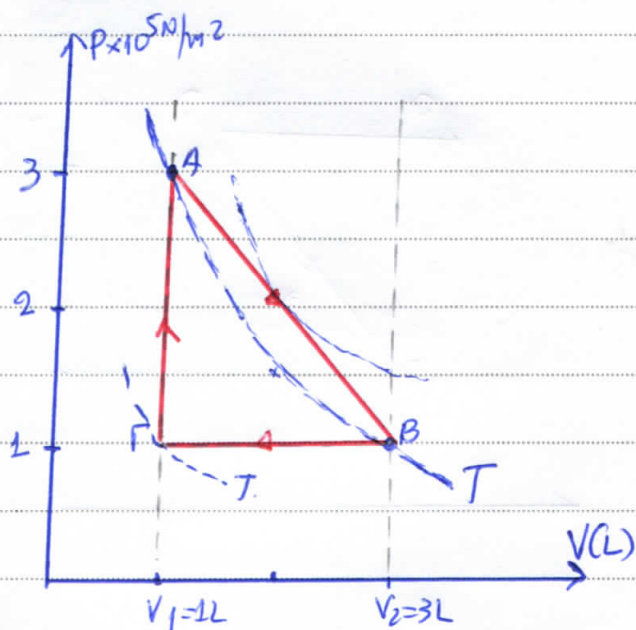
- α) Α, Β συνήκουν ίδια ισόθερμη - αλλά
η ΑΒ δεν είναι ισόθερμη -

$$P_A V_A = P_B V_B \Rightarrow V_B = 3L$$

$$W_{\text{cyc}} = \text{Εμβαδόν (ΑΒΓ)} \Rightarrow$$

$$W_{\text{cyc}} = \frac{1}{2} (B\Gamma) \cdot (ΓΑ) \stackrel{\text{SE}}{=} \frac{1}{2} \cdot 2 \cdot 10^3 \cdot 2 \cdot 10^5$$

$$\Rightarrow W_{\text{cyc}} = 200 \text{ J}$$



β) $Q_h = Q_{AB} + Q_{\Gamma A}$

$$Q_{AB} = \Delta U_{AB} + W_{AB} = 0 + W_{AB} = \frac{3 \cdot 10^5 + 1 \cdot 10^5}{2} \cdot (3-1) \cdot 10^3 \Rightarrow Q_{AB} = 400 \text{ J}$$

$$Q_{\Gamma A} = \Delta U_{\Gamma A} + W_{\Gamma A} = \Delta U_{\Gamma A} = \frac{3}{2} n R \Delta T \Rightarrow Q_{\Gamma A} = \frac{3}{2} (P_A - P_{\Gamma}) V_{\Gamma} \Rightarrow$$

$$Q_{\Gamma A} = \frac{3}{2} \cdot 2 \cdot 10^5 \cdot 1 \cdot 10^3 \Rightarrow Q_{\Gamma A} = 300 \text{ J}$$

$$Q_h = 400 \text{ J} + 300 \text{ J} \Rightarrow Q_h = 700 \text{ J} \quad \text{όρα } e = \frac{W_{\text{cyc}}}{Q_h} = \frac{200 \text{ J}}{700 \text{ J}} \Rightarrow e = \frac{2}{7}$$

δ) $P V_{\Gamma} = n R T_{\Gamma} \Rightarrow T_{\Gamma} = \frac{P_{\Gamma} V_{\Gamma}}{n R} = \frac{1 \cdot 10^5 \cdot 1 \cdot 10^3}{0,12 \cdot 2 \cdot 10^3} \Rightarrow T_{\Gamma} = 100 \text{ K}$

Η εξίσωση της p-v για mv AB είναι $p = 4 \cdot 10^5 - 10^8 V$ (SE)

$$\Rightarrow p = 4 \cdot 10^5 - 10^8 \frac{n R T}{p} \Rightarrow p = 4 \cdot 10^5 - 10^8 \frac{0,12 \cdot \frac{5}{3} T}{p} \Rightarrow p = 4 \cdot 10^5 - \frac{T}{p} 10^8$$

$$\Rightarrow p^2 - 4 \cdot 10^5 p + 10^8 T = 0 \quad \text{Αντι 3xει } \Delta \geq 0 \Rightarrow 16 \cdot 10^{10} - 4 \cdot 10^8 T \geq 0$$

$$\Rightarrow 10^8 T \leq 4 \cdot 10^{10} \Rightarrow T \leq 400 \text{ K} \Rightarrow T_{\text{max}} = 400 \text{ K}$$

$$\text{Άρα } e_{\text{Carnot}} = 1 - \frac{T_c}{T_h} = 1 - \frac{T_{\text{min}}}{T_{\text{max}}} = 1 - \frac{100}{400} \Rightarrow e_{\text{Carnot}} = 0,75$$

$$a) P = \frac{W_{\text{avg}}}{T} = W_{\text{avg}} \cdot f \Rightarrow W_{\text{avg}} = \frac{P}{f} \Rightarrow W_{\text{avg}} = \frac{16 \cdot 10^3 \text{ W}}{40 \text{ Hz}}$$

$$\Rightarrow W_{\text{avg}} = 400 \text{ Joule}$$

$$b) Q_h - |Q_c| = W_{\text{avg}} \Rightarrow Q_h = |Q_c| + W_{\text{avg}} = 2000 \text{ J}$$

$$e = \frac{W_{\text{avg}}}{Q_h} \Rightarrow e = \frac{400}{2000} = 0.2 \Rightarrow \underline{e\% = 20\%}$$

γ) Δύο η η απόδοσή του υαλίου απροσβαίει έχει κέκλιση.

$$Q_h = 5 \cdot 10^7 \frac{\text{J}}{\text{kg}} \cdot m \text{ kg} \Rightarrow m = \frac{Q_h}{5 \cdot 10^7} = \frac{2000}{5 \cdot 10^7} = 4 \cdot 10^{-5} \text{ kg}$$

$$\Rightarrow m = 4 \cdot 10^{-5} \text{ kg/κύκλιος}$$

$$V = \frac{m}{e} = \frac{4 \cdot 10^{-5} \text{ kg}}{0.72 \text{ kg/L}} = \frac{4}{0.72} \cdot 10^{-5} \text{ L/κύκλιος}$$

Σε μία ώρα $1 \text{ h} = 3600 \text{ s}$ το πλήθος των κύκλων είναι

$$N = f \cdot t = 40 \cdot 3600 = 144 \cdot 10^3 \text{ κύκλοι, αφού}$$

το βάθαινον τένο περιστάσιο είναι

$$V_{\text{ολ}} = \frac{4}{0.72} \cdot 10^{-5} \frac{\text{L}}{\text{κύκλιος}} \cdot 144 \cdot 10^3 \text{ κύκλοι}$$

$$V_{\text{ολ}} = 800 \cdot 10^{-2} \text{ L} \Rightarrow \boxed{V_{\text{ολ}} = 8 \text{ L περιστάσιο}}$$

6.46

$$P_{\text{prop}} = 2640 \text{ kW}$$

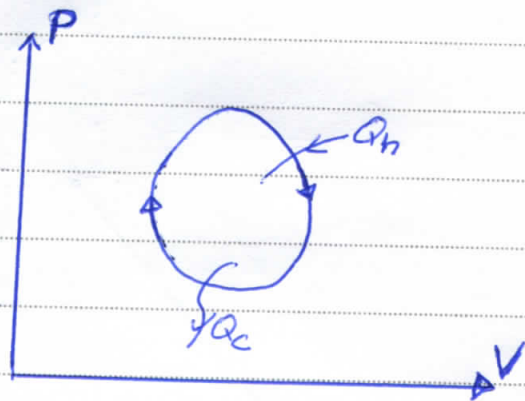
$$e = 0,264$$

$$|Q_c| = 1600 \text{ J}$$

$$\frac{Q}{m} = 4 \cdot 10^7 \frac{\text{J}}{\text{kg}}$$

$$\alpha. \quad P = \frac{W_{\text{exp}}}{t} \Rightarrow W_{\text{exp}} = P \cdot t \Rightarrow W_{\text{exp}} = 2640 \cdot 10^3 \text{ W} \cdot 3600 \text{ s}$$

$$\Rightarrow W_{\text{exp}} = 9504 \cdot 10^6 \text{ Joule}$$



$$\beta. \quad e = \frac{W_{\text{exp}}}{Q_h} \Rightarrow e = \frac{W_{\text{exp}}/t}{Q_h/t} \Rightarrow e = \frac{P_{\text{exp}}}{Q_h/t} \Rightarrow Q_h = \frac{P_{\text{exp}}}{e} \Rightarrow \frac{Q_h}{t} = \frac{P_{\text{exp}}}{0,264} \Rightarrow \frac{Q_h}{t} = 10^7 \text{ J/s}$$

\gamma. Θεωρούμε ότι όλη η ενέργεια που λαμβάνεται :

$$Q_h = 2 \cdot 10^5 \text{ kg} \cdot 4 \cdot 10^7 \text{ J/kg} \Rightarrow Q_h = 8 \cdot 10^{12} \text{ J}$$

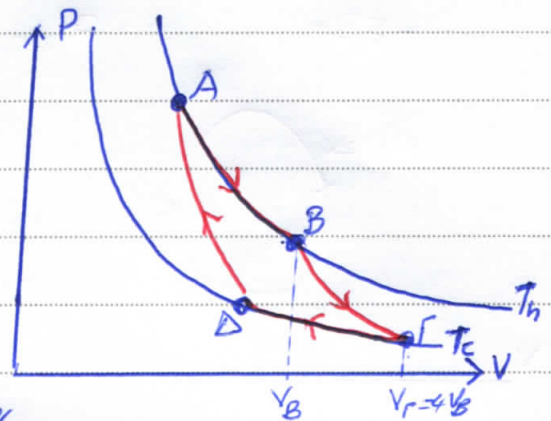
\delta. Η αρχαιότερη θεωρία $Q_h = 8 \cdot 10^{12} \text{ J}$ βόρειο ότι προσεγγίζεται
 σε χρόνο t , οπότε $\frac{Q_h}{t} = 10^7 \text{ J/s} \Rightarrow \frac{8 \cdot 10^{12}}{t} = 10^7 \Rightarrow t = 8 \cdot 10^5 \text{ s}$

Στο χρόνο αυτό το πλοίο διένυσε διάστημα

$$S = v \cdot t = 8 \text{ m/s} \cdot 8 \cdot 10^5 \text{ s} = 64 \cdot 10^5 \text{ m} \text{ ή } S = 6400 \cdot 10^3 \text{ m} \text{ ή } S = 6400 \text{ km}$$

6.47

a. $pV = 6 \text{ J}$
 $\frac{pV}{T} = 6 \text{ J}$ } $\Rightarrow T \cdot V^{\gamma-1} = 6 \text{ J}$
 $\Rightarrow T_B V_B^{\gamma-1} = T_C V_C^{\gamma-1} \Rightarrow T_B V_B^{\gamma-1} = T_C (4V_B)^{\gamma-1}$
 $\Rightarrow T_B V_B^{\gamma-1} = T_C \cdot 4^{\gamma-1} V_B^{\gamma-1}$
 $\Rightarrow T_B = T_C \cdot 4^{\gamma-1} \Rightarrow T_B = T_C \cdot 4^{\frac{1}{2}-1} \Rightarrow T_B = T_C \cdot 4^{\frac{1}{2}} \Rightarrow T_B = 2T_C$



$e_c = 1 - \frac{T_c}{T_h} = 1 - \frac{T_c}{2T_c} = 0,5 \Rightarrow e_c = 0,5 \text{ ή } 50\%$

b. $P = \frac{W_{\text{κρ}}}{t} \Rightarrow P = W_{\text{κρ}} \cdot f \Rightarrow W_{\text{κρ}} = \frac{P}{f} = \frac{10 \cdot 10^3 \text{ W}}{20 \text{ Hz}} \Rightarrow W_{\text{κρ}} = 500 \text{ J}$

γ. $e = \frac{W_{\text{κρ}}}{Q_h} \Rightarrow Q_h = \frac{W_{\text{κρ}}}{e} \Rightarrow Q_h = \frac{500 \text{ J}}{0,5} \Rightarrow Q_h = 1000 \text{ J}$ για κάθε κύκλο της μηχανής
 Η μηχανή σε χρόνο t (1 ώρα) έχει διασπείρει N κύκλους και έχει

$N = f \cdot t = 20 \text{ Hz} \cdot 3600 \text{ s} \Rightarrow N = 72 \cdot 10^3 \text{ κύκλοι}$

Παράγεται θερμότητα Q_h' σε 1 ώρα: $Q_h' = 1000 \text{ J/κύκλος} \cdot 72 \cdot 10^3 \text{ κύκλοι/h}$

$\Rightarrow Q_h' = 72 \cdot 10^6 \text{ J/h}$

δ. $pV^{\gamma} = 6 \text{ J}$
 $\frac{pV}{T} = 6 \text{ J}$ } $\Rightarrow P \cdot \left(\frac{6 \text{ J}}{P} \right)^{\frac{1}{\gamma-1}} = 6 \text{ J} \Rightarrow \dots \Rightarrow P^{\frac{1}{\gamma-1}} \cdot T^{\frac{\gamma}{\gamma-1}} = 6 \text{ J}$

$P_A^{\frac{1}{\gamma-1}} \cdot T_A^{\frac{\gamma}{\gamma-1}} = P_B^{\frac{1}{\gamma-1}} \cdot T_B^{\frac{\gamma}{\gamma-1}} \Rightarrow \left(\frac{P_A}{P_B} \right)^{\frac{1}{\gamma-1}} = \left(\frac{T_B}{T_A} \right)^{\frac{\gamma}{\gamma-1}} \Rightarrow \left(\frac{P_A}{P_B} \right)^{\frac{1}{\gamma-1}} = \left(\frac{T_c}{T_h} \right)^{\frac{\gamma}{\gamma-1}} \Rightarrow \left(\frac{P_A}{P_B} \right)^{\frac{1}{\gamma-1}} = \left(\frac{1}{2} \right)^{\frac{\gamma}{\gamma-1}}$

$\Rightarrow \left(\frac{P_A}{P_B} \right)^{\frac{1}{\gamma-1}} = \left(\frac{1}{2} \right)^{\frac{\gamma}{\gamma-1}} \Rightarrow \frac{P_A}{P_B} = \frac{1}{8} \Rightarrow P_A = 8P_B$

$\pi\% = \frac{\Delta P}{P_{\text{αρχ}}} 100\% = \frac{P_A - P_B}{P_B} 100\% = \frac{8P_B - P_B}{P_B} 100\% \Rightarrow \pi\% = 700\%$

6.48

$$\gamma = 1,5 \quad f = 40 \text{ Hz}$$

A (20.10⁵ N, 4,5L stok)

$$V_B = 9L, V_C = 25L$$

$$a) T \cdot V^{\gamma-1} = \text{const} \Rightarrow T_B \cdot V_B^{\gamma-1} = T_C \cdot V_C^{\gamma-1}$$

$$\Rightarrow T_C = T_B \left(\frac{V_B}{V_C} \right)^{\gamma-1} \Rightarrow$$

$$\Rightarrow T_C = T_B \left(\frac{V_B}{V_C} \right)^{1,5-1} \Rightarrow T_C = 500 \cdot \left(\frac{9}{25} \right)^{1/2} = 500 \cdot \left(\frac{3}{5} \right)^2 = 500 \cdot \frac{3}{5} = 300 \text{ K}$$

$$\Rightarrow T_C = 300 \text{ K}$$

$$b) Q_h = Q_{AB} = n R T_h \ln \frac{V_B}{V_A} = p_A V_A \ln 2 = 20 \cdot 10^5 \text{ N} \cdot 4,5 \cdot 10^{-3} \text{ m}^3 \cdot 0,7 \Rightarrow Q_h = 6300 \text{ J}$$

$$e = 1 - \frac{T_C}{T_h} = 1 - \frac{300}{500} \Rightarrow e = 0,4$$

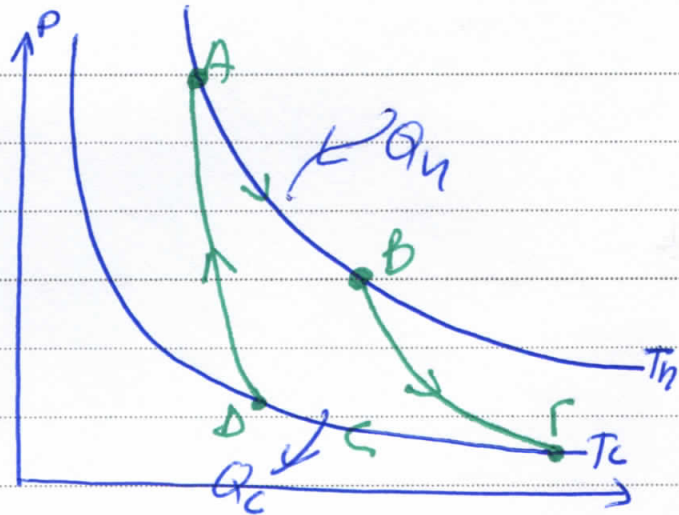
$$e = \frac{W_{\text{usef}}}{Q_h} \Rightarrow W_{\text{usef}} = e Q_h \Rightarrow W_{\text{usef}} = 0,4 \cdot 6300 \text{ J} \Rightarrow W_{\text{usef}} = 2520 \text{ J}$$

$$Q_h - |Q_c| = W_{\text{usef}} \Rightarrow |Q_c| = Q_h - |W_{\text{usef}}| = 6300 \text{ J} - 2520 \text{ J}$$

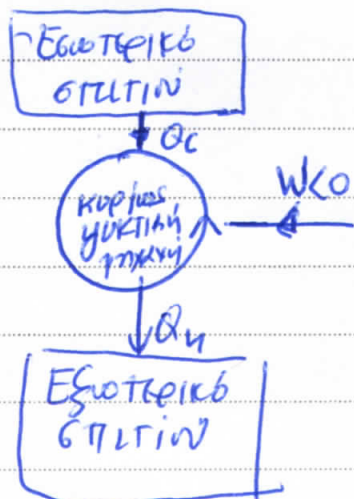
$$\Rightarrow |Q_c| = 3780 \text{ J} \quad \text{so } Q_c = -3780 \text{ J}$$

$$c) P = \frac{W_{\text{usef}}}{t} = W_{\text{usef}} \cdot f \Rightarrow P = 2520 \text{ J} \cdot 40 \text{ Hz}$$

$$\Rightarrow P_{\text{usef}} = 100800 \text{ W} \quad \text{so } \underline{P_{\text{usef}} = 100,8 \text{ kW}}$$



6.49



$$\Delta Q = \Delta U + W \Rightarrow$$

$$+ |Q_c| - |Q_h| = -|W| \Rightarrow |Q_h| = |Q_c| + |W|$$

$$\rightarrow |W| = |Q_h| - |Q_c|$$

a) $\frac{|W|}{t} = P = V \cdot I = 211 \text{ V} \cdot 10 \text{ A} \Rightarrow$

$$\Rightarrow \frac{|W|}{t} = 2110 \text{ J/s}$$

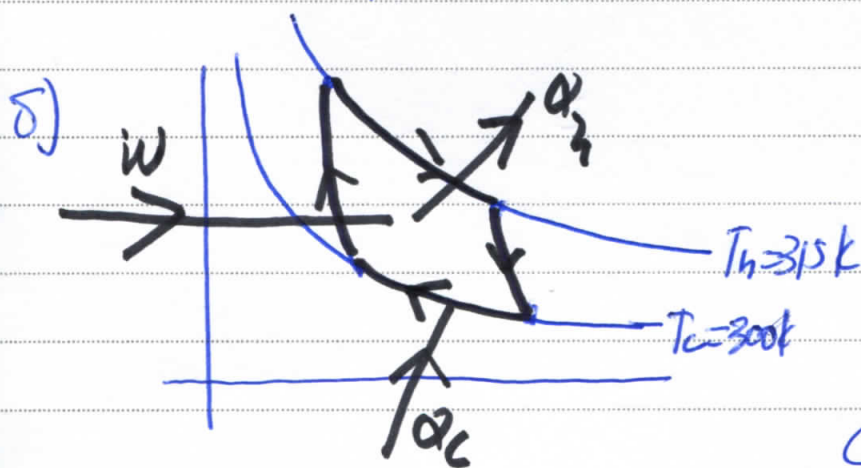
e) $\frac{|Q_c|}{t} = \frac{1800 \text{ BTU} \cdot 1055 \text{ J/BTU}}{3600 \text{ s}} \Rightarrow \frac{|Q_c|}{t} = 5275 \text{ J/s}$

$$|Q_h| = |Q_c| + |W| \Rightarrow \frac{|Q_h|}{t} = \frac{|Q_c|}{t} + \frac{|W|}{t} \Rightarrow \frac{|Q_h|}{t} = 5275 \frac{\text{J}}{\text{s}} + 2110 \frac{\text{J}}{\text{s}}$$

$$\Rightarrow \frac{|Q_h|}{t} = 7385 \text{ J/s}$$

δ) $e = \frac{|Q_c|}{|W|} \Rightarrow e = \frac{|Q_c|/t}{|W|/t} \Rightarrow e = \frac{5275 \text{ J/s}}{2110 \text{ J/s}} \Rightarrow e = 2.5$

$\hookrightarrow e = \frac{E_{\text{εκφ}}}{E_{\text{πρσβ}}}$



$$e = \frac{|Q_c|}{|W|} = \frac{|Q_c|}{|Q_h| - |Q_c|}$$

$$\hookrightarrow e = \frac{\frac{|Q_c|}{|Q_c|}}{\frac{|Q_h|}{|Q_c|} - \frac{|Q_c|}{|Q_c|}} = \eta$$

$$e = \frac{1}{\frac{|Q_h|}{|Q_c|} - 1} \Rightarrow e = \frac{1}{\frac{T_h}{T_c} - 1}$$

$$\Rightarrow e = \frac{1}{105 - 1} \Rightarrow e = 20 = e_{\text{max}}$$

7ο κριτήριο αξιολόγησης · Νόμοι Κίνησης και θερμοδυναμική

Θέμα Α

A-1: α-1, β-1, γ-1, δ-Σ

A-2: α-1, β-Ε, γ-1, δ-1

A-3: α-1, β-1, γ-1, δ-Σ

$$\frac{C_A}{P_A} = \frac{C_T}{P_T} \Rightarrow C_A P_T = C_T P_A$$

A-4 α-1, β-1, γ-Σ, δ-1

$$\left. \begin{aligned} \bar{K} &= \frac{3}{2} kT \\ V &= 6 \pi a^3 \cdot T \end{aligned} \right\} \bar{E} = \frac{3}{2} kT \Rightarrow V \propto T \Rightarrow K = 6 \pi a^3 \cdot V$$

A-5 [α-1, β-Σ, γ-Σ, δ-1, ε-1]

* 1-δ, 2-β, 3-δ, 4-γ 5(α-1, β-Σ, γ-Σ, δ-1, ε-1) *

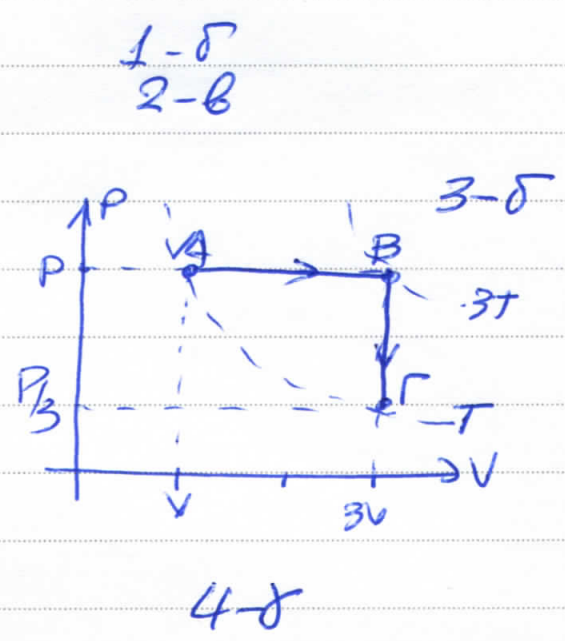
Θέμα Β Παραμαγνήτις ότι $C_T = 6 \pi a^3 = 1,28 \cdot 10^{-28} \text{ m}^3$

$$n \cdot C_T = 1,2 \cdot \frac{10^{25} \text{ kg}}{10^{-28} \text{ m}^3} \cdot 300 \text{ K} \Rightarrow C_T = 360 \text{ (SI)} = 6 \pi a^3 \text{ σε } \mu\text{m}^3$$

$$PV = nRT \Rightarrow P = \frac{nRT}{V} \Rightarrow P = C \cdot \frac{RT}{M_T} \Rightarrow C_T = \frac{P \cdot M_T}{R} = 6 \pi a^3 \text{ σε } \mu\text{m}^3$$

$$\frac{M_T = 6 \pi a^3}{R = 8,314} \rightarrow P = 6 \pi a^3 \text{ σε } \mu\text{m}^3 \text{ άρα } 100 \text{ } \mu\text{m}^3 \text{ γεμάτος}$$

Σωστή η' (γ)



$$\frac{\Delta T}{\Delta y} = \frac{1}{6,25 \cdot 10^4} \frac{\text{K}}{\text{m}} \Rightarrow \frac{\Delta T}{\Delta y} = 1600 \text{ K/m}$$

$$\Gamma.2. \quad \frac{Y}{T} = 25 \cdot 10^6 \text{ (st)} \Rightarrow \frac{A \cdot Y}{T} = 25 \cdot 10^6 \text{ (st)} \stackrel{\text{SI}}{\Rightarrow} \frac{4 \cdot 10^{-2} \cdot 25 \cdot 10^2}{T} = 25 \cdot 10^6$$

$$\Rightarrow T = 400 \text{ K}$$

$$\Gamma.3 \quad v_{EN} = \sqrt{\frac{3 \cdot R \cdot T}{M_r}} \Rightarrow v_{EN} = \sqrt{\frac{3 \cdot \frac{25}{3} \cdot 400}{10 \cdot 10^{-3}}} \Rightarrow v_{EN} = \sqrt{\frac{25 \cdot 400}{10^{-2}}} \Rightarrow v_{EN} = 1000 \text{ m/s}$$

$$\Gamma.4 \quad K_{02} = N \bar{K} = N \frac{3}{2} \frac{R}{N_A} T = \frac{3}{2} \frac{N}{N_A} R T = \frac{3}{2} n R T = \frac{3}{2} p V = \frac{3}{2} p \cdot A Y$$

$$\stackrel{\text{SI}}{\Rightarrow} K_{02} = \frac{3}{2} \cdot 1,1 \cdot 10^5 \frac{\text{N}}{\text{m}^2} \cdot 4 \cdot 10^{-2} \text{ m}^2 \cdot 0,75 \text{ m} \Rightarrow K_{02} = 1650 \text{ J}$$

$$\Gamma.5 \quad v_{EN} = 1000 + \frac{20}{100} \cdot 1000 \Rightarrow v_{EN} = 1200 \text{ m/s}$$

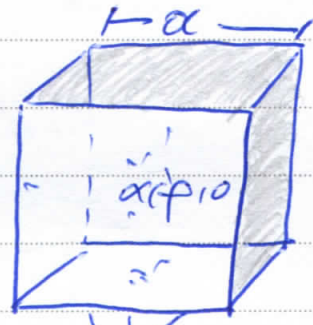
$$v_{EN}^2 = \frac{3 R}{M_r} T \Rightarrow T = \frac{v_{EN}^2 \cdot M_r}{3 R} \stackrel{\text{SI}}{\Rightarrow} T = \frac{1200^2 \cdot 10^{-2}}{3 \cdot \frac{25}{3}} \Rightarrow T = 576 \text{ K}$$

$$\frac{\Delta T}{\Delta y} = 1600 \text{ K/m} \Rightarrow \frac{576 - 400}{\Delta y} = 1600 \Rightarrow \Delta y = 0,11 \text{ m} \text{ n' } \Delta y = 11 \text{ cm}$$

0.81 α Δ!

$$\alpha = 0.2 \text{ m} \quad n = \frac{2}{R} \text{ mole}$$

160 x 10⁻⁴



$$\Delta-1) \quad PV = nRT \Rightarrow \frac{P}{T} = \frac{nR}{V} = \text{const}$$

$$\Rightarrow \frac{P}{T} = \frac{\frac{2}{R} \cdot R}{\alpha^3} \Rightarrow \frac{P}{T} = \frac{2}{8 \cdot 10^{-3}} = \frac{2500}{8} \Rightarrow \frac{P}{T} = 250 \text{ SI}$$

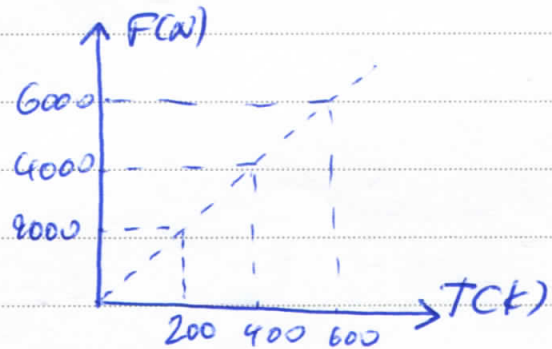
$$\Rightarrow \frac{P}{T} = 250 \text{ (SI)} \Rightarrow P = 250 T \text{ (SI)} \quad \checkmark$$

$$\Delta-2) \quad F = P \alpha^2 = 250 T \cdot 0.2^2 = 250 \cdot 4 \cdot 10^{-2} T \Rightarrow F = 10 T \text{ (SI)} \quad \checkmark$$

$$\Delta-3) \quad \frac{P}{T} = 250$$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} = \frac{P_2 - P_1}{T_2 - T_1} = \frac{\Delta P}{\Delta T} = 250$$

$$\Rightarrow \frac{\Delta P}{\Delta T} = 250 \text{ (SI)} \quad \checkmark$$



$$\Delta-4) \quad K_{02} = N \cdot E = n N_A \cdot \frac{3}{2} \cdot \frac{R}{N_A} T = \frac{3}{2} n R T = \frac{3}{2} P V$$

$$\Rightarrow K_{02} = \frac{3}{2} 250 T \cdot V = \frac{3}{2} 250 T \cdot 0.2^3 \quad T = 400 \text{ K}$$

$$\Rightarrow K_{02} = \frac{3}{2} \cdot 250 \cdot 400 \cdot 8 \cdot 10^{-3} \Rightarrow K_{02} = 1200 \text{ J} \quad \checkmark$$

$$\Delta-5) \quad \frac{v_{\text{RMS}}'}{v_{\text{RMS}}} = \sqrt{\frac{T'}{T}} \Rightarrow \frac{v_{\text{RMS}}'}{v_{\text{RMS}}} = \sqrt{\frac{P'}{P}} = \sqrt{\frac{1.21 P}{P}} = 1.1 \Rightarrow v_{\text{RMS}}' = 1.1 v_{\text{RMS}}$$

$$\eta \% = \frac{\Delta v_{\text{RMS}}}{v_{\text{RMS}}} 100\% = \frac{0.1 v_{\text{RMS}}}{v_{\text{RMS}}} 100\% = 10\% \quad \Rightarrow \eta \% = 10\% \quad \checkmark$$

8^ο βείτηριο αξιολόγησης

Θέμα Α!

1-β, 2-α, 3-δ, 4-δ 5(α-1, β-1, γ-ε, δ-ε, ε-1)

Θέμα Β!

B.1 Αρχικά $U = \frac{3}{2} n R T$

Τελικά $U' = \frac{3}{2} \frac{n}{2} R 4T = 2 \cdot \left(\frac{3}{2} n R T \right) = 2U \Rightarrow U' = 2U$

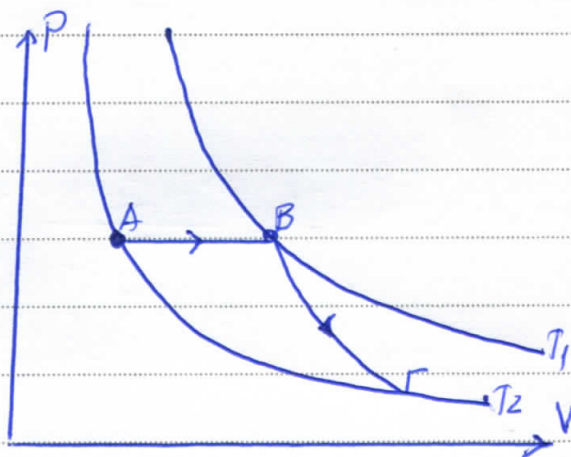
Άρα βλεπόμε το δ

B.2 $Q_{AB} = \Delta U_{AB} + W_{AB} \Rightarrow$

$\Rightarrow Q_{AB} + Q_{BF} = 0 + W_{ABF}$

$\xrightarrow{Q_{BF}=0} Q_{AB} = W_{ABF}$

$\Rightarrow \frac{Q_{AB}}{W_{ABF}} = 1$ ονεξολογητό
την αναδερη δ



Ανασώρο το (α)

Θεωρή!

$T_h = 400\text{ K}$

$T_c = 300\text{ K}$

$W_{\text{exp}} = 400\text{ J/kcal} \quad |Q_c| = 1600\text{ J/k}$

$f = 50\text{ Hz}$

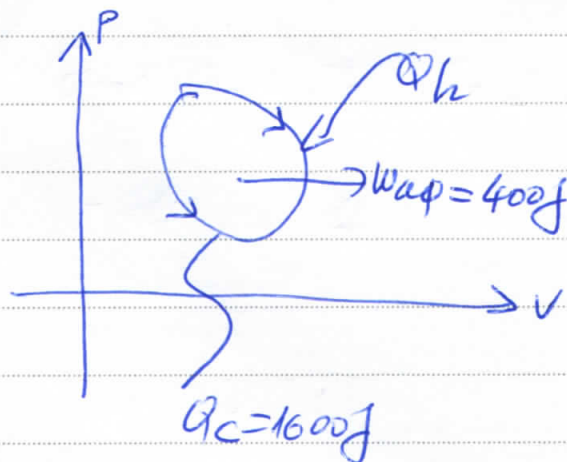
$\Gamma-1) \quad Q_2 = \Delta U_2 + W_{\text{exp}}$

$Q_h - |Q_c| = W_{\text{exp}}$

$Q_h = 2000\text{ J}$

$\epsilon = \frac{W_{\text{exp}}}{Q_h} = \frac{400\text{ J}}{2000\text{ J}}$

$\Rightarrow \epsilon = 0,2 \quad \text{ή} \quad \epsilon\% = 20\%$



$\Gamma-2) \quad P = \frac{W_{\text{exp}}}{T} = \frac{W_{\text{exp}}}{1/f} = W_{\text{exp}} \cdot f \Rightarrow P = 400 \frac{\text{J}}{\text{K}} \cdot 50\text{ Hz} \Rightarrow P = 2 \cdot 10^4\text{ W}$

$\Rightarrow P = 20 \cdot 10^3\text{ W} \Rightarrow P = 20\text{ kW}$

$\Gamma-3) \quad \frac{Q_h}{t} = \frac{Q_h(\text{Kcal})}{T_{\text{explos}} \cdot t} = \frac{Q_h(\text{Kcal})}{1/f} = Q_h \cdot f = 2000 \cdot 50 \Rightarrow \frac{Q_h}{t} = 10^5\text{ J/s}$

$\Gamma-4) \quad \frac{|Q_c|}{t} = \frac{|Q_c|(\text{Kcal})}{T_{\text{explos}} \cdot t} = \frac{|Q_c|(\text{Kcal})}{1/f} = |Q_c| \cdot f = 1600 \cdot 50 \Rightarrow \frac{|Q_c|}{t} = 8 \cdot 10^4\text{ J/s}$

$\Rightarrow |Q_c| = 8 \cdot 10^4\text{ J} \quad t = 3600\text{ s} \rightarrow |Q_c| = 288 \cdot 10^6\text{ J}$

$\Gamma-5) \quad \epsilon_{\text{max}} = \epsilon_{\text{Carnot}} = 1 - \frac{T_c}{T_h} = 1 - \frac{300}{400} = 0,25 \quad \Rightarrow \epsilon_{\text{max}}\% = 25\%$

... ΚΑΙ ΤΩΣ Carnot ...

Θέμα Δ!

A ($P_A = 3 \text{ atm}$, $V_A = 1 \text{ L}$, $T_A = T$) $\xrightarrow[\text{P=const}]{\text{Isochoric}}$ B ($P_B = 3 \text{ atm}$, $V_B = 3 \text{ L}$, $T_B = 3T$)

↑ Isochoric
Δ

↓ Isochoric
Γ

← Isochoric Γ ($P_\Gamma = 1 \text{ atm}$, $V_\Gamma = 3 \text{ L}$, $T_\Gamma = T$)

Δ-1) $W_{12} = (AB) \cdot B\Gamma \Rightarrow$
 $W_{12} = (3-1) \cdot 10^{-3} \text{ m}^3 \cdot (3-1) \cdot 10^5 \text{ N/m}^2$
 $\Rightarrow W_{12} = 400 \text{ J}$

Δ-2) $Q_{12} = \Delta U_{12} + W_{12}$
 $Q_{12} = 400 \text{ J}$

Δ-3) $Q_h = Q_{AB} + Q_{\Gamma A}$

$$Q_{AB} = \Delta U_{AB} + W_{AB} = \frac{3}{2} n R \Delta T + P \Delta V = \frac{3}{2} n P \Delta T + P(V_B - V_A)$$

$$= \frac{3}{2} P(V_B - V_A) + P(V_B - V_A) = \frac{5}{2} P(V_B - V_A) = \frac{5}{2} \cdot 3 \cdot 10^5 \cdot 2 \cdot 10^{-3}$$

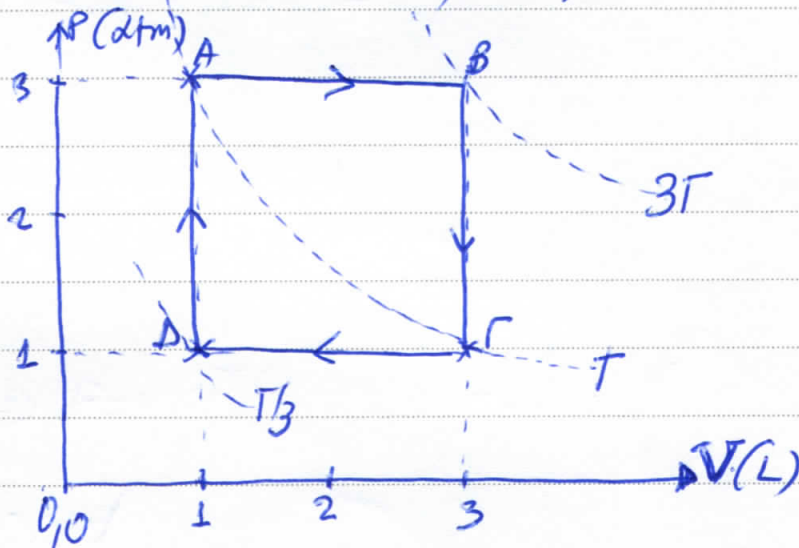
$\Rightarrow Q_{AB} = 1500 \text{ Jole}$

$$Q_{\Gamma A} = \Delta U_{\Gamma A} = \frac{3}{2} n R \Delta T = \frac{3}{2} \cdot P_A V - P_B V = \frac{3}{2} (P_A - P_B) V$$

$$= \frac{3}{2} \cdot 2 \cdot 10^5 \cdot 1 \cdot 10^{-3} = 300 \text{ J}$$

οπότε $Q_h = 1800 \text{ Jole}$

Δ-4) $e = \frac{W_{\text{net}}}{Q_h} = \frac{400}{1800} = \frac{2}{9}$ $\eta \text{ } e\% = \frac{200}{9} \%$



9ο κριτήριο αξιολόγησης. Θερμodynamική Θεωρία Πυλιν

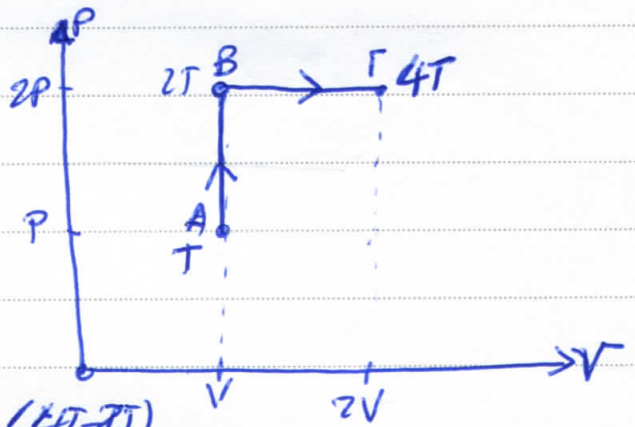
Θέματα Α:

1-δ, 2-δ, 3-β, 4-β, 5-γ

Θέματα Β:

B-1

$$\begin{aligned} Q_{AB} &= \Delta U_{AB} = \frac{3}{2} nR \Delta T \\ &= \frac{3}{2} nRT = 300 \text{ J} \\ \Rightarrow nRT &= 100 \text{ J} \quad (1) \end{aligned}$$

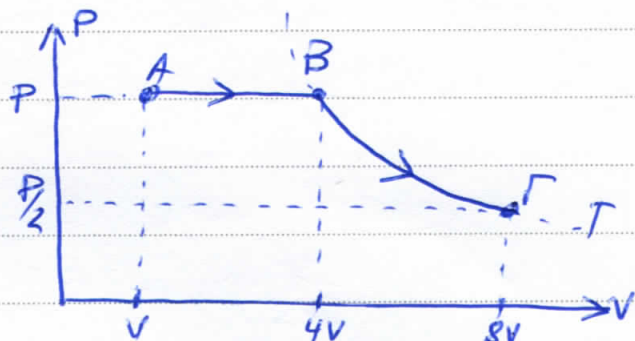


$$\begin{aligned} Q_{B\Gamma} &= \Delta U_{B\Gamma} + W_{B\Gamma} = \frac{3}{2} nR(4T - 2T) + nR(4T - 2T) \\ &= \frac{3}{2} nR \cdot 2T + 2nRT = 5nRT = 1000 \text{ J} \Rightarrow Q_{B\Gamma} = 1000 \text{ J} \end{aligned}$$

Άρα σωστή η (α)

B-2

$$\begin{aligned} W_{AB} &= P(4V - V) = 3PV = 720 \text{ J} \\ \Rightarrow PV &= 240 \text{ J} \end{aligned}$$



$$\begin{aligned} W_{B\Gamma} &= nRT \ln \frac{V_{\Gamma}}{V_B} \\ \Rightarrow W_{B\Gamma} &= P \cdot 4V \cdot \ln 2 = 4 \cdot 240 \cdot 0,7 \Rightarrow W_{B\Gamma} = 700 \text{ J} \end{aligned}$$

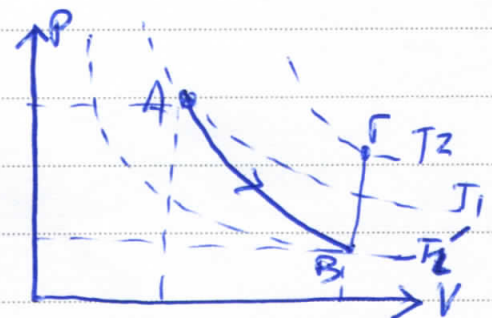
Άρα σωστή η (β)

B-3. $W_{AB} = Q_{B\Gamma}$

$$W_{AB} = \frac{P_B V_B - P_A V_A}{1 - \gamma} = \frac{nRT_2 - nRT_1}{1 - \gamma}$$

$$\begin{aligned} C_p - C_v &= R \\ \gamma C_v - C_v &= R \\ \gamma &= \frac{R}{C_v} \end{aligned}$$

$$Q_{B\Gamma} = n C_v \Delta T = n \frac{R}{\gamma - 1} (T_2 - T_1)$$



$$Q_{B\Gamma} = \frac{nR(T_2 - T_1)}{\gamma - 1}$$

$$W_{AB} = Q_{B\Gamma} \Rightarrow T_2 = T_1$$

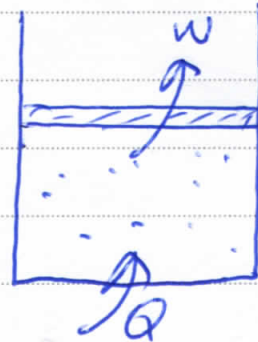
Άρα σωστή η (γ).

Θετα Γ!

$$n = 0,144 \text{ mol}$$

$$\delta = \frac{5}{3} \quad m = 5 \text{ kg}$$

$$\frac{Q}{t} = 1,5 \text{ J/s}$$



$$\Gamma.1 \quad \Sigma F_y = 0 \Rightarrow P \cdot A = P_{at} A + mg \Rightarrow P = P_{at} + \frac{mg}{A} = 10^5 + \frac{5 \cdot 10}{25 \cdot 10^{-4}}$$

$$\Rightarrow P = 1,2 \cdot 10^5 \text{ N/m}^2$$

$$\Gamma.2) \quad \frac{V}{T} = \text{const} = \frac{nR}{P} = \frac{0,144 \text{ mol} \cdot \frac{25 \text{ J}}{3 \text{ mol K}}}{1,2 \cdot 10^5 \text{ N/m}^2} \Rightarrow \frac{V}{T} = 1 \cdot 10^{-5} \text{ m}^3/\text{K} \Rightarrow \underline{V = 10^{-5} \text{ T (SI)}}$$

$\Gamma.3)$

$$\Delta Q = \Delta U + \Delta W = \frac{3}{2} nR \Delta T + P \Delta V = \frac{5}{2} P \Delta V = \frac{5}{2} P A \Delta Y$$

$$\Rightarrow \frac{\Delta Q}{\Delta t} = \frac{5}{2} P A \frac{\Delta Y}{\Delta t} = \frac{\Delta Q}{\Delta t} = \frac{5}{2} P A v \Rightarrow v = \frac{\frac{2}{5} \frac{\Delta Q}{\Delta t}}{P A}$$

$$\Rightarrow v = \frac{0,4 \cdot 1,5}{1,2 \cdot 10^5 \cdot 25 \cdot 10^{-4}} \Rightarrow v = 2 \cdot 10^{-3} \text{ m/s} \Rightarrow v = 2 \text{ mm/s}$$

$$\Gamma.4) \quad \frac{V}{T} = \text{const} \Rightarrow \frac{\Delta V}{\Delta T} = 10^{-5} \Rightarrow \frac{A \Delta Y}{\Delta T} = 10^{-5}$$

$$\Rightarrow \frac{A v \Delta t}{\Delta T} = 10^{-5} \Rightarrow \frac{25 \cdot 10^{-4} \cdot 2 \cdot 10^{-3} \Delta t}{\Delta T} = 10^{-5} \Rightarrow \frac{50 \cdot 10^{-7} \Delta t}{\Delta T} = 10^{-5}$$

$$+ 0,5 \frac{\Delta t}{\Delta T} = 1 \text{ K/s} \Rightarrow \Delta T = 0,5 \Delta t \text{ (SI)} \xrightarrow{\Delta t = 60 \text{ s}} \underline{\underline{\Delta T = 30 \text{ K}}}$$

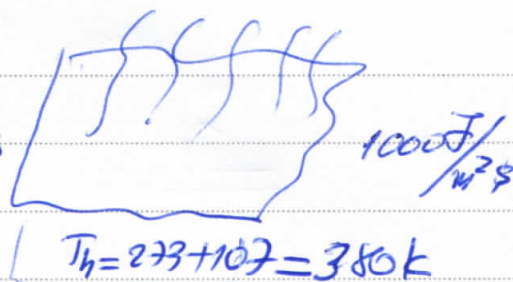
$$\ast \frac{Q}{\Delta t} = \frac{n C_p \Delta T}{\Delta t} = 1,5 \Rightarrow \frac{0,144 \cdot \frac{5}{2} R \Delta T}{\Delta t} = 1,5$$

$$\Rightarrow 0,144 \cdot \frac{5}{2} \frac{R}{\text{mol K}} \frac{\Delta T}{\Delta t} = 1,5 \Rightarrow \frac{\Delta T}{\Delta t} \cdot 3 = 1,5 \Rightarrow \frac{\Delta T}{\Delta t} = 0,5 \text{ (SI)}$$

ΘΕΜΑ Δ!

$$P_{\text{exp}} = 1 \text{ kW} = 10^3 \text{ W}$$

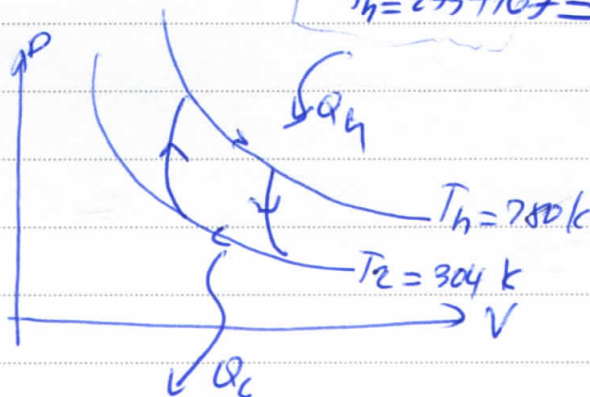
$$\frac{Q_h}{A \cdot t} = 1000 \frac{\text{J}}{\text{m}^2 \cdot \text{s}}$$



$$T_h = 273 + 107 = 380 \text{ K}$$

$$\Delta 1) \quad e = 1 - \frac{T_c}{T_h} = 1 - \frac{304}{380} = 0,2$$

$$e\% = 20\%$$



$$\Delta 2) \quad e = \frac{W_{\text{exp}}}{Q_h} \Rightarrow$$

$$e = \frac{P_{\text{exp}}}{\frac{Q_h}{t}} \Rightarrow \frac{Q_h}{t} = \frac{P_{\text{exp}}}{e} \Rightarrow \frac{Q_h}{t} = \frac{10^3 \text{ W}}{0,2} = 5 \cdot 10^3 \frac{\text{J}}{\text{s}}$$

$$\Rightarrow Q_h = 5 \cdot 10^3 \cdot t \quad (t = 1 \text{ min} = 60 \text{ s}) \quad Q_h = 300 \cdot 10^3 \text{ J} \Rightarrow \underline{\underline{Q_h = 3 \cdot 10^5 \text{ J}}}$$

$$\Delta 3) \quad \begin{array}{ll} 1 \text{ \$} & 1 \text{ m}^2 \\ 1 \text{ \$} & A = ? \end{array} \quad \begin{array}{l} \leadsto Q = 1000 \text{ J} \\ Q = 5 \cdot 10^3 \end{array}$$

$$\frac{1}{A} = \frac{1000}{5000} \Rightarrow \underline{\underline{A = 5 \text{ m}^2}}$$

$$\Delta 4) \quad 1 \text{ \$} \leadsto Q_h = 5 \cdot 10^3 \text{ J} \quad e = \frac{W_{\text{exp}}}{Q_h} = 0,2 = \frac{W_{\text{exp}}}{Q_h}$$

$$\Rightarrow W_{\text{exp}} = 0,2 \cdot 5 \cdot 10^3 \Rightarrow W_{\text{exp}} = 10^3 \text{ J}$$

$$1 \text{ \$} \leadsto Q_d = 4 \cdot 10^3 \text{ J}$$

$$1 \text{ T}$$

$$Q_d = 200 \text{ J}$$

$$\left. \begin{array}{l} Q_d = 4 \cdot 10^3 \text{ J} \\ Q_d = 200 \text{ J} \end{array} \right\} \frac{1}{T} = \frac{4 \cdot 10^3}{200} \Rightarrow T = \frac{200}{4 \cdot 10^3}$$

$$\Rightarrow T = 50 \cdot 10^{-3} \text{ s} \leadsto T = 5 \cdot 10^{-2} \text{ s} \leadsto f = \frac{1}{T} = \frac{1}{5 \cdot 10^{-2}} \leadsto \underline{\underline{f = 20 \text{ Hz}}}$$

10^ο κείμειο εξιστορήσεως

Θέμα Α: 1-δ, 2-δ, 3-δ, 4-δ, 5(α-1, β-1, γ-1, δ-ε, ε-ε)

Θέμα Β:

B.1
$$V' = V + \frac{25}{100} V = 1,25 V \Rightarrow \frac{3}{2} n R T_h = 1,25 \frac{3}{2} n R T_c \Rightarrow T_h = 1,25 T_c$$

$$e = 1 - \frac{T_c}{T_h} = 1 - \frac{T_c}{1,25 T_c} \Rightarrow e = 0,2 \text{ ή } e\% = 20\%$$

B.2
$$W_{FA} = P_0(V_0 - V_f) \Rightarrow$$

$$\Rightarrow -700 \text{ J} = P_0(V_0 - V_f)$$

$$\Rightarrow V_f = 8V_0$$

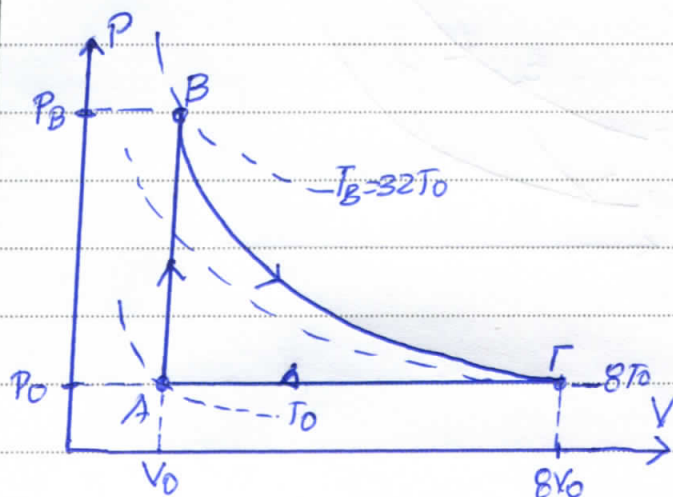
$$\frac{P_B}{T_B} = \frac{P_0}{T_0} \Rightarrow \frac{P_B}{32T_0} = \frac{P_0}{T_0} \Rightarrow P_B = 32P_0$$

$$P_B V_B = P_f V_f \Rightarrow 32P_0 V_0 = P_0(8V_0)^\gamma$$

$$\Rightarrow 32V_0 = 8^\gamma V_0^\gamma \Rightarrow 2^5 = 2^{3\gamma} \Rightarrow 5 = 3\gamma$$

$$\Rightarrow \gamma = \frac{5}{3}$$

Άρα σωστό το β



Θέμα Γ:

Γ.1.
$$\left. \begin{aligned} \frac{1}{\gamma} \frac{dV}{V} &= \frac{3}{2} \frac{nR dT}{T} \\ \frac{1}{\gamma} \frac{dV}{V} &= nR dT \end{aligned} \right\} \Rightarrow \frac{1}{\gamma} \frac{dV}{V} = \frac{2}{3} \Rightarrow \frac{1}{\gamma} = \frac{2}{3} \Rightarrow \gamma = \frac{3}{2}$$

$$\Rightarrow \frac{1}{\gamma} = \frac{2}{3} \Rightarrow \gamma = \frac{3}{2}$$

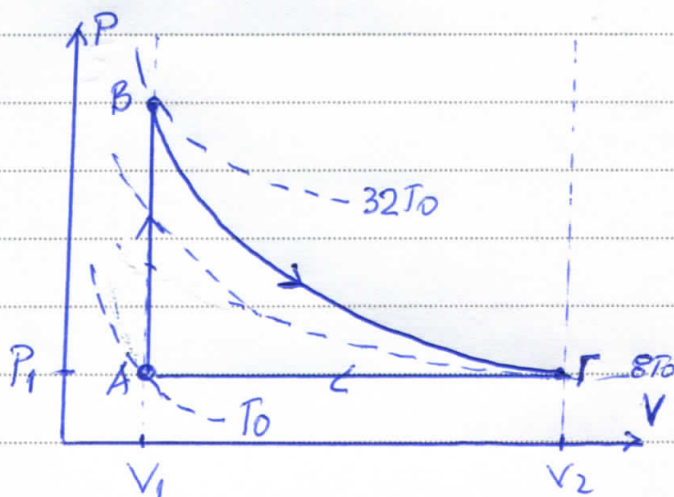
$$\text{ή } W_{FA} = -700 \text{ J}$$

$$W_{FA} = P_1(V_1 - V_2) \Rightarrow -700 = 10^5 (10^{-3} - V_2)$$

$$\Rightarrow V_2 = 8 \cdot 10^{-3} \text{ m}^3 \text{ ή } V_2 = 8 \text{ L}$$

$$P_B V_B^\gamma = P_f V_f^\gamma \Rightarrow P_B = P_f \frac{V_f^\gamma}{V_B^\gamma}$$

$$\Rightarrow P_B = 1 \text{ atm} \cdot \frac{(2^3)^{5/3}}{1^{5/3}} \Rightarrow P_B = 32 \text{ atm} \text{ ή } P_B = 32 \cdot 10^5 \text{ N/m}^2$$



Γ.2.
$$U_B = \frac{3}{2} n R T_B = \frac{3}{2} n R 32 T_0 = 48 n R T_0, U_f = \frac{3}{2} n R T_f = \frac{3}{2} n R 8 T_0 = 12 n R T_0$$

$$\Delta U_{BR} = U_F - U_B = -36nRT_0, \quad \eta\% = \frac{\Delta U_{BR}}{U_B} 100\% = \frac{-36nRT_0}{48nRT_0} 100\%$$

$$\Rightarrow \eta\% = -75\%$$

$$\Gamma.3 \quad W_{BR} = \frac{P_F V_F - P_B V_B}{1-\gamma} \Rightarrow W_{BR} = \frac{1 \cdot 10^5 \cdot 8 \cdot 10^{-3} - 32 \cdot 10^5 \cdot 1 \cdot 10^{-3}}{1-5/3} = \frac{800-3200}{-2/3} J$$

$$\Rightarrow W_{BR} = 3600 J, \quad W_{\Sigma} = W_{AB} + W_{BR} + W_{FA} = 3600 J - 700 J$$

$$\Rightarrow W_{\Sigma} = 2900 J$$

$$\Gamma.4. \quad Q_{AB} = \Delta U_{AB} = \frac{3}{2} n R \Delta T = \frac{3}{2} (n R T_B - n R T_A) = \frac{3}{2} (P_B - P_A) V_A \Rightarrow$$

$$Q_{AB} = \frac{3}{2} 31 \cdot 10^5 \cdot 10^{-3} \Rightarrow Q_{AB} = 4650 J \quad \text{και} \quad Q_h = 4650 J$$

$$e = \frac{W_{\Sigma}}{Q_h} = \frac{2900 J}{4650 J} \quad \text{και} \quad e = 0,6236 \quad \text{και} \quad e\% = 62,36\%$$

Θέμα Δ.

Δ.1 Αρχικά η γεωλογική είναι ισοβαρής

$$Q_1 = \Delta U + W = \frac{3}{2} n R \Delta T + p \Delta V = \frac{3}{2} n R \Delta T + n R \Delta T$$

$$\Rightarrow Q_1 = \frac{5}{2} n R \Delta T \stackrel{EF}{=} 550 = \frac{5}{2} n R \Delta T \Rightarrow n R \Delta T = 220 J$$

$$\Delta U_1 = \frac{3}{2} n R \Delta T = \frac{3}{2} \cdot 220 = 330 J \Rightarrow \Delta U_1 = 330 J$$

Δ.2 Η ατμόσφαιρα που υπάρχει η δοχική ισοβαρής

$$\text{γεωλογική εί'ται} \quad p = p_{at} + \frac{mg}{A} = 10^5 \frac{N}{m^2} + \frac{106 \cdot 10^{-4} \cdot 9,8}{10^{-2} m^2}$$

$$\Rightarrow p = 1,1 \cdot 10^5 N/m^2 \quad \text{και} \quad p = 1,1 \text{ atm}$$

$$Q_1 = \Delta U_1 + W_1 \Rightarrow W_1 = Q_1 - \Delta U_1 \Rightarrow W_1 = 220 J$$

$$W_1 = p \Delta V = p A \Delta y \Rightarrow \Delta y = \frac{W_1}{p A} = \frac{220 J}{1,1 \cdot 10^5 \cdot 10^{-2}} \Rightarrow \Delta y = 0,20 m$$

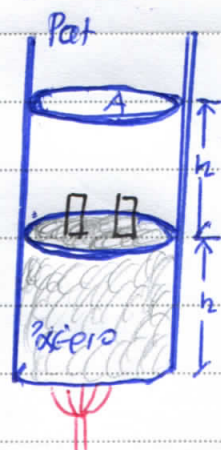
εφαρμόζοντας το θεώρημα του Γαλιλαίου

$$v = \frac{\Delta y}{\Delta t} \Rightarrow v = \frac{0,20 m}{1000 s} \Rightarrow v = 2 \cdot 10^{-4} m/s$$

Δ.3 Στο τέλος της ισοβαρούς γεωλογικής η θερμοκρασία είναι T_1
και ο όγκος $V_1 = A z h$ στο έμφυτο όγκο $T_0, V_0 = A h$

$$\frac{V_1}{T_1} = \frac{V_0}{T_0} \Rightarrow \frac{A z h}{T_1} = \frac{A h}{T_0} \Rightarrow T_1 = z T_0$$

$$Q_1 = \frac{5}{2} n R \Delta T = \frac{5}{2} n R (T_1 - T_0) = \frac{5}{2} n R (z T_0 - T_0) \Rightarrow Q_1 = \frac{5}{2} n R T_0 \Rightarrow n R T_0 = 220 J$$



Στην διαδικασία που γίνεται από T_1 έως $T_2 = 1,2T_1$ η προσφερόμενη θερμότητα είναι $Q_2 = \frac{3}{2} nR \Delta T = \frac{3}{2} nR (T_2 - T_1) \Rightarrow Q_2 = \frac{3}{2} nR 0,2T_1$
 $\Rightarrow Q_2 = \frac{3}{2} nR 0,2 \cdot 2T_0 \Rightarrow Q_2 = 0,6 nR T_0 \Rightarrow Q_2 = 0,6 \cdot 220J \Rightarrow Q_2 = 132J$

Δ.4 Η προσφερόμενη θερμότητα $\frac{\Delta Q_2}{\Delta t}$ στην διαδικασία γίνεται $\frac{\Delta Q_1}{\Delta t} = \frac{550J}{1000s} = 0,55 J/s$

Άρα $\frac{\Delta Q_2}{\Delta t} = 0,55 J/s \Rightarrow \frac{132J}{\Delta t} = 0,55 J/s \Rightarrow \Delta t = 240s$ ή $\Delta t = 4min$

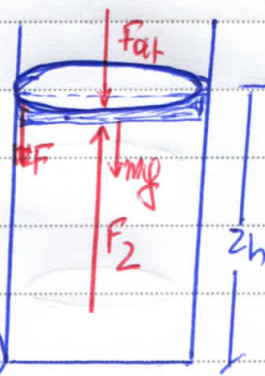
Δ.5 Όταν ξεκινάει ο διατεταρισμός η πίεση των αερίων είναι

$P_2 : \frac{T_2}{T_1} = \frac{P_2}{P_1} \Rightarrow P_2 = P_1 \cdot \frac{T_2}{T_1} = P_1 \cdot \frac{1,2T_1}{T_1} \Rightarrow P_2 = 1,2P_1 = 1,2 \cdot 1,1 \cdot 10^5 N/m^2$

$\Rightarrow P_2 = 1,32 \cdot 10^5 N/m^2$

Οι δυνάμεις που ασκούνται στο ανώτερο < δακτύλιο - έμβολο > είναι

- η δύναμη από το αέριο F
- το βάρος του εμβόλου mg (δραστηριοποιείται)
- η δύναμη της ατμόσφαιρας F_{at}
- η δύναμη $F_{αδ}$ το κυλινδρικό δοχείο στην διατεταρισμένη κατάσταση.



Στην οριζόντια κατάσταση ισχύει $\sum F_y = 0 \Rightarrow$

$F_2 = F_{at} + mg + F \Rightarrow P_2 A = P_1 A + mg + F \Rightarrow F = (P_2 - P_1) A - mg$
 $\Rightarrow F = (1,32 - 1) \cdot 10^5 \cdot 10^{-2} - 10 \cdot 10 \Rightarrow F = 220N$

11^ο περίπτωση αξιοθώμευς

Θέμα Α

1-α, 2-β, 3-β, 4-δ 5(α-1, β-ε, γ-1, δ-ε, ε-ε)

$$\text{... η } 5-\delta: \left. \begin{aligned} U &= \frac{3}{2} n R T = \frac{3}{2} \frac{m_0}{M_r} R T \\ U_{\text{ext}}^2 &= \frac{3 E T}{M_r} \end{aligned} \right\} \Rightarrow U = \frac{1}{2} m_0 v_{\text{ext}}^2$$

... η 5-ε:

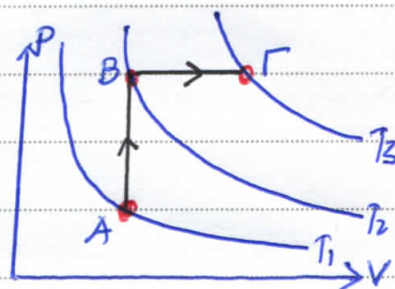
$$W_{\text{ολ}} = W_{AB} + W_{BF} = 0 + W_{BF} = W_{BF} \Rightarrow W_{\text{ολ}} = W_{BF} \quad (1)$$

$$Q_{AB} = \Delta U_{AB} + W_{AB} = \frac{3}{2} n R (T_2 - T_1) \Rightarrow Q_1 = \frac{3}{2} n R \Delta T_1 \quad (2)$$

$$Q_{BF} = \Delta U_{BF} + W_{BF} \Rightarrow Q_2 = \frac{3}{2} n R (T_3 - T_2) + W_{BF}$$

$$\Rightarrow Q_2 = \frac{3}{2} n R \Delta T_2 + W_{BF} \xrightarrow{\Delta T_2 = \Delta T_1} Q_2 = \frac{3}{2} n R \Delta T_1 + W_{BF} \xrightarrow{1,2}$$

$$\Rightarrow Q_2 = Q_1 + W_{\text{ολ}} \Rightarrow W_{\text{ολ}} = Q_2 - Q_1$$



Θέμα Β

B.1 Θερετική μηχανή Α

$$T_h = 500 \text{ K}, T_c = 400 \text{ K}, \quad Q_h - |Q_c| = W \Rightarrow Q_h = |Q_c| + W \Rightarrow \\ \Rightarrow Q_h = 600 \text{ J} + 300 \text{ J} \Rightarrow Q_h = 900 \text{ J}$$

$$\frac{Q_h}{|Q_c|} = \frac{900}{600} = \frac{3}{2} = 1,50$$

$$\frac{T_h}{T_c} = \frac{500}{400} = 1,25$$

$$\left. \begin{aligned} \frac{Q_h}{|Q_c|} &= 1,50 \\ \frac{T_h}{T_c} &= 1,25 \end{aligned} \right\} \Rightarrow \frac{Q_h}{|Q_c|} \neq \frac{T_h}{T_c} \quad \text{Άρα η θερετική μηχανή Α} \\ \text{δεν είναι μηχανή Carnot}$$

Θερετική μηχανή Β

$$T_h = 450 \text{ K}, T_c = 300 \text{ K}, \quad Q_h - |Q_c| = W \Rightarrow 600 - |Q_c| = 200 \text{ J} \Rightarrow |Q_c| = 400 \text{ J}$$

$$\frac{Q_h}{|Q_c|} = \frac{600}{400} = \frac{3}{2} = 1,50$$

$$\frac{T_h}{T_c} = \frac{450}{300} = \frac{3}{2}$$

$$\left. \begin{aligned} \frac{Q_h}{|Q_c|} &= 1,50 \\ \frac{T_h}{T_c} &= 1,50 \end{aligned} \right\} \Rightarrow \frac{Q_h}{|Q_c|} = \frac{T_h}{T_c} \quad \text{Άρα η θερετική μηχανή Β} \\ \text{είναι μηχανή Carnot}$$

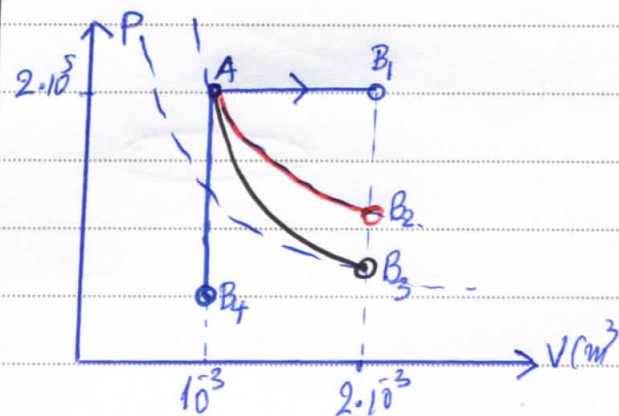
Σωστό 20 (Β)

B. 2

$$A(2 \cdot 10^5 \text{ N/m}^2, 10^{-3} \text{ m}^3) \rightarrow B(\dots 2 \cdot 10^{-3} \text{ m}^3) \quad W_{\text{αερίν}} = 115 \text{ J}$$

- Αν η γεωμετρία ήταν τριγωνική το ζήτημα θα ήταν $W_1 = p(V_B - V_A) = 2 \cdot 10^5 \text{ N/m}^2 \cdot (2 \cdot 10^{-3} - 1 \cdot 10^{-3}) \text{ m}^3 \Rightarrow W_1 = 200 \text{ J}$
Επειδή $W_1 < W_{\text{αερίν}}$ η γεωμετρία είναι αδύναμη
 - Αν ήταν τετακτομένη $W_2 = 0 \neq W_{\text{αερίν}} = 115 \text{ J}$ άρα είναι αδύναμη
 - Αν ήταν υδρόστατη $W_3 = nRT \ln \frac{V_B}{V_A} = p_A V_A \ln \frac{V_B}{V_A} = 2 \cdot 10^5 \cdot 10^{-3} \ln 2$
 $\Rightarrow W_3 = 200 \cdot 0,7 = 140 \text{ J} \neq 115 \text{ J} \dots$ άρα είναι αδύναμη
- Άρα ενώ τις δεδομένες γεωμετρίες μπορεί να είναι μόνο αδιαβατική. **Σωστό το Α)**

Σχόλιο: Δίνεται ότι $W_{\text{αε}} = 115 \text{ J}$
και είδαμε ότι μπορεί να είναι αδιαβατική ... και πάλι πάλι είναι ευκολότερο να είναι $p-V$



Θέμα Γ.

Γ.1 $Q_{AB} = \frac{3}{2} nRT = \Delta U_{AB} \Rightarrow 450 = \frac{3}{2} nR(4T_0 - T_0)$

$\Rightarrow nRT_0 = 100 \text{ J} \quad (1)$

$Q_{BG} = W_{BG} = nR4T_0 \ln \frac{4V_0}{V_0} = 4nRT_0 \ln 4$

$\Rightarrow Q_{BG} = 8nRT_0 \ln 2 \xrightarrow{(1)} Q_{BG} = 8 \cdot 100 \cdot 0,7$

$\Rightarrow Q_{BG} = 560 \text{ J}$

$Q_h = Q_{AB} + Q_{BG} = 450 \text{ J} + 560 \text{ J}$

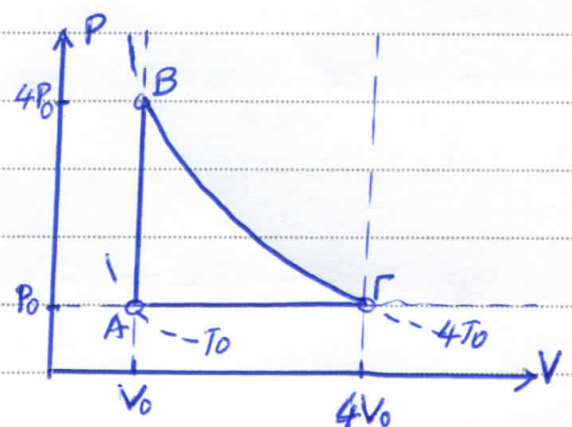
$\Rightarrow Q_h = 1010 \text{ J}$

Γ.2 $W_{\text{αφ}} = W_{AB} + W_{BG} + W_{GA} = 0 + W_{BG} + W_{GA}$

$W_{BG} = Q_{BG} = 560 \text{ J}$

$W_{GA} = p_0(V_0 - 4V_0) = -3p_0V_0 = -3nRT_0 = -300 \text{ J}$

$\Rightarrow W_{\text{αφ}} = 260 \text{ J}$



Γ.3 $e = \frac{W_{\text{usef}}}{Q_h} = \frac{260\text{J}}{1010\text{J}} \Rightarrow e = 0,2574 \text{ ή } e\% = 25,74\%$

Γ.4 $P_{\text{usef}} = \frac{W_{\text{usef}}}{T} = W_{\text{usef}} \cdot f = 260\text{J} \cdot 10\text{Hz} = 2600\text{W} \Rightarrow P_{\text{usef}} = 2600\text{W}$

Γ.5 $e_{\text{max}} = 1 - \frac{T_c}{T_h} = 1 - \frac{T_0}{4T_0} = 0,75 \Rightarrow e_{\text{max}} = 0,75 \text{ ή } e_{\text{max}}\% = 75\%$

Θέζα Δ.

Δ-1. ... η ποσότητα Q_c περιέχει την ενέργεια ...

1kg πέτρα κινείται με $3 \cdot 10^5\text{J}$
 50kg $|Q_c| = ? \Rightarrow$

$\frac{1}{50} = \frac{3 \cdot 10^5}{|Q_c|} \Rightarrow |Q_c| = 150 \cdot 10^5\text{J} \dots \text{nov}$

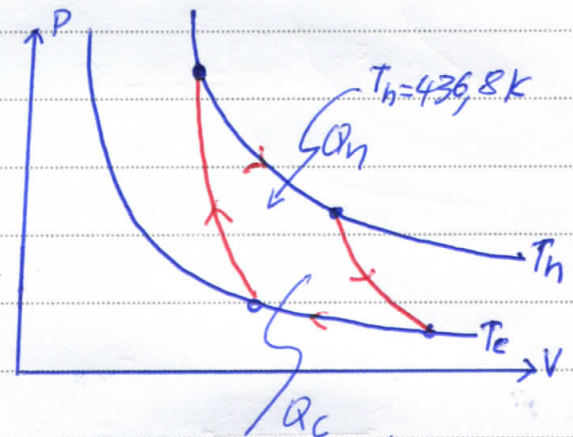
αποβλήθηκαν σε $\Delta t = 10\text{min}$

$\frac{Q_h}{|Q_c|} = \frac{T_h}{T_c} \Rightarrow \frac{Q_h}{|Q_c|} = \frac{436,8}{273} = 1,6$

$\Rightarrow Q_h = 1,6|Q_c|$ και για χρόνο $\Delta t = 10\text{min}$ $Q_h = 1,6 \cdot 150 \cdot 10^5\text{J} \Rightarrow Q_h = 240 \cdot 10^5\text{J}$

... και η προσφερόμενη θερμότητα γίνεται $4 \cdot 10^4\text{J/s}$

$\frac{Q_h}{t} = \frac{240 \cdot 10^5\text{J}}{10 \cdot 60\text{s}} = 4 \cdot 10^4\text{J/s} \Rightarrow \frac{Q_h}{t} = 4 \cdot 10^4\text{J/s}$



Δ-2 Ο ένας κύκλος της μηχανής Carnot έχει περίοδο $T = \frac{1}{f} = \frac{1}{10} = 0,1\text{s}$

στο ένα ώραρο προσφέρεται θερμότητα $\frac{Q_h}{t} = 4 \cdot 10^4\text{J/s} \Rightarrow$

$Q_h = 4 \cdot 10^4 \cdot T = 4 \cdot 10^4 \cdot 0,1 \Rightarrow Q_h = 4000\text{J/cycle}$

$\frac{Q_h}{|Q_c|} = \frac{T_h}{T_c} \Rightarrow \frac{Q_h}{|Q_c|} = \frac{436,8}{273} = 1,6 \Rightarrow \frac{4000}{|Q_c|} = 1,6 \Rightarrow |Q_c| = 2500\text{J/cycle}$

$W_{\text{usef, κύκλος}} = Q_h - |Q_c| \Rightarrow W_{\text{usef, κύκλος}} = 1500\text{J/cycle}$

Δ-3 $e = \frac{W_{\text{usef}}}{Q_h} = \frac{1500\text{J}}{4000\text{J}} \Rightarrow e = 0,375 \text{ ή } e\% = 37,5\%$

Δ-4. $P = \frac{W_{\text{usef}}}{t} \Rightarrow P = \frac{W_{\text{usef}}(\text{κύκλος})}{T} = \frac{1500\text{J}}{0,1\text{s}} \Rightarrow P_{\text{usef}} = 15000\text{W} \text{ ή } P_{\text{usef}} = 15\text{kW}$