

"مسائل فصل 1"

7) $R = 1.5 \text{ m}$ $\omega = 2000 \frac{\text{rev}}{\text{min}}$ $v = 480 \frac{\text{km}}{\text{h}} = 133.33 \frac{\text{m}}{\text{s}}$

ا) $v_0 = R\omega = 1.5 \times 2000 \times \frac{2 \times 3.14}{60} = 314 \frac{\text{m}}{\text{s}}$

ب) $v = \sqrt{v_0^2 + v_0^2} = \sqrt{(133.33)^2 + (314)^2} = 341 \frac{\text{m}}{\text{s}}$

8) $\theta = t^3 - 2t^2 + 1$ $\omega = \frac{d\theta}{dt} = 3t^2 - 4t$ $\alpha = \frac{d\omega}{dt} = 6t - 4$

ا) $\bar{\omega} = \frac{\theta_6 - \theta_4}{2} = \frac{145 - 33}{2} = 56 \frac{\text{rad}}{\text{s}}$ $\bar{\alpha} = \frac{\omega_6 - \omega_4}{2} = \frac{84 - 32}{2} = 26 \frac{\text{rad}}{\text{s}^2}$

ب) $v = R\omega_3 = 0.1 \times 15 = 1.5 \frac{\text{m}}{\text{s}}$

ج) $a = \sqrt{a_t^2 + a_r^2} = \sqrt{(r\alpha_3)^2 + (r\omega_3^2)^2} = \sqrt{1.96 + 506.25} = 22.54 \frac{\text{m}}{\text{s}^2}$

12) $t = 4 \text{ s}$ $\omega_0 = 500 \frac{\text{rev}}{\text{min}} = \frac{500}{60} \frac{\text{rev}}{\text{s}} = 8.3 \frac{\text{rev}}{\text{s}}$ $\omega = 300 \frac{\text{rev}}{\text{min}} = 5 \frac{\text{rev}}{\text{s}}$

ا) $\alpha = \frac{\Delta\omega}{\Delta t} = \frac{5 - 8.3}{4} = -0.8 \frac{\text{rev}}{\text{s}^2}$

$\omega^2 - \omega_0^2 = 2\alpha\Delta\theta$ $\Delta\theta = \frac{25 - (8.3)^2}{2 \times (-0.8)} = 27.43 \text{ rev}$

ب) $\omega_0 = 5 \frac{\text{rev}}{\text{s}}$ $\omega = 0$ $t = ?$ $t = \frac{\omega - \omega_0}{\alpha} = \frac{0 - 5}{-0.8} = 6 \text{ s}$

15) $\omega_0 = 0$ $\omega = 10 \frac{\text{rev}}{\text{s}}$ $\theta = 60 \text{ rev}$ $\omega = 15 \frac{\text{rev}}{\text{s}}$ $0 \rightarrow 10 \frac{\text{rev}}{\text{s}} \xrightarrow{60 \text{ rev}} 15 \frac{\text{rev}}{\text{s}}$

ا) $\alpha = ?$ $\omega^2 - \omega_0^2 = 2\alpha\Delta\theta$ $\alpha = \frac{(15)^2 - (10)^2}{2 \times 60} = \frac{125}{120} = 1.04 \frac{\text{rev}}{\text{s}^2}$

ب) $t_2 = ?$ $\omega = \alpha t + \omega_0$ $15 = 1.04 t + 10 \Rightarrow t = \frac{5}{1.04} = 4.81 \text{ s}$

ج) $t_1 = ?$ $\omega = \alpha t + \omega_0$ $10 = 1.04 t + 0 \Rightarrow t = \frac{10}{1.04} = 9.6 \text{ s}$

د) $\theta = ?$ $\omega^2 - \omega_0^2 = 2\alpha\Delta\theta$ $100 - 0 = 2 \times 1.04 \Delta\theta \Rightarrow \Delta\theta = \frac{100}{2.08} = 48.07 \text{ rev}$

20) $R = 1 \text{ m}$ $\omega = 100 \frac{\text{rev}}{\text{min}} = 10.47 \frac{\text{rad}}{\text{s}}$ ا) $v = ?$ ب) $\alpha = 2 \frac{\text{rad}}{\text{s}^2}$ $t = 180 \text{ s}$ $\omega = ?$ ج) $n = ?$

ا) $v = R\omega = 1 \times 10.47 = 10.47 \frac{\text{m}}{\text{s}}$

ب) $\omega = \alpha t + \omega_0$ $\omega = 2 \times 180 + 10.47 = 370.47 \frac{\text{rad}}{\text{s}}$

ج) $n = \frac{\Delta\theta}{2\pi}$ $\omega^2 - \omega_0^2 = 2\alpha\Delta\theta$ $(370.47)^2 - (10.47)^2 = 4\Delta\theta \Rightarrow \Delta\theta = 34284.6 \text{ rad}$

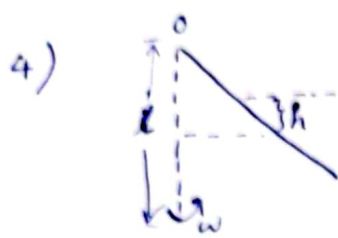
$n = \frac{34284.6}{2 \times 3.14} = 5459.3 \text{ rev}$

د) $a_t = r\alpha = 1 \times 2 = 2$ $a_r = r\omega^2 = 1 \times (370.47)^2 = 137248$ $a = \sqrt{a_t^2 + a_r^2} = 137248 \frac{\text{m}}{\text{s}^2}$
 $a_t = 0.5 \times 2 = 1$ $a_r = r\omega^2 = 0.5 \times (370.47)^2 = 68624$ $a = \sqrt{a_t^2 + a_r^2} = 68624 \frac{\text{m}}{\text{s}^2}$

25) $\alpha = 2.5 \text{ rad/s}^2$ $t = 5 \text{ s}$ $\Delta\theta = 80 \text{ rad}$ ا) $\omega = ?$ ب) $\theta_{10} - \theta_5 = ?$

ا) $\Delta\theta = \frac{1}{2} \alpha t^2 + \omega_0 t$ $80 = \frac{2.5}{2} \times 25 + 5\omega_0 \Rightarrow \omega_0 = 2.75 \text{ rad/s}$

ب) $\theta_{10} = \frac{2.5}{2} \times 100 + 10 \times 2.75 = 222.5 \text{ rad}$ $\theta_{10} - \theta_5 = 222.5 - 80 = 142.5 \text{ rad}$



"9 جيل جيل"

$$I_0 = \frac{1}{3} m l^2$$

$$mgh = \frac{1}{2} I_0 \omega^2$$

$$mgh = \frac{1}{2} \left(\frac{1}{3} m l^2 \right) \omega^2 \Rightarrow h = \frac{l^2 \omega^2}{6g}$$

5) $r = 30 \text{ cm} = 0.3 \text{ m}$ $F = 50 \text{ N}$ $I = 4 \text{ kg m}^2$ $\alpha = ?$

$\tau = r F \sin\theta = I \alpha \Rightarrow \alpha = \frac{r F}{I} = \frac{0.3 \times 50}{4} = 3.75 \text{ rad/s}^2$

7) $R = 20 \text{ cm}$ $m = 5 \text{ kg}$ $\omega = 1200 \frac{\text{rev}}{\text{min}} = \frac{1200 \times 2\pi}{60} = 125.6 \text{ rad/s}$

$F = 160 \text{ N}$ $t = 10 \text{ s}$ $\mu_k = ?$

$\omega = \alpha t + \omega_0$ $0 = 10 \alpha + 125.6 \Rightarrow \alpha = -12.56 \text{ rad/s}^2$

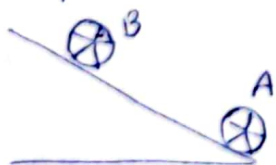
$\tau = I \alpha$ $RF - Rf_k = I \alpha$, $I_{\text{center of mass}} = \frac{1}{2} MR^2 \Rightarrow$

$R(F - f_k) = \frac{1}{2} MR^2 \alpha$ $160 - f_k = \frac{5}{2} \times 0.2 \times (-12.56) \Rightarrow f_k = 166.28 \text{ N}$

$f_k = \mu_k N = \mu_k mg \Rightarrow \mu_k = \frac{f_k}{mg} = \frac{166.28}{50} = 3.33$

9) $m = 40 \text{ kg}$ $R = 60 \text{ cm} = 0.6 \text{ m}$ $I = 0.8 \text{ m R}^2$ $\omega_0 = 50 \text{ rad/s}$

$\omega_f = 3000 \text{ J}$ $\omega = 0$ $h = ?$



A: $E_A = \frac{1}{2} m \omega_0^2 R^2 + \frac{1}{2} I_{cm} \omega_0^2$

B: $E_B = mgh$

$E_B - E_A = \omega_f$

$mgh - \frac{1}{2} m \omega_0^2 R^2 - \frac{1}{2} I_{cm} \omega_0^2 = \omega_f \Rightarrow 400h - \underbrace{20(50)^2(0.6)^2}_{18000} - \underbrace{0.4 \text{ m R}^2 (50)^2}_{14400} = 3000$

$\Rightarrow 400h - 32400 = 3000 \Rightarrow h = 73.5 \text{ m}$

11) $I = 68 \text{ kg m}^2$ $m = 30 \text{ kg}$ $\tau = 600 \text{ N.m}$ $\omega_0 = 0$

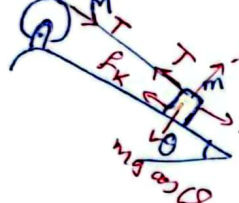
ا) $\alpha = \frac{\tau}{I} = \frac{600}{68} = 8.82 \text{ rad/s}^2$

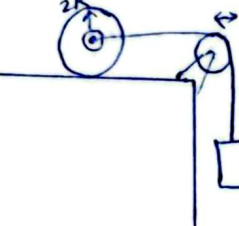
ب) $\omega^2 - \omega_0^2 = 2\alpha\Delta\theta$ $\omega^2 - 0 = 2 \times 8.82 \times 6 \times 2\pi \Rightarrow \omega = 25.78 \text{ rad/s}$

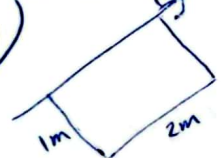
$\omega = \tau \Delta\theta = 600 \times 6 \times 2 \times 3.14 = 22608 \text{ J}$ $t = \frac{\omega}{\alpha} = 2.9$

$P = \frac{W}{t} = \frac{22608}{2.9} = 7795 \text{ watt}$

ج) $P = \tau \omega = 600 \times 25.78 = 15468 \text{ watt}$

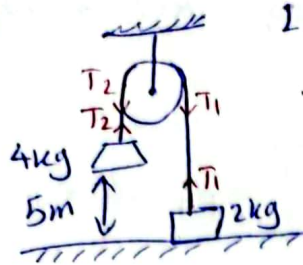
15)  $m = 8 \text{ kg}$ $\theta = 37^\circ$ $\mu_k = 0.25$ $M = 20 \text{ kg}$ $R = 20 \text{ cm} = 0.2 \text{ m}$
 $I = 0.4 \text{ kg m}^2$ $\alpha = ?$ $T = ?$
 ان) $\sum F_x = ma$ $mg \sin \theta - f_k - T = ma$
 $\sum F_y = 0$ $N = mg \cos \theta$
 $f_k = \mu_k N$
 $mg \sin \theta - \mu_k mg \cos \theta = ma + \frac{Ia}{R^2} = a(m + \frac{I}{R^2}) \Rightarrow a = \frac{80(0.6 - 0.25 \times 0.8)}{8 + 0.4/(0.2)^2} = 1.8 \text{ m/s}^2$
 ب) $\tau = I\alpha$ $TR = I\alpha \Rightarrow T = \frac{Ia}{R^2} = \frac{0.4 \times 1.8}{(0.2)^2} \Rightarrow T = 18 \text{ N}$

18)  $\begin{cases} \text{حسم: } mg - T_1 = ma \\ \text{قرقره: } T_1 R - T_2 R = I\alpha \\ \text{استوانه تیر: } T_2 R = I\alpha \end{cases} \Rightarrow \begin{cases} mg - T_1 = ma \\ R(T_1 - T_2) = \frac{1}{2} m R^2 \frac{a}{R} \\ T_2 R = \frac{1}{2} m R^2 \frac{a}{2R} \end{cases}$
 $\begin{cases} mg - T_1 = ma \quad (1) \\ T_1 - T_2 = \frac{1}{2} ma \quad (2) \\ T_2 = \frac{1}{4} ma \quad (3) \end{cases}$
 $(2), (3) \Rightarrow T_1 = \frac{1}{2} ma + \frac{1}{4} ma = \frac{3}{4} ma \quad (4)$
 $(1), (4) \Rightarrow mg - \frac{3}{4} ma = ma \Rightarrow a = \frac{40}{7} = 5.7 \text{ m/s}^2$

19)  $m = 40 \text{ kg}$ $t = 8 \times 10^{-3} \text{ s}$ $F = 2000 \text{ N}$ $\omega = ?$
 $\tau \Delta t = \Delta L = I\omega$
 $\frac{a}{2} F \Delta t = I\omega$
 $F \Delta t = 2000 \times 8 \times 10^{-3} = 16$
 $I = \frac{1}{3} m a^2 = \frac{1}{3} \times 40 \times 1^2 = \frac{40}{3}$
 $\Rightarrow \frac{1}{2} \times 16 = \frac{40}{3} \omega \Rightarrow \omega = \frac{8 \times 3}{40} = 0.6 \text{ rad/s}$

24) $M = 120 \text{ kg}$ $R = 2 \text{ m}$ $\omega_0 = 3 \text{ rad/s}$ $m = 100 \text{ kg}$ ان) $\omega = ?$ ب) $K_i = ?$ $K_f = ?$
 ان) $\tau_{ext} = 0$ $L_i = L_f$ $I_0 \omega_0 = I \omega = (I_0 + mR^2) \omega \Rightarrow \omega = \frac{I_0}{I_0 + mR^2} \omega_0$
 $I_0 = \frac{1}{2} MR^2 = \frac{1}{2} \times 120 \times 4 = 240 \text{ kg m}^2$
 $\omega = \frac{240}{240 + 100 \times 4} \times 3 = 1.125 \text{ rad/s}$
 ب) $K_i = \frac{1}{2} I_0 \omega_0^2 = \frac{1}{2} \times 240 \times 9 = 1080 \text{ J}$
 $K_f = \frac{1}{2} I \omega^2 = \frac{1}{2} (240 + 100 \times 4) (1.125)^2 = 405 \text{ J}$
 $K_f - K_i = 405 - 1080 = -675 \text{ J}$
 انرژی جنبشی دستگاه با سرعتی کمتر.

26)



$$I = 0.4 \text{ kg m}^2 \quad R = 0.2 \text{ m} \quad v = ?$$

$$\begin{aligned} 4\text{kg} \text{ for } : & \begin{cases} m_2 g - T_2 = m_2 a \\ T_1 - m_1 g = m_1 a \end{cases} \Rightarrow \begin{cases} 40 - T_2 = 4a \\ T_1 - 20 = 2a \end{cases} \end{aligned}$$

$$\begin{aligned} T_1 - T_2 &= 6a - 20 \\ T_2 - T_1 &= 20 - 6a \quad (1) \end{aligned}$$

$$\tau = I \alpha \quad T_2 R - T_1 R = I \frac{a}{R} \Rightarrow T_2 - T_1 = \frac{I a}{R^2} \quad (2)$$

$$(1), (2) \Rightarrow 20 - 6a = \frac{0.4 a}{(0.2)^2} \Rightarrow 10a = 20 - 6a \Rightarrow 20 = 16a \Rightarrow a = 1.25 \text{ m/s}^2$$

$$v^2 - v_0^2 = 2 a \Delta x \quad v^2 - 0 = 2 \times 1.25 \times 5 = 12.5 \Rightarrow v = 3.54 \text{ m/s}$$

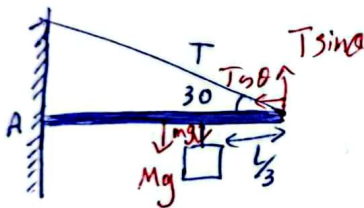
$$32) \quad m = 40 \text{ kg} \quad R = 0.6 \text{ m} \quad I = 0.8 \text{ m R}^2 \quad \omega_i = 50 \text{ rad/s} \quad \omega_f = 3000 \text{ J}$$

$$\text{باستفاده از انرژی} \quad E_1 + \omega_f = E_2 \quad E_1 = \frac{1}{2} I \omega_i^2 \quad E_2 = mgh$$

$$\frac{1}{2} 0.8 \times 40 (0.6)^2 (50)^2 - 3000 = 400h \Rightarrow h = 28.5 \text{ m}$$

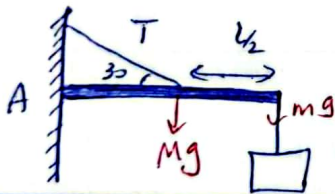
"مسائل فصل 10"

2)



$$\sum \tau_A = 0 \quad Mg \frac{L}{2} + mg \frac{2L}{3} - T \sin \theta L = 0$$

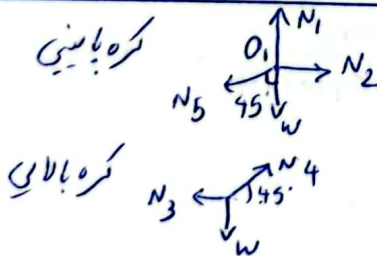
$$100 + 66.7 - \frac{T}{2} = 0 \Rightarrow T = 333.4 \text{ N}$$



$$\sum \tau_A = 0 \quad Mg \frac{L}{2} + mg L - T \sin 30 \frac{L}{2} = 0$$

$$100 + 100 - \frac{T}{4} = 0 \Rightarrow T = 800 \text{ N}$$

5)



$$N_2 = N_5 \sin 45^\circ = \frac{\sqrt{2}}{2} N_5 \quad (1)$$

$$N_1 = N_5 \cos 45^\circ + W = \frac{\sqrt{2}}{2} N_5 + W \quad (2)$$

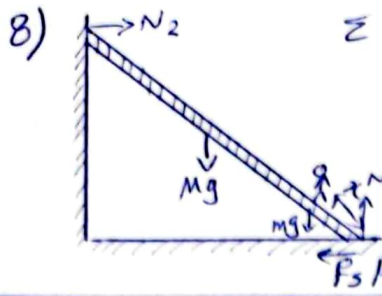
$$N_3 = N_4 \cos 45^\circ = \frac{\sqrt{2}}{2} N_4 \quad (3)$$

$$W = N_4 \sin 45^\circ = \frac{\sqrt{2}}{2} N_4 \quad (4)$$

$$b) \quad N_4 = N_5 \Rightarrow (4) : N_4 = N_5 = \sqrt{2} W$$

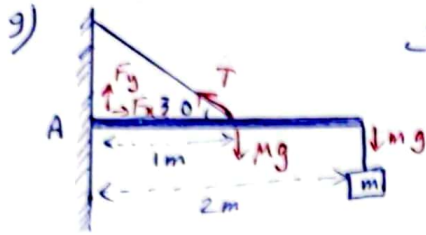
$$N_1 = 2W, \quad N_2 = W, \quad N_3 = W$$

جابشانی N_4 و N_5 در 1 و 2، 3 بار هم

8)  $\sum \tau_A = 0 \quad mgx \cos 60 + Mg \frac{L}{2} \cos 60 - N_2 L \sin 60 = 0 \quad (1)$

$$\begin{cases} \sum F_x = 0 \\ \sum F_y = 0 \end{cases} \Rightarrow \begin{cases} N_2 - f_s = 0 \Rightarrow N_2 = f_s = \mu_s N_1 = 0.27 \times 700 = 189 \text{ N} \\ N_1 - Mg - mg = 0 \Rightarrow N_1 = 700 \text{ N} \end{cases} \quad (2)$$

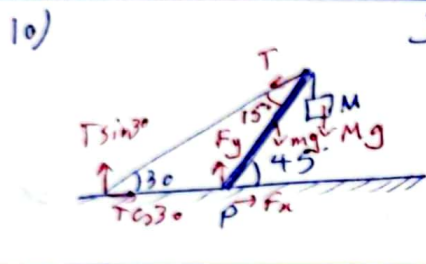
①, ② $\Rightarrow 250x + 500 - 1636.8 = 0 \Rightarrow x = 4.55 \text{ m}$

9)  ان) $\sum \tau_A = 0 \quad Mg \frac{L}{2} + mgL - T \sin 30 \frac{L}{2} = 0$

$$\frac{150}{2} + 10m - \frac{300}{2} = 0 \Rightarrow m = 7.5 \text{ kg}$$

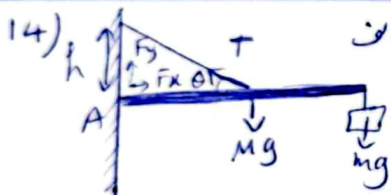
ب) $\begin{cases} F_x - T \cos 30 = 0 \\ F_y + T \sin 30 - Mg - mg = 0 \end{cases} \Rightarrow \begin{cases} F_x = 519.6 \text{ N} \\ F_y = -75 \text{ N} \end{cases}$

منفی نشان می دهد Fy خلاف جهت انتخاب شده است.

10)  ان) $MgL \cos 45 + mg \frac{L}{2} \cos 45 - TL \sin 15 = 0$

$$1000 \times 0.71 + \frac{250}{2} \times 0.71 - 0.26T = 0 \Rightarrow T = 3072.12 \text{ N}$$

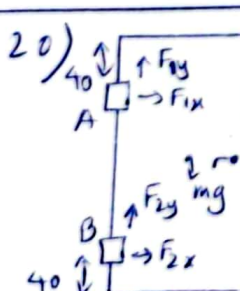
ب) $\begin{cases} F_x - T \cos 30 = 0 \\ F_y - Mg - mg - T \sin 30 = 0 \end{cases} \Rightarrow \begin{cases} F_x = 2660.5 \text{ N} \\ F_y = 2786.1 \text{ N} \end{cases}$

14)  ان) $\sum \tau_A = 0 \quad Mg \frac{L}{2} + mgL - T \sin \theta \frac{L}{2} = 0 \Rightarrow \sin \theta = \frac{650}{1000} \Rightarrow$

$$\theta = \sin^{-1} 0.65 = 40.5^\circ \quad h = \frac{L}{2} \tan \theta = 1.28 \text{ m}$$

ب) $\begin{cases} \sum F_x = 0 \\ \sum F_y = 0 \end{cases} \Rightarrow \begin{cases} F_x = T \cos \theta = 1520.8 \text{ N} \\ F_y = (m+M)g - T \sin \theta = -498.9 \text{ N} \end{cases}$

$$|F_A| = \sqrt{F_x^2 + F_y^2} = 1600.5 \text{ N} \quad \theta_F = \tan^{-1} \frac{-498.9}{1520.8} = -18.2^\circ$$

20)  $\sum \vec{F} = 0 \Rightarrow \begin{cases} F_{1x} + F_{2x} = 0 \quad (1) \\ F_{1y} + F_{2y} - mg = 0 \quad (2) \end{cases}$

$$F_{1y} = F_{2y} \text{ و } (2) \Rightarrow F_{1y} = F_{2y} = \frac{mg}{2} = \frac{13 \times 10}{2} = 65 \text{ N}$$

$$\sum \tau_B = 0 \quad F_{1x} (2.3 - 0.8) + mg \times 0.65 = 0 \Rightarrow 1.5 F_{1x} + 84.5 = 0$$

$\Rightarrow F_{1x} = -56.3 \text{ N}$. منفی نشان می دهد F1x در خلاف جهت انتخاب شده است.

با جا نشانی در (1) داریم: $F_{2x} = 56.3 \text{ N}$

"مسائل فصل 11"

5) $\Delta u_{\text{میانگین}} = \Delta u_{\text{جبهه}} - \Delta u_{\text{ظرف}}$ $0.006 = \beta V_0 \Delta T - 3\alpha V_0 \Delta T = V_0 \Delta T (\beta - 3\alpha)$
 $0.006 = 2 \times 60 (180 \times 10^{-6} - 3\alpha) \Rightarrow \alpha = 4.33 \times 10^{-5}$

9) $Q_1 + Q_2 + Q_3 = 0$ $80C(24-100) + 30 \times 1(24-20) + 15 \times 0.094(24-20) = 0$
 $Q = mc\Delta T$ $-6080C + 125.64 = 0 \Rightarrow C = 0.021 \frac{\text{cal}}{\text{g} \cdot \text{K}}$

13) $Q_1 + Q_2 + Q_3 = 0$ برای داشتن آب 40°C نیاز به ذوب یخ داریم

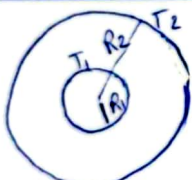
$mL_f + m_1 c_1 \Delta T + m_2 c_2 \Delta T = 0$
 $80m + 2000 \times 1(40-0) + 4000 \times 0.094(40-460) = 0 \Rightarrow m = 974 \text{ gr}$
 -157920

14) $H = \frac{KA(T_1 - T_2)}{L} = \frac{238 \times 3.14 (0.02)^2 \times (100-0)}{0.12} = 249.11 \frac{\text{J}}{\text{s}}$

از طرفی: $H = \frac{Q}{t} \Rightarrow Q = Ht$, $Q = mL_f \Rightarrow t = \frac{mL_f}{H} = \frac{50 \times 80 \times 4.2}{249.11} = 67.4 \text{ s}$

16) $H = \frac{Q}{t} = \frac{mL_f}{t} = \frac{3 \times 80 \times 4.2}{360} = 2.8 \frac{\text{J}}{\text{s}}$

از طرفی: $H = \frac{KA\Delta T}{L} \Rightarrow 2.8 = \frac{K \times 4 \times 10^{-4} \times 100}{1} \Rightarrow K = 70 \frac{\text{W}}{\text{mK}}$

23)  $H = -KA \frac{dT}{dr}$ $A = 4\pi r^2$ $\Rightarrow H = -K 4\pi r^2 \frac{dT}{dr} \Rightarrow H \frac{dr}{r^2} = -K 4\pi dT$

$\Rightarrow \int_{R_1}^{R_2} H \frac{dr}{r^2} = -4\pi K \int_{T_1}^{T_2} dT \Rightarrow H \left[-\frac{1}{r} \right]_{R_1}^{R_2} = -4\pi K (T_2 - T_1)$

$\Rightarrow H \left(-\frac{1}{R_2} + \frac{1}{R_1} \right) = -4\pi K (T_2 - T_1) \Rightarrow H = \frac{4\pi K (T_1 - T_2)}{\frac{R_2 - R_1}{R_1 R_2}}$

25) $v_1 = 1 \text{ lit}$ $\gamma = 1.3$ $T_1 = 273 \text{ K}$ $P_1 = 1 \text{ atm}$

الف) $P_1 v_1^\gamma = P_2 v_2^\gamma$ $v_2 = \frac{v_1}{2} = 0.5 \text{ lit}$

$P_2 = P_1 \left(\frac{v_1}{v_2} \right)^\gamma$ $P_2 = 1 \left(\frac{1}{0.5} \right)^{1.3} = 2.46 \text{ atm}$

$T_1 v_1^{\gamma-1} = T_2 v_2^{\gamma-1} \Rightarrow T_2 = T_1 \left(\frac{v_1}{v_2} \right)^{\gamma-1}$ $T_2 = 273 \left(\frac{1}{0.5} \right)^{0.3} = 336.1 \text{ K}$

ب) فشار ثابت $\frac{v_1}{T_1} = \frac{v_2}{T_2}$ $v_2 = v_1 \frac{T_2}{T_1} = 0.5 \left(\frac{273}{336.1} \right) = 0.41 \text{ lit}$

$$29) P = 25 \text{ Pa} \quad T_1 = 300 \text{ K} \quad V_1 = 3 \text{ m}^3 \quad V_2 = 1.8 \text{ m}^3$$

$$\text{الف) } W = P \Delta V \Rightarrow W = 25(1.8 - 3) = -30 \text{ J}$$

$$\Delta U = W + Q = -30 - 75 = -105 \text{ J}$$

$$\text{ب) } \frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow \frac{3}{300} = \frac{1.8}{T_2} \Rightarrow T_2 = \frac{1.8 \times 300}{3} = 180 \text{ K}$$

$$\text{ج) } PV = nRT \Rightarrow n = \frac{PV}{RT} = \frac{25 \times 3}{8.3 \times 300} = 0.03 \text{ mol}$$

$$\text{د) } Q = n c_p \Delta T \Rightarrow c_p = \frac{Q}{n \Delta T} = \frac{-75}{0.03 \times (-120)} = 20.8 = \frac{5}{2} R \Rightarrow \text{گاز تک اتمی است}$$

$$30) P_1 = 32 \text{ atm} \quad V_1 = 1 \text{ lit} \quad T_1 = 300 \text{ K} \quad V_2 = 4 \text{ lit}$$

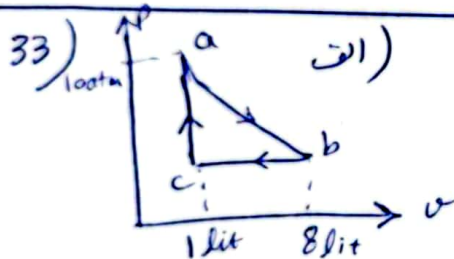
$$\text{الف) } P_1 V_1 = P_2 V_2 \quad 32 \times 1 = P_2 \times 4 \Rightarrow P_2 = 8 \text{ atm}$$

$$W = nRT \ln \frac{V_f}{V_i} \Rightarrow W = 1 \times 8.3 \times 300 \times \ln 4 = 3452 \text{ J}$$

$$\text{ب) } P_1 V_1^\gamma = P_2 V_2^\gamma \Rightarrow P_2 = P_1 \left(\frac{V_1}{V_2} \right)^\gamma = 32 \left(\frac{1}{4} \right)^{1.67} = 3.2 \text{ atm}$$

$$T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1} \Rightarrow T_2 = T_1 \left(\frac{V_1}{V_2} \right)^{\gamma-1} = 300 \left(\frac{1}{4} \right)^{0.67} = 118.51 \text{ K}$$

$$W = -n c_v \Delta T = -1 \times \frac{3}{2} \times 8.3 \times (118.51 - 300) = 2259.5 \text{ J}$$



$$\text{الف) } Q = Q_{ab} + Q_{bc} + Q_{ca} = Q_{\text{گاز درجه}} + Q_{\text{گاز درجه}} + Q_{\text{گاز درجه}}$$

$$= n c_p (T_c - T_b) + n c_v (T_a - T_c)$$

$$n = 1 \quad c_v = \frac{3}{2} R \quad c_p = \frac{5}{2} R \quad \text{گاز تک اتمی}$$

$$P_a V_a = n R T_a \Rightarrow T_a = \frac{P_a V_a}{n R} = \frac{10 \times 10.5 \times 10^{-3}}{1 \times 8.3} = 120.5 \text{ K}$$

$$T_b = T_a \left(\frac{V_a}{V_b} \right)^{\gamma-1} = 120.5 \left(\frac{1}{8} \right)^{1.67} = 3.74 \text{ K}$$

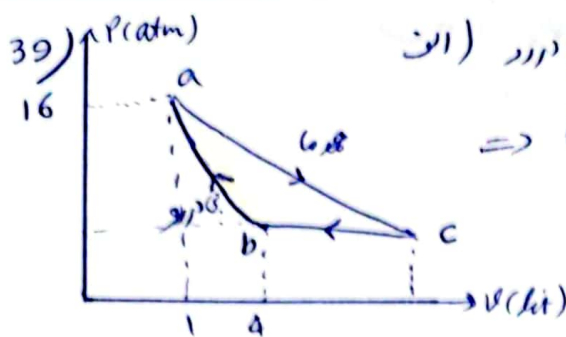
$$\frac{V_b}{T_b} = \frac{V_c}{T_c} \Rightarrow \frac{8}{3.74} = \frac{1}{T_c} \Rightarrow T_c = 0.47 \text{ K}$$

دماها را در رابطه Q میگذاریم:

$$Q = \underbrace{1 \times \frac{5}{2} \times 8.3 (0.47 - 3.74)}_{-67.85} + \underbrace{1 \times \frac{3}{2} \times 8.3 (120.5 - 0.47)}_{1494.37} = 1426.52 \text{ J}$$

$$\text{ب) } e = 1 - \frac{|Q_{\text{out}}|}{Q_{\text{in}}} = 1 - \frac{67.85}{1494.37} = 0.95$$

$$\text{ج) } K = \frac{Q_c}{W} = 1.05$$



$$P_a V_a^\delta = P_b V_b^\delta \quad 16 \times 1^{5/3} = P_b 4^{5/3}$$

$$\Rightarrow P_b = \frac{4^2}{4^{5/3}} = 1.59 \text{ atm}$$

$$T_a = T_c = 600 \text{ K} \quad P_c = P_b = 1.59 \text{ atm}$$

$$T_a V_a^{\delta-1} = T_b V_b^{\delta-1} \quad 600 \times 1^{2/3} = T_b 4^{2/3} \Rightarrow T_b = \frac{600}{4^{2/3}} = 238.11 \text{ K}$$

$$P_a V_a = P_c V_c \quad 4^{1/3} \times V_c = 16 \times 1 \Rightarrow V_c = \frac{4^2}{4^{1/3}} = 10.1 \text{ atm}$$

$$\rightarrow) m = n M \quad P_a V_a = n R T_a \quad 16 \times 1 = n \times 2 \times 600 \Rightarrow n = 0.13 \text{ mol}$$

$$m = 0.13 \times 40 = 0.53$$

$$\Sigma) Q_{ba} = 0 \quad Q_{cb} = n c_p \Delta T = 0.13 c_p (T_b - T_c)$$

$$\frac{c_p}{c_v} = \frac{5}{3} \Rightarrow c_p = \frac{5}{3} c_v = \frac{5}{3} (c_p - R) \Rightarrow c_p = \frac{5}{3} c_p - \frac{5}{3} R \Rightarrow$$

$$\frac{5}{3} R = \frac{2}{3} c_p \Rightarrow c_p = \frac{5}{2} R \quad c_v = c_p - R \Rightarrow c_v = \frac{3}{2} R$$

$$Q_{cb} = 0.13 \times \frac{5}{2} \times (238.11 - 600) = -23.52 \text{ J} \quad Q_{cb} < 0$$

$$Q_{ac} = n R T_a \ln \frac{V_c}{V_a} = 0.13 \times 2 \times 600 \ln 10.1 = 36.1 \text{ J} \quad Q_{ac} > 0$$

$$W_{ac} = 36.1 \text{ J} \quad W_{cb} = P \Delta V = 1.59 (4 - 10.1) = -9.7 \text{ J}$$

$$W_{ba} = -n c_v (T_a - T_b) = -0.13 \times \frac{3}{2} \times (600 - 238.11) = -14.11$$

$$W = W_{ac} + W_{cb} + W_{ba} = 36.1 - 9.7 - 14.11 = 12.29$$

$$e = \frac{W}{Q_{in}} = \frac{W}{Q_{ac}} = \frac{12.29}{36.1} = 0.34$$