① a) Kreftene på den øverste klossen:


T: Snorkraft , f: friksjonskraft

Siden klossen er i ro må $|T| = |f|$.

$$|T| = |f| = \mu_k N = \mu_k m_1 g = 0.4 \cdot 1\,\text{kg} \cdot 9.8\,\text{m/s}^2$$

$$= \underline{\underline{3.9\ \text{N}}}$$

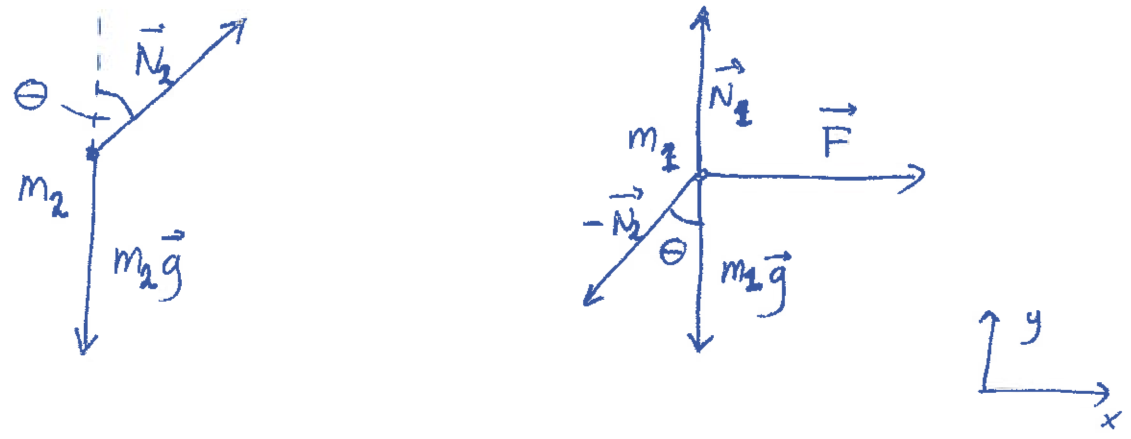
b) Kreftene som virker på nederste klossen:


Newtons 2. low:

$$m_2 a = F - f$$

$$a = \frac{F - f}{m} = \frac{20\,\text{N} - 3.9\,\text{N}}{2.0\,\text{kg}} = \underline{\underline{8.1\ \text{m/s}^2}}$$

② Tegn kreftene som virker på de to klossene:




- Kreftene på $m_1$ i horisontalplanet (x)

① $F - N_2 \sin\theta = m_1 a_x$ (Newtons 2. lov)

- Kreftene på $m_2$ i vertikalplanet (y)

$$N_{2y} - m_2 g = N_2 \cos\theta - m_2 g = 0$$

$a_y = 0$ når klossen ikke sklir.

② $\Rightarrow$ $N_2 = \dfrac{m_2 g}{\cos\theta}$

- Setter ② inn i ①

③ $F - \dfrac{m_2 g}{\cos\theta}\sin\theta = F - m_2 g\tan\theta = m_1 a_x$

- Kreftene på $m_2$ i horisontalplanet

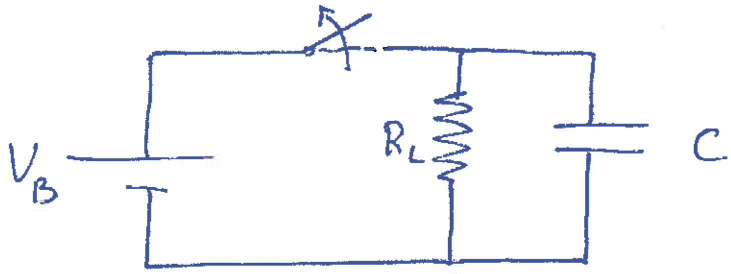
$$N_{2x} = N_2 \sin\theta = \frac{m_2 g}{\cos\theta}\sin\theta = m_2 g\tan\theta = m_2 a_x$$

④ $\Rightarrow$ $a_x = g\tan\theta$

- ④ → ③

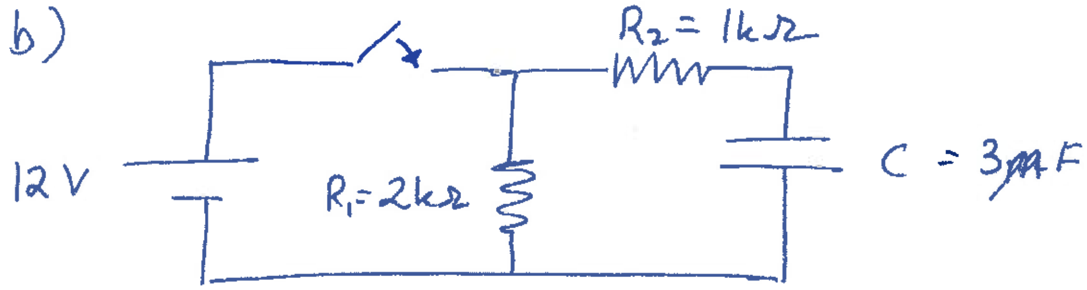
$$F = m_2 g\tan\theta + m_1 g\tan\theta = \underline{\underline{(m_1+m_2)g\tan\theta}}$$

③ a)




Bryteren er lukket når døren er åpen. C vil da være ladet opp og ha en spenning på 12 V. Bryteren åpnes når døren lukkes. Det vil da gå strøm fra kondensatoren gjennom motstanden som gradvis minker ettersom kondensatoren lades ut.

3 b)




Ser at spenningen over hoyre del av kretsen alltid er 12 V slikt at $R_1$ har ingen effekt på oppladningen

KVL: $V - IR_2 - V_c = 0$

$$\Rightarrow \quad V - \frac{dQ}{dt} R_2 - \frac{Q}{C} = 0$$

$$\Rightarrow \quad \frac{dQ}{dt} = -\frac{Q}{R_2 C} + \frac{V}{R_2}$$

Losning på diff. likning:

$$Q = A \exp\left(-\frac{t}{R_2 C}\right) + V \cdot C$$

$Q(0) = 0$

$\Rightarrow A = -VC$

$$Q = VC\left(-\exp\left(-\frac{t}{R_2 C}\right) + 1\right)$$

$$Q = 12V \cdot 3mF\left(-\exp\left(-\frac{3s}{1k\Omega \cdot 3mF}\right) + 1\right)$$

$$= 36mC\left(-\exp(-1) + 1\right)$$

$$= \underline{\underline{23mC}}$$

(4)

a) I pkt. A kjenner vi $p$, $V$ og $n$ og vi kan dermed finne $T$ via tilstandslikningen til en ideell gass, $pV = nRT$

$$T_A = \frac{p_A V_A}{nR} = \frac{300\,\text{kPa} \cdot \cancel{1}000\,\text{cm}^3}{\frac{120\,\text{mg}}{4.0\,\text{g/mol}} \cdot 8.3\,\frac{\text{J}}{\text{K}\cdot\text{mol}}}$$

$$= \frac{300 \cdot 10^3\,\frac{\text{N}}{\text{m}^2} \cdot \cancel{1}000\,(10^{-2}\,\text{m})^3}{30 \cdot 10^{-3}\,\text{mol} \cdot 8.3\,\frac{\text{J}}{\text{K}\cdot\text{mol}}}$$

$$= \frac{10 \cdot \cancel{1} \cdot 10^{+3}}{8.3} = \underline{\underline{1205\,\text{K}}} = \underline{\underline{932^\circ\text{C}}}$$

- $A \to B$ er isoterm slik at $T_B = T_A$
- Bruk tilstandslikningen for å finne trykket i B:

$$p_B V_B = p_A V_A \Rightarrow p_B = p_A \frac{V_A}{V_B}$$

$$= 300\,\text{kPa} \cdot \frac{1000\,\text{cm}^3}{3000\,\text{cm}^3}$$

$$= \underline{\underline{100\,\text{kPa}}}$$

4a) forts.

For å finne trykket i C bruker vi adiabatlikningen.

$$p_A V_A^\gamma = p_C V_C^\gamma$$

$$p_C = \frac{V_A^\gamma}{V_C^\gamma} p_A = \left(\frac{1000\,\text{cm}^3}{3000\,\text{cm}^3}\right)^\gamma 300\,\text{kPa}$$

$$\gamma = \frac{c_p}{c_v} = \frac{5}{3}$$

$$\Rightarrow \quad \underline{\underline{p_C = 48\,\text{kPa}}}$$

Vi kan så finne $T_C$.

$$\cancel{T_C =} \quad \frac{p_B V_B}{T_B} = \frac{p_C V_C}{T_C}$$

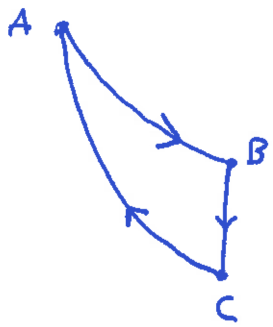
$$\frac{p_B V_B}{T_B} = \frac{p_c V_c}{T_c} \qquad V_c = V_B$$

$$T_c = \frac{p_c}{p_B} T_B = \frac{48\,kPa}{100\,kPa} \cdot 1205\,K = 580\,K$$

$$= \underline{\underline{307^\circ C}}$$

| | p | T |
|---|---|---|
| A | 300 kPa | 932 °C |
| B | 100 kPa | 932 °C |
| C | 48 kPa | 307 °C |

b)




gir positivt arbeid på omgivelsene

c) AB $W = \int_{V_A}^{V_B} p\,dV = nRT \int_{V_A}^{V_B} \frac{dV}{V}$

$= nRT \ln\left(\frac{V_B}{V_A}\right)$

$= 30 \cdot 10^{-3}\,\text{mol} \cdot 8.3 \frac{J}{k \cdot \text{mol}} \cdot 1205\,k \ln(3)$

$W = \underline{\underline{330\ J}}$

isoterm $\Rightarrow \Delta U = 0 \Rightarrow Q = W$

$\underline{\underline{Q = 330\ J}}$

B$\cancel{C}$ $W = 0$ $(\Delta V = 0,$ isokor$)$

$Q = n C_V \Delta T$

$= 30 \cdot 10^{-3}\,\text{mol} \cdot \frac{3}{2} \cdot 8.3 \frac{J}{k \cdot \text{mol}} \cdot (\cancel{1205 - 580})k$

$580 - 1205$

$= -233\ J$

CA
$\cancel{BC}$ $Q = 0$ (adiabatisk)

$W = -233$ $(\Delta U_{TOT} = 0$

| | W | Q | $\Delta U$ |
|---|---|---|---|
| AB | 330 | 330 | 0 |
| BC | 0 | -233 | -233 |
| CA | -233 | 0 | +233 |

5

$$R_{EQ} = 1\,\Omega + \frac{2\,\Omega \cdot 3\,\Omega}{2\,\Omega + 3\,\Omega} + 4\,\Omega$$

$$= 5\,\Omega + \frac{6}{5}\,\Omega = \underline{6.2\,\Omega}$$

$$I = \frac{V}{R_{EQ}}$$

$$V_{AB} = I \cdot R_{PP} = \frac{V}{R_{EQ}} \cdot R_{PP} = \frac{5\,V}{6.2\,\Omega} \cdot 1.2\,\Omega$$

$$= \underline{\underline{0.98\,V}}$$

C

6

$$E_T = E_A + E_B$$

$$= \frac{5\,mC}{(5\,m)^2} \cdot 9 \cdot 10^9 \frac{N\,m^2}{C^2}$$

$$+ \left( \frac{-2\,mC}{(6\,m)^2} \right) \cdot 9 \cdot 10^9 \frac{N\,m^2}{C^2}$$

$$= \left[ \frac{1}{5} \frac{mC}{m^2} - \frac{1}{18} \frac{mC}{m^2} \right] \cdot 9 \cdot 10^9 \frac{N\,m^2}{C}$$

$$= \underline{\underline{1.3 \cdot 10^6 \frac{N}{C}}}$$

C

7

$$F_E = G\frac{m_E m}{r_E^2} \Rightarrow g_E = G\frac{m_E}{r_E^2}$$

$$F_m = G\frac{m_m m}{r_m^2}$$

$$g_m = G\frac{m_m}{r_m^2} = G\frac{m_E\, 0.0123}{(r_E \cdot 0.27)^2}$$

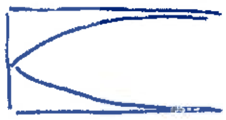
$$= g_E \frac{0.0123}{(0.27)^2} = 0.17\, g_E$$

$$\omega = \sqrt{\frac{g_m}{l}} = \sqrt{\frac{0.17\, g_E}{l}} = \sqrt{0.17} \cdot 1\,Hz$$

$$= \underline{\underline{0.41\,Hz}} \approx 0.4\,Hz$$

D

8



grunnmode : $\lambda = 4 \cdot L = 4m$

$$v = \frac{\lambda}{T} = \lambda f = 4m \cdot 150\,s^{-1}$$

$$= \underline{\underline{600\ m/s}} \qquad \text{A}$$

(9)

Varme tilført for å smelte 2kg is:

$$Q = mL_f = 2kg \cdot 333\ kJ/kg$$

$$= 666\ kJ$$

$$\Delta S = \frac{Q}{T} = \frac{666\ kJ}{273\ K} = \underline{\underline{2.4\ kJ/K}}$$

(B)

(10)

$$J = \Delta p = m\Delta v = 1000\,kg \cdot 100\,km/t$$

$$= 1000\,kg \cdot 100\,\frac{1000\,m}{3600\,s} = \underline{\underline{27.8\ \cancel{kg}\ kNs}}$$

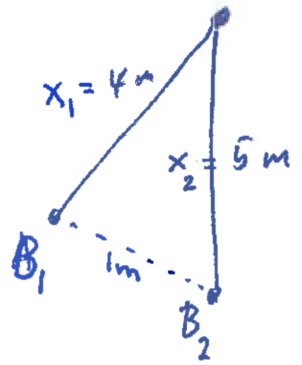
(E)

(11)

Temperaturen må være høyere enn 50°C slik at temperaturgradienten i kobberet blir mindre og man får samme varmestrøm selv om varmeledningsevnen er større

(C)

(12)




$$y = A\cos(kx_1 - \omega t) + A\cos(kx_2 - \omega t + \phi)$$

$$= 2A\cos\left(\frac{kx_1 + kx_2}{2} - \omega t + \frac{\phi}{2}\right)\cos\left(\frac{kx_1 - kx_2 - \phi}{2}\right)$$

*Nye amplituden er*

$$A' = 2A\cos\left(\frac{k(x_1 - x_2) - \phi}{2}\right)$$

$$= 2A\cos\left(\frac{\frac{1}{2}(4-5) - \pi}{2}\right)$$

$$\cancel{v} = \frac{\omega}{k} \qquad \cancel{= 2A\left(-\frac{1}{4} - \frac{\pi}{2}\right.} = 2A\cos\left(-\frac{1}{4} - \frac{\pi}{2}\right)$$

$$k = \frac{\omega}{v} = \frac{150\,\text{rad/s}}{300\,\text{m/s}} = \frac{1}{2}\,\frac{1}{m} \qquad = 2A\cos\left(\frac{1}{4} + \frac{\pi}{2}\right)$$

C

| | A | B | C | D | E |
|---|---|---|---|---|---|
| 5 | | | X | | |
| 6 | | | X | | |
| 7 | | | | X | |
| 8 | X | | | | |
| 9 | | X | | | |
| 10 | | | | | X |
| 11 | | | X | | |
| 12 | | | X | | |