(1) Assuming Quasi static expansion (valve opened slowly)

Pressure inside the balloon will be equal to atmosphere since the balloon is inelastic.

Work done $= P\Delta V$

$P = P_{atmosphere} = \rho g h$

$= 13.6 \times 10^3 \times 9.81 \times \frac{760}{1000}$

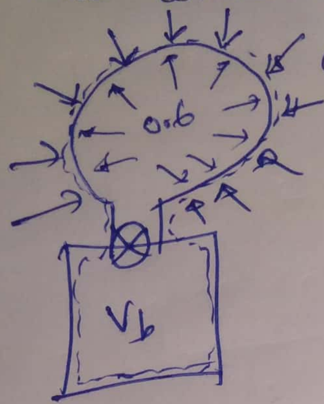
$= 101396.16$ Pa.

Work done by balloon $= P\Delta V$

$= 101396.16 \times (0.5 - 0)$

$= 50698.08$ J

(2) Lets consider a control mass around the air that goes into cylinder and the cylinder itself.



Lets consider quasistatic process (valve opened slowly)

Then Pressure remains ~~at~~ as 1atm

Initial Volume $V_1 = V_b + 0.6\ m^3$

$V_2 = V_b$

Work done by system on atmosphere

$= P(V_2 - V_1)$

$= 101325 \times (-0.6)$

$W = -60795\ J$

Work done by Atmosphere/Surrounding

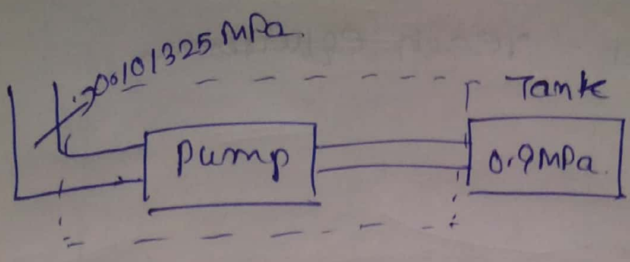
$= P_{atm}(V_1 - V_2)$

↳ Surrounding ~~Atmosphere~~ Expands by $0.6\ m^3$

$= 101325 \times 0.6$

$W_{atmosphere} = 60795\ J$

(3)



Work done by Pump = F x displacement

Power = F x Velocity

$= \left(\frac{F}{A}\right) \times AV$

$AV = \dot{V}$ = volumetric flow rate

$\frac{F_{pump}}{A} = (0.9 - 0.0101325)$ MPa.

Pump power $= (0.9 - 0.0101325) \times 10^6 \times \frac{1}{60}$

$= 13.31125$ KW

$W_{pump} = 13.31125 \times 3600 \times 10^3 = 47.92$ MJ

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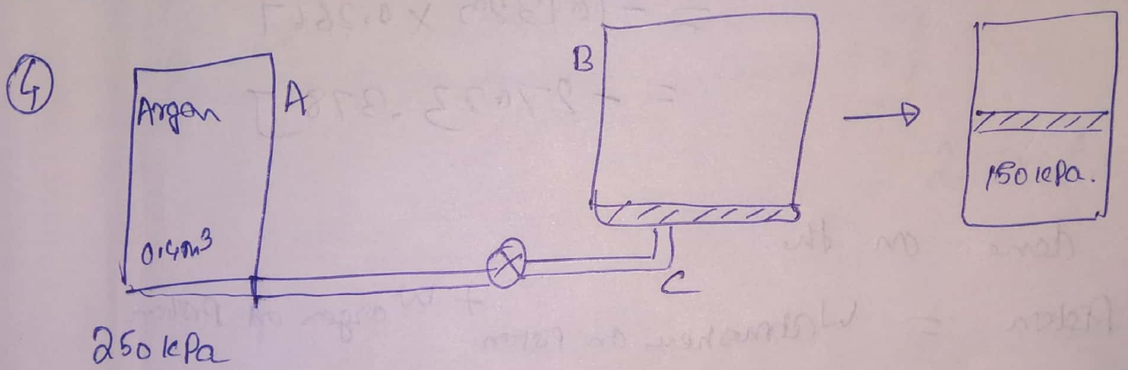
(4)



* Piston has mass also,
Both atmospheric force and gravitation on the piston should be overcome to move the piston up
* That requires $P_C >= 150$ kPa

$P_1 = 250$ kPa
$V_1 = 0.4\ m^3$
$P_2 = 150$ kPa. (required for equilibrium)
$V_2 =$?

Temperature will reach equilibrium

$\Rightarrow$ $PV = nRT$ = constant

$P_1 V_1 = P_2 V_2$

$$V_2 = \frac{250 \times 0.4}{150} = 0.6667 m^3 \Rightarrow \text{Total volume}$$

Volume of Cylinder B = $0.6667 - 0.4$
$= 0.2667 m^3$

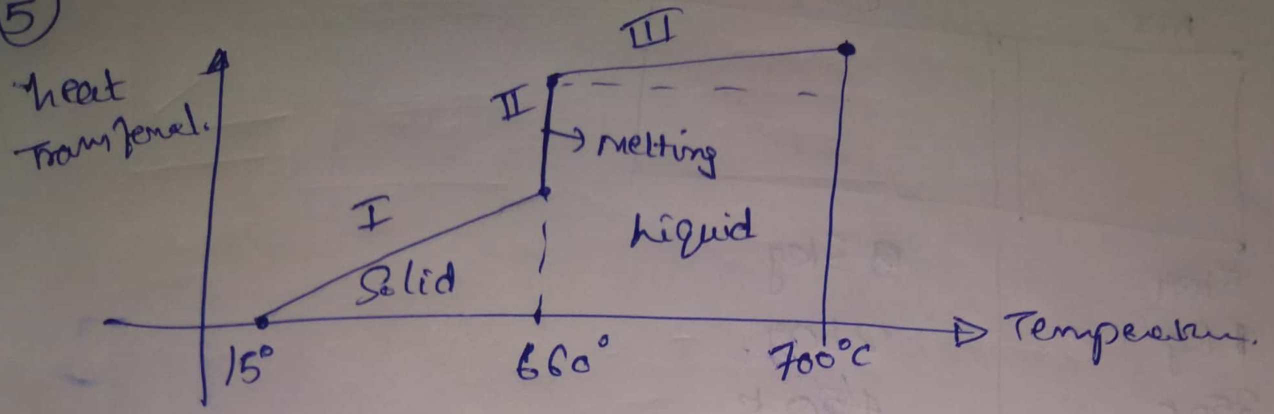
Work done by Argon $= 150 \times 10^3 (V_2 - V_1)$
$= 150 \times 10^3 \times 0.267$
$= 40.05$ kJ

Work done by Atmosphere $= P_{atm}(-(V_2 - V_1))$
$= -101325 \times 0.2667$
$= -27023.378$ J

Work done on the Piston = $W_{atmosphere\ on\ piston} + W_{argon\ on\ piston}$

$= -27023.378 + 40.05 \times 10^3$
$= +13.026$ kJ

(5)



Let the mass be x

For phase I $15° \rightarrow 660°C$

heat energy needed $Q_1 = x(C_1)(660-15)$

phase - II melting at 660°C

$Q_2 = x(390)$

Phase - III $660° \rightarrow 700°C$

$Q_3 = x C_2 (700-660)$

$Q = x[0.9 \times 645 + 390 + 1.11 \times 40]$

Energy given by Furnace in 1 hr $Q = 2.17 \times 10^6 \times 3600$

$$x = \frac{2.17 \times 10^6 \times 3600}{(0.9 \times 645 + 390 + 1.11 \times 40) \times 10^3} = 7.6973 \times 10^3 \text{ kg}$$

Q6 Mass of air, $m_a = 1kg$

Initial pressure, $P_a = 5$ bar

Initial temperature of CO_2, $T_c = 450 K$

Also, for air $Pv = 288.68 T$

$C_{v,a} = 733 J/kgK$

for CO_2 $Pv = 189 T$

$C_{v,c} = 750 J/kgK$

Initial volume of air, $V_{a,i} = \frac{288.68 m_a T_a}{P_a} = 0.20207 m^3$

Initial volume of CO_2, $V_{c,i} = \frac{189 m_c T_c}{P_c} = 1.27575 m^3$

When the pin is removed, the partition moves in such a way that it reaches a final equilibrium state where the temperature T_f (due to conducting partition) and pressure P_f of both gases will be the same. This corresponds to thermal and mechanical equilibrium.

Consider (air + CO_2) as combined system. The system is insulated and the total volume is constant.

Applying the first law, $\Delta E = Q - W = 0$

$\Delta E = \Delta E_a + \Delta E_c = 0$

$\Rightarrow m_a C_{v,a}(T_f - T_a) + m_c C_{v,c}(T_f - T_c) = 0$

from the above equation we get $T_f = 425.4\ K$

The next condition to be satisfied is that the total volume of the system (air + CO_2) is a constant i.e.,

$$V_{a,f} + V_{c,f} = V_{a,i} + V_{c,i} = 1.477826\ m^3$$

Substitute for $V_{a,f}$ $\left(= \frac{288.68\, m_a T_f}{P_f}\right)$ and $V_{c,f}$ $\left(= \frac{189\, m_c T_f}{P_f}\right)$

in terms of P_f.

Then, solve for P_f.

$$P_f = 246312\ Pa.$$