MECH - Thermo, P-S -1. :

1. $V_1 = 0.02\ m^3$ $P_1 = 200 \times 10^3\ Pa$ $T_1 = 303\ K$.

$V_2 = 0.002\ m^3$.

$P_1 V_1^{1.3} = P_2 V_2^{1.3}$

$P_2 = P_1 \left(\frac{V_1}{V_2}\right)^{1.3} = 3990 \times 10^3\ Pa = 3.99 \times 10^6\ Pa$.

$\therefore W = \frac{P_1 V_1 - P_2 V_2}{n-1} = \frac{-3980}{0.3} = -13.267\ kJ$.

$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \Rightarrow T_2 = \frac{P_2 V_2}{P_1 V_1} \times T_1 = 604.5\ K$.

$= 331.5°C$.

→ —

2. $m = 2kg$. $V_1 = 2m^3$. $P_1 = 10^5\ Pa$.

$V_2 = 5m^3$.

a) $P \to$ const.

$W = P \int dV = P(V_2 - V_1) = 10^5 (5-2)$

$= 3 \times 10^5\ J$.

b) $T \to$ const.

$W = P_1 V_1 \ln V_2/V_1 = 10^5 . (2) . \ln(5/2)$

$= 1.8326 \times 10^5\ J$.

c) $PV^2 \to$ const. $(n = 2)$.

$P_1 V_1^2 = P_2 V_2^2$

$\Rightarrow P_2 = P_1 \left(\frac{V_1}{V_2}\right)^2 = 1.6 \times 10^4\ Pa$.

$\therefore W = \frac{P_1 V_1 - P_2 V_2}{n-1} = 120\ kJ$.

→ —

3. $A = 0.0045\ m^2$ $dx = 75 \times 10^{-3}\ m$.

$\therefore dV = (0.0045 \times 75 \times 10^{-3})\ m^3$.

$\therefore$ Work $= P.dV = 80 \times 10^3 \times (0.0045 \times 75 \times 10^{-3})\ J$.

$= 27\ J$.

→ —

~~4. St. line on P-V curve ⇒ $PV = c$.~~

~~or $P_1V_1 = c$.~~

~~$\Rightarrow P_1\,dV + V_1\,dP = 0$~~

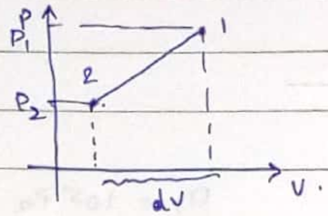
~~$\Rightarrow 1.5\times10^6[+0.12\times0.3] + V_1[-1.35\times10^6] = 0$.~~

~~$\Rightarrow V_1 = 0.04\ m^3$.~~

~~Now, $W = P_1V_1 \ln P_1/P_2 = 1.5\times10^6 \times 0.04 \times \ln \frac{1.5\times10^6}{0.15\times10^6}$~~

4. St. line graph; with P decreasing. $P_1 = 1.5\times10^6$ Pa. $P_2 = 1.5\times10^5$ Pa

∴ graph =



∴ Work done = area under trapezium

$= \frac{1}{2}$ (sum of ∥ sides) × dist. b/w them.

$= \frac{1}{2}(P_1+P_2) \times (0.12\times0.3)$

$= \frac{1}{2}(1.5+0.15)\times10^6 \times 0.036$

$= 29700$ J $= 29.7$ KJ.

5. $P_1 = 80\times10^3$ Pa. $P_2 = 0.4\times10^6$ Pa

$V_1 =$ ~~0.3 m³~~ $0.1\,m^3$ $V_2 = 0.03\,m^3$

$PV^n =$ const.

$\Rightarrow P_1V_1^n = P_2V_2^n$.

$\Rightarrow \left(\frac{V_1}{V_2}\right)^n = \frac{P_2}{P_1}$

$\Rightarrow n\log\left(V_1/V_2\right) = \log\left(P_2/P_1\right)$

$\Rightarrow n = 1.337$.

Now, W

$= \frac{P_1V_1 - P_2V_2}{1-1.337}$.

$= -11869$ J.

$= -11.86$ KJ. [Ans].

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6. $P_1 = 101.325$ kPa $\quad V_1 = V. \quad PV^{1.2} = c.$

$V_2 = \frac{1}{5}V.$

Bore = diam of piston = 0.15 m.

$\therefore$ Area $= \frac{\pi D^2}{4}$ (m²).

$\therefore |\Delta V| =$ Area x Stroke

$= \frac{\pi (0.15)^2}{4} \times 0.25 = 4.418 \times 10^{-3}\ m^3$

$\therefore |V_1 - V_2| = |\Delta V|$

$\Rightarrow V - \frac{1}{5}V = 4.418 \times 10^{-3}$

$\Rightarrow V = 5.52 \times 10^{-3}\ m^3.$

$\therefore V_1 = 5.52 \times 10^{-3}\ m^3$

$V_2 = 1.104 \times 10^{-3}\ m^3$

Now, $P_1 V_1^{1.2} = P_2 V_2^{1.2}$

$\Rightarrow P_2 = P_1 \left(\frac{V_1}{V_2}\right)^{1.2} = 699$ KPa.

$\therefore$ Work (1 compression stroke, 1 cylinder) $= \frac{P_1V_1 - P_2V_2}{1.2 - 1} = -1061.91$ J. [-ve since work is done on system].

$\therefore$ ~~Work~~

$\therefore$ |Work| [for $\frac{500}{60}$ compression strokes/sec ; for 2 cylinder]

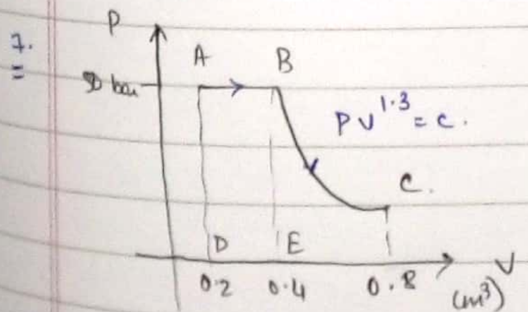
$= 1061.91 \times \frac{500}{60} \times 2$

$= 17698.5$ J.

$\therefore$ Power absorbed $= 17.7$ kW.

—x—

7.



Process BC :

$P_B = 50$ bar $= 50 \times 10^5$ Pa $= 5 \times 10^6$ Pa

$V_B = 0.4\ m^3. \quad V_C = 0.8\ m^3.$

$P_B V_B^{1.3} = P_C V_C^{1.3}.$

$\Rightarrow P_C = P_B \left(\frac{V_B}{V_C}\right)^{1.3} = 2.03 \times 10^6$ Pa

$$\therefore W_{BC} = \frac{P_B V_B - P_c V_c}{1.3 - 1}$$

$$= 1.253 \text{ MJ}.$$

$\therefore$ Total work = Area of rect. ABED + W_{BC}

$$= \{(50 \times 10^5) \times (0.4 - 0.2)\} + 1.253$$

$$= 1 \text{ MJ} + 1.253 \text{ MJ}.$$

$$= 2.253 \text{ MJ}.$$

— x —

8. $\left(P + \frac{a}{V^2}\right) (V - b) = mRT.$

$$\Rightarrow P = \frac{mRT}{V-b} - \frac{a}{V^2}$$

$$\text{Work} = \int P.dV.$$

$$= \int \frac{mRT}{V-b}.dV - \int \frac{a}{V^2} dV.$$

$$= mRT \left[\ln(V-b)\right]_{V_1}^{V_2} + \left[\frac{a}{V}\right]_{V_1}^{V_2}$$

$$= mRT \ln\left(\frac{V_2 - b}{V_1 - b}\right) + a\left[\frac{1}{V_2} - \frac{1}{V_1}\right]$$

$m = 10 \text{ kg}$; $V_1 = 1 m^3$ $V_2 = 2 m^3$ $T = 293 K$.

$a = 15.7 \times 10^4 \text{ N} m^4$ $b = 1.07 \times 10^{-2} m^3$ $R = 0.278 \text{ kJ/kg K}$.

$\therefore$ Work = ~~8744.64~~

569 ~~A~~ − 78500

$$= -77.93 \text{ kJ}.$$

— x —

9. $P \propto d$.

$\Rightarrow P = K.d.$

when $d = 1m$, $P = 1atm$

$= 101325\ Pa.$

$\therefore \boxed{K = 101325}$

Now, $P_2 = K.d_2.$

$\Rightarrow P_2 = 101325(1.1)$

$= 111457.5\ Pa.$

$V_1 = \frac{\cancel{4}}{\cancel{3}} \frac{\pi(1)^3}{6} = 0.524\ m^3$

$V_2 = \frac{\pi(1.1)^3}{6} = 0.697\ m^3.$

$V = \frac{4}{3}\pi.\frac{d^3}{8} = \frac{\pi d^3}{6}.$

$\Rightarrow d = \left(\frac{6V}{\pi}\right)^{1/3}.$

$P = K\left(\frac{6}{\pi}\right)^{1/3}.V^{1/3}.$

$\Rightarrow P.V^{-1/3} = C.$

$\therefore W = \frac{P_1V_1 - P_2V_2}{-1/3 - 1}$

$= \frac{101325 \times 0.524 - 111457.5 \times 0.697}{-4/3}.$

$= 18443\ J.$

$= 18.44\ kJ.$

— x —