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i) $V_1 = 5ms^{-1}$, $V_2 = 2ms^{-1}$

$P_{T_1} = 2.5m$

$P_{T_2} = ?$

$$P_{T_1} - P_{T_2} = \frac{0.35(V_1 - V_2)^2}{2g}$$

$$= \frac{0.33 \times 3^2}{2 \times 9.81} = 0.161$$

$P_{T_1} - P_{T_2} = 0.161$

$2.5 - P_{T_2} = 0.161$

$P_{T_2} = 2.3 + 0.161$

$P_{T_2} = 2.67m$

∴ Pressure head at lower end = 2.67m

2) $D = 200mm$

$= 0.020m$

$A_1 = \frac{\pi d^2}{4} = \frac{\pi (0.20)^2}{4} = 0.0314m^2$

$P_1 = 17.658N/cm^2 = \frac{17.658}{10^{-6}} = 17658000$

Specific gravity of mecury = 13.6

$\frac{P_1}{w} = \frac{P_1}{P_g} = \frac{17.658 \times 10^{-6}}{1000 \times 9.81} = 1.8 \times 10^{9}$

Vaccuum pressure $= \frac{P_2}{w} = 300mmHg$ $d_2 = 100mm = 0.10$

$= -0.30 \times 13.6$ $A_2 = \frac{\pi d^2}{4} = \frac{\pi (0.10)^2}{4} = 7.85 \times 10^{-3}$

$P_2 = -4.08$

$h = 1.8 \times 10^{-8} + 4.08$

$= 4.080000002m$

$h = \frac{P_1}{w} - \frac{P_2}{w}$

$Q_{actual} = \frac{C_d A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$

ii) $V = \frac{0.78 \times 0.0314 \times 7.85 \times 10^{-3} \sqrt{2 \times 9.8 \times 4.0}}{\sqrt{(0.0314)^2 - (7.85 \times 10^{-3})^2}}$

$= 0.07108691665$ m

3) $d_1 = 150\text{mm} = 0.15\text{m}$

Pipe diameter $d_2 = 300\text{mm} = 0.30\text{m}$

$A_2 = \frac{\pi d_2^2}{4} = \frac{3.142 \times 0.13^2}{4} = 0.0177\text{m}^2$

$A_1 = \frac{\pi . d_1^2}{4} = \frac{3.142 \times 0.30^2}{4} = 0.0707\text{m}^2$

$y = 300\text{mm} = 0.30\text{m}$

$cd = 0.64$

$h = \frac{\text{S.G of Hg} - \text{S.G of oil}}{\text{S.G of oil}} \times y$

$\frac{13.6 - 0.9}{0.9} \times 0.3$

7.06m

Rate of flow, $Q_{actual} = \frac{cd A_2 A_1 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$

$Q_{actual} = \frac{0.64 \times 0.0707 \times 0.0177 \sqrt{2 \times 9.81 \times 7.06}}{\sqrt{(0.0707)^2 - (0.0177)^2}}$

$= 0.377$

c) $V = \sqrt{2gh}$

$H = y\left(\frac{\text{S.G of mecury} - \text{S.G of water}}{\text{S.G of water}}\right)$

$H = 0.17\left(\frac{13.6 - 1.025}{1.026}\right)$

$= 0.17 \times 12.26$

$= 2.0842\text{m}$

$V = \sqrt{2 \times 9.81 \times 2.0842}$

6.39ms^{-1}

$=$ i- Speed of substance $= 6.39\text{ms}^{-1}$