Part a

$$P_1 - P_2 = (9.81 \times 0.9) \times 3.83$$
$$= 33.8 \text{ kN/m}^2$$

2) Specific gravity $= 0.8$, $D_1 = 150\text{mm} = 0.15\text{m}$, $D_2 = 75\text{mm} = 0.075\text{m}$, $Z_2 - Z_1 = 150\text{mm} = 0.15\text{m}$, $Q_{act} = 40 \text{ litres/sec} = 0.04 \text{ m}^3/\text{s}$, $C_d = 0.96$

$$A_1 = \frac{\pi}{4} \times D_1^2 = \frac{\pi}{4} \times 0.15^2$$
$$= 0.01767 \text{ m}^2$$
$$A_2 = \frac{\pi}{4} \times D_2^2 = \frac{\pi}{4} \times 0.075^2$$
$$= 0.00442 \text{ m}^2$$
$$Q_{act} = C_d \times \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$$
$$0.04 = 0.96 \times \frac{0.01767 \times 0.00442}{0.01767^2 - 0.00442^2} \times \sqrt{2 \times 9.81 \times h}$$
$$\therefore h = \left(\frac{0.04}{0.96 \times 0.004535 \times 4.429} \right)^2$$
$$= 4.247 \text{ m}$$

Also, $$h = \left(\frac{P_1}{w} + Z_1 \right) - \left(\frac{P_2}{w} - Z_2 \right)$$
$$= \left(\frac{P_1 - P_2}{\rho g} \right) - 0.15$$
$$\frac{P_1 - P_2}{\rho g} = h + 0.15$$
$$P_1 - P_2 = \rho g (h + 0.15)$$
$$= (0.8 \times 1000 \times 9.81)(4.247 + 0.15) \text{ N/m}^2$$
$$= 34.51 \text{ kN/m}^2$$

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Assignment

1) Inlet diameter, $D_1 = 300mm = 0.3m$
Inlet Area, $A_1 = \frac{\pi}{4} \times 0.3^2 = 0.07m^2$
throat diameter, $D_2 = 150mm = 0.15m$
throat Area, $A_2 = \frac{\pi}{4} \times 0.15^2 = 0.01767m^2$
Specific gravity of mercury in U-tube manometer, $S_m = 13.6$
Specific gravity of oil flowing through Pipe, $S_o = 0.9$
Differential manometer reading, $y = 250mm = 0.25m$
The differential 'h' is given by

$$h = \left(\frac{P_1}{w} + z_1\right) - \left(\frac{P_2}{w} + z_2\right)$$

$$= y\left[\frac{S_m}{S_o} - 1\right] = 0.25\left[\frac{13.6}{0.9} - 1\right]$$

$$= 3.53m \text{ of oil}$$

i) Using the equation

$$Q = C_d \times \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$$

$$Q = 0.98 \times \frac{0.07 \times 0.01767}{\sqrt{0.07^2 - 0.01767^2}} \times \sqrt{2 \times 9.81 \times 3.53}$$

$$= \frac{0.001212}{0.0677} \times 8.32$$

$$= 0.1489 m^3/s$$

ii) $$h = \left(\frac{P_1}{w} + z_1\right) - \left(\frac{P_2}{w} + z_2\right) = 3.53$$

$$\left(\frac{P_1}{w} - \frac{P_2}{w}\right) - 0.3 = 3.53$$