1) Comparing the water at the outlet to the top of the tanks

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2$$

$$0 + 0 + h = 0 + \frac{V_2^2}{2g} + 0$$

$$V_2^2 = 2gh$$

$$V_2 = \sqrt{2gh}$$

$\therefore$ the velocity of the water at all outlets is $\sqrt{2gh}$.

At h_1,

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + h_1 = \frac{P_0}{\rho g} + \frac{V_0^2}{2g} + z_0$$

$$0 + 0 + h_1 = 0 + \frac{\sqrt{2gh}^2}{2g} + 0$$

$$h_1 = h$$

1) At h_2,

$$\frac{P_2}{\rho g} + \frac{V_2^2}{2g} + h_2 = \frac{P_0}{\rho g} + \frac{V_0^2}{2g} + z_0$$

$$0 + 0 + h_2 = 0 + \frac{\sqrt{\cancel{2g}h}^2}{\cancel{2g}} + 0$$

$$h_2 = h$$

At h_3,

$$\frac{P_3}{\rho g} + \frac{V_3^2}{2g} + h_3 = \frac{P_0}{\rho g} + \frac{V_0^2}{2g} + z_0$$

$$0 + 0 + h_3 = 0 + \frac{(\sqrt{2gh}\sin 45^\circ)^2}{2g} + z_0$$

$$h_3 = \frac{1}{2}h$$

2) Comparing the surface of the oil to the exit nozzle,

$$p_1 + \frac{1}{2}V_1^2 \rho_{oil} + z\rho_{oil} g = p_2 + \frac{1}{2}V_2^2 \rho + z\rho g$$

$$0 + 0 + 4\rho_{oil} g = 0 + \frac{1}{2}V_2^2 \rho + 0$$

$$V_2^2 = \frac{8\rho_{oil} g}{\rho}$$

$$V_2 = \sqrt{8 SG g}$$

At height h,

$$\frac{p_1}{\rho g} + \frac{V_1^2}{2g} + h = \frac{p_2}{\rho g} + \frac{V_2^2}{2g} + z_2$$

$$0 + 0 + h = 0 + \frac{\sqrt{8 SG \cancel{g}}^{\,2}}{2\cancel{g}} + 0$$

$$h = 2.8 m$$

2) $A_1 V_1 = A_2 V_2$

$$\cancel{\pi}\left(\frac{0.2}{2}\right)^2 V_1 = \cancel{\pi}\left(\frac{0.1}{2}\right)^2 V_2$$

$$V_1 = \frac{1}{4} V_2$$

$\therefore$ Velocity of the water in the pipe is

$$V_{pipe} = \frac{1}{4}\sqrt{8SGg}$$

Comparing the water at the exit nozzle and at the pipe

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2$$

$$0 + \frac{\sqrt{8SG\cancel{g}}^2}{2\cancel{g}} + 1 = \frac{P_2}{\rho g} + \frac{\left(\frac{1}{4}\sqrt{8SG\cancel{g}}\right)^2}{2\cancel{g}} + 0$$

$$4SG + 1 - \frac{1}{4}SG = \frac{P_2}{\rho g}$$

$$P_2 = \left(\frac{15}{4}SG + 1\right)$$

$$= 35561.25$$

$$\approx 35.6\,kPa$$

3) Comparing the water at the surface of the tank with the water exiting the tube

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + z_2$$

$$0 + 0 + 4 = 0 + \frac{v_2^2}{2g} + 0$$

$$V_2 = \sqrt{8g}$$

Volumetric flowrate $= AV$

$$= \pi\left(\frac{5\times10^{-2}}{2}\right)^2 \times \sqrt{8\times9.81}$$

$$= 0.01739439737 m^3 s^{-1}$$

$$\approx 0.017 m^3 s^{-1}$$

b) Comparing the water at the highest point with the water exiting the tube

$$\frac{P_1}{\rho g} + \cancel{\frac{v^2}{2g}} + z_1 = \frac{P_2}{\rho g} + \cancel{\frac{v^2}{2g}} + z_2$$

$$0 + 0 = \frac{P_2}{\rho g} + 4 + H$$

$$H = -4 - \frac{P_2}{\rho g}$$

$$H = -4 - \frac{(1.8 - 101.3)\times10^3}{1000\times9.81}$$

$$H = 6.142711519 \approx 6.14 m$$

4) Volumetric flow rate $Q = A_1 V_1 = A_2 V_2$

$$\cancel{\pi}\left(\frac{d_1}{\cancel{2}}\right)^2 V_1 = \cancel{\pi}\left(\frac{d_2}{\cancel{2}}\right)^2 V_2$$

$$V_1 = \frac{d_2^2}{d_1^2} V_2$$

Comparing the oil at the narrower section of the pipe to the wider section of the pipe

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2$$

$$\frac{P_1 - P_2}{\rho g} = \frac{1}{2g}\left(V_2^2 - V_1^2\right) + z_2 - z_1$$

Sub $V_1 = \frac{d_2^2}{d_1^2} V_2$,

$$\frac{P_1 - P_2}{\rho g} = \frac{1}{2g}\left(V_2^2 - \frac{d_2^4}{d_1^4} V_2^2\right) + z_2 - z_1$$

$$\frac{P_1 - P_2}{\rho g} = \frac{V_2^2}{2g}\left(1 - \left(\frac{d_2}{d_1}\right)^4\right) + z_2 - z_1$$

$$\frac{V_2^2}{2g}\left(1 - \left(\frac{d_2}{d_1}\right)^4\right) = \frac{P_1 - P_2}{\rho g} + z_1 - z_2 \quad -(1)$$

4) Finding the pressure difference between p_1 and p_2

$$p_1 + \frac{SG_{Hg}}{SG_{oil}}\rho g h - \rho g(z_2 - z_1 + h) = p_2$$

$$p_1 + \frac{SG_{Hg}}{SG_{oil}}\rho g h - \rho g h + \rho g(z_1 - z_2) = p_2$$

$$p_1 + \rho g h\left(\frac{SG_{Hg}}{SG_{oil}} - 1\right) + \rho g(z_1 - z_2) = p_2$$

$$p_1 - p_2 = -\rho g h\left(\frac{SG_{Hg}}{SG_{oil}} - 1\right) - \rho g(z_1 - z_2)$$

$$\frac{p_1 - p_2}{\rho g} = z_2 - z_1 - h\left(\frac{SG_{Hg}}{SG_{oil}} - 1\right) \quad -(2)$$

Sub (2) into (1)

$$\frac{V_2^2}{2g}\left(1 - \left(\frac{d_2}{d_1}\right)^4\right) = \cancel{z_2} - \cancel{z_1} - h\left(\frac{SG_{Hg}}{SG_{oil}} - 1\right) + z_1 - z_2$$

$$V_2 = \sqrt{\frac{-2gh\left(\frac{SG_{Hg}}{SG_{oil}} - 1\right)}{1 - \left(\frac{d_2}{d_1}\right)^4}}$$

$$V_2 = \sqrt{\frac{-2(9.81)(100\times 10^{-3})\left(\frac{13.6}{0.9} - 1\right)}{1 - \left(\frac{300\times 10^{-3}}{100\times 10^{-3}}\right)^4}}$$

$$= 0.5882813953 \text{ ms}^{-1}$$

$$Q = A_2 V_2 = \pi\left(\frac{300\times 10^{-3}}{2}\right)^2(0.5882813953)$$

$$= 0.04158316147 \approx 0.042 \text{ m}^3\text{s}^{-1}$$