1) $0 = \sum \dot{m}_{out} - \sum \dot{m}_{in}$

$0 = \cancel{\rho}(V_3 A_3 - V_1 A_1 - Q_2)$

$\therefore Q_2 = V_3 A_3 - V_1 A_1$

$= (6 \times 0.075 - 80 \times 0.01)$

$= 0.15\ m^3/s$

$\boxed{\therefore \text{The Pumping rate is } 0.15\ m^3/s}$

2) $PV = RT$

$\rho = \frac{m}{V} = \frac{P}{RT}$

$\rho_{Hot} = \frac{P_H}{RT_H} = \frac{150 \times 10^3}{287.8 \times 350}$

$= 1.49\ kg/m^3$

$\rho_{cold} = \frac{P_c}{RT_c} = \frac{101 \times 10^3}{287.8 \times 250}$

$= 1.4\ kg/m^3$

$m_{Hot} = m_{cold}$

$\rho_H A_H \cancel{V} = \rho_c A_c \cancel{V}$

$\frac{A_H}{A_c} = \frac{\rho_c}{\rho_H} = \frac{1.4}{1.49} = 0.94$

$\boxed{\therefore \text{The ratio of the hot air exit area to cold exit area is } 0.94}$

3) $\sum F_x = \dot{m}_{out} u_{out} - \dot{m}_{in} u_{in}$

$= (998)\left[\frac{\pi}{4}(0.03)^2(5.56)(-5.56)\right.$

$\left. - \frac{\pi}{4}(0.05)^2(2)(-2)\cos 65^\circ\right]$

$= -18.46\ N$

$\sum F_y = -\dot{m}_{in} u_{in}$

$= -(998)\frac{\pi}{4}(0.05)^2(2)(-2\sin 65^\circ)$

$= 7.1\ N$

$\boxed{\therefore \text{The Horizontal forces are } 18.46\ N \text{ (left)} \quad \therefore \text{The vertical forces are } 7.1\ N \text{ (UP)}}$

4) $\dot{m} = \frac{\dot{W}}{g} = \frac{150}{9.81}$

$= 15.3 \frac{kg}{s}$

$\boxed{\therefore \text{The force on the flange bolts is } 2115\,N}$

$\Sigma F_x = -F_{bolts} + P_1 A_1$

$= \dot{m}u_2 - \dot{m}u_1$

$u_1 = \frac{Q}{A_1} = \frac{\dot{m}/\rho}{\pi D_1^2/4}$

$= \frac{15.3}{998} \times \frac{4}{\pi(0.1)^2} = 1.95\,m/s$

$u_2 = -\frac{Q}{A_2}\cos 40$

$= -\frac{\dot{m}/\rho}{\pi D_2^2/4}\cos 40$

$= -\frac{15.3}{998} \times \frac{4}{\pi(0.03)^2}\cos 40$

$= -16.6\,m/s$

$\therefore F_{bolts} = P_1 A_1 + \dot{m}(u_1 - u_2)$

$= (2.3 \times 101350)\left(\frac{\pi(0.1^2)}{4}\right)$

$+ 15.3(16.6 + 1.95)$

$= 2115\,N$