

Consider a flow system illustrated in the Figure below. An underground fuel storage tank is initially filled with only with nitrogen gas at  $P_{N2-initial} = 100,000$  [Pa]. A very volatile and flammable liquid fuel is slowly pumped into the tank.

a) What will be the maximum level,  $h_{max}$ , of the fuel in the tank if the pressure  $P_1$  at point 1 is 160,000. [Pa]? A centrifugal pump, which receives a shaft work of  $-W_{s-out}$  [J/kg], maintains pressure  $P_1$  constant. The tank headspace is NOT open to atmosphere; i.e., the vent is closed.

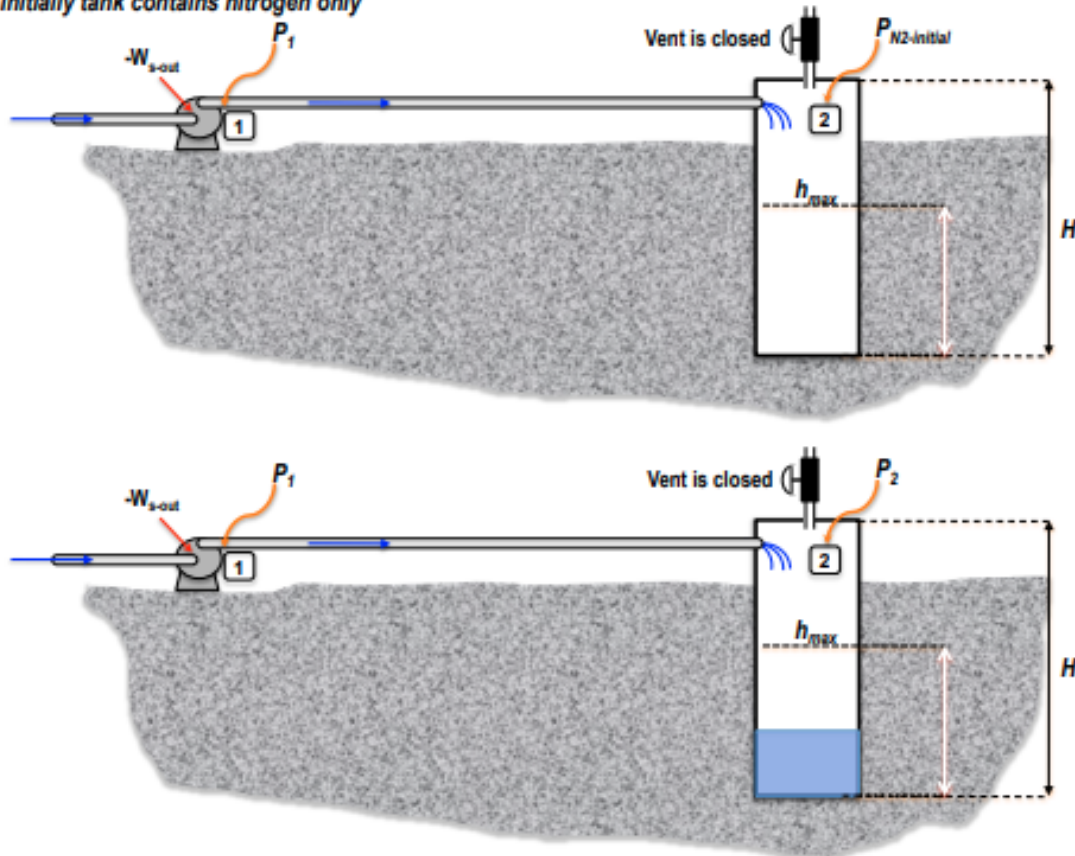
**Bonus Part (20 Bonus points)**

b) How long will it take for the fuel in the tank to reach the  $h_{max}$  level?

*Hint:* Consider nitrogen gas as an ideal gas; therefore, the ideal gas law applies]

**Illustration**

*Initially tank contains nitrogen only*



**Data**

$P_1 = 160,000$ .

$H = 3$ .

$h_{max} = ??$

$P_{N2-initial} = 100,000$ .

$P_2$

Pressure at point 1 maintained by a pump [Pa]

Total height of the tank [m]

Maximum level of fuel in the tank; [m]

Initial pressure in the empty tank; [Pa]

Pressure in the tank at any time; [Pa]