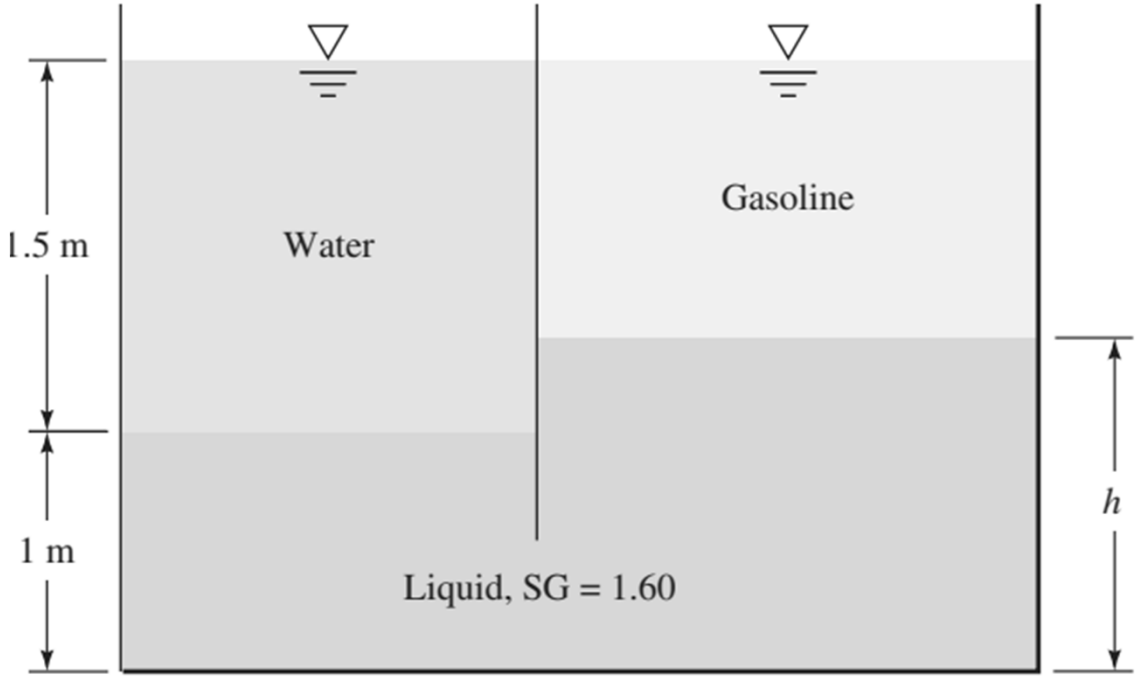
QUIZ II:

1) The mean free path of a gas, l, is defined as the average distance traveled by molecules between collisions. A proposed formula for estimating l of an ideal gas is

$$l = 1.26 \frac{\mu}{\rho\sqrt{RT}}$$

What are the *dimensions* and *common unit* of the constant 1.26? Use the formula to estimate the mean free path of air at 20 °C and 7 kPa. (R=287 J/kg.K and μ=1.8x10^{-5} Pa.s)

2) In the figure below, the 20 °C water and gasoline surfaces are open to the atmosphere and at the same elevation. What is the height h of the third liquid in the right leg? ($\rho_{gasoline}$=750 kg/m^3 and ρ_{water}=1000 kg/m^3)



1)

	common unit		mass M	length L	time t	temperature θ
μ	kg/ms		1	−1	−1	0
ρ	kg/m^3		1	−3	0	0
R	~~J~~/kgK	or m^2/s^2K	0	2	−2	−1
T	K		0	0	0	1

$$[f] = [1,26]\ \frac{[\mu]}{[\rho]([R][T])^{1/2}}$$

[ ] is used to denote dimensions of a variable.

$$L = [1,26]\ \frac{ML^{-1}T^{-1}}{ML^{-3}\left(L^2T^{-2}\theta^{-1}\ \theta^{+1}\right)^{1/2}} =$$

$$L = [1,26]\ \frac{L^{-1}T^{-1}}{L^{-3}LT^{-1}} \Rightarrow L = [1,26]\ L$$

1,26 is a dimensionless constant.

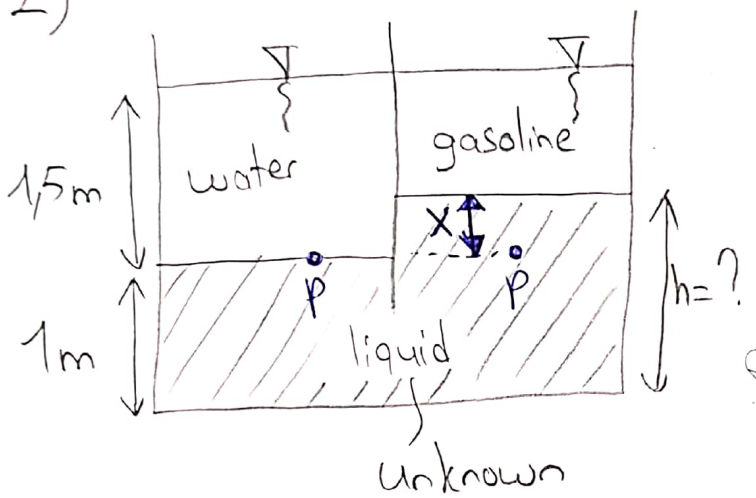
$$P = \rho RT \qquad 7000\ Pa = \rho(287\ J/kg.K)(293\ K)$$

$$\rho = 0,08324\ kg/m^3$$

$$l = 1{,}26\,\frac{\mu}{\rho\sqrt{RT}} = 1{,}26\,\frac{1{,}8\cdot10^{-5}}{0{,}0832\sqrt{287\cdot293}} = 0{,}94\cdot10^{-6}\ m$$

$\cong 1\ \mu m$ (mikron)

2)



pressures in the horizontal line are equal.

$$\rho_w g 1{,}5 = \rho_g g (1{,}5 - x) + \rho_l g x$$

$$1000 \cdot 1{,}5 = 750(1{,}5 - x) + 1600 \cdot x$$

$$x = 0{,}44\ m$$

$$\Rightarrow h = 1 + x = 1{,}44\ m$$