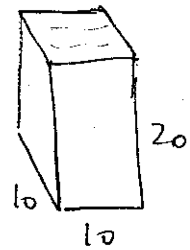
# Solution to Quiz #1.

1)




- Since water is being cooled and
- $\beta_{water} > \beta_{glass}$ the water level will go down.

$\Delta V = V_0 \ \beta_{water} \ \Delta T$ $\qquad \Delta T = 5 - 30 = -25°C.$

$V_0 = 10 \times 10 \times 20 = 2000 \text{ cm}^3 = 2.10^{-3} \text{ m}^3$

$= 2 . 10^{-3} \ 2.1 . 10^{-4} \times (-25) = - 1.05 . 10^{-5} \text{ m}^3$

↳ means decrease in volume

- To get the new height we can calculate the new size of glass container. $\Delta a = a \, \alpha_{glass} \, \Delta T$ $\qquad (\alpha = \frac{\beta}{3})$

($\alpha$ is needed since we are dealing with linear dimensions not volume)

$\Delta a = (10 \text{ cm}) \times 3.2 \, 10^{-6} \times (-25) = -8 . 10^{-4} \text{ cm}$

$\Delta a$ is in fact a negligible change.

$h_{new} \times (a + \Delta a)^2 = V_0 + \Delta V \qquad (h a^2 = V_0)$

$$\frac{h_{new}}{h} = \frac{V_0 + \Delta V}{(a + \Delta a)^2} \, \frac{a^2}{V_0} = \left(1 + \frac{\Delta V}{V_0}\right) \Big/ \left(1 + \frac{\Delta a}{a}\right)^2$$

If $h_{new} = h + \Delta h$ then $1 + \frac{\Delta h}{h} = \left(1 + \frac{\Delta V}{V_0}\right) / \left(1 + \frac{\Delta a}{a}\right)^2 \approx \left(1 + \frac{\Delta V}{V_0}\right)\left(1 - 2\frac{\Delta a}{a}\right).$

$$\Rightarrow \frac{\Delta h}{h} \simeq \frac{\Delta V}{V_0} - 2\frac{\Delta a}{a} = \left(\beta_{water} - 2\alpha_{glass}\right) \Delta T$$

$$= \left(2.1 \, 10^{-4} - 6.4 \, 10^{-6}\right)(-25) = -5.09 \, 10^{-3}$$

$$\Rightarrow h_{new} = h + \Delta h = 20\left(1 - 5.09 \, 10^{-3}\right) = 19.898 \text{ cm}$$

# Solution to Quiz #1

2) Use $PV = nRT$ as He is considered an ideal gas. (Note that by mistake the numbers I have given are such that He is in the liquid phase & therefore far from an ideal gas! Sorry about that.)

$$T = \frac{PV}{nR} = \frac{2 \times 1.013\, 10^5 \cdot 10^{-3}}{10 \cdot 8.31} = 2.44\ \text{K}.$$

$$V_{avg} = \sqrt{\frac{8 k_B T}{\pi m}} = \sqrt{1.28\, 10^4} = 113.25\ \text{m/s}$$

3) The definition of a critical point is generally for a phase transition, but here since this was in one of your homework assignments, we meant the water ↔ vapor phase transition: $\boxed{\frac{\partial P}{\partial V} = 0 ; \frac{\partial^2 P}{\partial V^2} = 0}$

It is the temperature above which a gas stays a gas regardless of the applied pressure or volume. Below this temperature, we might get coexistence of both phases for an appropriately chosen volume.