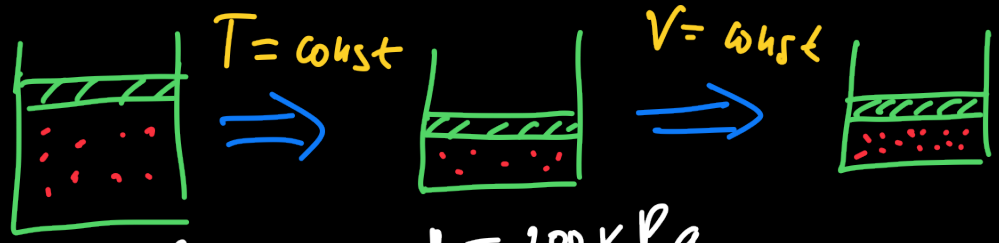
Homework 24

① $P_1 = 10\ kPa$, $t_1 = 20°C \rightarrow 293\ K$

$t_2 = 100°C \rightarrow 373\ K$

$V = const$

$$\frac{P_2}{P_1} = \frac{T_2}{T_1}, \quad P_2 \simeq 12.7\ kPa$$

② 

$P_1 = 100\ kPa$
$V_1 = 100\ cm^3$
$T_1 = 300\ K$

$P_2 = 200\ kPa$
$V_2 = 50\ cm^3$
$T_2 = 300\ K$

$T_3 \simeq 150\ K$

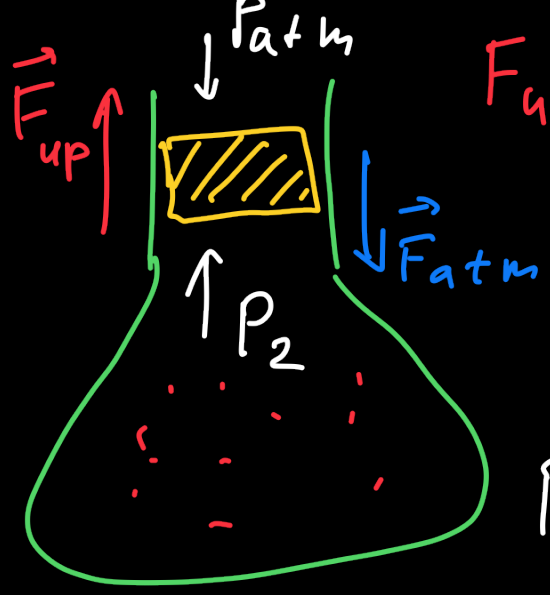
$$V_2 = \frac{V_1}{2} \Rightarrow P_2 = 200\ kPa$$

$$\frac{P_2}{T_2} = \frac{P_3}{T_3} \Rightarrow P_3 = \frac{T_3}{T_2} \cdot P_2$$

$$P_3 = \frac{150}{300} \cdot 200\ kPa = 100\ kPa$$

3.

$$F_{atm} = 100\,kPa \cdot 2 \cdot 10^{-4}\,m^2 = 20\,N$$



$$(p_2 - p_{atm}) \cdot A = F_{up}$$

$$p_2 = p_{atm} + \frac{F_{up}}{A} =$$

$$= 100\,kPa + \frac{10\,N}{2 \cdot 10^{-4}\,m^2} =$$

$$= 5 \cdot 10^4 \cdot Pa + 100\,kPa$$

$$= 50\,kPa + 100\,kPa = 150\,kPa$$

V = const:

$$\frac{p_1}{T_1} = \frac{p_2}{T_2}$$

$$T_2 = \frac{p_2}{p_1} \cdot T_1 = \frac{150}{100} \cdot 280\,K = 420\,K$$

$\rightarrow$ 147 °C

Classwork: Charles's law

$P = \text{const}$

$P_{inside} = ?$

Piston moves freely: $P_{inside} = P_{atm}$

$$\frac{V_2}{V_1} = \frac{T_2}{T_1} \quad \text{or} \quad \frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Charles's law:

$$\frac{V}{T} = \text{const}$$

for $p = \text{const}$

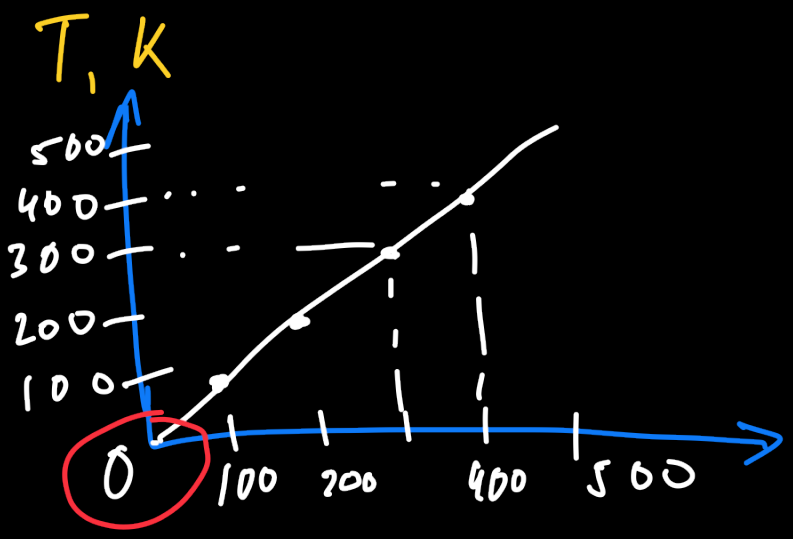
$T_1 = 300\ K$ $\quad T_2 = 400K$ $\quad T_3 = 500K$

$V_1 = 300\ cm^3$ $\quad V_2 = 400 cm^3$ $\quad V_3 = 500 cm^3$

$$\frac{V_2}{V_1} = \frac{T_2}{T_1} = \frac{400}{300} = 4/3$$

$$V_2 = 4/3 \cdot 300 \text{ cm}^3 = 400 \text{ cm}^3$$

$p = \text{const}$



$T \simeq 0$ K : $V = 0$ cm³

All three gas laws work for an ideal gas, which is only an approximation of any real gas!

Approx.: molecules do not interact in an ideal gas

Combined Gas law

Boyle's law: $T = \text{const}$

Gay-Lussac's law: $V = \text{const}$

Charles's law: $P = \text{const}$.

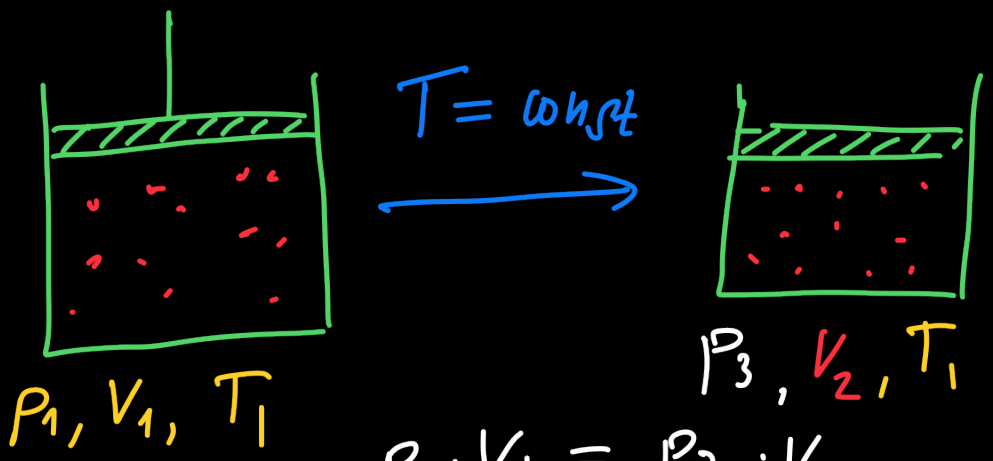
start with: P_1, V_1, T_1

end with: P_2, V_2, T_2

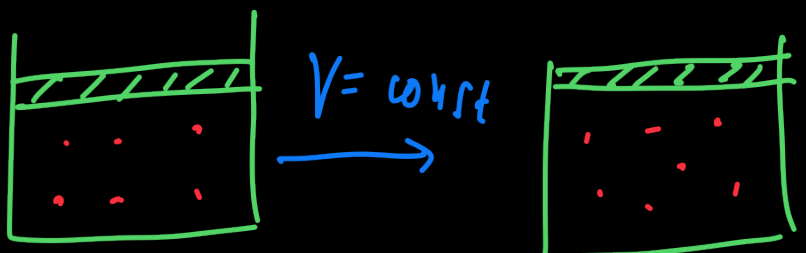
6 parameters in total!

How to relate them?

We will do two steps



$$P_1 \cdot V_1 = P_3 \cdot V_2$$



P_3, V_2, T_1 $\qquad$ P_2, V_2, T_2

$$\frac{P_3}{T_1} = \frac{P_2}{T_2}$$

$$\frac{P_2}{T_2} = \frac{P_3}{T_1} = \frac{P_1 \cdot V_1}{V_2 \cdot T_1}$$

$$\boxed{\frac{P_2 \cdot V_2}{T_2} = \frac{P_1 V_1}{T_1} = \text{const}}$$

Combined gas law