# Homework 27

① $R = 8.31 \dfrac{Pa \cdot m^3}{mole \cdot K}$

$T = 300 K$ , $M(H_2O) = 18 \dfrac{g}{mole}$

$V = 1$ liter $= 10^{-3}\ m^3$

$m = 1 kg$ $\qquad$ $\underline{P = ?}$

Moles of water: $n = \dfrac{m}{M} = 55.6$ moles

Then: $pV = n \cdot RT$

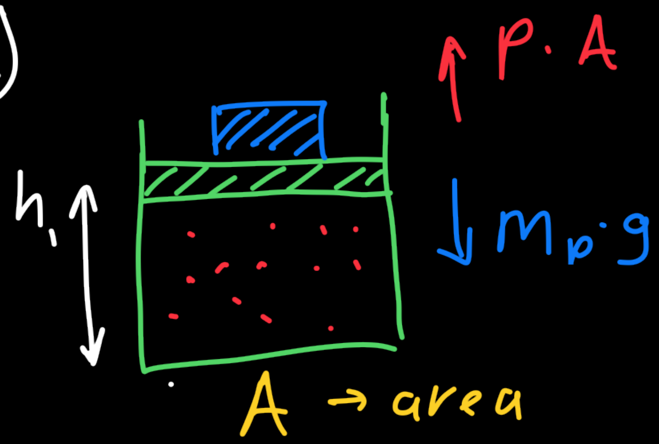
$$pV = \frac{m}{M} \cdot RT \simeq 1.39 \cdot 10^8 Pa$$

$\sim \underline{1390\ P_{atm.}}$

③ $p \cdot V = \dfrac{m}{M} RT$ , $M(O_2) = 32 \dfrac{g}{mole}$

$m \simeq 1.2$ kg ; time $\simeq 10$ hours

3.




$m_p = 100kg$

$T_1 = 273K$

$T_2 = 373K$

$\boxed{V_1 = h_1 \cdot A}$ , $V_2 = h_2 \cdot A$

$\Delta h = ?$ $\quad \Delta E_{pot} = ?$ $\quad W_{gas} = ?$

$$n = \frac{m_{O_2}}{M_{O_2}} = 1 \text{ mole}$$

$$p \cdot V_1 = n \cdot R T_1 \quad , \quad p = \frac{m_p \cdot g}{A}$$

$$\frac{m_p \cdot g}{\cancel{A}} \cdot h_1 \cdot \cancel{A} = n \cdot R T_1$$

$$\rightarrow h_1 = 231.5 \text{ cm}$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow h_2 = \frac{T_2}{T_1} \cdot h_1 \simeq 316.3 \text{cm}.$$

$$\Delta h = 84.8 \text{ cm} \simeq 0.85 \text{m}.$$

3. $\Delta E_{pot} = m_p \cdot g \cdot \Delta h =$

$= 833\ J$

$$W_{gas} = P \cdot \Delta V = \frac{m_p \cdot g}{\cancel{A}} \cdot \cancel{A} \cdot \Delta h$$

$$= 833\ J$$

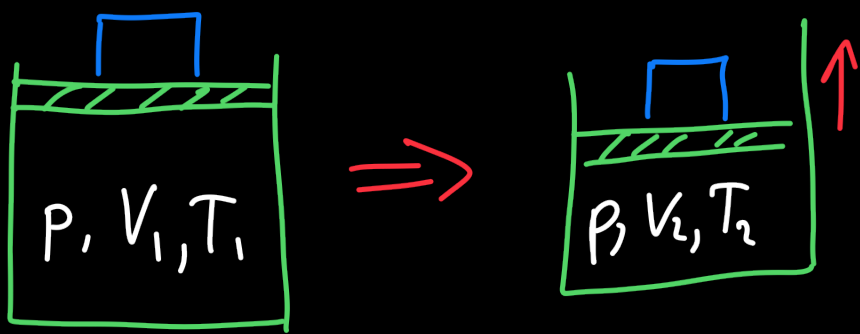
$$\Rightarrow \boxed{\Delta E_{pot} = W_{gas}}$$

## Classwork

Graphical representation of work.

## First law of thermodynamics

Recap:




$$W_{gas} = p \cdot \Delta V = p \cdot (V_2 - V_1)$$

$W_{gas} = 0$, if $V_2 = V_1$

$W_{gas} > 0$ if $\Delta V > 0$

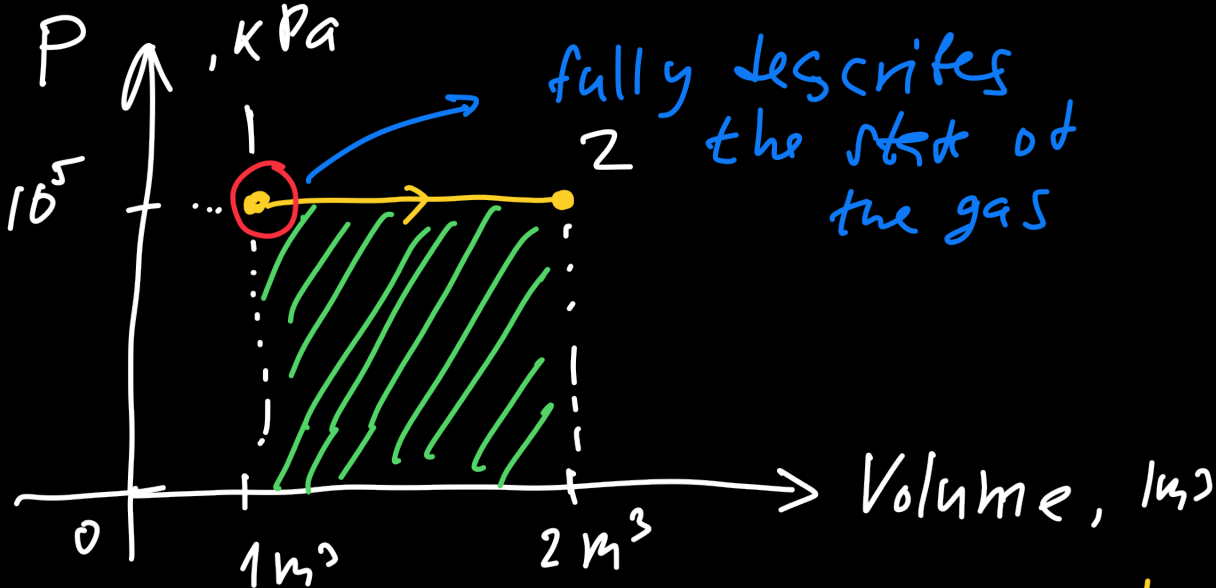
$W_{gas} < 0$ if $\Delta V < 0$

State of an ideal gas is fully described by 3 quantities $p, V, T$

Moreover, if we fix $n$ (moles)

Then: $$p \cdot V = nRT$$

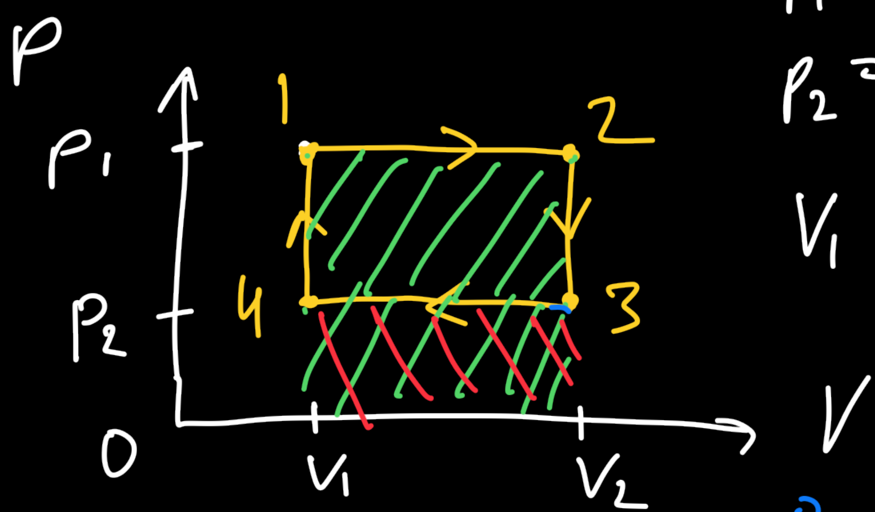
$p, V$ is enough to describe the ideal gas state.




line describes a process, where $p = const$, but $\Delta V = 1 m^3$

$$\boxed{W_{gas} = p \cdot \Delta V}$$

Cyclic process:




$p_1 = 10^5\ Pa$

$p_2 = \frac{1}{2} \cdot 10^5\ Pa$

$V_1 = 1\ m^3$

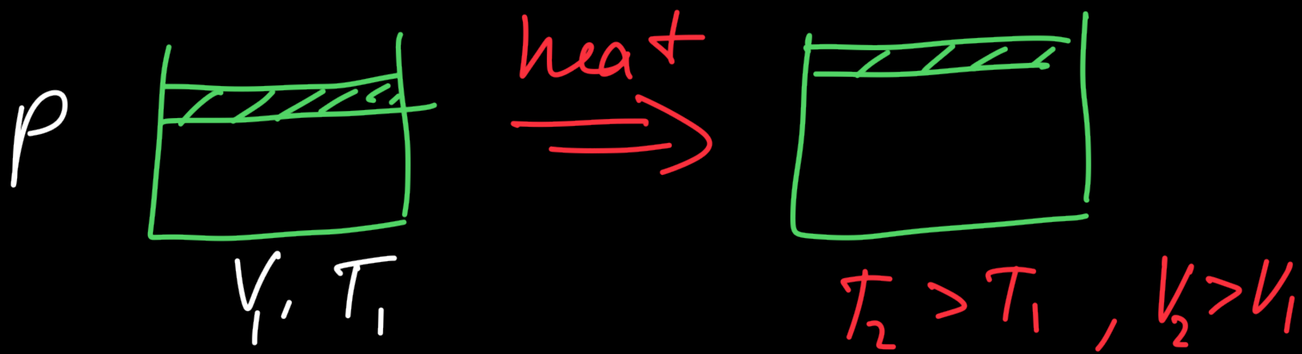
$V_2 = 2\ m^3$

$$
\begin{aligned}
W_{gas} &= W_{12} + \cancelto{0}{W_{23}} + W_{34} + \cancelto{0}{W_{41}} \\
&= p_1 (V_2 - V_1) + p_2 (V_1 - V_2) \\
&= (p_1 - p_2)(V_2 - V_1) > 0
\end{aligned}
$$

Think about energy conservation.

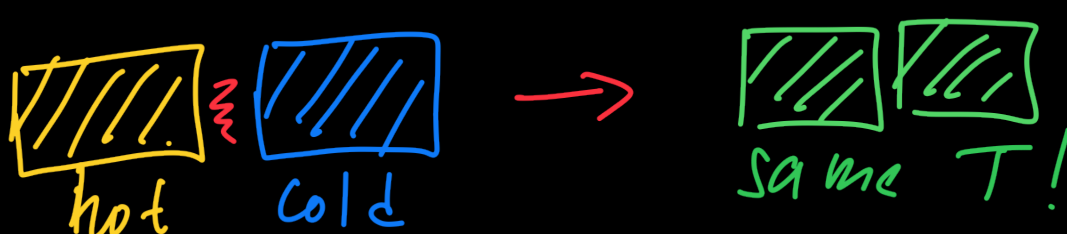
To produce work, there has to be an influx of energy

# First law of thermodynamics




Heat was transfered to the gas!

$$\boxed{Q = m \cdot c \cdot \Delta T}$$




c – specific heat of the colder body,

$\Delta T$ – change in temp.

We transfer heat Q to the gas, and if there is no work done by gas:

no work: $Q = \Delta E_{int} = m \cdot c \cdot \Delta T$

In the case when $W_{gas} \neq 0$

$$\boxed{Q = \Delta E_{int} + W_{gas}}$$

First law of thermodynamics