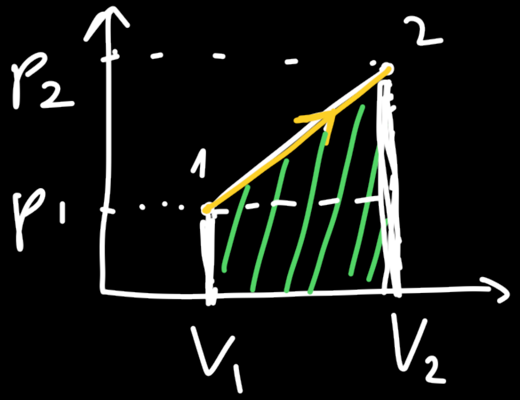
Homework 28

①



certain amount of gas.

$p_1 = 10^5$ Pa

$p_2 = 2 \cdot 10^5$ Pa

$V_2 = 2 \cdot V_1 = 0.2\, m^3$

$$W_{gas} = \frac{1}{2} \underbrace{(V_2 - V_1)} \cdot (p_2 - p_1) + p_1 \underbrace{(V_2 - V_1)}$$

$$= (V_2 - V_1) \left(\frac{1}{2}(p_2) - \frac{1}{2} p_1 + p_1 \right)$$

$$= \frac{1}{2} (p_1 + p_2)(V_2 - V_1)$$

$$= \frac{3}{2} \cdot 10^5 \cdot 0.1 \quad Pa \cdot m^3$$

$$\boxed{W_{gas} = 15\ kJ}$$

② $Q = 1000\,\text{cal} = 4.186\ \text{kJ}$

$Q = W + 0$

$W_1 = F_{grav} \cdot h = mgh$

$W_{total} = mgh \cdot N$

$$N = \frac{4.186 \cdot 10^3\ \text{J}}{30\,\text{kg} \cdot 9.8\,\frac{\text{N}}{\text{kg}} \cdot 2\,\text{m}} \simeq 7.12$$

③ $p = 10^5\ \text{Pa}$, $\Delta V = 1.0$ liters.

$Q = 300\ \text{J}$, $\Delta E_{int.} = ?$

$W_{gas} = p \cdot \Delta V = 10^5\ \text{Pa} \cdot 10^{-3}\ \text{m}^3$

$= 100\ \text{J}$

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

$\Delta E_{int} = 300\ \text{J} - 100\ \text{J} = 200\ \text{J}$

Classwork The first law of thermodynamics.

Specific heat of an ideal gas.

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

c^{molar} — molar specific heat.

First law of thermodynamics:

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

Focus on the ideal gas!

$W_{gas} \to p \cdot \Delta V$ when $p = const$

or area under the graph. with ± sign.

Work done on the gas ⟷ W_{gas}

$$\boxed{W_{\substack{on\\gas}} = -W_{gas}}$$

Second form:

$$Q = \Delta E_{int} - W_{\substack{on \\ gas.}}$$

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

change in the internal energy.

heat transfered to gas

work done on gas

What is $\underline{\Delta E_{int}}$?

$$\boxed{E_{internal} = PE + KE}$$

In ideal gas:

KE PE

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$PE = 0$, $KE > 0$

$$\boxed{E_{int} = KE_{tot}}$$

$$KE_{av.} = \frac{KE_1 + \dots + KE_N}{N} = \frac{KE_{tot}}{N}$$

$N \leftarrow$ # of molecules

$$\boxed{KE_{av.} = \frac{3}{2} K_B \cdot T}$$

monoatomic gases.

$$K_B = 1.38 \cdot 10^{-23} \text{ J/K}$$

$$\boxed{KE_{tot} = \frac{3}{2} N \cdot K_B \cdot T}$$

$$n = N/N_A \Rightarrow N = n \cdot N_A$$

$$\boxed{KE_{tot} = \frac{3}{2} n \cdot N_A \cdot K_B \cdot T}$$

$$N_A \cdot K_B = 6.02 \cancel{\cdot 10^{23}} \frac{1}{\text{mole}} \cdot 1.38 \cdot \cancel{10^{-23}} \frac{\text{J}}{\text{K}}$$

$$= 8.31 \frac{\text{J}}{\text{mole} \cdot \text{K}} = R$$

universal gas constant!

Finally: $KE_{tot} = \frac{3}{2} nRT$

$$\Delta E_{int} = \Delta KE_{tot} = \frac{3}{2} nR\Delta T$$

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

univ. gas const.

$$\boxed{n \cdot c^{molar} \cdot \Delta T = W_{gas} + \frac{3}{2} n R \Delta T}$$

molar specific heat

c^{molar} depends on the process

if $V =$ const. : $W_{gas} = 0$

$$\Rightarrow \boxed{\cancel{n} \cdot c_V^{molar} \cdot \cancel{\Delta T} = 0 + \frac{3}{2} \cancel{n} R \cancel{\Delta T}}$$

$$\boxed{C_V^{molar} = \frac{3}{2} R}$$

$$\boxed{C_p^{molar} = R + \frac{3}{2} R = \frac{5}{2} R}$$

$$\uparrow \; W_{gas} = p \cdot \Delta V = n R \Delta T$$