

PH202 Recitation 4

Thermodynamics Part 1

Warm-Up 1

- Say the equation in words

$$\overline{E_{th}} = N \frac{3}{2} k_B T$$

Warm-Up 1 Solution

Thermal Energy of a Monoatomic Gas

The diagram shows the equation $E_{th} = N \frac{3}{2} k_B T$ with several labels and arrows:

- A box labeled "Thermal Energy" has an arrow pointing to E_{th} .
- A box labeled "Number of particles" has an arrow pointing to N .
- A box labeled "Temperature" has an arrow pointing to T .
- A box labeled "Boltzman's constant" has an arrow pointing to k_B .
- A box at the bottom left contains the value $k_B = 1.38 \times 10^{-23} \text{ m}^2 \text{ kg s}^{-2} \text{ K}^{-1}$.

In words: The **thermal energy** is equal to the product of $\frac{3}{2}$ the **number of particles**, the **Boltzman's constant**, and the **temperature**.

Warm-Up 2

- Say this equation in words

$$\downarrow \quad \downarrow \quad \uparrow$$
$$PV = N k_B T$$

Warm-Up 2 Solution

Ideal Gas Law

The diagram shows the equation $PV = Nk_B T$ with the following labels and arrows:

- Pressure** (green box) points to P .
- Volume** (blue box) points to V .
- Number of particles** (black box) points to N .
- Boltzman's constant** (black box) points to k_B .
- Temperature** (orange box) points to T .

A separate box contains the value of Boltzman's constant:

$$k_B = 1.38 \times 10^{-23} \text{ m}^2 \text{ kg s}^{-2} \text{ K}^{-1}$$

In words: The product of **pressure** and **volume** is equal to the **number of particles** multiplied by the **Boltzman's constant** and **temperature**.

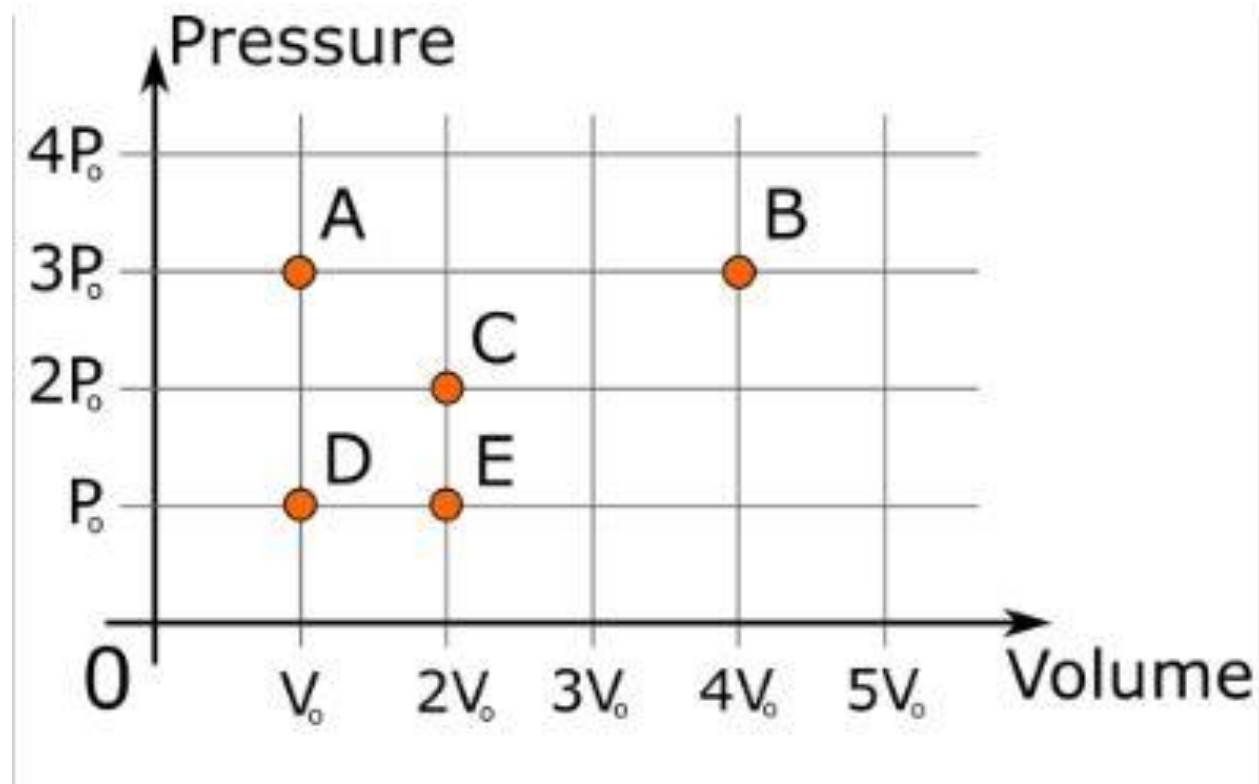
$Nk_B = nR$, $n = \#$ of moles and R is the Gas constant

Discussion Question 1: 3 minutes

- What is the average kinetic energy of a monoatomic gas molecule at 20°C?
- What is the rms speed of a Helium (4g/mol) molecule at this temperature?

Discussion Question 2: 3 minutes

- Each of the five points represent five different equilibrium states for a one mole of an ideal gas. Rank the temperatures of the different states.



Discussion Question 3: 3 minutes

- An ideal gas is in a sealed container. By what factor does the gas pressure change if
 - A. The volume is doubled and the temperature is tripled?
 - B. The volume is halved and the temperature is tripled?

Discussion Question 4: 3 minutes

- Calculate the number of molecules in a cubic meter of an ideal gas at standard temperature and pressure (STP). How many moles of gas is this?

Question 1: 7 minutes

- I have 2 moles of a monatomic gas that is initially at a temperature of 500K. If 5000J of heat is added to the gas and the gas performs 7.5kJ of work, what is the final temperature of the gas?

Question 2: 7 minutes

- Compute the internal energy change and temperature change for the 2 processes involving 1 mole of an ideal monatomic gas.
 - A. 1500 J of heat are added to the gas and the gas does no work and no work is done on the gas
 - B. 1500 J of work are done on the gas and the gas does no work and no heat is added or taken away from the gas