

PHYS430 - Thermal Physics

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Chapter 1

Energy in Thermal Physics

1.1 Thermal Equilibrium

- After two objects have been in contact long enough, we say that they are in **thermal equilibrium**.
- The time required for a system to come to thermal equilibrium is called the **relaxation time**.
- **Temperature** is a measure of the tendency of an object to spontaneously give up energy to its surroundings.
- The flow of energy is from the object with a higher temperature to the lower one.
- For low-density gas at constant pressure, the volume should go to *zero* at approximately -273°C . which defines the **absolute zero**, in the **absolute temperature scale**, in K (kelvin).

1.2 The Ideal Gas

$$PV = nRT; \quad R = 8.31 \text{ J/mol K} \quad (1.1)$$

- A **mole** of molecules is Avogadro's number of them, 6.02×10^{23} .
- Number of molecules is $N = n \times N_A$
- Ideal gas law becomes $PV = NkT$, where k is Boltzmann's constant.
- The average transnational kinetic energy is $\bar{K}_{\text{trans}} = \frac{3}{2}kT$, where $kT = \frac{1}{40}\text{eV}$

1.3 Equipartition of Energy

Equipartition theorem At a temperature T , the average energy of any quadratic degree of freedom is $\frac{1}{2}kT$.

For a system of N molecules, each with f degree of freedom, and there are no other (non-quadratic) temperature-dependent forms of energy, then its **total thermal energy** is

$$U = Nf\frac{1}{2}kT \quad (1.2)$$

Note, This is the *average* total thermal energy, but for large N , fluctuations become negligible.

1.4 Heat and Work

- Total amount of energy in the universe never changes, **Conservation of energy**
- **Heat** any spontaneous flow of energy from one object to another, caused by difference in temperature.
- **Work**, in thermodynamics, is any other transfer of energy into or out of a system.
- Work and heat refer to energy *in transit*.
- The total energy in a system is determined, but not the work nor the heat, it's meaningless.