THERMAL PROPERTIES OF MATTER

The thermal conductivity is a transport property and provides an indication of the rate at which energy is transferred by diffusion. It depends on the atomic and molecular structure of matter.

THERMAL CONDUCTIVITY

• Anisotropic vs. isotropic material
  - For an anisotropic material, thermal conductivity depends on the direction:
    \[
    k_x = -\frac{\dot{q}_x}{\partial T/\partial x} \quad k_y = -\frac{\dot{q}_y}{\partial T/\partial y} \quad k_z = -\frac{\dot{q}_z}{\partial T/\partial z}
    \]

  - For an isotropic material: \( k_x = k_y = k_z \)
  - Units: \([k] = W/m\cdot K\)

• Liquid vs solid materials

In general:

\[
\text{gas} < \text{liquid} < \text{solid}
\]

This trend is essentially governed by differences in intermolecular spacing between the three states.

Range of thermal conductivity for various states of matter at normal temperatures and pressure.
• Thermal conductivity dependence on temperature

Temperature dependence of the thermal conductivity of selected gases.

Temperature dependence of the thermal conductivity of selected solids.

Temperature dependence of the thermal conductivity of selected nonmetallic liquids under saturated conditions.
**THERMAL DIFFUSIVITY**

The thermal diffusivity $\alpha$ is an important thermal property defined as the ratio of the thermal conductivity to the heat capacity:

$$\alpha = \frac{k}{\rho c_p}$$

$[\alpha] = \text{m}^2/\text{s}$

$\alpha$ defines the ability of a material to conduct thermal energy relative to its ability to store thermal energy.

- materials with a large $\alpha$ : respond quickly to changes in their thermal environment
- materials with a small $\alpha$ : take longer to reach a new equilibrium condition.