Review Chapter 18

Temperature, Heat, and the First Law of Thermodynamics

Thermodynamics

is the study of thermal energy (internal energy) of systems.
Temperature is the central concept of thermodynamics.

Every body has a property called temperature

Measuring temperature by hand is not reliable

Temperature (T)

Temperature is one of the seven SI base quantities.

SI unit for temperature is the Kelvin (K)

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The zeroth law of thermodynamics

If bodies *A* and *B* are each in thermal equilibrium with a third body *T*, then *A* and *B* are in thermal equilibrium with each other.

The Celsius, Fahrenheit, and Kelvin Temperature Scales

Temperature Scale

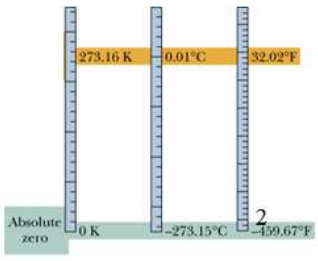
Kelvin scale T_K K — **Celsius scale** T_C °C — **Fahrenheit scale** T_F °F

$$T = T_C + 273.15\ ^oC$$

$$T_F = \frac{9}{5} T_C + 32^0$$

•The lowest temperature is zero on the Kelvin scale.

$$273.15\,K = 0\ ^oC = 32^oF$$



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Expansion of a solids

1D	2D	3D
linear expansion (ΔL)	surface area expansion (ΔA)	volume expansion (ΔV)
$\Delta L = L\,\alpha\,\Delta T$	$\Delta A = A\,2\alpha\,\Delta T$	$\Delta V = V\,\beta\,\Delta T$
ΔL is the change in length L is original length α is coefficient of linear expansion ΔT is *the change in temp.*	ΔA is the change in area A is original area α is coefficient of linear expansion ΔT is *the change in temp.*	ΔV is the change in volume V is original volume β is coefficient of volume expansion ΔT is *the change in temp.*

$$\beta = 3\alpha$$

coefficient of expansion

- It is constant
- it depends on the material of the substance
- It has the unit "per degree" or "per kelvien ($1/^0C$, $(^0C)^{-1}$)

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Heat (Q) is the energy that is transferred between two objects because of a temperature difference that exists between them.

Heat **always** flows from warmer to cooler objects.

SI unit for heat is joule (J) or non SI unit is calorie (cal)

1 cal = 4.1860 J

Heat (Q) is the energy that is transferred between a system and its environment because of a temperature difference that exists between them.

Positive and negative heat

Heat absorbed	No Heat	Heat released
(energy transfers to the system)	(no energy transfers)	(energy transfers from the system)
$Q > 0$ ➔ +ve Q	$Q = 0$	$Q < 0$ ➔ -ve Q

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Heat (J) $\leftarrow Q = C\ \Delta T = C\,(T_f - T_i)$

Heat capacity (J/K)

Change in temperature (K)

Specific heat

Heat (J) $\leftarrow Q = c\ m\ \Delta T$

Specific Heat (J/kg.K)

mass (kg)

Change in temperature (K) $T_f - T_i$

The specific heat for water is $C_w = 1\ cal/g.C^o = 4184\ J / kg.K$

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Heat of transformation

Heat of transformation is the heat per unit mass required to change a substance from one state to another.

Heat (J) $Q = \pm L\,m$

$+Q$ Energy absorbed

$-Q$ Energy released

Heat of transformation (J/kg) Latent Heat

Mass (kg)

State1 →	State2	L = Heat of transformation
Liquid →	Gas	L_V = Heat of vaporization
Solid →	Liquid	L_f = Heat of fusion

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The heat absorbed or lost by a substance is given by:

temperature — **change in temperature**

phase — **no change in the phase**

(i) If there is a change in temperature and there is no change in the phase

$$Q = \pm\, c\, m\, \Delta T$$

no change in the temperature

change in phase

(ii) If there is a change in phase and the temperature of the system remains the same

$$Q = \pm\, m\, L$$

If there is fusion (solid ➔ liquid), then we use L_f,
if there is vaporization (liquid ➔ gas), then we use L_v.

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This section is related to gases only

The first law of thermodynamics is the law of ***conservation of energy and given by***

$$\Delta E_{int} = Q - W$$

- ΔE_{int}: Change in the internal energy of a system
- Q: Heat transferred to the system
- W: Work done by it

- ***$W > 0$ if the gas does work***
- ***$W < 0$ if external work is done on the gas***

If P is constant ➔ $W = P\,\Delta V$

- ***$Q > 0$ if the gas absorbs (gains) heat***
- ***$Q < 0$ if the gas expels (lose) heat***

1- Adiabatic processes ➔ $Q = 0$ ➔ $\Delta E_{int} = -W$

2- Cyclical processes ➔ $\Delta E_{int} = 0$ ➔ $Q = W$

3- Constant-volume processes ➔ $W = 0$ ➔ $\Delta E_{int} = Q$

4- Free expansion processes ➔ $Q = 0$ $W = 0$ ➔ $\Delta E_{int} = 0$

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How does heat transfer take place?

Heat can be transferred between a system and the environment in three ways:

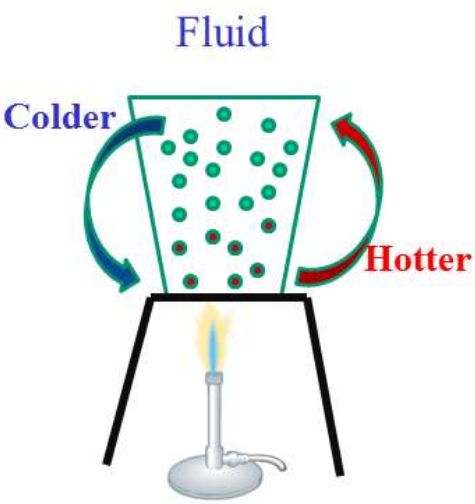
transfer mechanisms

Conduction
التوصيل الحراري

Heat is transferred along the material by means of conduction.

Energy transfer for
$T_{Hot} > T_{Cold}$

Convection
الحمل الحراري



Radiation
الإشعاع

Thermal radiation
(Electromagnetic waves)
No medium required
(Travel through vacuum)