## Heat and Latent heat

## Physical Basic of Heat and Temperature:

Heat and temperature have since been confused to mean the same thing. It is, therefore, necessary to distinguish the two to bring out a clear picture of the two.

Heat: defined as the energy transferred from hot subjects to the cold subjects caused rising the temperature of cold one until equilibrium is reached and the bodies reach thermal equilibrium (i.e., they are at the same temperature) Figure 1. Also defined as a process of transferring energy across the boundary of a system because of a temperature difference between the system and its surroundings.


Figure 1: (a) the soft drink and the ice have different temperatures, $T_{1}$ and $T_{2}$, and are not in thermal equilibrium. In figure (b), when the soft drink and ice are allowed to interact, energy is transferred until they reach the same temperature $T^{\prime}$, achieving equilibrium. Heat transfer occurs due to the difference in temperatures. In fact, since the soft drink and ice are both in contact with the surrounding air and bench, the equilibrium temperature will be the same for both.

In general, to describe the temperature as a physical phenomenon, we should try to understand it on a molecular scale. Matter is composed
of molecules that are in motion. In gas or liquid, the molecules move about, hitting one another or the walls of the container, even in solid the molecules have some motion about the sites that occupy within the crystal structure (vibration).

The fact that the molecules move means that they have kinetic energy and this kinetic energy is related to the temperature (KE $\alpha$ Temp.).
$K . E=\frac{3}{2} K T$

## K: Boltzmann constant

T: temperature
An increase of temperature of any material means an increase in the energy of molecules of that material.

$$
\text { Soled } \xrightarrow{\text { Heat }} \text { Liqued } \xrightarrow{\text { Heat }} \text { Gas } \xrightarrow{\text { Heat }} \text { Ions }
$$

## Temperature Scales:

## 1. Fahrenheit $\left({ }^{0} \mathbf{F}\right)$ scale

- Water freezes at $\left(32^{\circ} \mathrm{F}\right)$ and boils at $\left(212{ }^{\circ} \mathrm{F}\right)$

2. Celsius $\left({ }^{\circ} \mathrm{C}\right)$ scale

- Water freezes at $\left(0^{\circ} \mathrm{C}\right)$ and boils at $\left(100^{\circ} \mathrm{C}\right)$

3. Absolute $\left({ }^{\circ} \mathbf{K}\right)$ scal

- Water freezes at $\left(273.15^{\circ} \mathrm{K}\right)$ and boils at $\left(373.15^{\circ} \mathrm{K}\right)$


## Method of change temperature:

* To change ${ }^{0} \mathrm{C}$ to ${ }^{\circ} \mathrm{F}$ Use equation:

$$
T_{C}=\frac{5}{9}\left(T_{F}-32\right)
$$

* To change ${ }^{\mathbf{0}} \mathrm{Fto}^{\mathbf{0}} \mathrm{C}$ Use equation:

$$
\boldsymbol{T}_{\boldsymbol{F}}=\boldsymbol{T}_{\boldsymbol{C}}\left(\frac{9}{5}\right)+32
$$

* To change ${ }^{0} \mathrm{C}$ to ${ }^{0} \mathrm{~K}$ Use equation:

$\mathrm{T}_{\mathrm{C}}=\mathrm{T}-273$


## * To change ${ }^{0} \mathrm{~K}$ to ${ }^{0} \mathrm{C}$ Use equation:

$$
\mathrm{T}=\mathrm{T}_{\mathrm{C}}+273
$$

## Example:

One a day when the temperature reaches $50^{\circ} \mathrm{F}$, what is the temperature in degree Celsius and in Kelvins?

Solution:

$$
\begin{gathered}
T_{C}=\frac{5}{9}\left(T_{F}-32\right) \\
=\frac{5}{9}(50-32)=10^{\circ} \mathrm{C} \\
T=T_{C}+273 \\
=10^{\circ} \mathrm{C}+273=283^{\circ} \mathrm{K}
\end{gathered}
$$

## Example:

A pan of water is heated from $25^{\circ} \mathrm{C}$ to $80^{\circ} \mathrm{C}$. What is the change in its temperature on the Kelvin scale and on the Fahrenheit scale?

## Solution:

$$
\begin{aligned}
& \mathrm{T}=\mathrm{T}_{\mathrm{C}}+273 \\
& \mathrm{~T}_{1}=25^{\circ} \mathrm{C}+273=298^{\circ} \mathrm{K} \text { and } \mathrm{T}_{2}=80^{\circ} \mathrm{C}+273=353^{\circ} \mathrm{K} \\
& \Delta T=353-298=55^{\circ} \mathrm{K} \\
& \boldsymbol{T}_{\boldsymbol{F}}=\boldsymbol{T}_{C}\left(\frac{9}{5}\right)+32 \\
& \boldsymbol{T}_{F}=\left(25^{\circ} \mathrm{C}\right)\left(\frac{9}{5}\right)+32=77^{\circ} \mathrm{F} \\
& \boldsymbol{T}_{F}=\left(80^{\circ} \mathrm{C}\right)\left(\frac{9}{5}\right)+32=176^{\circ} \mathrm{F} \\
& \Delta \boldsymbol{T}_{\boldsymbol{F}}=176-77=99^{\circ} \mathrm{F}
\end{aligned}
$$

## Units of Heat:

Early studies of heat focused on the resultant increase in temperature of a substance, which was often water. Initial notions of heat were based on a fluid called calorie that flowed from one substance to another and caused changes in temperature. From the name of this mythical fluid came an energy unit related to thermal processes, the calorie (The "Calorie," written with a capital "C"), which is defined as the amount of energy transfer necessary to raise the temperature of 1 g of water from $14.5^{\circ} \mathrm{C}$ to $15.5^{\circ} \mathrm{C}$. The joule has already been defined as an energy unit based on mechanical processes. Scientists are increasingly turning away from the calorie and are using the joule when describing thermal processes.

$$
1 \mathrm{cal}=4.186 \mathrm{~J}
$$

## Temperature Change and Heat Capacity:

One of the major effects of heat transfer is temperature change: heating increases the temperature while cooling decreases it. We assume that there is no phase change and that no work is done on or by the system. Experiments show that the transferred heat depends on three factors-the change in temperature, the mass of the system, and the substance and phase of the substance.

The quantitative relationship between heat transfer and temperature change contains all three factors:

$$
Q=m c \Delta T
$$

Where
$Q:$ is the symbol for heat transfer. $m:$ is the mass of the substance, and
$\Delta T$ :is the change in temperature.
The symbol ( $c$ )stands for specific heat and depends on the material and phase. The specific heat is the amount of heat necessary to change the temperature of 1.00 kgof mass by $1.00^{\circ} \mathrm{C}$. The specific heat $c$ is a property of the substance; its SI unit is $\mathrm{J} /(\mathrm{kg} \cdot \mathrm{K})$ or $\mathrm{J} /\left(\mathrm{kg} \cdot{ }^{\circ} \mathrm{C}\right)$. Recall that the temperature change $(\Delta T)$ is the same in units of kelvin and degrees Celsius. If heat transfer is measured in kilocalories, then the unit of specific heat is $\mathrm{kcal} /\left(\mathrm{kg} \cdot{ }^{\circ} \mathrm{C}\right)$.

## Example:

A 0.500 kg aluminum pan on a stove is used to heat 0.250 liters of water from $20.0^{\circ} \mathrm{C}$ to $80.0^{\circ} \mathrm{C}$. (a) How much heat is required? What percentage of the heat is used to raise the temperature of (b) the pan and (c) the water?

## Solution:

Calculate the temperature difference:

$$
\begin{aligned}
\Delta T & =T_{f}-T_{i} \\
& =80-20=60^{\circ} \mathrm{C}
\end{aligned}
$$

Calculate the mass (m) of water:
1 liter = 1 kilogram

$$
\therefore 0.250 L=0.250 \mathrm{~kg}
$$

Calculate the heat transferred to the water:

$$
\begin{gathered}
Q_{w}=m_{w} c_{w} \Delta T \\
=(0.250 \mathrm{~kg})\left(4186 \mathrm{~J} / \mathrm{kg} .{ }^{\circ} \mathrm{C}\right)\left(60^{\circ} \mathrm{C}\right) \\
=62.8 \mathrm{~kJ}
\end{gathered}
$$

Calculate the heat transferred to the aluminum:

$$
\begin{gathered}
Q_{A l}=m_{A l} c_{A l} \Delta T \\
=(0.500 \mathrm{~kg})\left(900 \mathrm{~J} / \mathrm{kg} \cdot{ }^{\circ} \mathrm{C}\right)\left(60^{\circ} \mathrm{C}\right) \\
=27 \mathrm{~kJ}
\end{gathered}
$$

the total heat transferred is:

$$
\begin{gathered}
Q_{\text {Total }}=Q_{w}+Q_{A l} \\
=62.8 \mathrm{~kJ}+27 \mathrm{~kJ} \\
=89.8 \mathrm{~kJ}
\end{gathered}
$$

The percentage of heat going into the pan versus that going into the water is:
the amount of heat going into heating the pan is:

$$
\begin{gathered}
\frac{Q_{A l}}{Q_{\text {Totel }}} \times 100 \% \\
\frac{27 \mathrm{~kJ}}{89.8 \mathrm{~kJ}} \times 100 \%=30.1 \%
\end{gathered}
$$

the amount of heat going into heating the water is:

$$
\begin{gathered}
\frac{Q_{w}}{Q_{\text {Totel }}} \times 100 \% \\
\frac{62.8 \mathrm{~kJ}}{89.8 \mathrm{~kJ}} \times 100 \%=69.9 \%
\end{gathered}
$$

