TEMPERATURE

- ***Temperature*** is the measure of ***how hot or cold*** a substance is.

- ***Thermometer*** is an instrument that measures temperature and is based on ***thermometric properties*** (i.e. expansion of solids or liquids, color change, etc.) of matter.

- Three ***scales*** are used for measuring temperature:

1. ***Fahrenheit***	(32 - 212)
2. ***Celsius***	(0 - 100)
3. ***Kelvin (absolute)***	(273 -373)

<u>Examples:</u>

1. The melting point of silver is 960.8°C. Convert to Kelvin.

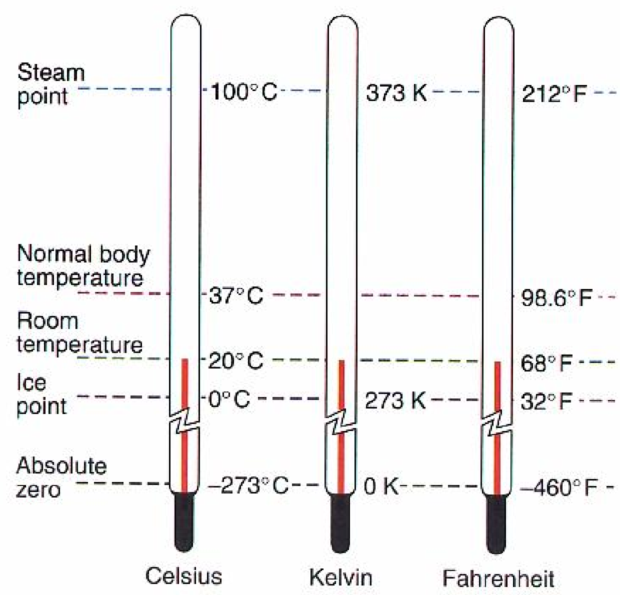
   $T_K = T_C + 273$

   $T_K =$

2. Pure iron melts at about 1800 K. What is this temperature in °C?

   $T_C = T_K – 273$

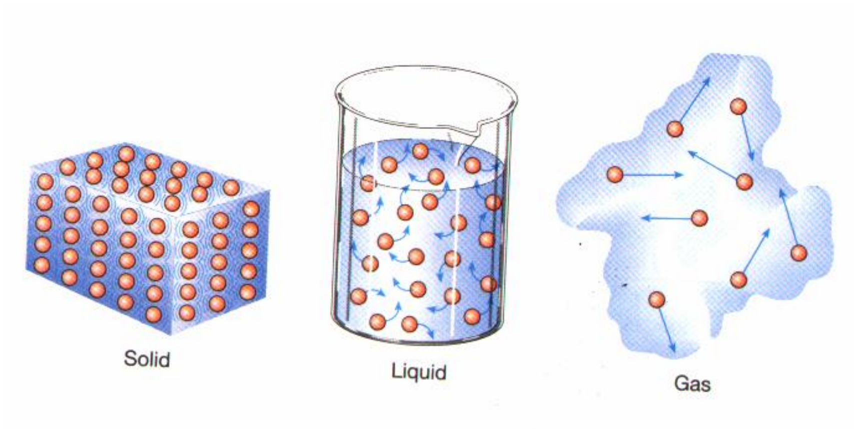
   $T_C =$



3. On a winter day the temperature is 5°F outside. What is this temperature on the Celsius scale?

KINETIC THEORY OF MATTER

- All ***matter*** is composed of tiny particles (***molecules***) that are in constant ***motion***.

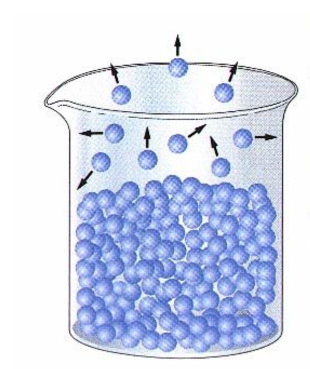


- Molecules of ***gases*** are ***far apart*** and in ***constant motion***. Gas ***pressure*** is caused by ***collisions*** of these molecules ***with the walls*** of the container. Gases have ***indefinite volume and shape***.

- Molecules in a ***liquid*** are ***closer together*** and held by attractions between them. Liquids have ***definite volume***, but ***indefinite shape***.

- ***Solid's*** molecules are ***closely packed*** together, with their molecules held tightly together. Molecules of solids cannot move but can ***vibrate***. Solids have ***definite volume and shape***.

- ***Increase*** in ***temperature increases*** the ***motion*** of molecules in any state. For example, ***evaporation*** of liquids results from ***loss of fast moving molecules*** at the ***surface***.



TEMPERATURE & HEAT

- ***Heat*** is the ***thermal energy*** that is ***transferred*** from one body to another because of ***temperature difference*** between the bodies.

- ***Heat flow*** occurs from ***high*** temperature to ***low*** temperature.

- ***Temperature*** *is the* ***average kinetic energy*** *of molecules in a substance.*

<u>Examples:</u>

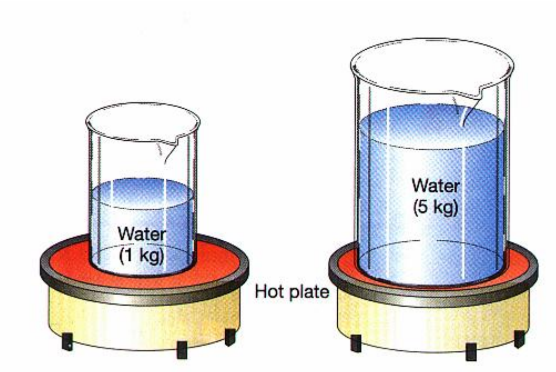
1. Consider a cup of hot coffee and a frozen lake. Which has higher temperature? Which has more heat?

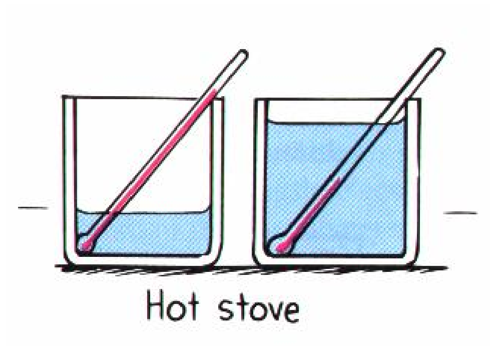
2. On a cold day when someone leaves a door open, it is often said that the person is letting in the cold air. Is this correct?

QUANTITY OF HEAT

- ***Heat*** is a physical quantity that can be ***measured***. The science of heat measurement is known as ***calorimetry***.

- Quantity of ***heat*** is proportional to ***amount*** of substance, its ***temperature***, and the ***nature*** of substance.





- It takes five times as much heat to boil 5 kg of water compared to 1 kg.
- Therefore **mass and heat** are **directly proportional.**

- Although the same amount of heat is added to both containers, the temperature increases more in the container with the smaller amount of water.
- Therefore **mass and temperature** are **indirectly proportional**.

- The ***SI*** unit of heat is ***joules***. Another convenient unit for heat is ***calorie***.

- A calorie is defined as the amount of heat required to change temperature of 1 g of water by 1°C.

SPECIFIC HEAT

- Different materials ***absorb or lose*** heat differently. For example, the filling of the hot apple pie may be too hot to eat, whereas the crust is not.
- ***Specific heat*** of a substance is the amount of ***heat required*** to increase the temperature of ***1 gram*** of that substance by ***1 °C***.
- SI units are ***J/g°C***; British units are ***cal/g°C***.
- Heat changes are measured using a ***calorimeter***. Based on ***conservation of energy***, the amount of ***heat lost*** by one body is ***gained*** by another.

$$\begin{pmatrix}\textbf{Heat lost}\\ \textbf{or gained}\end{pmatrix} = \begin{pmatrix}\textbf{Mass of}\\ \textbf{substance}\end{pmatrix} \textbf{x} \begin{pmatrix}\textbf{Specific}\\ \textbf{heat}\end{pmatrix} \textbf{x} \begin{pmatrix}\textbf{temperature}\\ \textbf{change}\end{pmatrix}$$

$$\uparrow \qquad \uparrow \qquad \uparrow \qquad \uparrow$$

$$\mathbf{H = m \times c \times \Delta T}$$

<u>Examples:</u>

1. How much heat must be supplied to 20 g of tin to raise its temperature from 25°C to 100°C? Specific heat of Sn is 0.055cal/g°C.

   m =
   c =
   ΔT =
   H = ????

2. Calculate the specific heat of a solid if 1638 J of heat raises the temperature of 125 g of the solid from 25.0 to 52.6 °C.

   m =
   c =
   ΔT =
   H =

CHANGE OF STATE

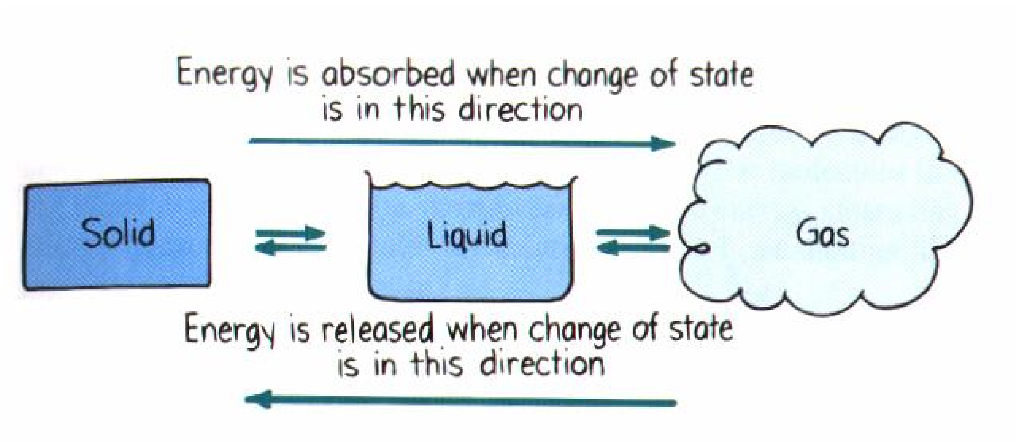
- When matter ***releases*** or ***absorbs energy without a change in temperature***, ***phase change*** occurs (e.g. melting, evaporation).

- The common phase changes are as follows:

$$\text{solid} \underset{\text{freezing}}{\overset{\text{fusion}\\ \text{melting}}{\rightleftharpoons}} \text{liquid}$$

$$\text{liquid} \underset{\text{condensation}}{\overset{\text{evaporation}}{\rightleftharpoons}} \text{gas}$$

$$\text{solid} \underset{\text{deposition}}{\overset{\text{sublimation}}{\rightleftharpoons}} \text{gas}$$

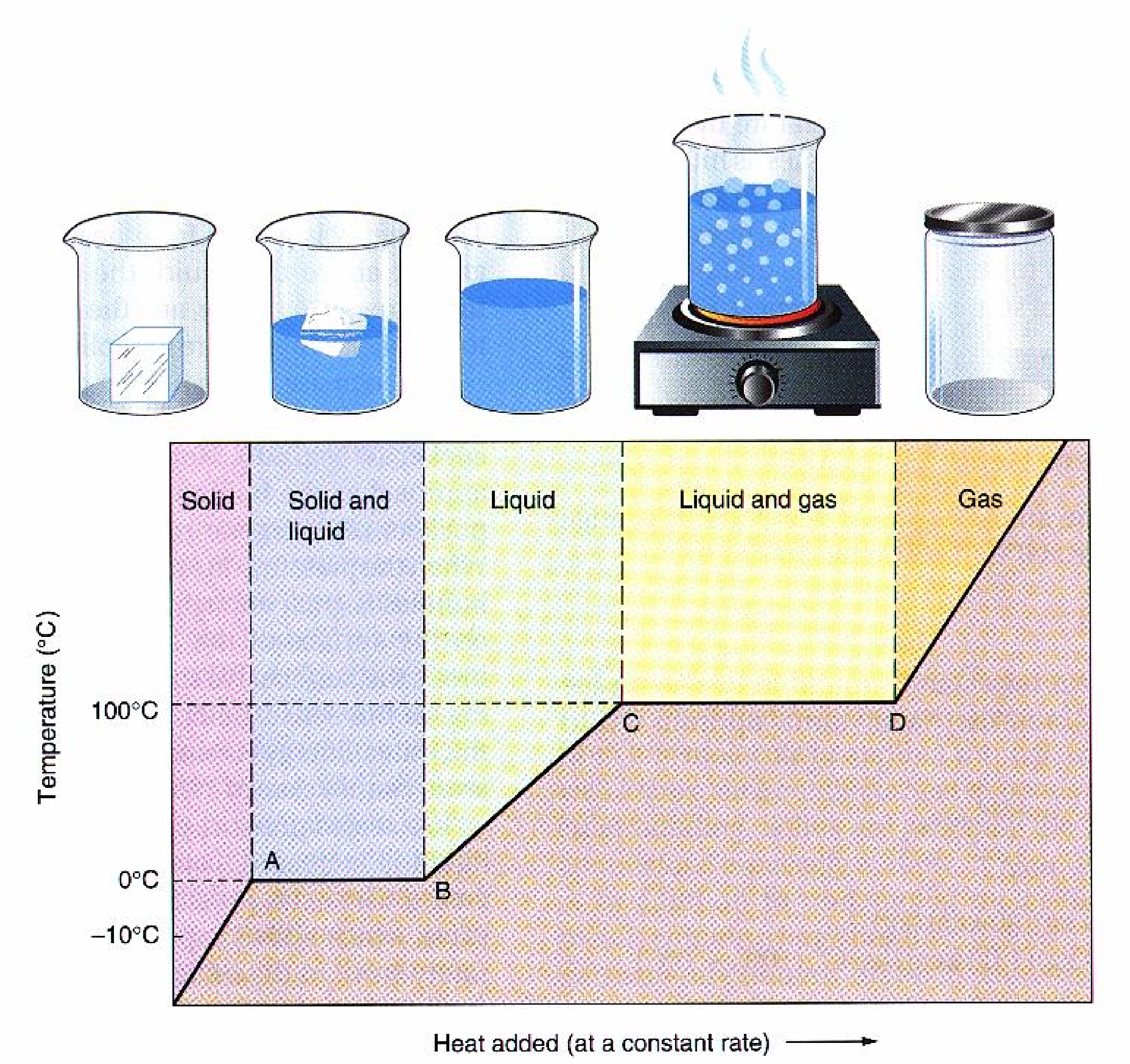


- Phase changes that involve **absorption of heat are cooling processes**.

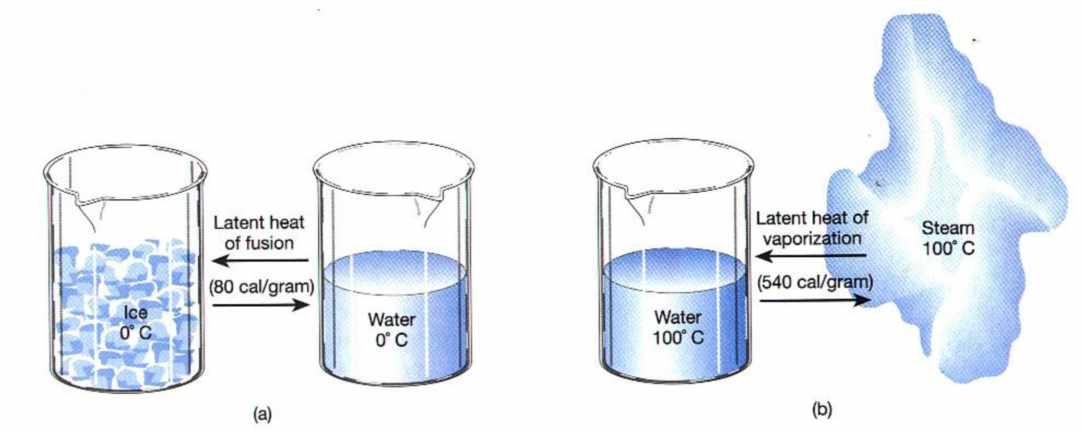
- Phase changes that involve **release of heat are warming processes**.

GRAPH OF TEMPERATURE vs. HEAT

- When ***heat is added*** to ice, it ***absorbs*** the heat ***without a change in temperature***, causing a ***phase change***.
- Similarly, when ***heat is added*** to hot water, a ***phase change*** occurs ***without an increase in temperature***.



LATENT HEAT OF FUSION & VAPORIZATION



Latent heat of fusion

- The quantity of heat required to melt 1 g of solid is called the latent heat of fusion.

Latent heat of vaporization

- The quantity of *heat* required to evaporate 1 g of liquid is called the latent heat of vaporization.

- The amount of ***heat***, released or absorbed during phase change, depends on the ***amount*** of substance and its ***latent heat***.

$$H = mL_f \quad \text{and} \quad H = mL_v$$

Examples:

1. How much heat is required to melt 50 g of ice at 0°C? Latent heat of fusion for ice is 80 cal/g.

   m =

   L_f =

   H = ???

Examples:

2. How much heat is required to vaporize 50.0 g of water at 100°C? Latent heat of vaporization for water is 540 cal/g.

$m =$

$L_v =$

$H = ???$

3. Calculate the amount of heat required to change 20 g of ice at 0°C to water at 10°C.

$$H_{total} = H_{melt\ ice} + H_{change\ T}$$

$$H_{melt\ ice} = mL_f =$$

$$H_{change\ T} = mc\Delta T =$$

$$H_{total} =$$

HEAT TRANSFER

- When there is a ***temperature difference*** between two objects, ***heat flows*** from the ***warmer*** to the ***cooler*** object.

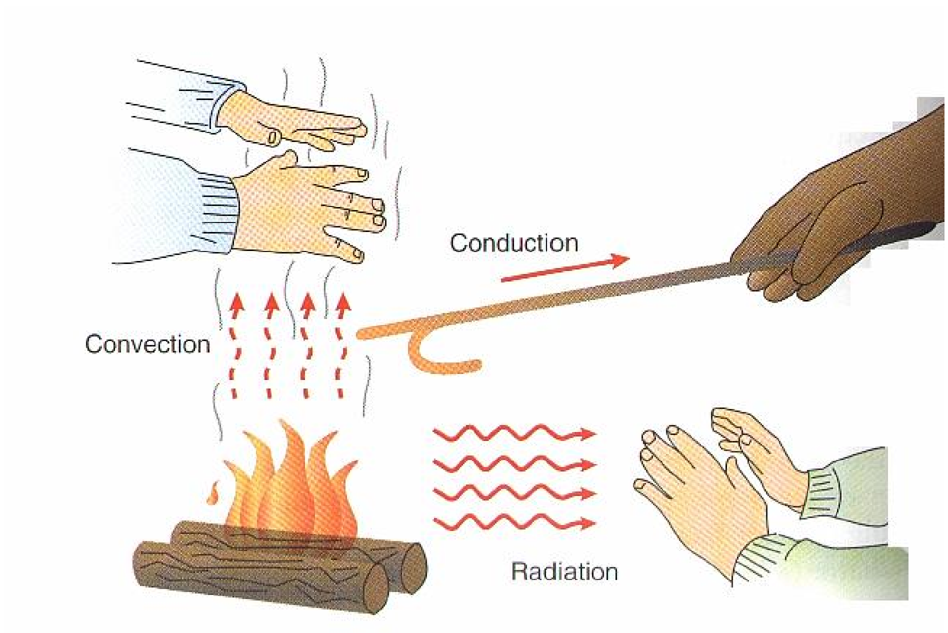
- ***Transfer of heat*** occurs by one of three methods: ***conduction***, ***convection***, and ***radiation***.

- ***Conduction*** is transfer of heat by ***contact*** between two objects through ***molecular collisions***.

- Metals are good ***conductors*** of heat, while glass and wood are poor conductors (***insulators***).

- ***Convection*** is transfer of heat by actual ***motion of molecules***. Liquids and gases transfer heat mainly by convection.

- ***Radiation*** is transfer of heat ***without molecules***. Heat from the sun reaches the earth through space by radiation.



THERMAL EXPANSION

- All ***matter expands when heated***, due to ***increased molecular motion*** which causes them to ***separate*** from each other.
- The amount of ***expansion increases with increased molecular motion***, therefore:

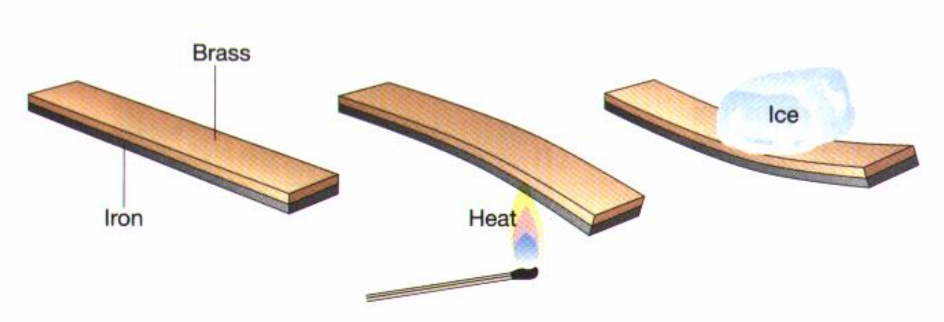
Gases > Liquids > Solids

Solids:

- Solids ***expand*** upon ***increase in temperature***, based on three factors:

  1. **increase in temperature**
  2. **the original length**
  3. **type of material**

- A practical use of ***thermal expansion*** of metals is use of ***bimetallic*** strip in operation of a ***thermostat***.



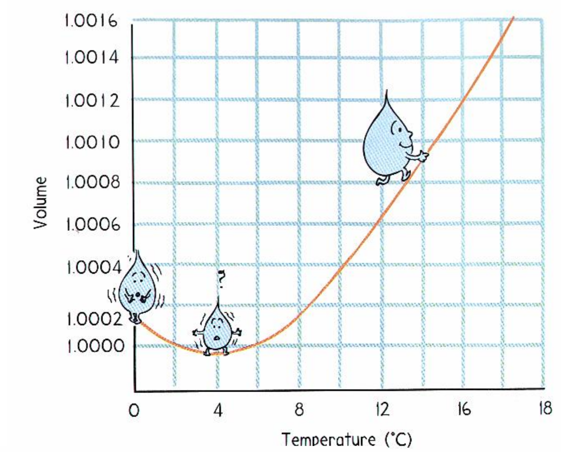
Liquids:

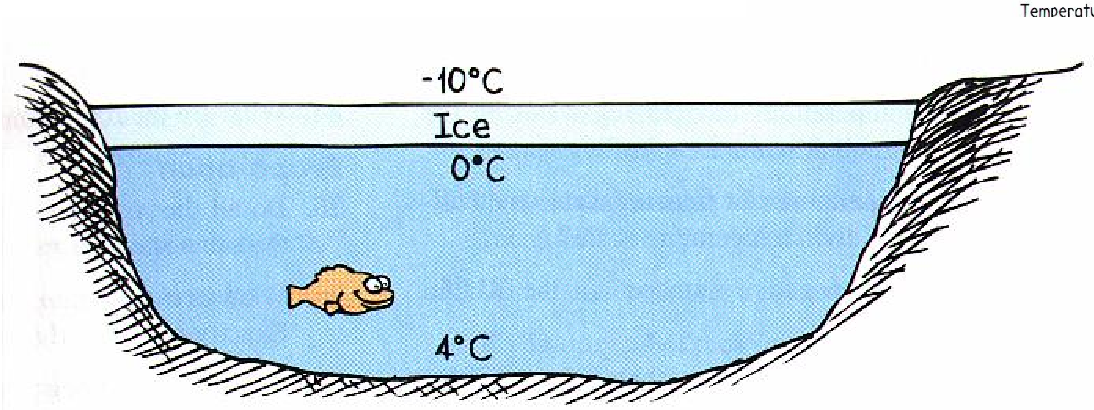
- When ***water at 0 ℃ is heated***, it first ***contracts*** and then ***expands***.

- Water has its ***smallest volume at 4 ℃***. Above and below this temperature it expands.

- Since density is ***inversely*** proportional to volume, water has its ***highest density at 4 ℃***.

- Thermal behavior of water is important in preserving aquatic life in colder climates. As ***water cools*** at the surface, it ***sinks due to its high density***, allowing for ***water circulation***.



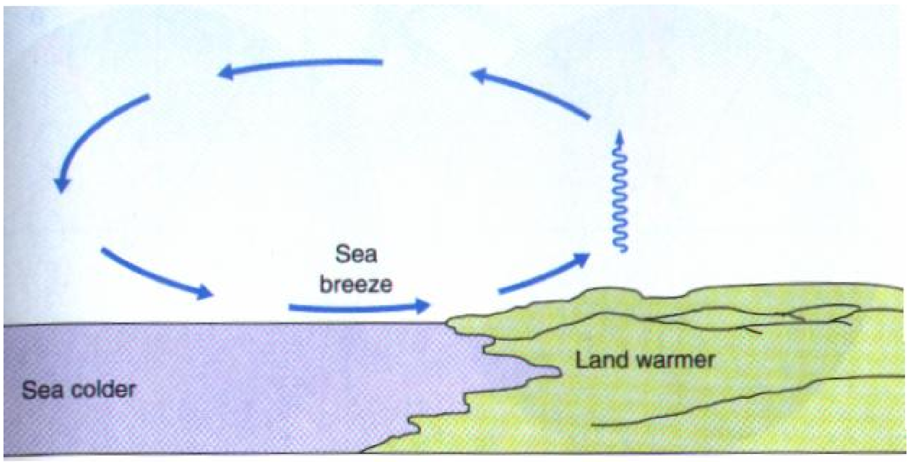


- When water ***cools below 4 ℃***, it becomes ***less dense*** and remains on surface. Large bodies of water ***freeze from top***, allowing for marine life to exist below the surface.

THERMAL CIRCULATIONS

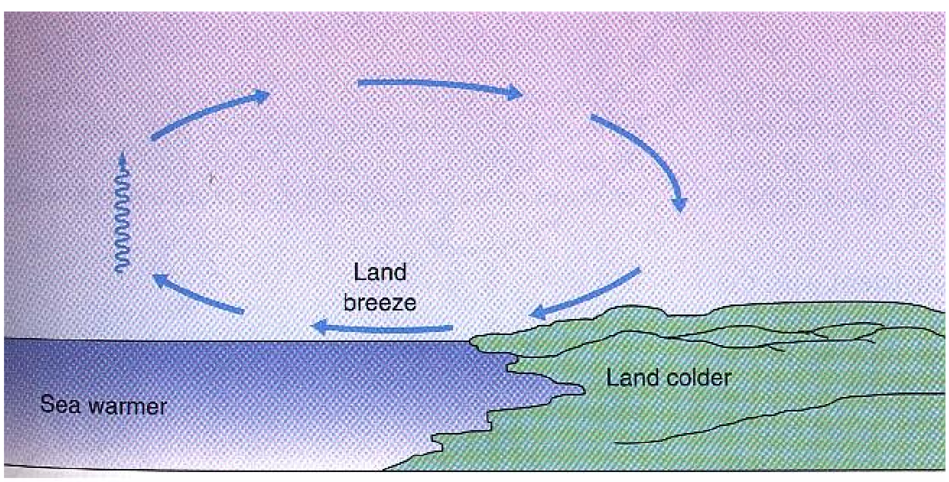
- The ***difference*** in the ***specific heat*** of water and land cause the land to ***warm up more quickly*** during the day.

- The ***less dense*** warm air ***rises***, and is ***replaced by cool air*** from the sea, causing a ***sea breeze***.



(a) Day

- During the night, the land ***cools faster*** than the sea, reversing the process, and causing a ***land breeze***.



(b) Night