4.9 Thermal Energy

Heat vs. Temperature

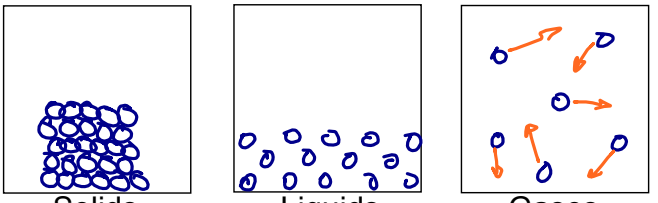
Thermal energy (Q) also known as heat, is the total amount of kinetic and potential energy of the particles in an object

Temperature, however, is a measure of the average thermal energy (heat) of the particles in a substance.

ex. Which contains more heat, a pot of boiling water or an iceberg? Why?

the iceberg... way more particles !!

Atoms and molecules are in constant motion:



Solids Liquids Gases

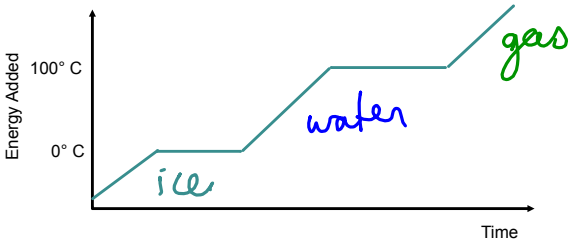
When a material is heated, the molecules move faster and as a result, will generally expand

If an object is heated, it will either

1) increase in temperature

or 2) change states

Consider the heating curve for H_2O



Heat will always flow from high to low concentration by either

1) Conduction (contact)
2) Convection (movement of fluid)
3) Radiation (no medium required)

The amount of heat transferred to an object is found with the equation:

$$Q = mc\Delta T$$

where Q = *heat (J)* — energy

m = *mass (kg)*

c = *Specific heat capacity (J/kg°C)* — each substance has a different

ΔT = *change in temperature (°C)*

Specific Heat Capacities

Water	4180
Carbon	720
Iron	460
Copper	390
Lead	130

ex. Mr. Grottoli makes a 250 g cup of boiling water that is initially 15°C. How much thermal energy is needed?

0.25 kg

$T_f = 100°C$

$T_i = 15°C$

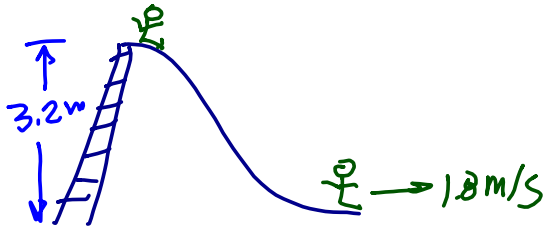
$\Delta T = 100 - 15 = 85°C$

$Q = mc\Delta T$

$= (0.25\,kg)(4180\,J/kg°C)(85°C)$

$= 89\,000\,J$

ex. A 35 kg child goes down a 3.2 m high slide. The child is initially at rest and moving at 1.8 m/s at the bottom of the slide. If the slide is made of 12 kg of iron and all the energy lost due to friction goes into heating up the slide, by how much does the temperature of the slide increase?



$E_{K_i}^{0} + E_{P_i} = E_{K_f} + E_{P_f}^{0} + Q$

$E_{P_i} = E_{K_f} + Q$

$Q = E_{P_i} - E_{K_f}$

$= mgh - \frac{1}{2}mv^2$

$= (35)(9.8)(3.2) - \frac{1}{2}(35)(1.8)^2$

$Q = 1041\,J$ ← goes into heating the slide

Now

$\frac{Q}{mc} = \frac{mc\Delta T}{mc}$

$\Delta T = \frac{1041\,J}{(12\,kg)(460\,J/kg°C)}$

$\Delta T = 0.19°C$

Practice: handout - #1-5