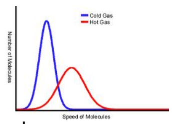
## Chapter 12 - Temperature and Heat

**Temperature** = avg KE of molecules in an object or sample of gas




- Some molecules move faster and some move slower
- Measured in °C, °F, or K
- K = absolute Temperature scale = no negative numbers
- -273 C = 0 K

## Temperature conversions

**Temperature Conversion Formulas**

Equations for converting between Celsius (C), Fahrenheit (F), and Kelvin (K) temperature scales

$°F = 1.8\,°C + 32$ (i)

$°C = (°F - 32) / 1.8$ (ii)

$K = °C + 273$ (iii)

Note:

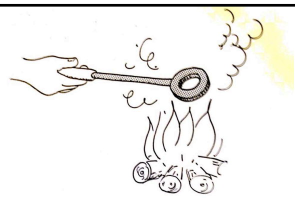
1. Fahrenheit is MOST accurate
2. Celsius is based on water
3. Kelvin is SI unit
4. $\Delta T\ C = \Delta T\ K \neq \Delta T\ F$

## Demo - bimetallic strip

## Thermal Expansion

Most object/samples expand as temperature increases

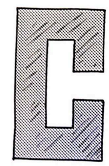
Materials DO NOT expand at same rate



WHEN THE TEMPERATURE OF A METAL RING INCREASES, DOES THE HOLE BECOME LARGER? SMALLER? OR STAY THE SAME SIZE?



WHEN THE TEMPERATURE OF THE PIECE OF METAL IS INCREASED AND THE METAL EXPANDS, WILL THE GAP BETWEEN THE ENDS BECOME NARROWER, OR WIDER, OR REMAIN UNCHANGED?



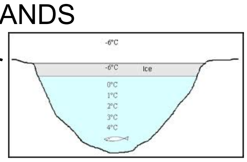


Water is the only material that when heated actually contracts

Water is MOST dense at 4$^{o}$C

From 0 to 4$^{o}$C water EXPANDS

Hence ice floats on water




Check Questions:

1) What is the temperature of water at the bottom of Lake Erie?

2) What is the temperature of water at the bottom of Lake Tahoe?

3) What is the temperature of water at the bottom of a puddle?

## Equations for Thermal Expansion

$\Delta L = \alpha L_o \Delta T$

where $\alpha$ = coefficient of linear expansion

$\Delta V = \beta V_o \Delta T$

where $\beta$ = coefficient of volumetric expansion

**Heat**- energy that flows from higher temperature to lower temperature due to a temperature difference

- Heat IS NOT Temperature
- *Demo - paper cup and water, hot and cold water*

## Equation

$\Delta Q = mc\Delta T$

Q = heat

units = Joules = J

c= specific heat = energy needed to raise or lower temperature of 1 g of the substance 1 $^oC$

****how fast or slow material heats or cools

units = J/kgK ****note /C or /K = SAME!!!

$c_{water}$ = 1 cal/g$^o$C = 4.18 J/g$^o$C = 4180 J/kgK

This is VERY high!!!

Most metals have a very low c (less than 1 J/g$^o$C)

Demo - peanuts calories

Check Q's:

1. Why is San Francisco always cool and about the same temperature?
2. Why is a desert VERY cold at night and VERY hot during the day?

Boiling water with ice demo

States of matter

latent heat absorbed — latent heat absorbed

solid → liquid → gas (cooling process)

gas → liquid → solid (warming process)

latent heat released — latent heat released

## Latent Heat

As materials change state, they do NOT change temperature

Energy is being absorbed or released

This energy is stored in the molecules = latent heat

solid ↔ liquid = latent heat of **fusion**

liquid ↔ gas = latent heat of **vaporization**

melting

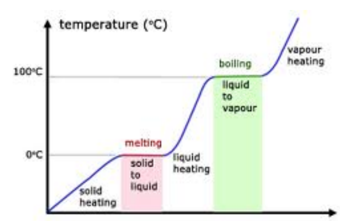
freezing

vaporization

condensation

Check questions:

1. Why do you feel cold when you stand on the pool deck on a windy day?
2. Why do you feel warm when you stay in the shower stall?
3. Why does rubbing alcohol feel cold when placed on your skin?




$\Delta Q = mL_f$ $L_f$ = latent heat of fusion

$\Delta Q = mL_v$ $L_v$ = latent heat of vaporization

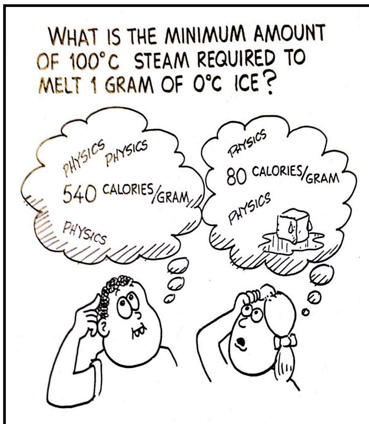
Check Questions:

1) A piece of iron at 100$^{o}$C is placed in 100 ml of water at 20$^{o}$C

a) How does the temperature change of the iron compare to the temperature change of the water?

b) How does the heat change of the iron compare to the heat change of the water?

What would the equation look like for the proceeding question?






Water freezes at _____ and boils at ____. The latent heat of vaporization for water is 2.26 x 10$^{6}$ J/kg and the latent heat of fusion for water is 3.35 x 10$^{5}$ J/kg. How much heat is absorbed as 5 kg of ice at -20$^{o}$C changes to 5 kg of steam at 110$^{o}$C?

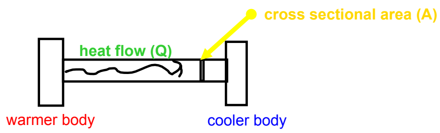
*Chapter 13.2 - conduction*

The rate at which heat travels through a solid

$$Q = \frac{kA\Delta T t}{L}$$

k = thermal conducitivty constant (J/(sm°C))

t = time (s)




## Chapter 14 - Ideal Gas Law

*Chemistry review*

Mole = unit of measurement

1 mol of gas at STP = $6.02 \times 10^{23}$ particles = 22.4 L

STP = $1 \times 10^{5}$ Pa and 273 K

Atomic mass unit = u = number on periodic table = mass per mole

1 u = $1.66 \times 10^{-27}$ kg

Molecular mass = add atomic mass of atoms

ex. water = $H_2O$ = 2(1u) + 1(16u) = ~~18 u/mol~~
= 18 g/mol
= 18 kg/kmol

$N_A$ = Avogadro's number = $6.02 \times 10^{23}$ = particles/mol

n = # of moles = $N/N_A$    N = # of particles

**Sample Q**

**How many moles are in 140 g of $N_2$ gas at STP?**

## Ideal Gas Law

All "ideal gases" obey the following equations

$PV = nRT$

R = ideal gas contant = 8.31 J/mol K

use with moles

or

$PV = Nk_BT$

$k_B$ = Boltzman's constant = $R/N_A$

= $1.38 \times 10^{-23}$ J/K....use with particles

Ideal Gas Law can be modified if...

**Constant P = Charles' Law**

$V/T = V/T$

**Constant T = Boyle's Law**

$PV = PV$

**Constant V = Guy-Lusaac's Law**

$P/T = P/T$

Contant n

$$\frac{PV}{T} = \frac{PV}{T}$$

Internal Energy

= stored energy

object CANNOT contain heat

They DO contain stored energy (internal energy)

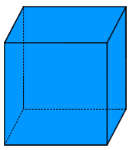
U = KE + U of molecules = internal energy

Internal Energy and KE of gasses

$KE = 1/2mv^2$ AND KE is proportional to Temperature

$PV = NkT$ so let's put these together

$P = F/A$ and $F = \Delta p/t$



As molecules hit the box they change mometum and exert a force which causes Pressure within a given volume

$t = 2L/v$ and $V = L^3$ and $\Delta p = -mv - mv = -2mv$ and there are THREE directions so only hit 1/3 of time

so.... $\frac{PV}{3} = \frac{FV}{3tA} = \frac{-2mv(L^3)}{3(2L/v)L^2} = \frac{mv^2}{3}$

however...there are N particles at any given time and they are moving at

vrms (root mean square) ...like an average so...

$PV = mv^2/3 \quad = 2/3N(1/2mv_{rms}^2)$

this means...

$PV = 2/3N(KE) = NkT$ rearranging gives

$KE = \boxed{1/2mv^2 = 3/2kT}$

$3/2NkT = 3/2nRT$ = Internal Energy ALWAYS!!!!!

$\boxed{U = 3/2nRT}$

$\boxed{U = 3/2NkT}$

****remember all equations with T MUST be in Kelvin*******

Fick's Law of Diffusion

Like conduction but through a gas

$\boxed{m = \frac{DA\Delta Ct}{L}}$

D = diffusion constant ($m^2/s$)

C = concentration ($kg/m^3$)

t= time

A = cross sectional area

L = distance between regions of various concentrations