Power

If a constant force is used to push an object at a constant velocity, the power produced by the force is the force times its velocity:

$$P = \frac{W}{\Delta t} = \frac{F\Delta d}{\Delta t} = Fv$$

Sample Problem #5

A crane is capable of doing 1.50×10^5 J of work in 10.0 s. What is the power of the crane in watts?

W= 1.50×10^5 J

Δt = 10.0 s

P = ?

$$P = \frac{W}{\Delta t} = \frac{1.50 \times 10^5 J}{10.0\ s} = 1.50 \times 10^4\ W = 15.0\ kW$$

Efficiency

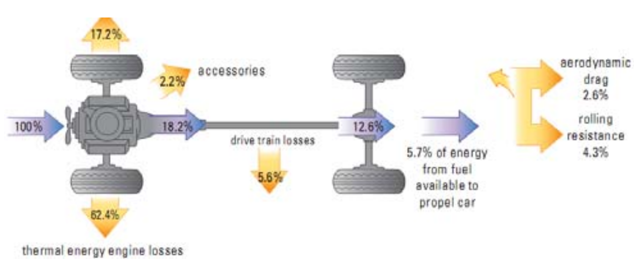
Efficiency is the ratio of useful energy or work output to the total energy or work input:

$$\eta = \frac{E_o}{E_i} \times 100\% \qquad \eta = \frac{W_o}{W_i} \times 100\%$$

Quantity	Symbol	SI Unit
Useful output energy	E_o	J (joules)
Input energy	E_i	J (joules)
Useful output work	W_o	J (joules)
Input work	W_i	J (joules)
Efficiency	η	no unit

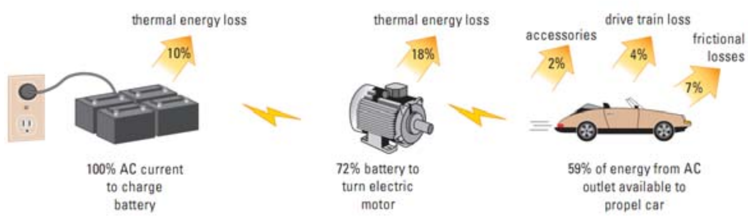
Internal Combustion Engine

Most of the energy from the combustion is converted into heat, which cannot do useful work (i.e. drive a car forward)



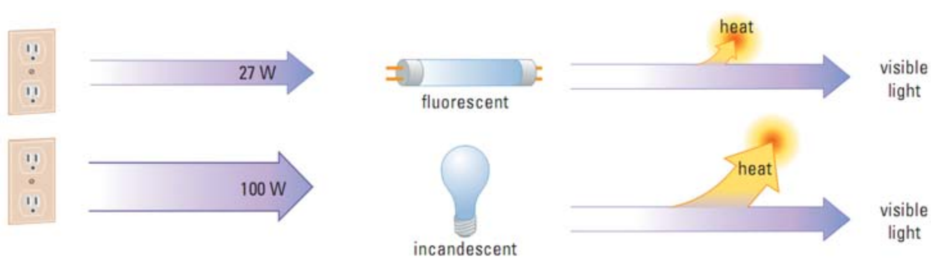
Electric Motors

This diagram is a bit outdated: electric motors used in solar-powered cars were already 93 to 96 % efficient in late 1990's. This diagram shows that electric cars are much more efficient than internal combustion cars.

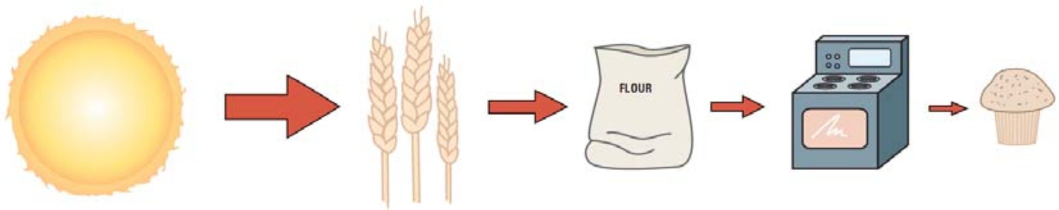


Light Bulbs

LED (light-emitting diodes) lights are even more efficient than fluorescent lights



Sunlight to Food



Sample Problem #6

A model rocket engine contains explosives storing $3.50\text{x}10^3$ J of chemical potential energy. The stored chemical energy is transformed into gravitational potential energy at the top of the rocket's flight path. Calculate how efficiently the rocket transforms stored chemical energy into gravitational potential energy if 0.500 kg rocket is propelled to a height of $1.00\text{x}10^2$ m.

$E_k = 0$, $E_g = mgh = (0.500\text{ kg})((9.81\text{m/s}^2)(1.00\text{ x}10^2\text{ m}) = 4.91 \text{ x } 10^2$ J, $E_{chem} = 0$,
$E_{T2} = 4.91 \text{ x } 10^2$ J

$$\eta = \frac{E_{T2}}{E_{T1}} = \frac{4.91\times10^2 J}{3.50\times10^3 J} = 0.14 = 14\%$$

$E_k = 0$, $E_g = 0$, $E_{chem} = 3.50\text{x}10^3$ J, $E_{T1} = 3.50\text{x}10^3$ J

Unit 5 – Heat, Nuclear Energy and Energy Transformation

- Grade 11 Physics
- Olympiads School

Thermal Energy

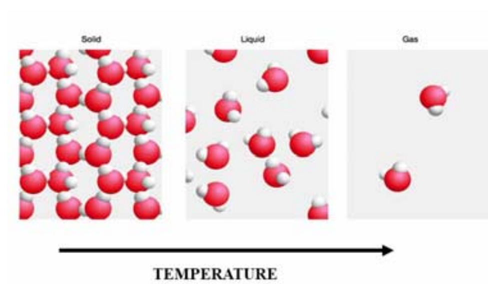
Kinetic Molecular Theory

All matter is composed of particles that are always in random motion.

- The particles exerts forces on one other that keep them a certain distance apart
- The distances between particles and the strength of force between them is responsible for three physical states of matter: solid, liquid and gas
- The motion of these particles is due to energy transformations between electrostatic potential energy and particle kinetic energy. The total thermal energy accounts both of these energies

Kinetic Molecular Theory

- Hotter objects:
  - Molecules have more kinetic energy
  - Moving more rapidly
- While, in colder objects:
  - Molecules have less kinetic energy
  - Do not move as rapidly



Thermal Energy

A total **kinetic** energy of **all** atoms or molecules of a substance due to their constant, random motion.

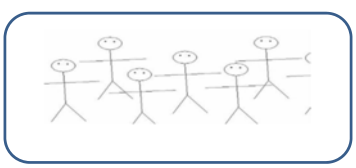
Thermal energy depends on :

- mass (number of molecules)
- temperature (speed of particles)
- substance (density, crystal structure, etc.)

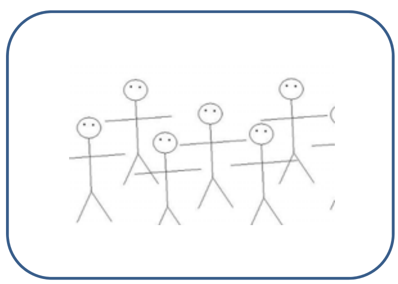
TEMPERATURE

A measure of average kinetic energy of atoms or molecules of the substance.

A good analogy to temperature is avg. height:



Grade 9 class: h_{av} = 162 cm

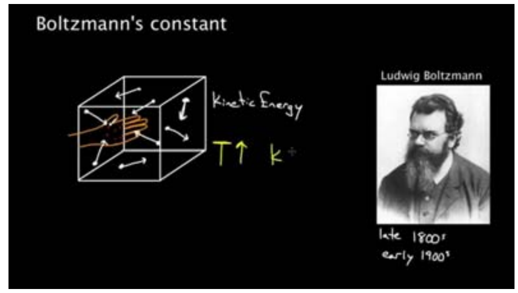


Grade 11 class: h_{av} = 167 cm

Boltzmann Constant

Average kinetic energy of a particle:

$$E_k = 3/2\ k\ T$$



$k = 1.38 \times 10^{-23}$ J/K (the Boltzmann constant)

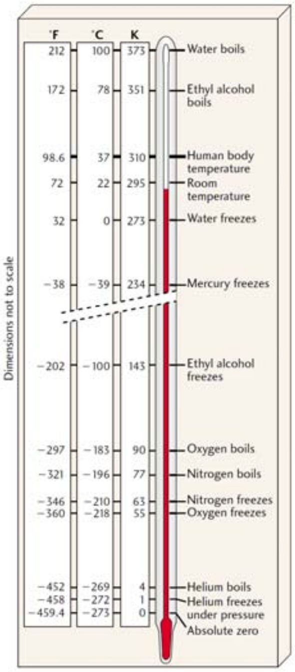
T – absolute temperature in Kelvins

Temperature Scales

Q: ***What temperature scales do you know?***

- Celsius Scale (^oC)
- Fahrenheit Scale (^oF)
- Kelvin Scale (K)

Fig.8.4 A comparison of three different temperature scales



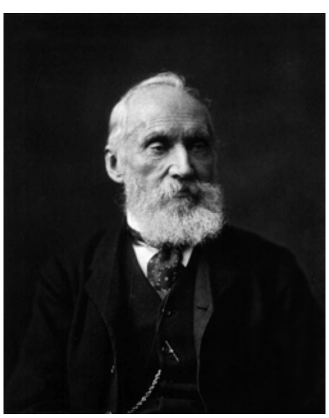
Temperature Scales

Celsius. Anders Celsius used the freezing and boiling points of water for his two calibration points of reference. He then divided this range into 100 degrees. *A lowercase* t *represents Celsius temperature*.

Fahrenheit. Daniel Fahrenheit used the lowest temperature of an ice-salt bath and body temperature to calibrate his thermometers. On this scale, freezing and boiling points appeared at 32°F and 212°F, respectively.

Kelvin. William Thomson (Lord Kelvin) devised a scale to put zero at the lowest possible temperature, when all molecular motion stops. The size of a degree Kelvin is the same as that of a egree Celsius. The lowest temperature is called absolute zero and is determined experimentally to be - 273°C. The SI unit of temperature is the kelvin (K) without a ° symbol. The freezing point of water is 273 K and the boiling point of water is 373 K.

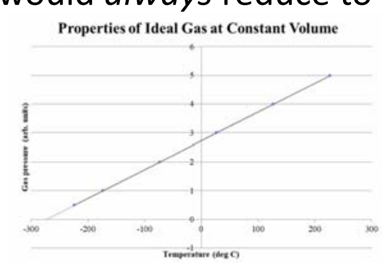
Absolute Temperature



William Thomson
1st Baron Kelvin (Lord Kelvin)

Thomson discovered that when different gases are cooled at constant volume:

- The relationship between pressure and temperature is *always* a straight line
- Pressure would *always* reduce to 0 at −273.15°C



The Kelvin Scale

The absolute temperature is related to the Celsius scale by a constant:

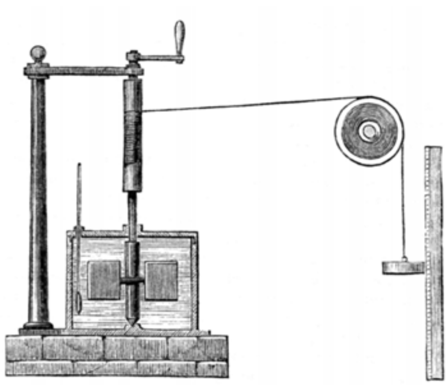
$$T = T_C + 273.15$$

Quantity	Symbol	SI Unit
Temperature in kelvin	T	K (kelvin)
Temperature in degree Celsius	T_C	(°C is not an SI unit)

The difference between the absolute and Celsius scales is only where zero is defined, therefore the change in temperature in both scales are the same, i.e.

$$\Delta T = \Delta T_C$$

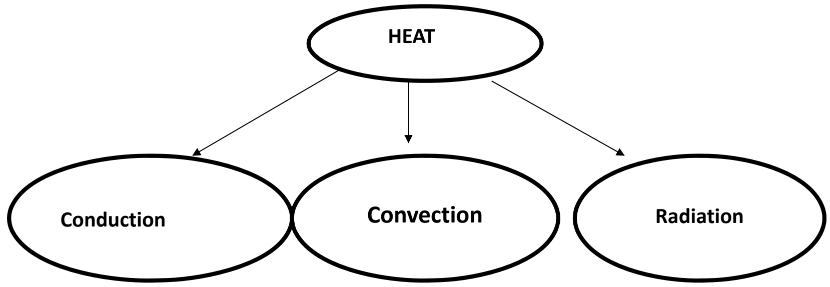
Heat – Thermal Energy Transfer



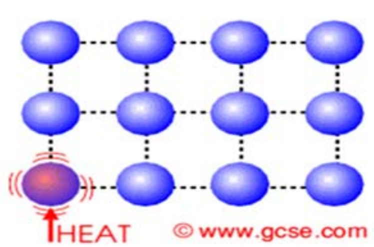
James Prescott Joule's experiment in June 1849 was the first definitive work to show the equivalence of heat and mechanical work (i.e. proving that heat is a form of energy)

- Water in an insulated container
- A thermometer is used to measure temperature
- A falling weight stirs the water inside
- Mechanical work is done on the water
- Temperature in the water is raised

Methods of Heat Transfer



CONDUCTION



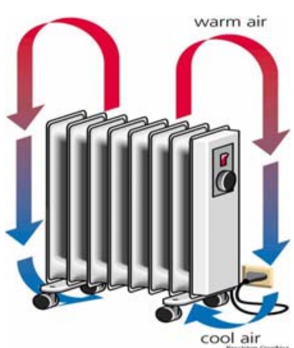
CONDUCTION: the process by which the collision of atoms and electrons transfers heat trough a material or between two materials in contacts. Metals are usually good heat conductors, but diamond has highest heat conductivity.

Relative Thermal Conductivities

Table 8.3
Thermal Conductivities

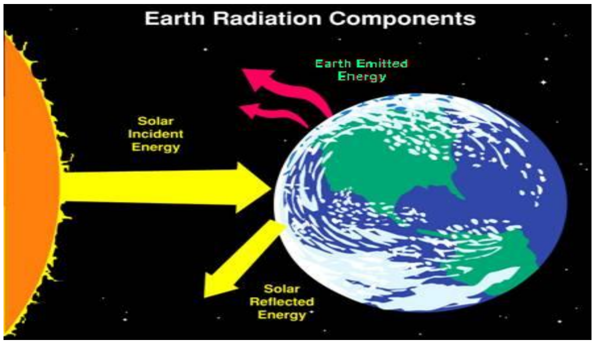
Material	Relative conductivity
Air	1.0
Down	1.1
Cork	1.8
Asbestos	6.7
Human tissue	8.7
Water	25
Glass	35
Brick	37
Concrete	37
Lead	1 400
Iron	2 800
Brass	4 600
Aluminum	8 800
Copper	16 000
Silver	17 000

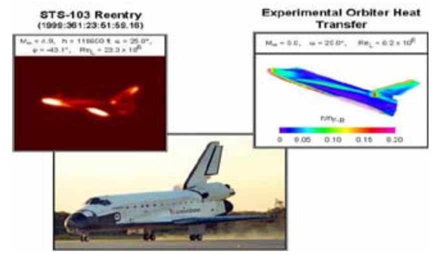
CONVECTION



CONVECTION: the process of transferring heat by a circlulating path of fluid (gas or liquid) particles.

RADIATION





RADIATION: the process in which energy is transferred by means of electromagnetic waves.

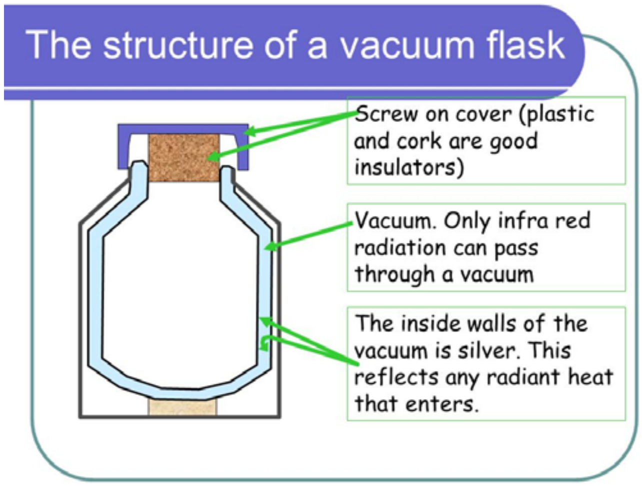
Thermal Radiation : Stefan – Boltzmann Law

For hot objects, the law of thermal radiation is expressed in the form:

$$\frac{P}{A} = e\sigma T^4$$

where e is the emissivity of the object ($e = 1$ for ideal radiator), $\boldsymbol{P}$ is the thermal power transmitted per unit area $\boldsymbol{A}$, and σ is the Stefan-Boltzmann constant. T is the temperature in K.

Controlling Heat Transfer



THERMAL ENERGY

For a particle:
$E_k = 3/2\ k\ T$

$$E_{th} = m\ c\ T$$

Kinetic energy cannot be negative, thus T cannot be negative, too.

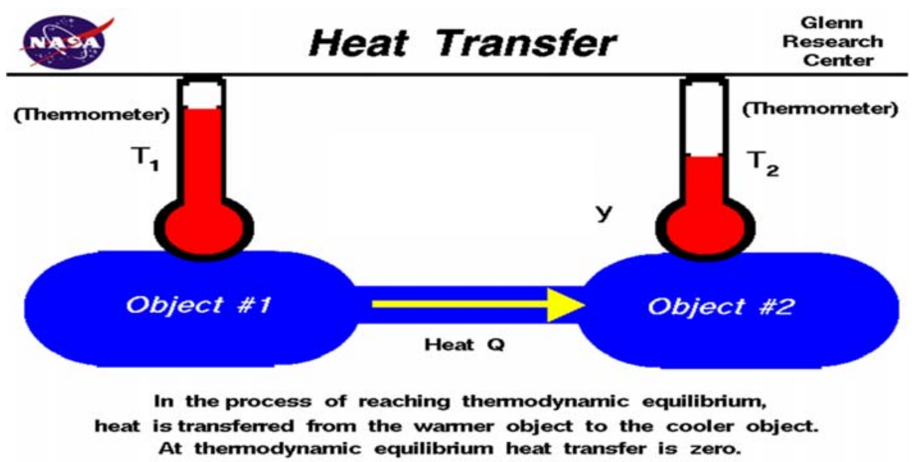
mass

Constant, depends on substance

Temperature in kelvins!

HEAT

Heat is a measure of thermal energy transferred from a warmer body to a cooler body.



HEAT

Heat is a transfer of thermal energy

$$Q = \Delta E_{th}$$

As a result of heat, the thermal energy and the temperature of an object of an object change,

$$\Delta T = T_f - T_i$$

$$\mathbf{Q = \Delta E_{th} = mcT_f - mcT_i = mc\,\Delta T}$$

$$\boxed{\mathbf{Q\ = mc\,\Delta T = mc\,\Delta t}}$$

kelvins *celsius*

Heat Required for a Temperature Change

Heat required to change the temperature is the product of **mass** m, **specific heat capacity** c, and **temperature change** ΔT, assuming that no work is done:

$$Q = mc\Delta T$$

Quantity	Symbol	SI Unit
Amount of heat transferred	Q	J (joules)
Mass	m	kg (kilogram)
Specific heat capacity	c	J/kg.K (joules per kilograms per kelvin)
Change in temperature	ΔT	K (kelvins)

Specific Heat Capacity

Specific heat capacity, c, is the amount of energy needed to raise 1 kg of a substance by 1 K.

Substance	Specific Heat Capacity J/kg · °C
Liquids	
ethyl alcohol	2450
glycerin	2410
mercury	139
water (15° C)	4186

Specific Heat Capacity

Substance	Specific Heat Capacity J/kg · °C
Solids	
aluminum	900
copper	387
glass	840
human body (37°C)	3500
ice (−15° C)	2000
steel	452
lead	128
silver	235

Specific Heat Capacity (Cont.)

	Specific heat capacity J/kg · °C	
Gas	Constant pressure, c_p	Constant volume, c_v
ammonia	2190	1670
carbon dioxide	833	638
nitrogen	1040	739
oxygen	912	651
water vapour (100°C)	2020	1520

All values are for 15°C and 101.3 kPa of pressure, except for water vapour.

Sample Problem #1

A 55.0 kg person going for an hour-long, brisk walk generates approximately 6.50×10^5 J of energy. If the body's temperature regulating systems did not remove this thermal energy, by how much would the walker's body temperature increase?

m = 55 kg
Q = 6.50×10^5 J
c = 3500 J/kg K
ΔT = ?

Q = mc ΔT

$$\Delta T = \frac{Q}{mc} = \frac{6.50\times10^5 J}{(55\text{ kg})(3500\text{ J/kg K})} =$$

3.4 K = 3.4^0C

ΔT= 3.4^0C *(dangerous level!)*

Sample Problem #2

A typical warm-water shower without an energy-saving showerhead) consumes 130 kg of water at a temperature of 65.0˚C.

- Calculate how much energy is required to heat the water if it begins at a temperature of 15.0˚C.
- Calculate the electrical cost of the shower if the utility company's charge is $0.15 per kilowatt-hour (kWh). A kilowatt-hour is a convenient way for electrical utility companies to track the amount of energy that your home consumes in a month.

Solution

m = 130 kg
$t_2 = 65^0C$
$t_1 = 15^0C$
$c = 4186\ J/kg^0C$
r = \$0.15/kWh
Payment, P = \$?

$Q = mc\Delta t = (130\ kg)(4186\ J/kg^0C)(65^0C - 15^0C) = 2.7 \times 10^7\ J$

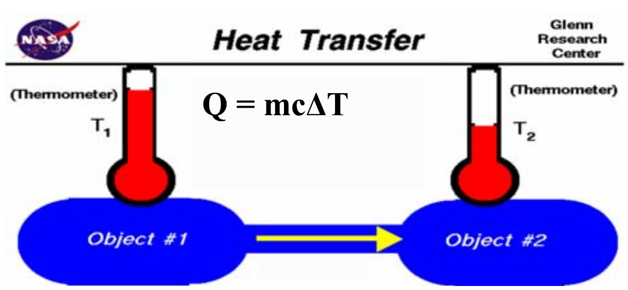
$1kWh = 1000 \times 3600\ Ws = 3.6 \times 10^6\ J$

$r = \$0.15/kWh = \$0.15/3.6 \times 10^6\ J = \$4.2 \times 10^{-7}/J$

$P = r\,Q = (\$4.2 \times 10^{-7}/J)(2.7 \times 10^7\ J) = \$11.13$ *(s.f.?)*

The Principle of Heat Exchange

(The law of conservation of thermal energy)



Q_1 - ENERGY LOST Q_2 - ENERGY GAINED

$$Q_1 + Q_2 = 0 \qquad Q_1 = -Q_2$$

Sample Problem #3

2.0 kg of water at 20.0^0C was mixed with 4.0 kg of water at 70.0^0C. Find the final temperature of the mixture.

$m_1 = 2.0$ kg
$t_1 = 20.0^0$C
$m_2 = 4.0$ kg
$t_2 = 70.0^0$C

$t_f = ?$

$Q_1 + Q_2 = 0$ *(The Law of Conserv. of Thermal Energy)*

$Q_1 = - Q_2$

$m_1 c \Delta t_1 = - m_2 c \Delta t_2$

$\Delta t_1 = t_f - t_1$, $\Delta t_2 = t_f - t_2$

$m_1(t_f - t_1) = - m_2(t_f - t_2)$,
solve it for t_f

$$t_f = \frac{m_1 t_1 + m_2 t_2}{m_1 + m_2}$$

$$t_f = \frac{(2.0)(20.0)\ \text{kg}^0\text{C} + (4.0)(70.0)\ \text{kg}^0\text{C}}{(2.0 + 4.0)\text{kg}}$$

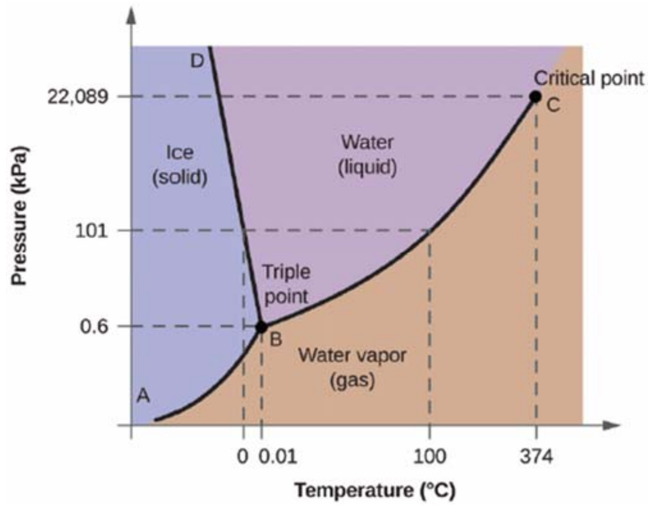
$t_f = 53\ ^0$C

Phase Change

We generally understand that there are three phases of matter: solid, liquid and gas (vapour)

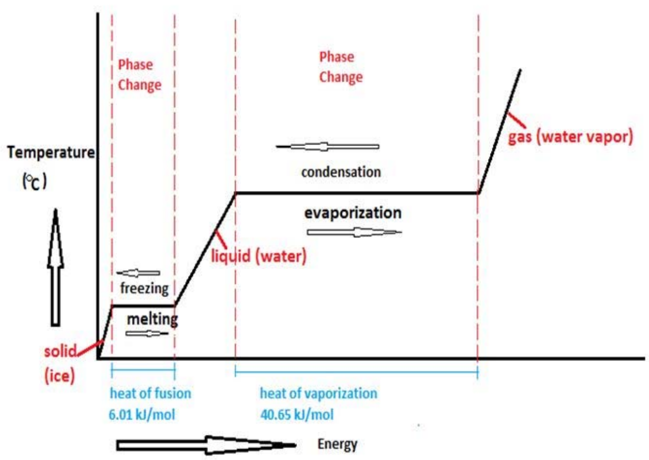
- **Melting:** from solid to liquid
- **Freezing:** from liquid back to solid
- **Boiling:** from liquid to gas
- **Condensing:** from gas back to liquid
- **Sublimation:** from solid directly to gas
- **Deposition:** from gas directly to solid

Phase Diagrams



- Which phase exists depends on pressure and temperature.
- For example, water in its liquid form cannot exist below 6 kPa, and so adding enough energy to ice will directly change it to water vapour.

Heat Diagram of H_2O



During phase change, heat is either added or taken away from a substance, but the temperature does not change.

Phase Change

Specific latent heat is the amount of heat required to change the phase of 1 kg of a substance. In Grade 11 Physics, we are only concerned with latent heat of fusion L_f (for melting and freezing) and latent heat of vapourization L_v (boiling and condensing) at atmospheric pressure

$$Q = mL_f \qquad Q = mL_v$$

Quantity	Symbol	SI Unit
Heat required to change state	Q	J (joules)
Mass	m	kg (kilograms)
Specific latent of fusion	L_f	J/kg (joules per kilogram)
Specific latent of vapourization	L_v	J/kg (joules per kilogram)

Specific Latent Heat

Specific latent heat values for some common substances:

Substance	Latent heat of fusion L_f (J/kg)	Latent heat of vaporization L_v (J/kg)
helium	5 230	20 900
oxygen	13 800	213 000
ethyl alcohol	104 000	854 000
water	334 000	2 260 000
lead	24 500	871 000
gold	64 500	1 578 000

Sample Problem #4

When the ambient temperature is higher than your body temperature, the only way your body can rid itself of excess heat is by sweating. The sweat evaporates from the surface of your skin by absorbing energy from your body, thus lowering your temperature. Calculate the amount of energy that must be absorbed to evaporate 5.0 g of water.

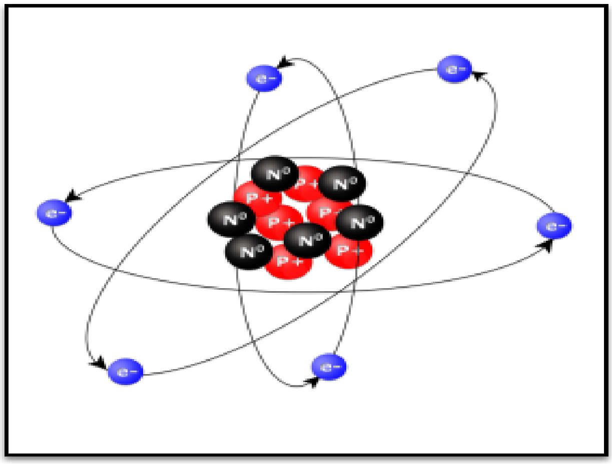
$m = 5.0 \times 10^{-3}$ kg
$L_v = 2.26 \times 10^{6}$ J/kg
$Q = ?$

$Q = m L_v = (5.0 \times 10^{-3} \text{ kg})(2.26 \times 10^{6} \text{ J/kg}) = 1.1 \times 10^{4}$ J

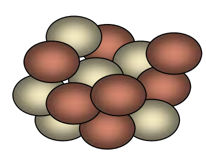
$Q = 1.1 \times 10^{4}$ J

Nuclear Physics

Model of an Atom



Properties of the nucleus



Consists of protons p^+ and neutrons n^0

Z= # of protons,(Atomic number)

(Z is also the electric charge of a nucleus)

N= # of neutrons (Neutron number)

A = Z+N (Mass number)

Notation: $^{A}_{Z}X$

Example: $^{4}_{2}He$ $^{0}_{-1}e$

Units in Nuclear Physics

Energy:

J - Joule big unit

eV – Electron volt – small unit

$$1\ \mathrm{eV} = 1.602 \times 10^{-19}\ \mathrm{J}$$

Also, energy can be expressed in MeV

$$1\mathrm{MeV} = 10^{6}\ \mathrm{eV}$$

Units in Nuclear Physics

Mass:

kg - kilogram *(big unit)*

u – atomic mass unit *(small unit)*

$$1\ \mathrm{u} = 1/12\ m\,(^{12}\mathrm{C\ atom})$$

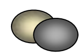
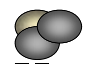
$$1\mathrm{u} = 1.66 \times 10^{-27}\ \mathrm{kg}$$

Isotopes

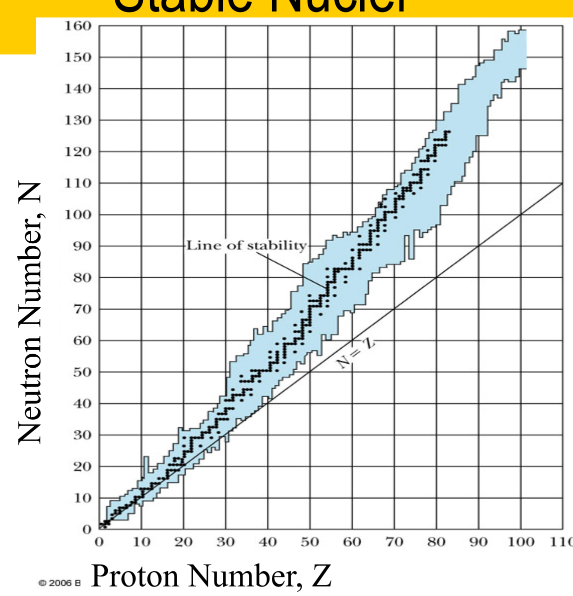
Isotopes are nuclei that have the same no. of protons, but different no. of neutrons

The chemical properties are the same, but nuclear properties are different. Some isotopes may be unstable and are radioactive

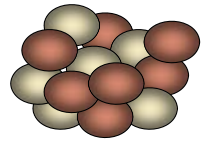
Examples

hydrogen	deuterium	tritium
		
${}^{1}_{1}\mathrm{H}$	${}^{2}_{1}\mathrm{H}$	${}^{3}_{1}\mathrm{H}$
stable	stable	radioactive

Stable Nuclei



Forces in the nuclei



1. **Coulomb force** (Electrostatic repulsion between protons

2. **Strong nuclear force** (Attraction between proton-proton, proton-neutron that is independent on charge)

Equivalence of mass and energy

A famous result from Einstein's Special Theory of Relativity

$$E = mc^2$$

$$1uc^2 = 931.5\ MeV$$

$$1u = 931.5\ MeV/c^2$$

Mass can be converted into energy

Energy equivalent of an electron mass:

$E= mc^2 = (9.1x10^{-31}\ kg)(3x10^8\ m/s)^2 = 8.2x10^{-14}\ J = 5.1x10^5\ eV = 0.51\ MeV$

An electron can be annihilated(converted completely to energy). A 0.51MeV photon is produced.

Binding Energy

The binding energy, *B*, of the nucleus can be determined by measuring the mass of the components and the final product

m_{p+} = 1.007 280 u

m_n = 1.008 665 u

Mass of $^{12}_{6}C$ = 12 u

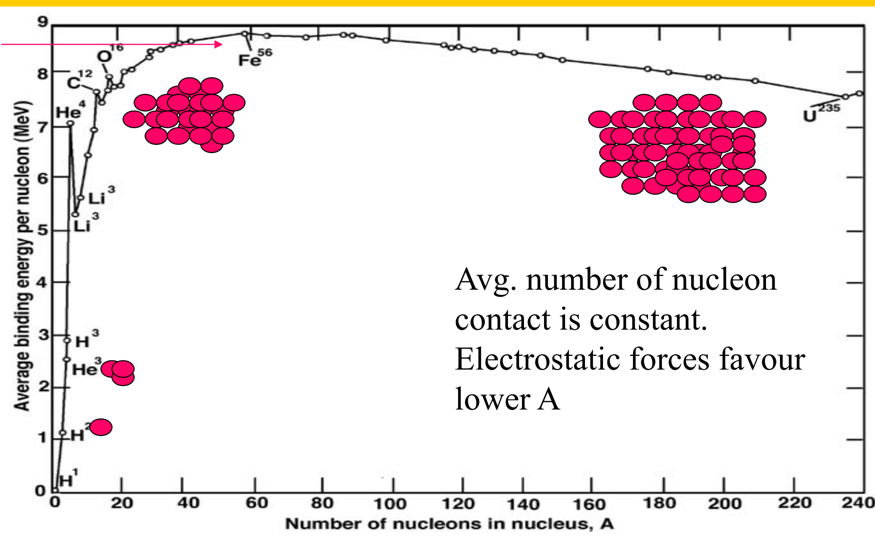
$6 \times 1.007\,28 + 6 \times 1.008665 = 12.096$ u

$$\Delta m = 0.096\ u$$
$$1u = 931.5\ MeV/c^2$$
$$\Delta m = 89.4\ MeV/c^2$$
$$E = 89.4\ MeV,\ A = 12$$
$$E/A = 89.4\ MeV/12$$
$$E/A = 7.5\ MeV$$
$$(Binding\ energy\ per\ nucleon)$$

Binding energy per nucleon, B/A

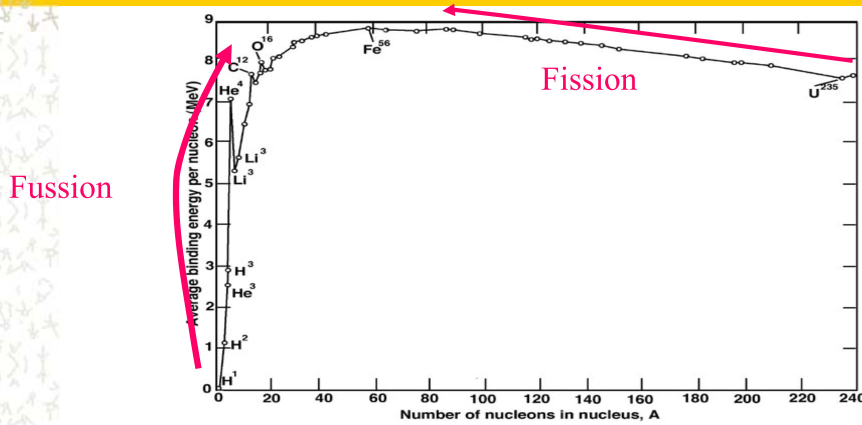
Maximum at ^{56}Fe

Average number of nucleon contacts increases with A



Avg. number of nucleon contact is constant. Electrostatic forces favour lower A

Binding Energy per Nucleon



Fussion of small nuclei increases binding energy

Fission of large nuclei increases binding energy

Binding energy – Sample problem

A deuteron is the name given to the nucleus of a deuterium atom. It is composed of a proton and a neutron. Calculate the binding energy per nucleon in a deuteron knowing that its mass is 2.013 553 u, m_p = 1.007 276 u and m_n = 1.008 665 u. (1 u = 931.5 MeV/c^2)

Answer: E = 1.11 MeV

Radioactivity

SPH 3 U

Monday, March 25, 2019

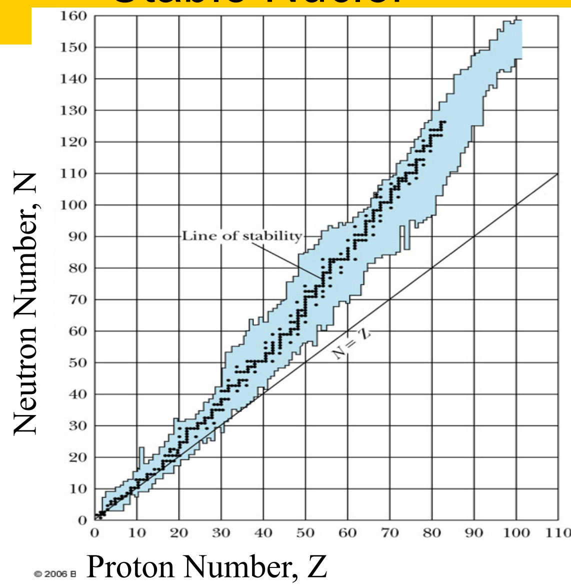
Radioactivity

The spontaneous emission of electromagnetic radiation or particles by a nucleus

Discovered in 1896 by Henri Becquerel in uranium ores

Pierre and Marie Currie isolated more radioactive elements

Stable Nuclei



Types of Radioactivity

Alpha (α) particles – $^{4}_{2}He$ nuclei (+2 charge)

Beta (β) particles – electrons (– charge)

positrons (+ charge)

Gamma (γ) particles – Electromagnetic radiation
(Uncharged)

Penetration Depth

alpha particles – Stopped by a sheet of paper

beta particles - Stopped by a mm of aluminum

gamma particles - Stopped by a few cm of lead

Alpha decay

When a radioactive material emits an α particle, the nucleus of one of its atom loses two protons and two neutrons, changing to another element. This process is called **transmutation**. The nucleus of a new atom is called the **daughter nucleus.**

$$ {}_{Z}^{A}X \rightarrow {}_{2}^{4}He + {}_{Z-2}^{A-4}Y $$

Sample problem

An unstable polonium atom spontaneously emits an α particle and transmutates into an atom of some other element. Show the process, including the new element.

$$\boxed{{}^{A}_{Z}X \rightarrow {}^{4}_{2}He + {}^{A-4}_{Z-2}Y}$$

$$ {}^{218}_{84}Po \rightarrow {}^{4}_{2}He + {}^{214}_{82}Y$$

$$ {}^{214}_{82}Y = {}^{214}_{82}Pb$$

Polonium transmutates into lead by α decay

Two forms of beta decay

In β^- decay, a neutron is replaced with a proton, β^- particle (a high-speed electron) and electron anti-neutrino

$$ {}^{1}_{0}\boldsymbol{n} \rightarrow {}^{1}_{1}\boldsymbol{p} + {}^{0}_{-1}\boldsymbol{e} + \bar{\boldsymbol{\nu}}_{\boldsymbol{e}}$$

In β^+ decay, a proton is replaced with a neutron, β^+ particle (a high-speed positron) and electron neutrino

$$ {}^{1}_{1}\boldsymbol{p} \rightarrow {}^{1}_{0}\boldsymbol{n} + {}^{0}_{+1}\boldsymbol{e} + \boldsymbol{\nu}_{\boldsymbol{e}}$$

Examples of Beta decay

For clarity, neutrinos have been omitted in the following nuclear reactions

$$^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$$

In general:

$$\boxed{^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e}$$

$$\boxed{^{A}_{Z}X \rightarrow {}^{A}_{Z-1}Y + {}^{0}_{+1}e}$$

Beta decay – Sample problem

An atom of sodium-24 can transmute into an atom of some other element by emitting β^- particle. Write down this reaction and identify the daughter element

$$\boxed{^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e}$$

$$^{24}_{11}Na \rightarrow {}^{24}_{12}Y + {}^{0}_{-1}e$$

$$^{24}_{12}Y = {}^{24}_{12}Mg$$

When sodium –24 undergoes β^- decay, magnesium-24 is produced.

Gama (γ) Decay

- During a nuclear reaction a nucleus may became excited, or "hot"
- Excited nucleus "cools down" to the lower energy state.
- Excessive energy is released as a high-energy **γ** photon
- No transmutation takes place during gamma emission.

$$ {}^{A}_{Z}X \rightarrow {}^{A}_{Z}Y + \gamma $$

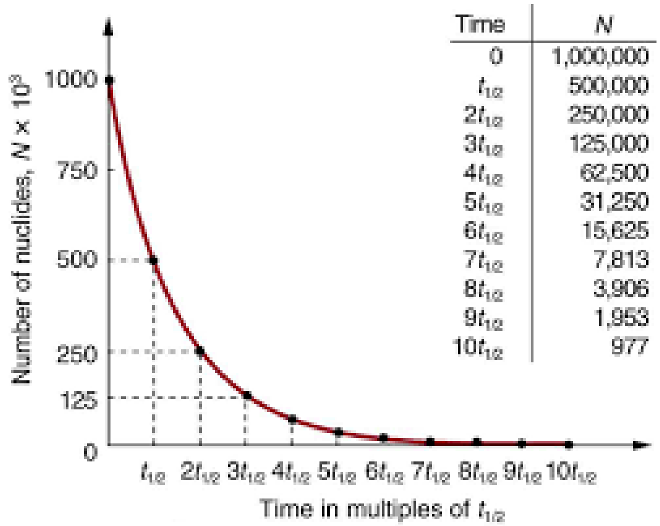
Rate of Radioactive Decay

- The probability of transmutation depends on the structure of the nucleus .
- As the result of a decay, the amount of radioactive material decreases in time
- The half-time, $t_{1/2}$,which is unique to any given isotope, is the time required for one-half of the original to decay.
- The activitty ***A,*** measured in decays per second (***Bq***) is proportional to the number ***N*** of unstable nuclei

$$ N = N_0 \left(\frac{1}{2}\right)^{\frac{t}{t_{1/2}}} $$

$$ A = A_0 \left(\frac{1}{2}\right)^{\frac{t}{t_{1/2}}} $$

Radioactive Decay

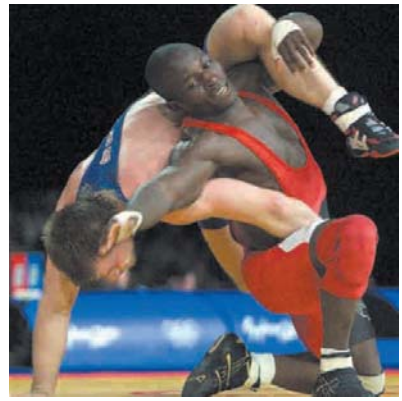


Half-Life for Common Isotopes

Isotope	$t_{½(}$ (a)
Carbon-14	5 730
Thorium-230	75 000
Potassium-40	$1.3x10^9$
Helium-4	$4.5x10^9$

Energy for Today and Tomorrow

- Muscle Power
  - Advantages
    - Environmentally sustainable
    - No toxic by-product
    - Expired equipments (aka animal or human) goes back to the energy cycle
  - Disadvantages
    - Limited to physical strength and power of the work force
    - Rights violations



Fossil Fuels

- Advantage
  - Relatively inexpensive to process
- Disadvantage
  - Releases harmful by-products
  - Source of greenhouse gases
  - Contribute to global warming
  - Supplies are limited

Biofuels- solid, liquid and gaseous fuels derived from organic material such as wood, biowaste, etc.

- Renewable source of energy
  - Highly suitable for liquid manure and industrial wastes.
  - Left over aka by-product can be use for fertilizers (a very good one at that, too)
  - Burning the fuels may produce air pollutants

Wind Power

- Advantage
  - Possible with zero emissions of greenhouse gases
  - Limited potential for accidents
- Disadvantage
  - Expensive
  - Need constant wind of sufficient strength
  - Might kill birds
  - Requires a large site for a large city.

Hydroelectric Power

- Advantage
  - Efficient
  - Limited environmental impact after the operation of the facility
  - Well-developed technologies and infrastructure.
- Disadvantage
  - Requires fast-flowing water
  - Large ecological damage

Ocean Thermal Power

Advantages:

- Practically unlimited source of energy

- Disadvantages

  - Difficult to harness
  - Only suitable in tropical ocean waters near the equator
  - Floating platform construction is expensive.

Energy for Today and Tomorrow (Cont.)

Geothermal Power

Advantages:

- Virtually unlimited supply of thermal energy

Disadvantages:

- Limited locations are suitable
- Naturally occurring, dissolved corrosive salts cause problems for equipment
- Hydrogen sulfide gas discharge (toxic)

Energy for Today and Tomorrow (Cont.)

- Photovoltaic Cells
  - Disadvantage
    - Potentially toxic chemicals
    - Significant land area required

Energy for Today and Tomorrow (Cont.)

- Nuclear Power
  - Disadvantage
    - Accident could happen (regardless how small the possibility is)
    - Requires highly trained specialists 24/7
    - Very expensive to build (rate of return is longer than usual)

Unit 5 – Homework Answers

- 5. a) 32N; b) 128 J; c)128J
- 6. 24 m/s
- 7. No, it is lead ring
- 8. 76^0C
- 9. a) 31%; b) 1.3×10^{20} atoms/s
- 10. 1.38×10^{12} J
- 11. $ 0.29
- 12. 18 minutes
- 13 9.0^0C
- 14. a
- 15. b
- 16. b
- 17. c
- 18. a
- 19. d
- 20. b
- 21. b
- 22. d
- 23. c

24. c
25. b
26. d
27. c