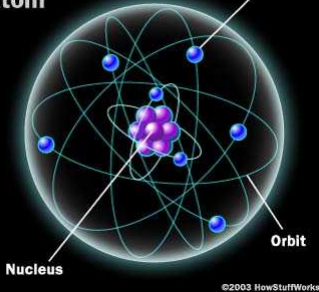


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Inside an Atom

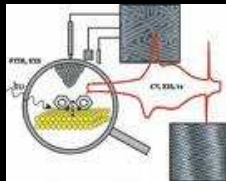


Electron

Nucleus

Orbit





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Prof Mike Lyons  
School of Chemistry  
Trinity College Dublin.

# INTRODUCTION TO CHEMISTRY.

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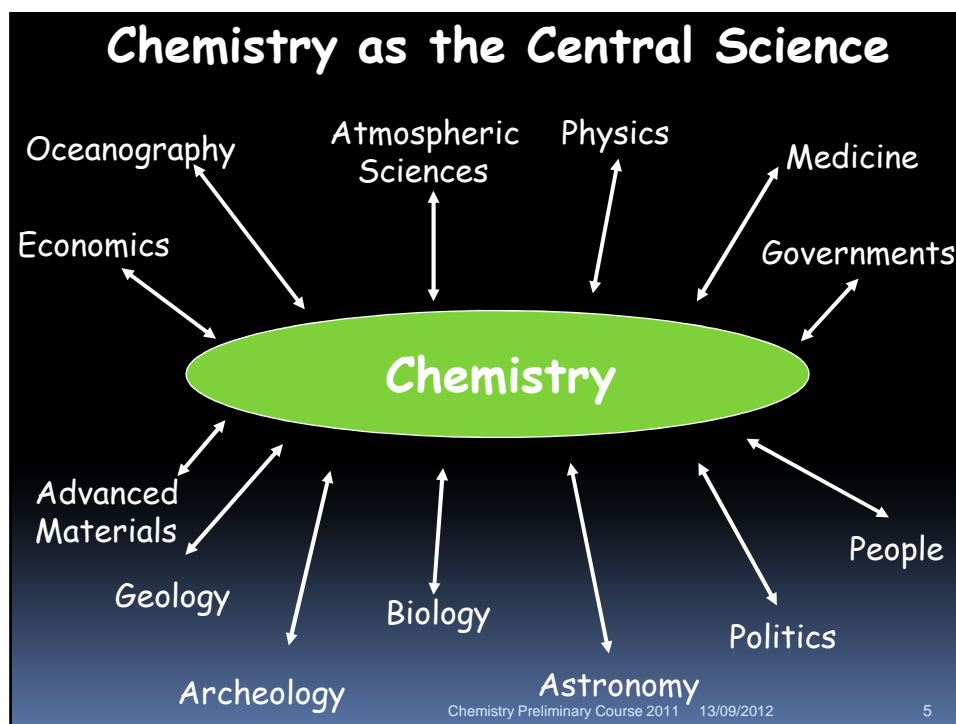
Chemistry Preliminary Course 2011 13/09/2012 2

## Welcome to CHEMISTRY !!!

- An Observational Science
- An Experimental Science
- A Laboratory Science
- An Interesting Science
- An Important Science
- A "Hard" Science
- A science rooted in the real world !

## What is chemistry?

- **Chemistry** is the science which deals with the composition and properties of material substances, and the reactions by which one substance is converted into another.
- **Chemistry** is a core science and along with **Physics** and **Biology** provides an understanding of the material universe.





Chemistry .. Is a social activity..science distributed via human interaction



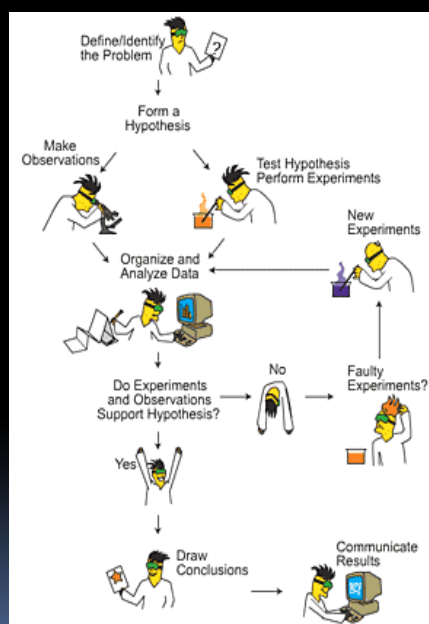
## Chemistry: the major subject areas.

- Physical Chemistry.
  - Organic Chemistry.
  - Inorganic Chemistry.
  - Analytical Chemistry.
  - Biochemistry.
  - Environmental Chemistry.
  - Medicinal Chemistry.
  - Computational Chemistry.
  - Materials Chemistry.
  - Chemical Physics.
  - Biological Chemistry.
- Many of these topics will be studied in the Chemistry course at Trinity.
  - At the research level, chemists may work in more than one of these areas, and may be involved in research programmes straddling disciplines such as physics and molecular biology.

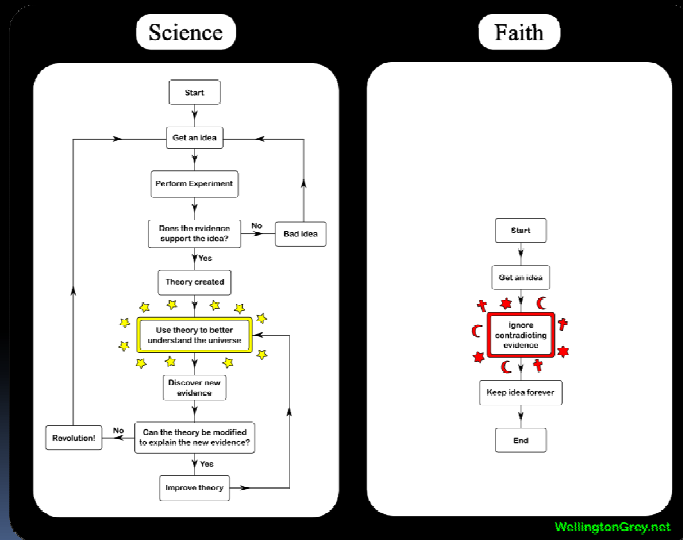
**The scientific method...**  
**... The best baloney detector there is ...**

Use scientific method to distinguish between science and pseudo-science.

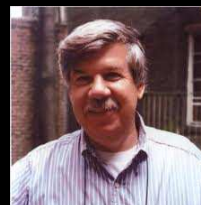
1. Define/Identify the Problem .
2. Form a Hypothesis .
3. Make Observations or Test Hypothesis and Perform Experiments.
4. Organize and Analyze Data.
5. Do Experiments and Observations Support Hypothesis?  
 If No, Perform New Experiments and Repeat Step 4
6. Draw Conclusions
7. Communicate Results



## Science vs Faith : Non Overlapping Magisteria or Mutually Exclusive Worldviews ?

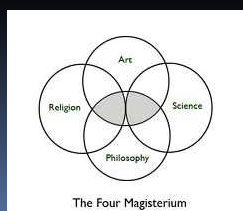


**S.J. Gould (NOMA) Hypothesis:**  
science and religion occupy non-overlapping magisteria (NOMA) - i.e. that each rules over its own domain and as such cannot be in conflict.

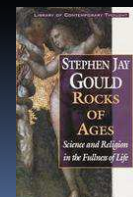


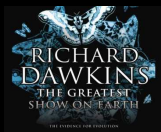
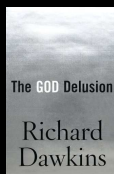
Gould addresses the conflict between secular scientists and religious believers who question or deny scientific theory when it is in discrepancy with religious teachings on the origin and nature of the natural world. Borrowing a term from the Catholic Church, Gould describes science and religion as each comprise a separate magisterium of human understanding. Science defines the natural world, and religion the moral world. If each realm is separate, then according to Gould, they are not in conflict. He calls this the principle of non-overlapping magisteria, abbreviated NOMA.

Science tries to document the factual character of the natural world, and to develop theories that coordinate and explain these facts. Religion, on the other hand, operates on the equally important, but utterly different, realm of human purposes, meanings and values - subjects that the factual domain of science might illuminate, but can never resolve. ~ **Stephen Jay Gould**



Science deals with 'how' questions.  
Faith deals with 'why' questions.





Whatever else they may say, those scientists who subscribe to the 'separate magisteria' school of thought should concede that the universe with a supernaturally intelligent creator is a very different kind of universe from one without. The difference between the two hypothetical universes could hardly be more fundamental in principle, even if it is not easy to test in practice. And it undermines the dictum that science must be completely silent about religion's central existence claim. The presence or absence of a creative super-intelligence is unequivocally a scientific question, even if not in practice -- or not yet -- a decided one. ~

Richard Dawkins

When faced with miracle stories, Gould would presumably retort along the following lines. The whole point of NOMA is that it is a two-way bargain. The moment religion steps on science's turf and starts to meddle in the real world with miracles, it ceases to be religion in the sense that Gould is defending, and his *amicabilis concordia* is broken. Note, however, that miracle-free religion defended by Gould would not be recognized by most practicing theists in the pew or on the prayer mat. It would, indeed, be a grave disappointment to them. ~

Richard Dawkins

## Is 'Creation Science' Science or pseudoscience?

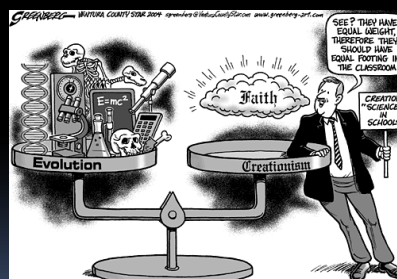


- <http://en.wikipedia.org/wiki/Creationism>
- <http://www.nwcreation.net/anticreation.html>
- <http://en.wikipedia.org/wiki/Pseudoscience>
- <http://www.chem1.com/acad/sci/pseudosci.html>

A **pseudoscience** is any body of alleged knowledge, methodology, belief, or practice that claims to be scientific but does not follow the **scientific method**.

A **pseudoscience** is an established body of knowledge which masquerades as science in an attempt to claim a legitimacy which it would not otherwise be able to achieve on its own terms.

The most important of its defects is usually the lack of the carefully controlled and thoughtfully interpreted experiments which provide the foundation of the natural sciences and which contribute to their advancement.



## Pathological Science

- N Rays
- Polywater
- Cold Fusion

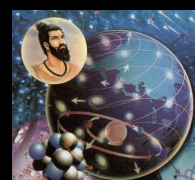
Personal enthusiasm takes precedence over peer review.

## Junk Science

Term often used to describe scientific theories or data which, while perhaps legitimate in themselves, are believed to be mistakenly used to support an opposing position.

- Political ideological bias in presentation of data.
- Commercial advertising.

## The atom concept.



The underlying concept of atoms as the basic building blocks of matter has been around for a long time.

As early as 600 BCE, the Gujarati (Indian) philosopher [Acharya Kanad](#) wrote that "*Every object of creation is made of atoms which in turn connect with each other to form molecules*".

A couple of centuries later in 460 BCE, the Greek philosopher [Democritus](#) reasoned that if you keep breaking a piece of matter into smaller and smaller fragments, there will be some point at which the pieces cannot be made any smaller.

He called these "basic matter particles"— in other words, atoms.

But this was just philosophy; it would not be until 1800 when John Dalton showed how the atomic concept followed naturally from the results of quantitative experiments based on weight measurements.

## The components of matter.

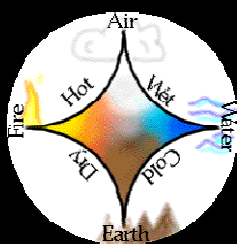
- Matter is the 'stuff' of the universe : books, trees, students etc. It has mass and volume.
- Modern chemistry is based on the **atomic** theory of matter.
- The fundamental unit of a chemical substance is called an **atom**.
- Atoms combine to make all substances in the world around us.
- A **molecule** is a combination of two or more atoms held together in a specific shape by attractive forces called **chemical bonds**.
- Each different type of atom is called an **element**. At present there are 109 elements. Elements cannot be decomposed into simpler substances.
- A **chemical compound** is a substance that contains more than one element. The relative amounts of each element in a particular compound do not change.
- Every molecule of a particular chemical substance contains a characteristic number of atoms of its constituent elements.

## Development of the element concept.

The concept of the element is an ancient one which developed in many different civilizations in an attempt to rationalize the variety of the world and to understand the nature of change, such as that which occurs when a piece of wood rots, or is burnt to produce charcoal or ash.

Most well known to us are the four elements "earth, air, fire and water" that were popularized by Greek philosophers (principally Empedocles and Aristotle) in the period 500-400 BCE.

To these, Vedic (Hindu) philosophers of India added space, while the ancient Chinese concept of Wu Xing regarded earth, metal, wood, fire and water as fundamental.



These basic elements were not generally considered to exist as the actual materials we know as earth, water, etc., but rather to represent the principles or essences that the elements conveyed to the various kinds of matter we encounter in the world.

Eventually, practical experience (largely connected with the extraction of metals from ores) and the beginnings of scientific experimentation in the 18th Century led to our modern concept of the element:

An element is the simplest form to which any other chemical substance can be reduced through appropriate thermal or chemical treatment.



Antoine-Laurent Lavoisier  
1743-1794



Substances simples qui appartiennent aux trois regnes, et qu'on peut regarder comme les éléments des corps	Lumière Calorique Azote Hydrogène
Substances simples, non métalliques, oxydables et acidifiables	Soufre Phosphore Carbone Radical muriatique Radical Fluorique Radical boracique
Substances simples, métalliques, oxydables et acidifiables	Antimoine Argent Arsenic Bismuth Cobalt Cuivre Étain Fer Manganèse Mercure Molybdène Nickel Or Platine Plomb Tungstène Zinc
Substances simples salifiables, terreuses	Chaux Magnésie Baryte Alumine Silice

*Traité Élémentaire de Chimie*  
1789

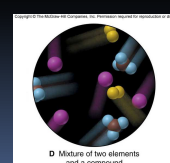
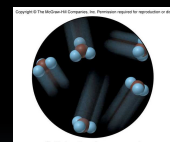
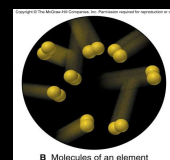
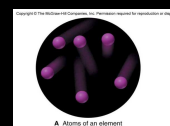
## Definitions for Components of Matter

**Element** - the simplest type of substance with unique physical and chemical properties. *An element consists of only one type of atom.* It cannot be broken down into any simpler substances by physical or chemical means.

**Molecule** - a structure that consists of two or more atoms which are chemically bound together and thus behaves as an independent unit.

**Compound** - a substance composed of two or more elements which are chemically combined.

**Mixture** - a group of two or more elements and/or compounds that are physically intermingled.

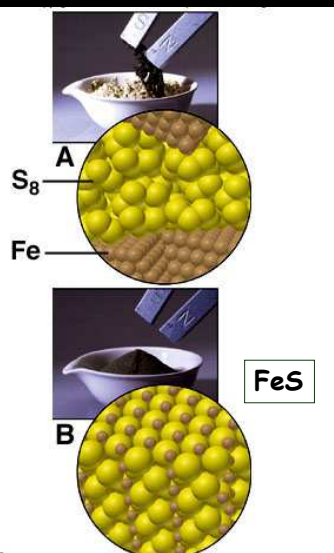


## The Distinction Between Mixtures and Compounds




**Heterogeneous mixtures** : has one or more visible boundaries between the components.

**Homogeneous mixtures** : has no visible boundaries because the components are mixed as individual atoms, ions, and molecules.

**Solutions** : A homogeneous mixture is also called a solution. Solutions in water are called *aqueous solutions*, and are very important in chemistry. Although we normally think of solutions as liquids, they can exist in all three physical states.



**Table 2.1 Some Properties of Sodium, Chlorine, and Sodium Chloride**

Property	Sodium	+ Chlorine	→ Sodium Chloride
			
Melting point	97.8°C	-101°C	801°C
Boiling point	881.4°C	-34°C	1413°C
Color	Silvery	Yellow-green	Colorless (white)
Density	0.97 g/cm <sup>3</sup>	0.0032 g/cm <sup>3</sup>	2.16 g/cm <sup>3</sup>
Behavior in water	Reacts	Dissolves slightly	Dissolves freely

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23

While chemical weapons were nothing new to war, World War I was the first time that they figured prominently in battle strategy. They were used by both sides, to varying degrees.

In late 1914, German scientist Fritz Haber came up with the idea of creating a cloud of poison gas by using thousands of cylinders filled with chlorine. Deployed in April 1915 during the battle for Ypres, France, the attack might have broken the Allied lines if German troops understood how to follow up the gas attack.

By late 1915, Allied troops made their own chlorine gas attacks. It led to a race for more and more toxic chemicals. Germany came up with diphosgene gas; the French tried cyanide gas.

In July 1917, Germany introduced mustard gas, which burned the skin as well as the lungs.

Biological warfare was generally less successful. Most of these efforts focused on infecting enemy livestock with anthrax or glanders.



'Gassed'  
John Singer Sargent

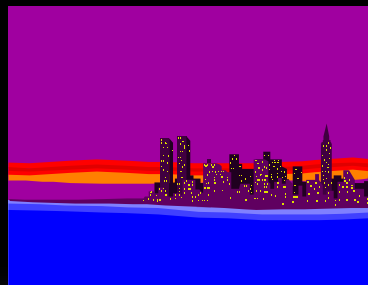


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24

## STATES OF MATTER - and the World Around US

- SOLID - The Earth
- LIQUID - Water
- GAS - The Atmosphere



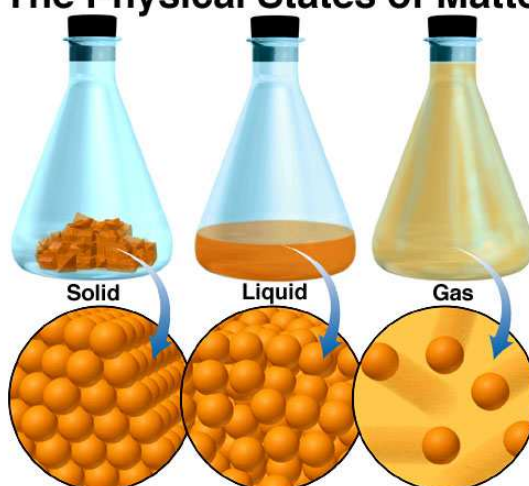
The properties of the different types of matter can be explained in terms of the properties exhibited by the component atoms and molecules.

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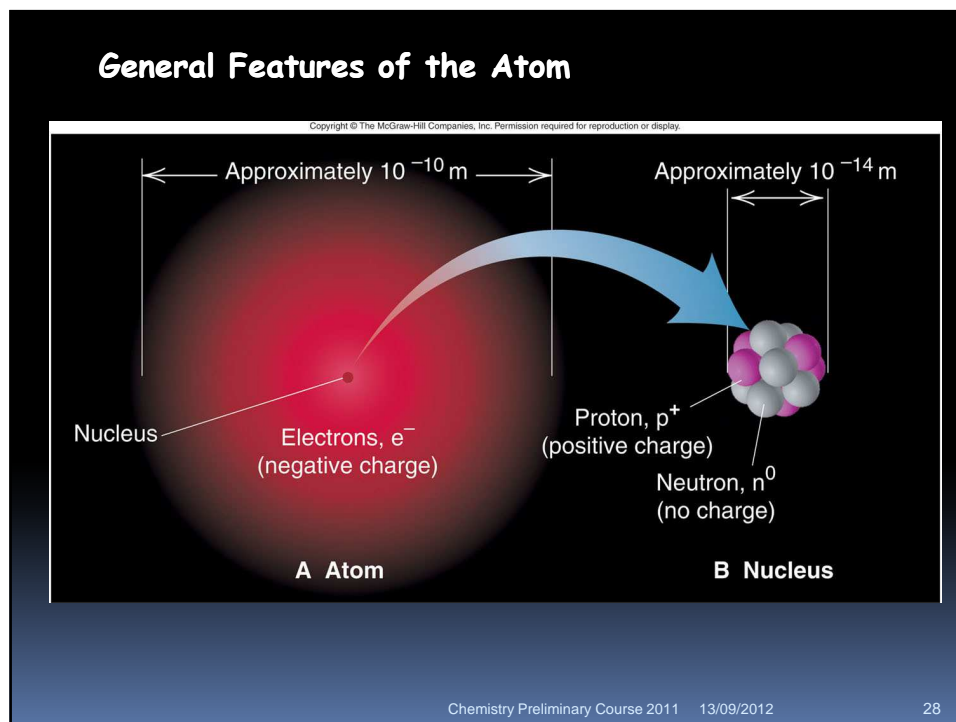
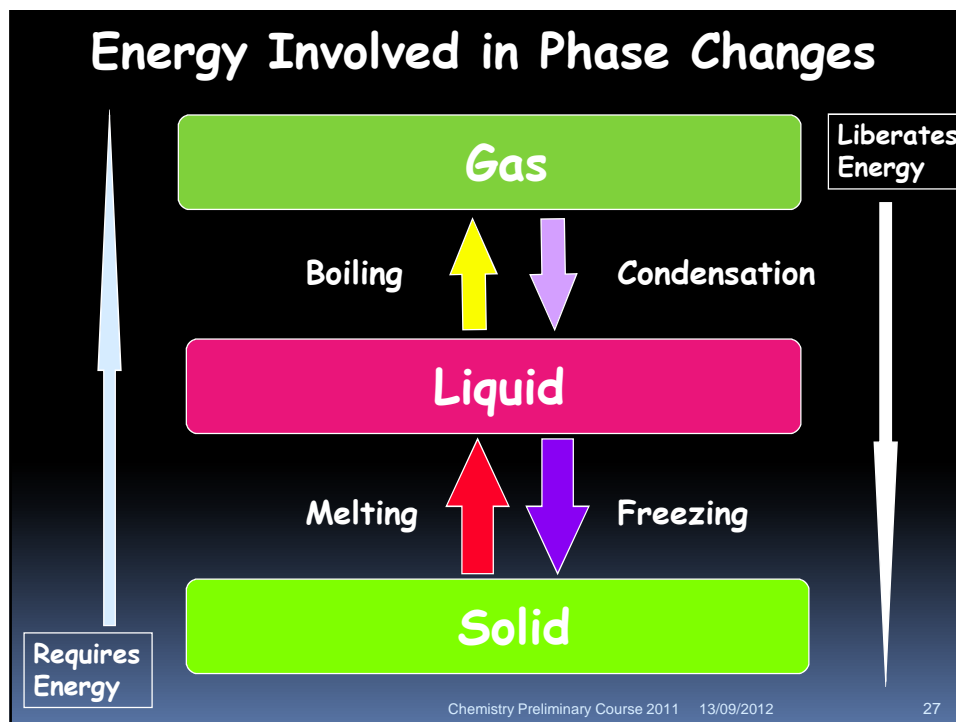
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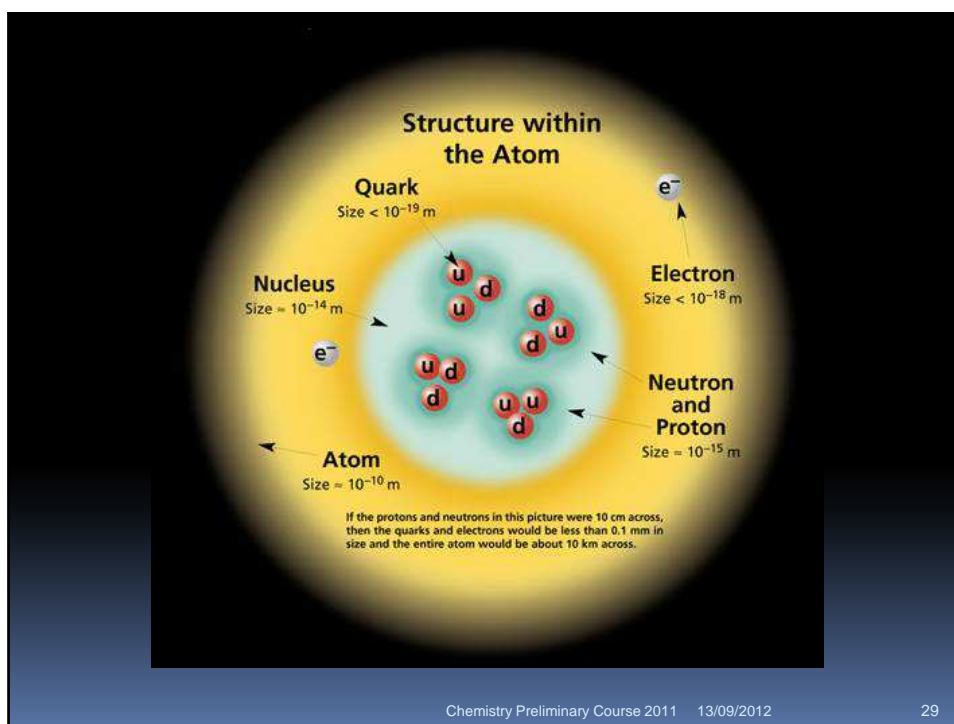
### The Physical States of Matter



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26

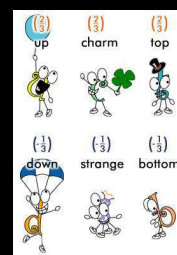
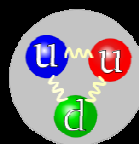




## Quarks : the fundamental constituent of matter

A quark (/ˈkwɔːk/ or /ˈkwɑːk/) is an elementary particle and a fundamental constituent of matter. Quarks combine to form composite particles called **hadrons**, the most stable of which are **protons** and **neutrons**, the components of atomic nuclei. Due to a phenomenon known as **color confinement**, quarks are never directly observed or found in isolation; they can only be found within hadrons. For this reason, much of what is known about quarks has been drawn from observations of the hadrons themselves.

There are **six** types of quarks, known as **flavors**: up, down, strange, charm, bottom, and top. Up and down quarks have the lowest masses of all quarks. The heavier quarks rapidly change into up and down quarks through a process of particle decay: the transformation from a higher mass state to a lower mass state. Because of this, up and down quarks are generally stable and the most common in the universe, whereas strange, charm, top, and bottom quarks can only be produced in high energy collisions (such as those involving cosmic rays and in particle accelerators).



Quarks have various intrinsic properties, including electric charge, color charge, spin, and mass. Quarks are the only elementary particles in the **Standard Model** of particle physics to experience all four fundamental interactions, also known as fundamental forces (electromagnetism, gravitation, strong interaction, and weak interaction), as well as the only known particles whose electric charges are not integer multiples of the elementary charge. For every quark flavor there is a corresponding type of antiparticle, known as antiquark, that differs from the quark only in that some of its properties have equal magnitude but opposite sign.

## Standard Model of FUNDAMENTAL PARTICLES AND INTERACTIONS

The Standard Model summarizes the current knowledge in Particle Physics. It is the quantum theory that includes the theory of strong interactions (quantum chromodynamics or QCD) and the unified theory of weak and electromagnetic interactions (electroweak). Gravity is included on this chart because it is one of the fundamental interactions even though not part of the "Standard Model".

### FERMIONS

**Leptons** spin = 1/2

Flavor	Mass GeV/c <sup>2</sup>	Electric charge
$\nu_e$ electron neutrino	$<1 \times 10^{-6}$	0
$\bar{\nu}_e$ anti electron neutrino	$<1 \times 10^{-6}$	0
$e^-$ electron	0.000511	-1
$\mu^-$ muon	0.106	-1
$\tau^-$ tau	1.777	-1

**Quarks** spin = 1/2

Flavor	Approx. Mass GeV/c <sup>2</sup>	Electric charge
u up	0.003	2/3
d down	0.006	-1/3
s strange	0.1	-1/3
t top	175	2/3
b bottom	4.3	-1/3

### Structure within the Atom

### BOSONS

**Unified Electroweak** spin = 1

Name	Mass GeV/c <sup>2</sup>	Electric charge
$\gamma$ photon	0	0
$W^-$	80.4	-1
$W^+$	80.4	+1
$Z^0$	91.187	0

**Strong (color)** spin = 1

Name	Mass GeV/c <sup>2</sup>	Electric charge
g gluon	0	0

### PROPERTIES OF THE INTERACTIONS

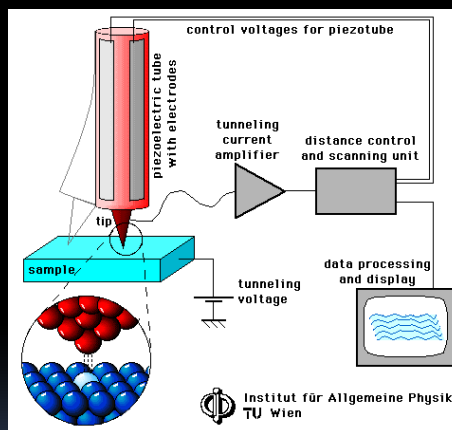
Property	Interaction	Gravitational		Weak (flavor-specific)		Electromagnetic		Strong	
		Mass-Energy	Acts on:	Mass-Energy	Acts on:	Mass-Energy	Acts on:	Mass-Energy	Acts on:
Strength (relative to electromagnetism)		$10^{-41}$	all particles	$10^{-6}$	quarks, leptons	1	electrically charged particles	25	quarks, gluons
Range		$10^{-17}$ m		$10^{-16}$ m		$10^{-14}$ m		$10^{-15}$ m	

## Properties of the Three Key Subatomic Particles

Name(Symbol)	Charge		Mass		Location in the Atom
	Relative	Absolute(C)*	Relative(amu)†	Absolute(g)	
Proton (p <sup>+</sup> )	1+	+1.60218x10 <sup>-19</sup>	1.00727	1.67262x10 <sup>-24</sup>	Nucleus
Neutron (n <sup>0</sup> )	0	0	1.00866	1.67493x10 <sup>-24</sup>	Nucleus
Electron (e <sup>-</sup> )	1-	-1.60218x10 <sup>-19</sup>	0.00054858	9.10939x10 <sup>-28</sup>	Outside Nucleus

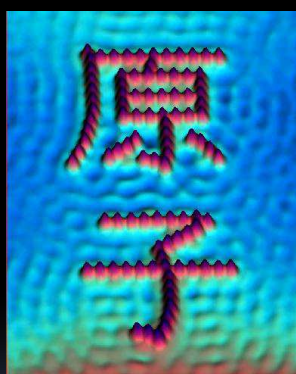
## Imaging atoms in real time: Scanning Tunneling Microscopy.

- Scanning tunneling microscopy is a technique developed in the eighties and allows imaging solid surfaces with unprecedented resolution.
- The operation of a scanning tunneling microscope (STM) is based on the so-called tunneling current, which starts to flow when a sharp tip approaches a conducting surface at a distance of approximately one nanometer.
- The tip is mounted on a piezoelectric tube, which allows tiny movements by applying a voltage at its electrodes.
- Thereby, the electronics of the STM system control the tip position in such a way that the tunneling current and, hence, the tip-surface distance is kept constant, while at the same time scanning a small area of the sample surface.
- This movement is recorded and can be displayed as an image of the surface topography.
- Under ideal circumstances, the individual atoms of a surface can be resolved and displayed.

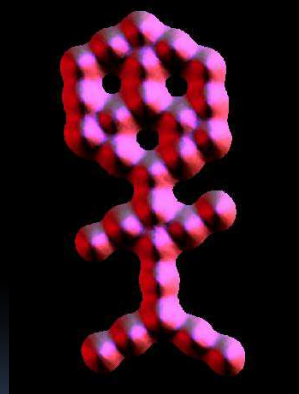


## STM Magic (I).

Manipulating atoms on metal surfaces.

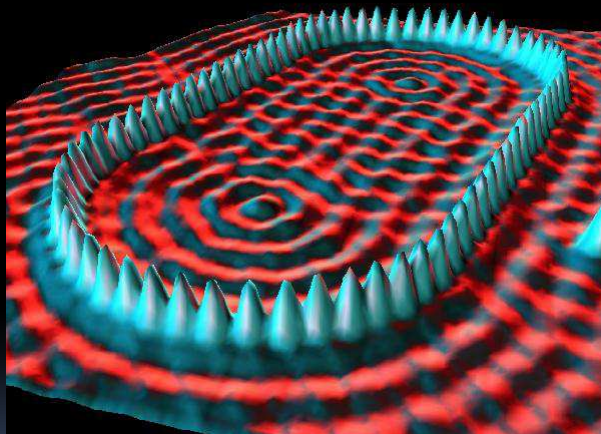


Fe on Cu(111). Kanji characters for 'atom': literal translation: 'original child'.



The carbon monoxide man. CO on Pt(111).

## STM Magic (II).



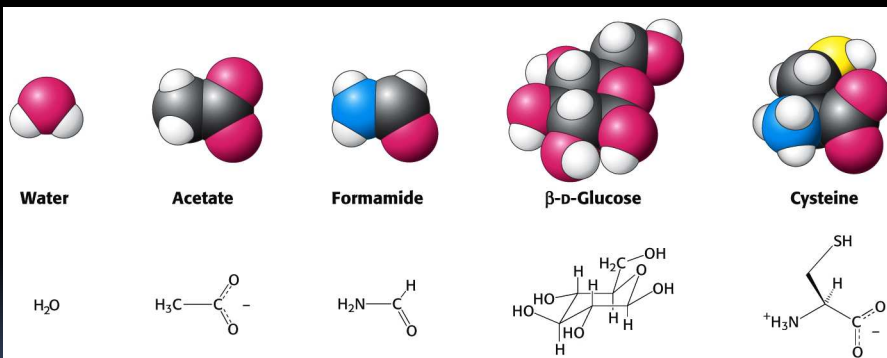
A corral of Fe atoms on a Cu surface.

## The Modern Reassessment of the Atomic Theory

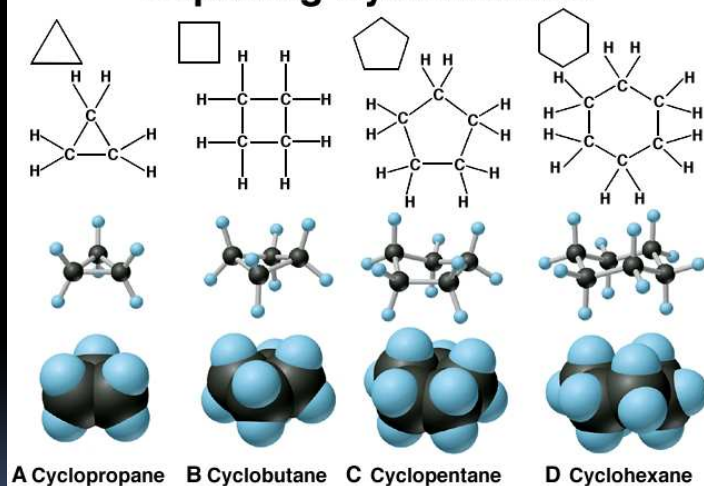
1. **All matter is composed of atoms.** The atom is the smallest body that *retains the unique identity* of the element.
2. **Atoms of one element cannot be converted into atoms of another element in a chemical reaction.** Elements can only be converted into other elements in nuclear reactions.
3. **All atoms of an element have the same number of protons and electrons, which determines the chemical behavior of the element.** Isotopes of an element differ in the number of neutrons, and thus in mass number. A sample of the element is treated as though its atoms have an *average* mass.
4. **Compounds are formed by the chemical combination of two or more elements in specific ratios.**



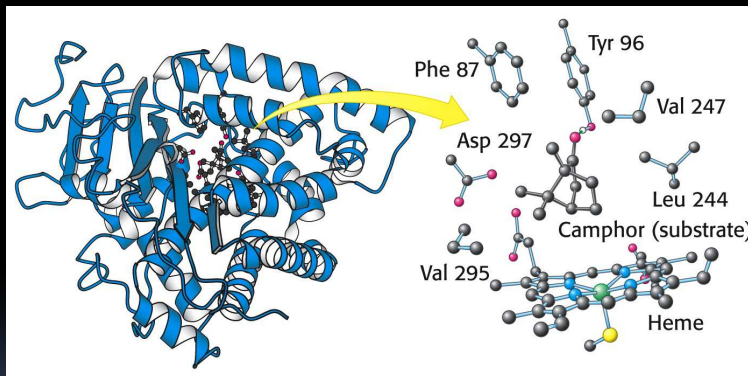
Molecules can be simple or more complex.  
They are made from many  
atoms joined together via chemical bonds.



### Depicting Cycloalkanes



Molecules in biological systems can become very large and complex.

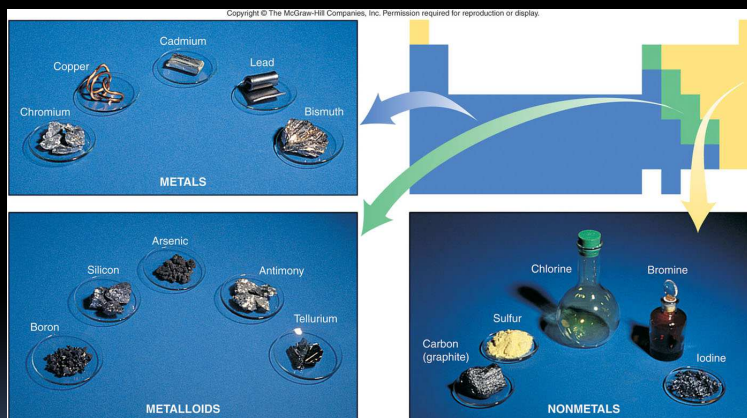


## The Modern Periodic Table

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MAIN-GROUP ELEMENTS		TRANSITION ELEMENTS																MAIN-GROUP ELEMENTS					
1A (1)		2A (2)		3B (3)	4B (4)	5B (5)	6B (6)	7B (7)	8B (8, 9, 10)						1B (11)	2B (12)	3A (13)	4A (14)	5A (15)	6A (16)	7A (17)	8A (18)	
1	1 H 1.008	2	2 He 4.003																				
2	3 Li 6.941	4 Be 9.012																					
3	11 Na 22.99	12 Mg 24.31																					
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80					
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3					
6	55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)					
7	87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 (269)	111 (272)	112 (277)	114 (285)										
INNER TRANSITION ELEMENTS																							
6	Lanthanides		58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0							
7	Actinides		90 Th 232.0	91 Pa (231)	92 U 238.0	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)							

## Metals, Metalloids, and Nonmetals



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13/09/2012

41

## SI : Base Units

Physical Quantity	Unit Name	Abbreviation
mass	kilogram	kg
length	meter	m
time	second	s
temperature	kelvin	K
electric current	ampere	A
amount of substance	mole	mol
luminous intensity	candela	cd

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42

### Common Decimal Prefixes Used with SI Units

Prefix	Prefix Symbol	Number	Word	Exponential Notation
tera	T	1,000,000,000,000	trillion	$10^{12}$
giga	G	1,000,000,000	billion	$10^9$
mega	M	1,000,000	million	$10^6$
kilo	k	1,000	thousand	$10^3$
hecto	h	100	hundred	$10^2$
deka	da	10	ten	$10^1$
-----	----	1	one	$10^0$
deci	d	0.1	tenth	$10^{-1}$
centi	c	0.01	hundredth	$10^{-2}$
milli	m	0.001	thousandth	$10^{-3}$
micro	$\mu$	0.000001	millionth	$10^{-6}$
nano	n	0.000000001	billionth	$10^{-9}$
pico	p	0.000000000001	trillionth	$10^{-12}$
femto	f	0.000000000000001	quadrillionth	$10^{-15}$

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43

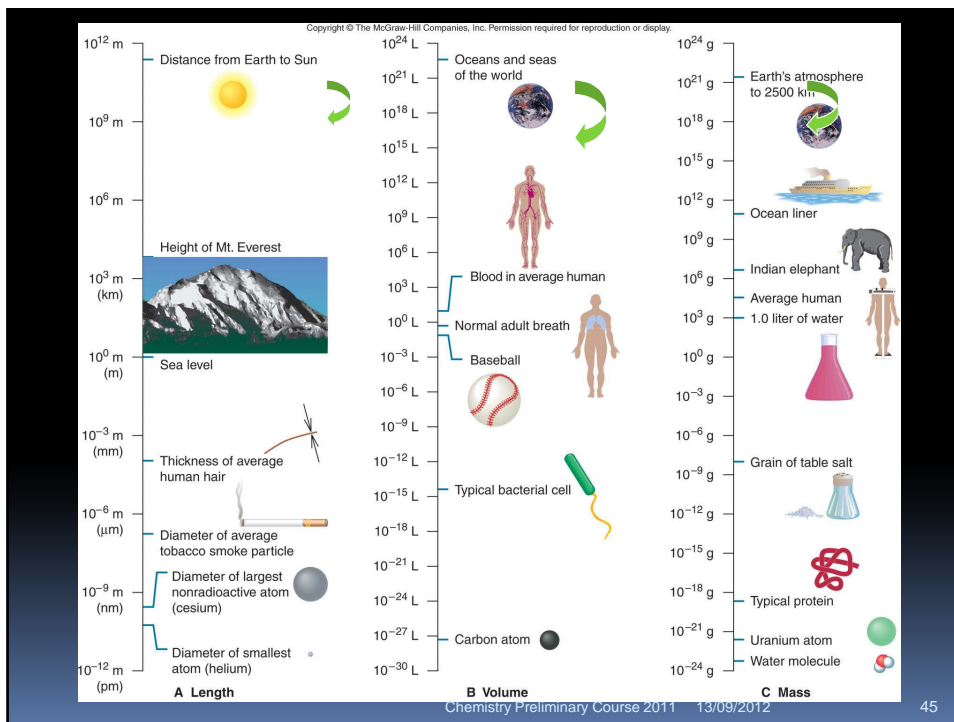
### Derived SI Units

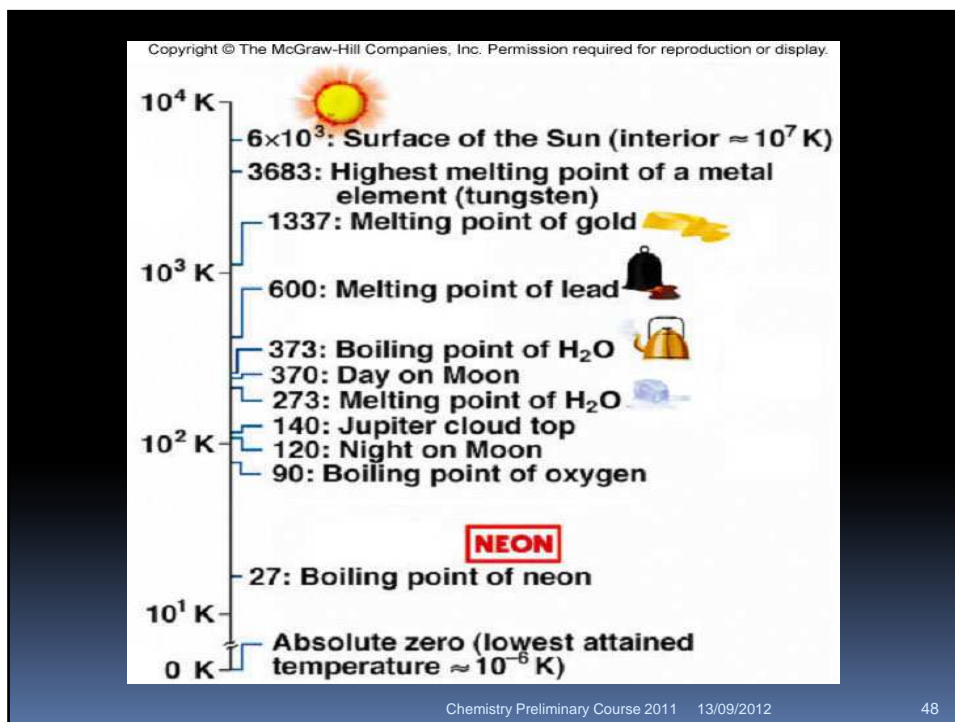
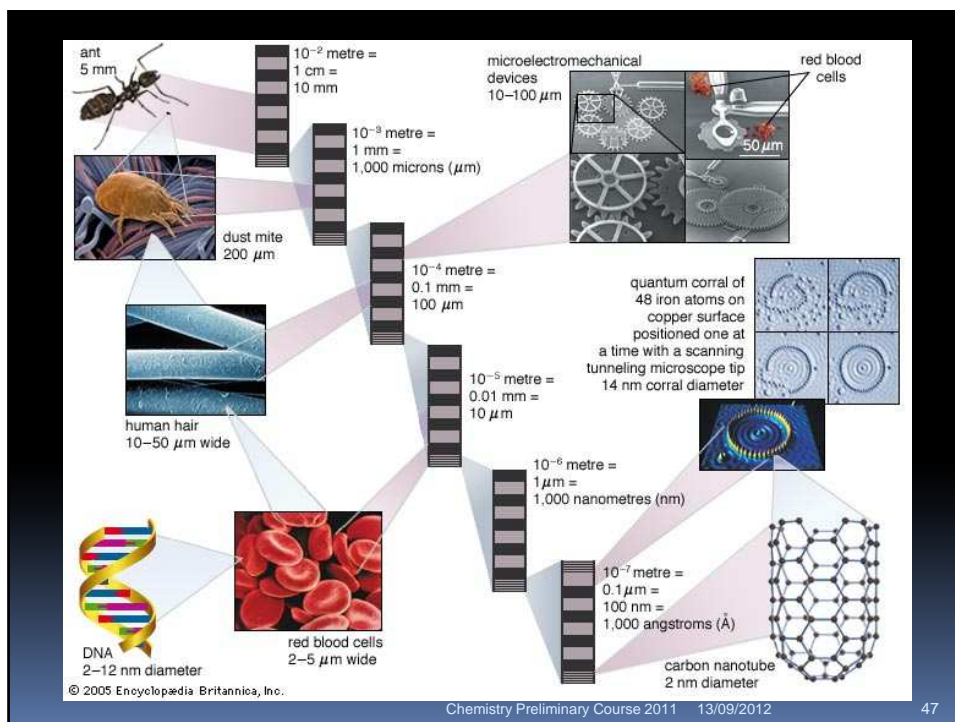
Quantity	Definition of Quantity	SI unit
Area	Length squared	$m^2$
Volume	Length cubed	$m^3$
Density	Mass per unit volume	$kg/m^3$
Speed	Distance traveled per unit time	$m/s$
Acceleration	Speed changed per unit time	$m/s^2$
Force	Mass times acceleration of object	$kg \cdot m/s^2$ (= newton, N)
Pressure	Force per unit area	$kg/(ms^2)$ (= pascal, Pa)
Energy	Force times distance traveled	$kg \cdot m^2/s^2$ (= joule, J)


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13/09/2012

44












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**Scientific research ...is a human activity**  
**Trinity Electrochemical Energy Conversion & Electrocatalysis Group.**

TEECE Group funded by Science Foundation Ireland (SFI) Principal Investigator Programme.  
 Grant Number SFI/10/IN.1/I2969.  
 Title: Redox and catalytic properties of hydrated metal oxide electrodes for use in energy conversion and storage devices, 2011-2016.


## The Ying / Yang of Electrochemistry

Isolated oxidation and reduction processes are not much good. These reactions must be coupled together in some way to perform a technologically useful function.

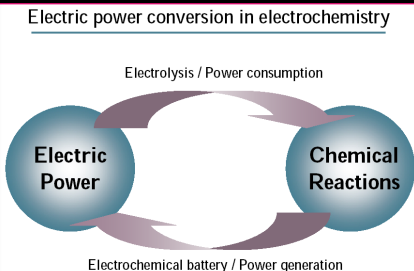
An electrochemical cell is formed by coupling together individual oxidation and reduction processes in a specific configuration to form a useful device.

There are two types of electrochemical cells based upon the general thermodynamic nature of the reaction (expressed as whether the change in Gibbs energy is positive or negative).

Oxidation and reduction reactions occurring at individual electrode/electrolyte interfaces can be coupled together either to produce an electrical voltage or to produce chemicals.



Electric power conversion in electrochemistry

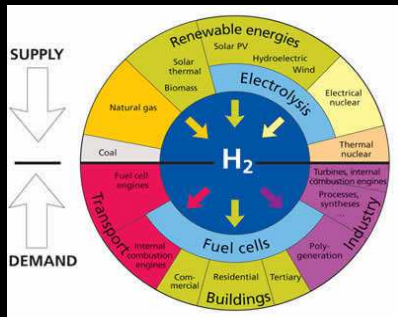


- **Galvanic cell.**
  - This is an electrochemical power source.
  - The cell does work by releasing free energy from a spontaneous reaction to produce electricity.
    - Battery
    - Fuel cell

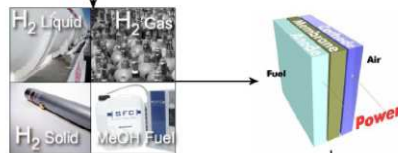
- **Electrolytic cell.**
  - This is an electrochemical substance producer.
  - The cell does work by absorbing free energy from a source of electricity to drive a non-spontaneous reaction.
    - Electrosynthesis.
    - Electroplating.

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### The Hydrogen Economy: Hydrogen as an energy carrier.

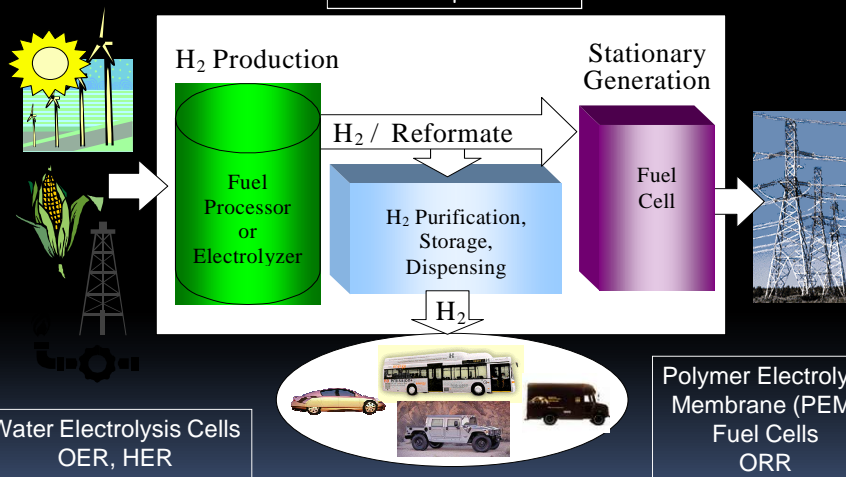


G.W. Crabtree, M.S. Dresselhaus, M.V. Buchanan, 'The hydrogen Economy' Physics Today, Dec.2004, pp.39-45.  
U. Bossel, 'Does a hydrogen economy make sense?' Proc. IEEE, 94 (10)(2006), pp.1826-1836.



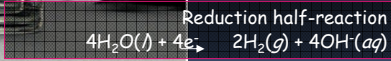
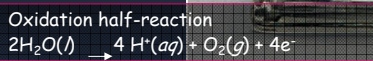
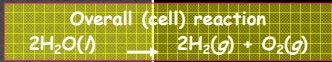
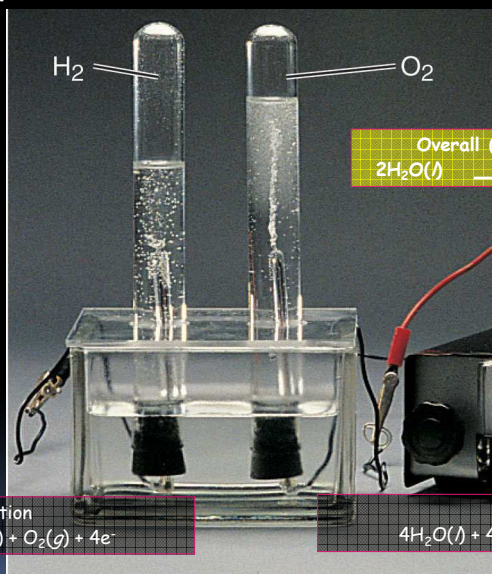
### Electrochemical energy conversion and storage.

Electrochemical Energy Storage  
Redox switching  
Redox Capacitance



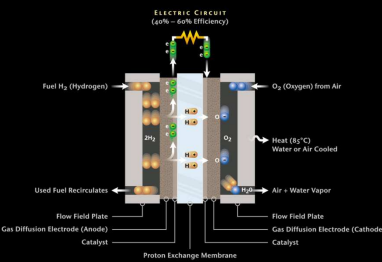
# The electrolysis of water

Weinberg, J. Chem. Ed.,60 (1983) 268-271.



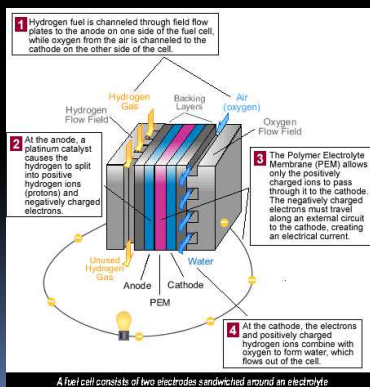
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53

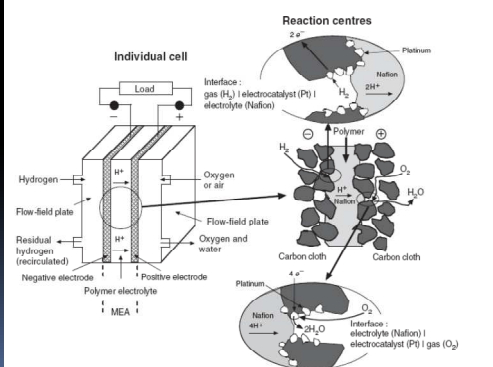


## Electrocatalytic Reactions

- Oxidation (several possible fuels)
  - $\text{H}_2 \rightarrow 2\text{H}^+ + 2e^-$
  - $\text{CH}_3\text{OH} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + 6\text{H}^+ + 6e^-$
  - $\text{CH}_4 + 2\text{H}_2\text{O} \rightarrow \text{CO}_2 + 8\text{H}^+ + 8e^-$
  - $\text{C}_x\text{H}_y\text{O}_z + (2x - z)\text{H}_2\text{O} \rightarrow x\text{CO}_2 + (4x + y - 2z)(\text{H}^+ + e^-)$
- Reduction
  - $\text{O}_2 + 4\text{H}^+ + 4e^- \rightarrow 2\text{H}_2\text{O}$



A fuel cell consists of two electrodes sandwiched around an electrolyte



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54

## Recommended Reading : Maths & Physics for Chemistry

- Basic Material:
  - Maths for Chemistry, 2<sup>nd</sup> Edition, Paul Monk & Lindsey J Munro, Oxford, 2010.
  - Foundations of Physics for Chemists, G.A.D. Ritchie & D.S. Sivia, Oxford Chemistry Primers 93, Oxford, 2000.
  - Mathematics for Chemistry, G. Doggett & B.T. Sutcliffe, Longman, 1995.
  - Essential Mathematics for Chemists, John Gormally, Prentice Hall, 2000.
  - More advanced material:
  - Foundation Mathematics for the Physical Sciences, K.F. Riley, M.P. Hobson, Cambridge University Press, 2011.
  - The Chemistry Maths Book, E. Steiner, Oxford Science Publications, 2<sup>nd</sup> edition, 2008
  - Mathematics for Physical Chemistry: Opening doors, University Science Books, 2008
  - Applying maths in the chemical & biomedical sciences, Godfrey Beddard, Oxford,
- Learn how to operate your calculator !
  - Basic algebraic manipulations.
  - Powers & indices
  - Algebraic expressions, trigonometric, logarithmic, exponential functions
  - Properties and applications of logarithms.
  - Solving linear and quadratic equations.
  - Simple differentiation and integration.
  - Simple differential equations.

## Summary

- Chemistry is the central science and is understood via a molecular perspective.
- Chemistry is the basis of modern biology.
- Chemical manipulations provides the materials which underlie much of modern life.
- Science, via application of the scientific method, provides a firm basis to understand physical reality, and to enable one to distinguish between useful information and nonsense.
- Need a minimum basis of Maths & Physics to succeed at Chemistry.