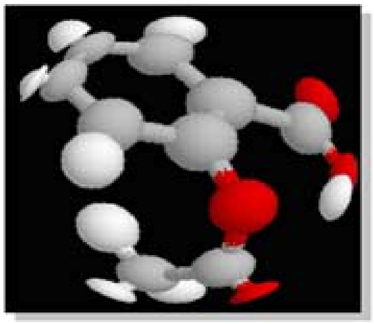


CHEMISTRY
AND ENGINEERING I

Worksheet 5

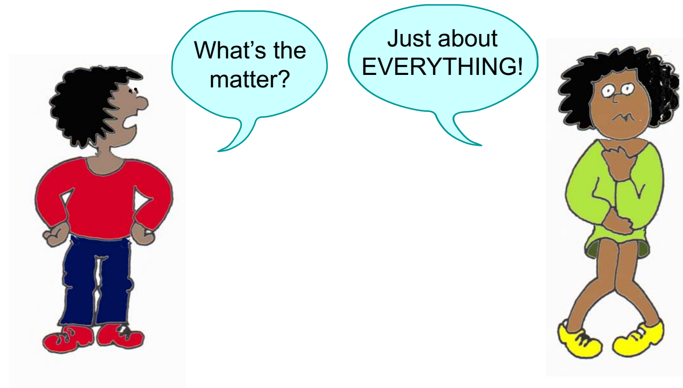
A worksheet produced by the Native Access to Engineering Programme

What is Chemistry?

According to the Merriam Webster Dictionary chemistry is the branch of the natural sciences dealing with the composition of substances and their properties and reactions.

In other words, chemistry is the study of matter, the elements that make up matter, how they combine and the changes they undergo. Matter, in scientific terms, is anything that takes up space and has mass, even if it is a very, very tiny space and a very, very tiny mass.

What is NOT matter?



Elements

Matter, all matter everywhere (at least as far as we know so far), is made up of combinations of just over 110 chemical elements. Only 93 of these elements occur naturally. The others can only be created under very strict laboratory conditions (and possibly in the middle of stars).

Krypton does not actually affect Superman.

The Silicon Valley in California is named after silicon because it is the main element used in makingcomputer chips.

1 IA IA	2 IIA IIA	3 IIIA IIIB	4 IVA IVB	5 VA VB	6 VIA VIB	7 VIIA VIIB	8	9 VIIIA VIII	10	11 IB IB	12 IIB IIB	13 IIIB IIIA	14 IVB IVA	15 VB VA	16 VIB VIA	17 VIIB VIIA	18/VIII/0
H 1 1.00794 Hydrogen																	He 2 4.002602 Helium
Li 3 6.941 Lithium	Be 4 9.012182 Beryllium											B 5 10.811 Boron	C 6 12.011 Carbon	N 7 14.00674 Nitrogen	O 8 15.9994 Oxygen	F 9 18.9984032 Fluorine	Ne 10 20.1797 Neon
Na 11 22.989768 Sodium	Mg 12 24.3050 Magnesium											Al 13 26.981539 Aluminum	Si 14 28.0855 Silicon	P 15 30.973762 Phosphorus	S 16 32.066 Sulfur	Cl 17 35.4527 Chlorine	Ar 18 39.948 Argon
K 19 39.0983 Potassium	Ca 20 40.078 Calcium	Sc 21 44.955910 Scandium	Ti 22 47.88 Titanium	V 23 50.9415 Vanadium	Cr 24 51.9961 Chromium	Mn 25 54.93805 Manganese	Fe 26 55.847 Iron	Co 27 58.93320 Cobalt	Ni 28 58.6934 Nickel	Cu 29 63.546 Copper	Zn 30 65.39 Zinc	Ga 31 69.723 Gallium	Ge 32 72.61 Germanium	As 33 74.92159 Arsenic	Se 34 78.96 Selenium	Br 35 79.904 Bromine	Kr 36 83.80 Krypton
Rb 37 85.4678 Rubidium	Sr 38 87.62 Strontium	Y 39 88.90585 Yttrium	Zr 40 91.224 Zirconium	Nb 41 92.90638 Niobium	Mo 42 95.94 Molybdenum	Tc 43 (97.9072) Technetium	Ru 44 101.07 Ruthenium	Rh 45 102.90550 Rhodium	Pd 46 106.42 Palladium	Ag 47 107.8682 Silver	Cd 48 112.411 Cadmium	In 49 114.818 Indium	Sn 50 118.710 Tin	Sb 51 121.757 Antimony	Te 52 127.60 Tellurium	I 53 126.90447 Iodine	Xe 54 131.29 Xenon
Cs 55 132.90543 Cesium	Ba 56 137.327 Barium	La† 57 138.9055 Lanthanum	Hf 72 178.49 Hafnium	Ta 73 180.9479 Tantalum	W 74 183.85 Tungsten	Re 75 186.207 Rhenium	Os 76 190.23 Osmium	Ir 77 192.22 Iridium	Pt 78 195.08 Platinum	Au 79 196.96654 Gold	Hg 80 200.59 Mercury	Tl 81 204.3833 Thallium	Pb 82 207.2 Lead	Bi 83 208.98037 Bismuth	Po 84 (208.9824) Polonium	At 85 (209.9871) Astatine	Rn 86 (222.0176) Radon
Fr 87 (223.0197) Francium	Ra 88 (226.0254) Radium	Ac‡ 89 (227.0278) Actinium	Unq 104 (261.11) Unnilquadium	Unp 105 (262.114) Unnilpentium	Unh 106 (263.118) Unnilhexium	Uns 107 (262.12) Unnilseptium	Uno 108 (265) Unniloctium	Une 109 266) Unnilennium	Uun 110 (272) Ununnilium								
		†	Ce 58 140.115 Cerium	Pr 59 140.90765 Praseodymium	Nd 60 144.24 Neodymium	Pm 61 (144.9127) Promethium	Sm 62 150.36 Samarium	Eu 63 151.965 Europium	Gd 64 157.25 Gadolinium	Tb 65 158.92534 Terbium	Dy 66 162.50 Dysprosium	Ho 67 164.93032 Holmium	Er 68 167.26 Erbium	Tm 69 168.93421 Thulium	Yb 70 173.04 Ytterbium	Lu 71 174.967 Lutetium	
		‡	Th 90 232.0381 Thorium	Pa 91 231.03588 Protactinium	U 92 238.0289 Uranium	Np 93 (237.0482) Neptunium	Pu 94 (244.0642) Plutonium	Am 95 (243.0614) Americium	Cm 96 (247.0703) Curium	Bk 97 (247.0703) Berkelium	Cf 98 (251.0796) Californium	Es 99 (252.083) Einsteinium	Fm 100 (257.0951) Fermium	Md 101 (258.10) Mendelevium	No 102 (259.1009) Nobelium	Lr 103 (262.11) Lawrencium	

Nirvana's song Lithium refers to the anti-depressant drug made from lithium salts.

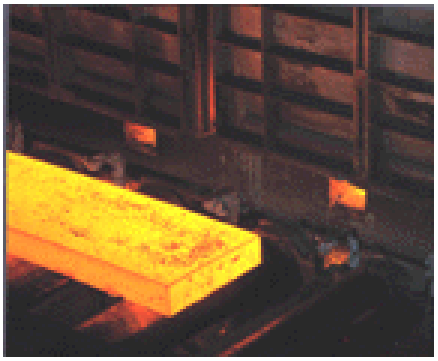
Diamonds are carbon, though they little resemble graphite, their elemental twin.

All the elements are listed in the Periodic Table which ranks them according to atomic mass and groups them according to similar properties. In the Periodic Table, the name for each element appears in its abbreviated form. These abbreviations are standard all over the world. When they are combined with other standardized symbols, they give people who work with chemistry a common language to work in.

How many elements can you identify from their abbreviated forms?

Engineers and chemistry

Chemistry is one of the subjects which engineers study in a pure, theoretical form and then apply to solve problems in the real world. For instance, did you know that the making of steel is chemistry?



Steel is a very strong and versatile metal. It is used in hundreds of ways, to reinforce bridges and roads, to build automotive bodies, to support huge buildings and to make cutlery, just to name a few. Steel is made by mixing iron compounds with carbon and limestone under temperatures of more than 500ºC. Depending on what the steel will be used for, other metallic compounds may be added to the molten mixture in order to get specific properties in the final product like strength, chemical-resistance or hardness. For example, the addition of chromium in carefully measured amounts creates stainless steel, something you probably have in your home. Stainless steel is used to make cutlery, sinks and surgical tools because of its high resistance to rust.

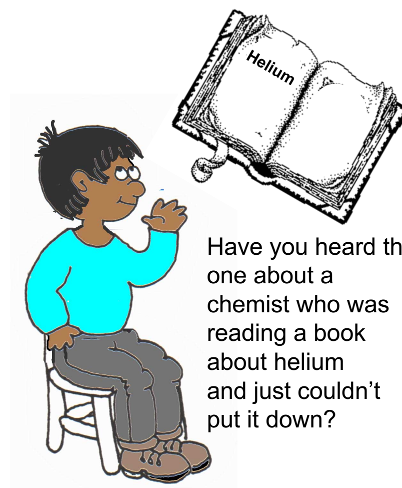
Chemical engineers study and develop chemically-based industrial processes by understanding how and why the elements interact. They might apply this knowledge to figuring out how to remove pollution from a river or mine, how to get plastic wrap from petrochemical products or how to burn coal more cleanly and efficiently. What chemical engineers do with chemistry is very complex, but it all begins with a basic understanding of some very small particles.

Atoms

The smallest unit of each element is the atom. Atoms are made up of three different types of particles - protons, electrons, and neutrons.

+ *What do oppositely charged particles do?* -

Protons have a positive charge.
Electrons have a negative charge..
Neutrons have no charge, and therefore are not attractive.
All atoms have the same number of protons and electrons, and are neutrally charged.



Have you heard the one about a chemist who was reading a book about helium and just couldn't put it down?

What does neutrally charged mean?

Atomic Number ↓ | Atomic Mass ↓

26 | 55.8
Fe

Protons and neutrons are the only parts of the atom which have any mass.

In the Periodic Table, 2 numbers appear beside each element. The whole number is the element's atomic number and is equal to the number of protons it has. The other number is the element's atomic mass. Neutrons and protons have almost exactly the same mass, so you can figure out the number of neutrons in an element by subtracting the atomic number from the atomic mass.

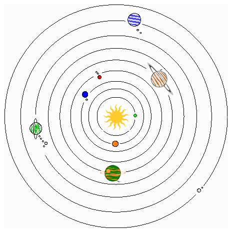
Number of neutrons = atomic mass- atomic number.

Source: http://www.animation.usa.com/hb.html

Atom Ant, the world's smallest superhero.

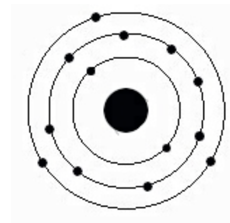
A model atom

Just like a building, an atom of any element has a distinct structure. And just like a building, there are rules as to how that structure is put together. In the center of the atom is a heavy nucleus; this is where the protons and neutrons are. Massless electrons orbit the nucleus. So a model of an atom, looks a bit like a model of the solar system.



Solar System

What is different about the models?



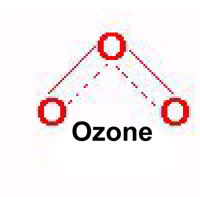
Atom

Not all electrons orbit at the same distance from the nucleus. In fact, electrons orbit the nucleus at several distinct energy levels, each of which can hold a different number of electrons. The first energy level can hold up to 2 electrons, the second up to 8. As you get further from the nucleus the orbits hold more electrons.

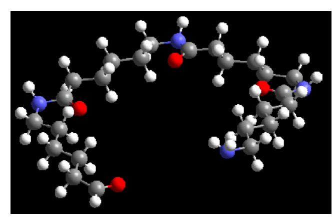
Molecules

When atoms join together they make molecules.

O_3 is the chemical designation for a molecule of ozone. From it we can tell that each ozone molecule is made up of 3 oxygen atoms.

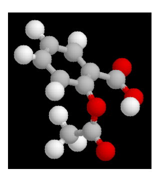


Molecules can be fairly simple and small like water or they can huge; plastics are made up of extremely long chains of atoms.



Nylon

Things like aspirin fall in the middle somewhere.



Aspirin

The chemical formula for water is H_2O. Can you explain what this means?

Chemicals in nature

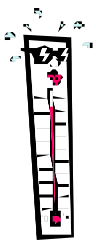
Chemistry and chemicals play a role in just about everything you see. Our bodies are teeming chemical factories where thousands of molecules interact to make our hearts beat, to digest food and to help us grow. Plants would not survive without chemicals, in fact very little would exist. By harnessing the power of chemicals in nature, people have been able to use them for a number of purposes.

How do we get things like aspirin?

The active ingredient in aspirin, salicylic acid, is related to an ingredient found in white willow bark called salicin. Aspirin is produced in a complex industrial chemical process and reduces fever, swelling and pain. Willow bark tea does exactly the same thing because boiling the bark in water releases salicin. The healing properties of willow bark have been known to the Chinese and Aboriginal peoples for thousands of years; they were only recognized by western scientists in the 1800s century and today's form of buffered aspirin was developed in 1897.

Physical and chemical changes

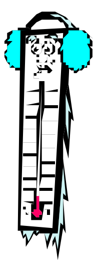
Matter and changes in matter are key concerns of people studying chemistry. There are two types of change which matter can undergo.



Physical change: Physical changes are also known as changes in state. Matter exists in three states, solid, liquid and gas.

What is the difference between the states? Can you identify the 3 states of water?

Physical changes usually occur with changes in temperature or changes in pressure.



Can you think of anything which undergoes a physical change due to pressure?

No matter what kind of physical change a substance has undergone, it remains exactly the same chemically.

Chemical change: In a chemical change, two or more substances or compounds are mixed together and become something completely new.

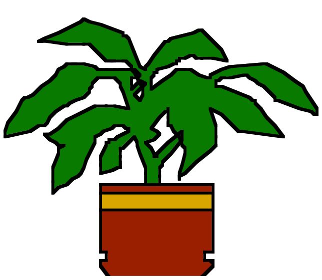
Baking a cake is a chemical change.

What are the differences between physical and chemical changes?

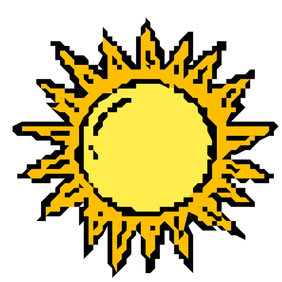
Chemical reactions

Chemical changes take place because the elements in the compounds being combined react with one another. The chemical reaction that takes place in baking a cake involves a lot of different compounds. It would be very difficult to write down all the different chemical changes which occur in that process. But, we know that eggs, flour, milk and chocolate combine to become delicious! In laboratories, however, chemists do write down what happens using specialized symbols and abbreviations in the form of equations.

This is the chemica equation for photosynthesis, the method by which plants get nourishment from the sun.



$$6CO_2 + 6H0_2 \rightarrow C_6H_{12}O_6 + 6O_2$$



What does the equation tell us?

It tells us that plants take carbon dioxide and water from their environments and through a chemical reaction convert them into glucose and oxygen. Plants use the glucose as food and emit the oxygen into the atmosphere.

What does the equation not tell us?

The equation doesn't tell us that photosynthesis requires more than just carbon dioxide and water. It also requires sunlight and a green pigment called chlorophyll. Chlorophyll converts the energy from the sun into chemical energy which is used by the plant to drive a number of chemical reactions, including photosynthesis.

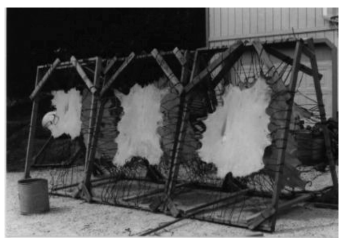
What else can you say about the equation?

Aboriginal people and chemistry

Aboriginal peoples could not have survived without an understanding of chemical properties and reactions. Many traditional practices which continue today involve chemistry in some form.

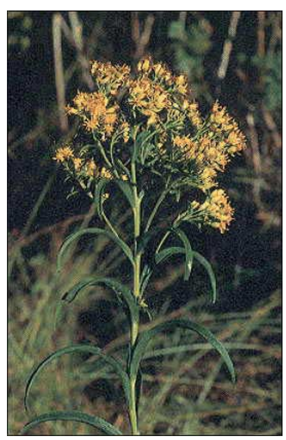
Clothing manufacture: Making leather from animal skins involves a chemical reaction between the skin, water and the animal brains used for tanning. The reactions which take place in the tanning process break down the properties of the animal skin and enable it to be transformed into leather.

Dyes and household products: Many plants and berries produce dyes which can be used on clothing and for other decorative purposes. Blueberries make a purple dye and Goldenrod makes a yellow one. Plants can also be used for "household' purposes. The chemical makeup of the horsetail flower includes silica which is a good wood polish.



Source: http://www.healingearth.com/btar/images/hides.jpeg

Waterproofing: Animal fat, spruce gum and plants can be used as waterproofing agents on canoes, clothing and dwellings.



Food preservation: Aboriginal peoples have used a number of methods of food preservation which require an understanding of the chemical change that takes place in the food. In pemmican, animal fat serves as a preservative so the mixture will last for long journeys. Smoking and drying are also preserving methods; they rid meat and fish of excess moisture which might cause it to rot before it can be eaten.

Medicinals: The chemical properties of plants were recognized by Aboriginal people for their medicinal uses. Juniper berries, for instance, can be crushed to stop mosquito from biting. They contain a chemical substance which acts as an insect repellent.

Sources

On-line

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http://www.aspirin.org/
2. Chemistry
http://www.schoolnet.ca/aboriginal/science2/chem-e.html
3. Delicious On-line
http://www.delicious-online.com/health/articles/injd0696hs.html
4. Molecule of the Month: Aspirin
http://www.bristol.ac.uk/Depts/Chemistry/MOTM/aspirin/aspirin.htm
5. The Ozone Notepad
http://tiger.chm.bris.ac.uk/cm1/EloiseS/
6. Periodic Table of Elements
http://www.universe.digex.net/~kkhan/periodic.html
7. Stainless Steel Information Centre
http://www.ssina.com/student.html

Books

Physical Science: Discovering Matter and Energy, Copp Clark Pittman Ltd., 1991

Math problems

1. You are a science teacher who has ordered special periodic table posters for your class. Each poster shows an element, its atomic weight and number, and the number of protons, neutrons and electrons it has. When the posters arrive you find that some of the values have been left blank! Can you fill them in so you can use the posters in class?

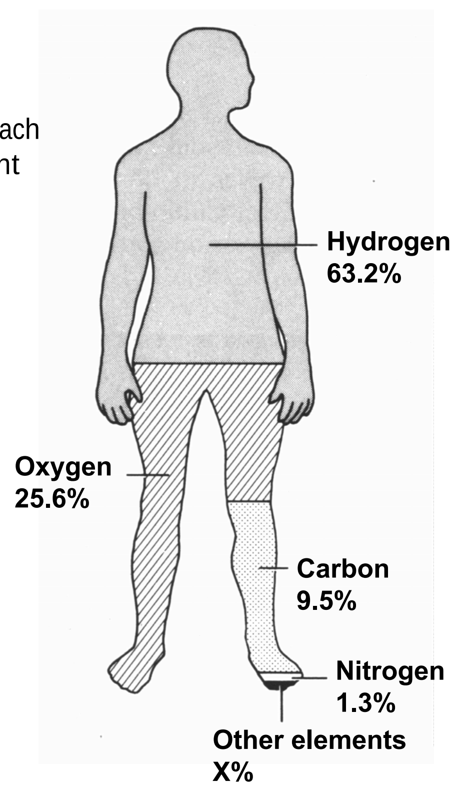
Number	Weight	Symbol	Protons	Neutrons	Electrons	Name
12	24.3	Mg	12			Magnesium
	190.2	Os	76			Osmium
	261.1	Unq			104	Unnilquadium
50		Sn	50	69		Tin
2	4.0	He				Helium
	244.1	Pu		150		Plutonium
	196.9	Au			79	Gold
70	173.0	Yb				Ytterbium

2. The human body is 63.2% hydrogen, 25.6% oxygen, 9.5% carbon, 1.3% nitrogen, 0.2% phosphorus and 0.2% other elements. You are a biochemical engineer who needs to present this information to your client in concrete terms.

a) You decide to tell your client how many how many kilograms of each element is in his body. If he weighs 73 kg, how much of his weight is hydrogen? Oxygen? Carbon? Nitrogen? Phosphorus? Other?

b) You then draw a pie chart which shows the proportion of each element in a human body. What does it look like?

c) Finally you decide the best way to present your information is in the graph to the left. In this graph, what is the percentage of "Other" elements? What does it represent? Why?



Source: Physical Science: Discovering Matter and Energy (Copp Clark Pittman, 1991)