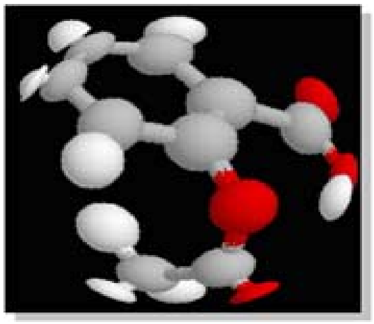


CHEMISTRY
AND ENGINEERING I

Worksheet 5

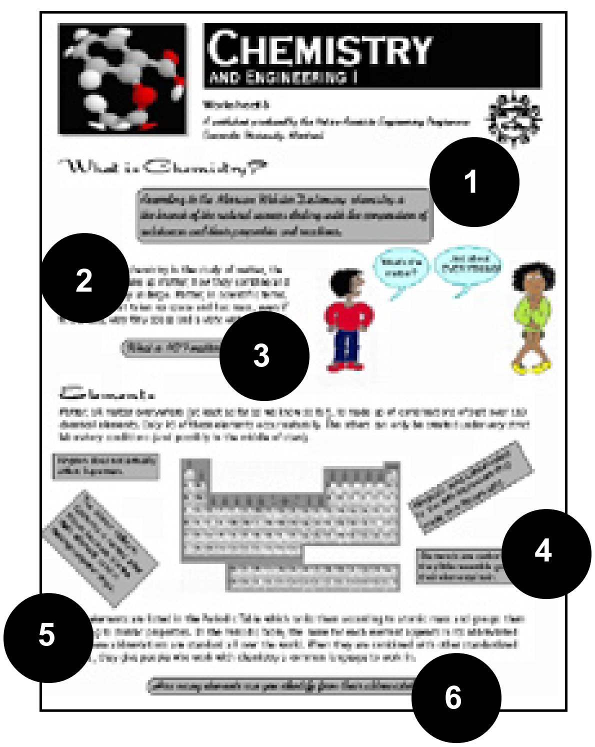
A worksheet produced by the Native Access to Engineering Programme

Teacher's Guide

Here are some suggestions for how you can work with this worksheet.

1. Definition
   Ask the students if the definition is clear. Do they understand the terms used in the definition? What is their understanding of what chemistry is?

2. Matter
   What is the smallest, lightest thing the students can think of? Matter can be so small as to be almost undetectable. Chemists used special instruments - called electron microscopes - to see and study very small bits of matter.



3. What is not matter?
   Energy is not matter.

4. Diamonds
   Graphite is the substance used in most "lead" pencils. Even though it is chemically identically to diamonds, the 2 substances are subjected to much different forces during their formation. The carbon in diamonds has been subjected to very high pressures, which cause it to form shiny, perfect crystals.

   You can demonstrate the difference that pressure can make in the formation of a substance by baking cookie crumb pie crusts.

   <u>You need:</u>
   3 pieces of paper
   For each group:
   - a pie plate
   - 1 1/3 cups cookie crumbs (Oreo or graham cracker)
   - 1/2 cup melted butter
   - 1/3 cup sugar
   - measuring cup(s)
   - wooden spoon
   - mixing bowl
   - a knife

Preparation
Before class, write one of the following instructions on a separate sheet paper:
#1 "Just put pie crust compound in plate and do nothing."
#2 "Shape the pie crust compound to the pie plate, but leave it fairly loose."
#3 "Shape the pie crust compound to the pie plate and make sure it is very tightly packed together."

Demonstration
Divide your class into 2 or 3 groups. Have each group measure and prepare the pie crust ingredients. They should mix the sugar and cookie crumbs together in the mixing bowl first, then stir in the butter. When the pie crust compound is ready, have one member from each team pick up one of the instructions you prepared before class (if you only have 2 groups, use instructions 1 and 3 only). The groups should then follow the instructions on the paper for making their crust. When they are ready, cook each of the crusts in an oven (325-350^{0}F, for about 15 minutes) and then bring them out and let cool for a few minutes.

Once the crusts are cool, the students can examine them to see the differences. You can ask them a series of questions like:
Which one is the hardest? What does each crust look like? Which one is easier to cut? What difference does pressure make to the crust? etc…

5. Periodic table
   If your students are interested in how the elements are classified in the periodic table, there is lot of extra information you can give them.

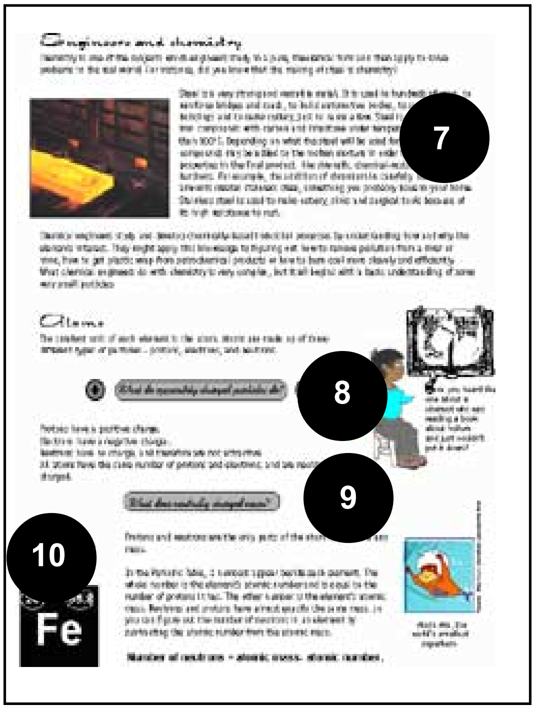
   The rows of the Periodic Table are called periods, the columns are called groups or families. Elements within families share common properties. For instance

   - Group 1 (Hydrogen to Francium) are alkali metals, which are all so reactive that they never exist by themselves as free elements, they only exist as compounds.
   - Group 2 (Beryllium to Radium) are alkaline earth metals, which are also very reactive. They also do not exist as free elements - at least on Earth. They are, however, among the most common elements found in compounds on Earth.
   - The short groups, between Group 2 and group 3 are called the transition metals.
   - The Lanthanide (Lanthanum to Lutetium) and Actinide (Actinium to Lawrencium) series are called the rare earth metals, because they are found rarely or can only be made synthetically.
   - Group 7 (Fluorine to Astatine) are the halogens. They are very reactive. Each of the halogens readily combines with Sodium (Na); the word halogen comes from Greek and means "salt former".
   - Group 8 (Helium to Radon) are known as the Noble or inert gases. These elements react very rarely, but can be made to react with other elements under specific conditions.

6. Elements
   If you have a periodic table in the classroom you can turn naming the elements into a game and see how many the class can name. Some of the elements like Curium and Eisteinium are named for famous scientists (in this case Marie Curie and Albert Einstein), can you students guess which ones they are?

7. Carbon in steel
   The carbon used in steel is actually called coke. It is made by processing naturally occurring coal in large industrial ovens.

8. Oppositely charge particle
   Oppositely charged particles attract each other. So the opposite charges of the protons and electrons in an atom attract each other and help hold the atom together. In order to remain neutrally charged, all atoms must have the same number of protons and electrons.



9. Neutral Charge
   Neutrally charged means that the atom is neither positively charged (which would happen if there were more protons than electrons) nor negatively charged (which would happen if there were more electrons than protons).

10. Mass
    The mass of a proton is 1.6726 x 10^{-27} kg. A neutron is actually heavier. Its mass is 1.6749 x 10^{-27} kg. Electrons do have mass, but it is such a tiny mass that it isn't accounted for within the significant digits of an atom's mass. The mass of an electron is 9.1094 x 10^{-31} kg. To help your students understand just how small matter can be tell them a grain of salt is billions of times heavier than protons, neutrons or electrons.

    Students may wonder how scientists can know that "invisible" things this tiny can exist when they cannot see or touch them. Scientists can often tell a lot about something without actually seeing it. A lot of information can be inferred from how an object or substances behaves. Scientists base their knowledge on observation, even if something cannot be seen or touched there is generally some evidence of its existence. From that evidence, scientists can begin to guess what it is they are observing.

    <u>You will need</u>
    3 small boxes with lids
    Cotton (or some other lightweight material)
    Small metal objects such as washers or paper clips
    Masking tape
    Knitting needles, barbecue skewers or some other thin stick which can be pushed through the box

    <u>Preparation</u>
    Fill one of the small boxes with cotton. Put several washers (or paper clips) in the second box. Leave the third box empty. Seal all three boxes with the masking tape.

    <u>In class</u>
    Ask the students to describe what is in the boxes without using their eyes. They may shake the boxes, poke them with needles etc… but they cannot open the boxes up (nor should they try to peer through any holes they pierce in the box). How do they know if there is anything in the boxes? What observations can they make about the objects, what conclusions can they reach? Can they determine anything about the shape of the object? the texture? the size? Can they tell if there are more than one object in the box? Do they know what the object is? Once the students have made their observations (they may want to write them down), they can see how close they came to the actual objects by opening the boxes.

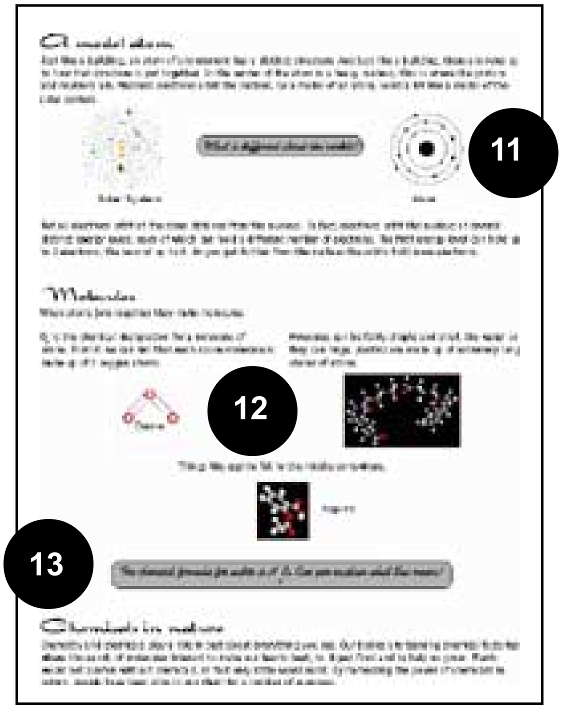
11. Models
    While there is only one planet in each orbit around the sun, there can be more than one electron in each orbit around an atom's nucleus. In fact, each orbit - or energy level - around the atom holds a different number of electrons, and orbits farther away from the nucleus hold more electrons.
    Energy level 1 - 2 electrons
    Energy level 2 - 8 electrons
    Energy level 3 - 18 electrons
    Energy level 4 - 32 electrons
    Energy level 5 - 50 electrons
    Energy level 6 - 72 electrons

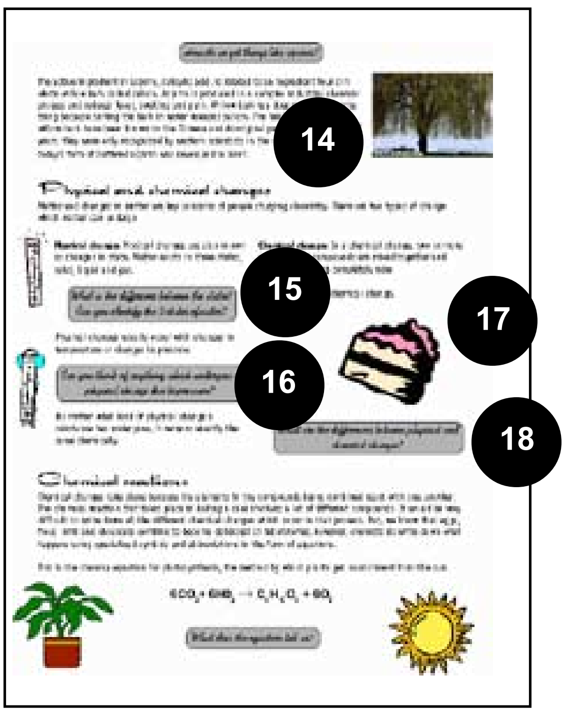
12. Molecules
Molecules are structures. It might be interesting for your students to learn more about some molecules that they have heard of.

Ozone: Ozone is one of the chemicals which is crucial to the survival of life on Earth. In the upper atmosphere, high-level ozone forms a shield which keeps harmful radiation from reaching the planet's surface, a bit like a natural sunscreen. Low-level ozone is not so friendly, it is one of the components which reacts to create smog in cities and acid rain.

Nylon: Nylon is a polymer. This means it is made of long chains of molecules sometimes called macromolecules. Nylon was invented at the beginning of World War II, and was first used commercially for toothbrush bristles. It is a very versatile substance which is used in hundreds of applications including, hosiery, rope, clothing, parachutes and racing tires.

13. H_2O
It means there are 2 hydrogen atoms and one oxygen atom in each water molecule.





14. Other plants
At this point you may want to discuss other plants and herbs which have traditionally been used in your community for healing.

15. States
As substances move from one state to another they gain or lose energy. So the difference between the states is primarily a difference in the amount of energy. Molecules with more energy move around more and are farther apart, molecules with less energy move less and are closer together.

Solid - Solid substances have the least amount of energy. The molecules are packed close together. Solids have a definite shape.

Liquid - The molecules in liquids have more energy; they flow over one another. Liquids take the shape of their container. (When you watch something melt, you can almost see that the molecules are farther apart than in a solid.)

Gas - In gases, molecules have lots of energy; they will expand to fill whatever space is available to them.

(Plasma - There are actually 4 states of matter. If a substance has a huge amount of energy (like the amount of energy generated by an atomic blast), it will become plasma. In plasma, the energy is so great that electrons get knocked off their atoms.)

The three states of water are - ice(solid), water (liquid) and steam (gas).

16. Pressure changes
Non-Newtonian fluids are a special type of fluid, some of which undergo changes of state due to change pressure. You can make a non-Newtonian fluid called Goop with your class.

WARNING: THIS IS MESSY, BUT FUN!!!!!

<u>You need:</u>
A shallow tub
Cornstarch
Water

<u>Preparation</u>
In proportions of (approximately) 2:1 mix the warm water and cornstarch in the tub. You want to make enough Goop so the bottom of the tub is covered. You'll know the mixture is ready when you punch it and it doesn't splash up.

<u>Demonstration</u>
Let the students play with and make observations about substance. When does Goop act like a solid? When does it act like a liquid? What happens if they try to quickly push their fingers into it? What happens if they slowly push their fingers into it?

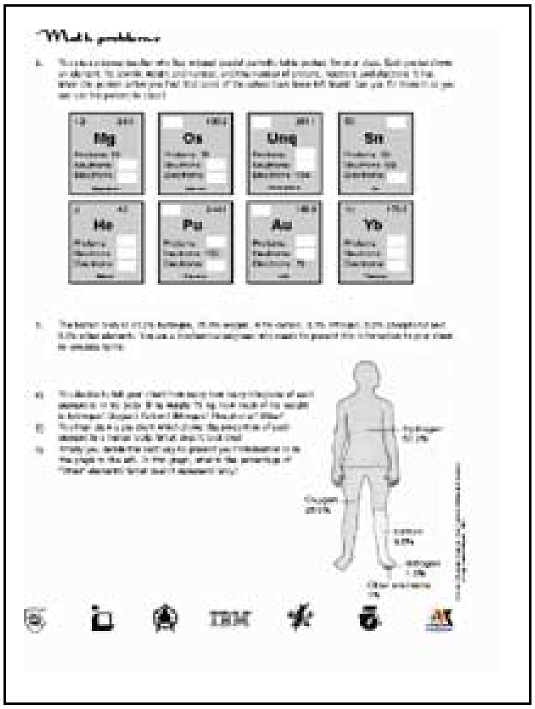
The physics of what is happening here are quite complicated. Part of the explanation is in the shape of the molecules. Water and cornstarch form long stringy molecules that are all tangled together, a bit like messy hair. What happens when you try to brush tangled hair? If you try and move the brush quickly through tangled hair it just knots up more and your brush can't move. But if you move slowly, the brush works its way through the tangles and pulls the hairs in the same direction. A similar thing is happening in the Goop. When the students try to move through the tangled molecules quickly, the molecules all bunch together and act like a solid; if the students try to move through the goop more slowly, the molecules come apart and act like liquid.

17. Chemical change
Why not demonstrate chemical change by baking a cake, or muffins or anything with your class?

18. Differences between physical and chemical changes
Physical changes are reversible - ice can become water and vice-versa, while chemical changes are not - you can't unbake a cake. In a physical change the substance remains chemically the same, in a chemical change it does not.

19. Chemical equations
The equation is balanced. This means that while the chemicals from the left side get rearranged into new substances during the reaction, they all still appear in the same amounts on the right hand side of the equation.

20. Aboriginal chemistry
Perhaps a community member would be willing to come in and talk to the students about one of the listed examples.



Math Problems

<u>Problem 1.</u>

I. What do you know?

You know the rules for how an atom is constructed.

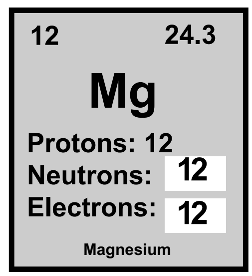
- # protons = #electrons
- # protons = Atomic #
- #neutrons = Atomic mass - Atomic #

All of these problems can be solved using addition or subtraction and the communicative law. The key is to start with the equalities and fill in as many spaces as possible.

II. Filling in the posters

Magnesium

Given: Atomic #: 12
Atomic mass: 24.3
protons: 12

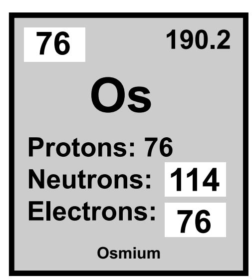


electrons = # protons = 12

neutrons = Atomic mass - Atomic
= 24.3 - 12
= 12.3
= 12 neutrons (rounded to the nearest whole number because you can't have a partial neutron)

Osmium

Given: Atomic mass: 190.2
protons: 76



Atomic # = # protons = 76

electrons = # protons = 76

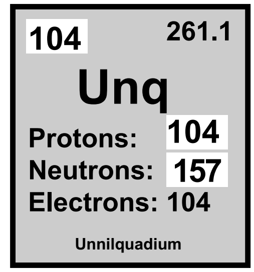
neutrons = Atomic mass - Atomic
= 190.2 - 76
= 114.2
= 114 neutrons (rounded to the nearest whole number)

Unnliquadium

Given : Atomic mass: 261.1
electrons: 104

electrons = # protons = Atomic # = 104

# neutrons	=	Atomic mass - Atomic #
	=	261.1 - 104
	=	157.1
	=	157 neutrons (rounded to the nearest whole number)

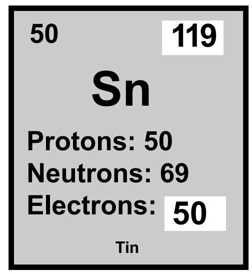


Tin

Given: Atomic #: 50
protons: 50
neutrons: 69

electrons = # protons = 50

# neutrons	=	Atomic mass - Atomic #
69	=	Atomic mass - 50
69 + 50	=	Atomic mass
Atomic mass	=	119

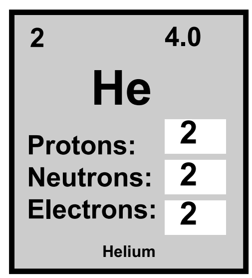


Helium

Given: Atomic number: 2
Atomic mass: 4.0

protons = atomic # = # electrons = 2

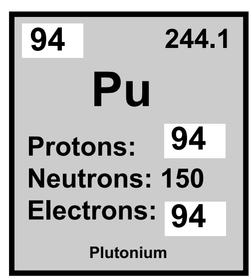
# neutrons	=	Atomic mass - Atomic #
	=	4.0 - 2
	=	2 neutrons



Plutonium

Given: Atomic mass: 244.1
neutrons: 150

# neutrons	=	Atomic mass - Atomic #
150	=	244.1 - Atomic #
Atomic #	=	244.1 - 150
	=	94.1
	=	94 (rounded to the nearest whole number)



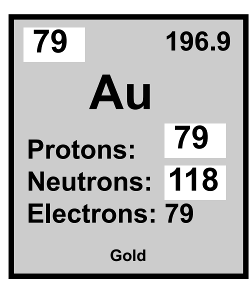
Atomic # = # protons = # electrons = 94

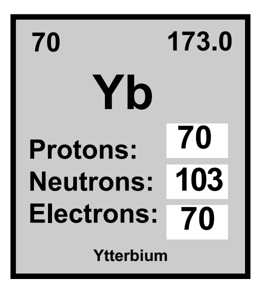
Gold

Gold can be solved in the same way as Osmium.

Ytterbium

Ytterbium can be solved in the same way as Helium.





Problem 2a.

I. What do you know?

- Percentages of elements in the human body.
  Hydrogen: 63.2%   Oxygen: 25.6%   Carbon: 9.5%
  Nitrogen: 1.3%   Phosphorus: 0.2%   Other: 0.2%
- You client mass 73 kg.

II. Convert percentages to decimal values.

To use percentages in calculations they must be expressed as decimal values.

Hydrogen

$$\text{decimal value} = \frac{\text{\% of hydrogen}}{100} = \frac{63.2}{100} = 0.632$$

The decimal values for the other elements may be calculated in a similar way.

Oxygen: 0.256   Carbon: 0.095   Nitrogen: 0.013
Phosphorus: 0.002   Other: 0.002

III. Calculating the mass of each element in the client's body.

Hydrogen

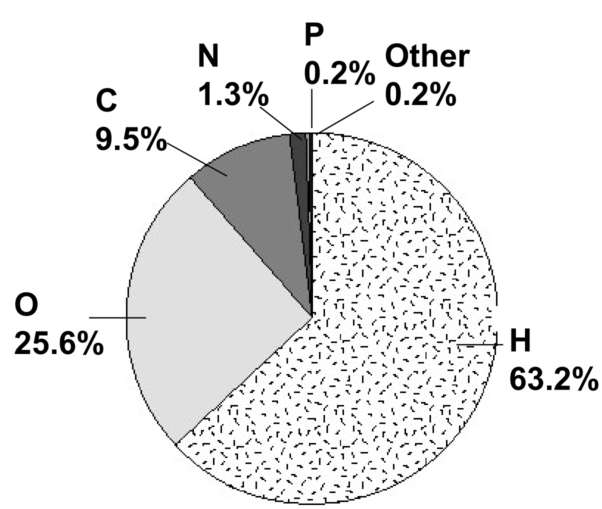
mass of hydrogen in body = decimal value of % x client's mass
= 0.632 x 73 kg
= 46.136 kg of hydrogen

The mass of the other elements may be calculated in a similar way.

Answer
Hydrogen: 46.136 kg.   Oxygen: 18.688 kg   Carbon: 6.935 kg
Nitrogen: 0.949 kg   Phosphorus: 0.146 kg   Other: O.146 kg

Problem 2b.

The pie chart should look something like the example given.



Proportion of elements in the human body

Problem 2c.

In the body-shaped graph the percentage of other elements is 0.4%. It represents Phosphorus and "other" elements. It is very difficult to show small percentages in graphs (as the students will find out from making the pie charts) and so small percentages are sometimes grouped together in order to make them easier to graph and to see.