Chemistry - 101

02/28/21

Making pottery and bricks

mullite

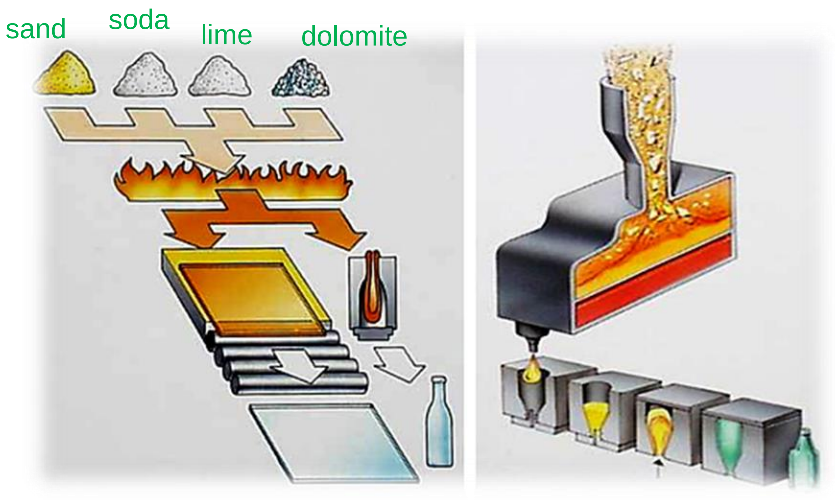
$$3Al_2Si_2O_5(OH)_4(s) \xrightarrow{\Delta} Al_6Si_2O_{13}(s) + 4SiO_2(s) + 6H_2O(g)\uparrow$$

Kaolinite from the lake

The castaways mixed clay with sand, molded 3000 bricks in 2 days and baked them by the heat of fire.

Jules Verne:

“As to the substance used in the composition of glass, they are simply sand, chalk and soda, either carbonate or sulfate. Now the beach supplied sand, lime supplied chalk Seaweeds supplied soda, … and the ground supplied coal to heat the kiln to the desired temperature. Cyrus Harding thus soon had everything ready for setting to work…” A hundred parts of sand, thirty-five of chalk, forty of sulfate of soda, mixed with two or three parts of powdered coal, composed the substance, which was placed in the crucibles.



http://www.carmeusena.com/markets/markets-milled-limestone/glass-manufacturing

Glass is made in much the same way today with soda-lime glass consisting of ~ 25% sodium carbonate, 12.5% lime and 62.5% silicon dioxide

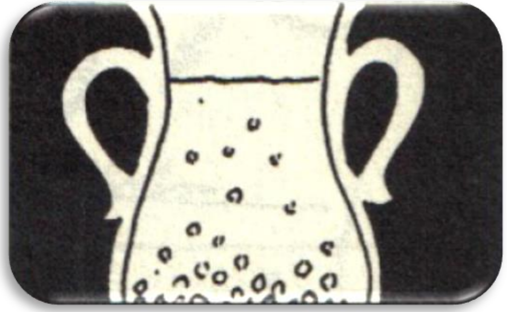
Soap

1. Burn seaweed to get a white, powdery mixture of *soda ash* Na_2CO_3 and *potash* K_2CO_3

2. Combine with whitewash:

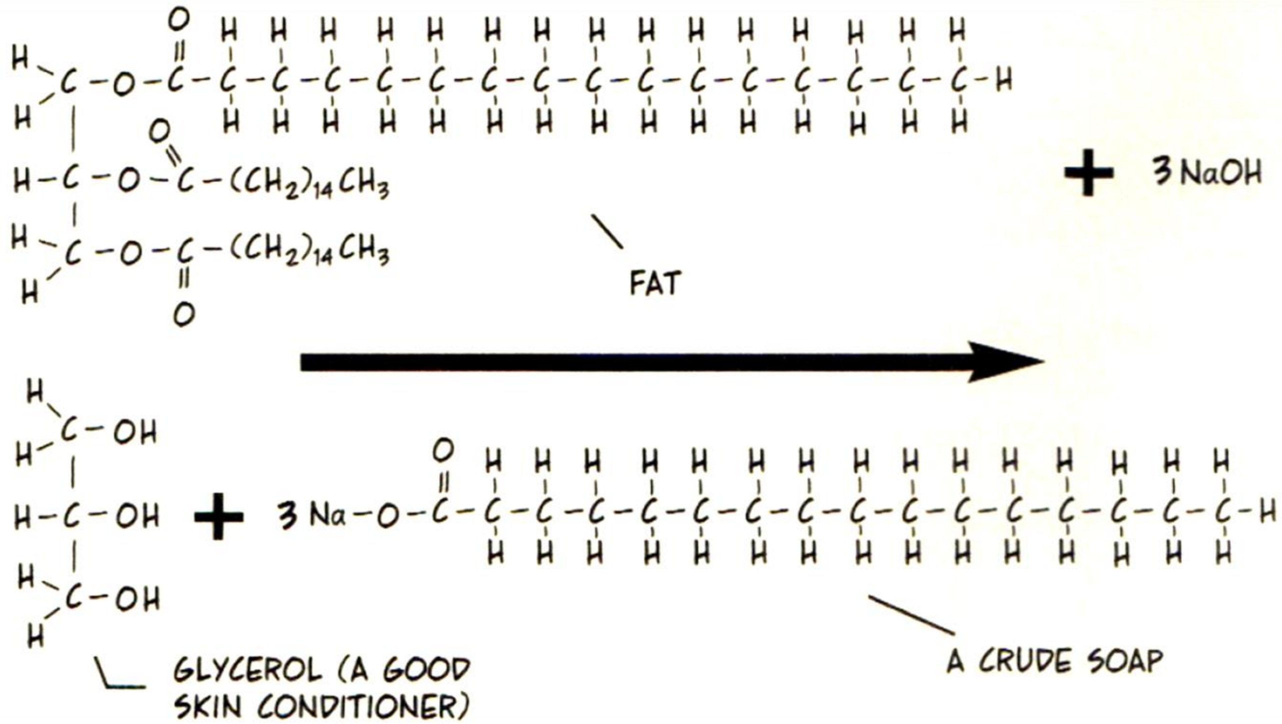
$$Ca(OH)_2(aq) + Na_2CO_3(aq) \rightarrow$$

$$2NaOH(aq) + CaCO_3(s) \downarrow$$



3. *Decant* carefully to get clear Solution of NaOH (*caustic lye*), highly alkaline

4. Boil some animal or plant fat with caustic lye



FAT
+ 3 NaOH
3 Na
+
GLYCEROL (A GOOD SKIN CONDITIONER)
A CRUDE SOAP

Jules Verne – Soap and saponification reactions

Hydrolysis of the ester in alkali environment gives soap:

$$C_3H_5(OOC_{11}H_{23})_3 + 3\ NaOH \rightarrow C_3H_5(OH)_3 + 3C_{11}H_{23}COONa$$

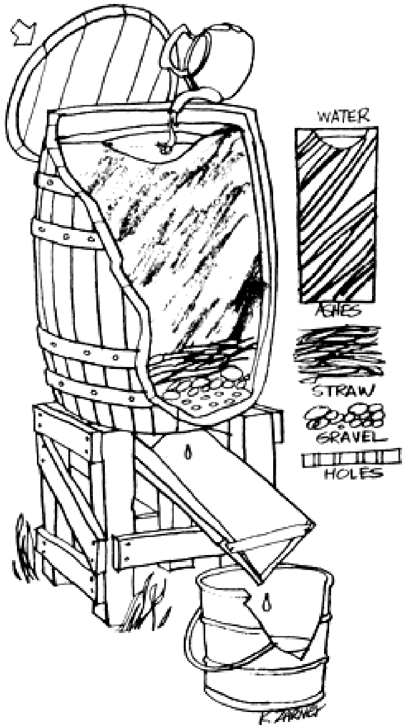
glycerin soap

Why not $Ca(OH)_2$(slacked lime)?

"Neb and Pencroft had taken away the fat… placed it in large earthen pots.
It was then necessary to separate the glycerin from the fat by *saponifying* it.
Now, to obtain this result, it had to be treated either with soda or lime.
In fact, one or other of these substances, after having attacked the fat, would form soap by separating glycerin, and it was just this glycerin which the engineer wished to obtain. There was no want of lime; only treatment by lime would give calcareous soap, insoluble, and consequently useless, while treatment by *soda* would furnish, on contrary, a soluble soap, which could be put to domestic use."

Colonial ash hopper

"Now a practical man like Cyrus Harding, would rather try to obtain soda. Was this difficult? No; for marine plants abounded on the shore… . A large quantity of these plant was collected , first dried, then burned in holes in the open air. The combustion of these plants was kept up for several days, and the result was a compact gray mass, which has long been known under the name of "natural soda". This obtained, the engineer treated the fat with soda, which gave both a soluble soap and that neutral substance, glycerin."



Home soap was obtained from fat and rain water trickling through wood ashes:
K_2O and Na_2O are produced along with CO_2 they give carbonates:

$Na_2O + CO_2 \rightarrow Na_2CO_3$ "soda"

$Na_2CO_3 + H_2O \rightarrow NaHCO_3 + NaOH$

Explosive powder to signal passing ships

Charcoal, saltpeter (KNO_3) and … sulfur

Potassium is in potash from…
Nitrate will come from $Ca(NO_3)_2$
From **bat guano**
Sulfur will come from volcano (yellow stuff)

Boil the guano in water with potash and get a double displacement reaction:

$$Ca(NO_3)_2(aq) + K_2CO_3\ (aq) \rightarrow CaCO_3\ (s) + 2KNO_3\ (aq)$$

The chalk settles out of the solution

Decant

Crystallization

Let the water evaporate and we are left with needle-like crystals of $K_2(NO_3)_2$

Explosive powder to signal passing ships

Charcoal, saltpeter (KNO_3) and … sulfur

What will the reaction products be when we set this stuff off?

$C + S + KNO_3 \rightarrow$?

We can make a good guess by following the electrons from one atom to another. This is **oxidation-reduction reaction** or **redox** for short.

Examples of redox reactions:

Combustion

$C + O_2 \rightarrow CO_2$

Corrosion

$4Fe + 3O_2 \rightarrow 2Fe_2O_3$

Examples of redox reactions:

Or rotten egg:

$H_2 + S_2 \rightarrow H_2S$

Redox reactions can be balanced by following the electrons

C + KNO3 → ?

$C + KNO_3 \rightarrow N_2\ (gas) + CO_2\ (gas) + K_2CO_3\ (solid)$

$5C + 4KNO_3 \rightarrow 2N_2\ (gas) + 3CO_2\ (gas) + 2K_2CO_3\ (solid)$

This reaction will produce a pretty good fizz, but centuries of experiments have shown that adding sulfur makes a much bigger pop.

$C + KNO_3 + S \rightarrow ?$

$C + KNO_3 + S \rightarrow CO_2(g) + N_2(g) + K_2S(s)$

Each C looses 4 electrons

Each N gains 5 electrons

Each S gains 2 electrons

$3C + 2KNO_3 + S \rightarrow 3CO_2(g) + N_2(g) + K_2S(s)$ + BANG!

IF YOU TRY THIS AT HOME **(NOT RECOMMENDED** IN THE FIRST PLACE), ALWAYS BE SURE TO GRIND THE INGREDIENTS **SEPARATELY**— UNLESS YOU WANT TO BLOW OFF YOUR FINGERS, OR EVEN YOUR WHOLE HAND.

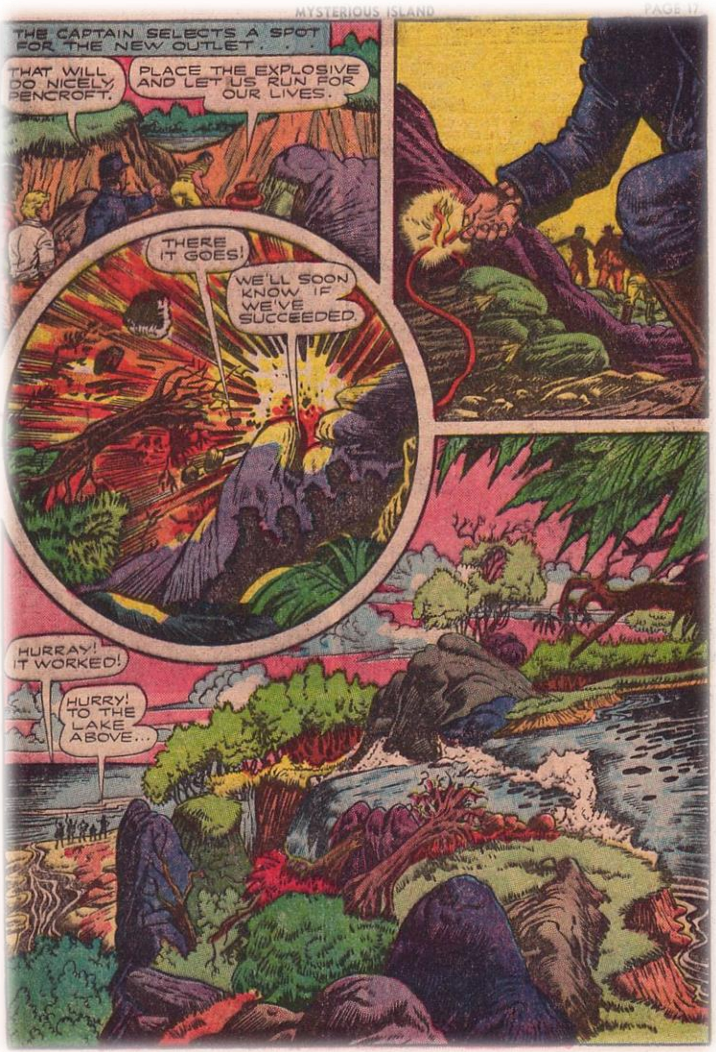
Pack the powder into bamboo tubes and – here comes a ship, light the fuse!


Congratulations! You are rescued!
Who wants to be rescued? We were just showing off!
Could you bring us some lab gear and books of Jules Verne?

Jules Verne – Sulfuric acid, Nitric acid
(sulfuric acid also used by settlers to manufacture candles, tan skins etc.)

Glycerin was obtained to make a dynamite to explode a mountain and expose an opening that connects a lake with the sea, making a water-fall on the beach

DYNAMITE – invented by Alfred Nobel and patented in 1867



pyrites

$FeS_2\ [Fe_xS_x] + 7/2O_2 \rightarrow 1/2Fe_2(SO_4)_3(s) + 1/2SO_2(g)$

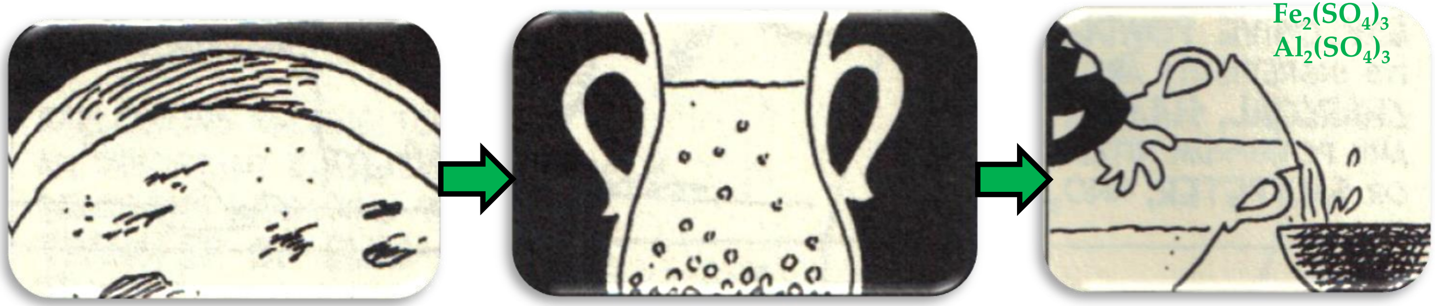
$FeS_2 + 11/4\ O_2 \rightarrow Fe_2O_3 + 2SO_2$

Also possible: FeS, FeO, Fe_3O_4, Fe_2O_3, $FeSO_4$, S_8 and other compounds

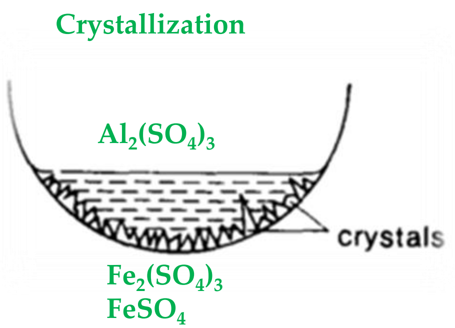
1. Burn pyrites by layering:

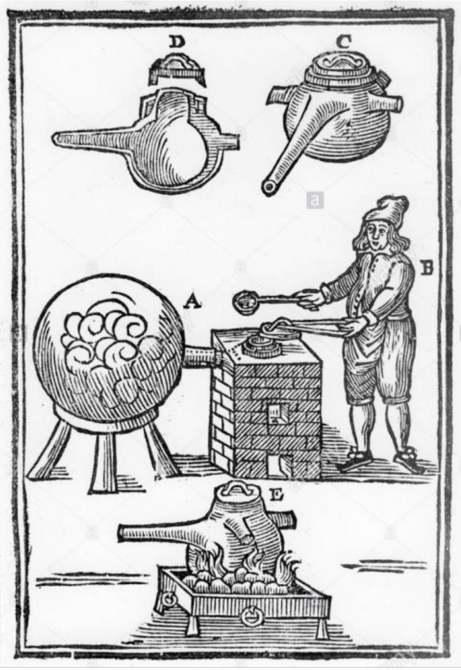
"… the *sulphuret of iron* to be changed into *sulphate of iron* and the *alumina* into *sulphate of alumina*, two equally soluble substances, the others, *flint* (quartz), burned coal, and cinders, not being so."

2. Combine the heap of pyrites entirely reduced by fire with water. Stir the mixture, let it settle, decant it, obtain a clear liquid.



3. Partially evaporate the liquid, “this liquid being partially evaporated, crystals of sulphate of iron were deposited, and the not evaporated liquid, which contained the sulphate of alumina, was thrown away”.





4. “…*Calcine* the sulphate of iron crystals in a close vase, so that the sulphuric acid should *distill* in vapor, which vapor by *condensation*, would produce the acid.” **Obtaining sulphuric acid – Nordhausen acid ($H_2S_2O_7$ pyrosulfuric acid)**

From other chemical writings of the period:
“Nordhausen sulfuric acid… is manufactured by the original process-the distillation of dried ferrous sulfate in earthen retorts.”

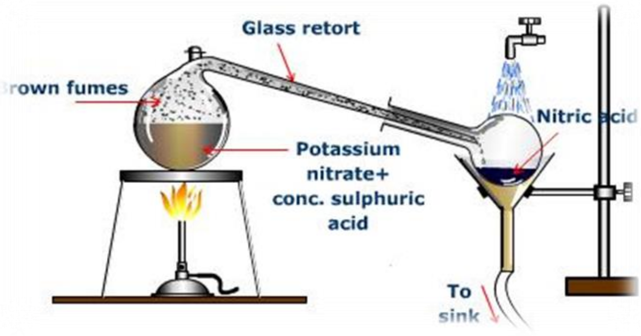
We still need nitric acid…

Nitric acid from saltpeter (KNO_3)

"And why did he wish for this agent? Simply to produce ***azotic acid***; and that was easy since, ***saltpeter***, attacked by sulfuric acid, gives this acid by distillation."

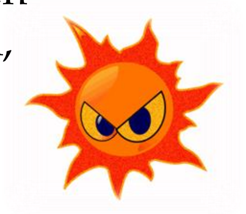
Until the early 1900s the nitric acid was produced by heating saltpeter with sulfuric acid:

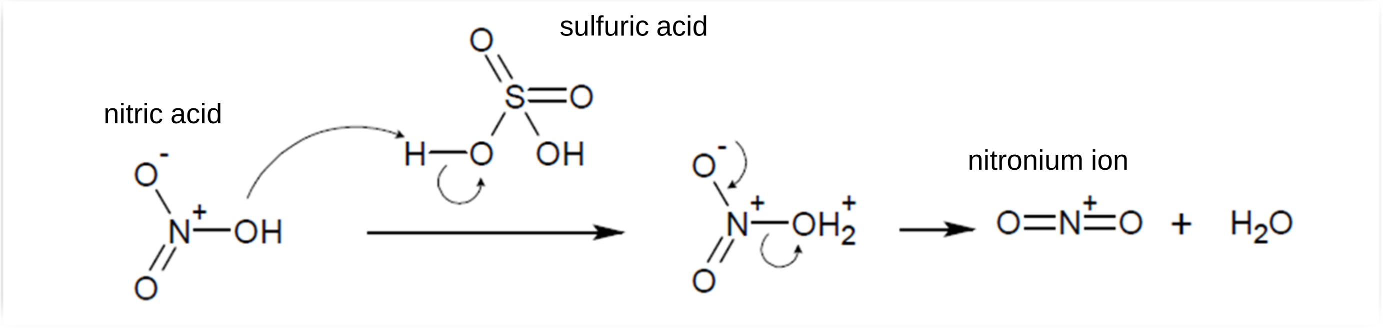
$$KNO_3 + H_2SO_4 \rightarrow HNO_3 + KHSO_4$$



Dynamite

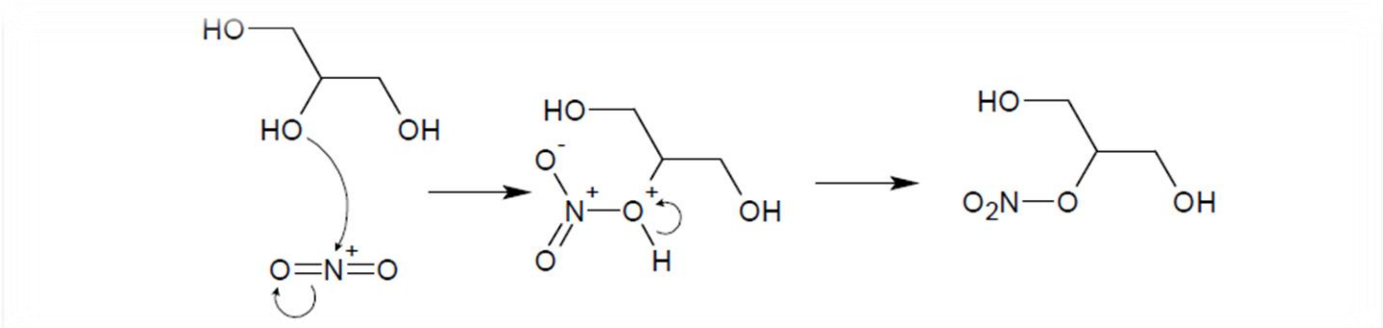
"Taking some azotic acid, he mixed it with glycerine, which had been previously concentrated by evaporation, subjected to the water-bath, and he obtained, without even employing a refrigerant mixture, several pints of an oily yellow mixture... Here is ***nitro-glycerine***!"





glycerin

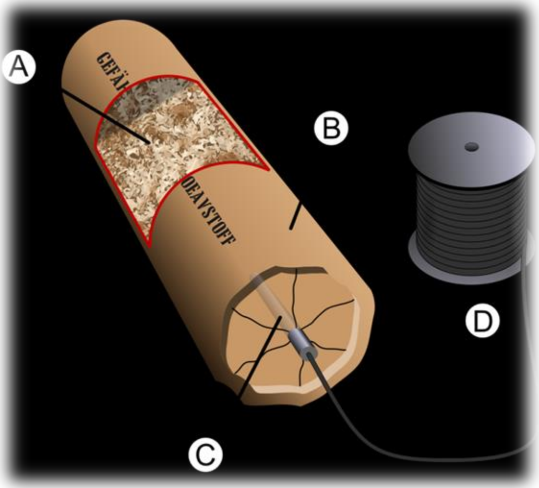
First nitration step of nitroglycerin synthesis



"… the way was found to transfer it (nitroglycerine) to *dynamite*, that is to say, to mix with it some solid substance, clay or sugar porous enough to hold it…"

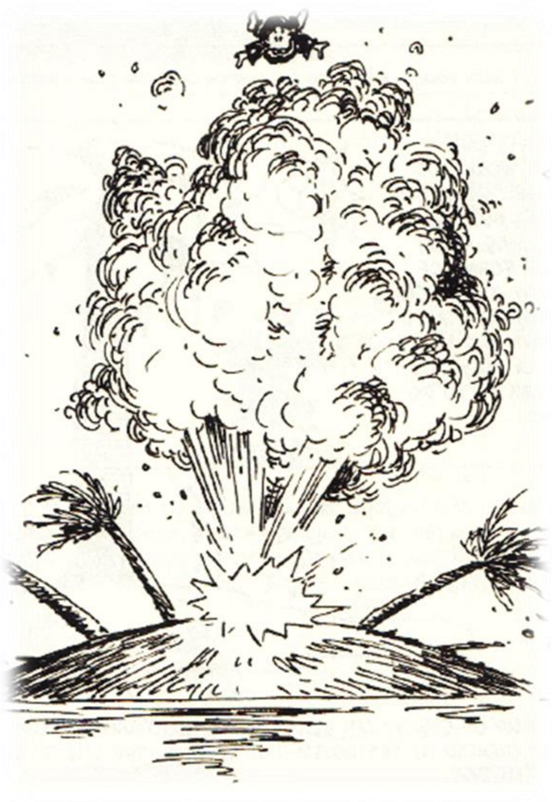
Diagram:

a. Absorbent material soaked in nitroglycerin.
b. Protective coating surrounding the explosive material
c. Fuse connected to the blasting cap



Conclusions:

1. Read books
2. Read good books
3. Have fun
4. BUT: Safety first!



This class uses the materials from the following books:

Larry Gonick and Graig Criddle “The cartoon guide to chemistry”

Manyuilov and Rodionov “Chemistry for children and adults”

Kuzmenko, Eremin, Popkov “Beginnings of chemistry”

http://school-collection.edu.ru (experiments)