«The development of society is possible only through the advancement of industry, science and education»

Dmitri Mendeleev

Humanitarian Aspects in Chemistry and Chemical Engineering Education

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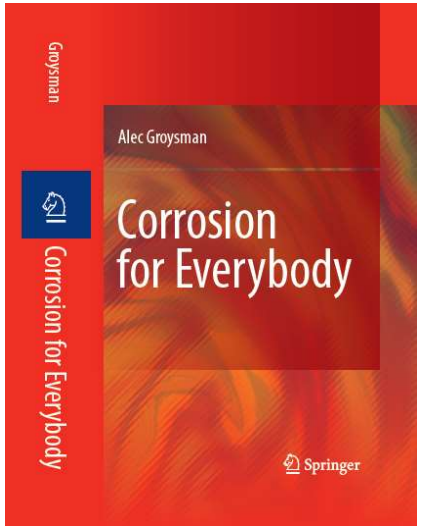
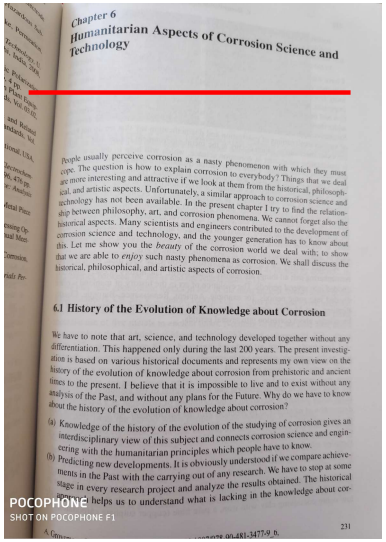
The aim - to show how humanitarian aspects (art, history, music, poetry, humor) can help in chemistry and chemical engineering education.

The Humanities Comeback:
For High-Tech work, go study philosophy !
[Calcalist - Economics, 13.12.2019, in Hebrew].

When students learn chemistry using humanitarian aspects, they are more successful.

1. ***Creativity.***
2. ***Philosophy gives opportunity to connect different subjects and to ask correct questions.***
3. ***Connections in brains which help in solutions of chemistry problems.***




Chapter 6
Humanitarian Aspects of Corrosion Science and Technology

People usually perceive corrosion as a nasty phenomenon with which they must cope. The question is how to explain corrosion to everybody? Things that we deal are more interesting and attractive if we look at them from the historical, philosophical, and artistic aspects. Unfortunately, a similar approach to corrosion science and technology has not been available. In the present chapter I try to find the relationship between philosophy, art, and corrosion phenomena. We cannot forget also the historical aspects. Many scientists and engineers contributed to the development of corrosion science and technology, and the younger generation has to know about this. Let me show you the *beauty* of the corrosion world we deal with; to show that we are able to *enjoy* such nasty phenomena as corrosion. We shall discuss the historical, philosophical, and artistic aspects of corrosion.

6.1 History of the Evolution of Knowledge about Corrosion

We have to note that art, science, and technology developed together without any differentiation. This happened only during the last 200 years. The present investigation is based on various historical documents and represents my own view on the history of the evolution of knowledge about corrosion from prehistoric and ancient times to the present. I believe that it is impossible to live and to exist without any analysis of the Past, and without any plans for the Future. Why do we have to know about the history of the evolution of knowledge about corrosion?

(a) Knowledge of the history of the evolution of the studying of corrosion gives an interdisciplinary view of this subject and connects corrosion science and engineering with the humanitarian principles which people have to know.
(b) Predicting new developments. It is obviously understood if we compare achievements in the Past with the carrying out of any research. We have to stop at some stage in every research project and analyze the results obtained. The historical [illegible] helps us to understand what is lacking in the knowledge about cor-

231

Creative people become inspiring leaders, innovative entrepreneurs, and students' favorite teachers.

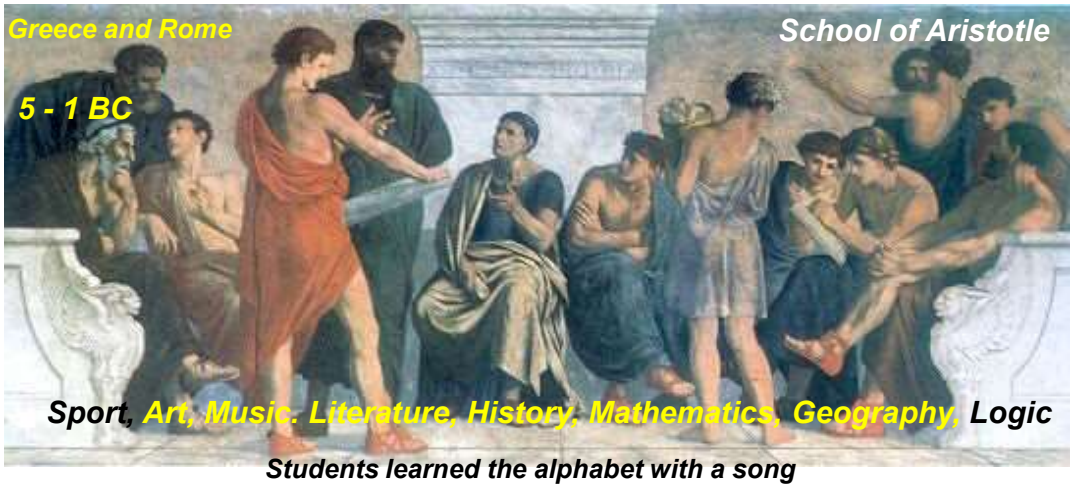
To show educators how to catch the attention of new generation to study chemistry in enjoyable manner.

A humanitarian education allows us to bring up the ethical standards of behavior of an educator, a scientist, an engineer.

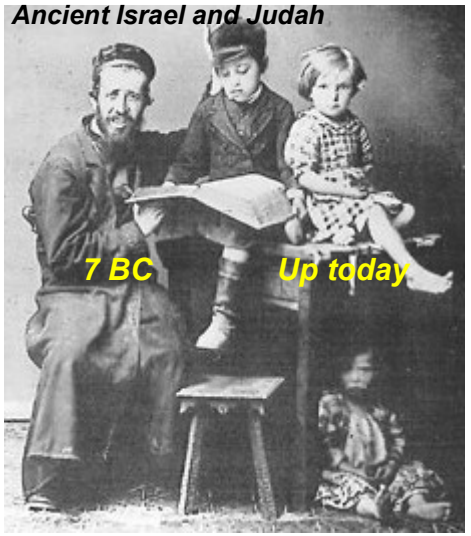
One of the mission of ART is EDUCATION

Education is a discovery!

Art activates brain!



Students learned the alphabet with a song



Education - fundamental aspect of the imparting of culture from generation to generation

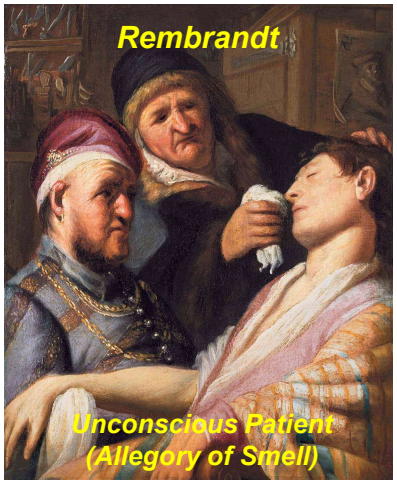
Use of organs of sense

1. Colors:

Red - Fe_2O_3

White – $BaSO_4$

Blue - green - $Cu_2(OH)_2CO_3$ (patina)



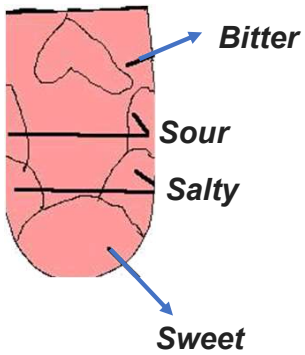
2. Smell:

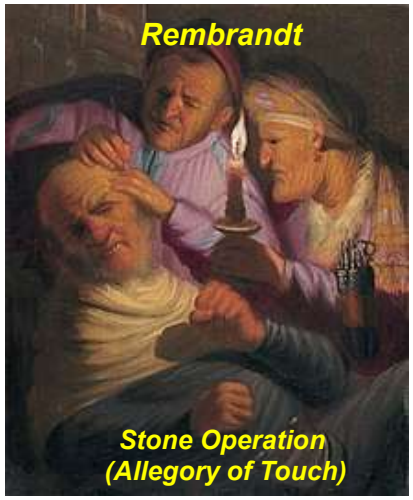
NH_3

H_2S

Acetone

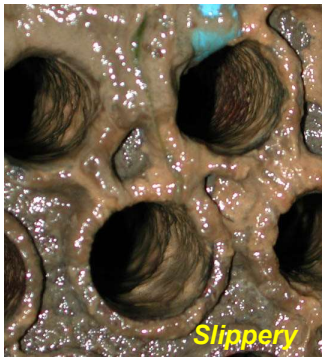
5. Taste





3. Touching:

Biofouling



4. Hearing

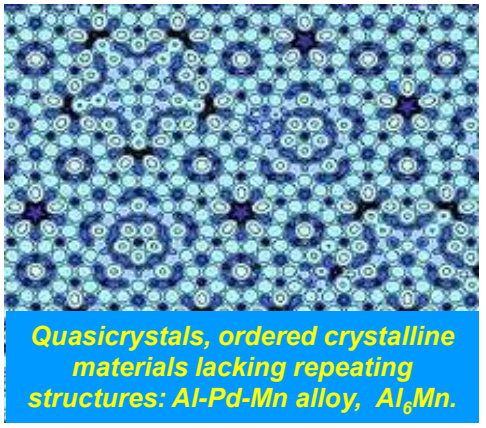
An engineer is "listening" to the pump: cavitation

Quasicrystals in Art and Design

Alhambra palace in Spain

Darb-e Imam shrine in Iran, 1453

Art Helps Science



Quasicrystals, ordered crystalline materials lacking repeating structures: Al-Pd-Mn alloy, Al_6Mn.

and Nature

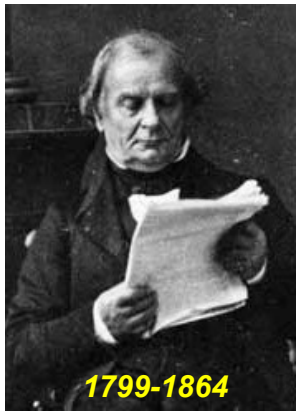
Aperiodic mosaics, such as those found in the medieval Islamic mosaics of the Alhambra palace in Spain and the Darb-e Imam shrine in Iran, have helped scientists understand what quasicrystals look like at the atomic level. In those mosaics, as in quasicrystals, the patterns are regular -- they follow mathematical rules -- but they never repeat themselves.

History Is Not Only the Past

History teaches that knowledge is not fixed.

How do we know what we know, and how might it be otherwise?

1834 $PV = nRT$ *The ideal gas law*



On the question what is R, students answer that R is a universal gas constant, but find it difficult to explain physical meaning of R and why the letter R is used.

$$\Delta(P \cdot V) = n \cdot R \cdot \Delta T$$

$$\Delta(P \cdot V) = \text{Work}$$

Benoît Paul Émile Clapeyron $n = 1$ Mol $\Delta T = 1$ K

a French chemist - measurements of the thermal properties of gases.

R = *Work of 1 Mol of ideal gas at heating on 1 degree.*

"Any fool can know. The point is to understand."
Albert Einstein

The 2nd Law of Thermodynamics

Entropy of the universe strives to the maximum !

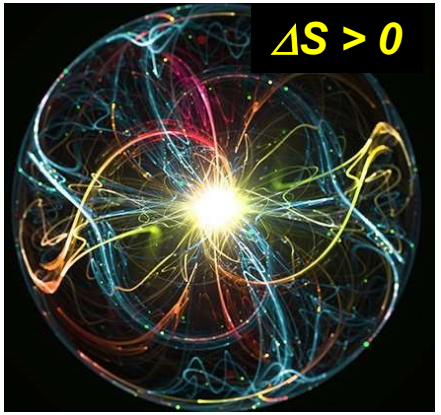
Increase of Chaos in Art !

"The Entropy Song" *1948*

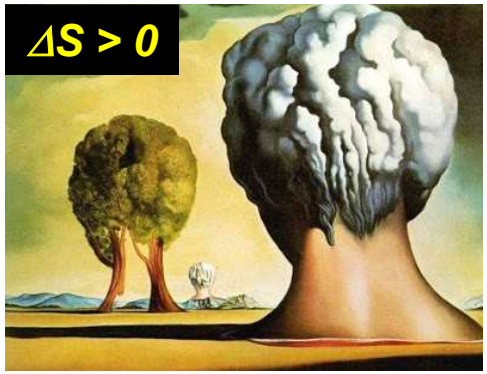
1907  *1973*

Wyston Hugh Auden

I'm not being negligent
Nor plain, messy no!
But somebody intelligent
Once made up a law:



This is not a simple verse,
It's a scholar's rhyme -
Entropy in the universe
Increases all the time.

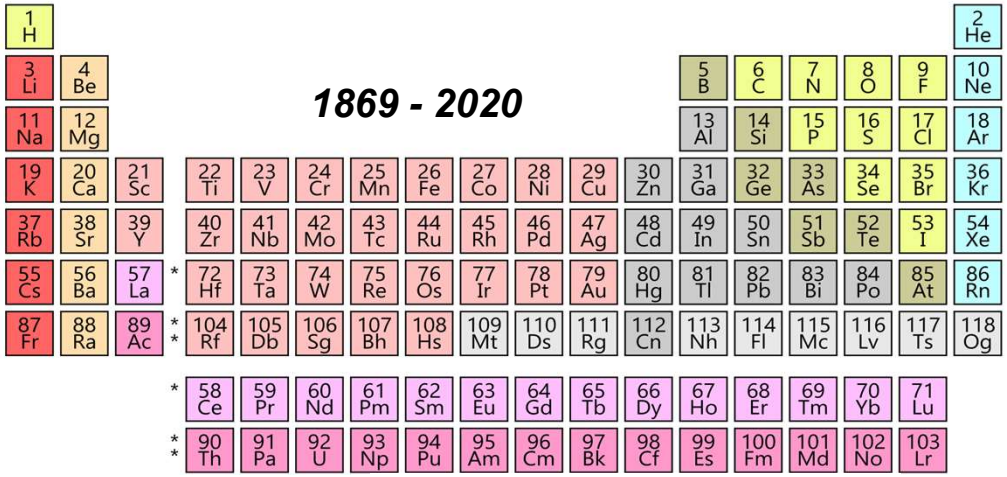


From Big Bang to Bigger Boom
One thing just we may assume:
Universe-roulette-wheel spins -

Order loses! Chaos wins!

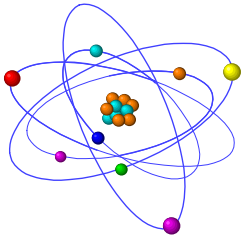
Periodic Table of the Chemical Elements and Philosophy

Dialectics is a philosophical concept of evolution and offers a tool to understand the way things are and the way things change.



Dialectics - the 1st Law:

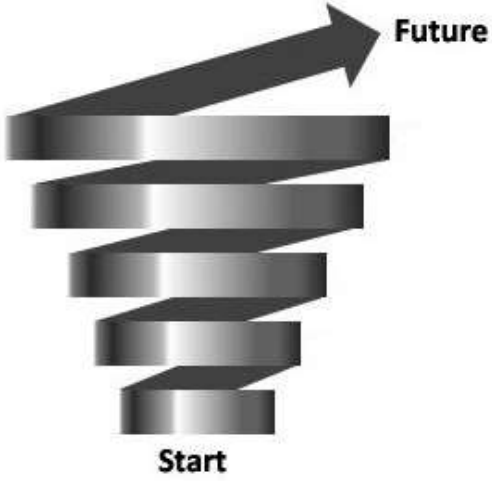
"Unity of opposites" (The Law of Contradiction):
Everything is made of opposing forces.



An atom is a unity of two opposites:
positive nucleus and negative electrons.

Dialectics - the 2nd Law:

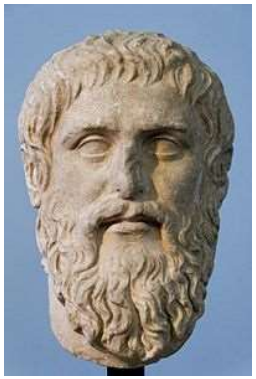
Quantitative Change Becomes Qualitative



Dialectics - the 3rd Law:

"Negation of Negation": Changes move in spirals, not circles.

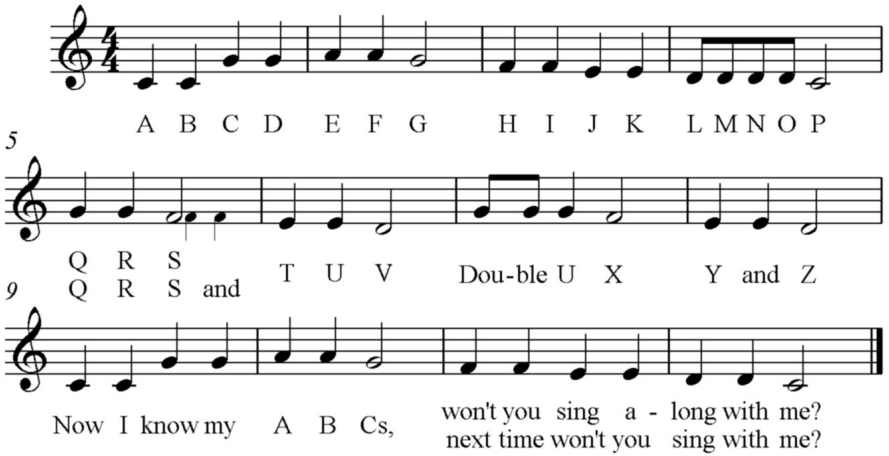
Chemistry and Music



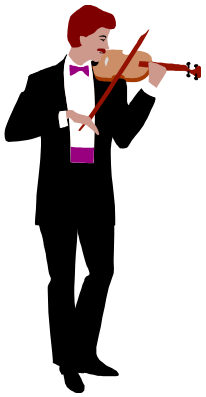
Plato (428 – 348 BC)

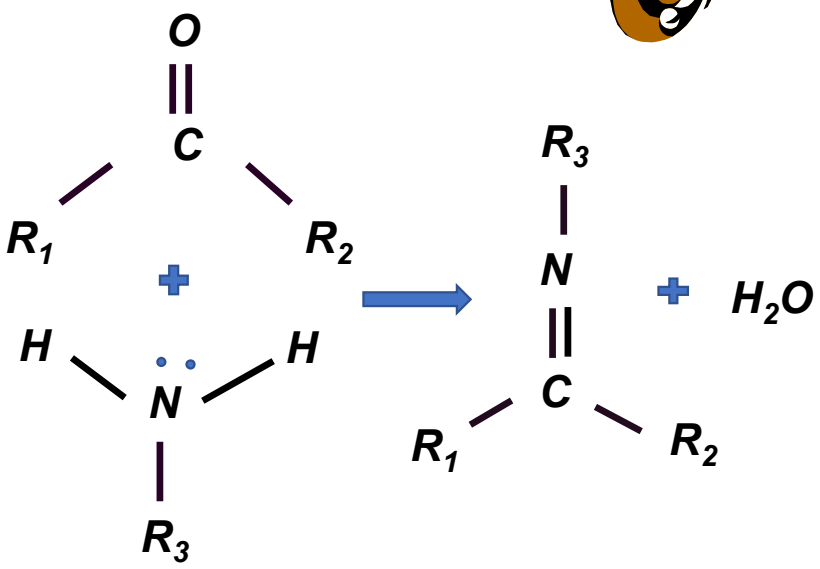
"Education through music is important because rhythm and harmony penetrate to the depths of the soul, seize and ennoble it"

"The Alphabet Song" (The A.B.C., 1835)



"Twinkle, Twinkle, Little Star" (Mozart, piano variations)





To the tune of the
"Oh My Darling, Clementine"

"Oh, My Ketone!"

Oh, my ketone! Oh, my ketone!
And my primary amine.
You reacted, lost some water and
You formed a new imine.

Now the lone pair on the N then
Bonds with carbonyl C.
Pi electrons go to O, a
Proton shifts fast as can be.

Now the O is feeling greedy
Grabs an H from NH_2.
Free electrons from the N then
Form a pi bond, water leaves.

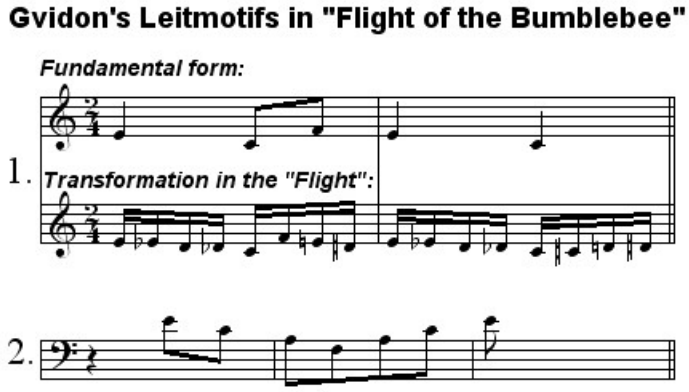
Oh, my ketone! Oh, my ketone!
And my primary amine.
You reacted, lost some water and
You formed a new imine.

By William Evans, 6 May 1997

Thermodynamic reversible process = True chemical equilibrium

Music and "Perpetual Motion"

N. A. Rimsky-Korsakov
Russian composer



"Flight of the Bumblebee"

$$N_{2(g)} + 3H_{2(g)} \leftrightarrow 2NH_{3(g)}$$

Humor in Education

Humor creates a relaxed environment for communication.

Gelo-education …
Gelos is "laughter“ in Greek.

The components of humour:

- ***Surprise***
- ***Contradiction***
- ***Paradox***
- ***Ambiguity***
- ***Metaphor***

A person should know:

- ***Language well***
- ***Be professionally skillful***
- ***At suitable age***
- ***Prepared culturally***
- ***Intellectually***
- ***Opportune moment***

Humour (like beauty) is something that exists only in our minds and not in the real world.

The accuracy of experiments

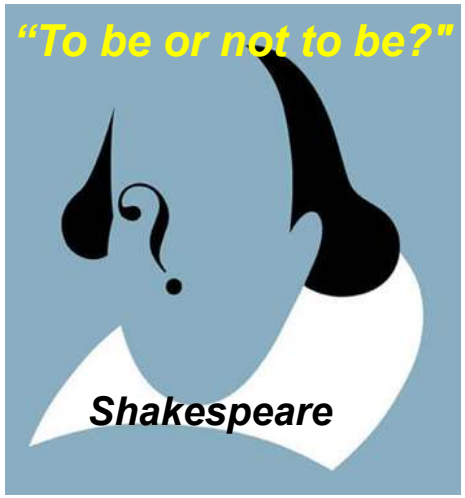
King David with his army is returning home.

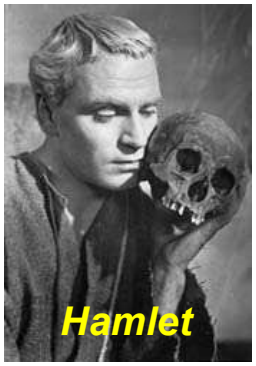
Suddenly he sees targets on trees with arrows stuck exactly in their centres.

"How do you do this?"

First you shoot and then draw targets around the arrow stuck.

The Main Question of Thermodynamics





$Au_{(s)} + H_2O_{(l)} \rightarrow$ ⛔

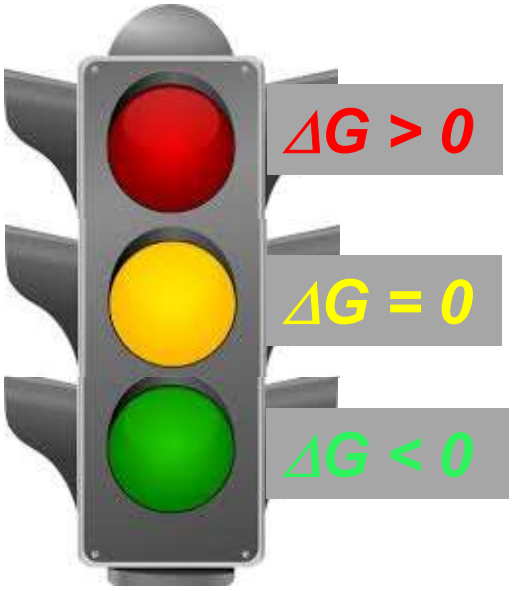
?

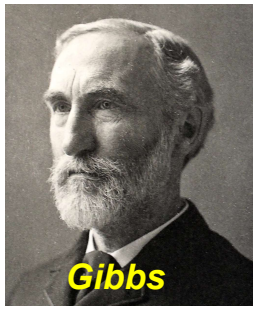
$N_{2(g)} + H_{2(g)} \Longleftrightarrow NH_3$

$Fe_{(s)} + H_2O_{(l)} \rightarrow$!

Lights  Truth

To be or not to be ???





1876

Ethical (moral) principles of behavior of scientists are part of humanistic education.

German gas attack
22.4.2015

The first use of chlorine gas during the WWI at Ypres, resulting in over 15,000 deaths.

$N_{2(g)} + H_{2(g)} \leftrightarrow NH_3$

Fertilizers ("Bread" from the Air)
1918 – Nobel Prize.

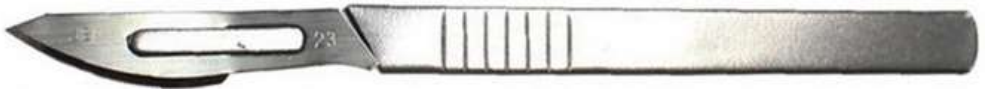
She opposed Haber's work in chemical warfare.

The morning after her death, Haber left for the first gas attack against the Russians on the Eastern Front.

*Cyanide gas formulation Zyklon A – **Nazi concentration camps – Haber`s relatives were killed with this gas.***

Science does not have a moral dimension.

It is like a knife.



If you give it to a surgeon

or a murderer,

each will use it differently.

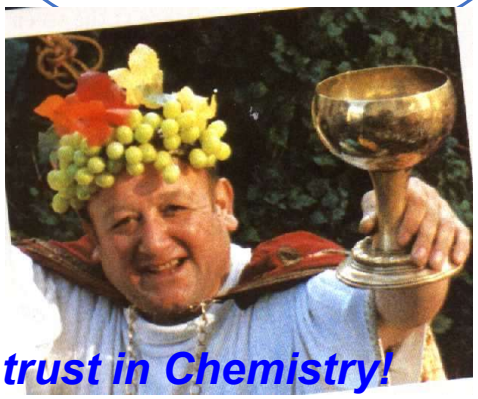
Shortage in the near Future:

Skilled knowledgeable specialists !

Energy ?

Water ?

Chemists



Fuel ?

Food ?

I trust in Chemistry!