CML 514: Chemistry of the main group elements

- Introduction: Historical Perspective;
- Shapes of molecules VSEPR & Basics of point groups; Importance in Industry
- Hypervalency and d orbital participation
- Boron group
- Carbon group
- Nitrogen group
- Oxygen group
- Halogen group
- Rare gases

http://chemistry.iitd.ac.in/faculty/elias.html

Instructor: Prof. Anil J. Elias

Room: LH 619 Tu, Th, Fr 11 AM

Evaluation and study material

- **Minor 1 (20 Marks) +5 marks for assignment**
- **Minor 2 (22 Marks) + 3 marks for assignment**
- **Major (48 Marks) + 2 marks on a question based on assignment : Total 100**

Material: What the instructor teaches and provided on his website

Lecture Notes/powerpoint slides will be provided from time to time

Books: *Inorganic chemistry: Huheey, Keiter and Keiter*
Inorganic Chemistry: Housecroft and Sykes
Chemistry of the p block elements Elias (upcoming)

Your duty:

Attend all classes, be punctual, do a serious effort in making and submitting assignments, be sincere and straightforward in your dealings

General guidance:

Have a plan for your future and work towards achieving it systematically. Improve your capabilities in communicating scientifically and focusing on fundamentals

Attendance requirements: If less than 75%, student will receive one grade lower than the actual grade which can also be E or F

Assignment 1 **to be submitted within 5 days after first minor examination**

Reading, understanding and analysis of a given research paper:

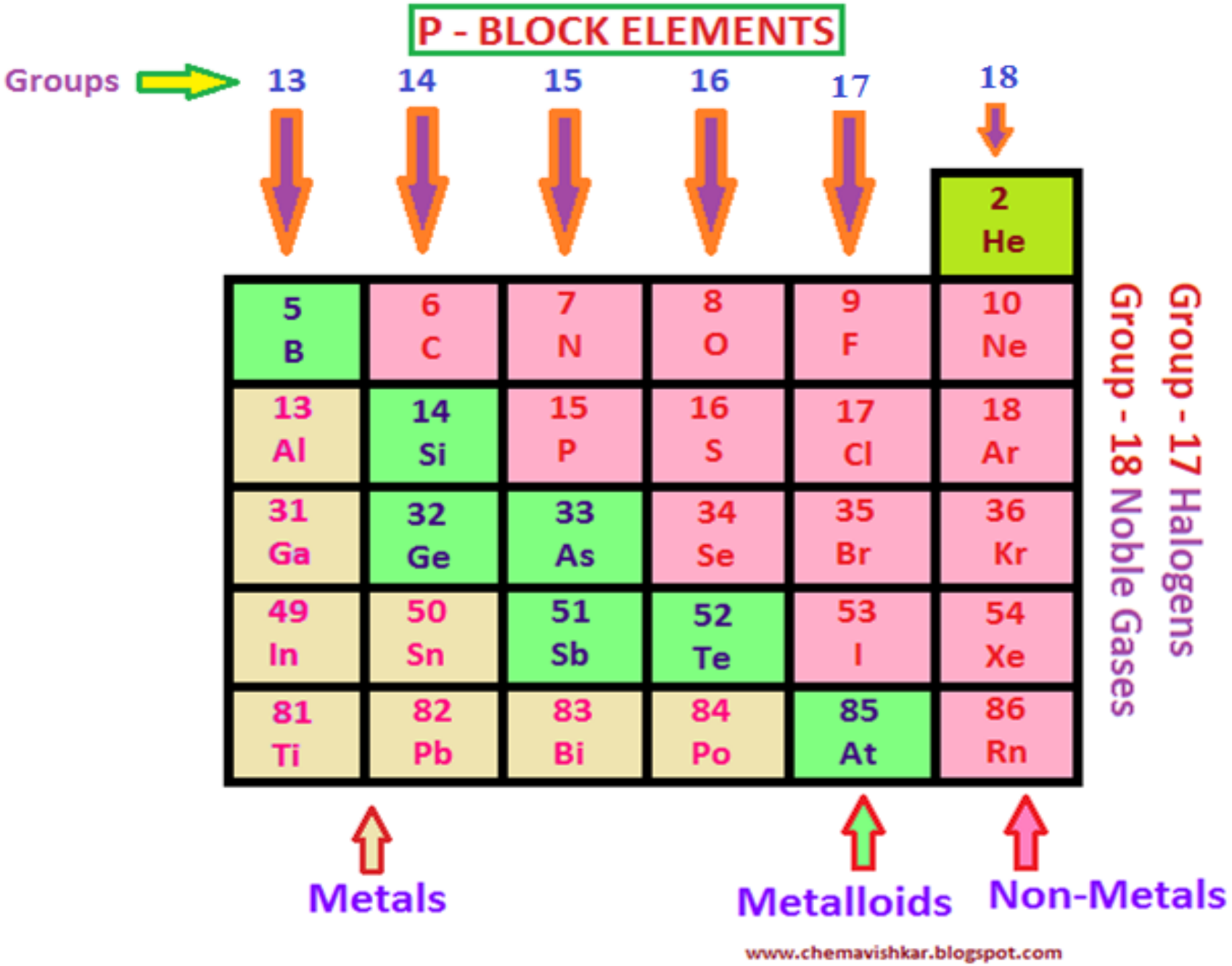
Each student will be given the reference of an important latest research in main group element chemistry: Students will download/print, read, study the research paper and answer five questions about the research paper in their own words. Grammatical mistakes will lose marks. (1 mark each for the five individual answers)

Assignment 2 **to be submitted within 5 days after second minor examination**

Critically analysing the findings of a colleague on a research paper:

The assignment 1 along with the research paper given by a student will be given to another student to re-analyze and critically evaluate the answers and findings. (1 mark each for the three analysis questions) Grammatical mistakes will lose marks.

"Before we begin, please turn off all cell phones."


P - BLOCK ELEMENTS
Groups
13
14
15
16
17
18
2 He
5 B
6 C
7 N
8 O
9 F
10 Ne
13 Al
14 Si
15 P
16 S
17 Cl
18 Ar
31 Ga
32 Ge
33 As
34 Se
35 Br
36 Kr
49 In
50 Sn
51 Sb
52 Te
53 I
54 Xe
81 Ti
82 Pb
83 Bi
84 Po
85 At
86 Rn
Group - 17 Halogens
Group - 18 Noble Gases
Metals
Metalloids
Non-Metals
www.chemavishkar.blogspot.com

What does an average student or teacher think about p block chemistry ?

Very boring

Lot of equations to mug up

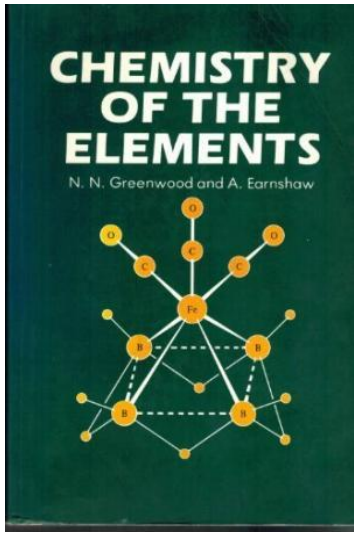
No color, no magnetism- No high spin low spin; no CFT.

Text books are huge is size and too much of information

How do we know which equation is important ?

This is something about boron and sulfuric acid etc. boring stuff

What is the use ? No use of these chemistry in catalysis, in organic chemistry or bioinorganic chemistry ?



Transition Metal Chemistry	Main Group Chemistry
Partially filled d orbitals	Filled d orbitals
d-d transitions and color related to it	No d-d transitions and no color related to it
Unpaired electrons and magnetic properties related to it	No magnetic properties
Interesting Bio inorganic chemistry	Routine Bio inorganic chemistry
Almost all TM are toxic (except Fe)	Generally non toxic but has also very lethal compounds
Only applications: As specialty chemicals for anti cancer drugs and catalysis	**Maximum number of applications: agriculture, infrastructure, industry, catalysis, medicines, explosives, solar energy, electronics…….**

A p block Element quiz

What is called as the tiger of chemistry ?

Fluorine

Which element has the maximum number of allotropes?

Carbon

Which metallic element will melt in your hand without burning your hand

Gallium

Which element is found to be present in most of the offensive smelling compounds

Sulfur

Which element binds with oxygen very readily but does not form double bonds with O?

Silicon

Which noble gas has the highest number of compounds?

Xenon

Which element is found in almost all explosive materials?

Nitrogen

Which element mimick's potassium but is extremely toxic?

Thallium

What element is obtained if you take 5000 litres of urine, concentrate it add sand and heat it ?

Phosphorus

Which was the very first chemical warfare agent

Chlorine

Which elements will save you if there is a nuclear disaster

Boron and Lead

A Compound Quiz!

1. Which is the most important discovery which has helped the survival of the human species?

   Haber-Bosch Process

2. What makes the smart phone screen transparent and conducting ?

   Indium Tin Oxide (ITO)

3. What are the medicinal ingredients of Gelusil? ?

   Simethicone (PDMS), Aluminium hydroxide Magnesium hydroxide

4. What makes safety airbags work in modern cars?

   Sodium Azide

5. What is the drug (Medicine) which has the maximum sales in the world (cost wise) and what is unique about its composition?

   Atrovastatin (Lipitor) 141 billion USD from 1996 Aryl-F group

6. Which is the strongest of the acids?

   $H_2F.SbF_6$ fluoroantomonic acid

7. Which gases are produced by human body and what are their uses?

   NO, H_2S, CO signaling

8. What is the material which is responsible for making IIT Delhi roads so bright in the night?

   GaN (gallium nitride)

9. Which country is called the 'Saudi Arabia of phosphorus'?

   Morocco (40% of world Phosphorus)

How are p block elements different from the rest of the elements of the periodic table?

s Block

P block

partially filled p orbitals

filled d and f orbitals

No spectral and magnetic properties

No homogenous and heterogenous catalysts (?)

So are they monotonus, uninteresting almost dead elements and compounds?

Transition Metals

partially filled d orbitals

↓

unpaired electrons

↙ ↘

spectral and magnetic properties

Homogenous and heterogenous catalysts

Lanthanides	partially filled f orbitals	
Actinides	spectral and magnetic properties	Homogenous and heterogenous catalysts

Where does p block elements stand with regard to Industrial Applications ?

s Block

Transition Metals

Industrial applications??

Bulk Usage Iron and Steel
Alloys, additives (e.g. TiO2)

Homogenous and heterogenous catalysts, Magnets ,materials

Biological Role?

Oxygen storage, Transport,Metalloenzymes
Biocatalysts, methylation etc

P block

Industrial applications??

Yes Maximum in bulk usage

Fertilizers
Building materials
Transportation: Al & CFRP
Semiconductors
Solar cells
Explosives
Pesticides
LED Lights
Detergent additives
Disinfectants
Devices- Touch screen
medicine making
Inorganic polymers
Catalysts

Lanthanides

Homogenous and heterogenous catalysts

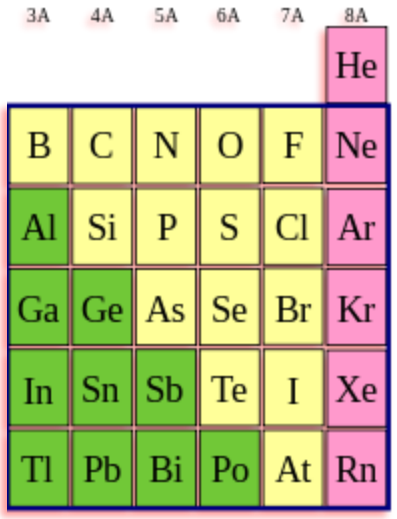
Magnets, materials

Actinides

Nuclear fuels

	THE P - BLOCK ELEMENTS APPLICATIONS				Helium He Maintaining Magnets
Boron B Neutron capture	Carbon C CMS, CFRP	Nitrogen N Fertilizers, Explosives	Oxygen O Iron ore smelting Ethylene oxide	Fluorine F Nuclear fuel	Neon Ne Lighting
Aluminum Al Airplanes	Silicon Si Solar Cells, Silicone polymer	Phosphorus P Fertilizers, fire retardants	Sulfur S Sulfuric acid	Chlorine Cl PVC, polyurethanes disinfectants	Argon Ar Blanket gas
Gallium Ga LED, Solar cells	Germanium Ge Night vision, fibreoptics	Arsenic As POISON	Selenium Se Biochemistry Red glass	Bromine Br Fire retardants	Krypton Kr Lighting
Indium In LED, Transparent conduct. oxides	Tin Sn Tinplate	Antimony Sb Fire retardants, Superacid	Tellurium Te Bi2Te3 CdTe	Iodine I Biochemistry	Xenon Xe Anesthetic, LASIK
Thallium Tl POISON	Lead Pb Nuclear shield Lead acid battery	Bismuth Bi Pepto bismol Lead substitute	Polonium *Po* RADIOACTIVE	Astatine *At* RADIOACTIVE	Radon *Rn* RADIOACTIVE

Unique property of the element		Application
Electron deficiency		Lewis acid
Light metal		Aero planes
Band gap		Better Solar Cells, LED lights
Transparent and conducting		Touch screen
Essential elements for plant growth		Fertilizer
Relative low bond enthalpy		Explosives, Reactivity
High electro negativity		less weak interactions; Volatility
High nuclear cross section		Nuclear reactors



Landmark discoveries in the chemistry of p block Elements

An introductory lecture presentation to main group chemistry

Instructor: Prof. Anil J. Elias, Room: MS 733: IIG1

3000 BC

Zebu Bull from Mohenjo-Daro and Harappa

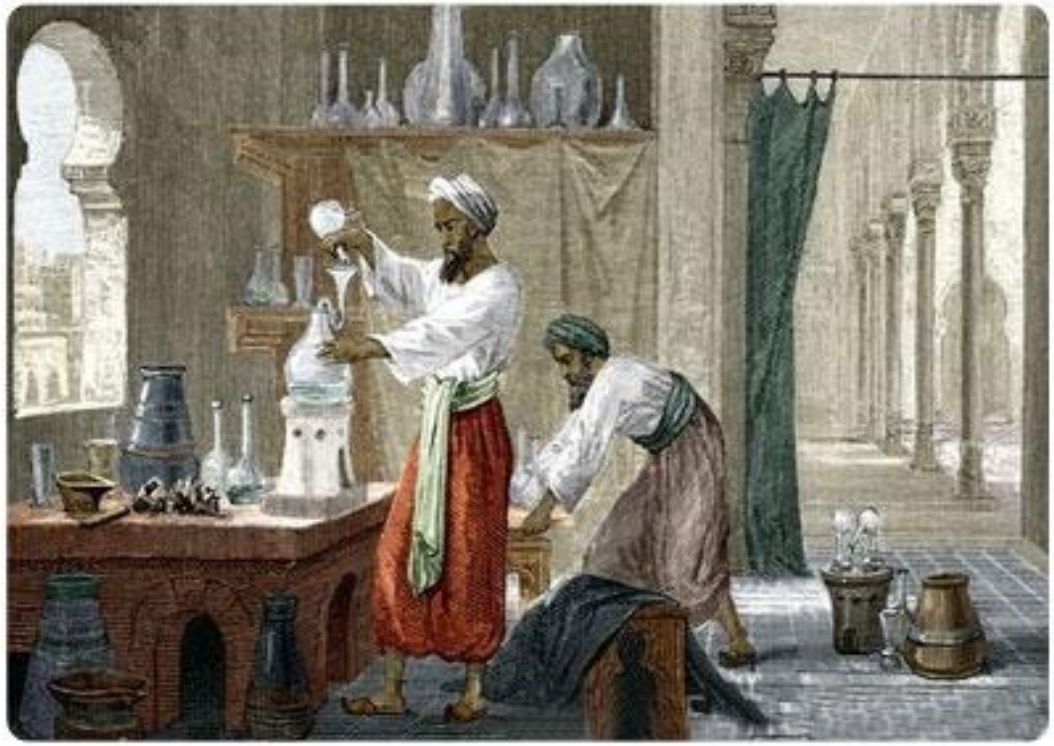
BRONZE AGE

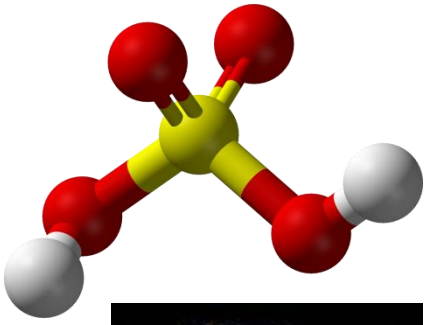
Dancing Girl a bronze statuette dating around 2500 BC, from the Mohenjo-daro site

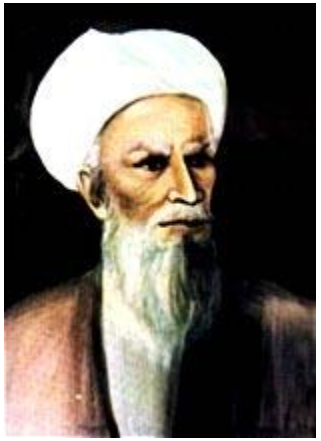
Pure tin candlestick

Bronze, an alloy of tin and copper was the first alloy to be used around 3000 BC. After 600 BC pure metallic tin was produced.

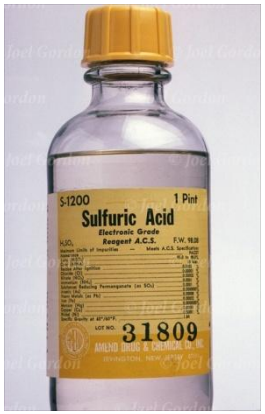
940 AD



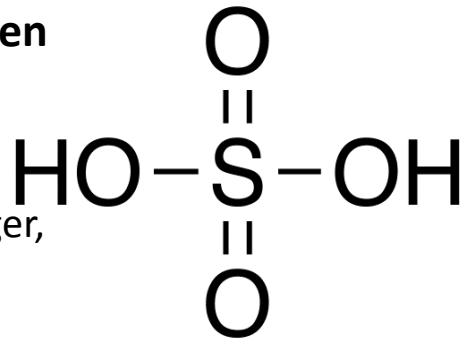




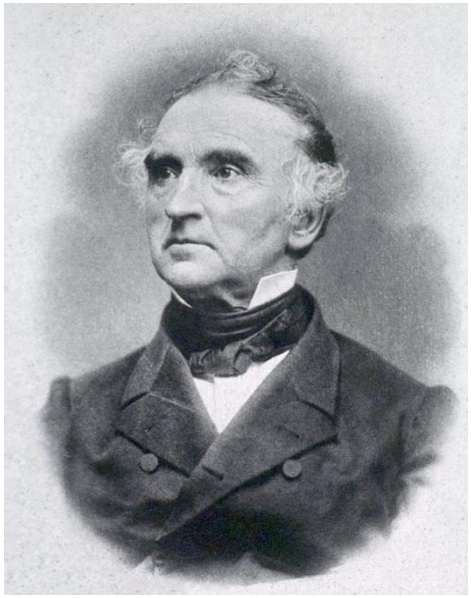
Sulfuric acid was first prepared by the physician, alchemist and writer from Bagdad, **Abu Bekr** Mohammad Ibn **Zakariya Razi (Rhazes) posssibly by roasting green vitriol ($FeSO_4$)**



In 1746 in Birmingham, England, John Roebuck began producing sulfuric acid in lead-lined chambers, which were stronger, less expensive, and could be made much larger than the glass containers which had been used previously.



1840



Justus von Liebig

"Father of the fertilizer industry"

One of the greatest chemistry teachers of all time.
Devised the modern laboratory-oriented teaching method

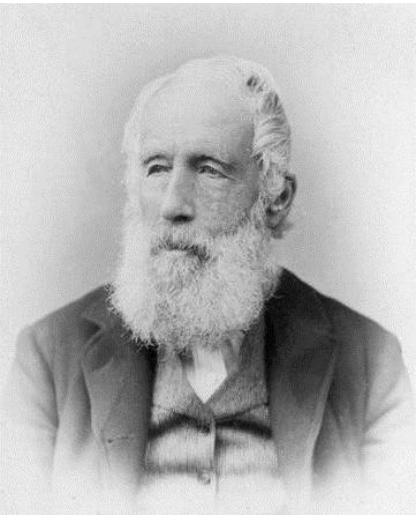
In his theory of mineral nutrients, Liebig identified the chemical elements of nitrogen (N), phosphorus (P), and potassium (K) as essential to plant growth.

Liebig believed that nitrogen could be supplied in the form of ammonia and recognized the possibility of substituting chemical fertilizers for natural ones

Die organische Chemie in ihrer Anwendung auf Agricultur und Physiologie (Organic Chemistry in its Application to Agriculture and Physiology) **(1840)**

Justus Liebig's *Annalen der Chemie*

Justus Liebigs chemisches Laboratorium auf dem Seltersberg zu Gießen um das Jahr 1840.
(Erbaut vom Universitäts-Baumeister Hofmann im Herbst 1839.)



1842

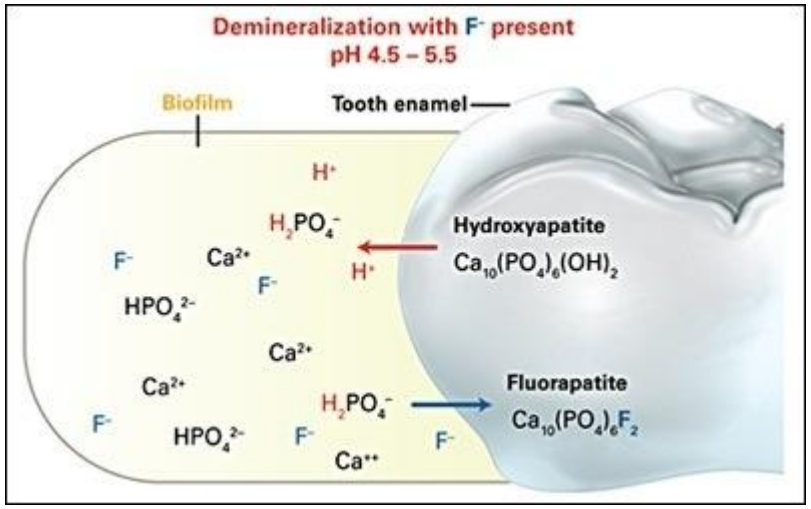
In 1842, Lawes patented a manure formed by treating rock phosphate (mixture of hydroxyapatite and fluorapatite) with sulphuric acid and thus initiated the artificial manure industry.

Sir John Bennet Lawes, 1st Baronet, FRS

Rothamsted Experimental Station

$$Ca_5(PO_4)_3X + 5\ H_2SO_4 + 10\ H_2O \rightarrow 3\ H_3PO_4 + 5\ CaSO_4 \cdot 2\ H_2O + HX$$

hydroxyapatite



fluorapatite

Common inorganic fertilizers

The multibillion dollar chemical equation!

$$Ca_5(PO_4)_3X + 5\ H_2SO_4 + 10\ H_2O \rightarrow 3\ H_3PO_4 + 5\ CaSO_4 \cdot 2\ H_2O + HX$$

X=F (fluorapatite) OH hydroxyapatite)

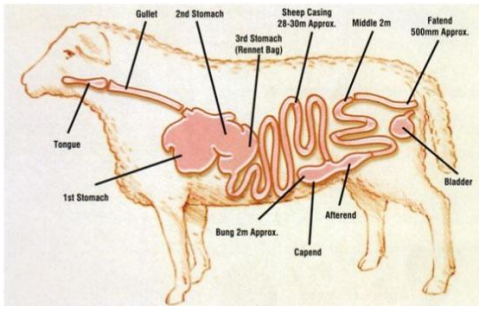
Chemical name of fertilizer	Industrial Name	Formula	NPK value
Ammonia	Ammonia	NH_3	82-00-00
Urea	Urea	$(H_2N)_2CO$	46-00-00
Ammonium Sulfate	Ammonium sulfate	$(NH_4)_2SO_4$	21-00-00
Calcium nitrate	Norvegian Saltpeter	$Ca(NO_3)_2$	15-00-00
Ammonium nitrate	Ammonium nitrate	NH_4NO_3	33-00-00
Mono ammonium phosphate	Mono ammonium phosphate	$(NH_4)H_2PO_4$	11-48-00
Diammonium phosphate	Diammonium phosphate	$(NH_4)_2HPO_4$	18-46-00
Mono calcium phosphate	Triple superphosphate	$Ca(H_2PO_4)_2$	00-44-00
Mono calcium phosphate + gypsum	Single superphosphate	$Ca(H_2PO_4)_2$ + 2 $CaSO_4$	00-17-00

Antoine-Germain Labarraque (1777-1850)

chlorinated lime and chlorine water

The small intestine has an average length of **40 m** in the ox and 25 m in the sheep and goat. The average diameter is **5 to 6 cm** in the ox and **2 to 3 cm** in the small ruminants
In humans, the small intestine is **about 6 meters** or **20 feet** long

Cat Gut



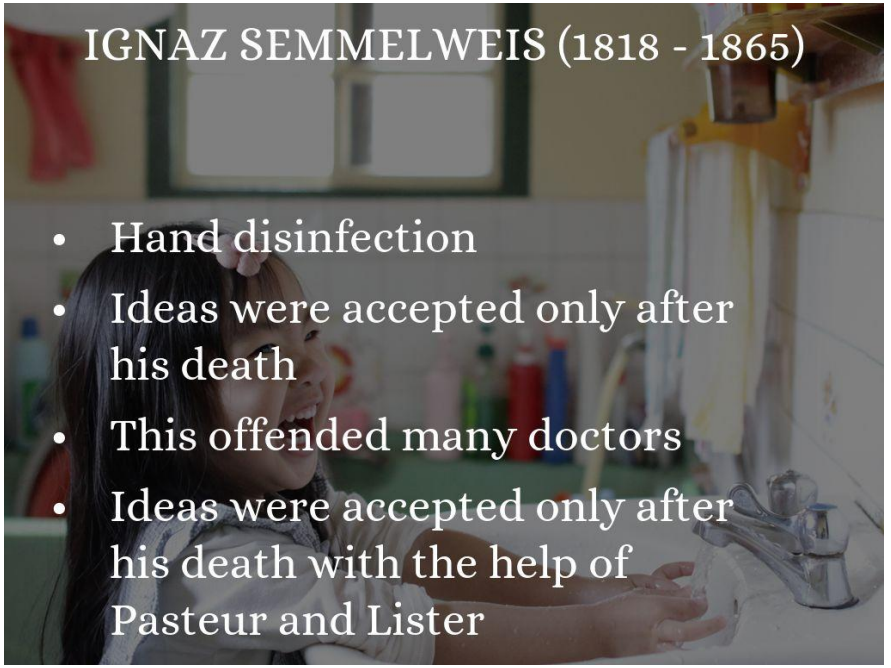
Antoine-Germain Labarraque was a French chemist and pharmacist who discovered that chlorinated bleaching solutions not only destroyed the smell of putrefaction of animal tissue decomposition, but also actually retarded the decomposition helping catgut industry. chlorinated lime and chlorine water were used for this

$$2Cl_2 + 2\ Ca(OH)_2 \longrightarrow Ca(OCl)_2 + CaCl_2 + H_2O$$

$$Cl_2 + H_2O \rightarrow HOCl + HCl$$

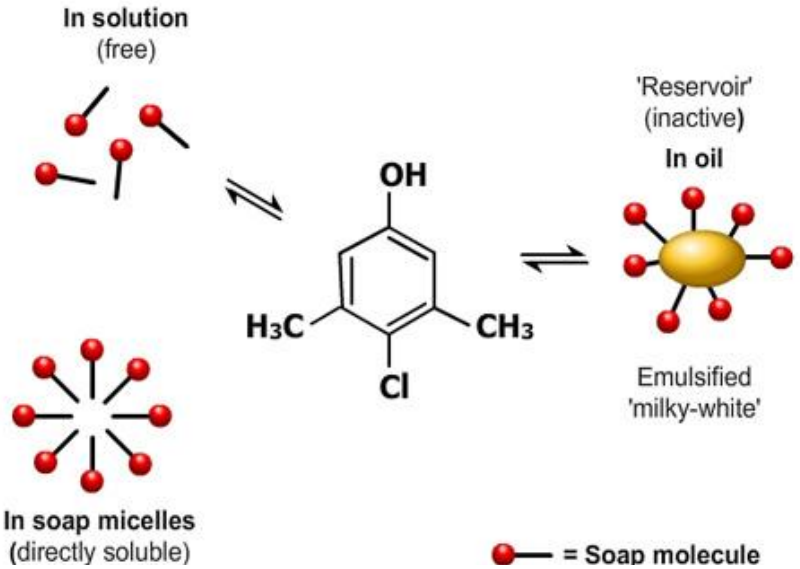
(Hypochlorous acid)

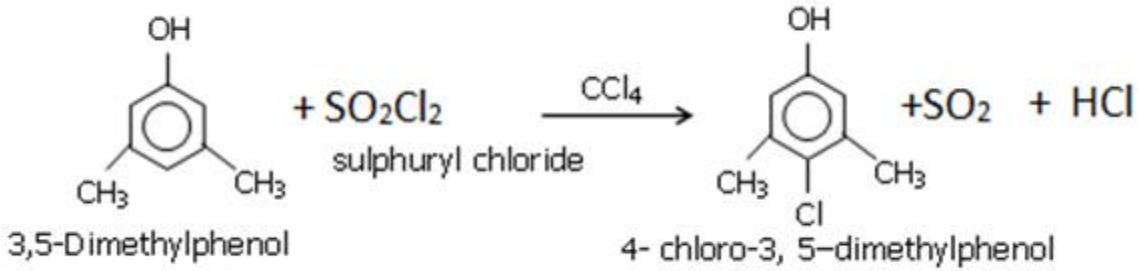
Saviour of Mothers



Ignaz Semmelweis used chlorine-water (chlorine dissolved in pure water) to disinfect the hands of Austrian doctors, which Semmelweis noticed still carried the stench of decomposition from the dissection rooms to the patient examination rooms. Stopped Child bed fever at the Vienna general hospital.

Para chloro meta xylenol- PCMX

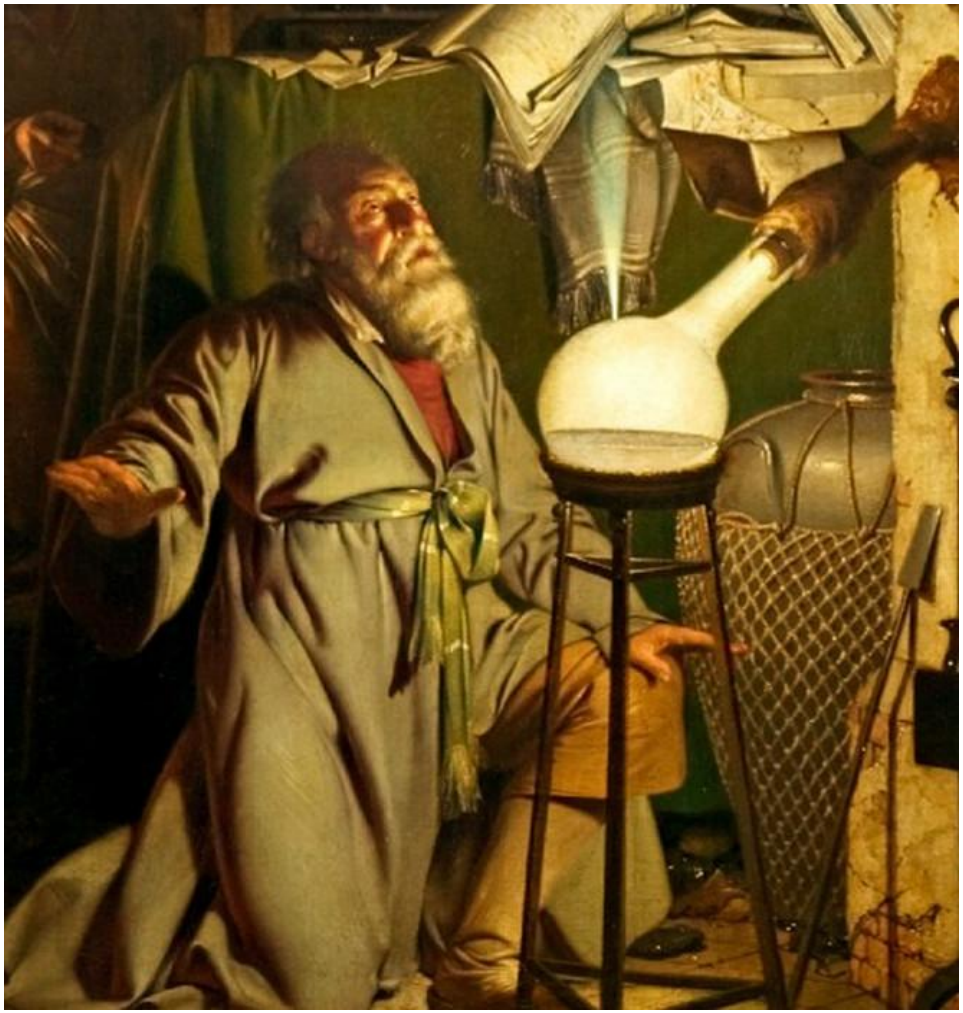




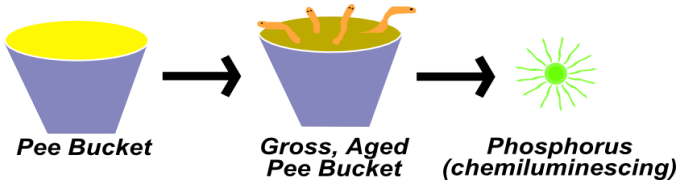
Chemical Name	CAS No	Proportion (%w/w)
Chloroxylenol	88-04-0	4.8 (%w/v)
Pine Oil	8002-09-3	<10
Isopropyl alcohol	67-63-0	10 - 30
Other ingredients classified as not hazardous according to NOSCH		to 100

Adapted from Chemistry in the cupboard; RSC chemistry, UK , 2010

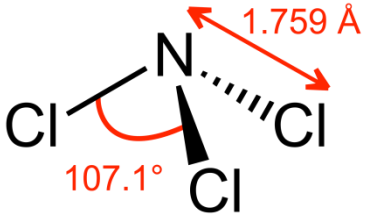
1669



The Alchemist Discovering Phosphorus : a painting by Joseph Wright



Hennig Brandt discovers phosphorus from reductive distillation of urine concentrate
by evaporating urine to dryness and distilling the residue with sand.



1811

Nitrogen compounds as explosives

Nitrogen trichloride.—Dulong (1811) by the action of chlorine on a solution of ammonium chloride obtained a yellow oily liquid which was violently explosive. He lost an eye and three fingers in the research. Dulong did not publish his work; an abstract of it by Thenard and Berthollet appeared later. In the meantime Davy (1813) obtained the compound by the same method, and concluded that its formula was NCl_4. Balard prepared it by the action of hypochlorous acid on ammonia, and Böttger and Kolbe found that it separated at the anode in the electrolysis of ammonium chloride solution at 28°. The substance is nitrogen trichloride, NCl_3:

$$NH_3 + 3Cl_2 = NCl_3 + 3HCl;$$
$$NH_3 + 3HOCl = NCl_3 + 3H_2O.$$

Nitrogen trichloride may be prepared by inverting a flask of chlorine over a 25 per cent. freshly prepared solution of ammonium chloride, a lead saucer being placed under the mouth of the flask (Fig. 269). The chlorine is absorbed and oily drops of the trichloride float on the surface of the solution. These fall into the lead saucer, which should be removed when a little liquid has collected in it. If a little turpentine is passed by a long pipette into

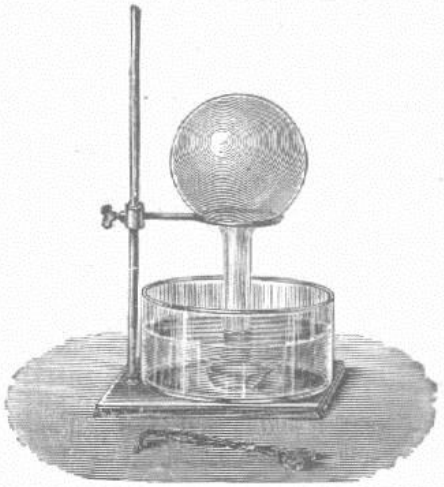


FIG. 269.—Preparation of nitrogen trichloride.

Dulong

Pierre Louis Dulong prepares **nitrogen trichloride, NCl_3** and looses two fingers and an eye in two explosions. An NCl_3 explosion also blinded Humphry Davy (famous for Davies Safety lamp) triggering him to hire Michael Faraday as a co-worker.

1812
Tin plate

Napolean's buttons (Russian campaign 1812

At 13.2 °C pure tin transforms from the silvery, ductile metallic allotrope of β-form *white tin* to brittle, nonmetallic, α-form *grey tin* with a diamond structure. The transformation is slow to initiate due to a high activation energy very low temperatures of roughly −30 °C aids the initiation.

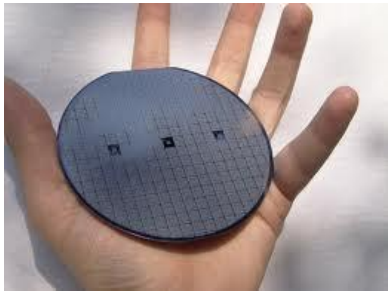
William Edward Parry made two arctic expeditions to the Northwest Passage in the 1820's and took canned provisions on his journeys. One four-pound **tin** of roasted veal, carried on both trips but never opened, was kept as an artifact of the expedition in a museum until it was opened in 1938. The contents, then over one hundred years old, were chemically analyzed and found to have kept most of their nutrients and to be in fairly perfect condition. The veal was fed to a cat, who had no complaints whatsoever.

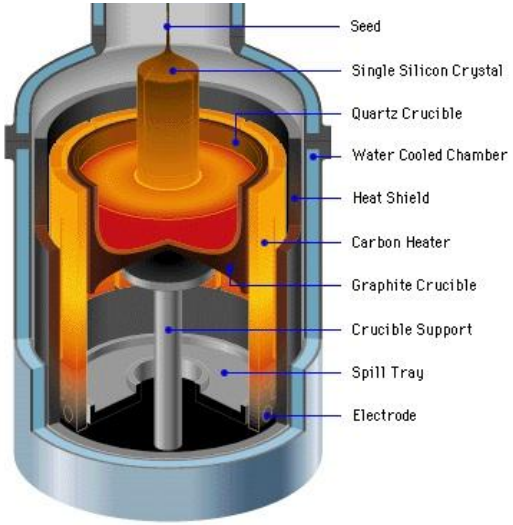
Scurvy- Vit C; synthesis of <u>collagen</u>

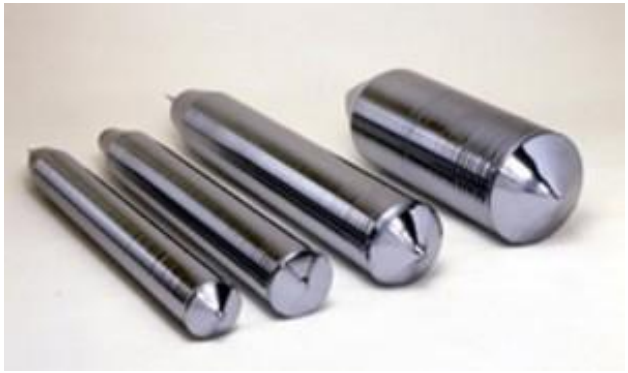
1824

Jöns Jacob Berzelius
(1779-1848)

Silicon: a versatile element with myriad aplications



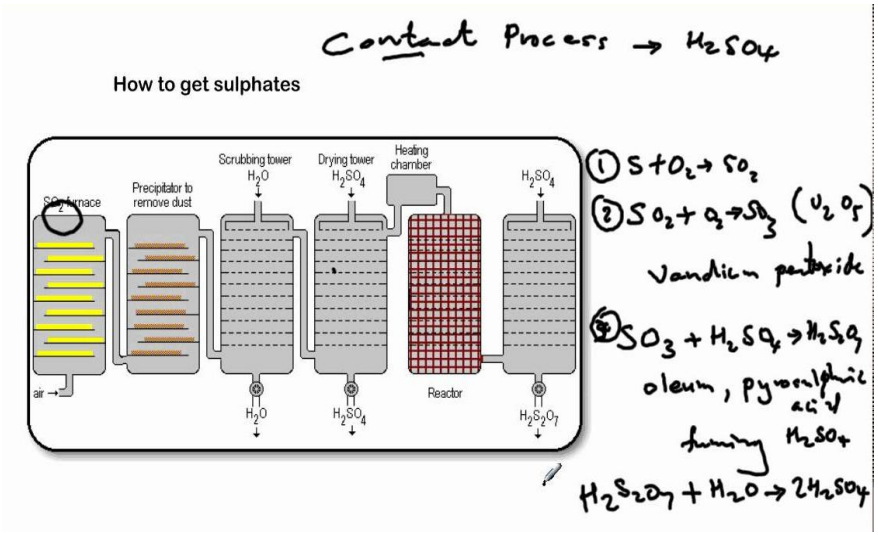




Silicon discovered by Berzelius from the reduction of potassium fluorosilicate with metallic potassium:

1831
Contact process for sulphuric acid

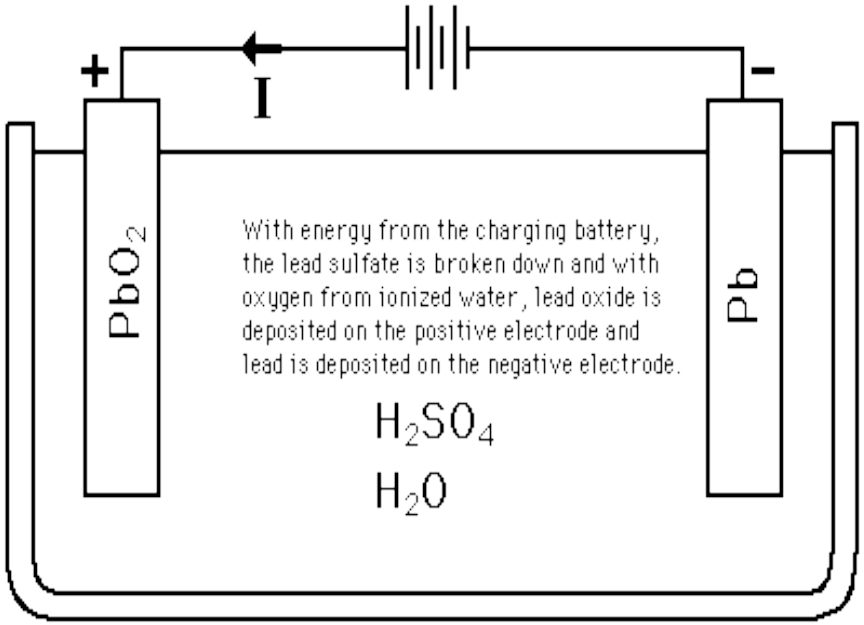

yuli.trustpass.alibaba.com



Contact process for sulphuric acid patented by the British vinegar merchant Peregrine Phillips. In addition to being a more economical process for concentrated sulfuric acid than the previous lead chamber process, the contact process also produces sulfur trioxide and oleum. Sulfuric acid is the second largest inorganic chemical produced worldwide (200 million tonnes)

1859

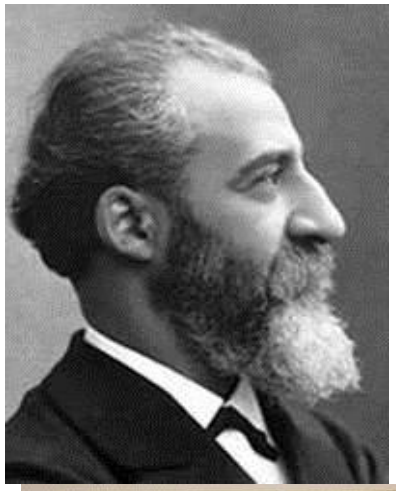
lead–acid battery

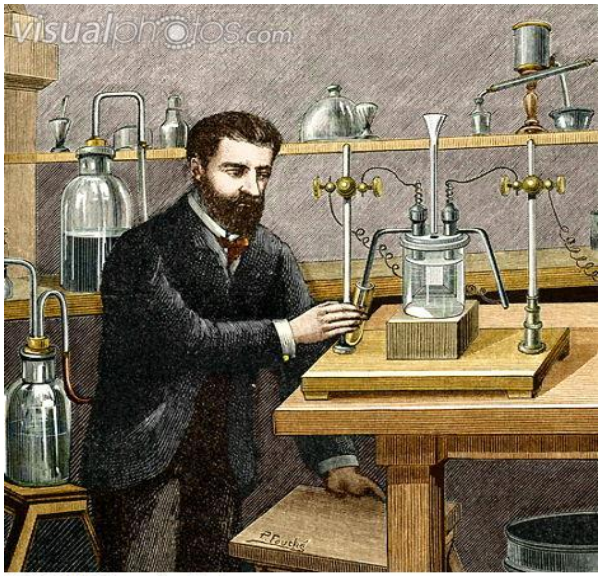


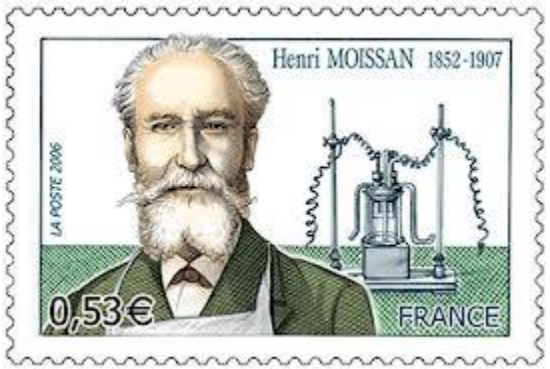
Planté Battery (circa 1859)

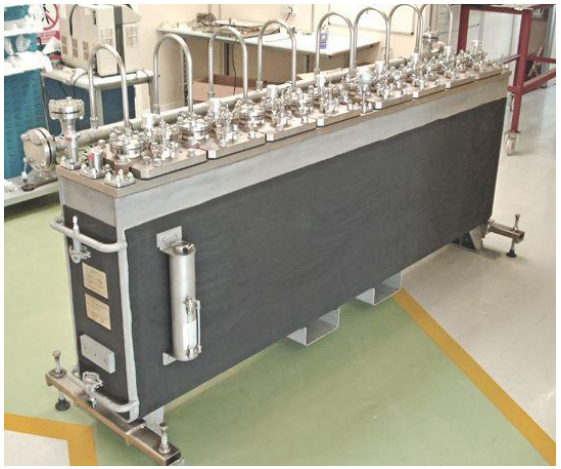
The French physicist **Gaston Planté discovers the lead–acid battery,** the oldest type of rechargeable battery

1886
Henri Moissan



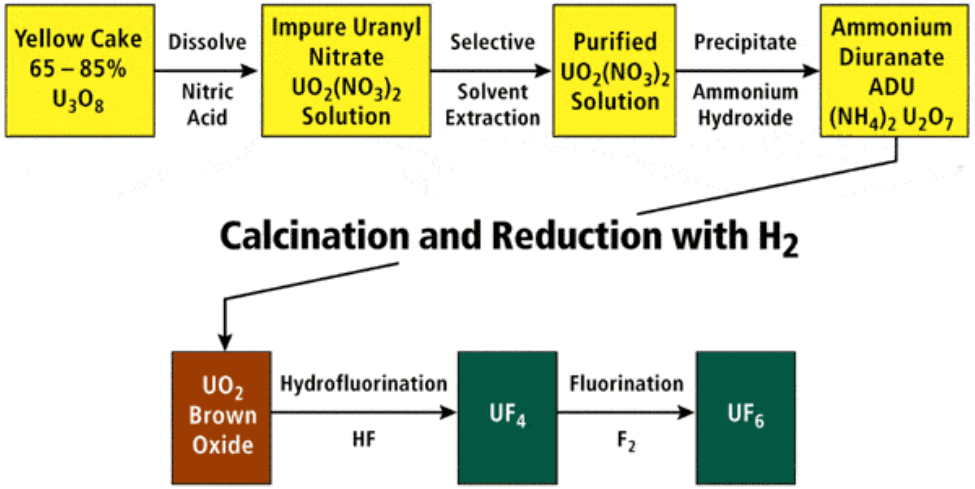




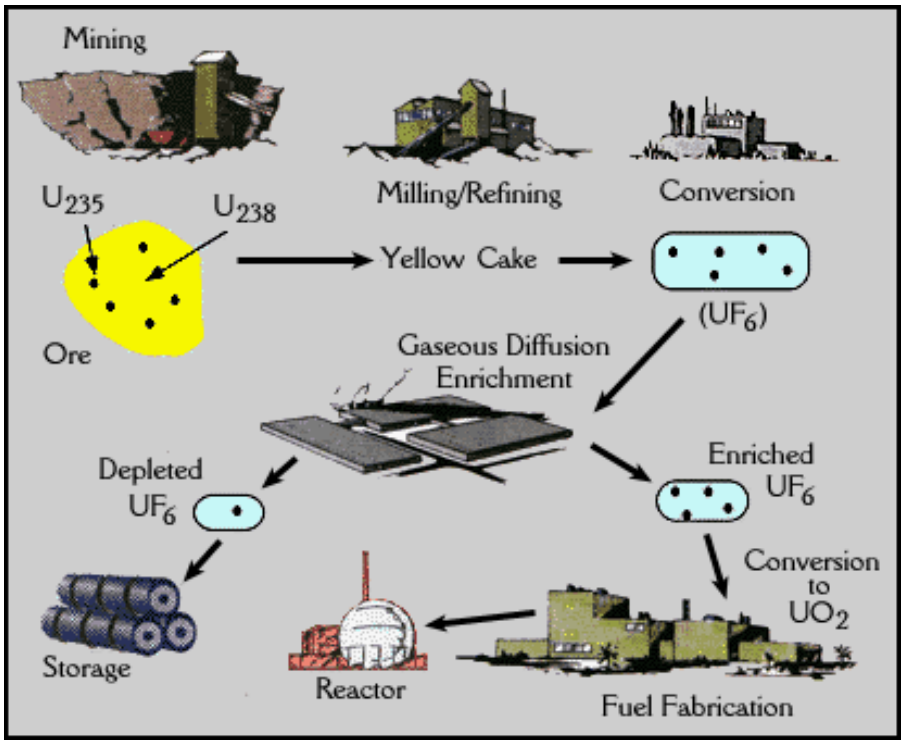


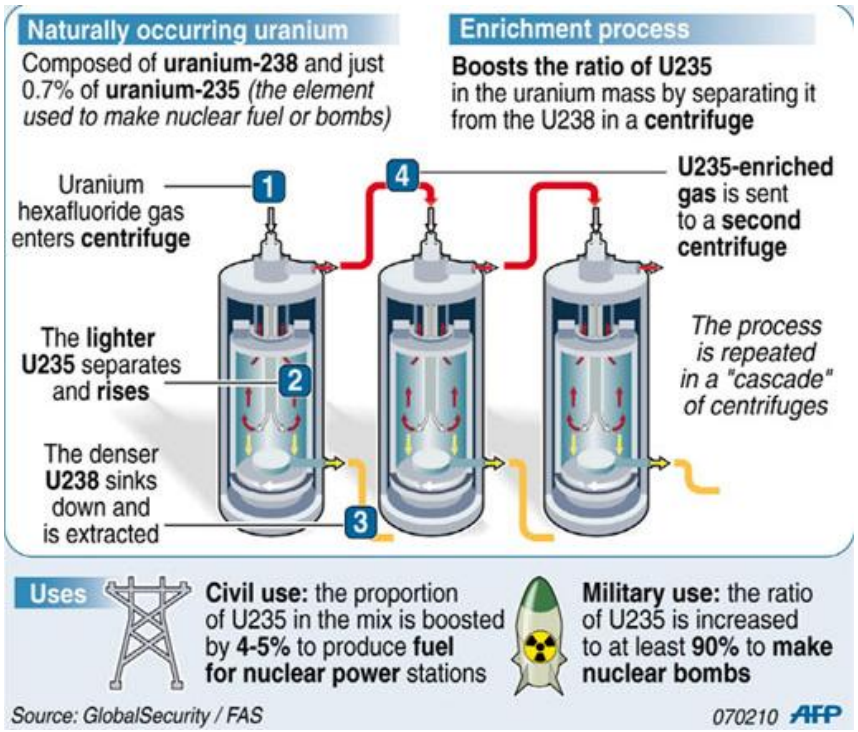
Henri Moissan prepared fluorine gas, F_2 by the electrolysis of a solution of potassium hydrogen difluoride in liquid hydrogen fluoride. **For this discovery he received the Nobel prize in 1906.** Two electrodes were made from an alloy of platinum and iridium. These were sealed into a platinum U-tube closed with caps made from the mineral fluorspar, the caps being covered with a layer of gum-lac. The U-tube was chilled to 10 degrees below zero Fahrenheit to reduce the rate of the action of the fluorine on the platinum. The first test made with the gas was to bring it in contact with the element silicon. There was an immediate burst of flame, a gaseous product being formed."

Ferdinand Frederic Henri Moissan died, aged 55, in 1907; a year after receiving the Nobel prize

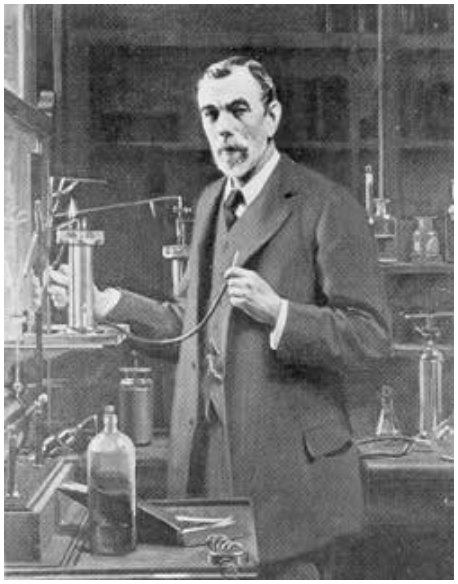


Compound	UO_3	U_3O_8	UO_2	UO_2F_2	UF_4	UF_6
M.P. (°C)	200-650	1150	2865	300 (dec)	1036	57



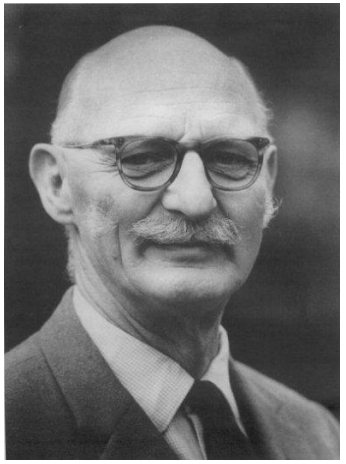


1904

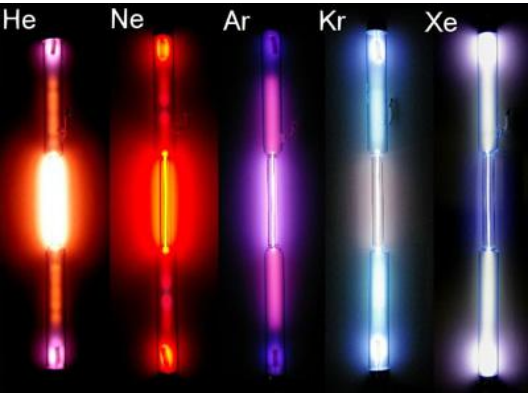


Sir William Ramsay

In 1901-1902 Ramsay had been asked to advise the Indian government on the founding of a science institute and the institute was established in Bangalore with the help of the Government of Mysore and JN Tata. Ramsay suggested his student Morris Travers as a possible director for this institute and in 1906, Travers was appointed as the **first director of the new Indian Institute of Science**



Morris M. Travers
(1862-1961)

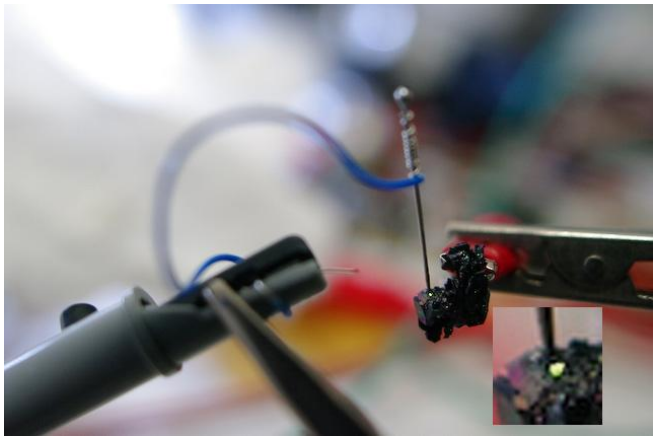


Sir William Ramsay discovered neon, krypton, and xenon and received Nobel Prize in 1904. He also isolated helium which had been observed in the spectrum of the sun but had not been found on earth till then. In 1910 he also made and characterized radon. (1894 argon with Lord Raleigh)

Henry Joseph Round

1907

The first light emitting diode (LED) made of SiC



Gallium nitride (GaN)
Aluminium gallium arsenide (AlGaAs)
Silicon carbide
Gallium phosphide
Indium gallium nitride etc

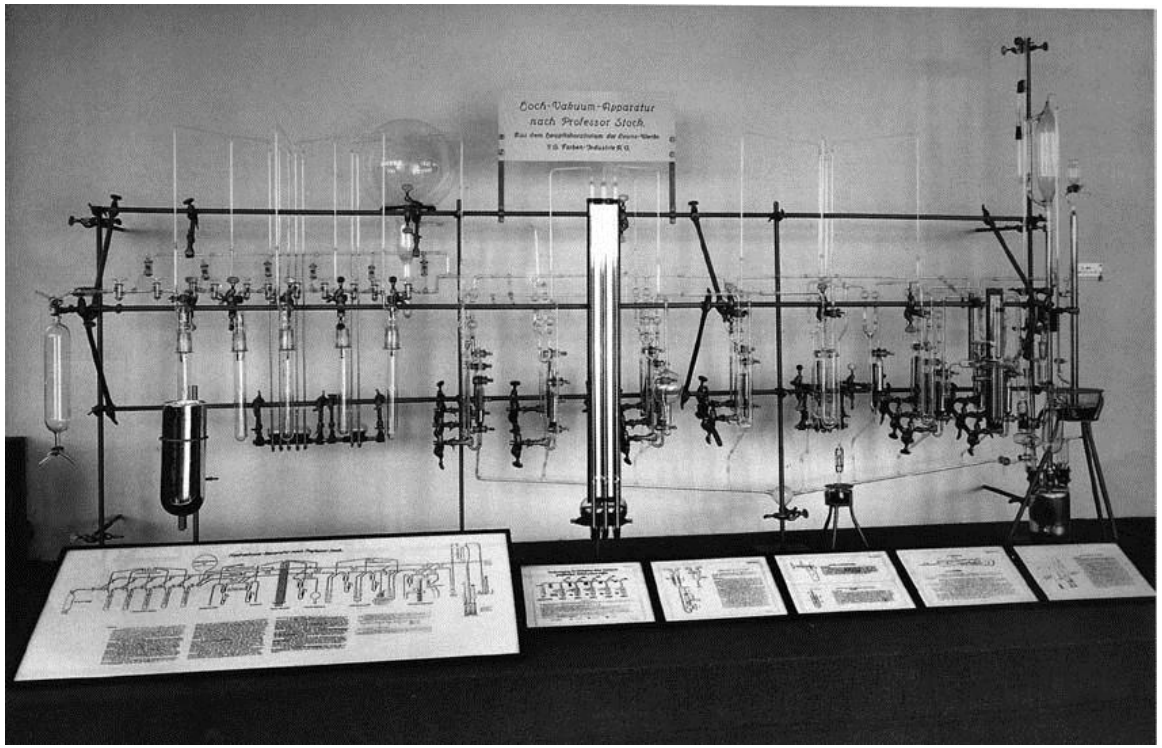
To the Editors of Electrical World:

SIRS: – During an investigation of the unsymmetrical passage of current through a contact of **carborundum** and other substances a curious phenomenon was noted. **On applying a potential of 10 volts between two points on a crystal of carborundum, the crystal gave out a yellowish light.** Only one or two specimens could be found which gave a bright glow on such a low voltage, but with 110 volts a large number could be found to glow. In some crystals only edges gave the light and others gave instead of a yellow light green, orange or blue. In all cases tested the glow appears to come from the negative pole, a bright blue-green spark appearing at the positive pole. In a single crystal, if contact is made near the center with the negative pole, and the positive pole is put in contact at any other place, only one section of the crystal will glow and that same section wherever the positive pole is placed.

There seems to be some connection between the above effect and the e.m.f. produced by a junction of carborundum and another conductor when heated by a direct or alternating current; but the connection may be only secondary as an obvious explanation of the e.m.f. effect is the thermoelectric one. The writer would be glad of references to any published account of an investigation of this or any allied phenomena.

New York, N. Y.

Alfred Stock- the father of boron hydride chemistry



1912

	B. P
B_2H_6	-92.5 °C
B_4H_{10}	16 °C
B_5H_9	58 °C
B_5H_{11}	65 °C
B_6H_{10}	108 °C
$B_{10}H_{14}$	213°C
	m.p. 99.7 °C

Alfred Stock prepares a series of boron hydrides including B_2H_6 and separates them using the first sophisticated vacuum manifold. Due to their very high air and moisture sensitivity and flammability, till then they were not separable. He published his work in 1933.

$$Mg_3B_2 + H_3PO_4\,(aq) \longrightarrow B_4H_{10}, B_5H_9, B_6H_{10}$$

$$NaBH_4 + H_3PO_4 \longrightarrow B_2H_6 + 2NaH_2PO_4 + H_2$$

$$B_2H_6 \xrightarrow[\text{pyrolysis}]{\triangle} B_4H_{10}, B_5H_9, B_5H_{11}, B_{10}H_{14}$$

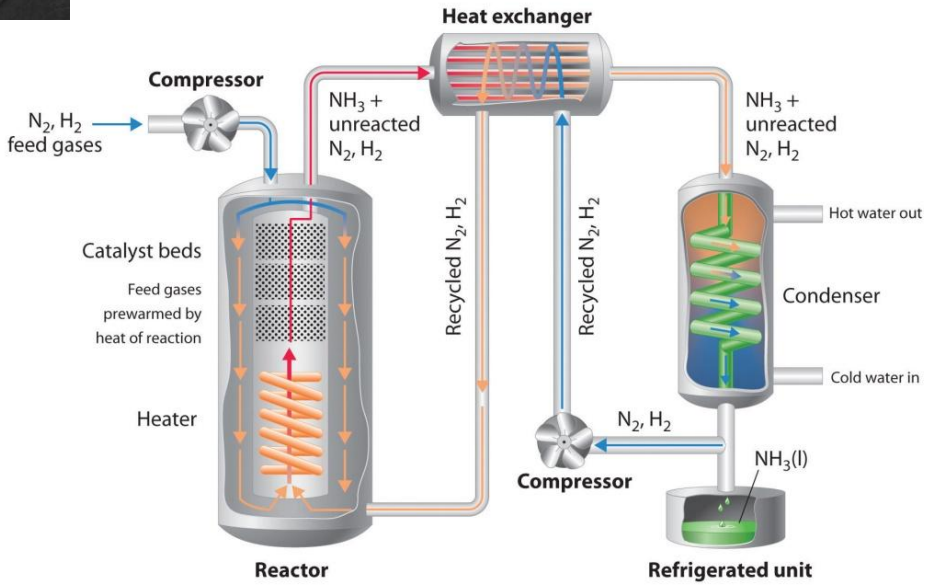
1913

Haber

Bosch

Ammonia based Fertilizers

Necessity is the mother of creation , Wars



•Fritz Haber reports Haber process for the catalytic synthesis of NH_3 which was made into a large scale industrial process along with C. Bosch in 1913.

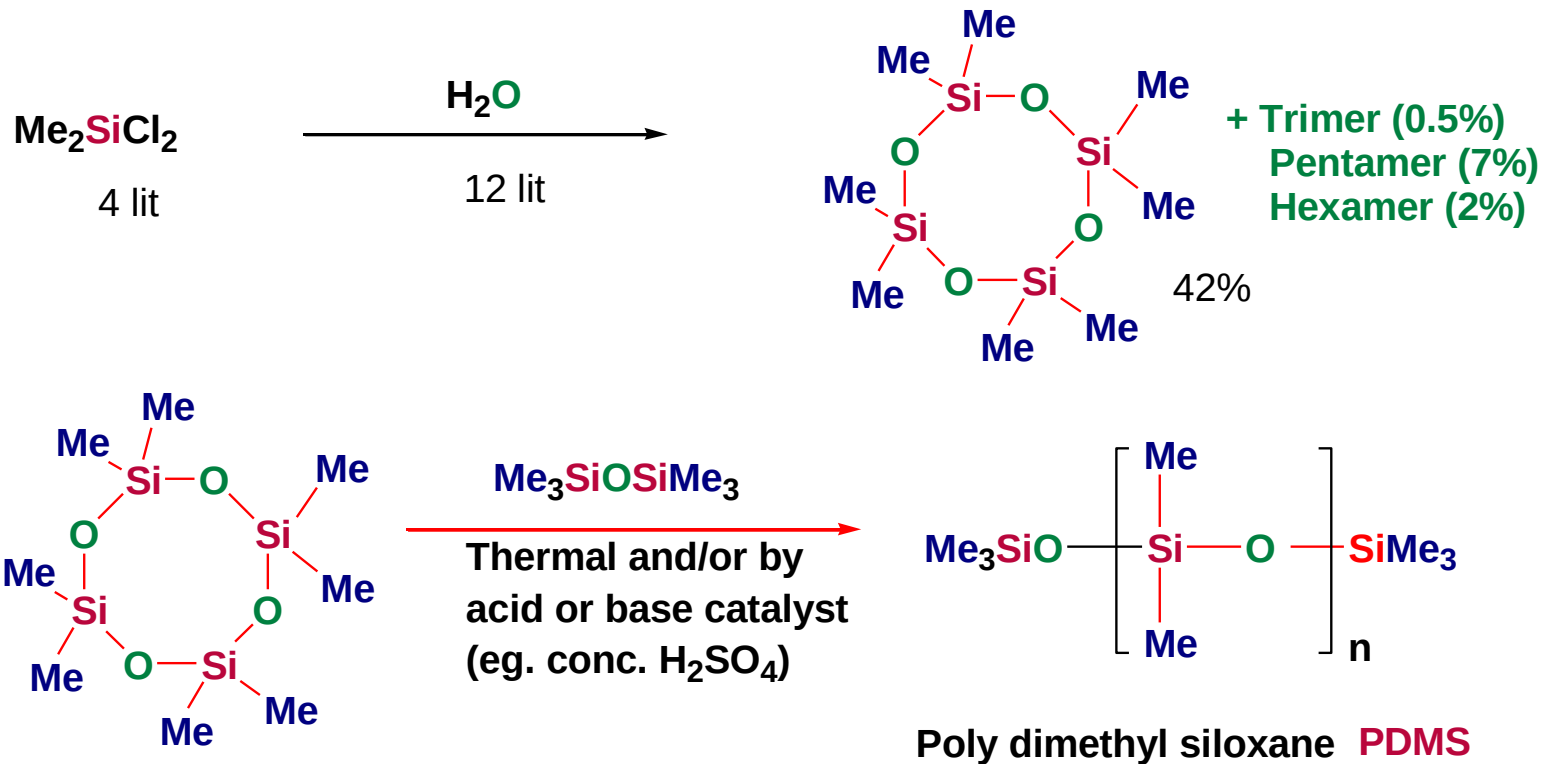
• **Haber received the Nobel Prize in Chemistry in 1918.**

•According to an estimate, nearly 80% of nitrogen present in the human tissue has had its origins from Haber process.

•The worldwide production of ammonia exceeds 140 million tonnes and is the third largest inorganic chemical produced in the world.

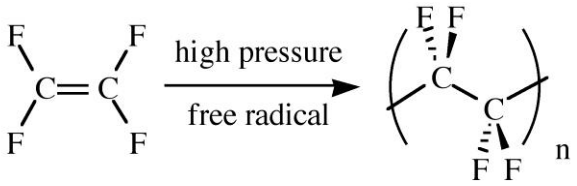
Silicone Polymers

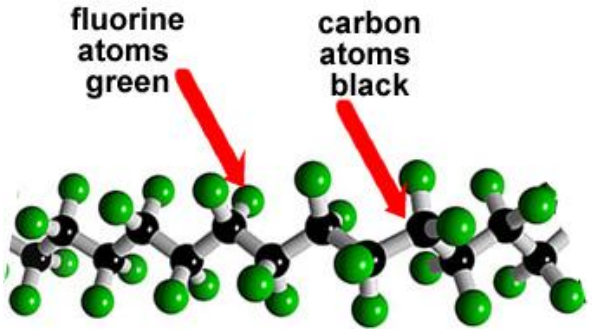
In 1937 after 30 years of research, Kipping In the Bakrerian lecture of the Royal Society said "**The prospect of any immediate and important advance in this section of organic chemistry does not seem to be very hopeful."**



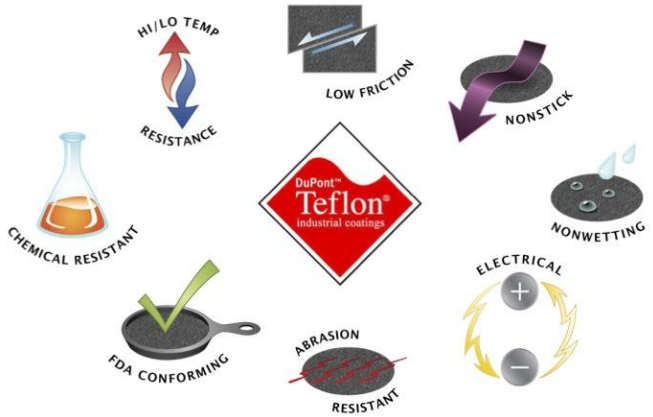
Lowest glass transition temperature, Tg = -127 °C

1938



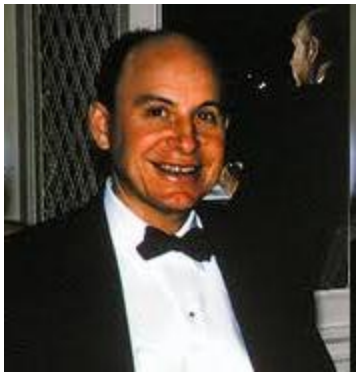


Roy J. Plunkett



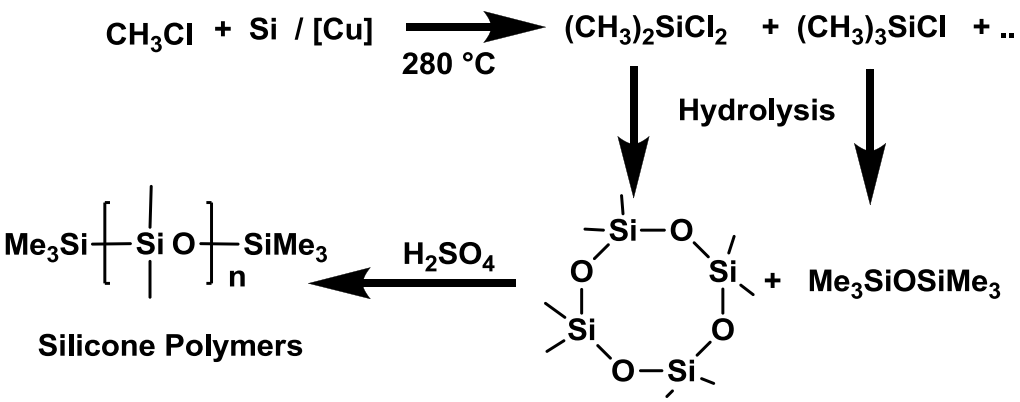
Poly tetrafluoroethylene (Teflon) accidentally discovered by **Roy J. Plunkett** of kinetic chemicals (A subsidiary of DuPont) while attempting to make a new CFC using tetrafluoroethylene. He observed that there was no gas flowing out of a small cylinder of tetrafluoroethylene whose weight indicated no loss of substance. On cutting open the cylinder, he observed a waxy white highly slippery solid on its interior walls whose analysis indicated polymerized tetrafluoroethylene.

Industrial success of Silicones

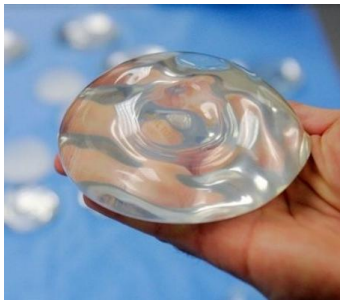


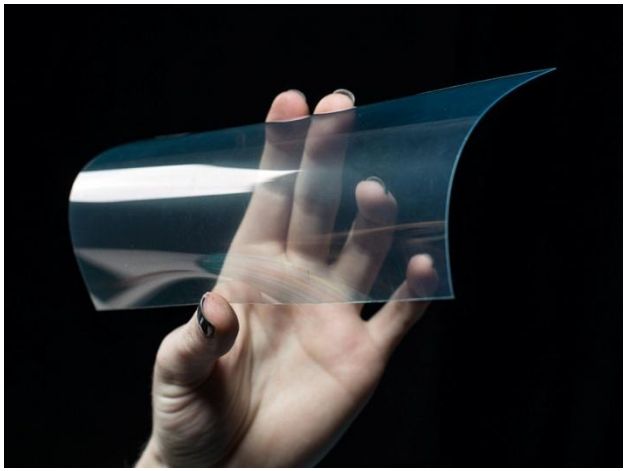
E.G. Rochow

Rochow Mueller Process (1943)



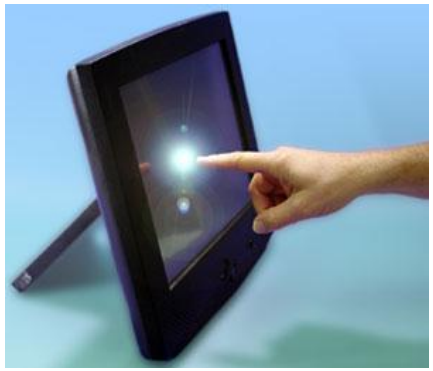
World Silicone Demand, 2010
($12.4 billion)

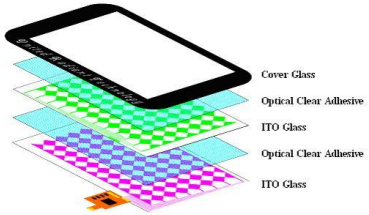


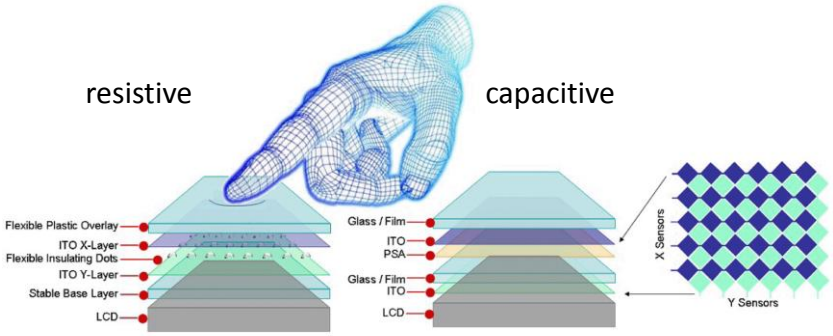


1954

ITO



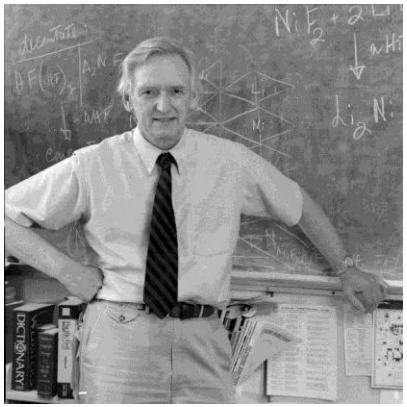




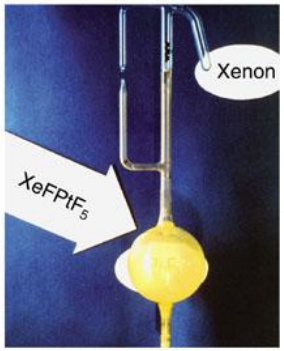
G. Rupprecht reports the semi conducting properties of Indium oxide, In_2O_3. This was followed by the report by V. A. Williams in 1966 on the potential of tin doped indium oxide (Indium tin oxide, ITO) as a transparent conducting material. ITO is a solid solution of indium(III) oxide and tin(IV) oxide, typically 90% In_2O_3, 10% SnO_2 by weight. It is the most widely used transparent conducting oxide, especially as films because of its electrical conductivity, optical transparency, as well as the ease of depositing as thin films. Applications include liquid crystal, flat panel and plasma displays, touch screen technology of mobile phones and ATM's, electronic ink, light-emitting diodes, solar cells, antistatic coatings, defrosting aircraft wind shields and infrared reflecting coatings.

1962

The discovery of the first noble gas reaction



In March of 1962, Bartlett set up a glass apparatus containing PtF_6, a red gas in one container and xenon, a colorless gas in an adjoining container, separated by a seal. Here's his recollection of the ensuing experiment, which he conducted while working alone in his laboratory: "Because my co-workers at that time (March 23, 1962) were still not sufficiently experienced to help me with the glassblowing and the preparation and purification of PtF_6 [platinum hexafluoride] necessary for the experiment, I was not ready to carry it out until about 7 p.m. on that Friday. When I broke the seal between the **red PtF_6 gas and the colorless xenon gas**, there was an immediate interaction, causing an **orange-yellow solid to precipitate**. At once I tried to find someone with whom to share the exciting finding, but it appeared that everyone had left for dinner!"
The reaction took place at room temperature "in the twinkling of an eye" and was "extraordinarily exhilarating," recalls Bartlett. He was certain that the orange-yellow solid was the world's first noble gas compound. But convincing others would prove somewhat difficult. The prevailing attitude was that no scientist could violate one of the basic tenets of chemistry: the inertness of noble gases. That orange-yellow solid was subsequently identified in laboratory studies as xenon hexafluoroplatinate ($XePtF_6$), the world's first noble gas compound.



Bartlett's Conclusion

$$O_2 + PtF_6 \longrightarrow [O_2]^{\oplus}\,[PtF_6]^{\ominus}$$

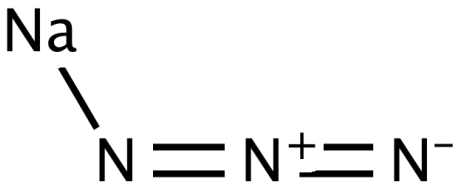
IP = 12.2 eV

$$Xe + PtF_6 \longrightarrow [XeF]^{\oplus}\,[PtF_6]^{\ominus}$$

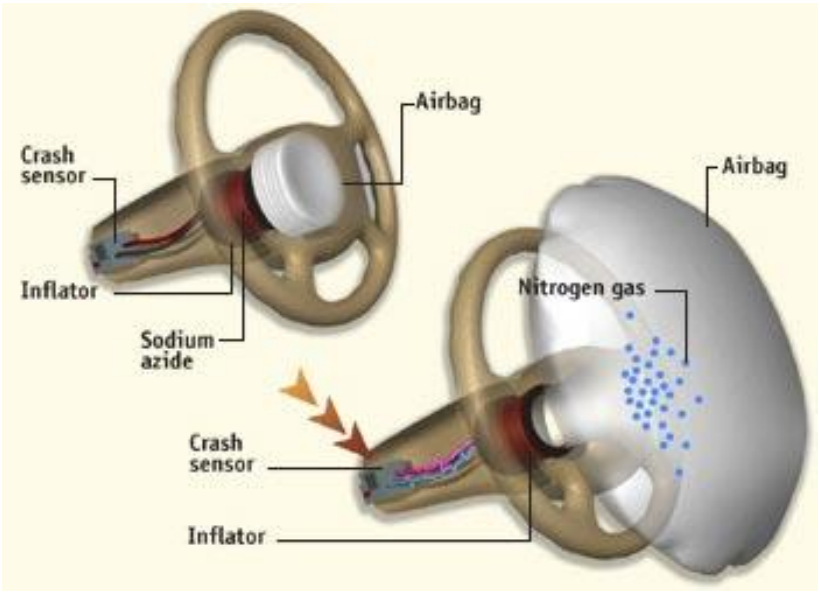
IP = 12.1 eV

Allen K. Breed

1967



One azido group contributes about 335 kj/mol (80 kcal/mol) of endothermicity to a compound

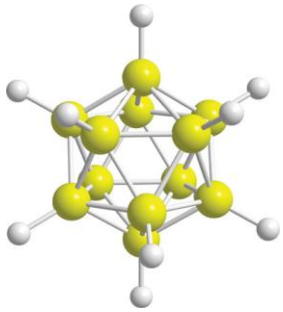


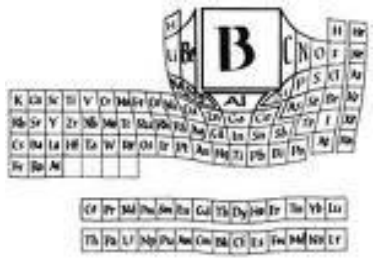
Allen K. Breed uses sodium azide, NaN_3 along with a collision sensor in automobile airbags (instead of compressed air) and achieves inflation of the airbag under 30 milliseconds required for collision safety

Ken Wade, Durham

1971

Wade's Rules

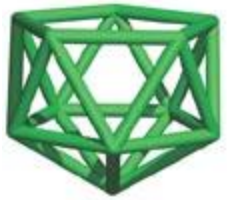




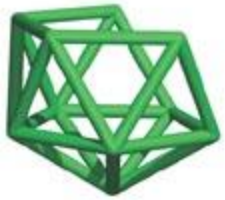
$$B_2H_6 + 2\,Et_3N \longrightarrow 2\,Et_3N.BH_3 \xrightarrow{B_4H_{10},\ 190\ ^\circ C} [Et_3NH]_2[B_{12}H_{12}]$$

For borane and carborane clusters, the structures are based on deltahedra, which are polyhedra in which every face is triangular. The clusters are classified as *closo-, nido-, arachno- or hypho-,* based on whether they represent a complete (*closo*-) deltahedron, or a deltahedron that is missing one (*nido*-), two (*arachno*-) or three (*hypho*) vertices.

Closo



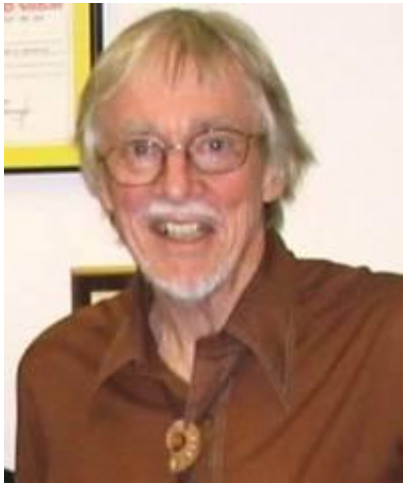
Nido



Arachno

Boron hydride	Name	No. of skeletal electron pairs	Examples
$[B_nH_n]^{2-}$ or B_nH_{n+2}	Closo	n+1	$B_6H_6^{2-}$, $B_{12}H_{12}^{2-}$
B_nH_{n+4}	Nido	n+2	B_2H_6,B_5H_9, $B_{10}H_{14}$
B_nH_{n+6}	Arachno	n+3	B_4H_{10}
B_nH_{n+8}	Hypho	n+4	$B_5H_{12}^-$

Each BH unit furnishes 2 skeletal bonding electrons
Each additional H· furnishes 1 skeletal bonding electron
Ionic charges must be included in the electron count

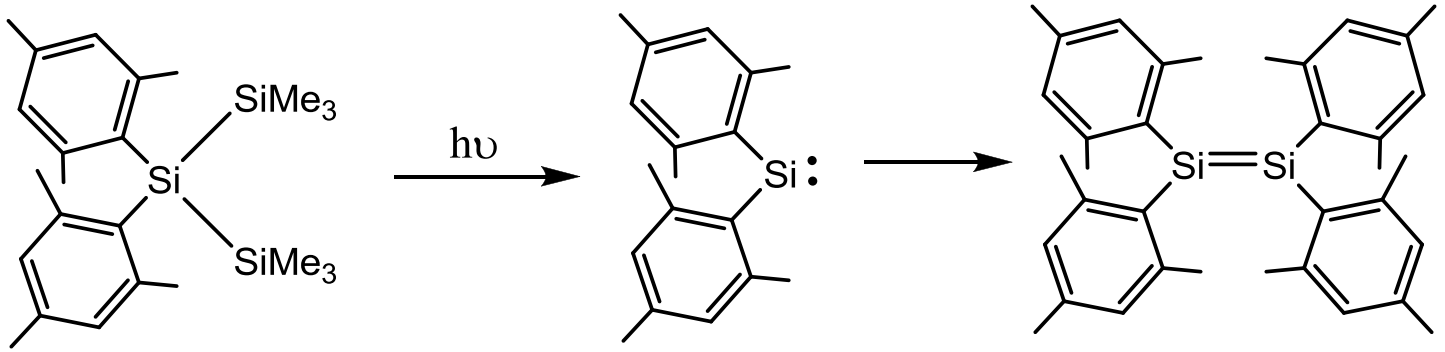


1981

"Why do you want to climb mount Everest"?
"Because it's there"

George Mallory :British mountaineer, 1886-1924

ROBERT WEST

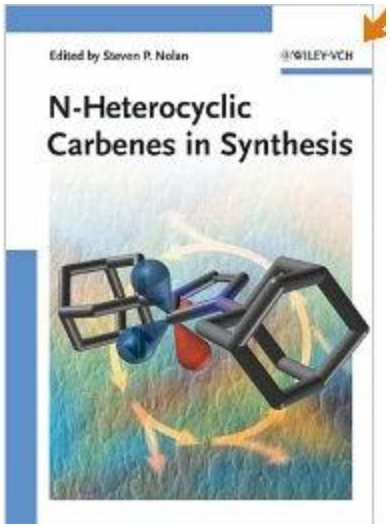


2.160Å

Robert West makes the first stable silicon–silicon double bonded compound

Anthony J. Arduengo, III

1991



Carbene Is Genie In A Bottle

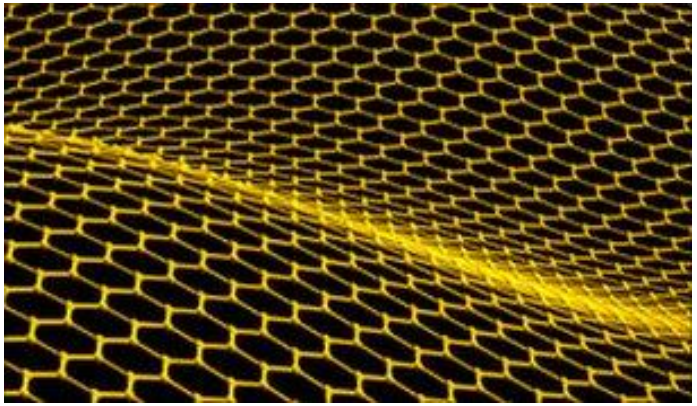
Chemists are particularly drawn to molecules that behave like **ferocious cats**, reacting rapidly and often violently and hence cannot seem to resist the temptation to control them. One such species is the carbene which is imperative for an entire framework of organic reactions thereby leading to an altogether a separate branch named---**Carbene Chemistry**.

Anthony J Arduengo III prepares the first stable carbene now well known as the NHC or N-Heterocyclic Carbene

Sir Andre Geim

2004

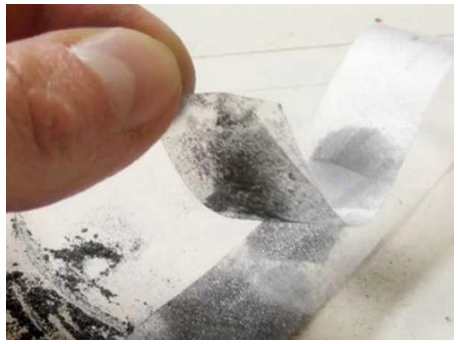
- Stronger than steel: 200 times
- Thinner than hair: 1 million times
- Worlds most conductive material
- Stretchable, transparent, flexible permeable
- Worlds first 2D material



Graphene

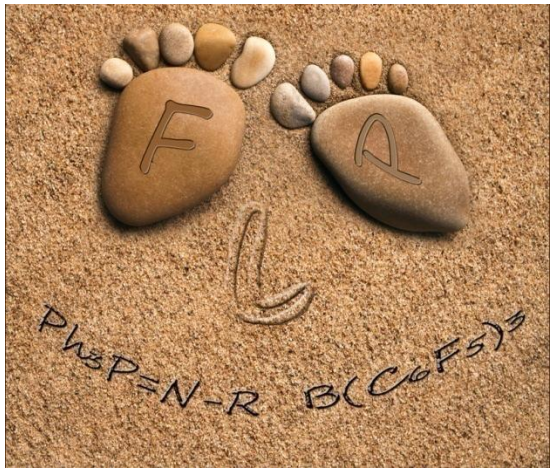
Geim was awarded the 2010 Nobel Prize in Physics jointly with Novoselov "for groundbreaking experiments regarding the two-dimensional material graphene".

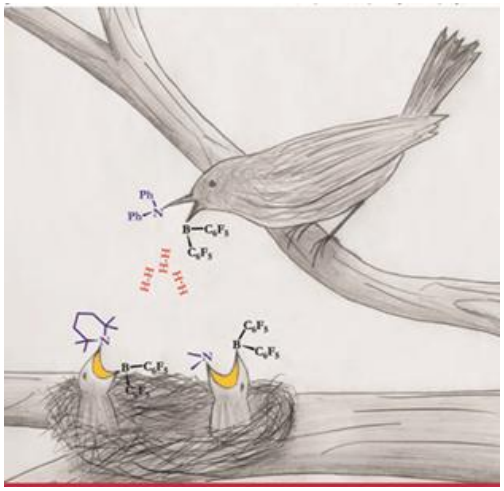
Graphene consists of one-atom-thick layers of carbon atoms arranged in two-dimensional hexagons, and is the thinnest material in the world, as well as one of the strongest and hardest.The material has many potential applications and is considered a superior alternative to silicon. Geim's achievements include the discovery of a simple method for isolating single atomic layers of graphite, known as graphene. The team published their findings in October 2004 in *Science*

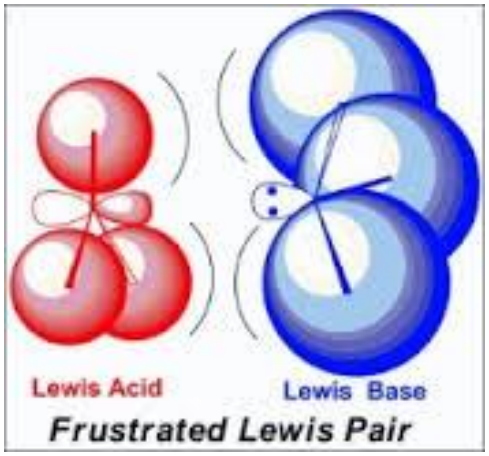


2006

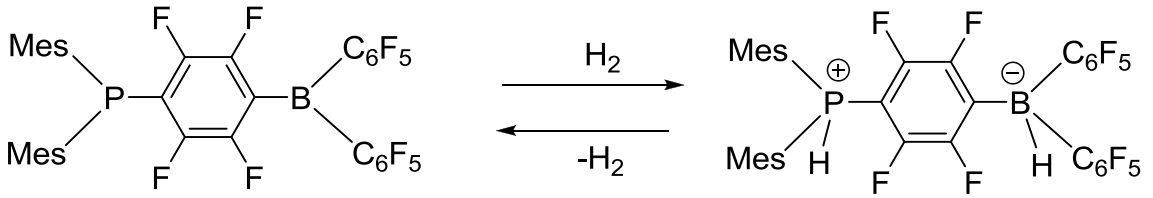
Douglas Stephan







frustrated Lewis acid base pair



Mes = 2, 4, 6 $(CH_3)_3C_6H_2$

Douglas W. Stephan discovers the first example of a **frustrated Lewis acid base pair** based on boron and phosphorus. Due to their unquenched reactivity such molecules are able to heterolytically cleave dihydrogen molecule making them potential metal free hydrogenation catalysts.

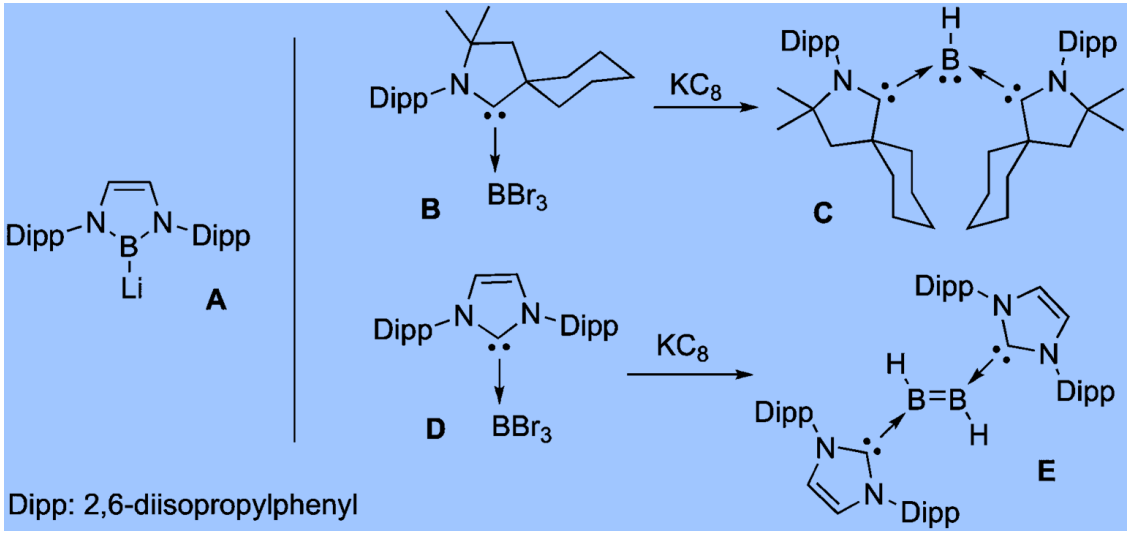
GREG ROBINSON

2007-2008

G.M Robinson proposed the first gallium–gallium triple bonded compound in 1997 which evoked the famous comment from F.A Cotton that, "**That's no more a triple bond than I'm the Dalai Lama!"**

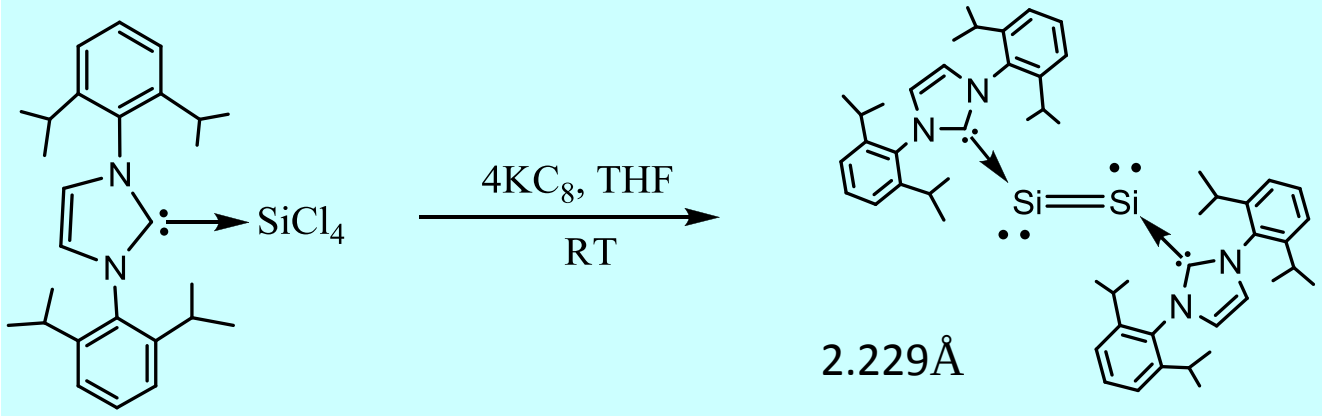
B=B

2007



2008

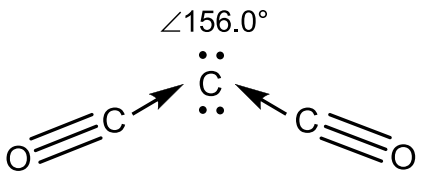
Si=Si
(0 state)



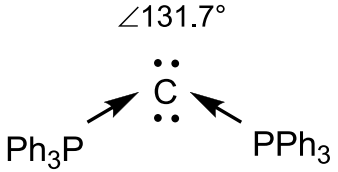
GUY BERTRAND

2007-2008
Carbones

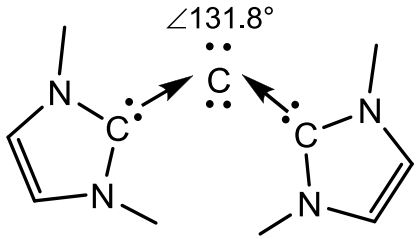
G. Bertrand and coworkers prepared an extremely bent acyclic allene (carbodicarbene) which passes the test for zerovalent carbon compounds of the type (L→C^0←L) predicted earlier by G. Frenking as 'carbone' compounds



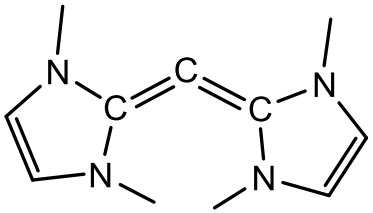
Carbon suboxide (vapour phase)



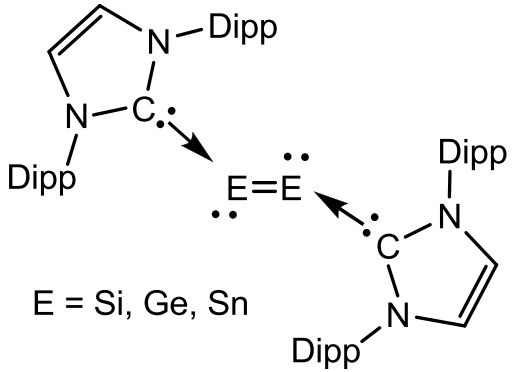
Carbodiphosphorane



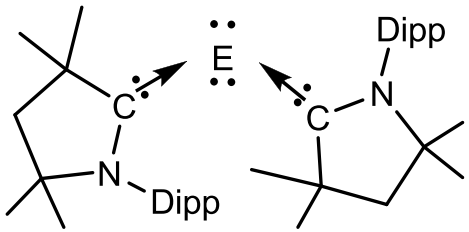
Carbone (carbodicarbene)



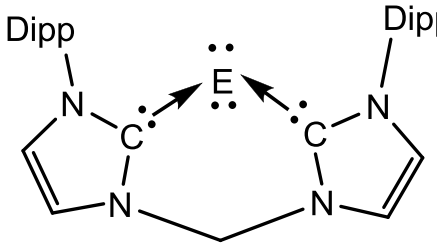
Carbone
(bent allene format)



E = Si, Ge, Sn

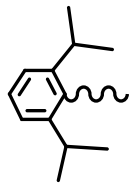


E = Si, Ge



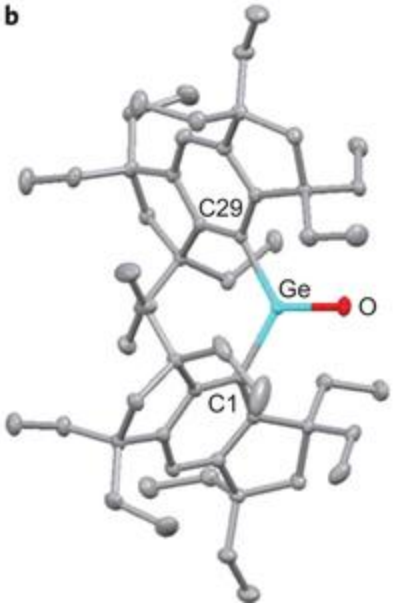
Silylone and Germylone

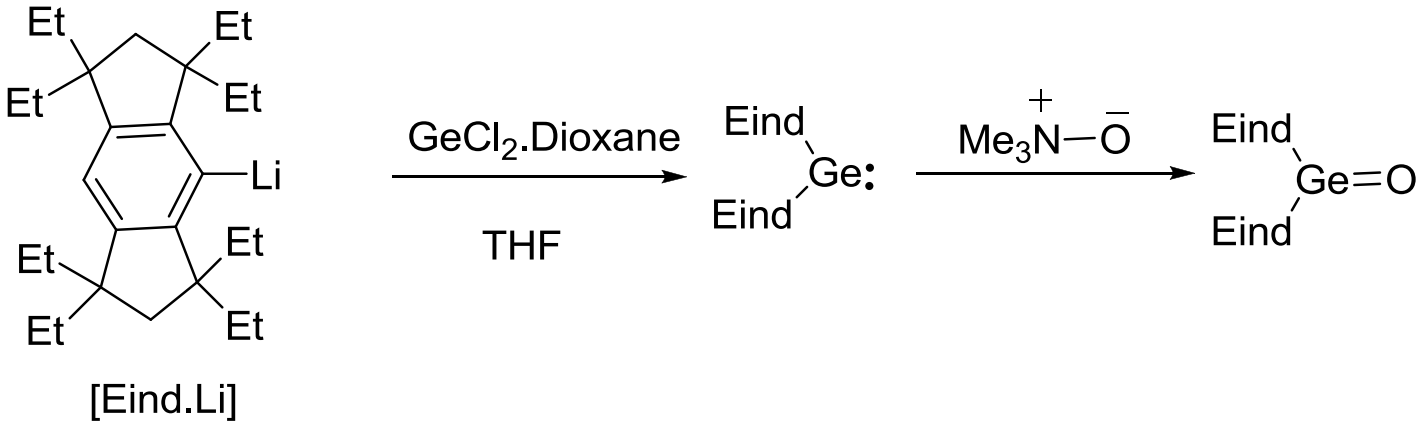
Dipp =



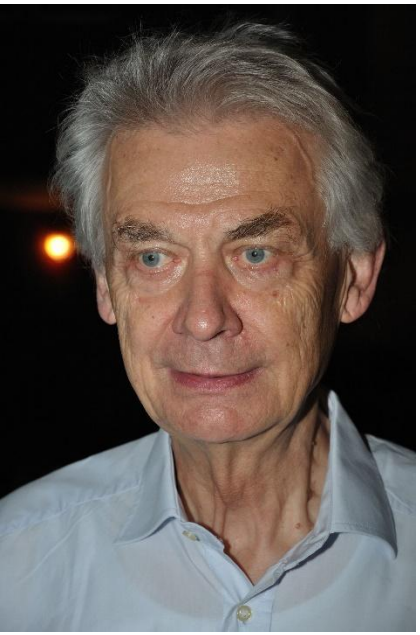
K Tamao

2012
Germanone





K Tamao prepares a stable germanone molecule having a Ge=O bond. This is the first example of a heavier element ketone analogue

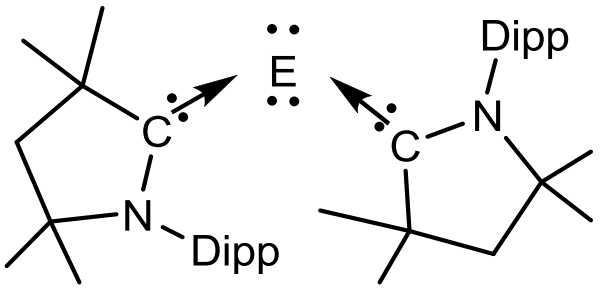


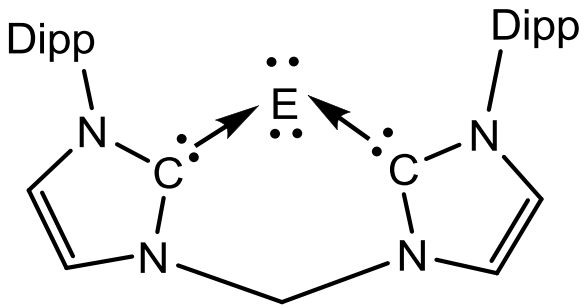
Herbert ROESKY

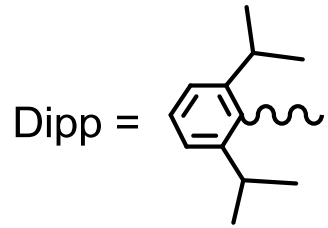
2013

Silylones and Germylones

Herbert W. Roesky and co-workers prepared the first examples of silylones ($L \rightarrow Si^0 \leftarrow L$) and germylones ($L \rightarrow Ge^0 \leftarrow L$) using cyclic alkyl (amino) carbene (cAAC) ligands

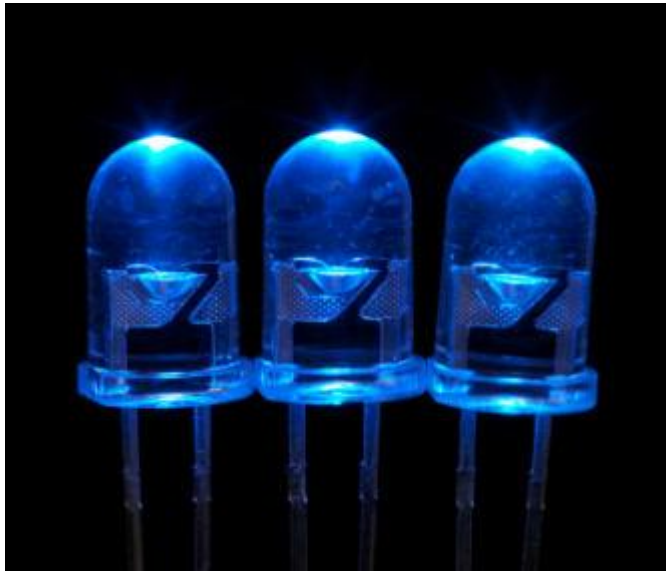


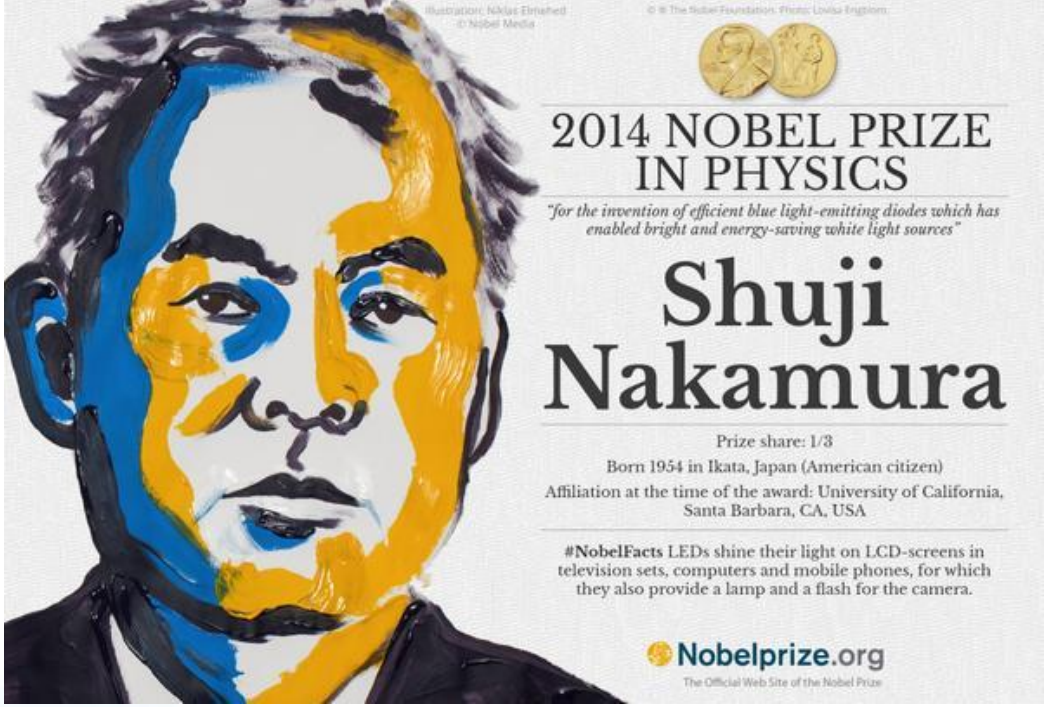


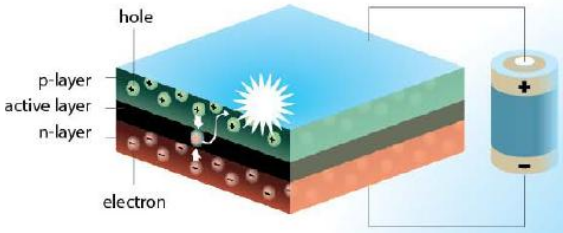


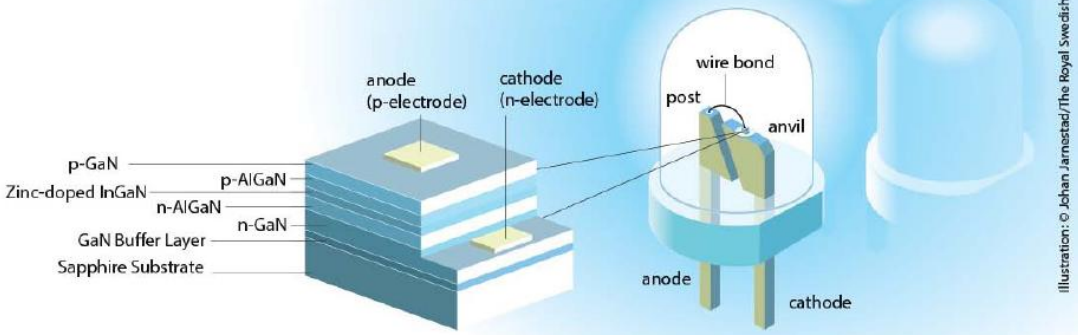
E = Si, Ge Silylone and germylone

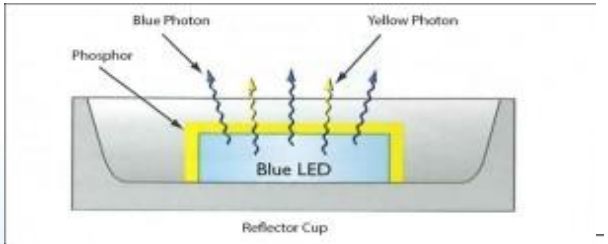
2014

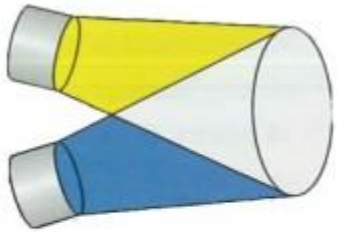










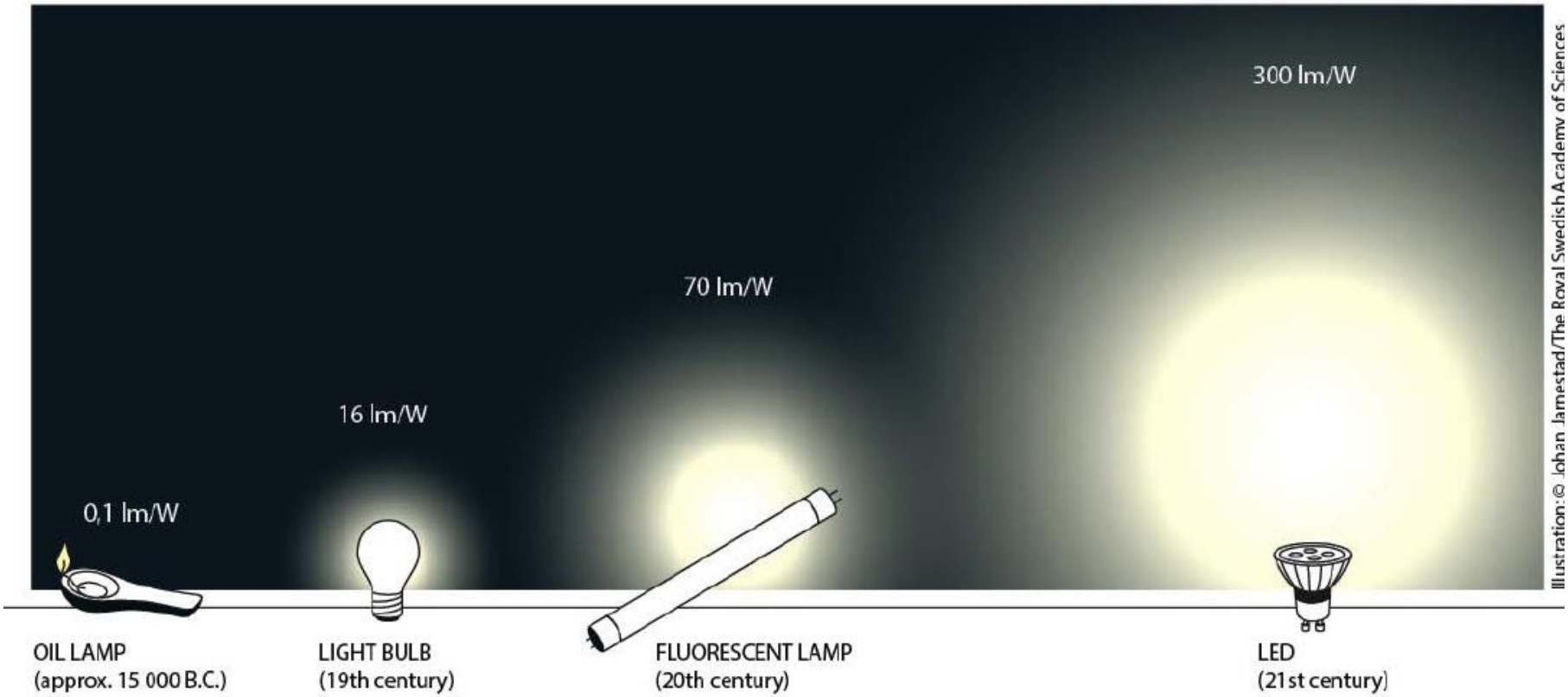


White light can be produced by combining the wavelengths of yellow and blue light only. Sir Isaac Newton discovered this effect when performing colour-matching experiments in the early 1700s.

~ **40 % Electricity Savings (261 TWh)** in USA in 2030 due to LEDs

Eliminates the need for **30+** 1000 MW **Power Plants** by 2030

Avoids Generating ~ 185 million tons of CO_2

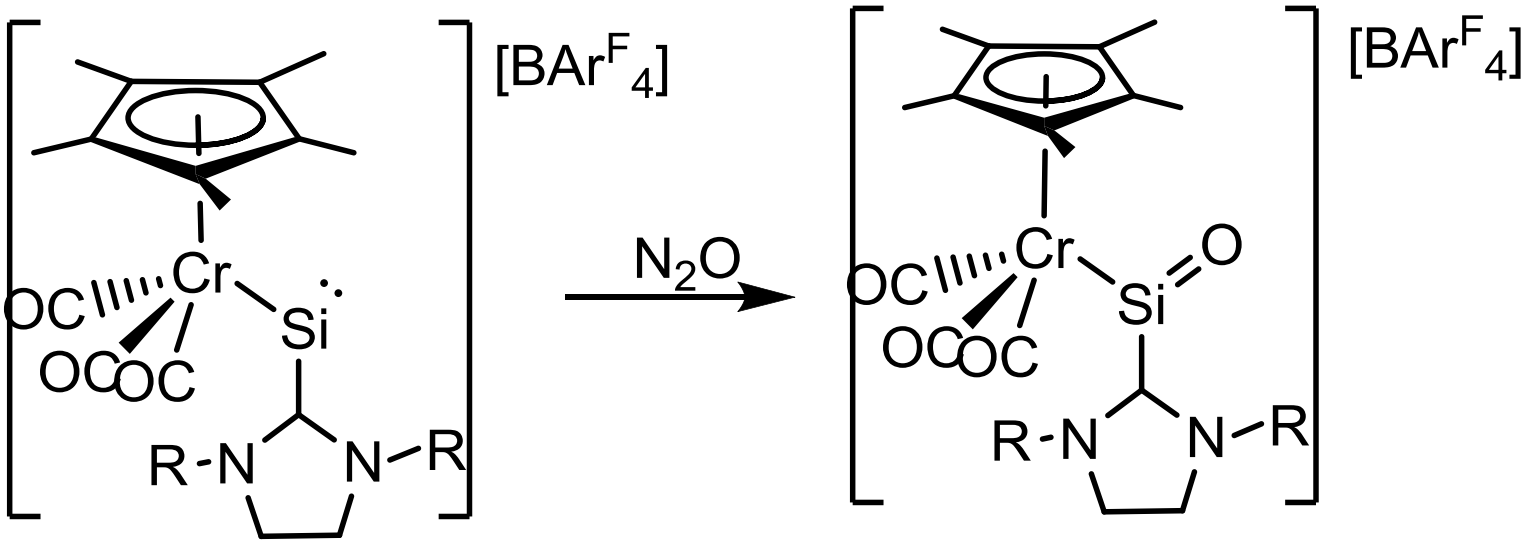


Sources: www.nobelprize.org, US Department of Energy

A C FILIPPOU

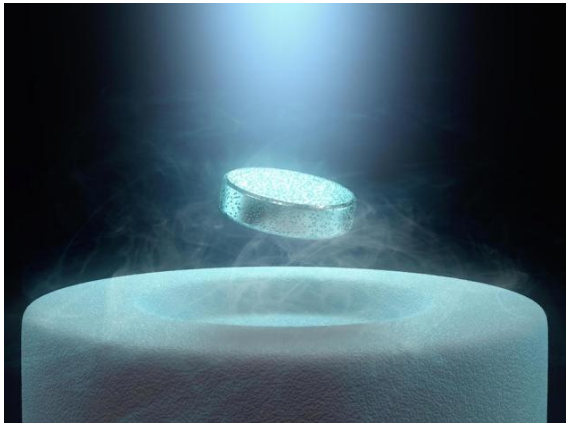
2014

The first stable silanone having a tri-coordinate silicon atom was prepared by A C Filippou.



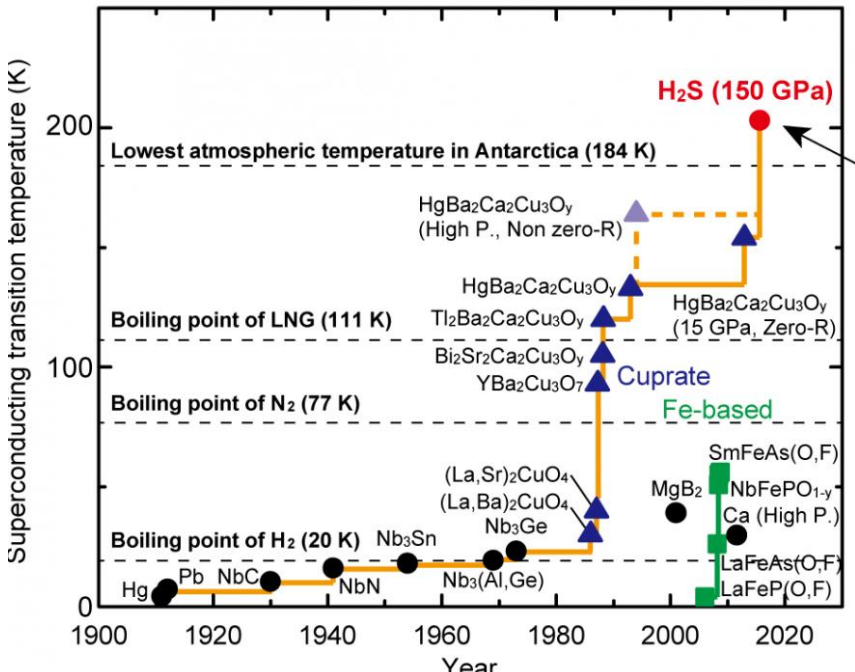
2015

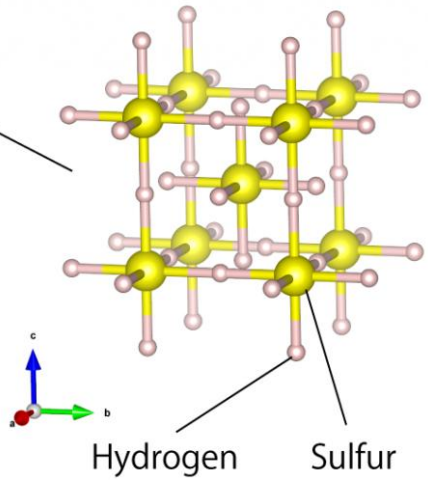
Stinky hydrogen sulfide smashes superconductivity record

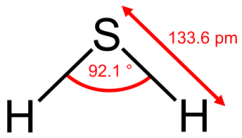


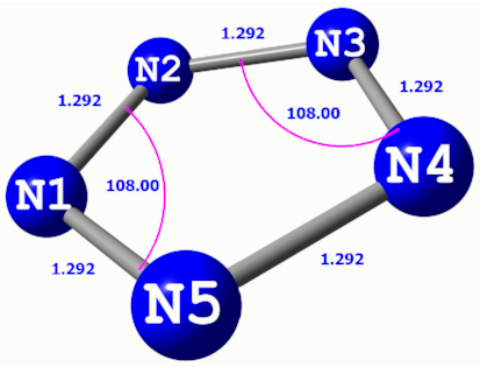
EREMETS

Drozodov, **Eremets** and co-workers discovered that compressed hydrogen sulfide (H_2S) shows superconductivity with the highest T_c observed for any material so far, 203 K (-70 °C) at 153 GPa pressure.

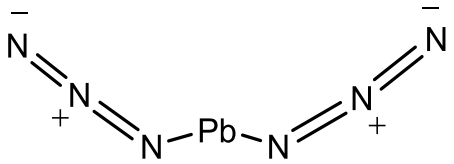




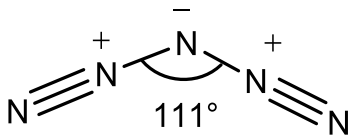




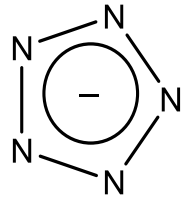
2017



Lead azide
1891

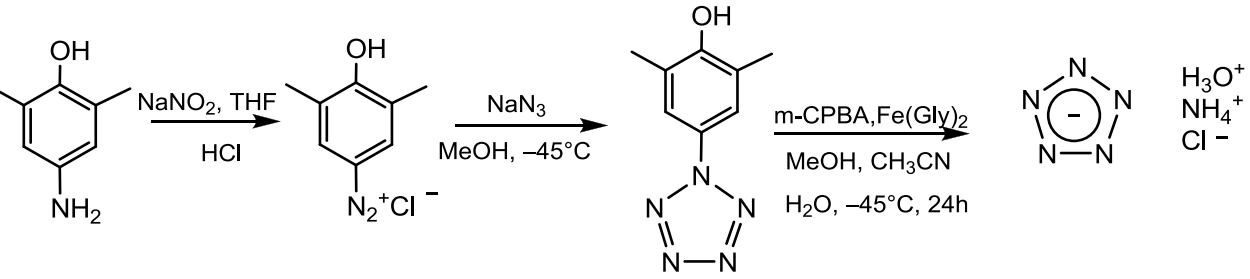


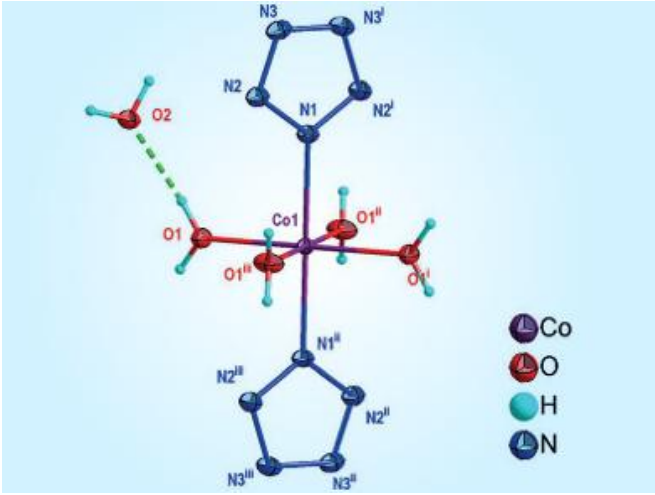
Pentazenium
1999

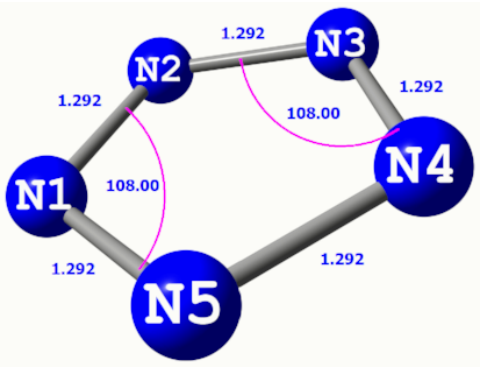


Pentazolate
2017

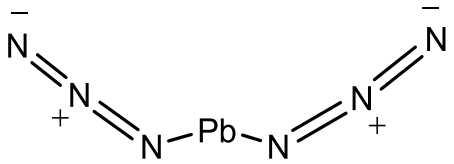
The first example of a stable pentazolate (cyclo-N_5^-) anion as $(N_5)_6(H_3O)_3(NH_4)_4Cl$ was prepared and characterised by Zhang and coworkers. The methodology was modified by others to make $[Na(H_2O)(N_5)]\cdot 2H_2O$ and a host of transition metal complexes of the cyclic pentazolate



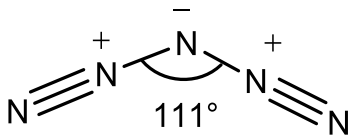




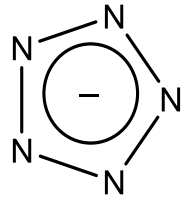
2017



Lead azide
1891



Pentazenium
1999



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