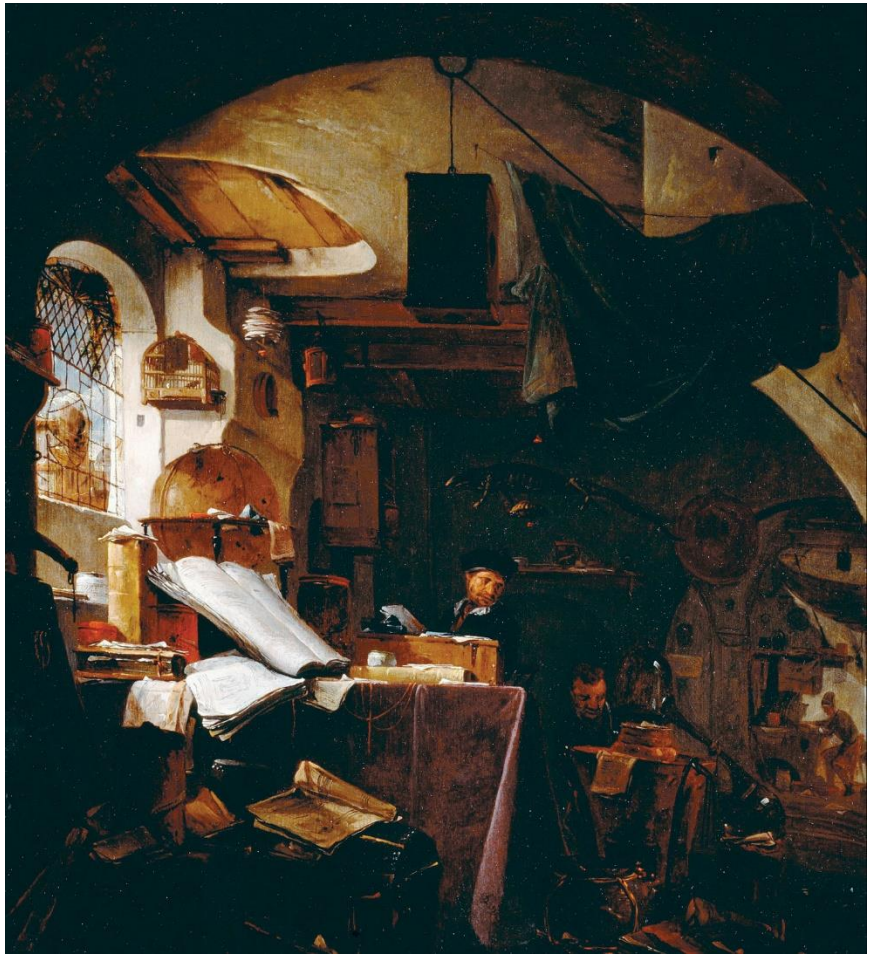
Alchemy and Organic Chemistry

Learning Outcomes

1. Describe the connections between alchemy and modern-day chemistry and medicine
2. Describe what an organic compound is
3. Identify elements most often used in organic chemistry
4. Recognize organic structures in industry, biology, and daily life
5. Describe what a functional group is

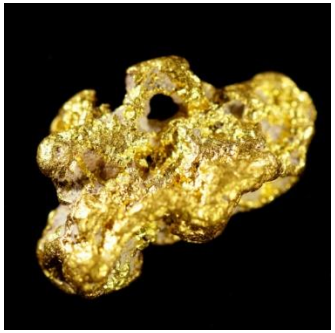
Alchemy!!



Goals of Alchemy

Chrysopeia (cry-so-p-ah): Transmutation of base metals (lead) into noble metals (gold)

Transmutation



Lead

Gold

Goals of Alchemy

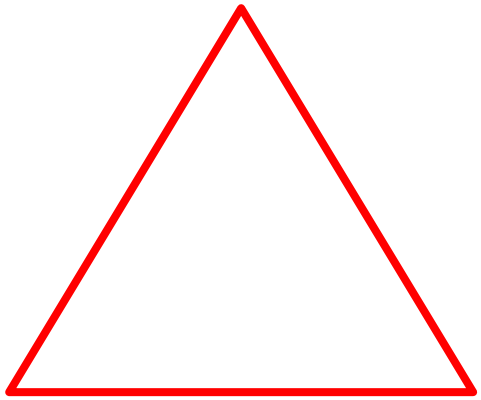
Chrysopeia (cry-so-p-ah): Transmutation of base metals (lead) into noble metals (gold)

Symbol of eternal cyclic renewal
“The all is one”

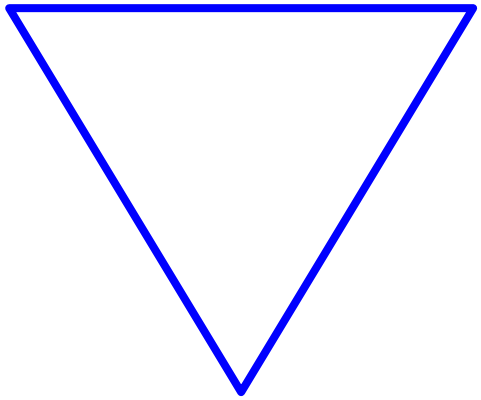
Ouroboros

Goals of Alchemy

Chrysopeia (cry-so-p-ah): Transmutation of base metals (lead) into noble metals (gold)



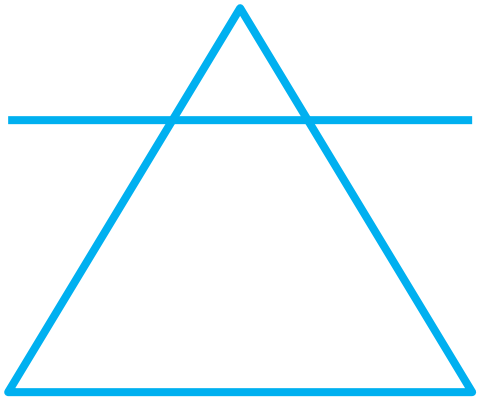
Fire



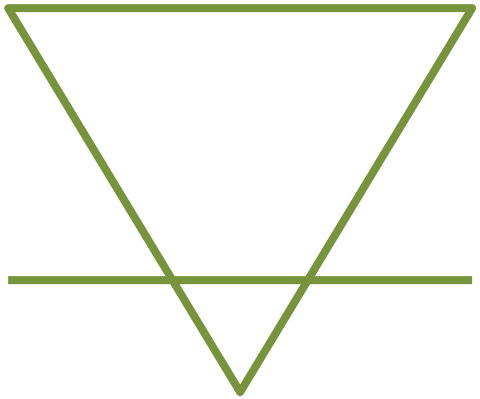
Water

Goals of Alchemy

Chrysopeia (cry-so-p-ah): Transmutation of base metals (lead) into noble metals (gold)



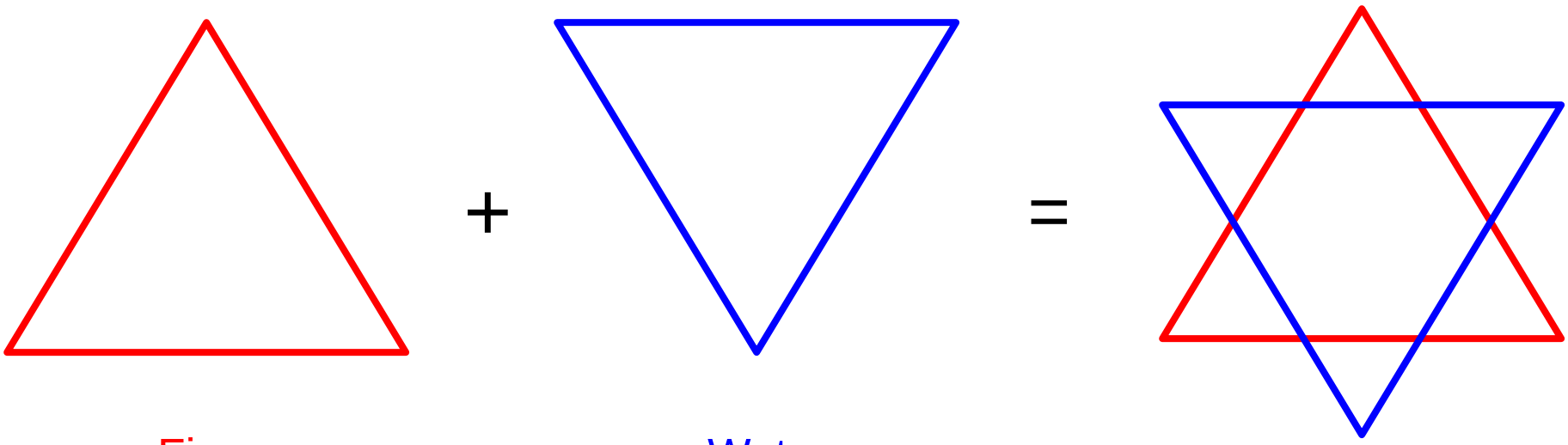
Air



Earth

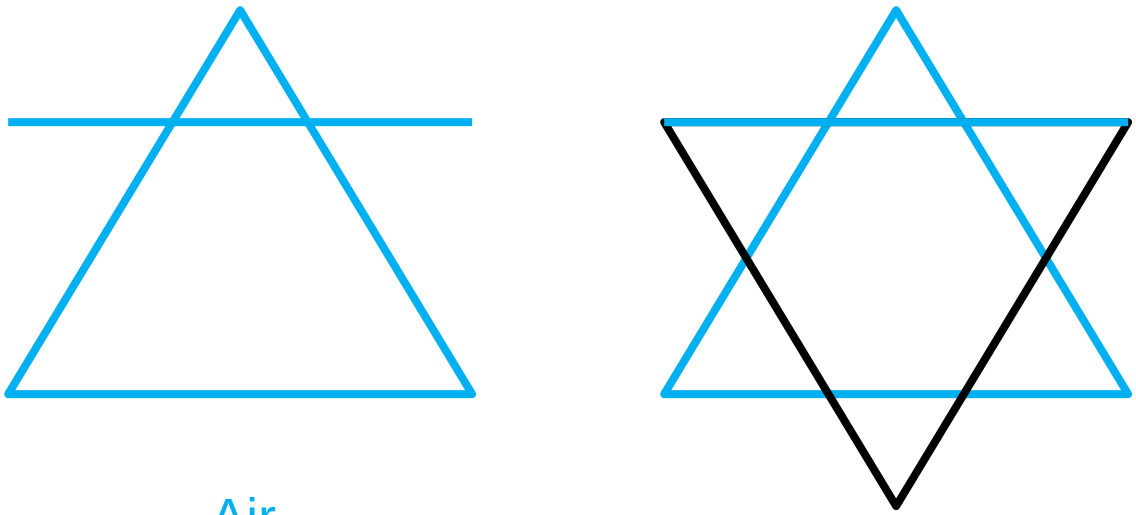
Goals of Alchemy

Chrysopeia (cry-so-p-ah): Transmutation of base metals (lead) into noble metals (gold)



Goals of Alchemy

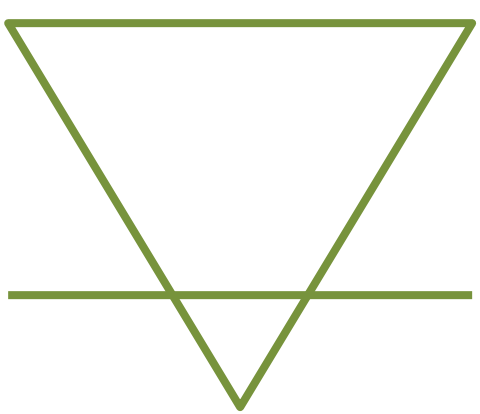
Chrysopeia (cry-so-p-ah): Transmutation of base metals (lead) into noble metals (gold)



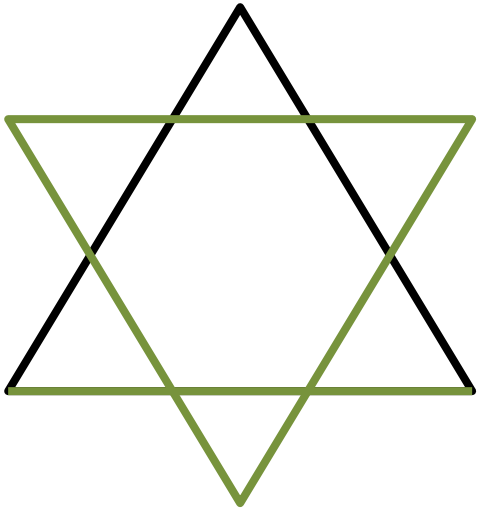
Air

Goals of Alchemy

Chrysopeia (cry-so-p-ah): Transmutation of base metals (lead) into noble metals (gold)

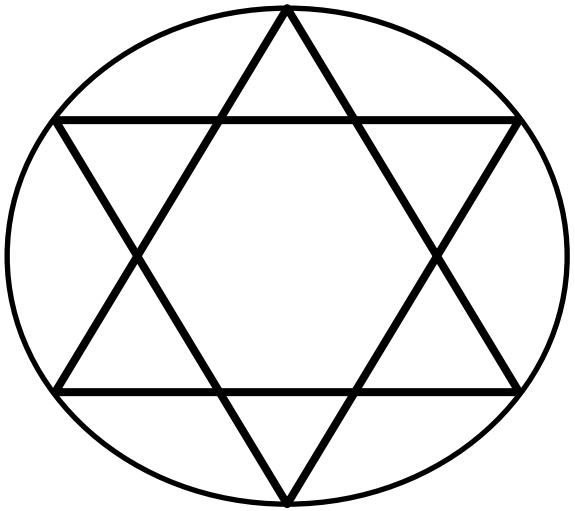


Earth



Goals of Alchemy

Chrysopeia (cry-so-p-ah): Transmutation of base metals (lead) into noble metals (gold)

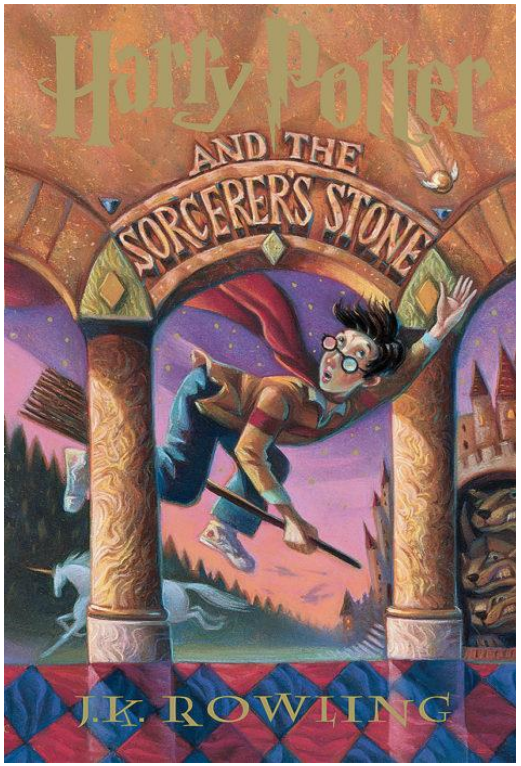


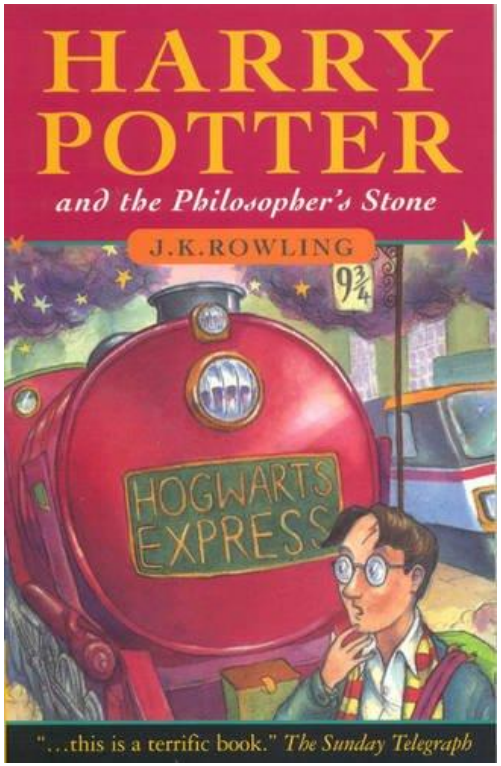
Seal of Solomon

Combination of opposites
Symbol of balance and transmutation

Goals of Alchemy

Elixir of Life/Philosopher's Stone: Eternal youth





Goals of Alchemy

Panacea: A cure-all

Theophrastus von Hohenheim

Physician and alchemist

One of the first individuals that connected chemistry to medicine

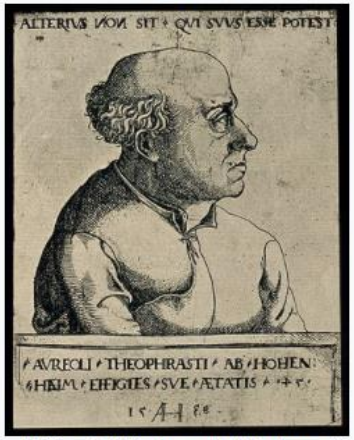
Father of toxicology

"Only the dose makes the poison"

Inspiration for the character Von Hohenheim in *Full Metal Alchemist*

Monument to Paracelsus in Beratzhausen, Bavaria

Paracelsus



1538 portrait by Augustin Hirschvogel

Born	Theophrastus von Hohenheim 1493 or 1494[1] Egg, near Einsiedeln, Schwyz,[2] Old Swiss Confederacy (present-day Switzerland)
Died	24 September 1541 (aged 47) Salzburg, Archbishopric of Salzburg (present-day Austria)
Other names	Philippus Aureolus Theophrastus, Doctor Paracelsus
Education	University of Basel University of Ferrara (M.D., 1515/16)
Era	Renaissance philosophy
Region	Western philosophy
School	Renaissance humanism
Notable ideas	Toxicology "The dose makes the poison"
Influences	[show]
Influenced	[show]

Goals of Alchemy

Alkahest: Universal solvent

Connections Between Alchemy and Modern Chemistry: Transmutation

Fact or Fiction?: Lead Can be Turned into Gold

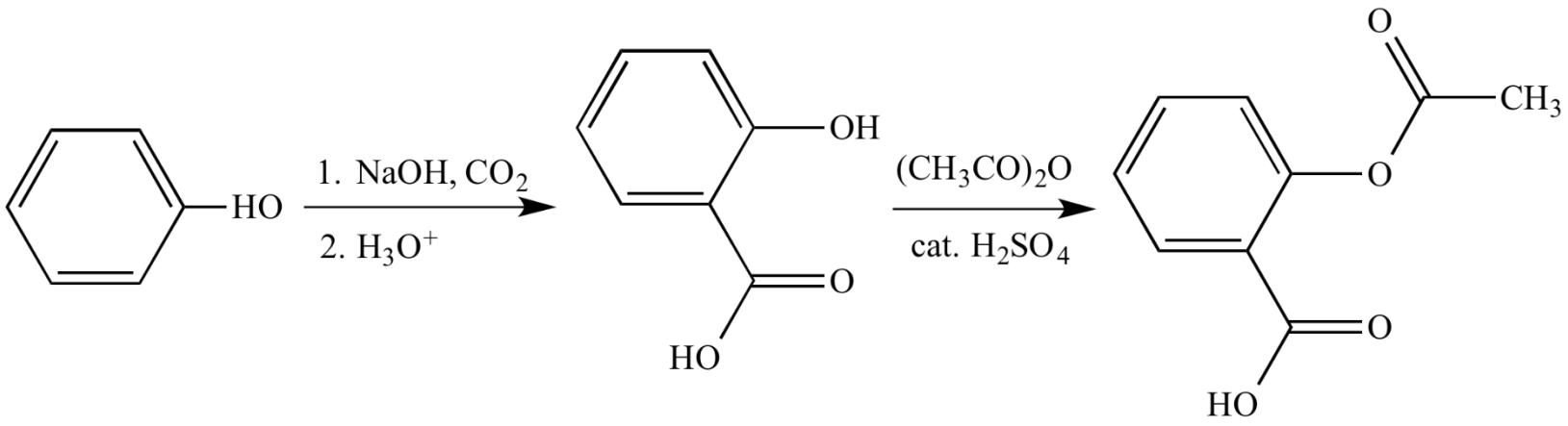
https://www.scientificamerican.com/article/fact-or-fiction-lead-can-be-turned-into-gold/

"It is relatively straightforward to convert lead, bismuth or mercury into gold. The problem is the rate of production is very, very, small and the energy, money, etcetera expended will always exceed the output of gold atoms."

"It would cost more than one quadrillion dollars (1×10^{15}) per ounce to produce gold by this experiment."

Price of gold on 11-03-2020: 1,896 dollars/ounce

Connections Between Alchemy and Modern Chemistry: Transmutation

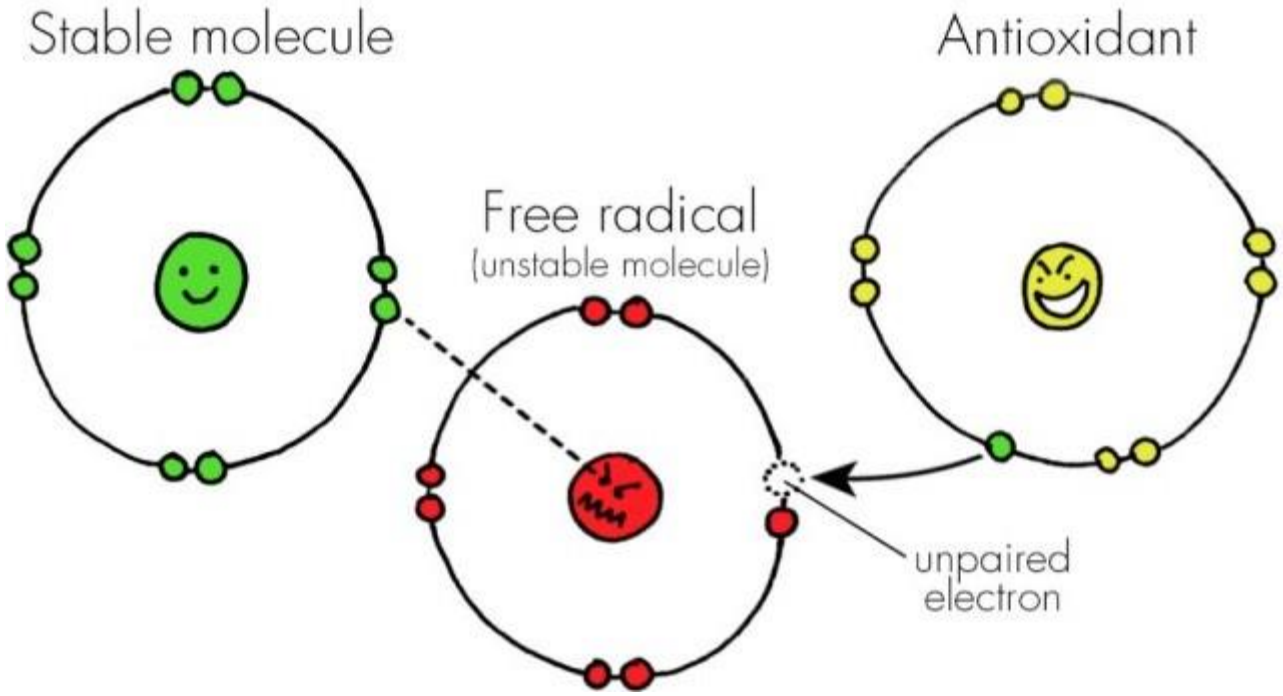


Aspirin!
(Acetylsalicyclic Acid)

Connections Between
Alchemy and Modern Chemistry: Philosopher's Stone

Molecules in Body

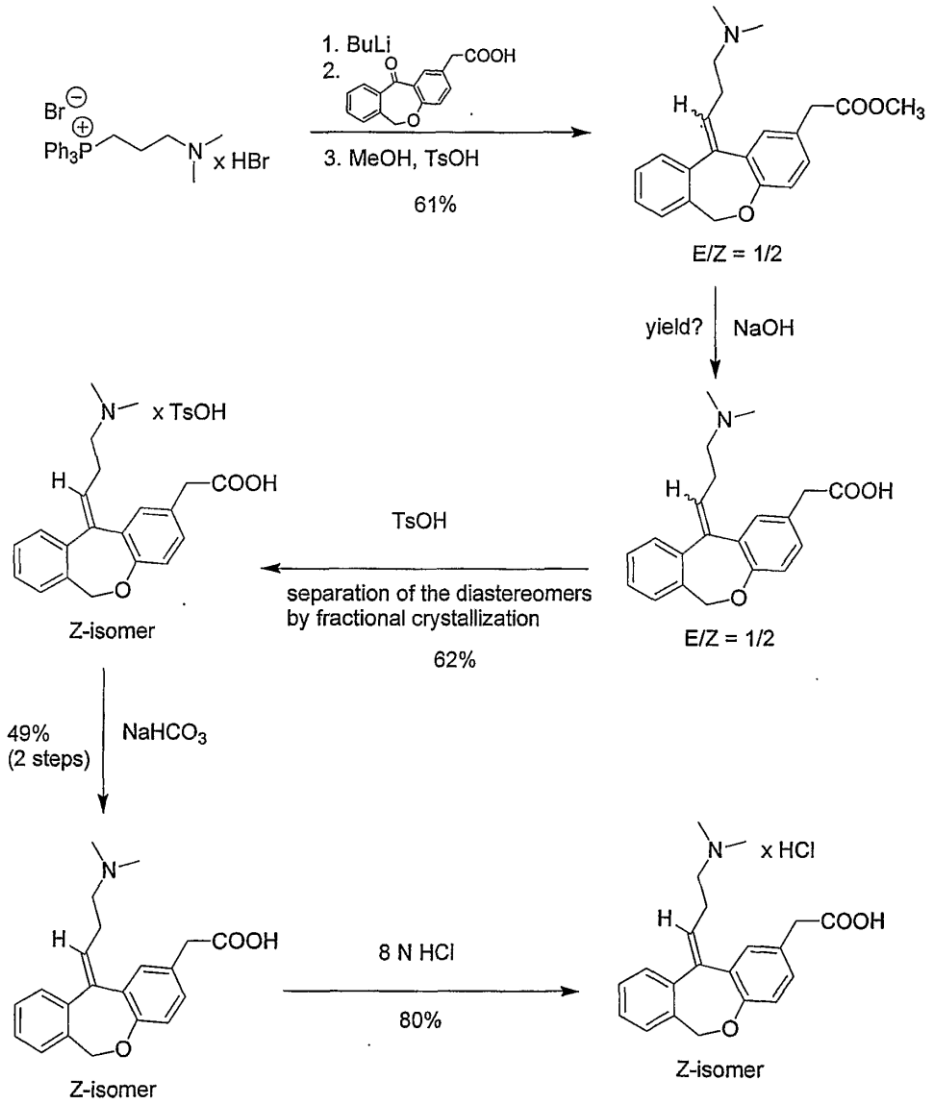
Anthocyanins
(found in berries!)



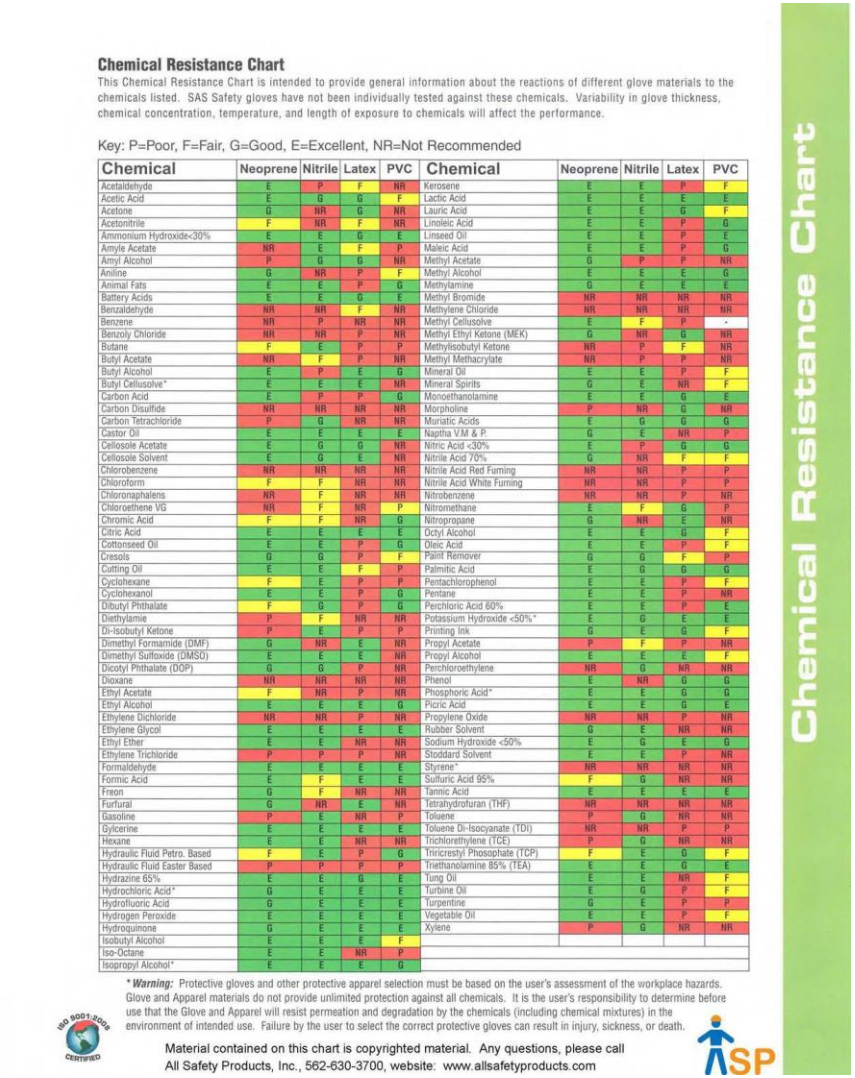
Free Radicals

Connections Between Alchemy and Modern Chemistry: Panacea

Patanol!
(Olopatadiene)



Connections Between Alchemy and Modern Chemistry: Universal Solvent



Chemical Resistance Chart

This Chemical Resistance Chart is intended to provide general information about the reactions of different glove materials to the chemicals listed. SAS Safety gloves have not been individually tested against these chemicals. Variability in glove thickness, chemical concentration, temperature, and length of exposure to chemicals will affect the performance.

Key: P=Poor, F=Fair, G=Good, E=Excellent, NR=Not Recommended

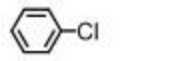
Chemical	Neoprene	Nitrile	Latex	PVC	Chemical	Neoprene	Nitrile	Latex	PVC
Acetaldehyde	E	P	F	NR	Kerosene	E	E	P	F
Acetic Acid	E	G	G	F	Lactic Acid	E	E	E	E
Acetone	G	NR	G	NR	Lauric Acid	E	E	G	F
Acetonitrile	F	NR	F	NR	Linoleic Acid	E	E	P	G
Ammonium Hydroxide<30%	E	E	G	E	Linseed Oil	E	E	P	E
Amyle Acetate	NR	E	F	P	Maleic Acid	E	E	P	G
Amyl Alcohol	P	G	G	NR	Methyl Acetate	G	P	P	NR
Aniline	G	NR	P	F	Methyl Alcohol	E	E	E	G
Animal Fats	E	E	P	G	Methylamine	G	E	E	E
Battery Acids	E	E	G	E	Methyl Bromide	NR	NR	NR	NR
Benzaldehyde	NR	NR	F	NR	Methylene Chloride	NR	NR	NR	NR
Benzene	NR	P	NR	NR	Methyl Cellusolve	E	F	P	-
Benzoly Chloride	NR	NR	P	NR	Methyl Ethyl Ketone (MEK)	G	NR	G	NR
Butane	F	E	P	P	Methylisobutyl Ketone	NR	P	F	NR
Butyl Acetate	NR	F	P	NR	Methyl Methacrylate	NR	P	P	NR
Butyl Alcohol	E	P	E	G	Mineral Oil	E	E	P	F
Butyl Cellusolve*	E	E	E	NR	Mineral Spirits	G	E	NR	F
Carbon Acid	E	P	P	G	Monoethanolamine	E	E	G	E
Carbon Disulfide	NR	NR	NR	NR	Morpholine	P	NR	G	NR
Carbon Tetrachloride	P	G	NR	NR	Muriatic Acids	E	G	G	G
Castor Oil	E	E	E	E	Naptha V.M & P.	G	E	NR	P
Cellosole Acetate	E	G	G	NR	Nitric Acid <30%	E	P	G	G
Cellosole Solvent	E	G	E	NR	Nitrile Acid 70%	G	NR	F	F
Chlorobenzene	NR	NR	NR	NR	Nitrile Acid Red Fuming	NR	NR	P	P
Chloroform	F	F	NR	NR	Nitrile Acid White Fuming	NR	NR	P	P
Chloronaphalens	NR	F	NR	NR	Nitrobenzene	NR	NR	P	NR
Chloroethene VG	NR	F	NR	P	Nitromethane	E	F	G	P
Chromic Acid	F	F	NR	G	Nitropropane	G	NR	E	NR
Citric Acid	E	E	E	E	Octyl Alcohol	E	E	G	F
Cottonseed Oil	E	E	P	G	Oleic Acid	E	E	P	F
Cresols	G	G	P	F	Paint Remover	G	G	F	P
Cutting Oil	E	E	F	P	Palmitic Acid	E	G	G	G
Cyclohexane	F	E	P	P	Pentachlorophenol	E	E	P	F
Cyclohexanol	E	E	P	G	Pentane	E	E	P	NR
Dibutyl Phthalate	F	G	P	G	Perchloric Acid 60%	E	E	P	E
Diethylamie	P	F	NR	NR	Potassium Hydroxide <50%*	E	G	E	E
Di-Isobutyl Ketone	P	E	P	P	Printing Ink	G	E	G	F
Dimethyl Formamide (DMF)	G	NR	E	NR	Propyl Acetate	P	F	P	NR
Dimethyl Sulfoxide (DMSO)	E	E	E	NR	Propyl Alcohol	E	E	E	F
Dicotyl Phthalate (DOP)	G	G	P	NR	Perchloroethylene	NR	G	NR	NR
Dioxane	NR	NR	NR	NR	Phenol	E	NR	G	G
Ethyl Acetate	F	NR	P	NR	Phosphoric Acid*	E	E	G	G
Ethyl Alcohol	E	E	E	G	Picric Acid	E	E	G	E
Ethylene Dichloride	NR	NR	P	NR	Propylene Oxide	NR	NR	P	NR
Ethylene Glycol	E	E	E	E	Rubber Solvent	G	E	NR	NR
Ethyl Ether	E	E	NR	NR	Sodium Hydroxide <50%	E	G	E	G
Ethylene Trichloride	P	P	P	NR	Stoddard Solvent	E	E	P	NR
Formaldehyde	E	E	E	E	Styrene*	NR	NR	NR	NR
Formic Acid	E	F	E	E	Sulfuric Acid 95%	F	G	NR	NR
Freon	G	F	NR	NR	Tannic Acid	E	E	E	E
Furfural	G	NR	E	NR	Tetrahydrofuran (THF)	NR	NR	NR	NR
Gasoline	P	E	NR	P	Toluene	P	G	NR	NR
Gylcerine	E	E	E	E	Toluene Di-Isocyanate (TDI)	NR	NR	P	P
Hexane	E	E	NR	NR	Trichlorethylene (TCE)	P	G	NR	NR
Hydraulic Fluid Petro. Based	F	E	P	G	Tricrestyl Phosophate (TCP)	F	E	G	F
Hydraulic Fluid Easter Based	P	P	P	P	Triethanolamine 85% (TEA)	E	E	G	E
Hydrazine 65%	E	E	G	E	Tung Oil	E	E	NR	F
Hydrochloric Acid*	G	E	E	E	Turbine Oil	E	G	P	F
Hydrofluoric Acid	G	E	E	E	Turpentine	G	E	P	P
Hydrogen Peroxide	E	E	E	E	Vegetable Oil	E	E	P	F
Hydroquinone	G	E	E	E	Xylene	P	G	NR	NR
Isobutyl Alcohol	E	E	E	F					
Iso-Octane	E	E	NR	P					
Isopropyl Alcohol*	E	E	E	G					

* ***Warning:*** Protective gloves and other protective apparel selection must be based on the user's assessment of the workplace hazards. Glove and Apparel materials do not provide unlimited protection against all chemicals. It is the user's responsibility to determine before use that the Glove and Apparel will resist permeation and degradation by the chemicals (including chemical mixtures) in the environment of intended use. Failure by the user to select the correct protective gloves can result in injury, sickness, or death.

Chemical Resistance Chart

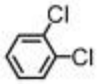
Connections Between Alchemy and Modern Chemistry: Universal Solvent

Halogenated Solvents



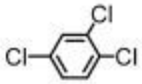
Chlorobenzene (CB)

Chloroform (CF)

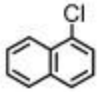


1,2-Dichlorobenzene (DCB)

1,8-Diiodooctane (DIO)



1,2,4-Trichlorobenzene (TCB)

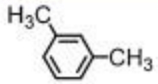


1-chloronaphthalene (CN)

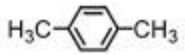
1,6-Diiodohexane (DIH)

Halogen-free/"Green" Solvents

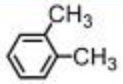
Toluene



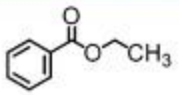
m-Xylene (m-XY)



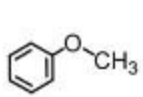
p-Xylene (p-XY)



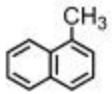
o-Xylene (o-XY)



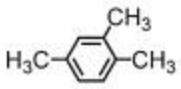
Ethyl benzoate (EB)



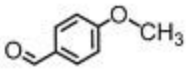
Anisole



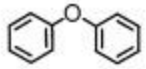
1-Methylnaphthalene (MN)



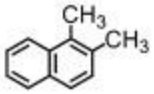
1,2,4-Trimethylbenzene (TMB)



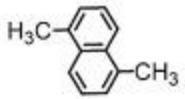
p-Anisaldehyde (AA)



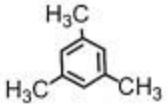
Diphenyl ether (DPE)



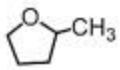
1,2-Dimethylnaphthalene (1,2-DMN)



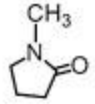
1,5-Dimethylnaphthalene (1,5-DMN)



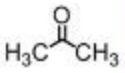
Mesitylene(MS)



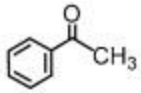
2-Methyltetrahydrofuran (MTHF)



N-Methyl-pyrrolidone (NMP)



Acetone



Acetophenone (AP)

Carbon disulphide (CS_2)

n-Butanol

CH_3OH

Methanol

H_2O

Water

Organic Compounds

Chemical Compound: Most commonly molecules (ex: H_2O) or ionic compounds (ex: NaCl, LiF)

Organic Compound: Most commonly a chemical compound that ***contains carbon***.

Methane: CH_4

Pentane: C_5H_{12}

Benzene: C_6H_6

Tryptophan: $C_{11}H_{12}N_2O_2$

1,8-Diiodooctane (DIO): $C_8H_{16}I_2$

Why Are Organic Compounds Called “Organic”

Organic compounds are produced by living matter.

Examples: Oxalic Acid (plant), Urea (kidney)

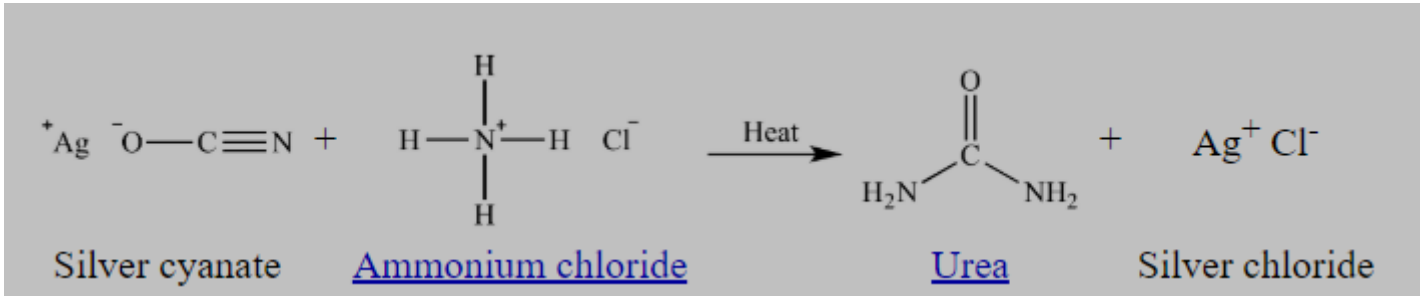
Vitalism: Why Organic Compounds are Called “Organic”

Vitalism (dates to ancient times and alchemy) teaches the “vital force” of living organisms produce organic compounds

Consumption of the vital principle (ethereal substance), prolongs life; commonly prepared from various components and called an elixir.

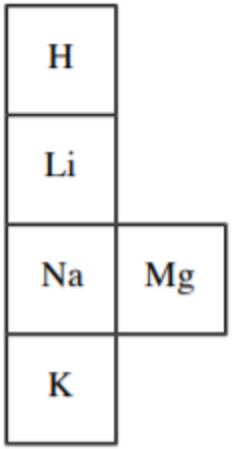
Organic substances cannot be prepared from inorganic components

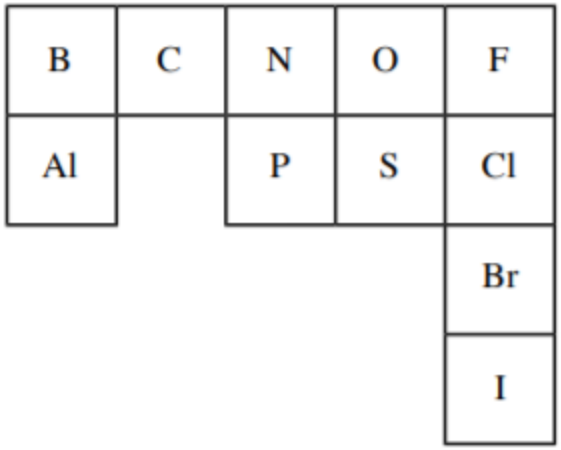
Vitalism Disproved by Friedrich Wohler's 1828 Synthesis of Urea



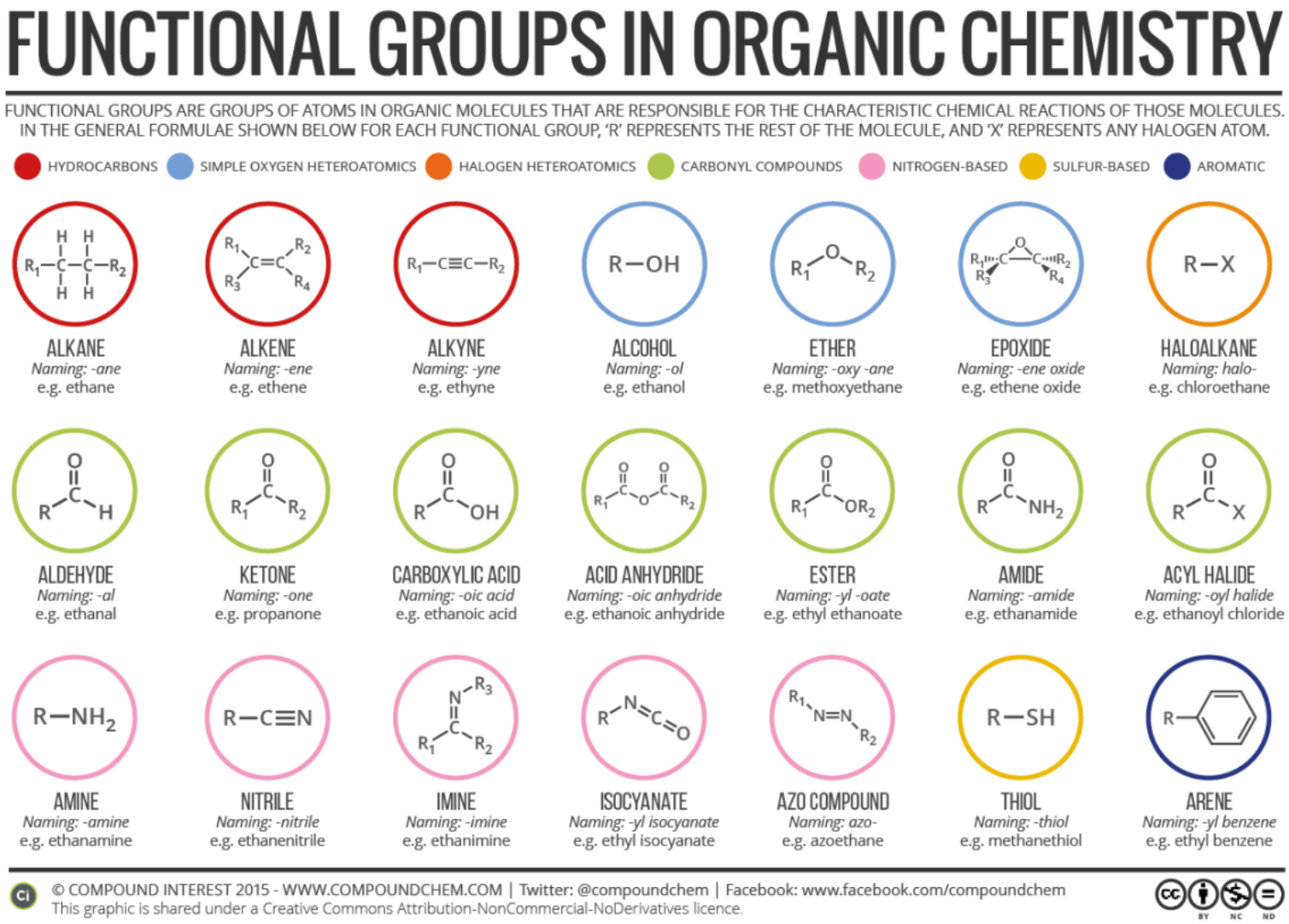
The Organic Chemist's Periodic Table

Elements most often used in organic chemistry:

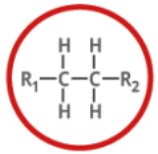




Common Functional Groups



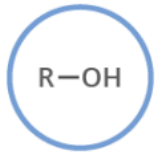
Functional Groups You Need to Know for CHEM 60



ALKANE
Naming: -ane
e.g. ethane

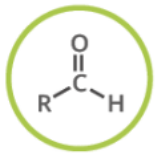
ALKENE
Naming: -ene
e.g. ethene

ALKYNE
Naming: -yne
e.g. ethyne

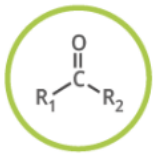


ALCOHOL
Naming: -ol
e.g. ethanol

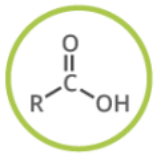
AMINE
Naming: -amine
e.g. ethanamine



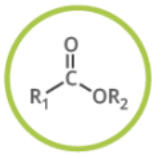
ALDEHYDE
Naming: -al
e.g. ethanal



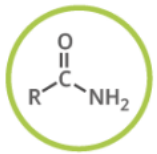
KETONE
Naming: -one
e.g. propanone



CARBOXYLIC ACID
Naming: -oic acid
e.g. ethanoic acid



ESTER
Naming: -yl -oate
e.g. ethyl ethanoate



AMIDE
Naming: -amide
e.g. ethanamide

What is “R”?

R is commonly used to represent “hydrocarbon”.

Example: CH_3CH_2OH can be represented as ROH

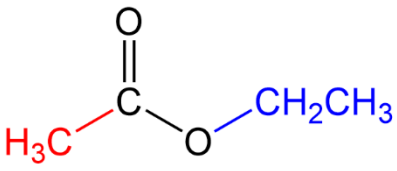
Likewise, $CH_3CH_2CH_2CH_2CH_2OH$ can also be represented as ROH

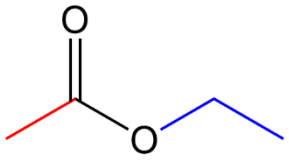
R is used when you want to draw out the specific functional group, but not the rest of the hydrocarbon part.

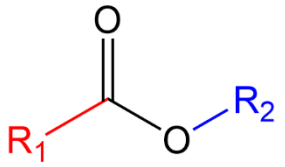
R_1 and R_2

R_1 and R_2 are used when the two R groups are not the same.

Example:





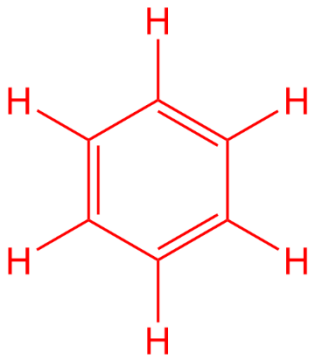


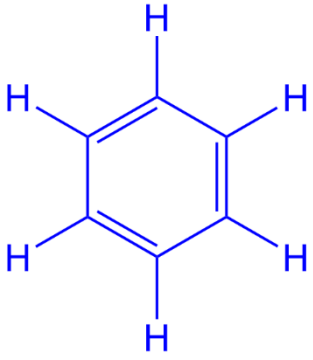
$R_1 = -CH_3$

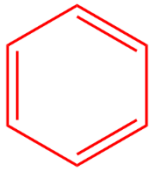
$R_1 = -CH_2CH_3$

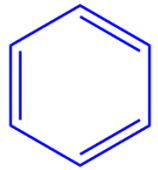
Benzene Ring

You may see this on OWL homework questions. Presented below are representations of a benzene ring. ***All*** are equivalent representations.



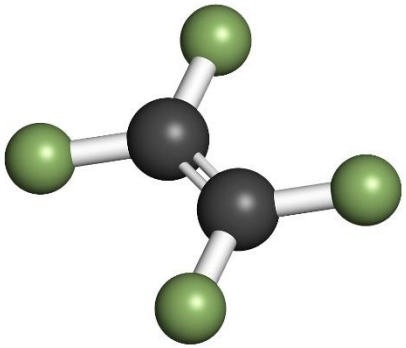




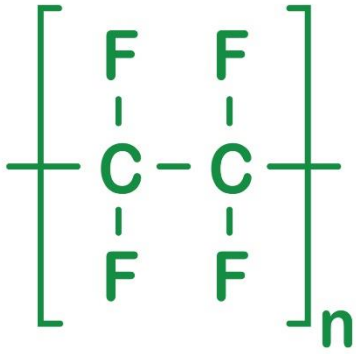


Because the double-bond electrons are moving all around the ring, we can draw two equivalent representations (red and blue). Since the actual benzene is a hybrid of the red and blue representations, the double-bond electrons are represented by the purple structure, where the circle represents the double-bond electrons moving across the entire ring.

Organic Structures: Industry



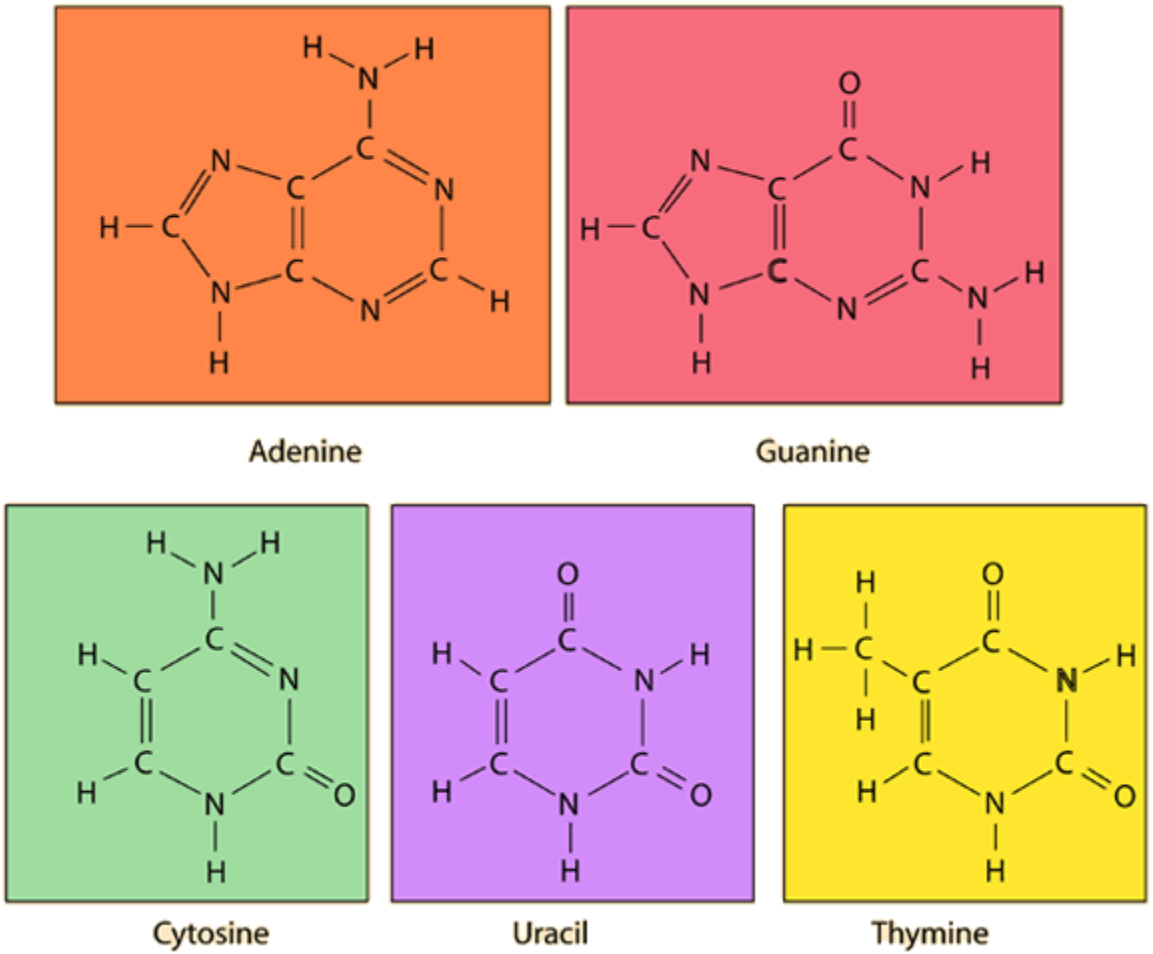
Monomer



Polymer

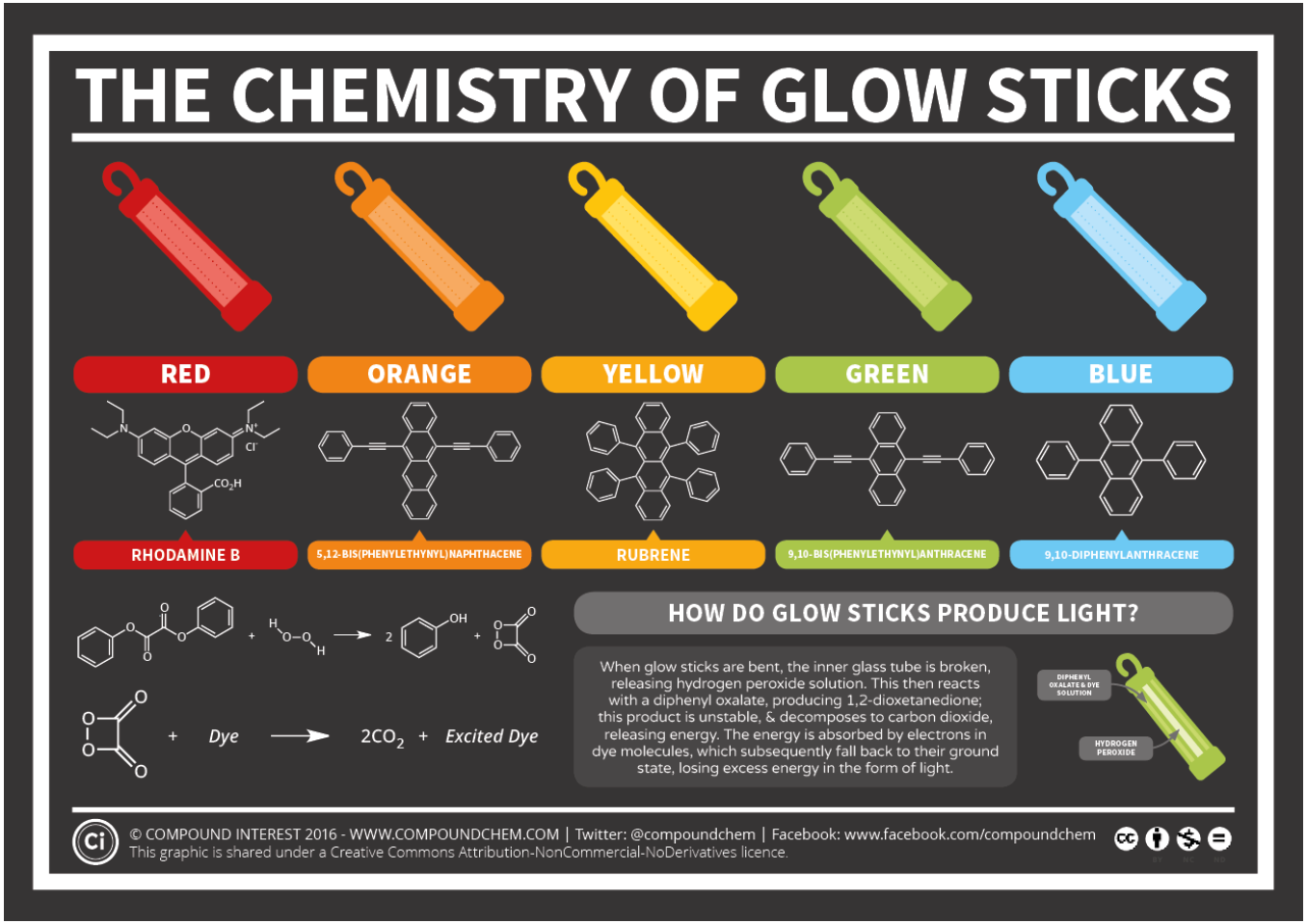
Organic Structures: Biology

Nitrogenous Bases



Organic Structures: Daily Life

Glow Sticks!



Organic Structures: Daily Life

Catnip!