Chemistry for Non-Chemists

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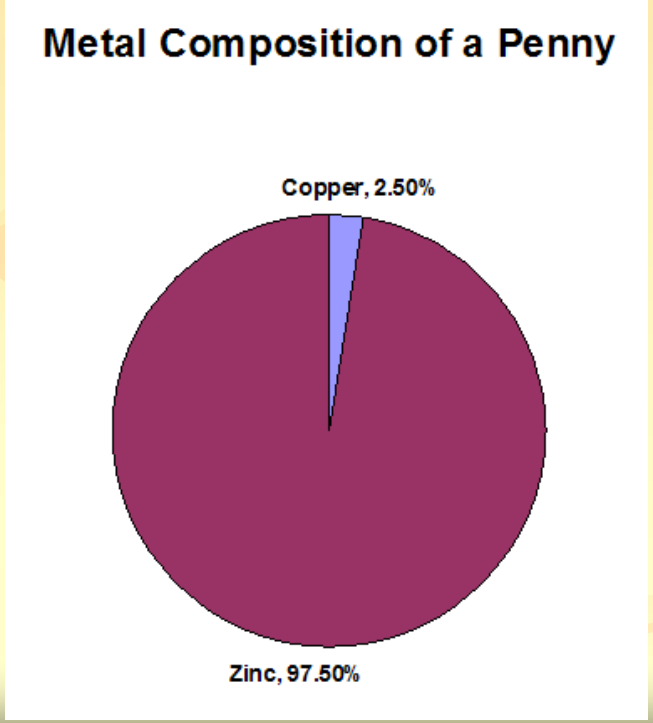
Our first experiment



- Pennies + salt + lemon juice
  - Partially immerse the penny for 5 seconds
  - What happened?
  - Now let's soak 4 pennies in solution for 10 minutes
- Coating of penny is pure copper (Cu)

Periodic Table of Elements

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VII		IB	IB	IIIA	IVA	VA	VIA	VIIA	0
1	1 H																2 He
2	3 Li	4 Be										5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg										13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	57 *La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	89 +Ac	104 Rf	105 Ha	106 106	107 107	108 108	109 109	110 110								

* Lanthanide Series	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
+ Actinide Series	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Legend - click to find out more...

H - gas **Li - solid** **Br - liquid** **Tc - synthetic**

Non-Metals
Transition Metals
Rare Earth Metals
Halogens
Alkali Metals
Alkali Earth Metals
Other Metals
Inert Elements

The Periodic Table

metals

non-metals

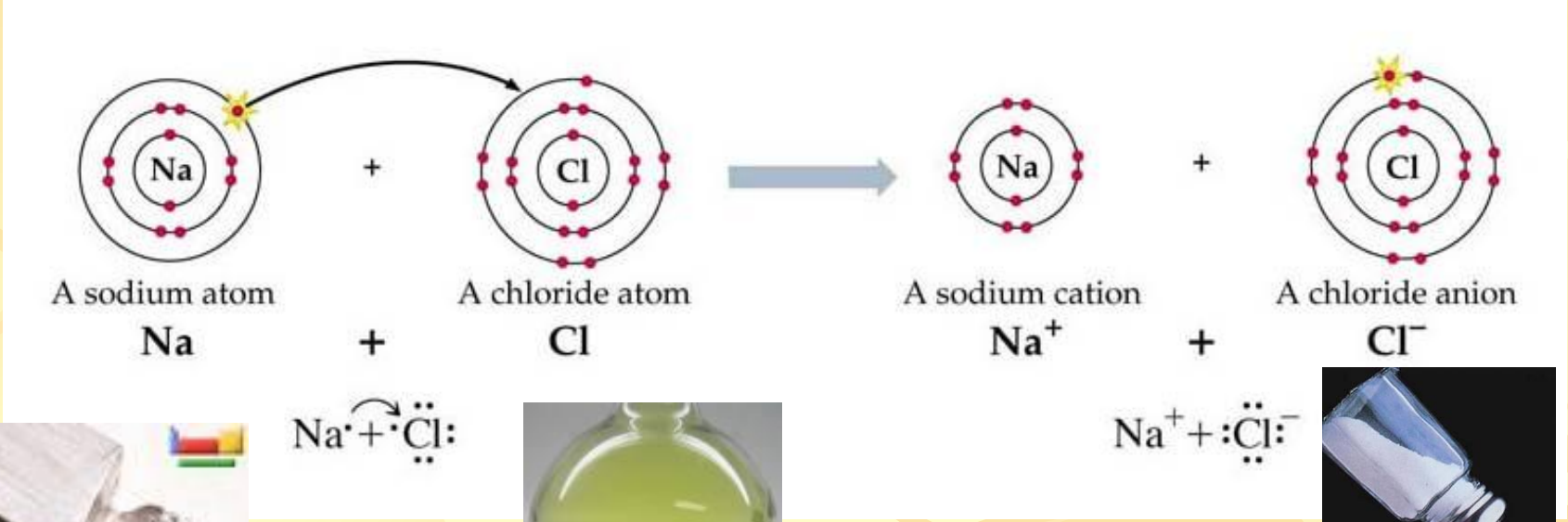
noble gases

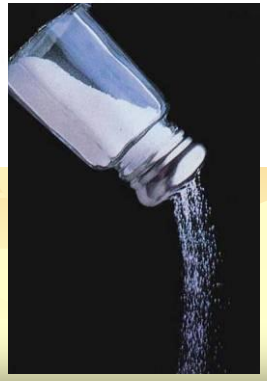
1 H 1.008																	1 H 1.007	2 He 4.0026
3 Li 6.941	4 Be 9.012											5 B 10.811	6 C 12.0107	7 N 14.00	8 O 15.9994	9 F 18.9984	10 Ne 20.1797
11 Na 22.9897	12 Mg 24.3050											13 Al 26.9815	14 Si 28.0855	15 P 30.9737	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.9559	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.938	26 Fe 55.845	27 Co 58.9332	28 Ni 58.6934	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.921	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.9058	40 Zr 91.224	41 Nb 92.906	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.905	46 Pd 106.42	47 Ag 107.868	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.760	52 Te 127.60	53 I 126.904	54 Xe 131.29
55 Cs 132.905	56 Ba 137.327	57 La 138.90	72 Hf 178.49	73 Ta 180.947	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.078	79 Au 196.966	80 Hg 200.59	81 Tl 204.383	82 Pb 207.2	83 Bi 208.980	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)									

58 Ce 140.116	59 Pr 140.90765	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.92534	66 Dy 162.50	67 Ho 164.93032	68 Er 167.26	69 Tm 168.93421	70 Yb 173.04	71 Lu 174.967
90 Th 232.0381	91 Pa 231.03588	92 U 238.0289	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)

Chemical Bonding - Ionic Bonds

- Formed by taking of electrons
  - creating anions (-) and cations (+)



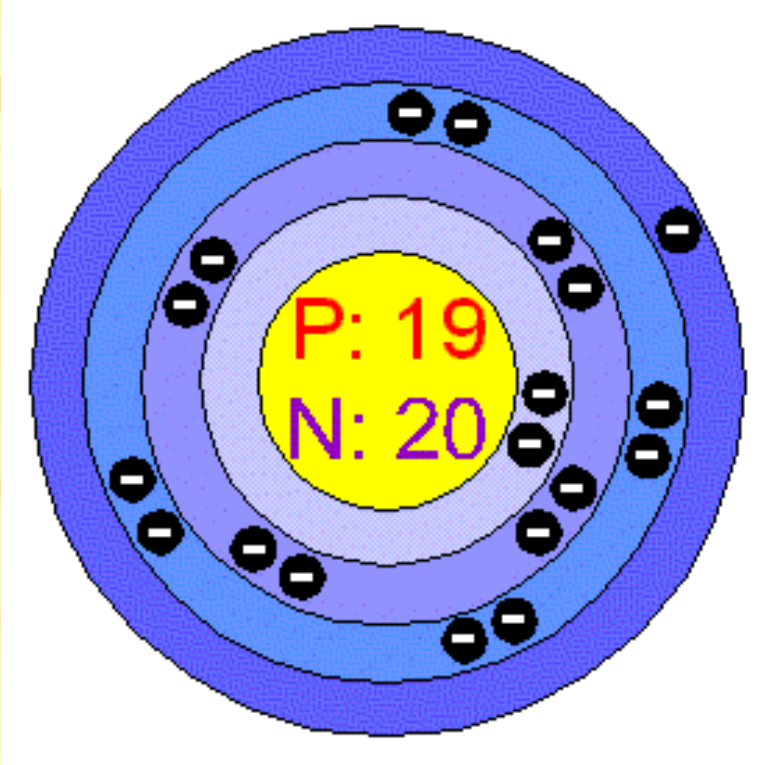


Chemical Bonding

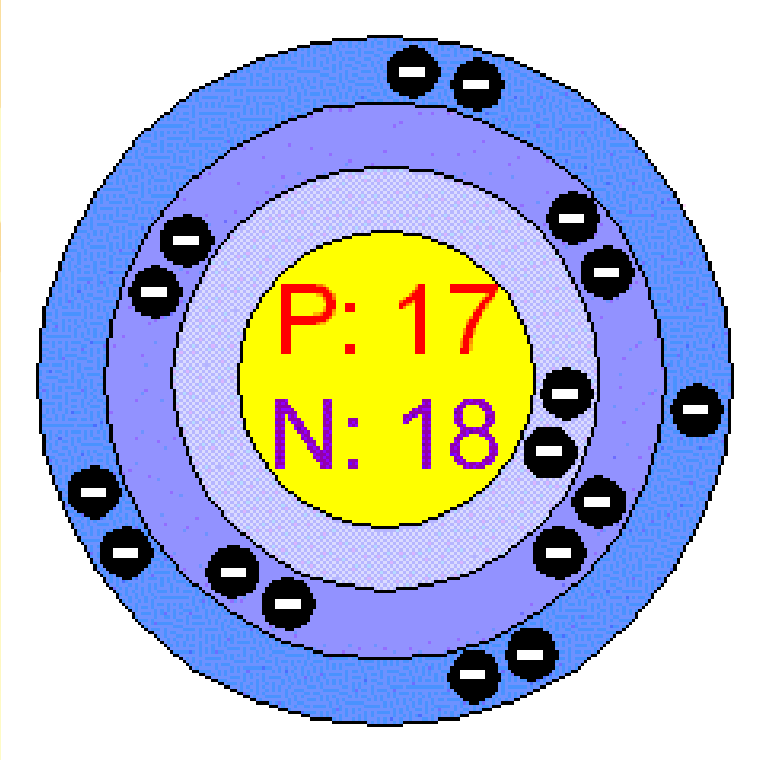
- Atoms like to have a full outer shell and will gain lose or share electrons to achieve a full outer shell
- Electron configuration

1A	2A	3A	4A	5A	6A	7A	0
IA	IIA	IIIA	IVA	VA	VIA	VIIA	0
Li ·	· Be ·	·B·	·C·	·N:	:O:	:F:	: Ne :

Electron Configuration



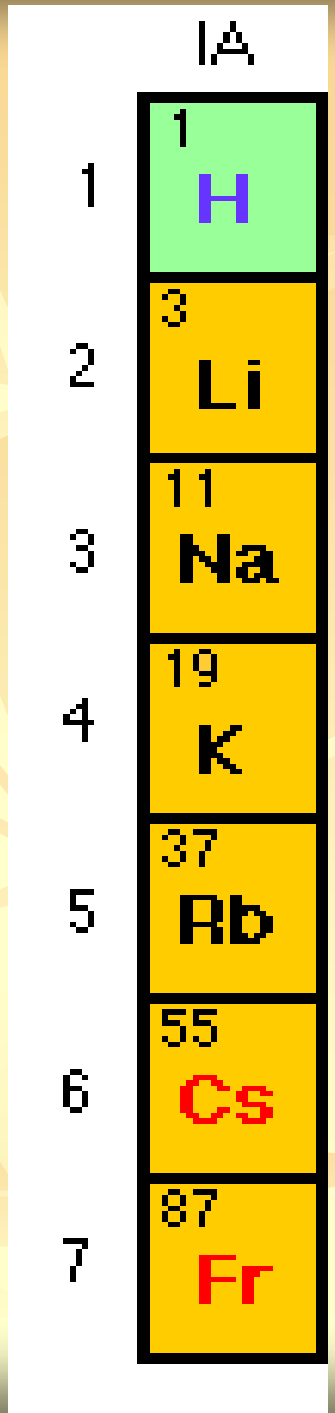
Potassium



Chlorine

Group IA- Alkali Metals

- Hydrogen is the odd duck here
- Lithium, Sodium, Potassium – common
- Water reactive
- Na (Sodium) and K (Potassium) are very common and readily form ionic compounds (sodium chloride = salt)



Lithium in Water

Least water reactive of Group I metals

- Lithium reacts with water & fizzes
- The fizzing is from released hydrogen gas
- Generated by splitting water into H + OH then forming 2LiOH + H_2 gas

Sodium in Water

Increasing reactivity as we go down in Group IA

- Sodium reacts with water & turns molten
- Heat & hydrogen gas are released
- Splits water into H + OH then forming $2NaOH + H_2$ gas
- Large quantities will detonate

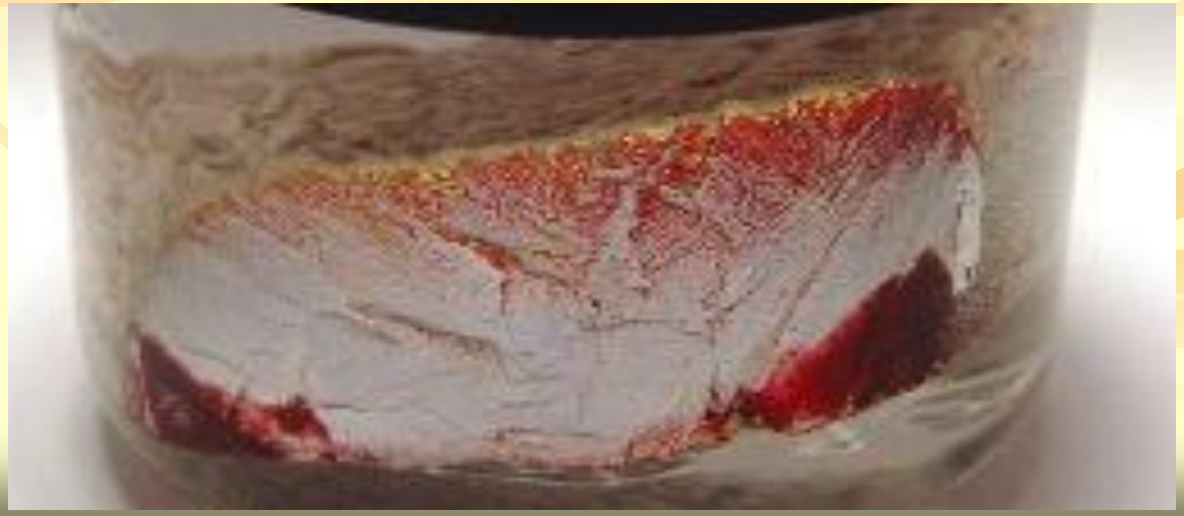
Potassium in Water

Even more water reactive

- Potassium reacts with water igniting hydrogen
- Burns out very quickly
- Generated by splitting water into H + OH then forming 2KOH + H_2 gas
- Detonation will occur if larger amounts are used

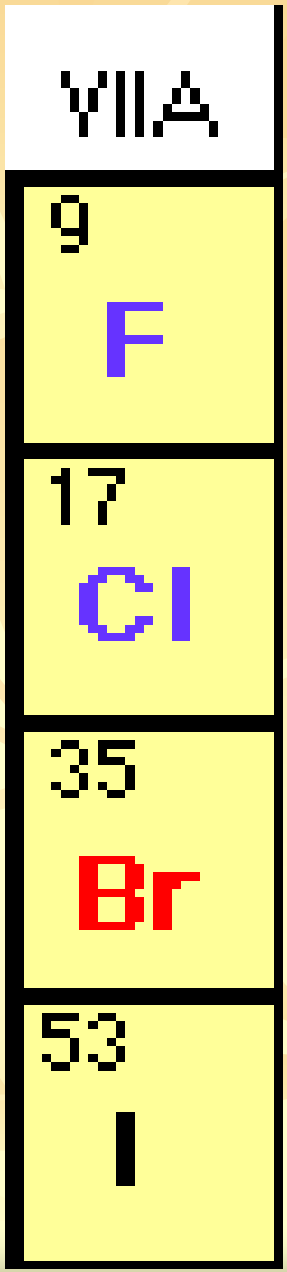
Potassium Metal (K_2) – Color Key

- Silver – Potassium metal -Water Reactive
- White – P. Hydroxide – Corrosive
- Yellow/Orange – P. Superoxide
  - Water reactive, corrosive, unstable
- Red – P. Ozonide - Highly reactive, explosive



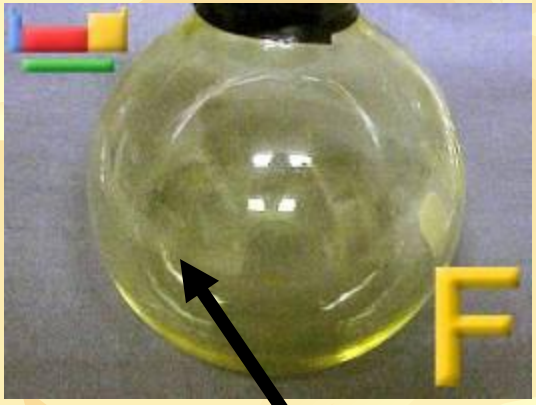
Group VIIA - Halogens

- Chlorine, Bromine, Iodine - common
- Increased hazard as you move **up** chart
- Volatile, corrosive hazards as elements
- Reactive, so readily form salts
- Sodium chloride = salt = NaCl
- Halogenated organic compounds contain these little dookers…
  - Methylene chloride (CH_2Cl_2)



Pure Halogens Found as F_2, Cl_2, Br_2, I_2

Increased density as you move down periodic table



Fluorine gas

Chlorine gas

Iodine sublimate

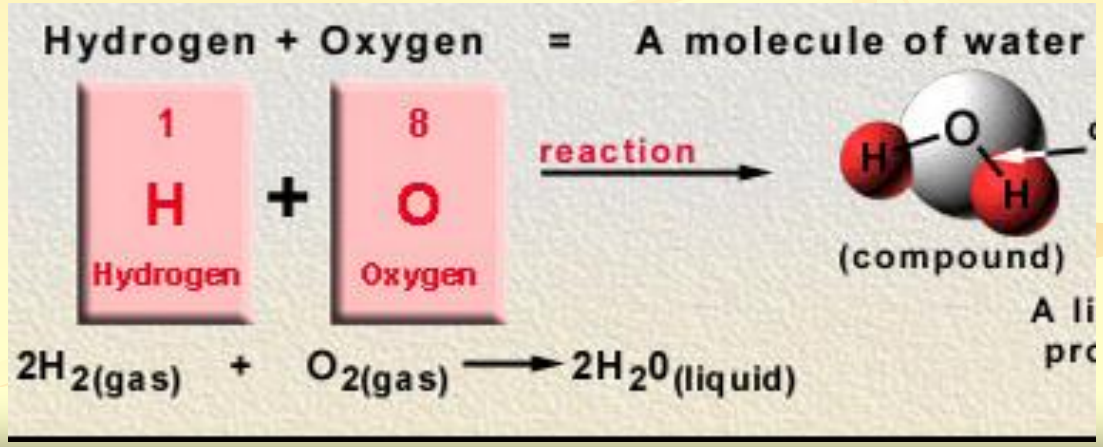
Iodine solid

Bromine vapor

Bromine liquid

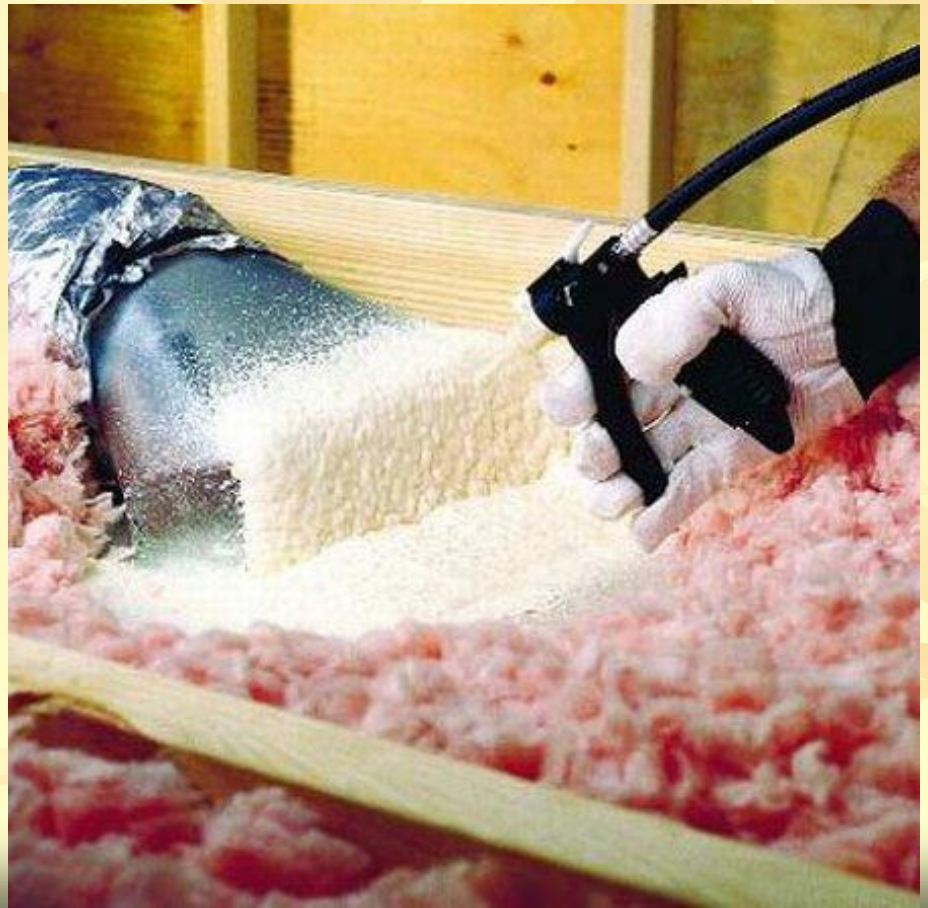
Compounds

- Two or more elements bonded together
- Naming, prefixes (cation) and suffixes (anion)
- Sodium (Na) + chlorine (Cl) = sodium chloride
- Some common groups
  - NO_3 = (one nitrogen + 3 oxygen) is called Nitrate
  - SO_4 = sulfate
  - PO_4 = phosphate



Two-Part Products: Organic Peroxides

- Isocyanates (polyurethanes) and others
- Foam, adhesive, paint: catalyst, activator, initiator



Oil and What?

DANGER

What Can go Wrong

- Hydrogen Peroxide reacting with hydrocarbon

Inorganic vs. Organic

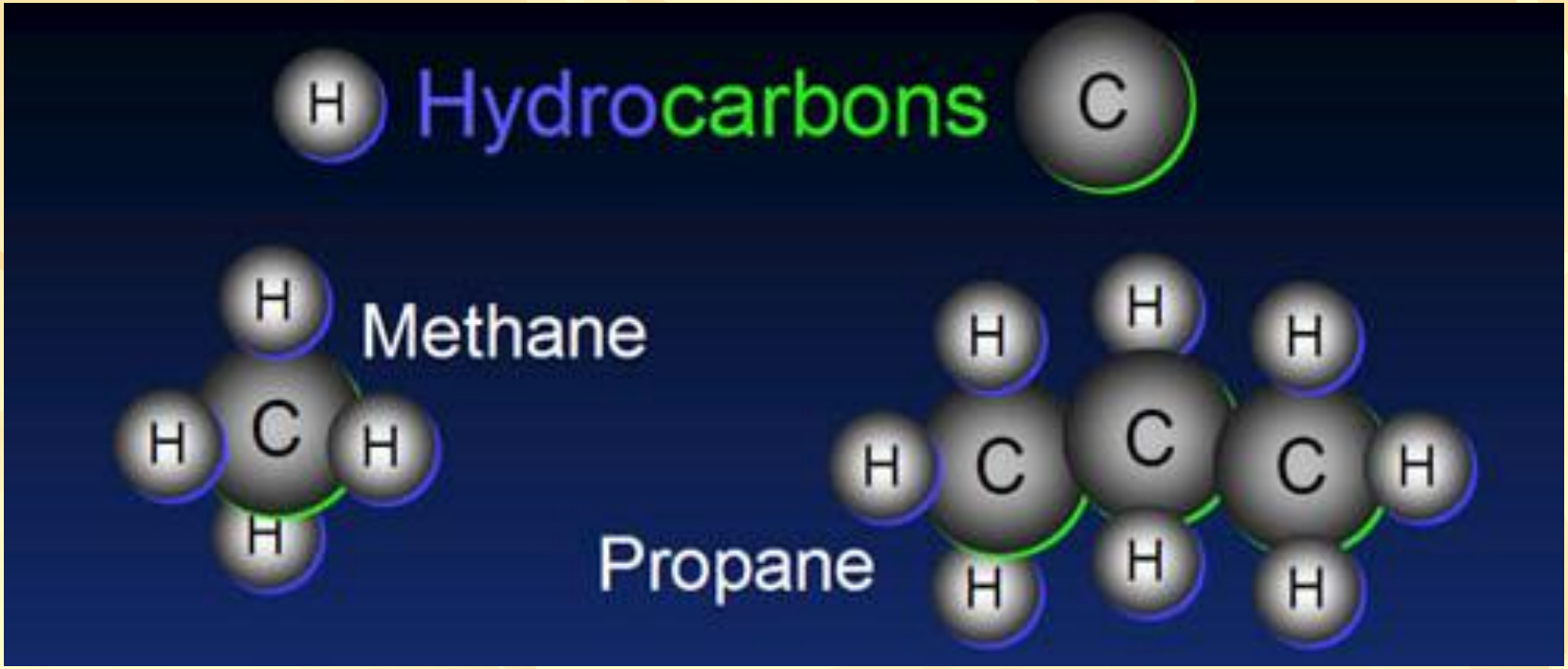
What's the Difference Between an Inorganic & Organic Compound?

Can be confusing.

- Organic = produced by living things, inorganic not.
  - **Worked OK until 1828 & start of organic synthesis**
- Organic compounds contain carbon-hydrogen bonds. Inorganic compounds don't.
  - **This is close enough**.

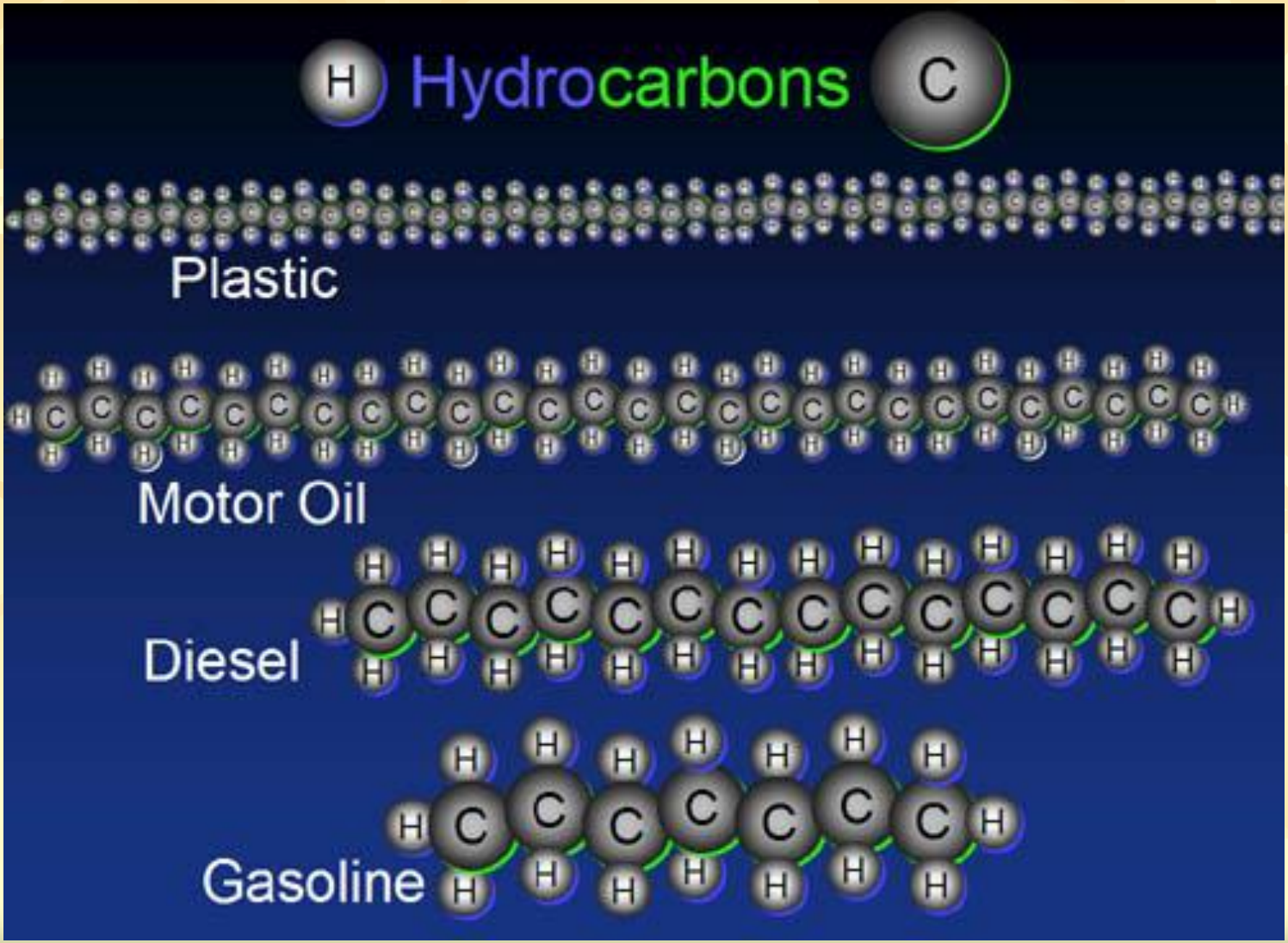
Organic Compounds

- Carbon bonded to hydrogen plus whatever
- If only **hydro**gen & **carbon** it's a Hydrocarbon



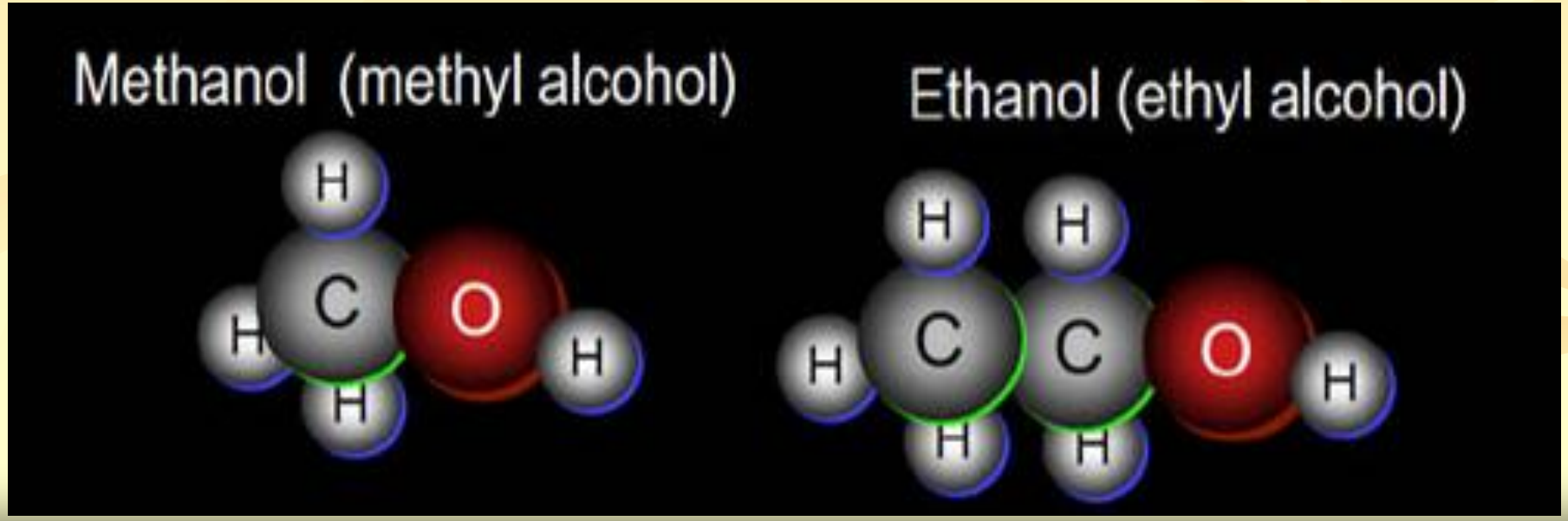
http://www.chemistryland.com/ElementarySchool/BuildingBlocks/BuildingOrganic.htm

Example Hydrocarbons

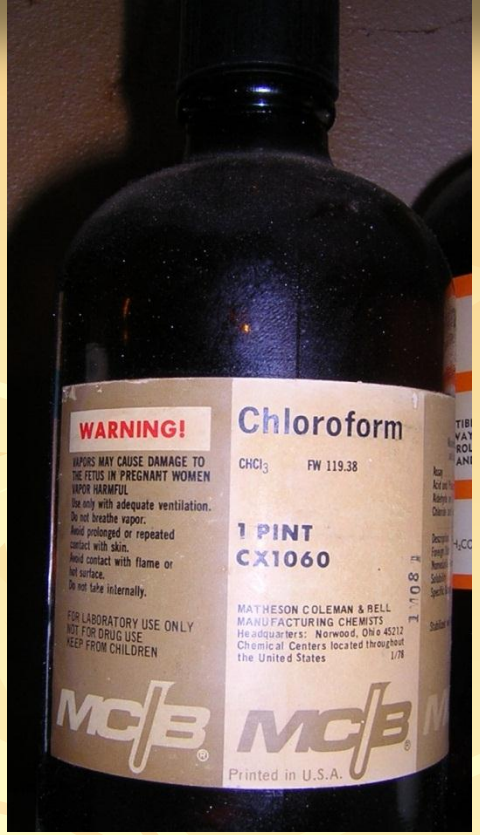


Alcohols

- Hydrocarbon with an oxygen between at least 1 carbon and hydrogen (-OH)
- Organic –OH = alcohol (CH3OH=methanol)
- Inorganic –OH = caustic base (more later)



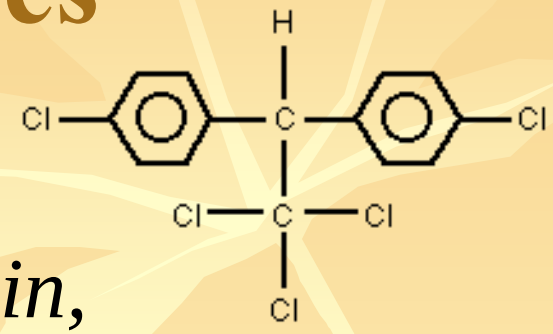
aldehyde
1 PT.
Mallinckrodt
FORMALDEHYDE SOLUTION
HCHO Approx. 37%
ANALYTICAL REAGENT
MALLINCKRODT CHEMICAL WORKS
37878
Mallinckrodt
FORMALDEHYDE SOLUTION
U.S.P.
DANGER! • POISON
Benzene
1 PINT
BX220
1 pt.
1-9154
BENZENE
Baker Analyzed REAGENT
1 pt.
1-9172
CARBON DISULFIDE
Baker Analyzed REAGENT


WARNING!
VAPORS MAY CAUSE DAMAGE TO THE FETUS IN PREGNANT WOMEN
VAPOR HARMFUL
Use only with adequate ventilation.
Do not breathe vapor.
Avoid prolonged or repeated contact with skin.
Avoid contact with flame or hot surface.
Do not take internally.
FOR LABORATORY USE ONLY
NOT FOR DRUG USE
KEEP FROM CHILDREN
Chloroform
$CHCl_3$ FW 119.38
1 PINT
CX1060
MATHESON COLEMAN & BELL
MANUFACTURING CHEMISTS
Headquarters: Norwood, Ohio 45212
Chemical Centers located throughout the United States
Printed in U.S.A.

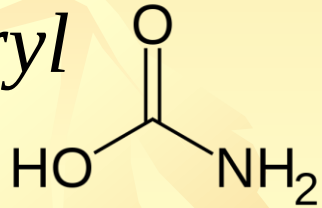
ORGANIC

Turpentine
METAL CLEANER
Prestone
ADVANCED FORMULA
ORTHO
WEED-B-GON
Weed Killer
SAVOGRAN
Kutzit
paint & varnish remover
liquid stripper
fast acting
DANGER POISON
FLAMMABLE – MAY BE FATAL OR CAUSE BLINDNESS IF SWALLOWED
VAPOR HARMFUL
SKIN AND EYE IRRITANT
1 U.S. GALLON 3.785 LITERS
Exterior
54-305

Organic Pesticides



- Organohalogenated - *DDT*, *Aldrin*, *Chlordane*, *Methyl Bromide*
- Organophosphates - *Parathion*, *Malathion Diazinon*, *Dichlorvos*, *Chlorpyrifos*
- Carbamates - *Baygon*, *Aldicarb*, *Carbaryl (Sevin)*
- Urea Derivatives - *Linuron*

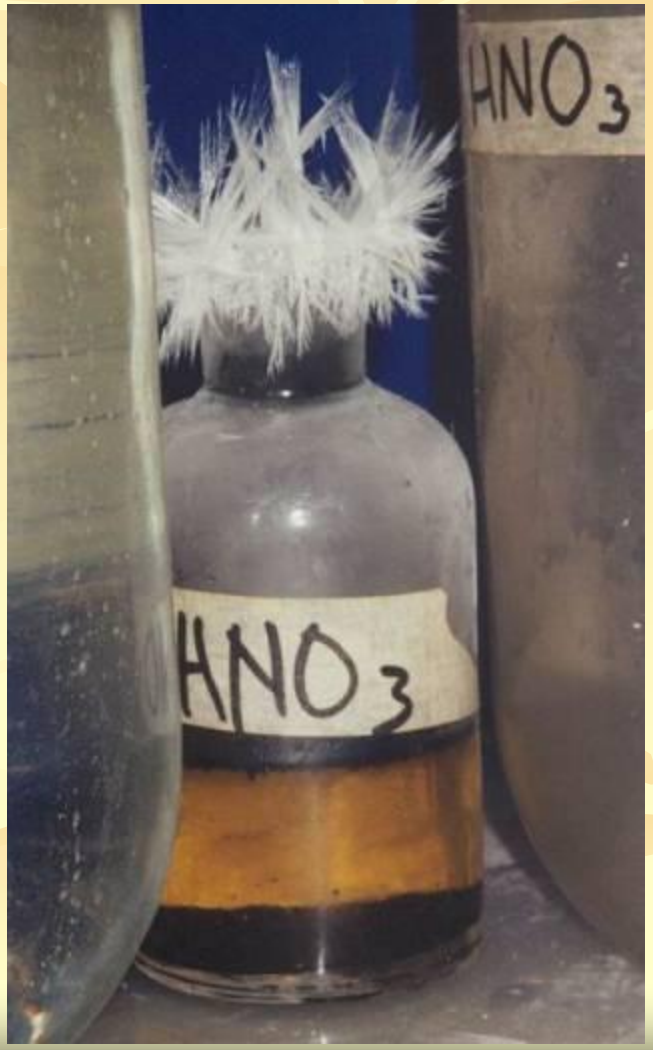


Inorganic Pesticides

- Compounds containing heavy metals - lead, mercury, zinc, copper
- Compounds containing semimetallics - arsenic
- Compounds containing nonmetals - sulfur, fluoride, boron

Inorganic Compounds

- Mostly carbon-free
- Some can contain carbon & hydrogen??
  - Baking Soda $NaHCO_3$
- Includes caustics (corrosive acids & bases)
- Metals & salts



Transition Metals – Groups 3-12

- Ductile & Malleable
- Conduct electricity and heat ‘
- Metals commonly found in electronics

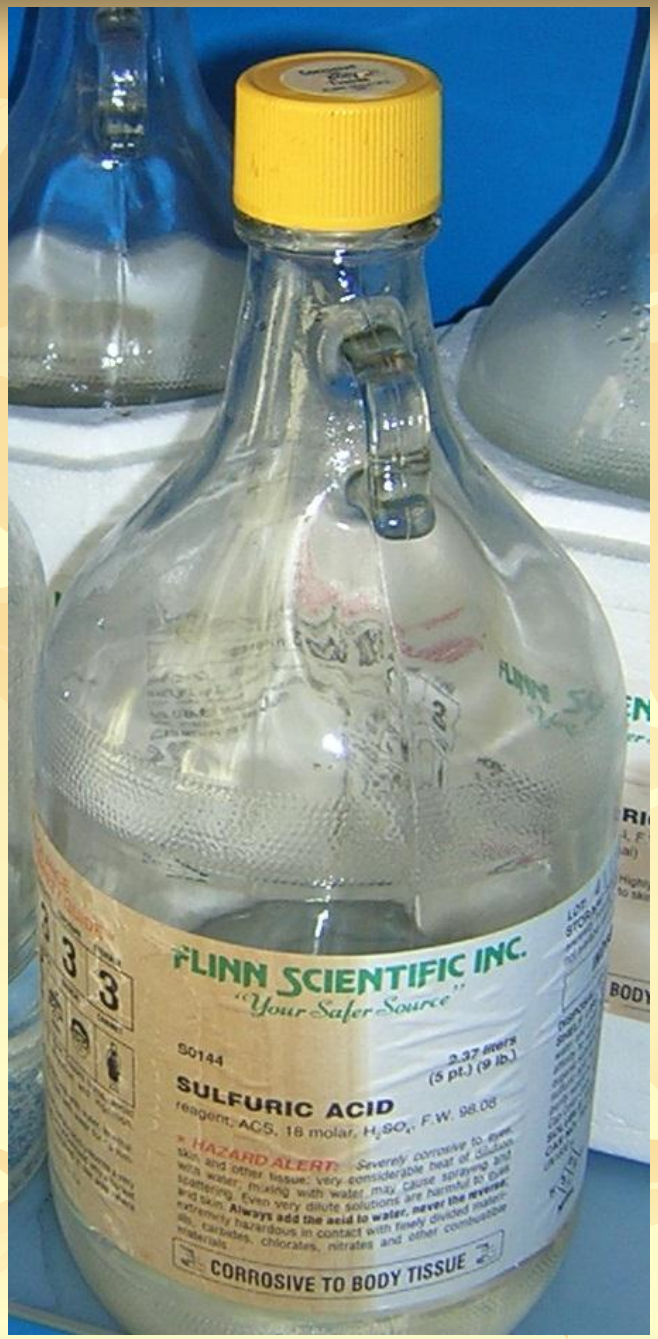
3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIIB	10	11 IB	12 IIB
21 44.956 Sc SCANDIUM	22 47.867 Ti TITANIUM	23 50.942 V VANADIUM	24 51.996 Cr CHROMIUM	25 54.938 Mn MANGANESE	26 55.845 Fe IRON	27 58.933 Co COBALT	28 58.693 Ni NICKEL	29 63.546 Cu COPPER	30 65.39 Zn ZINC
39 88.906 Y YTTRIUM	40 91.224 Zr ZIRCONIUM	41 92.906 Nb NIOBIUM	42 95.94 Mo MOLYBDENUM	43 (98) Tc TECHNETIUM	44 101.07 Ru RUTHENIUM	45 102.91 Rh RHODIUM	46 106.42 Pd PALLADIUM	47 107.87 Ag SILVER	48 112.41 Cd CADMIUM
57-71 La-Lu Lanthanide	72 178.49 Hf HAFNIUM	73 180.95 Ta TANTALUM	74 183.84 W TUNGSTEN	75 186.21 Re RHENIUM	76 190.23 Os OSMIUM	77 192.22 Ir IRIDIUM	78 195.08 Pt PLATINUM	79 196.97 Au GOLD	80 200.59 Hg MERCURY
89-103 Ac-Lr Actinide	104 (261) Rf RUTHERFORDIUM	105 (262) Db DUBNIUM	106 (266) Sg SEABORGIUM	107 (264) Bh BOHRIUM	108 (277) Hs HASSIUM	109 (268) Mt MEITNERIUM	110 (281) Uun UNUNNILIUM	111 (272) Uuu UNUNUNIUM	112 (285) Uub UNUNBIUM

Identifying Acids

- Have pH less than 7
  - Hazardous waste is ≤ 2
  - Practical < 4
- Turns pH paper red
- Taste tart
- React with metal to form hydrogen gas
- Often have “acid” in the name
- Often have a chemical formula that begins with “H”

Inorganic Acids

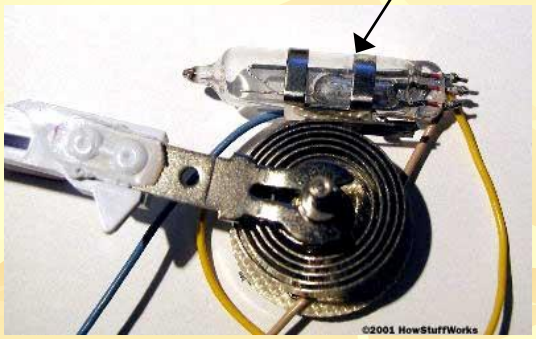
- Fully water soluble
- Hydrogen is cation (“+”) & makes it acidic
- Remainder is anion (“-”) & gives name
- $2H^+$ plus SO_4 (sulfate) gives H_2SO_4 = sulfuric acid
- H^+ + Cl (chloride) = HCl = hydrochloric acid



Exercise: Corrosivity

- What is the pH of elemental (pure liquid) mercury?
  - No water is present, so pH has no meaning
- Is mercury corrosive?
  - Yes, mercury dissolves many metals, for example by forming an amalgam

Liquid mercury in a glass ampoule inside a thermostat



Identifying Bases

- Have a pH greater than 7
  - Hazardous waste is ≥12.5
  - Practical > 10
- Turn pH paper blue
- Taste bitter
- Have a slippery, soapy feel
- May have “hydroxide”, or “alkali”, or “caustic” in the name
- Often has “OH” in the chemical formula

Inorganic Bases

- Strong bases are generally hydroxides (-OH)
- Hydroxides are very corrosive, especially to eyes & slippery
- Soaps use hydroxides. It's why they're slippery.
  - Turn your skin into soap…
- Drano = sodium hydroxide

Crystals on Bottles

- Takes two to tango
- Crystals form when some compounds combine
- Must be volatile and able to travel. Either:
  - Two leaking containers, or
  - One leaking container that's air reactive

Hydrochloric acid, round crystals White powder all over the place

- Old bottles with degraded caps
- Reacting with ammonia vapors
- Ammonium chloride
- Non-toxic
- Replace polyethylene septum under the cap

Nitric acid – white crystals

- Old bottles with degraded caps
- Nitric oxidizes cap in 7 to 10 years
- Reacting with ammonia vapors
- Ammonium nitrate
- Powerful oxidizer
- Replace the cap

Crystals all over the bottle: Sodium hydroxide solutions

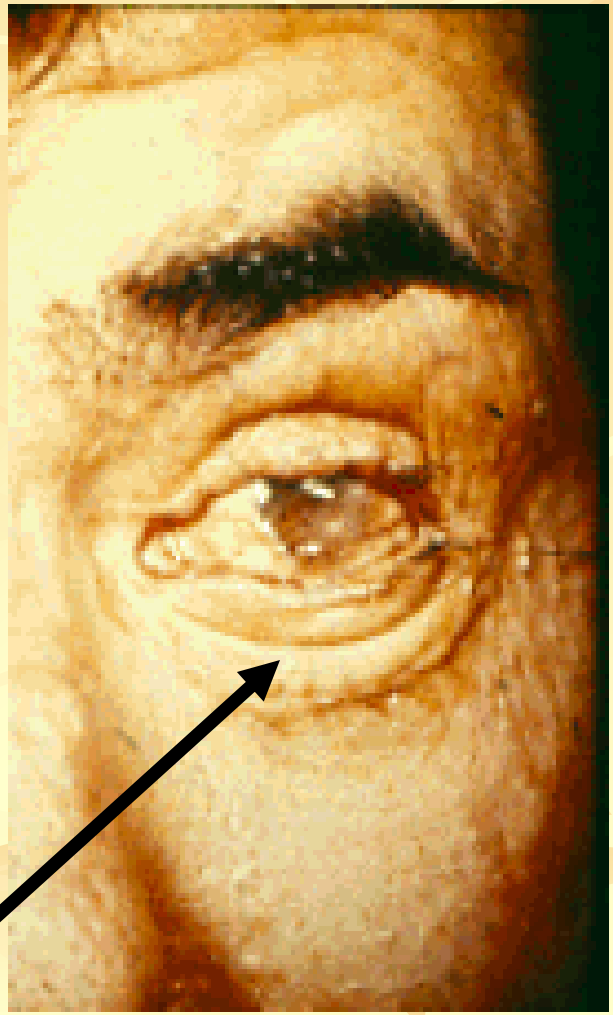
Sodium hydroxide solutions crystallize in valves, leads to this

Assessing Risk of Crystals

- Crystals on acids & bases = common
- Crystals on brown glass bottles = scary!!!

Do What You Ought To…

- Do what you "oughter", add acid **to** water (same is true for bases)
  - Corrosives react with water & create a lot of heat (exothermic)
  - Pour water on top of strong acid or base = spattering
- ALWAYS wear goggles when working near them
  - *Results of a 30 second exposure to sodium hydroxide solution*



Still awake?

Good! You passed your first test.
Let’s take a break!

Back to our experiment

- Remove the pennies
- Put them on paper towel and set aside
- Partially submerge the nail in the solution & set aside

What's in a name? Clues to a compound's nature!

- Nitrate, chlorate, bromate = oxidizer
- Per = oxidizer if <u>inorganic</u>
  - Perchlorate, permanganate, peroxide, persulfate, perborate
  - Perchloroethylene (perc) is organic, not oxidizer
- Dinitro-, Trinitro- = explosives if organic
- Chromate, Dichromate = toxic, oxidizer
- Sulfide, cyanide = poison gas if acidified

More Chemical Clues from Names

- Fluoride = toxic
  - Yep, toothpaste can contain a toxic ingredient
- Amine (“ah-meen”) = corrosive, flammable
- Chloro-, iodo-, fluoro-, bromo- = halogens, so if organic compounds = persistent toxins
- Words ending in –ane, -ene, -ol = organic
- Words starting w/ meth-, eth-, prop-, but- means they’re organic compounds

Names which leave you clueless

- Chloride, bromide, iodide, oxide
- Sulfate, phosphate, carbonate, acetate

It all depends on what's precedes those suffixes

- Sodium Chloride is salt
- Lead Chloride is a deadly poison
  - Not a function of chloride, but of cation

RCRA Hazardous Waste Cheat Sheet

- Easily show RCRA solid wastes & hazardous wastes
- Useful for inspectors and teachers.
- Let’s everyone figure out what’s not a big deal
- Cations plus anions that are not federally hazardous

RCRA Hazardous Waste Cheat Sheet

Non-Hazardous Combinations

Must be combined to be accurate
Calcium + Chloride = $CaCl_2$

Aluminum (Al)
Ammonium (NH_4)
Calcium (Ca)
Iron (ferric, ferrous) (Fe)
Lithium (Li)
Magnesium (Mg)
Manganese (Mn)
Potassium (K)
Sodium (Na)
Strontium (Sr)
Zinc (Zn)

+

Acetate ($C_2H_3O_2$)
Bicarbonate (H_2CO_3)
Borate (BO_3)
Carbonate (CO_3)
Chloride (Cl)
Iodide (I)
Phosphate (PO_4)
Silicate (SiO_2)
Sulfate (SO_4)
Tartrate (Organic)
Thiosulfate (S_2O_3)

= Non-Hazardous

RCRA Cheat Sheet Test
Which are <u>not</u> RCRA hazardous?

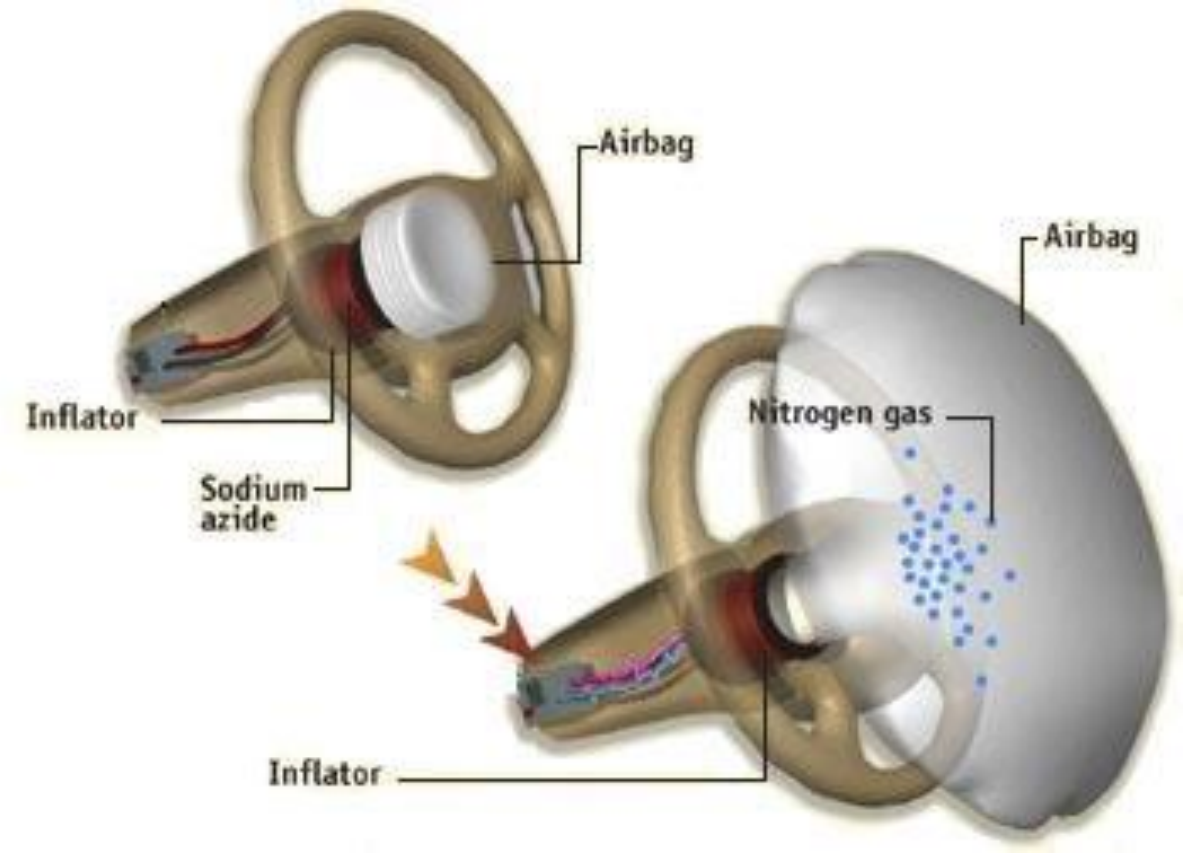
- Sodium Phosphate
- Lithium Nitrate
- Iron
- Zinc Acetate
- Iodide Phosphate
- Manganese Chloride
- Aluminum

- Non-haz combination
- Nitrates are oxidizers
- Powder is flammable solid
- Non-haz combo
- No such chemical name
- Non-haz combo
- Powder is flammable solid & water-reactive

Why are some chemicals incompatible with others?

- What does “incompatible” mean?
- Examples of common incompatibilities

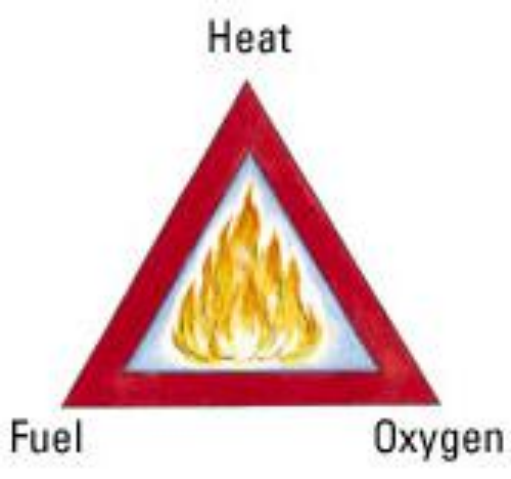
- Could be with:
  - Heat
  - Another chemical
  - Series of conditions



Tanker holding contaminated acid
Often incompatibles create heat & vapors

Incompatible chemical reaction oxidizers & organics

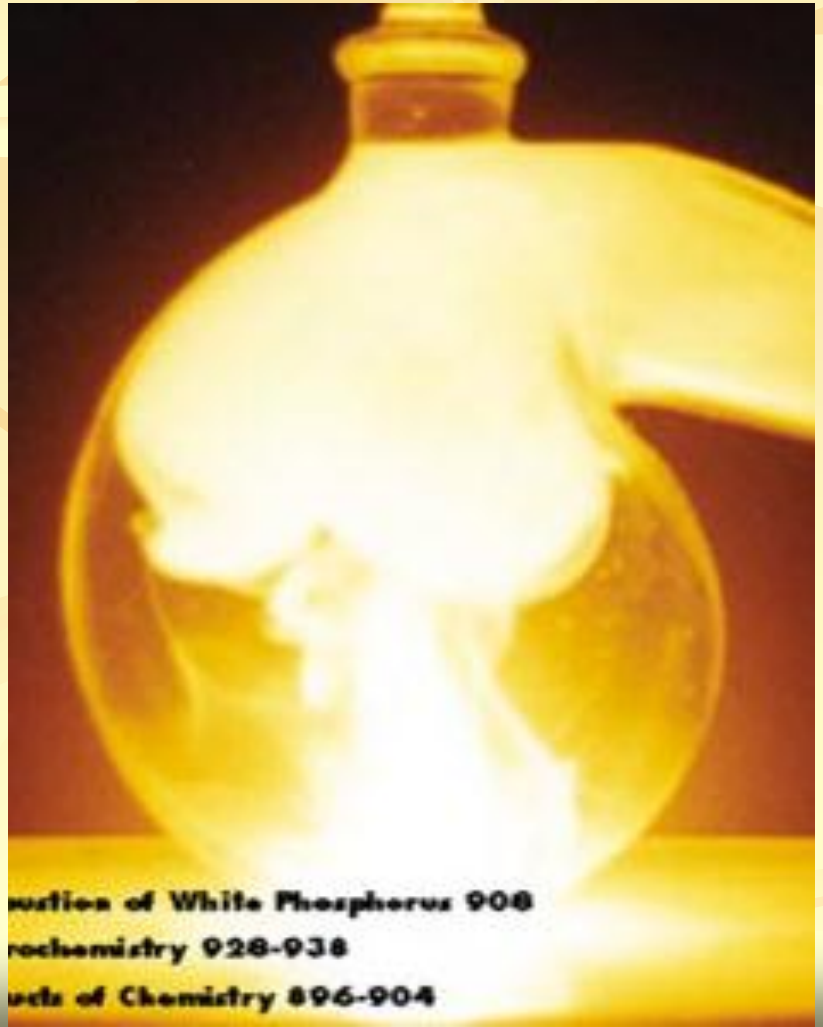
- Nitric acid mixed with solvent
- Nitric acid HNO_3
  - HNO_3 - 3 oxygens
  - Oxidizer!
- Solvent is fuel
- Reaction creates heat
- Fire triangle



Alka-Seltzer Reaction

- Citric acid is a weak organic acid
- Sodium bicarbonate is a weak base
- Combine them to form sodium citrate and carbonic acid
- Carbonic acid is carbon dioxide (CO_2) dissolved in water (carbonation)
- CO_2 is a gas. It releases and expands.

- White & yellow phosphorus
  - Incompatible w/ oxygen (air)
  - Store under water
  - Incompatible with metal lid!



Strike a Match
Chemistry in Action

- Safety match head is sulfur, glass powder & an oxidizer
- Match box surface is sand, powdered glass & red phosphorus
- Oxidize red phosphorus = white phosphorus
  - Which reacts with air to set sulfur on fire

School Chemicals Database

A chemical-by-chemical resource

- At King County Rehab the Lab site
- http://lhwmp.org/HWApp/projects/schools/ChemList.aspx

Local Hazardous Waste Management Program in King County

HOME EXTRANET PROGRAMS ABOUT US

Search: copper sulfate Go Clear

Chemical Name	Acute Exposure Hazard	Chronic Exposure Hazard	Environmental Toxicity
Copper Sulfate	Toxic by ingestion	Teratogen	Poisonous to fish. Persistent bioaccumulative toxin.

Can Search for Classes of Chems

in this case carcinogens…

Search: carcin Go Clear Ex

Page: 1 | (View All) | ...You are viewing page 1 of 11 for 108 records.

Chemical Name	Acute Exposure Hazard	Chronic Exposure Hazard	Environmental Toxicity	Hazard Rank	Minimum Grade Level Restrictions
Acrylamide	Neurotoxin by ingestion & skin contact	Carcinogen	Non-toxic to fish	5	Ban Candidate
Acrylonitrile	Flammable. Poison by inhalation and skin contact. Toxic by ingestion.	Carcinogen. Teratogen.	Slightly Toxic to fish	5	Ban Candidate
Aminodiphenyl, 4-	Toxic by ingestion. Irritant.	Carcinogen. Mutagen.	No fish toxicity data	5	Ban Candidate
Ammonium Chromate	Oxidizer. No acute toxicity data reported. Irritant.	Carcinogen	No fish toxicity data	3	High School

A final look at our experiment

- What do you see on your pennies?
  - Are they a bit blue?
  - The blue is “verdigris”
  - Copper Oxide from reaction with O_2 in air
- Remove the nails
- What happened & why?
  - Copper plating (subbed for iron on surface)

Chemical Reactions

- Chemical changes are a result of chemical reactions
- All chemical reactions involve a change in substance and a change in energy

Bombs in the Basement
HHW Hazline Gets a Call

- My father died.
- I found old chemicals in the basement
- Can I drive them over to the HHW site?

Collection Folks Asked for a List

- It included Picric Acid
- Don’t come to us, we’ll visit you first !

First Impression

- Crystals
- Corks
- Residue on shelf
- Tripping hazards

COCHINEAL
POISON
POTASSIUM FERROCYANIDE
AMMONIUM OXALATE
Red Phosphorus
LEAD NITRATE
FERRIC AMMONIUM CITRATE
THE GOLDSMITH
The world's
ost sought-
ter hair-
auty

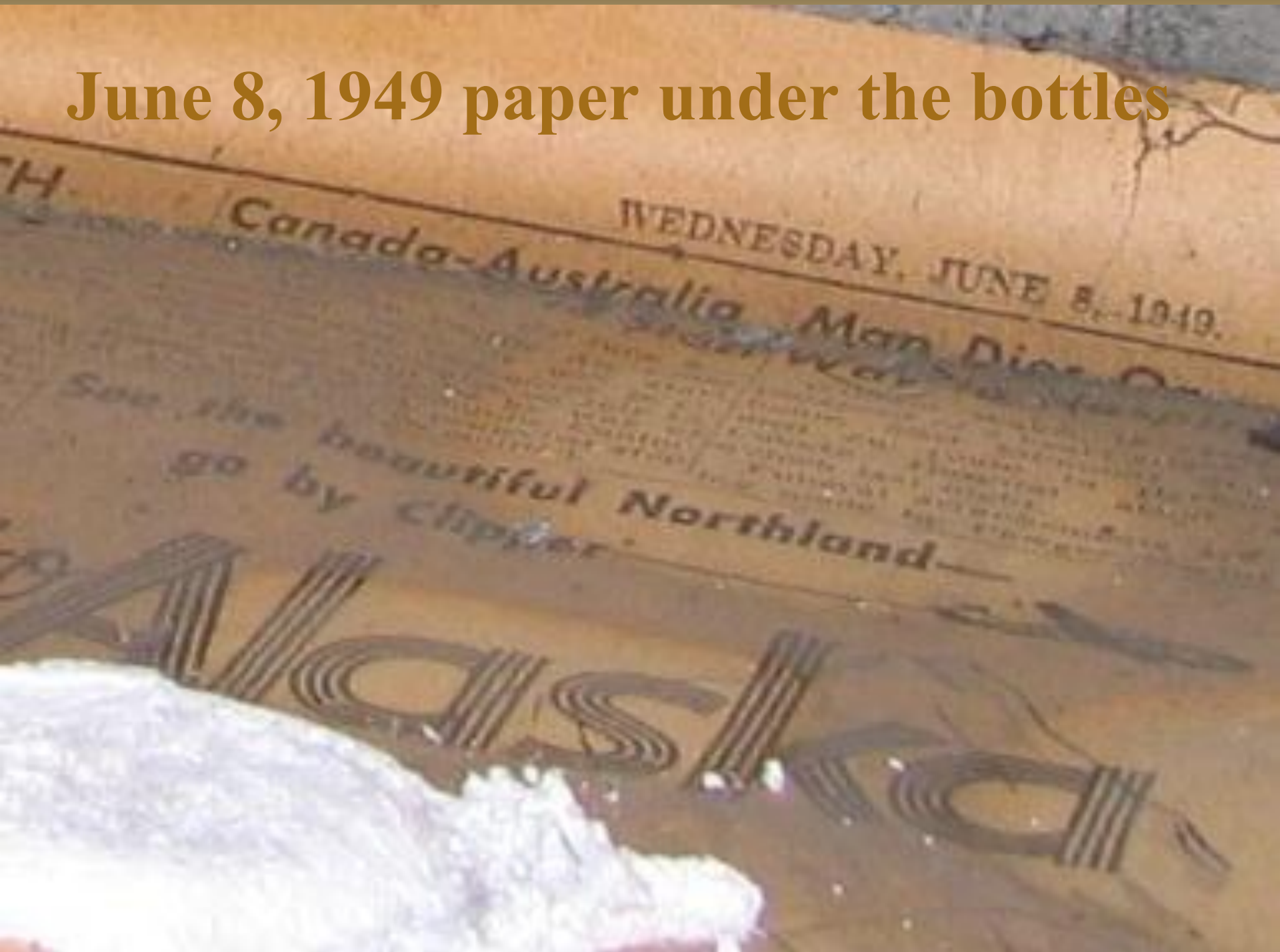
Ammon. Sulphide,
HYDROSULPHIDE SOLUTION
POISON
Baker's Analyzed
THE HIGHEST TYPE OF
Chemical Reagents
SCIENTIFIC SUPPLIES COMPANY
SEATTLE, WASH.
OXALIC ACID
Fir
McKessons
STRONGER AMMONIA
POISON
McKESSON & ROBBINS

ZINC SULPHATE
ZnSO4
Potassium chromate
K2CrO4
STRONTIUM NITRATE
Sr(NO3)2
POISON
TARTARIC ACID
U. S. P.
Frank Drug Co.
PORTLAND, ORE.
FERROUS SULPHATE
FeSO4
COPPER CHLORIDE
CuCl

POISON
4 OZ.
quantities lost, you get regulc

- Gilbert Chemistry Outfit
- “Not for children who can’t read”
- Copyright 1936
- Came with 75 chemicals & assorted apparatus

June 8, 1949 paper under the bottles



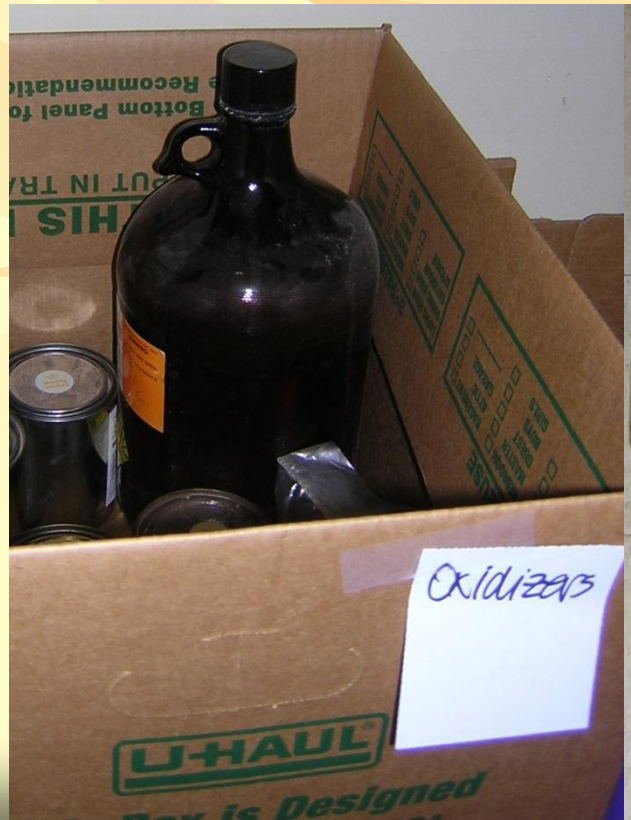
ETHER
Picric Acid

ACID
PICRIC.
Picric

Oregon
908 BW

Unfortunate Mixtures

- Incompatibles together in lab or car
- Combine chemicals to fill bottles

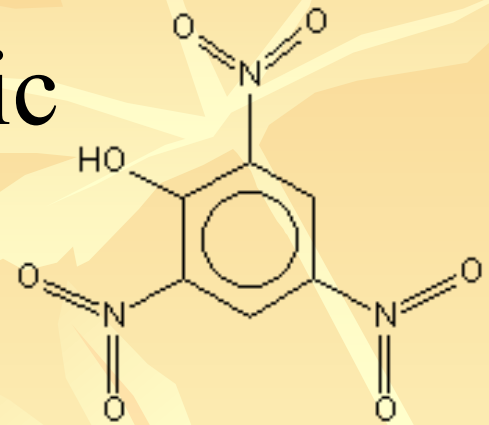


Heading to the HHW Site?

Fortunately This Was Just Latex Paint

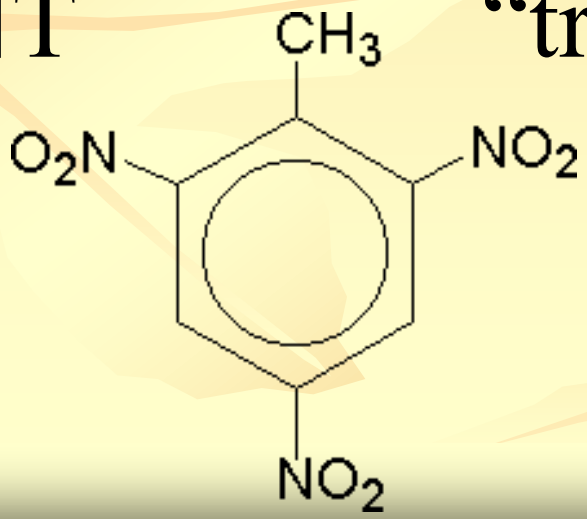
Reactivity: "Nitro"

- Beware of polynitro organic compounds

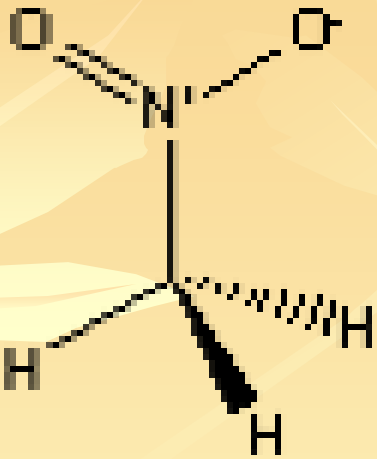


Picric Acid "tri-nitro-phenol"

TNT "tri-nitro-toluene"



Nitromethane

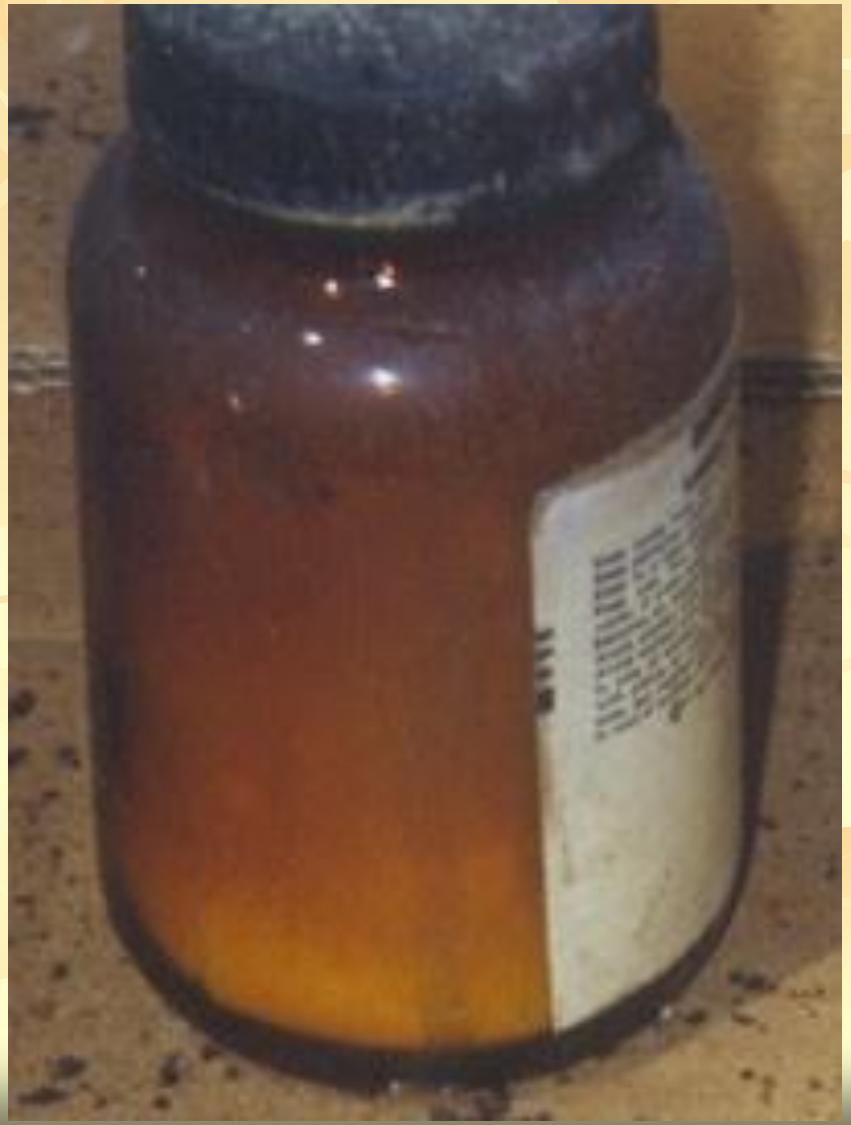


Race Car Fuel

- Shock & heat sensitive
- Thermally unstable
- Reacts violently w/ broad range of materials
- Heating of closed containers may cause detonation

www.nhra.com

Picric Acid



MSDS Material Safety Data Sheet

24 Hour Emergency Telephone: 908-859-2151
CHEMTREC: 1-800-424-9300

National Response in Canada
CANUTEC: 613-996-6666

Outside U.S. And Canada
Chemtrec: 703-527-3887

NOTE: CHEMTREC, CANUTEC and National Response Center emergency numbers to be used only in the event of chemical emergencies involving a spill, leak, fire, exposure or accident involving chemicals.

From: Mallinckrodt Baker, Inc.
222 Red School Lane
Phillipsburg, NJ 08865

J.T.Baker®

All non-emergency questions should be directed to Customer Service (1-800-582-2537) for assistance.

Picric Acid, Wet

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Picric Acid	88-89-1	60 - 70%	Yes
Water	7732-18-5	30 - 40%	No

3. Hazards Identification

Emergency Overview

DANGER! KEEP WET. EXPLOSIVE IF DRY. FLAMMABLE SOLID. CAUSES SEVERE EYE IRRITATION. HARMFUL IF SWALLOWED, INHALED OR ABSORBED THROUGH SKIN. CAUSES IRRITATION TO SKIN AND RESPIRATORY TRACT. MAY CAUSE ALLERGIC SKIN REACTION. AFFECTS LIVER, KIDNEYS AND BLOOD.

MSDS Physical Properties

- Yellow crystalline solid
- Odorless
- Moderate solubility (1-10%)
- Specific Gravity 1.77
- pH: no information found
- Boiling point: explodes above 572°F

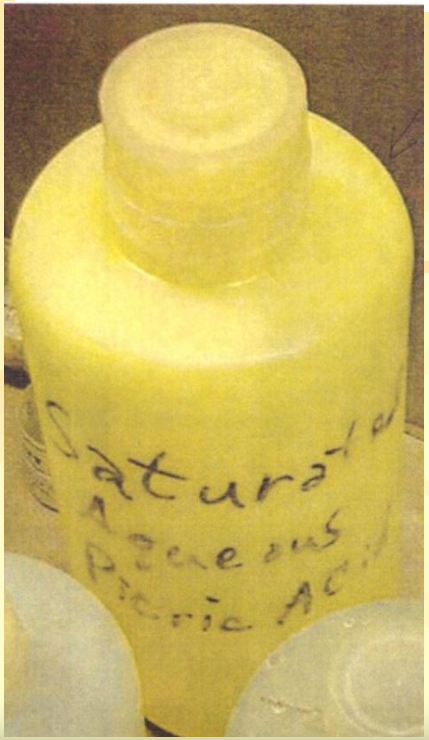
“Wet” Picric Acid Descriptions (from multiple sources)

- Yellow powder or crystals packaged under a layer of water, like slush
- Orange colored, compact crystalline solid with the consistency of lumpy sand
- Paste
- It doesn’t look wet, it looks like a fluffy powder
- Pasty, smooth texture, no jagged edges, no light-reflective surfaces

JT Baker Description

6. Accidental Release Measures

If handling picric acid contained in a jar, gently tilt bottle to see if crystals roll over each other. If they do, the acid is dry and capable of explosion--contact personnel trained in explosives. Dried crystals may also be present within threads of screw top containers and present a detonation hazard when opening container.

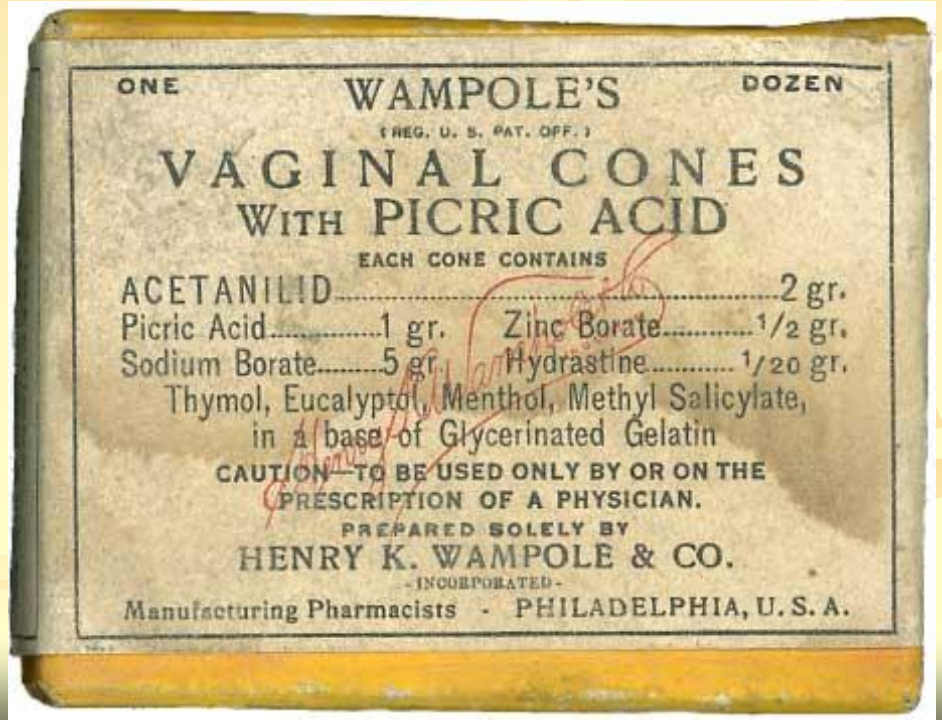


Challenges

- DOT requires 30% water or more, but we can't tell by looking
- Water sitting on top is ideal, but doesn't address potential crystals around the lid
- Metal lid or container, assume the worst
- Metal picrates are much more explosive.

Picric Acid Uses

- Biological stain – university & hospital labs
- Military explosive or priming charge: shells, torpedoes, grenades
- Medicine: wound antiseptic, homeopathic remedy, and …



Early Use: Synthetic Dye

http://www.colorantshistory.org/RobertsDaleCompany.html

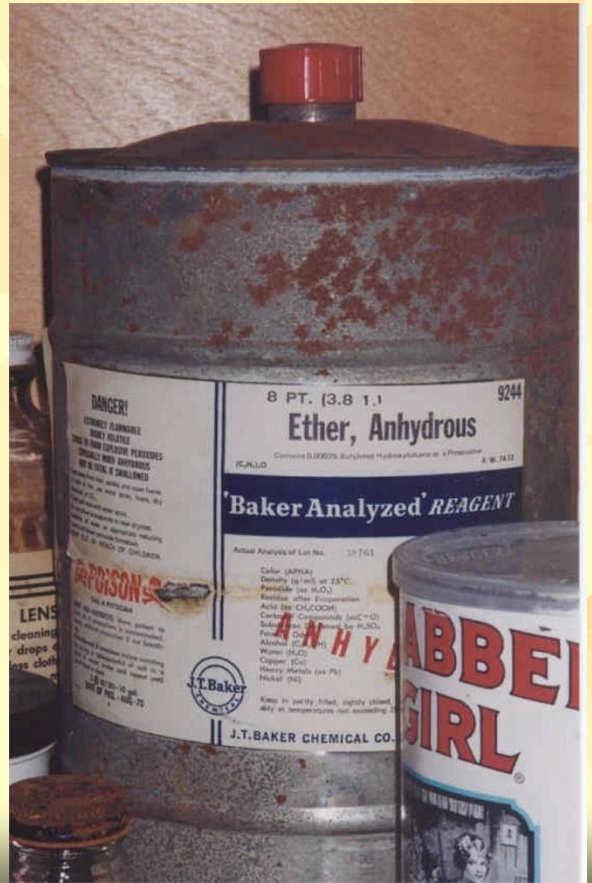
Picric Acid Explosion

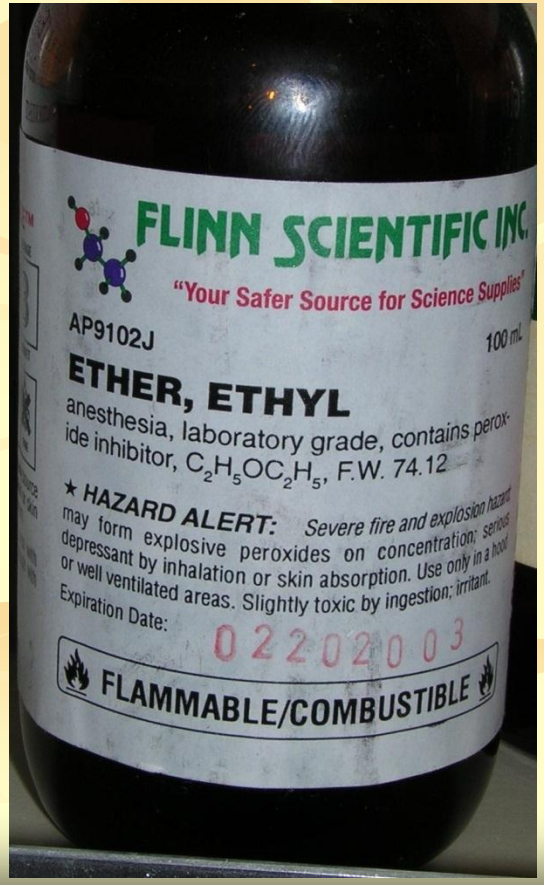
Ether

1 LB.
ÆTHER ANÆSTHETICUS
(B.P.)
S.G. ·720
To be stored in a cool place and protected from light.
Craint la Chaleur et la Lumière.
Manufactured by
DUNCAN, FLOCKHART & CO.
EDINBURGH AND LONDON.

Diethyl Ether

- aka – Ether, Ethyl Oxide, Ethyl Ether
- Used as anesthetic & organic solvent





Scariest One You May Find

Isopropyl Ether = Bomb Squad

They took bottle outside, spontaneously shattered

It then Auto-Detonated

Shock and Light-sensitive

Bomb Squad Thing with Ether

Half Pint of Ethyl Ether
25 foot fireball

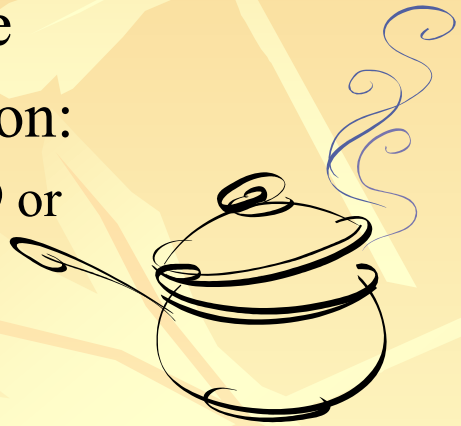
Flash Point

- Flash: a flame appears and instantaneously propagates itself over the entire surface of the liquid sample

www.koehlerinstrument.com/ products/K14601.html

Flash point

- Flash point: lowest temperature that flash occurs
- Flash point less than 140°F is ignitable waste
- Approved Methods for Waste Characterization:
  - Pensky-Martin Closed Cup tester (ASTM D93-79 or D-93-80)
  - Setaflash Closed Cup tester (ASTM D-3278-78)
- Keep the lid on! Avoid “open cup” tests



SW-846 Online, Test Methods for Evaluating Solid Wastes
http://www.epa.gov/epaoswer/hazwaste/test/main.htm

Jim Fitch, "The Enduring Flash Point Test". *Practicing Oil Analysis Magazine* March 2000

Formalin

Section 01: Identification

Section 5: Fire Fighting Measures

General Information:

Flammable liquid.
Auto-Ignition Temperature: 430°C (806°F)
Flash Points: Closed Cup: 50°C (122°F) **Open Cup:** 60°C (140°F)
Flammable Limits:
The greatest known range is **Lower:** 6%
Upper: 36.5% (Methyl alcohol)

Combustion Products: Carbon monoxide, Carbon dioxide

Flash points on MSDS:

Closed Cup: 50°C (122°F)
Open Cup: 60°C (140°F)

Purge Solvent

If SWALLOWED: Do not induce vomiting. Get medical attention immediately.

Section 5 — Fire Fighting Measures

FLAMMABILITY CLASSIFICATION -

RED LABEL -- Extremely Flammable, Flash below 21 °F

FLASH POINT - 4 °F PMCC *LEL* 1.0 *UEL* 36.5

EXTINGUISHING MEDIA - Carbon Dioxide, Dry Chemical, Foam

Flash point on MSDS:

- 4 °F PMCC

Wipe Solvent

SECTION 5 - FIRE FIGHTING MEASURES		
FLASH POINT (METHOD USED) 115° F (TCC)	FLAMMABLE LIMITS LEL: 1.5% UEL: 11.0% AUTOIGNITION TEMPERATURE: 660° F	NFPA CLASS: II
GENERAL HAZARDS: Product is combustible. Products of combustion include compounds of carbon, hydrogen and oxygen, including carbon monoxide.		
EXTINGUISHING MEDIA Carbon dioxide, water, water fog, dry chemical, chemical foam		
FIRE FIGHTING PROCEDURES Self - contained respiratory equipment; cool containers to prevent pressure buildup and possible explosion when exposed to extreme heat. Caution - material is combustible!		
UNUSUAL FIRE AND EXPLOSION HAZARDS Closed containers can explode due to buildup of pressure when exposed to extreme heat.		
HAZARDOUS COMBUSTION PRODUCTS Smoke, fumes, oxides of carbon		

Flash point on MSDS:

115°F (TCC)

Safety Solvent

Fire and Explosion Hazard Data:

Flammable Limits:	LEL=0.7% UEL=6.1%
Flash Point:	>117° F
Flammability Classification:	OSHA: Flammable DOT: Flammable
Extinguishing Media:	CO_2, chemical foam, water fog.

Special Fire Fighting Features: Wear self-contained breathing gear when in confined area.

Flash point on MSDS:

>117° F

Exercise:
Big Number or Small Number?

- Exercise is on handout
- Take about 5 minutes to complete it
- We will go thru answers next
- For these tests, which is more hazardous, a big or small number?

50

150

Which is more hazardous? Big Number or Small Number?

1. Flash point: 50°F or 150°F?
   - small is more ignitable or flammable
2. Oral rat toxicity, LD_{50}: 400 mg/kg or 4,000 mg/kg?
   - small is more toxic, small amount can kill half the rats
     - LD_{50} is a lethal dose to 50% of the rats tested
     - 400 mg refers to amount of toxic substance
     - 1 kg refers to body weight of rat

Which is more hazardous? Big Number or Small Number?

3. pH: 1 or 7?
   - Small, 1 is more acidic and corrosive than 7 (neutral)
4. pH: 7 or 14?
   - Big, 14 is more caustic (basic) and corrosive than 7
5. pH: 1 or 14?
   - Small & Big, pH is most hazardous at the high and low extremes, 7 is neutral

Which is more hazardous? Big Number or Small Number?

9. Stoddard Solvent, TLV is 100 ppm TWA or Solvent Cleaner, TLV is 50 ppm TWA?

- Small number, because when the threshold concentration (the edge of safe or dangerous) is low, the substance is more hazardous.

10. **Metformin (diabetes drug) in treated sewage, 0.15 mg/L "part per million" or 0.15 ug/L "part per billion"**

- Big number (more drug in water), 0.15 ppm

Reading Material Safety Data Sheets

One resource for chem info

- 1st off, they vary a lot in quality
  - See examples in handouts
- Then there's Trade Secrets
- A **trade secret** is **proprietary info** which the holder of the secret doesn't wish to be known to others, especially his competitors.
- It can also be a way to avoid paying someone to do research

MSDS Definitions

http://www.ilpi.com/MSDS/ref/index.html

A1, A2, A3
ACC
Acid
Acidosis
ACGIH
Acre
Action Level
Activated Charcoal
Acute Toxicity
Administrative Controls
AFI
AIHA
Air

Exothermic
Explosive
Explosive Limit
F and F+
F1 - F8
Fahrenheit
Fatigue
Fetotoxin
Fibrosis
Fire Point
Flammable
Flammable Aerosol
Flammable Gas

Neoplasm
Nephrotoxin
Neurotoxin
NF
NFPA
NIIN
NIOSH
Nitrile
N/K (or NK)
nm = nanometer
N/P (or NP)
NSN
NTP

A1, A2, A3
ACC
Acid
Acidosis
ACGIH
Acre
Action Level
Activated Charcoal
Acute Toxicity
Administrative Controls
AFI
AIHA
Air
ALARA
Alcohol
Aldehyde
Aliphatic
Alkali Metal
Alkaline
Alkaline Earth
Alkane
Alkene
Alkyl
Alkyne
Alopecia
Ames Test
Amine
Ammonia
Ammonium
Analgesia
Anesthesia
Anhydride
Anhydrous
Anorexia
Anosmia
Anoxia
ANSI
Antidote
Exothermic
Explosive
Explosive Limit
F and F+
F1 - F8
Fahrenheit
Fatigue
Fetotoxin
Fibrosis
Fire Point
Flammable
Flammable Aerosol
Flammable Gas
Flammable Limits
Flammable Solid
Flashpoint
Foot
Formula Weight
Formyl
Freezing Point
FSC
Fume
Fume Hood
Fume Extractor
G1 - G9
Gallon
Gangrene
Gastric
Gastroenteritis
Gingivitis
Globally Harmonized System
Gram
H1
Halide
Halogen
Hazardous
HAZWOPER
Health Hazard
Neoplasm
Nephrotoxin
Neurotoxin
NF
NFPA
NIIN
NIOSH
Nitrile
N/K (or NK)
nm = nanometer
N/P (or NP)
NSN
NTP
Nystagmus
Oliguria
Organic
OSHA
Ounce (fluid)
Ounce (mass)
Oxetane
Oxidation
Oxirane
P1, P2
Palpitation
Pascal
Paresthesias
PEL
Percutaneous
Peroxide
Petroleum Ether
Physical Hazard
pH
Phlegm
Pint
Pint
Pneumoconiosis
Poison
Polymer

Antidote
Anuria
Aqueous
Are
Area Units**
Aromatic
Aryl
Asphyxia
Asphyxiant
Asphyxiation
ASSE
Asthma
ASTM
Asymptomatic
Atm (atmosphere)
Atomic Mass
Atrophy
ATSDR
Autoignition
B1, B2, B3
Bar
Base
Baumé scale**
Benign
Biodegradable
Biological Oxygen Demand
Boiling Point
Bradycardia
Bronchitis
C
C1, C2, C3
Calorie
Carbon Dioxide
Carbon Monoxide
Carbon Tetrachloride
Carboxylic Acid
Carcinogen
Carcinoma
CAS Number

Health Hazard
HCC
Heavy Metal
Hectare
Hematuria
HEPA
Hepatic
Highly Toxic
Hives
HMIRS
HMIS
HRS
Hydrocarbon
Hydroperoxide
Hygroscopic
Hypergolic
Hypertension
Hypertonic
Hypokalemia
Hyponatremia
Hypoglycemia
Hyposmia
Hypotension
Hypotonic
Hypoxia
Hz = Hertz
IARC
Immiscible
Inch
Incompatible
Inert
Inflammation
Ingestion
Inhalation
Intraperitoneal
Intravenous
I.P. or ipr
Iridocyclitis
Irritant

Polymer
Pound
PPB
PPE
PPM
PPT
Precipitate
Pressure Units**
Proprietary
Prostration
PSI
Pulmonary edema
Pyrophoric
Quart
R1, R2
Rankine
Rash
RCRA
REACH
REC
Reduction
Respirator
Respiratory
Reportable Quantity (RQ)
Reproductive Toxin
Right-to-Know
Risk Phrases
RTECS
S/A (or SA)
Safety Phrases
Saline
SARA
SCBA
Sclera
Sensitizer
SIC Code
SKN
Smoke
Solution

Cataract
Catharsis
Cathartic
Caustic
Ceiling Level
Celsius
CERCLA
CFR
Chemical
Chemical Formula
CHIP
Chlorocarbon
Chronic Effect
Clastogen
cm = centimeter
cm-1
Coma
Combustible
Concentration**
Conjunctivitis
COSHH
Corrosive
Cutaneous
Cyanide
Cyano
Cyanosis
Cyclic
Cytotoxin
D1, D2, D3, D4
Decomposition
Deliquesce
Density**
Dermal
Dermal toxicity
Dermatitis
Dermatosis
Desiccant
Diaphoresis
Distance units**
Diuresis
Diuretic
DOT
IUPAC
I.V.
Isotonic
Jaundice
Joule
K1, K2
Kelvin
Ketone
Ketosis
Kilocalorie
Kilogram
Kilojoule
Kilopascal
kcal/mol
kJ/mol
km = kilometer
Lachrymator
LC_{50}
LC_{Lo}
LD_{50}
LD_{Lo}
LEL
Lesion
Lethargy
Leukemia
LEV
Liter
Local Exhaust Ventilation
m
M1
Malaise
Malignant
Manufacturer
Mass Units**
Metastasis
meter
mg = milligram
MHz = megahertz
Mile
Miscible
Mist
Mixture
Solubility
Solvent
Soot
Spasm
Specific Gravity
Spontaneous Combustion
Square...(area units)**
Standard State
STEL
Sternutator
STP
Stupor
Subcutaneous
Supernatant
Swiss Poison Class
Syncope
Symptomatic
Systemic
SUP DAT
SuperFund
T and T+
T1 - T7
Tachycardia
Target Organ Effects
Temperature Units**
Teratogen
Threshold Limit Value (TLV)
Thrombosis
Tinnitus
Toxics Release Inventory
TS
TSCA
TWA
Torr
Toxic
Trade Secret
UEL
UN or UN/NA Number
UNK
UNR
Urticaria
Useless Abbreviations

With this many terms, no wonder they can be bewildering

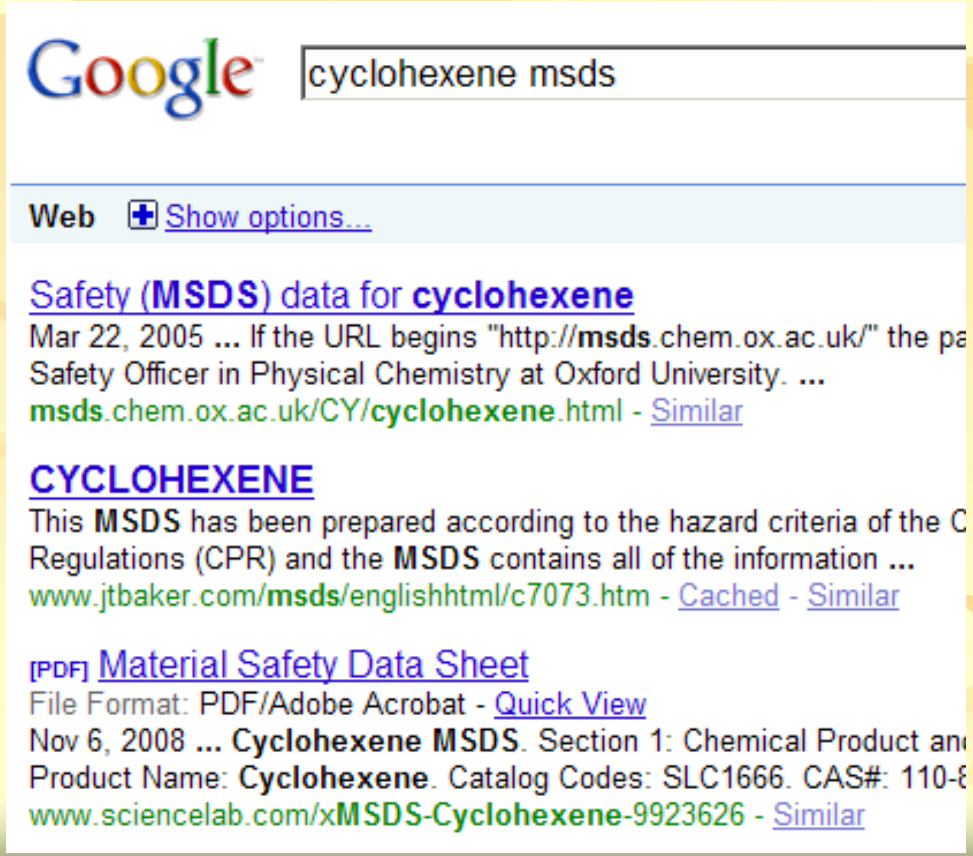
DOT
Dust
Dysosmia
Dyspnea
E1, E2
EC Number
Edema
EINECS
Electrolyte
ELINCS
Embolism
Emetic
Emesis
Emphysema
Endothermic
Energy Units**
Engineering Controls
EPCRA
Epistaxis
Epoxide
EST
Erythema
Ether
eV = electron volt
Evaporation Rate
Mixture
mL = milliliter
mm = millimeter
MSHA
Molarity
Molar Mass
Mole
Molecular Weight
MST
mus
Mutagen
Myalgia
N1
N/A (or NA)
N/Ap
N/Av
NA Number
NAICS
Narcosis
Nausea
ND
NE
Necrosis
NEGL
Useless Abbreviations
V1 - V7
Vapor
Vapor Pressure
Ventilation
Vertigo
Vesicant
Viscosity
VOC
Volatility
Volume Units**
Wavenumber
Water Reactive
WGK
WHC
WHMIS
Wilson RISK Scale
Work Practice Controls
X1
Xi and Xn
Xu
Y1 and Y2
Yard
Z1 - Z7

Getting the info you need from an MSDS

- Define the info you need
- Find a good quality MSDS
- Find the important info in the MSDS
- Let's look at two examples
  - A pure compound
  - A commercial product

Cyclohexene shows up at your site

- I'd start with the school chemicals database, but…
- Go to Google and type cyclohexene msds



- **<u>Look at where it's from</u>**
- msds.chem.ox.ac.uk
  - Oxford University
- jtbaker.com
  - JT Baker Chemical Co.
- sciencelab.com
  - Science Lab equipment co.

JT Baker MSDSs are excellent

- For on-line data on pure chemical compounds, I look for jtbaker.com MSDSs
- Science Lab's are also good
- The Oxford ones are useful, but have less data and it's geared for European Union

What's JT say about Cyclohexene?

- First, check to make sure it's the right compound. Cyclohex**a**ne is very different

CYCLOHEXENE

1. Product Identification

Synonyms: 1,2,3,4-Tetrahydrobenzene; benzene tetrahydride
CAS No.: 110-83-8
Molecular Weight: 82.15
Chemical Formula: C6H10
Product Codes: G045

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Cyclohexene	110-83-8	99 - 100%	Yes

Next, read emergency overview

Provides a quick peek at the hazards

3. Hazards Identification

Emergency Overview

DANGER! EXTREMELY FLAMMABLE LIQUID AND VAPOR. VAPOR MAY CAUSE FLASH FIRE. HARMFUL IF SWALLOWED OR INHALED. AFFECTS CENTRAL NERVOUS SYSTEM. MAY CAUSE IRRITATION TO SKIN, EYES, AND RESPIRATORY TRACT.

SAF-T-DATA(tm) Ratings (Provided here for your convenience)

Health Rating: 2 - Moderate
Flammability Rating: 3 - Severe (Flammable)
Reactivity Rating: 2 - Moderate
Contact Rating: 2 - Moderate
Lab Protective Equip: GOGGLES & SHIELD; LAB COAT & APRON; VENT HOOD; PROPER GLOVES; CLASS B EXTINGUISHER
Storage Color Code: Red (Flammable)

- Flammable liquid. Harmful if swallowed or inhaled. Irritating. Affects nervous system.
- Don’t drop it!!

Now check the health effects

Potential Health Effects

Inhalation:
May cause irritation to the respiratory tract. Symptoms may include coughing, sore throat, labored breathing, and chest pain. High concentrations have a narcotic effect.
the air cause a deficiency of oxygen with the risk of unconsciousness.
Ingestion:
May produce abdominal pain, nausea. Aspiration into lungs can produce severe lung damage and is a medical emergency. Other symptoms expected to parallel inhalatio
Skin Contact:
May cause irritation with redness and pain.
Eye Contact:
May cause irritation, redness and pain.
Chronic Exposure:
Chronic exposure may cause skin effects.
Aggravation of Pre-existing Conditions:
No information found.

- Painful if inhaled, ingested, touched, in eyes
- Seems manageable as long as not spilled and you're wearing PPE

Next, let's see whether there are other risks
Check fire risks, since it's flammable

Fire Fighting Measures

Fire:
Flash point: < -7C (< 19F) CC
Autoignition temperature: 244C (471F)
Extremely Flammable Liquid.
Explosion:
Above the flash point, explosive vapor-air mixtures may be formed. Vapors can flow along surfaces to distant ignition source and flash
mixtures. Sensitive to static discharge.
Fire Extinguishing Media:
Dry chemical, alcohol foam or carbon dioxide. Water may be ineffective. Water spray may be used to keep fire exposed containers co
personnel attempting to stop leak and disperse vapors.
Special Information:
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operate
This highly flammable liquid must be kept from sparks, open flame, hot surfaces, and all sources of heat and ignition.

- Flash point is under 19 degrees F.
- This is extremely flammable

I next look at its physical properties

9. Physical and Chemical Properties

Appearance:
Clear, colorless liquid.
Odor:
Sweet odor.
Solubility:
Insoluble in water.
Specific Gravity:
0.81 @ 20C/4C
pH:
No information found.
% Volatiles by volume @ 21C (70F):
100
Boiling Point:
83C (181F)
Melting Point:
-103.7C (-155F)
Vapor Density (Air=1):
2.8
Vapor Pressure (mm Hg):
160 @ 30C (86F)
Evaporation Rate (BuAc=1):
No information found.

- Insoluble in water
- Specific gravity <1
- So it floats
- 100% volatile
- Vapor density heavier than air
- Flammable vapors floating too

OK, let's look at reactivity

Stability and Reactivity

Stability:
Stable under ordinary conditions of use and storage. Readily auto oxidizes in air at room temperature to form peroxide.
distilled, especially if vacuum distilled.
Hazardous Decomposition Products:
Carbon dioxide and carbon monoxide may form when heated to decomposition.
Hazardous Polymerization:
Will not occur.
Incompatibilities:
Strong oxidizers.
Conditions to Avoid:
Heat, flame, ignition sources, air, incompatibles

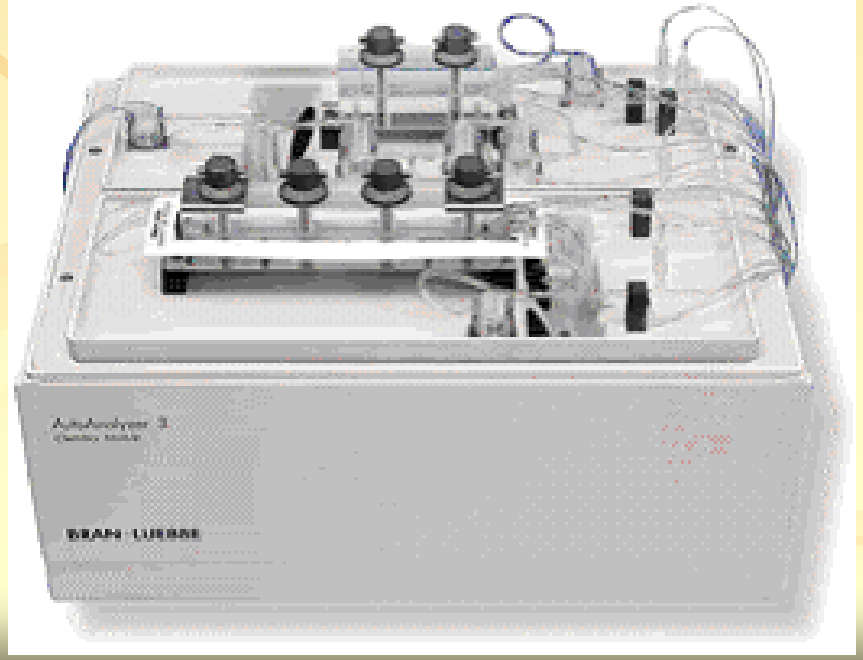
- A flammable solvent that readily forms peroxides means you have to consider contacting the bomb squad
- Now we're looking for signs it's been exposed to air
- **Let's see that bottle again**

Carefully examine peroxide formers

- Potentially a shock-sensitive explosive
- Is the lid still sealed?
- Does it appear to be full of liquid?
- Is it clear, not cloudy?
- If yes to all, probably OK
- Dispose as ignitable HW

Small Scale Chemistry

- The future of chemistry is microscale in size
- Can be high tech or done w/ 99¢ store materials
- One drop's all you need, testing at ppb levels



Small Scale Chemistry Experiment
Double Displacement Reaction

- Qualitative analysis
  - Look for changes in the chemical's qualities
- Two compounds in solution mixed together
- Trade cations and new compounds are formed
- $PbNO_3$ (lead nitrate) + KI (potassium iodide)
- $Pb^+ + NO_3^- + K^+ + I^-$ in water
- Now PbI (lead iodide) + KNO_3 (potassium nitrate)

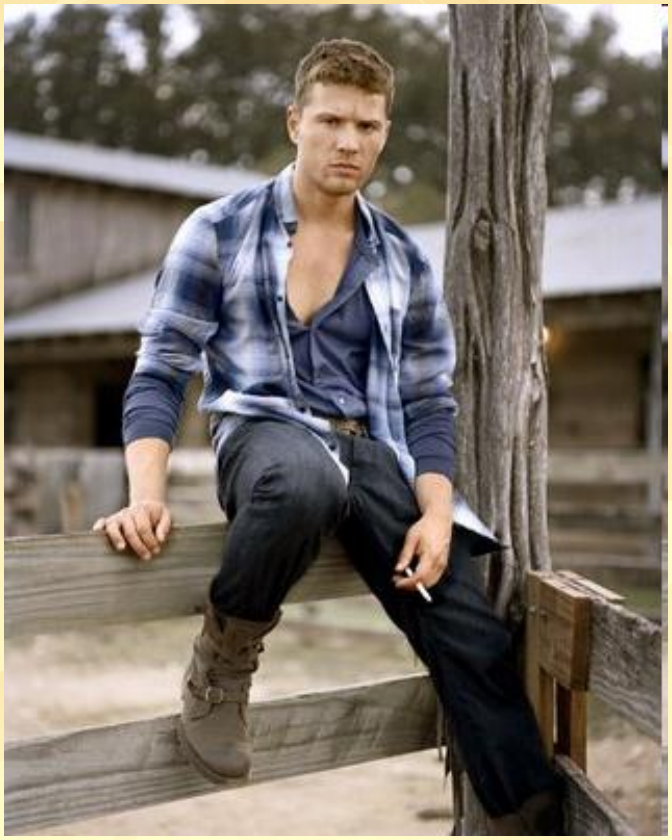
Each cell gets drops going down and across

- One drop in each cell going down that matches formula above it
- One drop in each cell going across that matches formula beside it
- If there's a drop in the cell already, place the new drop ON the drop in there
- DO NOT TOUCH THE PIPET TO THE DROPS. IT WILL CONTAMINATE THE SOLUTIONS
- What did you observe? Why did it happen?

Meet Farmer Dave

Dave Owns 17 Cows

Farmer Dave Has Three Sons



Dave’s Not Looking Healthy!

He Wills 17 Cows to His Sons

- 1/2 to eldest
- 1/3 to middle
- 1/9 to youngest

It Doesn't Work – Tempers Rise!

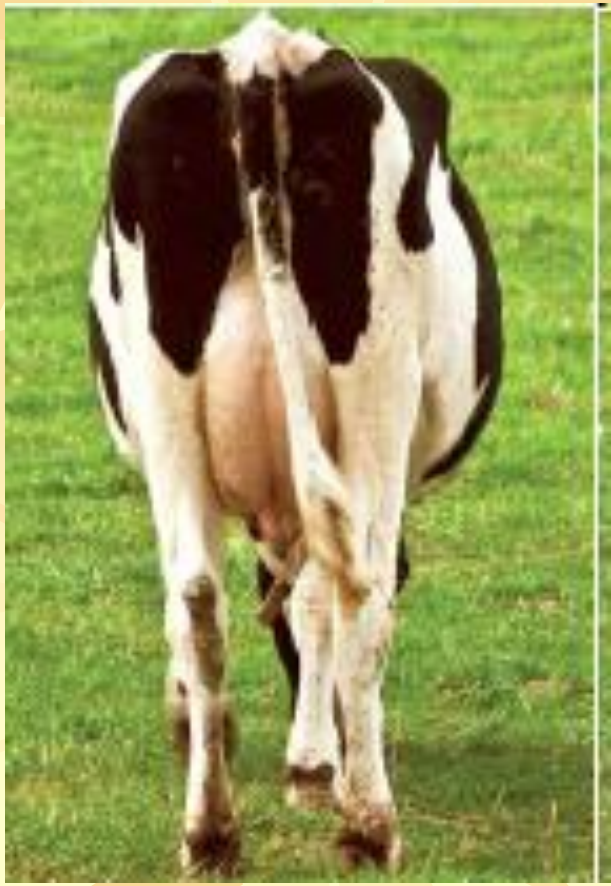
- 17/2 = 8.5
- 17/3 = 5.7
- 17/9 = 1.9

Neighbor Pam Hears the Ruckus

- “I can fix this”
- Goes to her farm
- “You can have my biggest cow”

They Do The Math

- 18/2 = 9
- 18/3 = 6
- 18/9 = 2
- 17 cows
- Everybody's happy
- Pam takes her cow home



Be Careful of Initial Assumptions

- Ask questions before handling
- Do you have any lab chemicals?
- Anything weird I should know about?
- Did you combine chemicals together?

Familiarity Breeds Contempt

- Don’t be chemically complacent

Let's Get to Your Questions