Chemical Principles Visualized

David A. Katz

Department of Chemistry

Pima Community College

Tucson, AZ USA

Email: dkatz45@pima.edu

Web site: http://www.chymist.com

A demonstration is an explanation by example or experiment

A demonstration:

- Encourages observations
- Arouses curiosity and stimulates thought
- Produces excitement or surprise
- Presents complex concepts on a concrete level

FACTORS FOR AN EFFECTIVE DEMONSTRATION

1. Prepare ahead
2. Practice the demonstration
3. Make the demonstration visible
4. Present the demonstration to the audience
5. Get the audience involved
6. Encourage responses
7. Keep the demonstration simple
8. Practice showmanship
9. Explain the concept
10. Repeat the demonstration (when possible or practical)
11. Practice safety
12. Summarize

How many demonstrations can I, or should I, present in class?

- **Ideally, one demonstration or activity for every class**
- **Start out by trying to do one demonstration or activity every two weeks**
- **Be prepared for student excitement and commotion, that is normal – try to develop a dialogue with your students**
- **As you gain experience, present one demonstration or activity every week**

How many demonstrations can I, or should I, present in class?

- **Continue increasing the frequency of demonstrations and activities. This may take several years**
- **Remember, demonstrations are a means of visualizing scientific phenomena, not a substitute for teaching**

The First Day

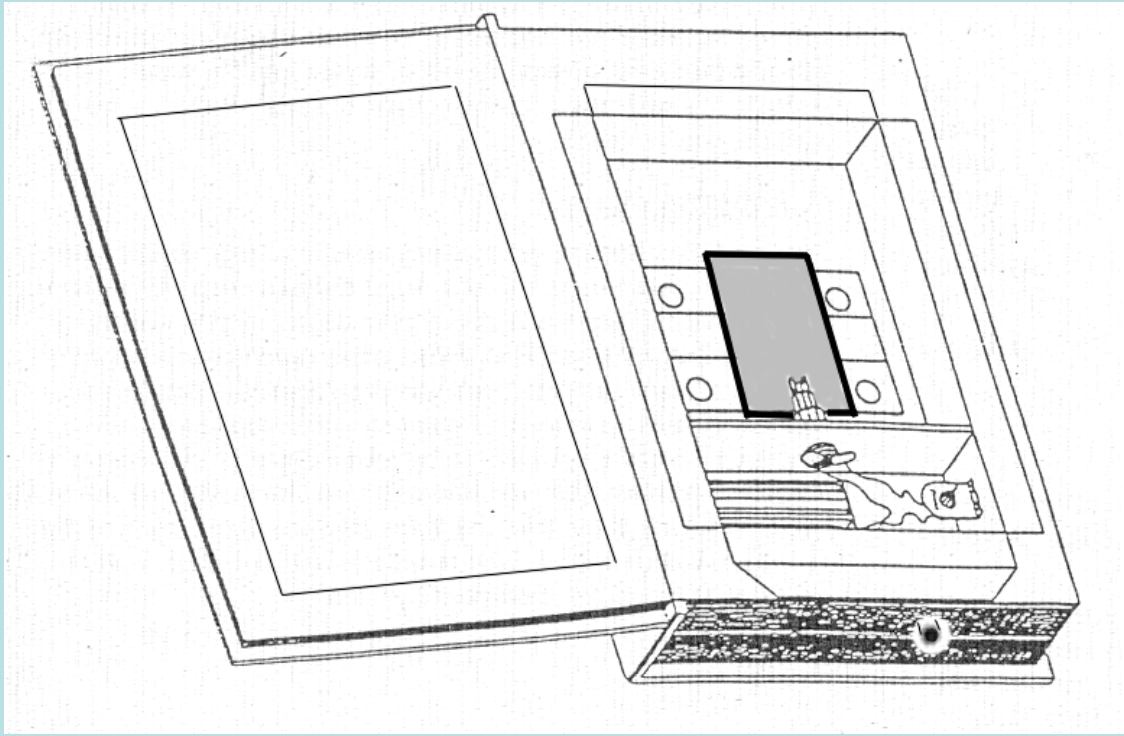
- **Students should see and experience chemistry. That means chemical demonstrations and activities**
- **Save that discussion of the course topics or class rules for the second class. Make your class different from that history class, math class, etc.**
- **Your students should leave that first class thinking that chemistry is neat, exciting, interesting, and fun**

The First Day

- **Find a starting point, for each new class, that is related to something in the news and/or in the experience of your students**
  - **A historical background of chemistry**
  - **Life in the universe**
  - **Atmospheric chemistry, light, UV, ozone, etc.**
  - **Chemistry and the elements**
  - **Chemistry and materials – metals, polymers, composites, etc.**
  - **A series of interesting, and fun, demonstrations**

Chemistry Book

Purchase from magic supply company or make your own



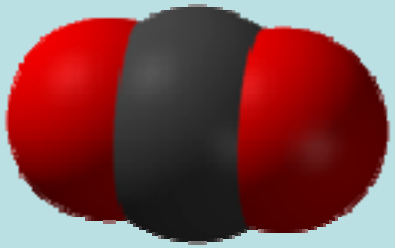
A Chemical Genie

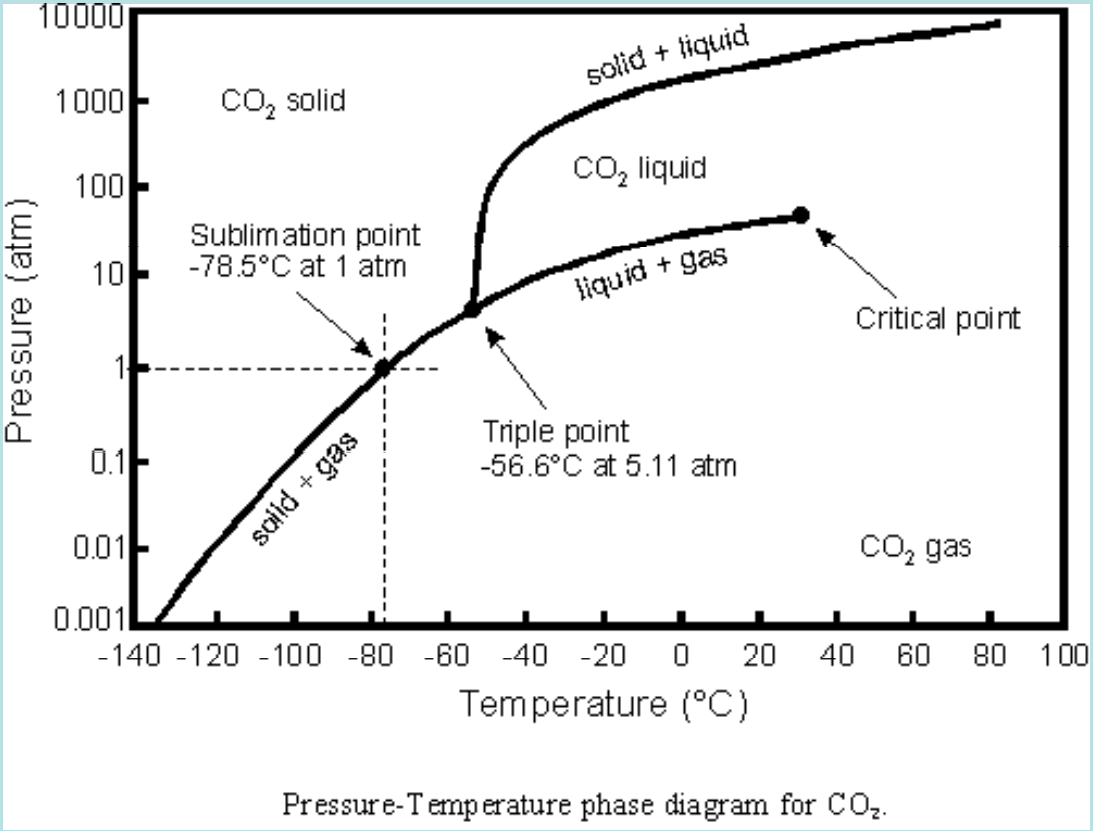
Oxygen

Joseph Priestley

Carl Wilhelm Scheele

Carbon dioxide

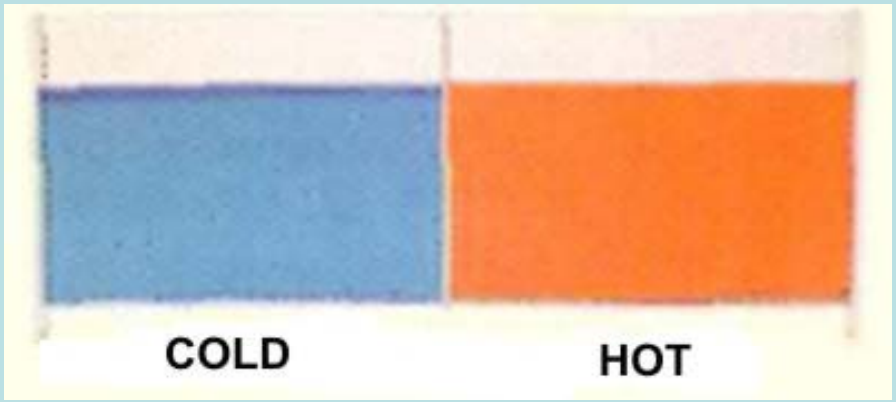




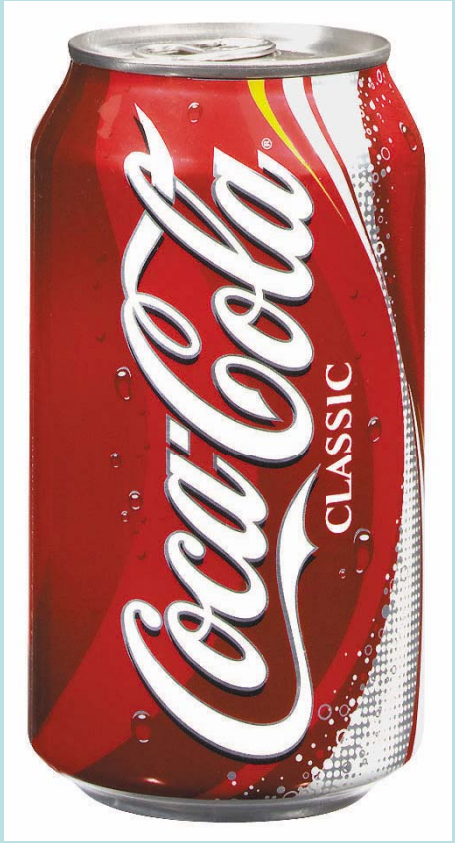
Pressure-Temperature phase diagram for CO_2.

Hot and Cold

Separate water by density

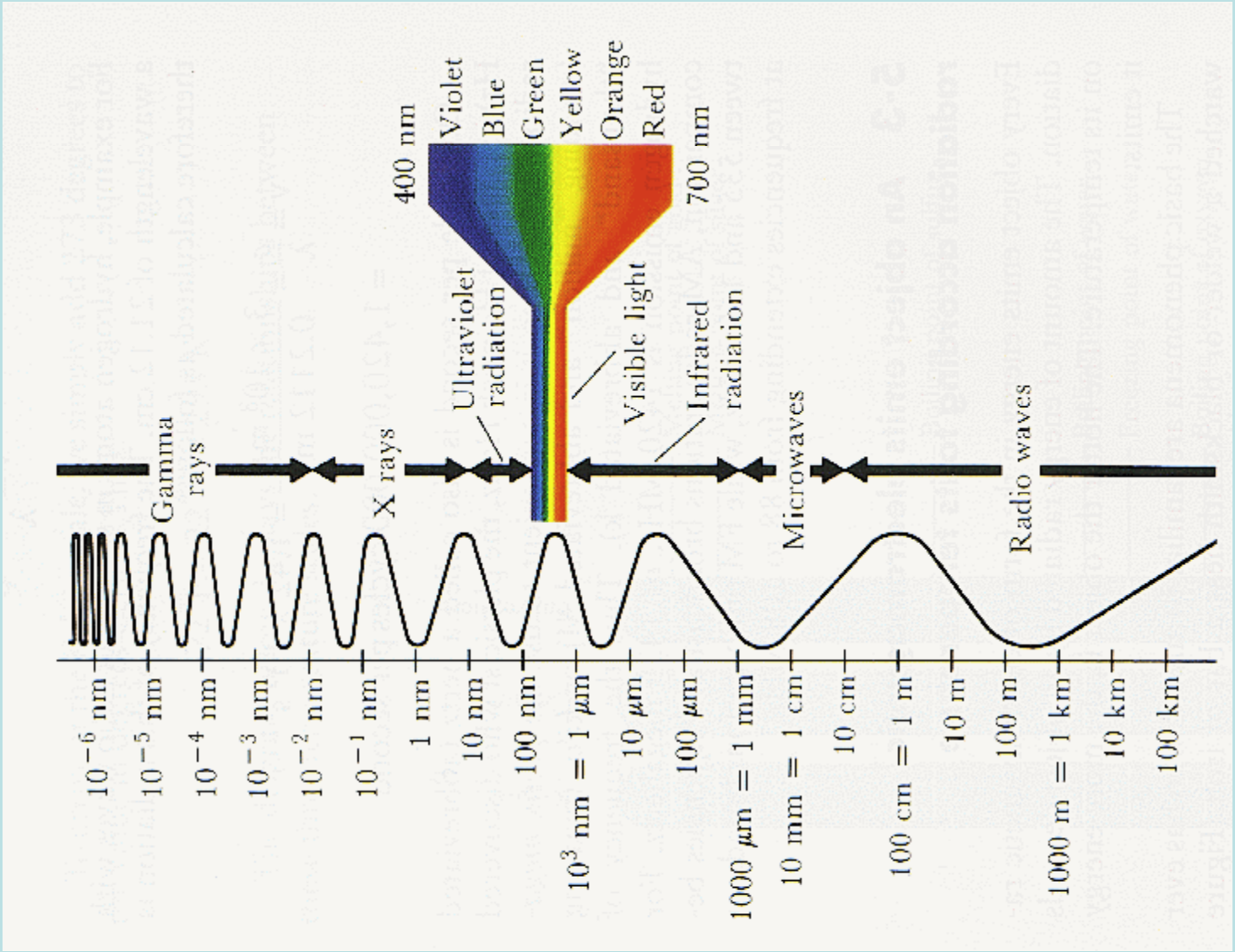


Coke vs. Diet Coke

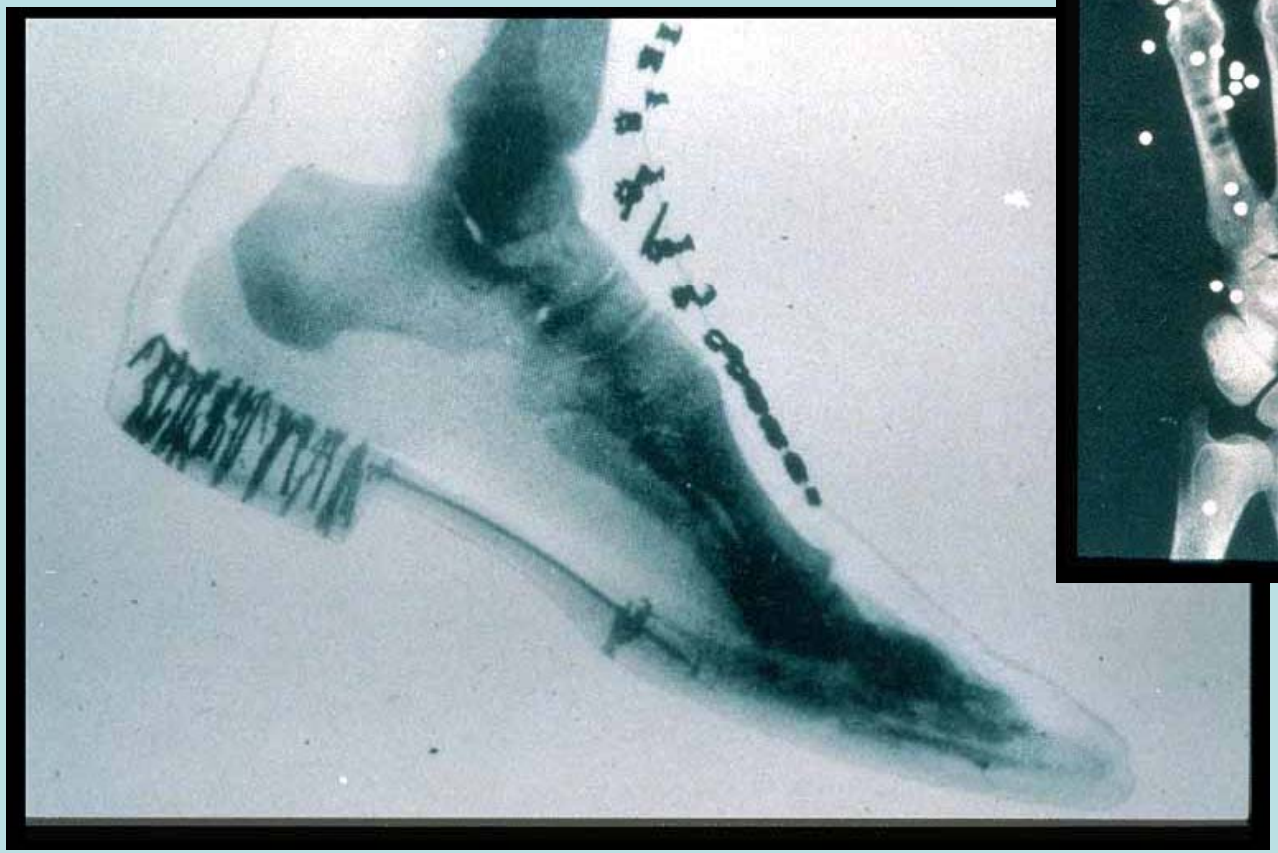


Density

The Electromagnetic Spectrum



X-Rays



Visible Light

Colored Flames

Strontium – red

Lithium - red

Calcium – red/orange

Copper – green or blue

Barium – yellow-green

Potassium – violet

Sodium - yellow

The Electromagnetic Spectrum

How do we identify elements in space?

Build a spectroscope:

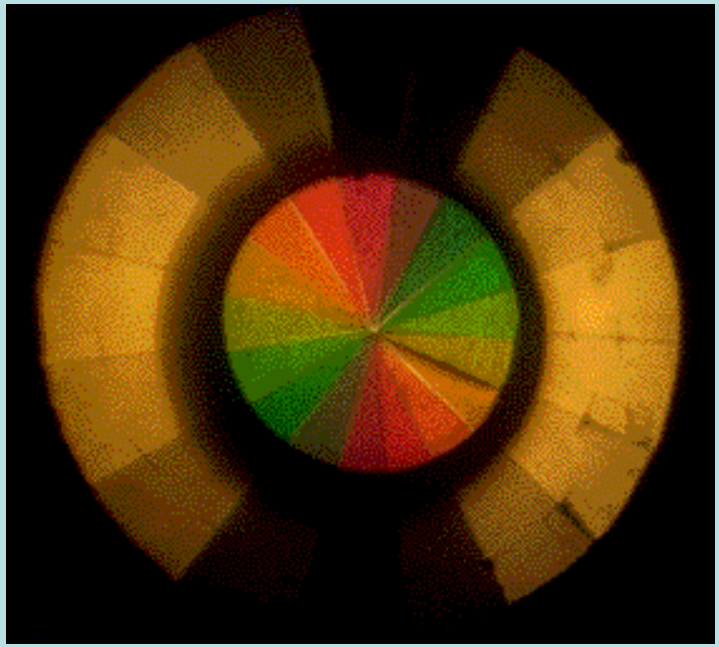
Find elements in your environment

The Electromagnetic Spectrum

Optical Rotation

- An optically active compound can rotate light
- Due to an asymmetrical carbon atom (carbon bonded to 4 different groups)
- Enantiomers: molecules are mirror images of themselves
- Solutions of the *d*-isomer twists the light clockwise;

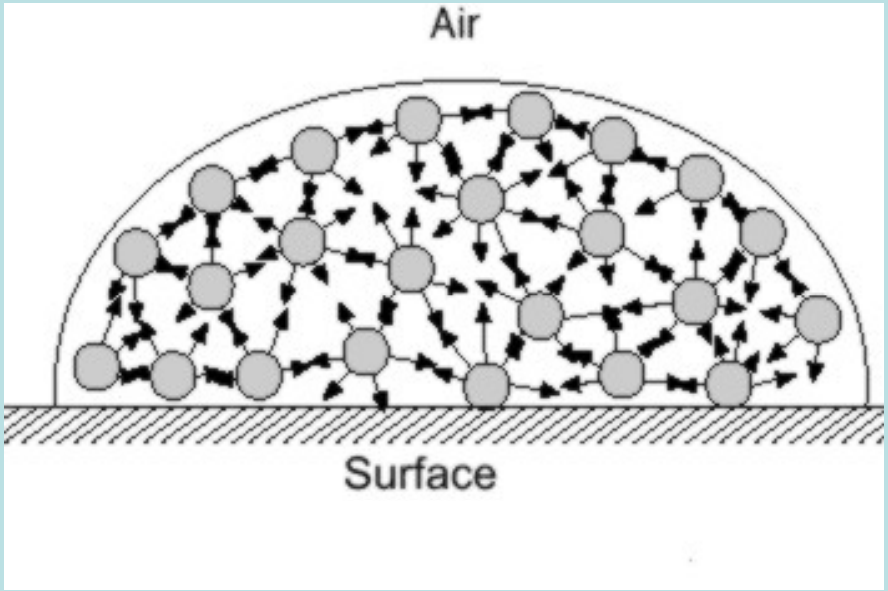
  ℓ-isomer twists light counter-clockwise



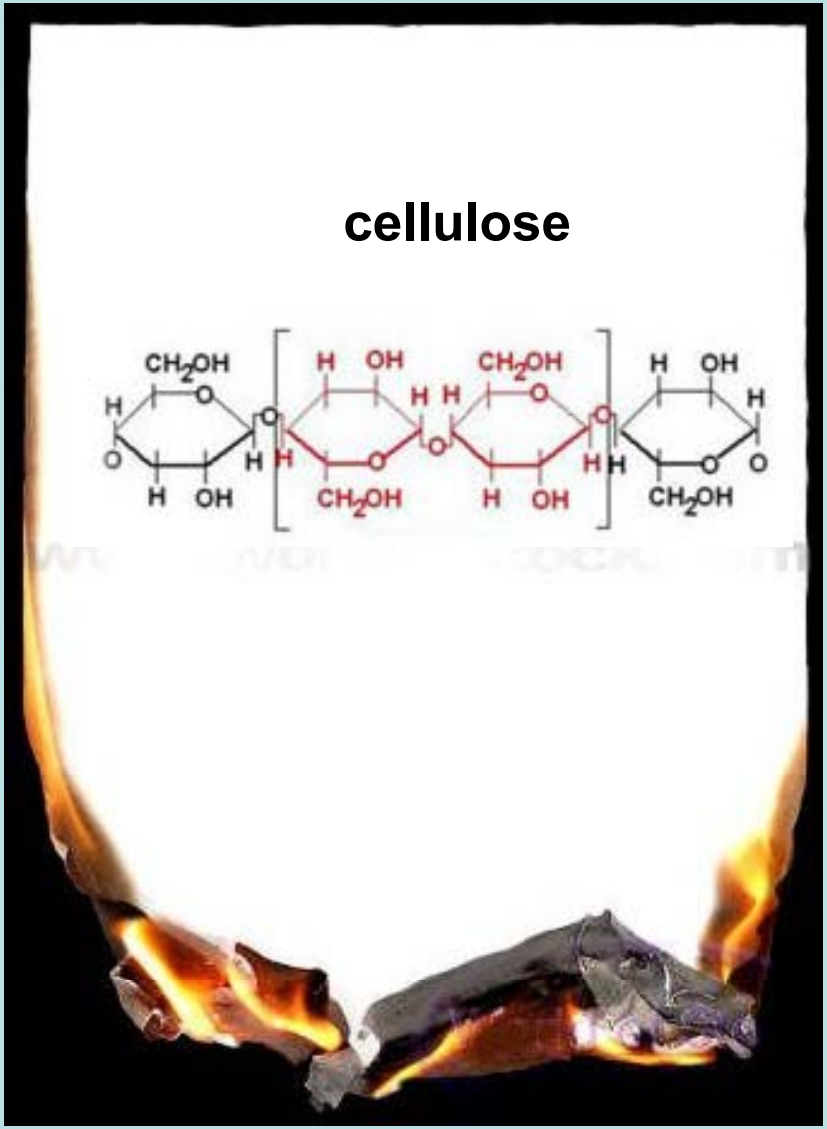
Dextrose (*d*-glucose) solution in polarized light

Intermolecular forces 1: Drops of water on a coin

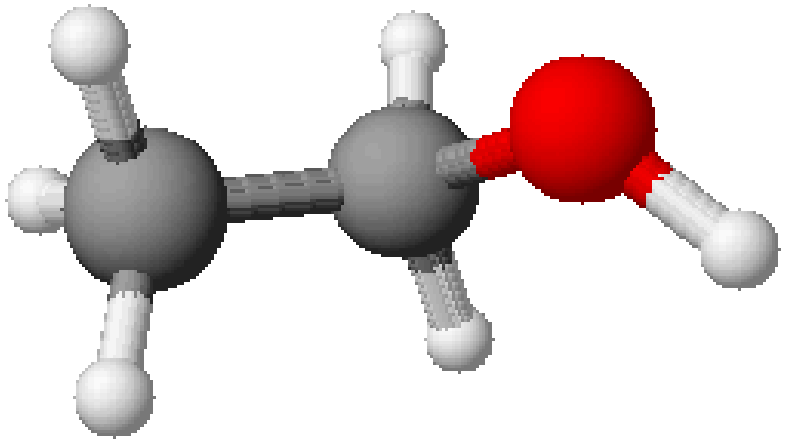
How many drops of water can you put on a coin?



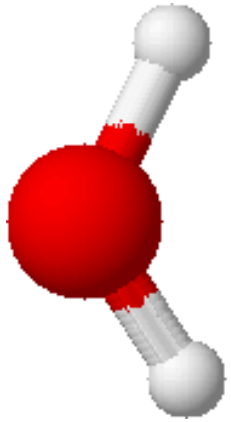
What happens when paper burns?



Intermolecular forces 2: Decrease in Volume



ethanol



water

Intermolecular forces 3: Chemical reactions Increase in Volume

$$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$$

Before: H_3O^+, OH^-, Na^+, and Cl^- hydrated ions

After: H_2O liquid and Na^+ and Cl^- hydrated ions

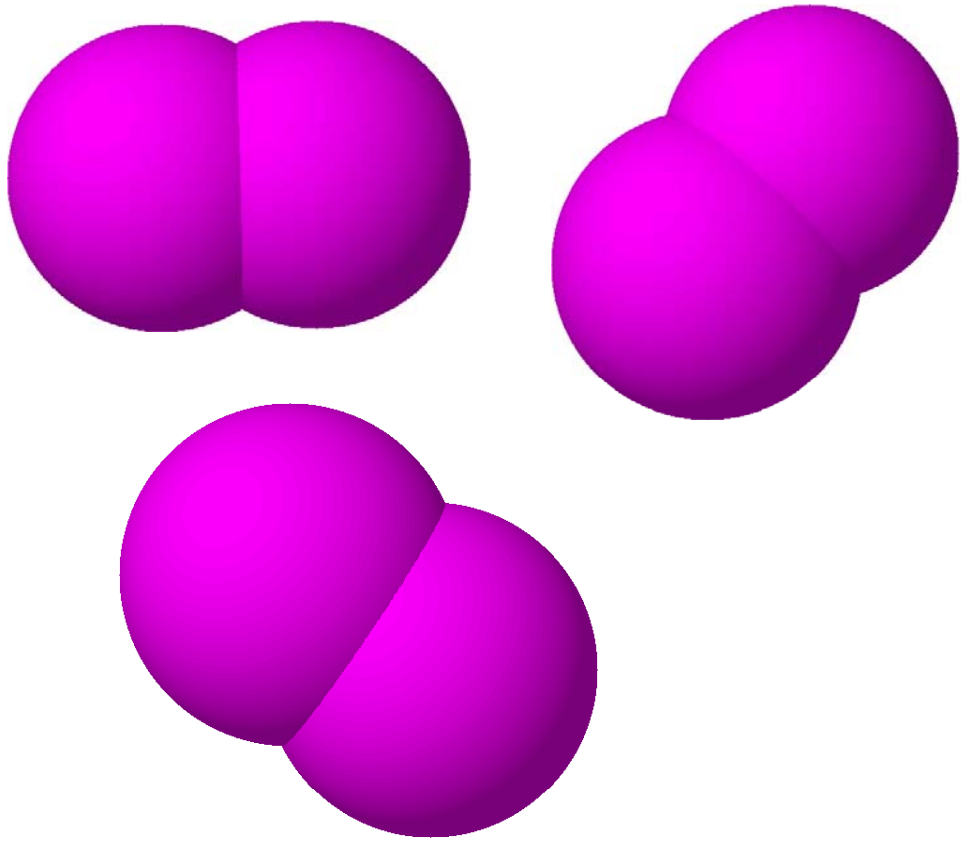
Phenolphthalein

Acid **Base**

?

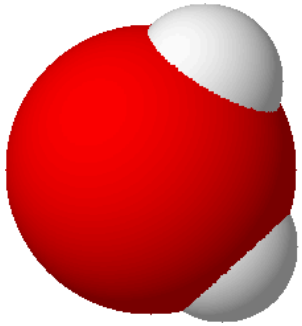
Intermolecular forces 4: Intermolecular forces using I_2

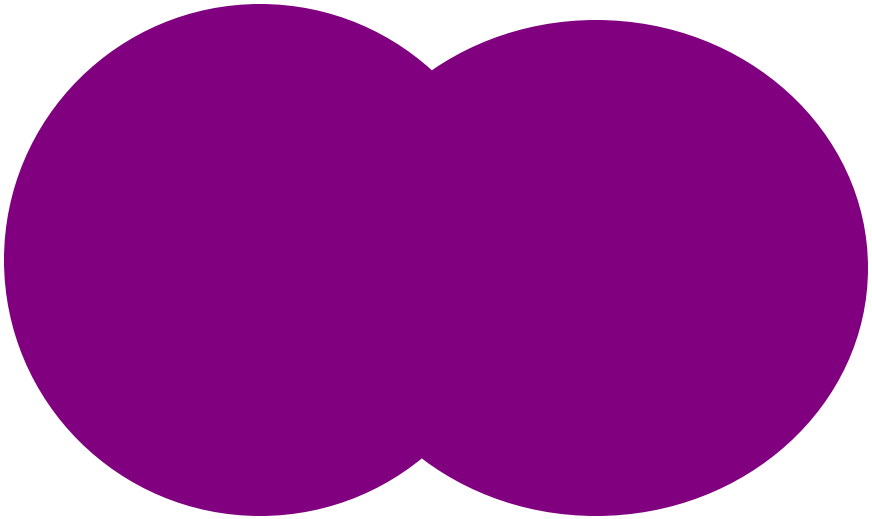
1. Iodine vapor
2. Iodine-hexane: Nonpolar interactions (London forces)



Intermolecular forces 4: Intermolecular forces using I_2

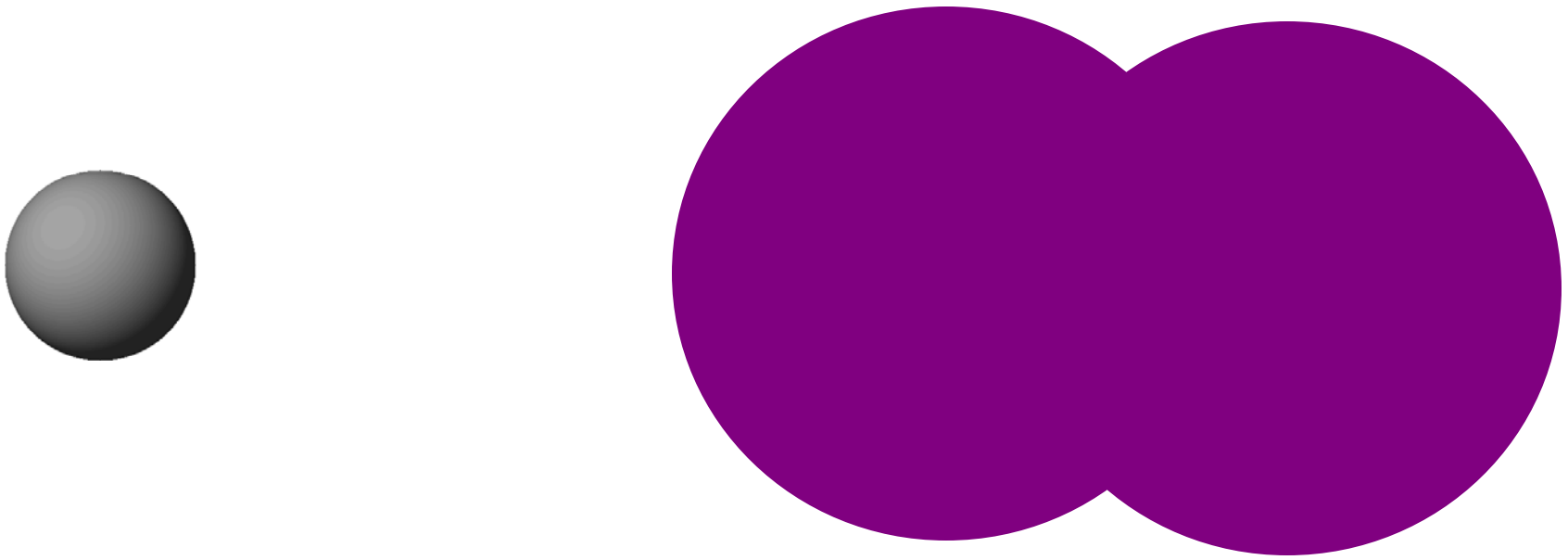
Dipole - Induced dipole





Intermolecular forces 4: Intermolecular forces using I_2

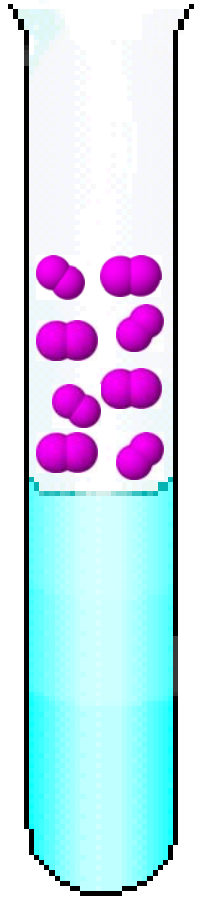
Ion – induced dipole



Intermolecular forces 4: Intermolecular forces using I_2

Solubility preference:

Like dissolves like

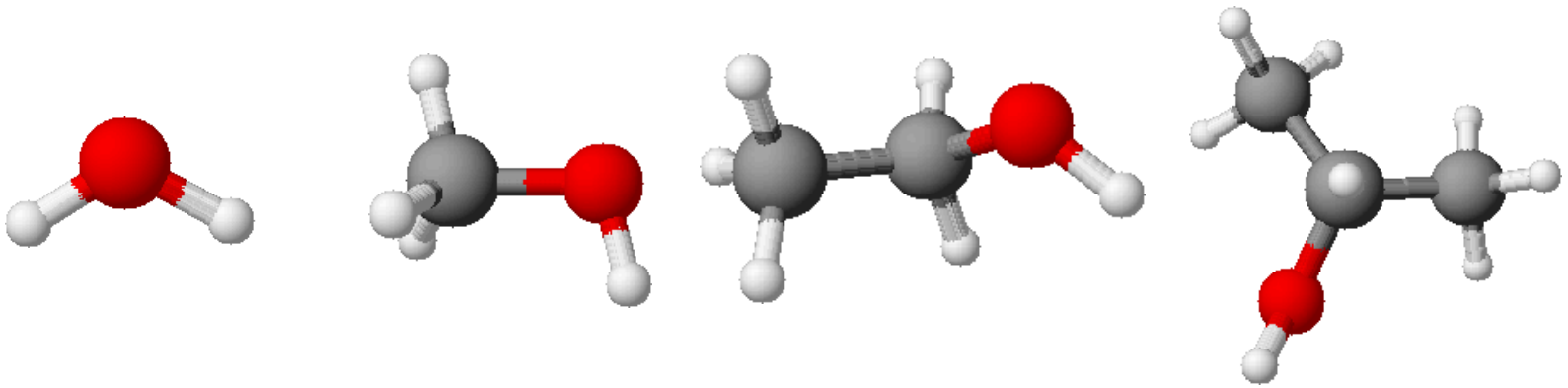


Hexane layer

Water layer

Intermolecular Forces:
Which Will Evaporate First?

What factors affect evaporation?



Water methanol ethanol 2-propanol

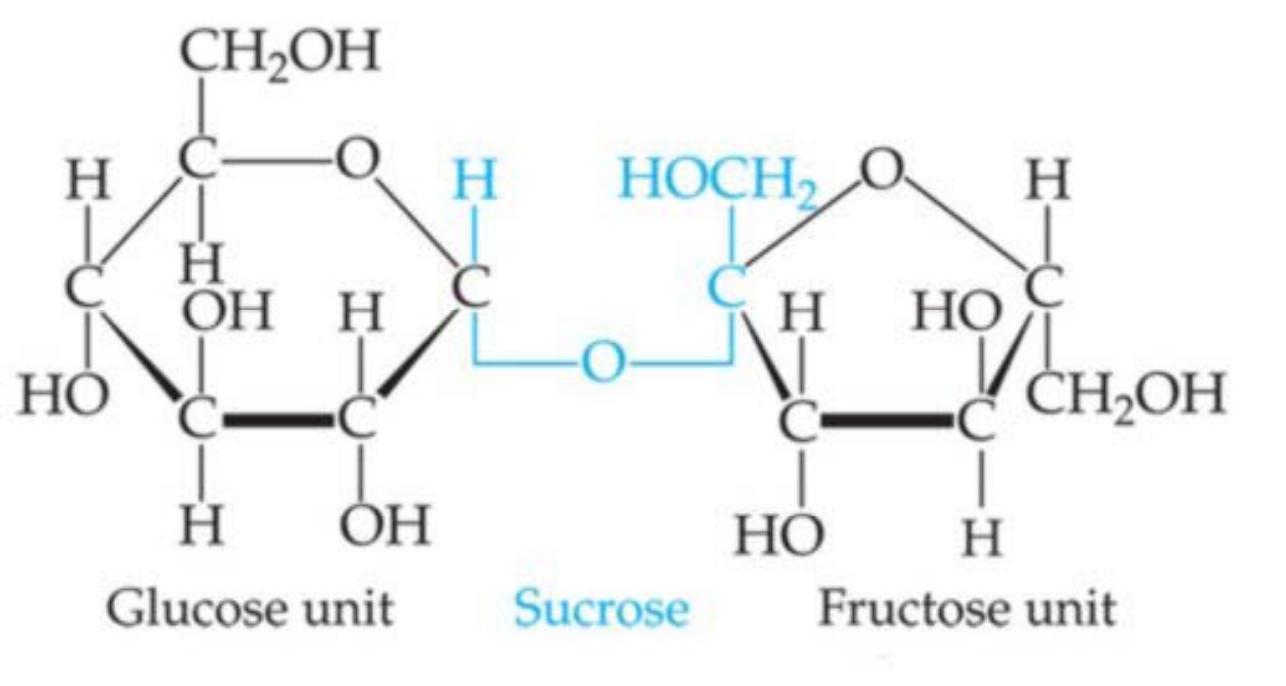
Effect of molecular weight:

$H_2O = 18$ $CH_3OH = 32$ $C_2H_5OH = 46$ $C_3H_8OH = 60$

Effect of polarity

Solutions: Sugar cube

Why does a substance dissolve?



Colorful Catalysis

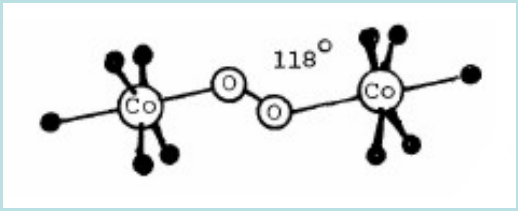
The oxidation of tartaric acid by hydrogen peroxide with a cobalt(II) chloride catalyst

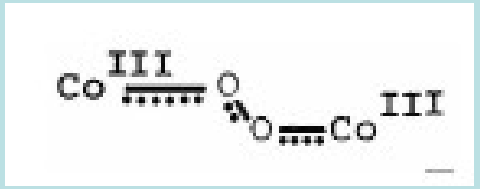
A hypothetical mechanism

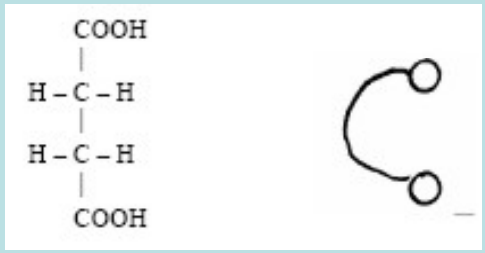
In the presence of H_2O_2 cobalt forms a green complex with a superoxide linkage

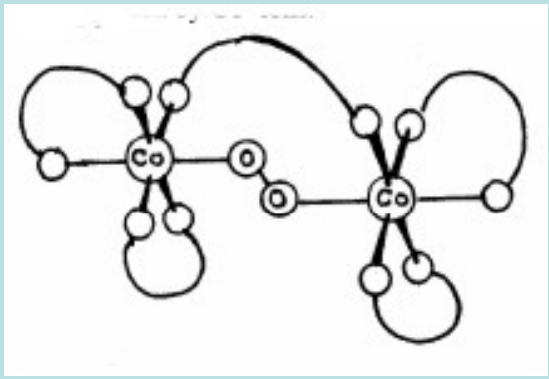
According to literature information the O-O bond length is 131 pm

The tartrate ions bridge the cobalt complex allowing for oxidation of the middle carbons









Chemistry and Light

Red sunset

The Tyndall effect or why your car's tail lights are red

More details of these demonstrations can be found at

http://www.chymist.com

On the left-hand menu, click on

Compleat Chymical Demonstrator
and/or
Magic Into Science

Demonstrations

- Chemistry Book
- A density experiment: Hot and Cold
- Chemistry and Light 1: Overhead projector spectroscope
- Chemistry and Light 2: Overhead Projector Polarimeter
- Intermolecular forces 1: Drops of water on a coin
- Non-burning paper
- Intermolecular forces 2: Decrease in Volume
- Intermolecular forces 3: Chemical reactions: Increase in Volume
- Phenolphthalein red with acid
- Intermolecular forces 4: Intermolecular forces using I_2
- Which will evaporate first?
- Solutions: Sugar cube (this is a magic trick – not on web site)
- Kinetics: Colorful catalysis
- Chemistry and Light 3: Red sunset