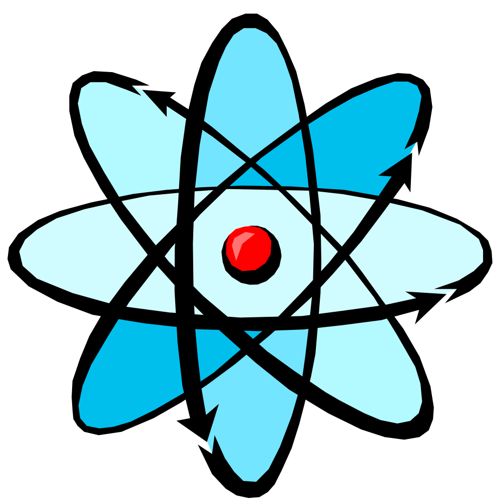
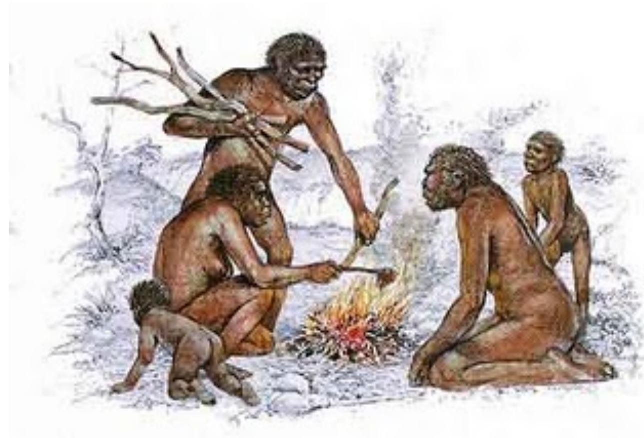
化学

Lecture Notes Chemistry E-1a

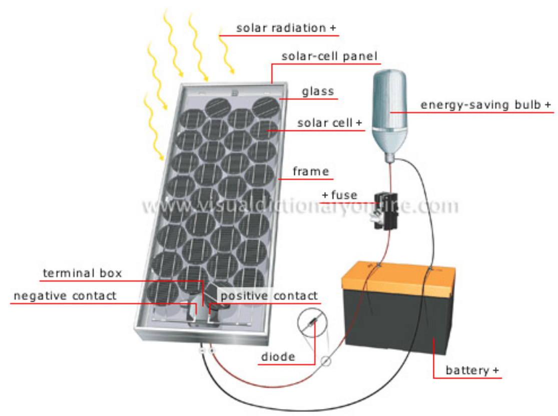
Chapters 1 and 2



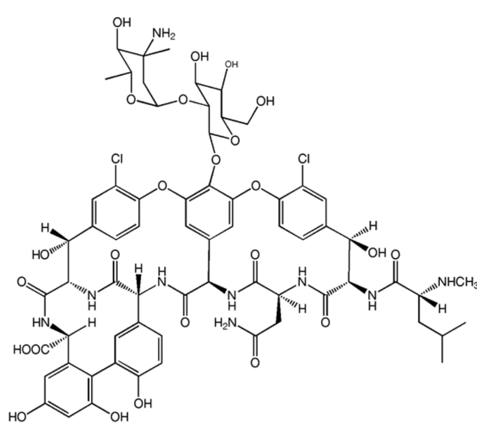
Overview of Important Questions for the Course



http://rakhaingthar360.blogspot.com/2011/01/fire.html



http://visual.merriam-webster.com/images/energy/solar-energy/solar-cell-system.jpg



http://www.3dchem.com/imagesofmolecules/Vancomycin.gif

http://www.taf.org/graphics/vancomycin.jpg

Chemistry E-1 a Introduction

Course Content

Chemistry E-1a is a course in general chemistry which is appropriate for students interested in pursuing graduate school in science, fulfilling entrance requirements for professional, medical, veterinary schools or completing undergraduate degree

Course Organization

Textbook provides much more detail and explains how to solve problems

Lectures give overview of each topic, conceptual background, and demonstrations

Clickers engage you in solving problems during lecture

Laboratory gives hands-on experience and reinforces chemical concepts

Discussion Sections show how to solve problems and give you practice

Practice Problems give you more practice in solving problems

Problem Sets give you practice in problem-solving and feedback on your success

Friday Reviews provides an extra forum problem solving

Examinations evaluate your ability to solve chemistry problems and apply the concepts that you have learned.

How to succeed:

To be studying science you have to have a pencil in your hand writing something. One key to success is going to be working all of the practice problems, homework problems, section problems, and Friday Reviews problems each week so that you are able to master the material.

Course Philosophy

The Balloons: Observations

Two balloons (blue and green) are here in the room. What do you think is in them, Why?

What are the differences between an element, a compound, and a mixture?

Element: is a substance that cannot be decomposed (broken down) into a simpler substance by chemical reactions.

Compound: is a substance that is composed of two or more elements in fixed proportions

Mixture: are combinations of two or more substances.

Does the balloon contain atoms of helium? molecules of helium? What's the difference?

Atoms: smallest particle of an element that can display the properties of the element.

Molecules: two or more atoms joined together.

Molecules of an element: Two or more atoms of the same element joined together:

Molecules of a compound: Two or more atoms of a different elements joined together

Put a box around the molecules of an element and a circle around molecules of a compound:

Hg F_2 HF H_2S

How can we determine the identities of the substances in these two balloons?

Physical Properties: Matter displays these properties without changing composition. Example:

Chemical Properties: Ability or inability of a sample of matter to undergo a change in composition. Example:

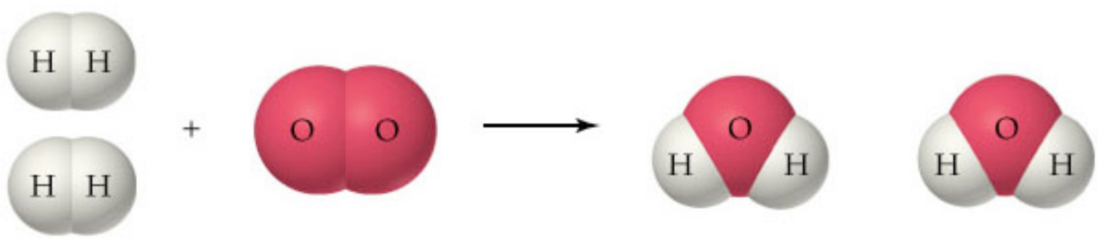
Chemical Changes

What evidence is there that a chemical reaction took place?

What chemical reaction took place?

How can we describe that chemical reaction?

How can we describe it in a picture?



At room temperature hydrogen (H_2) is a gas, oxygen (O_2) is a gas and water (H_2O) is a liquid. Imagine a reaction that happens at room temperature between H_2 and O_2. In this reaction all of the hydrogen and oxygen react completely such that there is only liquid water left at the end of the reaction and there are no molecules of hydrogen or oxygen present. What can we say about the mass of the reactants before the reaction compared to the mass of the products after the reaction.

A. Mass of O_2 and H_2 before the reaction is **greater than** the mass of the liquid water after the reaction.

B. Mass of O_2 and H_2 before the reaction is **equal to** the mass of the liquid water after the reaction.

C. Mass of O_2 and H_2 before the reaction is **less than** the mass of the liquid water after the reaction.

Energy and Power: The Balloon Observations

- Let's consider one more balloon. It contains roughly an equal amount of hydrogen gas as the previous balloon, but it also has some oxygen gas mixed in. What will happen with this balloon is combusted?

- Which one will yielded more energy when combusted?

- What is the difference between the way these two balloons react?

Review Self Quiz

Which of the following true statements describe physical properties and which describes chemical properties. Explain your answer. (*Chang*, **1.41**)

a. Iron has a tendency to rust

b. Hemoglobin molecules have a red color.

c. When a glass of water is left out in the sun, the water gradually disappear.

d. Carbon dioxide in air is converted to more complex molecules by plants during photosynthesis.

Units of Measurement

Here are examples of units for:

Length:

Meter (m): First standardized in late 18th century as one ten-millionth of the distance between the North Pole and the Equator.*

In 1960 re-standardized to as equal the length of a certain kind of light emitted by the element krypton.

Foot (ft): In 1959 foot defined as 0.3048 meters.

Mass:

Gram (g) In late 18th century standardized as the mass of one cubic centimeter of water at 4 ºC

Temperature

Celsius (ºC): Freezing point of water was defined as zero degrees Celsius and boiling point of water was defined as 100 degrees Celsius.

Time

Seconds (s): a second was initially defined as 1/86,400 of a mean solar day.

Volume:

Density:

Energy and Power:

* Wikipedia pages on standards accessed September 2013.

Temperature and Density

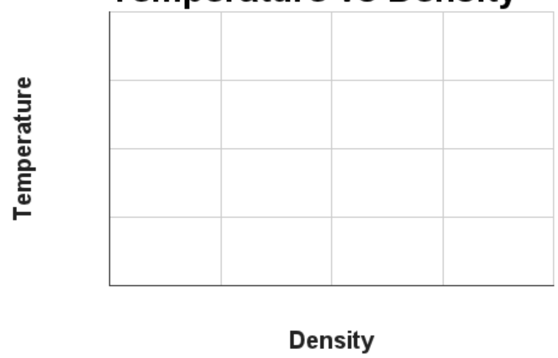
What would a graph of temperature versus density look like?

Use the tabulated data on the element mercury found below to determine which plot (A, B or C) best represents a plot of temperature versus density for mercury.

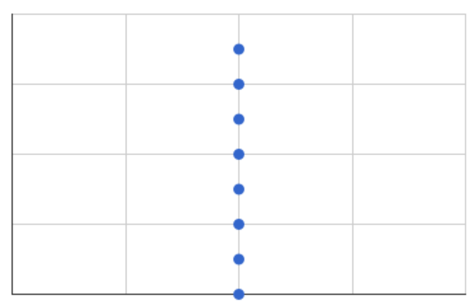
Temp (^{0}C)	Volume (in ml)
0	0.0733
20	0.0736
50	0.0740

Temp (^{0}C)	Mass (grams)
0	1.0
20	1.0
50	1.0

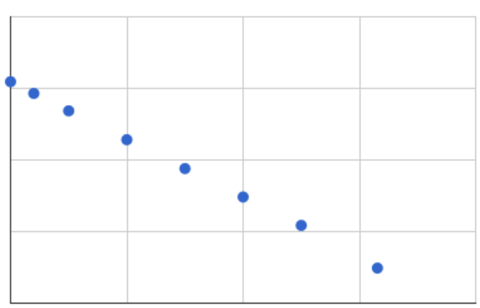
Determine the Plot of Temperature vs Density



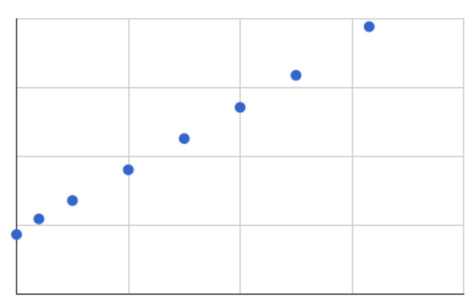
Plot A



Plot B



Plot C



Powers of Ten and Scientific Notation

- One problem with any system of measure is that the sizes of the units often turn out to be inconveniently large or small for the problem at hand. For this reason, metric and SI units can be modified by prefixes to refer to either smaller or larger quantities.

Common Prefixes Used for SI Units

Prefix	Symbol	Meaning	Numerical Value	Scientific Notation
Giga-	G	Billion	1,000,000,000	10^9
Mega-	M	Million	1,000,000	10^6
Kilo-	k	Thousand	1,000	10^3
Deci-	d	Tenth	0.1	10^{-1}
Centi-	c	Hundredth	0.01	10^{-2}
Milli-	m	Thousandth	0.001	10^{-3}
Micro-	μ	Millionth	0.000 001	10^{-6}
Nano-	n	Billionth	0.000 000 001	10^{-9}
Pico-	p	Trillionth	0.000 000 000 001	10^{-12}

- Express the units of the following measurements using the appropriate prefixes:

0.000005 meters

150,000,000,000 meters
(average distance from the earth to the sun)

- A number is written in scientific notation as the product of a number between 1 and 10, times the number 10 raised to a power. For example, 215 is written in scientific notation as 2.15×10^2.

Step 1. Move the decimal point to give a number between 1 and 10.
Step 2. Multiply the result by 10^x, where x is the number of places the decimal point was moved (move left, x is positive; move right, x is negative).

Dimensional Analysis: Introduction

- Often a measurement is recorded in one unit, and then it must be converted to another unit. To convert one unit to another, we use one or more conversion factors.

Original quantity × Conversion factor = Desired quantity

- A conversion factor is a term that converts a quantity in one unit to a quantity in another unit. It is formed by taking an equality and writing it as a fraction.

For example, 60 minutes = 1 hour

- How many minutes are in 3.5 hours?

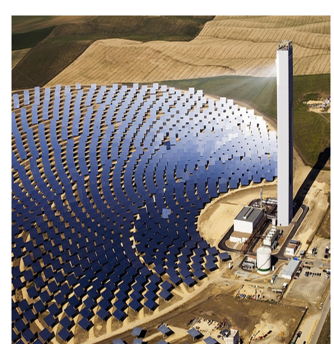
- A 2013 Toyota Hybrid Highlander gets 28 miles per gallon. What is the fuel efficiency of this car in rods per hogshead?

Useful Information:	1 liter = 0.264 gallon	1 km = 0.6213 mile
	1 rod = 5.029 meters	1 hogshead = 238.48 liters

Dimensional Analysis: Solar Thermal Power

- One of the worlds largest concentrated solar thermal power plants is operating in Gila Bend, Arizona. If the united states wanted to use electricity generated by concentrated solar power plants to supply 1/3 of all the energy used by the US in one year, what fraction of land in Arizona would be required to do this? Some conversion factors are below:

US power consumption is 3.27 TW
Efficiency of solar thermal power plant: 30%
Solar energy delivered to Arizona: 7 kW-h/m^2-day
Total Area of Arizona: 2.95 X 10^{11} m^2
1 W = 1 J/s
1 T = 1×10^{12}
1 year = 3.15 X 10^7 s



om/tag/concentrated-solar-thermal/

Atomic Structure and the Periodic Table

All elements are made up of atoms. *What are atoms composed of?*

The nucleus of an atom is composed of protons and in many cases also neutrons.

The **protons** are positively charged particles while the **neutrons** are uncharged particles.

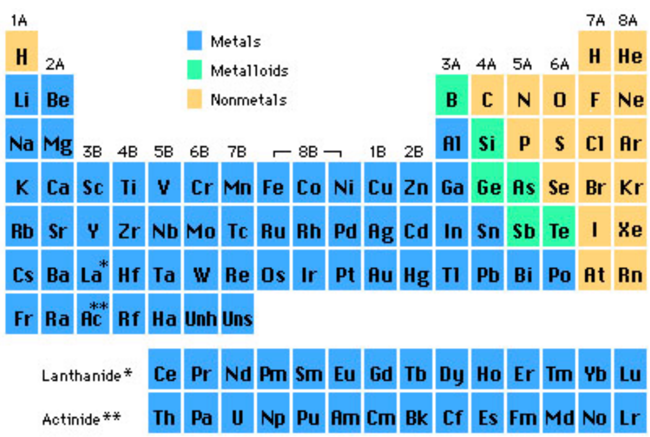
Electrons are negatively charged particles; these exist outside of the nucleus.

An atom is **neutral** if it has the same number of protons and electrons.

- *How can we classify atoms? How are atoms similar and different?*

The number of protons an element has is equal to the **atomic number** of that element.

The elements on the periodic table are arranged by increasing atomic number. Elements that share similar properties are in the same column on the table. Broadly, there are three categories that all elements can be placed into: **Metals, Nonmetals,** and **Metalloids**.



a. What are some properties and examples of metals?

b. What are some properties and examples of nonmetals?

c. True or False: Photovoltaic cells are likely to use elements that are metalloids.

PERIODIC TABLE OF THE ELEMENTS

1 **H** 1.008																	2 **He** 4.003
3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.61	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.91	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	57 **La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.85	75 **Re** 186.21	76 **Os** 190.20	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.20	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226.03	89 **Ac** 227.03	104 **Rf** (261)	105 **Ha** (262)	[106] (263)	[107] (262)	[108] (265)	[109] (266)									

Lanthanide series	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04	71 **Lu** 174.97
Actinide series	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** 237.05	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** (260)

Molecules and Ions

- Molecules are made up of two or more atoms that are nonmetals.

  a. Circle the molecules in the list of materials below

  H H_2 H_2O HF NaH NaF Na CH_4 H_2O_2

  Explain why some of the materials are not molecules:

- Below are three ways that molecules can be represented:

  An **empirical formula** gives the relative number and type of atoms present.

  HO CH CH_2 CH_4 CH_2O

  A **molecular formula** gives the number and type of atoms present in a molecule.

  b. Match the molecular formulas below with their empirical formulas above.

  H_2O_2 C_2H_4 CH_4 CH_2O C_2H_2 C_6H_{12} $C_3H_6O_3$

  A **structural formula** gives the number and type of atoms present in a molecule as well as a description of how the atoms are connected to each other.

  c. Match the structural formula with a molecular formula above.

  H-O-O-H H-C-C-H

- An ion is either an atom or a molecule that has gained or lost electrons so that it has either a positive charge or a negative charge.

  When an atom becomes an ion, it is called a monatomic ion (Cl^-, Mg^{2+}, Na^+, O^{2-})

  When a molecule gains or loses an electron it is called a polyatomic ion (NH_4^+, PO_4^{3-}, SO_4^{2-})

  Ionic compounds can be *composed of either*

  (1) A metal and a non-metal: NaCl, KBr, Na_2O

  (2) A metal and a polyatomic ion $NaNO_3$, K_2SO_4

  (3) Two polyatomic ions $(NH_4)_3PO_4$

Bonus: circle all of the ions in the ionic compounds above

Naming Ionic Compounds

Know the names, formula, and charges of the ions below

Table 2.3 Names and Formulas of Some Common Inorganic Cations and Anions

Cation	Anion
aluminum (Al^{3+})	bromide (Br^-)
ammonium (NH_4^+)	carbonate (CO_3^{2-})
barium (Ba^{2+})	chlorate (ClO_3^-)
cadmium (Cd^{2+})	chloride (Cl^-)
calcium (Ca^{2+})	chromate (CrO_4^{2-})
cesium (Cs^+)	cyanide (CN^-)
chromium(III) or chromic (Cr^{3+})	dichromate ($Cr_2O_7^{2-}$)
cobalt(II) or cobaltous (Co^{2+})	dihydrogen phosphate ($H_2PO_4^-$)
copper(I) or cuprous (Cu^+)	fluoride (F^-)
copper(II) or cupric (Cu^{2+})	hydride (H^-)
hydrogen (H^+)	hydrogen carbonate or bicarbonate (HCO_3^-)
iron(II) or ferrous (Fe^{2+})	hydrogen phosphate (HPO_4^{2-})
iron(III) or ferric (Fe^{3+})	hydrogen sulfate or bisulfate (HSO_4^-)
lead(II) or plumbous (Pb^{2+})	hydroxide (OH^-)
lithium (Li^+)	iodide (I^-)
magnesium (Mg^{2+})	nitrate (NO_3^-)
manganese(II) or manganous (Mn^{2+})	nitride (N^{3-})
mercury(I) or mercurous (Hg_2^{2+})*	nitrite (NO_2^-)
mercury(II) or mercuric (Hg^{2+})	oxide (O^{2-})
potassium (K^+)	permanganate (MnO_4^-)
rubidium (Rb^+)	peroxide (O_2^{2-})
silver (Ag^+)	phosphate (PO_4^{3-})
sodium (Na^+)	sulfate (SO_4^{2-})
strontium (Sr^{2+})	sulfide (S^{2-})
tin(II) or stannous (Sn^{2+})	sulfite (SO_3^{2-})
zinc (Zn^{2+})	thiocyanate (SCN^-)

a. Look at the list of compounds below, put a box around the molecules and circle the ionic compounds.

$NaCl$	KNO_3	N_2O_4	$SiCl_4$	$PbSO_4$	NaH
HCl	$BrCl_3$	XeF_6	CH_3COOH	NH_4NO_2	H_2O

Nomenclature Flowchart

Diatomic Elements: Br_2 I_2 N_2 Cl_2 H_2 O_2 F_2 "Brinclhof"

Greek Prefixes

1	Mono-
2	Di-
3	Tri-
4	Tetra-
5	Penta-
6	Hexa-
7	Hepta-
8	Octa-
9	Nona-
10	Deca-

Does the compound contain more than two elements?

- **no** → **Is the compound ionic (contains a metal) or covalent?**
  - **ionic** → **Does the compound contain a transition metal?**
    - **no** → Name the ions according to the pattern: Element element-ide

      Ex. NaCl Sodium Chloride
      Ex. CaO Calcium Oxide
      Ex. Li_3N Lithium Nitride
    - **yes** → Determine the charge on the cation from the charge on the anion. Then name both ions including a roman numeral.

      Ex. $FeCl_3$ Iron (III) chloride
      Ex. MnO_2 Manganese (IV) Oxide
  - **covalent** → Use greek prefixes to indicate how many of each atom is present according to the pattern: Prefix-element Prefix-element-ide

    Ex. N_2O_5 Dinitrogen pentoxide
    Ex. CCl_4 Carbom tetrachloride
    Ex. CO Carbon monoxide (mono- only necessary for second element)
- **Yes (polyatomic ions)** → **Does the compound contain a transition metal?**
  - **no** → Name both ions (if necessary, consult the polyatomic ions list).

    Ex. $NaHCO_3$ Sodium bicarbonate
    Ex. $Ca_3(PO_4)_2$ Calcium Phosphate
    Ex. NH_4Cl Ammonium Chloride
  - **yes** → Determine the charge on the cation from the charge on the anion. Then name both ions including a roman numeral.

    Ex. $CuSO_4$ Copper (II) sulfate
    Ex. $Fe_2(CO_3)_3$ Iron (III) carbonate

Chem E-1a Nomenclature: What you need to know

Ionic Compounds:
Know the names, symbols, and charges of **all** ions (monatomic and polyatomic ions) that appear in Table 2.2 and Table 2.3 on pages 45-46 of the textbook. Note that the charges of many of the monatomic ions are easy to determine from their position on the periodic table (see Figure 2.10 on page 40 for an example of the trends.) For transition metal ions with multiple oxidation states (e.g. Fe^{2+} and Fe^{3+}) you should be familiar with both the newer system ("iron (II)" and "iron (III)") and the older names ("ferrous" and "ferric"). You should be able to write the names and chemical formulas of any ionic compound formed from any of these ions.

Molecular Compounds:
You should know the names and symbols of all of the nonmetals on the periodic table. (These are the elements shaded blue on the periodic table on page 38 of your textbook.) You should know the Greek prefixes listed in Table 2.4 on page 48 of your textbook, and you should know the rules for naming molecular compounds using these Greek prefixes. You should be able to name and write the chemical formulas for any binary molecular compound. You only need to know the "common" or "non-systematic" names of the molecular compounds water (H_2O) and ammonia (NH_3).

Elemental Diatomic Molecules:
You should know the 7 elemental diatomic molecules: H_2, N_2, O_2, F_2, Cl_2, Br_2, and I_2. These are easiest to "memorize" by noting the position of each on the periodic table: there is hydrogen, and then the other 6 elements form an inverted "L" on the periodic table. Or, alternatively, you could remember the mnemonic "BrINClHOF".

Acids:
You should know the names and formulas of the following acids. HF, HCl, HBr, HI, HNO_3, H_2SO_4, H_3PO_4, and CH_3COOH (acetic acid).

Bases:
You should know the names and formulas of the following bases: NaOH, KOH, $Ba(OH)_2$, and NH_3 (ammonia).

Hydrates:
You do not need to know how to name hydrates.

Organic Compounds:
You do not need to know how to name organic compounds.

Note: The periodic table you will be given on the exams is identical to the one posted on the course website and included in your *Practice Problems*.