Welcome to CEM 141
Dr. JAMES GEIGER

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Office: Room 9 Chemistry

Office Hours: MWF 1:30pm - 2:30pm
and by appointment
CEM 141 website

www.chemistry.msu.edu

click course web page (lower right corner)

click General Chemistry Courses

click CEM 141
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Recitation

• No recitation this week
• Recitation begins next week, after Labor Day
• Work in small groups to solve problems
• Earn a maximum of 5 points per recitation
• Earn a maximum of 50 points for the semester
CONNECT Problem Sets

• You MUST purchase an CONNECT access code

• Problem sets are due Saturdays by 8:00am

• The first problem set is due Saturday, September 8th

• Instructions for registering your access code can be found on the CEM 141 website
Do you need help with CONNECT?

Representatives from McGraw Hill are outside of rooms 103 and 113 in the Chemistry Building this week to help you get started using CONNECT.
Examinations

Exam 1: Monday, September 24th at 7:15pm

Exam 2: Monday, October 22nd at 7:15pm

Exam 3: Monday, November 19th at 7:15pm

Final Exam: Thursday, December 13th at 7:45AM
Grades

Your grade is determined by the total points you earn out of 1000:

• In-Term Exam 180 points each
• Final Exam 250 points
• CONNECT Sets 160 points
• Recitation Problems 50 points
Grades

The grade scale shown below is fixed, guaranteed, and will NOT be curved:

<table>
<thead>
<tr>
<th>Points Range</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 - 800 points</td>
<td>4.0</td>
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<tr>
<td>799 - 740 points</td>
<td>3.5</td>
</tr>
<tr>
<td>739 - 680 points</td>
<td>3.0</td>
</tr>
<tr>
<td>679 - 620 points</td>
<td>2.5</td>
</tr>
<tr>
<td>619 - 560 points</td>
<td>2.0</td>
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<td>559 - 500 points</td>
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<tr>
<td>499 - 440 points</td>
<td>1.0</td>
</tr>
<tr>
<td>439 - 0 points</td>
<td>0.0</td>
</tr>
</tbody>
</table>
Lecture notes 1
Review of Math and calculations

- Units of measurement: SI
- Basic SI measurements
  - Mass (Kg) kilogram
  - Length (m) meter
  - Time (s) second
  - Temperature (K) Kelvin
  - Amount mole
  - Current (A) ampere
Common Derived Units

- Velocity = length/time m/s
- Acceleration = velocity/time m/s²
- Force = mass * acceleration = kg m/s² Newton (N)
- Energy = force*distance = Nm = Kg m²/s² Joule (J)
- Power = energy/time = J/s = = Kg m/s³ Watt (W)
- Frequency = 1/time = s⁻¹ = Hertz (Hz)
- Pressure = force/area = Nm⁻² = Kg/m s⁻² Pascal (Pa)
Prefixes

- pico $10^{-12}$
- micro $10^{-6}$
- milli $10^{-3}$
- Kilo $10^3$
- mega $10^6$
Significant Figures

• Answers should always be rounded to appropriate significant figures.
Significant Figures

• The term significant figures refers to digits that were measured.

• When rounding calculated numbers, we pay attention to significant figures so we do not overstate the precision of our answers.
Significant Figures

1. All nonzero digits are significant. (sig figs in red) 
   423.444

2. Zeroes between two significant figures are themselves significant. 
   42,300045  42,340.0025

3. Zeroes at the beginning of a number are never significant. 
   00042345

4. Zeroes at the end of a number are significant if a decimal point is written in the number. 
   423000 versus: 423000. or: 423000.000
Significant Figures

- When addition or subtraction is performed, answers are rounded to the least significant decimal place.

\[
\begin{align*}
24.245 + 22.33488 &= 46.57988 \\
&= 46.580
\end{align*}
\]

- When multiplication or division is performed, answers are rounded to the number of digits that corresponds to the least number of significant figures in any of the numbers used in the calculation.

\[
\begin{align*}
35.8750 \times 40.006800 &= 1435.24395 \\
&= 1435.24
\end{align*}
\]
Accuracy versus Precision

• **Accuracy** How close a measurement is to the true value. (How right you are)

• **Precision** How close measurements are to each other. (Reproducability)
Dimensional analysis

What do virtually all problems in chemistry have in common?

Dimensional analysis

Convert centimeters to feet: 1 cm = ? feet
Know: 2.54 cm = 1 in, 12 in = 1 foot.

\[
\frac{1\text{ in}}{2.54\text{ cm}} \left( \frac{1\text{ ft}}{12\text{ in}} \right) = 0.032 \frac{\text{ft}}{\text{cm}}
\]
Dimensional Analysis

• What do I need on top?
• What do I need on the bottom?
• What do I know?
• How do I get there?
• Note: You will always be given the conversion factors you need, you don’t have to memorize them.
Dimensional analysis, examples

The speed of light is $2.998 \times 10^8 \text{m/s}$. What is it in km/hr?

Know: $1 \text{ km} = 1000 \text{m}$, $1 \text{m} = 100 \text{cm}$, $60 \text{ min} = 1 \text{ hr}$, $60 \text{ sec} = 1 \text{ min}$

What do I need on top? *meters*

What do I need on the bottom? *hours*

$$2.998 \times 10^8 \ \text{cm/s} \left( \frac{1 \text{m}}{100 \text{cm}} \right) \left( \frac{\text{km}}{1000 \text{m}} \right) \left( \frac{60 \text{ s}}{1 \text{ min}} \right) \left( \frac{60 \text{ min}}{1 \text{ hr}} \right) = 1.079 \times 10^7 \ \frac{\text{km}}{\text{hr}}$$
Dimensional analysis, examples

The Vehicle Assembly Building (VAB) at the Kennedy Space Center has a volume of: 3,666,500 m³. What is it in liters?

Know: 1 L = 1 dm³, 1 dm = 0.1 m

What do I need on top? *Liters*

What do I need on the bottom? *nothing*

\[
3,666,500 \text{ m}^3 = \left(\frac{\text{dm}}{0.1 \text{ m}}\right)^3 \left(\frac{1 \text{ L}}{1 \text{ dm}^3}\right) = 3.6665 \times 10^9 \text{ L}
\]
Dimensional analysis, examples

An individual suffering from high cholesterol has 232 mg cholesterol per 100.0 mL of blood. How many grams of cholesterol in the blood, assuming a blood volume of 5.2 L?

Know: 1 L = 1000 mL, 1 g = 1000 mg

What do I need on top? grams

What do I need on the bottom? patient

\[
232 \frac{mg}{100.0\ mL} = \left( \frac{1000\ mL}{1\ L} \right) \left( \frac{5.2\ L_{blood}}{patient} \right) \left( \frac{1\ g}{1000\ mg} \right) = 12. \ \frac{g}{patient}
\]
Scientific notation

• The custom is to write answers in scientific notation
• Means that only 1 number after decimal
• Examples:
  • $63.51 = 6.351 \times 10^1$
  • $0.0271 = 2.71 \times 10^{-2}$
  • $10068 = 1.0068 \times 10^4$
Matter

Substance

Element

Compound

Mixture of Substances

physical separation

Homogeneous solution

Perfectly mixed. Same properties throughout

Heterogeneous solution

More than one phase.

chemical separation

113 different
Cannot be decomposed into simpler substances (by chemistry)
**Elements**

- Cannot be decomposed by chemistry
- Each element has a symbol, 1 or 2 letters
- The smallest particle is an atom.
- The **Atom** is indivisible by chemistry
- Elements are found in nature as:
  - Diatomic molecules (H₂ N₂ F₂ Cl₂)
  - Discrete molecular clusters (P₄ S₈)
  - Solids (the metals, gold Au, sodium N, etc.)
• $\text{H}_2 + \frac{1}{2}\text{O}_2 \rightarrow \text{H}_2\text{O}$

Elements

compound

unique properties

can be decomposed into

simpler substances
Molecules

- Each **element** is made of the same kind of atom.
- Molecule of oxygen, cluster of 2 O atoms tightly bound.
Molecules

- Molecular **compounds**, made of two or more different kinds of elements tightly bound together.
Compounds

• Two main types
  – Molecular
  – Ionic
  – Defined by what holds the atoms together

Each compound has a formula indicating the composition (amount of each element) in the compound.

• $H_2O$
• $CO_2$ Molecular compounds
• $CH_4$
• $NaCl$ Ionic Compounds
• $CuCl$
Properties of Matter

- Physical Properties:
  - Must be observed without changing a compound/element into another compound/element.
    - Boiling point, density, mass, volume, etc.
- Chemical Properties:
  - Can only be observed when a compound/element is changed into another compound/element.
    - Flammability, corrosiveness, reactivity with acid, etc.
Properties of Matter

• Intensive Properties:
  - Independent of the amount of the matter that is present.
    - **Density, boiling point, color, etc.**

• Extensive Properties:
  - Dependent upon the amount of the matter present.
    - **Mass, volume, energy, etc.**
Changes of Matter

• Physical Changes:
  □ Changes in matter that do not change the composition of a substance.
  • Changes of state, temperature, volume, etc.

• Chemical Changes:
  □ Changes that result in new substances.
  • Combustion, oxidation, decomposition, etc.
Atomic Theory of Matter

The theory of atoms:
Original to the Greeks
Leucippus, Democritus and Lucretius
(Aristotle thought they were nuts)
He believed that one could divide up a piece of matter an infinite number of times, that is, one never came up with a piece of matter that could not be further divided. He suggested that everything in the world was made up of some combination of four elements: earth, fire, water, and air. The elements were acted upon by the two forces of gravity and levity. Gravity was the tendency for earth and water to sink, and levity the tendency for air and fire to rise.

John Dalton (1805-1808)
Revived the idea and made it science by measuring the atomic weights of 21 elements.

That’s the key thing because then you can see how elements combine.
Dalton’s Postulates

Each element is composed of extremely small particles called atoms.

Tiny balls make up the world
Dalton’s Postulates

All atoms of a given element are identical to one another in mass and other properties, but the atoms of one element are different from the atoms of all other elements.

O

N
Dalton’s Postulates

Atoms of an element are not changed into atoms of a different element by chemical reactions; atoms are neither created nor destroyed in chemical reactions. (As far as Dalton knew, they couldn’t be changed at all).

Red O’s stay Os and aqua N’s stay N’s.
Dalton’s Postulates

Compounds are formed when atoms of more than one element combine; a given compound always has the same relative number and kind of atoms.

Chemistry happens when the balls rearrange.
Law of Constant Composition
Joseph Proust (1754–1826)

• Also known as the law of definite proportions.
• The elemental composition of a pure substance never varies.
• The relative amounts of each element in a compound doesn’t vary.

ammonia always has 3 H and 1 N.
Law of Conservation of Mass

The total mass of substances present at the end of a chemical process is the same as the mass of substances present before the process took place.

$$3\text{H}_2 + \text{N}_2 \rightarrow 2\text{NH}_3$$

ammonia

The atoms on the left all appear on the right.
The Electron

- Streams of negatively charged particles were found to emanate from cathode tubes.
- J. J. Thompson (1897).
- Maybe atoms weren’t completely indivisible after all.
The Atom, circa 1900:

- “Plum pudding” model, put forward by Thompson.
- Positive sphere of matter with negative electrons imbedded in it.
- most of the volume = positive stuff because most of the mass is positive
- **Expectation:** density more or less uniform throughout.
Discovery of the Nucleus
The Gold Foil Experiment

Ernest Rutherford shot $\alpha$ particles at a thin sheet of gold foil and observed the pattern of scatter of the particles.
The Nuclear Atom

Virtually all the particles went straight through.
Most of the atom essentially empty.
A few particles deflected, some straight back.
A very small part of the atom is very dense, impenetrable.
The mass must be concentrated.
The size of nucleus will be proportional to the # of highly scattered versus not.
The Nuclear Atom

- Rutherford postulated a very small, dense nucleus with the negative electrons around the outside of the atom.
- Most of the volume of the atom is empty space.
Other Subatomic Particles

• Protons were discovered by Rutherford in 1919. Have the positive charge in the atom.

• Neutrons were discovered by James Chadwick in 1932. Have mass like proton, but no charge. Why was it harder to discover them?
Subatomic Particles

• Protons and electrons are the only particles that have a charge.
• Protons and neutrons have similar mass.
• The mass of an electron is so small we can often ignore it.

<table>
<thead>
<tr>
<th>Particle</th>
<th>Charge</th>
<th>Mass (amu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proton</td>
<td>Positive (1+)</td>
<td>1.0073</td>
</tr>
<tr>
<td>Neutron</td>
<td>None (neutral)</td>
<td>1.0087</td>
</tr>
<tr>
<td>Electron</td>
<td>Negative (1−)</td>
<td>$5.486 \times 10^{-4}$</td>
</tr>
</tbody>
</table>
Symbols of Elements

Elements are symbolized by one or two letters.

Mass number (number of protons plus neutrons)

Atomic number (number of protons or electrons)
All atoms of the same element have the same number of protons:
The atomic number (Z)
The mass of an atom in atomic mass units (amu) is approximately the total number of protons and neutrons in the atom.
Isotopes:

- Elements are defined by the number of protons.
- Isotopes are atoms of the same element with different masses.
- Isotopes have different numbers of neutrons.

<table>
<thead>
<tr>
<th>Carbon Isotope</th>
<th>Neutrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{11}_6\text{C}$</td>
<td>5</td>
</tr>
<tr>
<td>$^{12}_6\text{C}$</td>
<td>6</td>
</tr>
<tr>
<td>$^{13}_6\text{C}$</td>
<td>7</td>
</tr>
<tr>
<td>$^{14}_6\text{C}$</td>
<td>8</td>
</tr>
</tbody>
</table>
Average Mass

• Because in the real world all the elements exist as mixtures of isotopes.
• And we measure many many atoms at a time

“Natural abundance”

• Average mass is calculated from the isotopes of an element weighted by their relative abundances.
### Average mass, example

<table>
<thead>
<tr>
<th>Isotope</th>
<th>abundance</th>
<th>Atomic mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{24}\text{Mg}$</td>
<td>78.99%</td>
<td>23.98504 amu</td>
</tr>
<tr>
<td>$^{25}\text{Mg}$</td>
<td>10.00%</td>
<td>24.98584 amu</td>
</tr>
<tr>
<td>$^{26}\text{Mg}$</td>
<td>11.01%</td>
<td>25.98259 amu</td>
</tr>
</tbody>
</table>

Given the above data, what is the average molecular mass of magnesium (Mg)?

$$0.7899(23.98504)+0.1000(24.98584)+0.1101(25.98259)=18.95 + 2.499 + 2.861 = 24.31$$
Periodic Table:

- A systematic catalog of elements.
- Elements are arranged in order of atomic number.
- But why like this?
When one looks at the chemical properties of elements, one notices a repeating pattern of reactivities.
The rows on the periodic chart are periods.
Columns are groups.
Elements in the same group have similar chemical properties.
Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Name</th>
<th>Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>Alkali metals</td>
<td>Li, Na, K, Rb, Cs, Fr</td>
</tr>
<tr>
<td>2A</td>
<td>Alkaline earth metals</td>
<td>Be, Mg, Ca, Sr, Ba, Ra</td>
</tr>
<tr>
<td>6A</td>
<td>Chalcogens</td>
<td>O, S, Se, Te, Po</td>
</tr>
<tr>
<td>7A</td>
<td>Halogens</td>
<td>F, Cl, Br, I, At</td>
</tr>
<tr>
<td>8A</td>
<td>Noble gases (or rare gases)</td>
<td>He, Ne, Ar, Kr, Xe, Rn</td>
</tr>
</tbody>
</table>

These five groups are known by their names. You gotta know these very well.
Nonmetals are on the upper right-hand corner of the periodic table (with the exception of H).
Metalloids border the stair-step line (with the exception of Al and Po, which are both metals).
Metals are on the left side of the chart.
Chemical Formulas

The subscript to the right of the symbol of an element tells the number of atoms of that element in the compound.
Molecular Compounds

Molecular compounds are composed of molecules and almost always contain only nonmetals.

- Water, H₂O
- Carbon dioxide, CO₂
- Carbon monoxide, CO
- Methane, CH₄
- Hydrogen peroxide, H₂O₂
- Oxygen, O₂
Diatomic Molecules

These seven elements occur naturally as molecules containing two atoms.

You should know these guys.
Types of Formulas

• Empirical formulas give the lowest whole-number ratio of atoms of each element in a compound.

• Molecular formulas give the exact number of atoms of each element in a compound.

Example: ethane:

Empirical formula: \( \text{CH}_3 \)
Molecular formula: \( \text{C}_2\text{H}_6 \)
Structural Formulas

• Show how the atoms are bound together

Ethane  molecular formula $C_2H_6$
empirical formula:  $CH_3$

Benzene  molecular formula  $C_6H_6$
empirical formula:  $CH$
Nomenclature of Binary Compounds

- Elements closest to the bottom left of periodic table go 1\textsuperscript{st}.
- A prefix is used to denote the number of atoms of each element in the compound (\textit{mono}- is not used on the first element listed, however.)

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mono-</td>
<td>1</td>
</tr>
<tr>
<td>Di-</td>
<td>2</td>
</tr>
<tr>
<td>Tri-</td>
<td>3</td>
</tr>
<tr>
<td>Tetra-</td>
<td>4</td>
</tr>
<tr>
<td>Penta-</td>
<td>5</td>
</tr>
<tr>
<td>Hexa-</td>
<td>6</td>
</tr>
<tr>
<td>Hepta-</td>
<td>7</td>
</tr>
<tr>
<td>Octa-</td>
<td>8</td>
</tr>
<tr>
<td>Nona-</td>
<td>9</td>
</tr>
<tr>
<td>Deca-</td>
<td>10</td>
</tr>
</tbody>
</table>
Nomenclature of Binary Compounds (two nonmetals)

- The ending on the more electronegative element is changed to -ide.
  - CO₂: carbon dioxide
  - CCl₄: carbon tetrachloride

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<td>9</td>
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<tr>
<td>Deca-</td>
<td>10</td>
</tr>
</tbody>
</table>
Nomenclature of Binary Compounds

If the prefix ends with a or o and the name of the element begins with a vowel, the two successive vowels are often merged into one:

\[ \text{N}_2\text{O}_5: \text{ dinitrogen pentoxide} \]

not: dinitrogen pentaoxide

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<td>5</td>
</tr>
<tr>
<td>Hexa-</td>
<td>6</td>
</tr>
<tr>
<td>Hepta-</td>
<td>7</td>
</tr>
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<td>Nona-</td>
<td>9</td>
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<tr>
<td>Deca-</td>
<td>10</td>
</tr>
</tbody>
</table>
When atoms lose or gain electrons, they become ions. Often they lose or gain electrons to have the same number of electrons as the nearest noble gas.

- Cations are positive and are formed by elements on the left side of the periodic chart (metals).
- Anions are negative and are formed by elements on the right side of the periodic chart (nonmetals).
Mono-atomic ions

- Metals usually become cations (+)
- Nonmetals usually become anions (-)
Ionic compounds

- A metal will give up electrons to a nonmetal forming a cation (+) (the metal), and an anion (-) (the nonmetal).

\[
\begin{align*}
\text{Na} + \text{Cl} & \rightarrow \text{Na}^+ + \text{Cl}^- & \rightarrow \text{NaCl} \\
\text{Mg} + 2\text{Cl} & \rightarrow \text{Mg}^{2+} + 2\text{Cl}^- & \rightarrow \text{MgCl}_2
\end{align*}
\]

Note, everybody gains or loses electrons to be like the nearest noble gas.

Compounds are always electrically neutral!!
Writing Formulas

- Because compounds are electrically neutral, one can determine the formula of a compound this way:
  - The charge on the cation becomes the subscript on the anion.
  - The charge on the anion becomes the subscript on the cation.
  - If these subscripts are not in the lowest whole-number ratio, divide them by the greatest common factor.

\[
\text{Mg}^{2+} \quad \text{O}^{2-} \quad \rightarrow \quad \text{MgO} \quad \text{Not Mg}_2\text{O}_2
\]
# Common Cations

<table>
<thead>
<tr>
<th>Charge</th>
<th>Formula</th>
<th>Name</th>
<th>Formula</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1+</td>
<td>★H⁺</td>
<td>Hydrogen ion</td>
<td>★NH₄⁺</td>
<td>Ammonium ion</td>
</tr>
<tr>
<td></td>
<td>★Li⁺</td>
<td>Lithium ion</td>
<td>★Cu⁺</td>
<td>Copper(I) or cuprous ion</td>
</tr>
<tr>
<td></td>
<td>★Na⁺</td>
<td>Sodium ion</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>★K⁺</td>
<td>Potassium ion</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>★Cs⁺</td>
<td>Cesium ion</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>★Ag⁺</td>
<td>Silver ion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2+</td>
<td>★Mg²⁺</td>
<td>Magnesium ion</td>
<td>Co²⁺</td>
<td>Cobalt(II) or cobaltous ion</td>
</tr>
<tr>
<td></td>
<td>★Ca²⁺</td>
<td>Calcium ion</td>
<td>★Cu²⁺</td>
<td>Copper(II) or cupric ion</td>
</tr>
<tr>
<td></td>
<td>★Sr²⁺</td>
<td>Strontium ion</td>
<td>★Fe²⁺</td>
<td>Iron(II) or ferrous ion</td>
</tr>
<tr>
<td></td>
<td>★Ba²⁺</td>
<td>Barium ion</td>
<td>Mn²⁺</td>
<td>Manganese(II) or manganous ion</td>
</tr>
<tr>
<td></td>
<td>★Zn²⁺</td>
<td>Zinc ion</td>
<td>Hg²⁺</td>
<td>Mercury(I) or mercurous ion</td>
</tr>
<tr>
<td></td>
<td>★Cd²⁺</td>
<td>Cadmium ion</td>
<td>Hg₂⁻</td>
<td>Mercury(II) or mercuric ion</td>
</tr>
<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td>3+</td>
<td>★Al³⁺</td>
<td>Aluminum ion</td>
<td>★Cr³⁺</td>
<td>Chromium(III) or chromic ion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>★Fe³⁺</td>
<td>Iron(III) or ferric ion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The most common ions are in boldface.

*You should know these.*
# Common Anions

<table>
<thead>
<tr>
<th>Charge</th>
<th>Formula</th>
<th>Name</th>
<th>Formula</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1−</td>
<td><em>H^−</em></td>
<td>Hydride ion</td>
<td><em>C_2H_3O_2^−</em></td>
<td>Acetate ion</td>
</tr>
<tr>
<td></td>
<td><em>F^−</em></td>
<td>Fluoride ion</td>
<td><em>ClO_3^−</em></td>
<td>Chlorate ion</td>
</tr>
<tr>
<td></td>
<td><em>Cl^−</em></td>
<td>Chloride ion</td>
<td><em>ClO_4^−</em></td>
<td>Perchlorate ion</td>
</tr>
<tr>
<td></td>
<td><em>Br^−</em></td>
<td>Bromide ion</td>
<td><em>NO_3^−</em></td>
<td>Nitrate ion</td>
</tr>
<tr>
<td></td>
<td><em>I^−</em></td>
<td>Iodide ion</td>
<td><em>MnO_4^−</em></td>
<td>Permanganate ion</td>
</tr>
<tr>
<td></td>
<td><em>CN^−</em></td>
<td>Cyanide ion</td>
<td><em>ClO_2</em></td>
<td>Chlorite</td>
</tr>
<tr>
<td></td>
<td><em>OH^−</em></td>
<td>Hydroxide ion</td>
<td><em>ClO</em></td>
<td>Hypochlorite</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>CO_3^{2−}</em></td>
<td>Carbonate ion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>CrO_4^{2−}</em></td>
<td>Chromate ion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Cr_2O_7^{2−}</em></td>
<td>Dichromate ion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>SO_4^{2−}</em></td>
<td>Sulfate ion</td>
</tr>
<tr>
<td>2−</td>
<td><em>O^{2−}</em></td>
<td>Oxide ion</td>
<td><em>PO_4^{3−}</em></td>
<td>Phosphate ion</td>
</tr>
<tr>
<td></td>
<td>*O_2^{2−}</td>
<td>Peroxide ion</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>S^{2−}</em></td>
<td>Sulfide ion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3−</td>
<td><em>N^{3−}</em></td>
<td>Nitride ion</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The most common ions are in boldface.

*You should know these.*
More polyatomic anions

<table>
<thead>
<tr>
<th>Anion</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCN⁻</td>
<td>Thiocyanate</td>
</tr>
<tr>
<td>NO₂⁻</td>
<td>Nitrite</td>
</tr>
<tr>
<td>SO₃²⁻</td>
<td>sulfite</td>
</tr>
<tr>
<td>HSO₃⁻</td>
<td>bisulfite</td>
</tr>
<tr>
<td>HSO₄⁻</td>
<td>bisulfate</td>
</tr>
<tr>
<td>HCO₃⁻</td>
<td>bicarbonate</td>
</tr>
<tr>
<td>HPO₄²⁻</td>
<td>Hydrogen phosphate</td>
</tr>
<tr>
<td>H₂PO₄⁻</td>
<td>Dihydrogen phosphate</td>
</tr>
<tr>
<td>ClO⁻</td>
<td>hypochlorite</td>
</tr>
<tr>
<td>ClO₂⁻</td>
<td>chlorite</td>
</tr>
</tbody>
</table>
Patterns in Oxyanion Nomenclature

• When there are only two oxyanions involving the same element:
  – The one with fewer oxygens ends in -ite
    • NO$_2^-$: nitrite; SO$_3^{2-}$: sulfite
  – The one with more oxygens ends in -ate
    • NO$_3^-$: nitrate; SO$_4^{2-}$: sulfate
Patterns in Oxyanion Nomenclature

When there are more than two:

- The one with the fewest oxygens has the prefix *hypo*- and ends in *-ite*
  - $\text{ClO}^-$: hypochlorite
- The one with the second fewest oxygens ends in *-ite*
  - $\text{ClO}_2^-$: chlorite
- The one with the second most oxygens ends in *-ate*
  - $\text{ClO}_3^-$: chlorate
- The one with the most oxygens has the prefix *per*- and ends in *-ate*
  - $\text{ClO}_4^-$: perchlorate
Inorganic Nomenclature

• Write the name of the cation.
• If the anion is an element, change its ending to \textit{ide}; if the anion is a polyatomic ion, simply write the name of the polyatomic ion.
• If the cation can have more than one possible charge, write the charge as a Roman numeral in parentheses.
Examples
naming inorganic compounds

• Write the name of the cation.
• If the anion is an element, change its ending to -ide; if the anion is a polyatomic ion, simply write the name of the polyatomic ion.
• If the cation can have more than one possible charge, write the charge as a Roman numeral in parentheses.

NaCl  sodium chloride
NH₄NO₃ ammonium nitrate
Fe(SO₄) Iron(II) sulfate
KCN  potassium cyanide
RbOH  Rubidium hydroxide
LiC₂H₃O₂ lithium acetate
NaClO₃ sodium chlorate
NaClO₄ sodium perchlorate
K₂CrO₄ potassium chromate
NaH  Sodium hydride
Examples
naming inorganic compounds

• Write the name of the cation.
• If the anion is an element, change its ending to -ide; if the anion is a polyatomic ion, simply write the name of the polyatomic ion.
• If the cation can have more than one possible charge, write the charge as a Roman numeral in parentheses.

potassium permanganate $\text{KMnO}_4$
Calcium carbonate $\text{CaCO}_3$
Calcium bicarbonate $\text{Ca(HCO}_3\text{)}_2$
ammonium dichromate $\text{NH}_4(\text{Cr}_2\text{O}_7)$
potassium phosphate $\text{K}_3\text{PO}_4$
Lithium oxide $\text{Li}_2\text{O}$ (O$^{2-}$ is the anion)
sodium peroxide $\text{Na}_2\text{O}_2$ (O$^{2-}_2$ is the anion)
Calcium sulfide $\text{CaS}$
Hydrogen

- H can be cation or anion
- H⁻ hydride
- H⁺ (the cation of an inorganic compound) makes an acid, naming different.
Acid Nomenclature

• If the anion in the acid ends in \(-ide\), change the ending to \(-ic\) acid and add the prefix \textit{hydro-}:
  - HCl: hydrochloric acid
  - HBr: hydrobromic acid
  - HI: hydroiodic acid
Acid Nomenclature

- If the anion in the acid ends in -\textit{ate}, change the ending to -\textit{ic acid}:
  - \textit{HClO}_3: chloric acid
  - \textit{HClO}_4: perchloric acid
Acid Nomenclature

- If the anion in the acid ends in -ite, change the ending to -ous acid:
  - HClO: hypochlorous acid
  - HClO₂: chlorous acid
Ionic Bonds

Ionic compounds (such as NaCl) are generally formed between metals and nonmetals.
Barking Dog

\[ 2\text{HNO}_3 + 2\text{Cu} \rightarrow \text{NO} + \text{NO}_2 + 2\text{Cu}^{2+} + 2\text{H}^+ \]

\[ 3\ \text{NO} + \text{CS}_2 \rightarrow \frac{3}{2} \text{N}_2 + \text{CO} + \text{SO}_2 + \frac{1}{8} \text{S}_8 \]

\[ 4\ \text{NO} + \text{CS}_2 \rightarrow 2\ \text{N}_2 + \text{CO}_2 + \text{SO}_2 + \frac{1}{8} \text{S}_8 \]
In the course of a chemical reaction, the reacting substances are converted to new substances.
Compounds can be broken down into elements.
After Lecture 2 you should be able to answer:

questions # 4 and 6
from Examination 1, Spring 2007
General Information

This is a first, introductory course in General Chemistry
No knowledge of Chemistgry is assumed
Fullfills the requirements for many degrees:

NOT meant for: Biochemistry, Chemistry (BS), or Chemical Engineering degrees
A 1.0 in CEM 141 required to go on to CEM 142 and 143

Lectures
Six Lecture series throughout the day. This one is 6-7:20 pm.
Every effort will be made to keep all of these lectures on the same schedule.
Attendance is expected, but not recorded.

General Chemistry Office
General information and assistance is available at the General Chemistry Office
Room 185 (M-F 8-12 noon and 1-5 pm; tel 5-9715 ext 323).
General Chemistry Coordinator Wendy Whitford email: tsuji@chemistry.msu.edu
Undergraduate Program Manager Steve Poulios email: poullos@msu.edu
See these guys for purchasing exam books, scheduling, grades, pretty much any administrative questions. They are very competent!
CEM 141 Joins the new era!

- **CEM 141 web site** [http://www.cem.msu.edu](http://www.cem.msu.edu) Go to Course Web Pages (at lower right), then General Chemistry Courses, then CEM 141.
- **Cemscores web site** From any computer on campus, enter cemscores as the url. From computers off-campus, you can access the site through the CEM 141 web site.
- **CONNECT© problem sets web site** Use the access code purchased with the textbook and instructions posted separately to complete your problem sets.
- **CEM 141 Social Media sites** Twitter @MSUCEM141
- Facebook [http://www.facebook.com/MichiganStateUniversityCem141](http://www.facebook.com/MichiganStateUniversityCem141)
- **Textbook**
  The text assigned to CEM 141 is Volume 1 of *Chemistry by Hunter & Pollock* (ISBN 0078043980 McGraw-Hill). This volume contains only that portion of the regular text that is relevant to CEM 141. It is recommended that you purchase the text bundled with the CONNECT access code (ISBN 0077705092) — reducing the total cost. Note that a CONNECT access code is required, and can be purchased separately (ISBN 0077762304).
- **Lecture Notes** that closely follow each lecture throughout the semester are available at the bookstores (ISBN 9780963047137 $10). These notes are intended to make it easier for you to follow the lectures - you should supplement them with your own notes during lecture. **Get them!!**
Recitations

• Your recitation time in on your schedule, the time that is NOT MW 6 pm.
• Limited to about 30 students
• You can directly ask questions and discuss the course material.
• Attendance at the recitation section for which you are enrolled is expected!
• Strive to participate actively!
• relevant exam questions will be presented.
• You will receive credit for your attempts to answer the questions — 5 points for each problem set, maximum 50 points (5% of grade).
• Recitations will start during the second week of the semester (after Labor Day). **DON’T GO THIS WEEK, YOU WILL BE LONELY.**
• Laboratory
• The laboratory associated with this class is CEM 161 but concurrent enrollment is not required (CEM 161 requires separate enrollment). The CEM 161 labs start during the second week of the semester.
• That is everything I know about the lab. I have nothing to do with it.
Connect on line homework

- (CONNECT© Homework)
  - Eleven problem sets will be issued this term.
  - no make-ups or extensions!
  - You can work and study together
  - but you are responsible for completing your own set of questions
  - Due time: Saturday mornings at 8:00 am. Due-dates are noted on the calendar.
  - It is essential to do these problems—essential for success.
  - they will contribute 16% to your final grade in the course. You must complete all the CONNECT problem sets correctly to obtain the full 160 points.
Examinations

• Three one-hour examinations (worth 180 points each)
• 7:15 pm on Monday evenings (see calendar)
• 1 Final examination at the end of the course (worth 250 points)
• Rooms will be announced later.
• Absence from an examination because of illness must be substantiated by a physician.
• Absence due to extenuating circumstance must be preapproved.
• Alternate exams are offered the Monday mornings or the exam at 6:45 am if you have a scheduling conflict.
• If you cannot take the alternate exam, you will be assigned a score based upon a weighted average of your other two examinations or the final exam, whichever is lower.
• Only one exam may be missed—if a second (or third) exam is missed the grade on that exam will be zero. Students registered with RCPD must start the exams early so that they finish at the scheduled time.
Grades

• The grade you receive in this course will be calculated from the total number of points out of 1000:
  • In-term Exams 180 each Final Exam 250 Problem sets 160 Recitation 50
  • You must take the final exam **at the assigned time to achieve a passing grade in the course**
  • Each CONNECT problem is worth 1 point for a total of 160 points. The deadline for reporting grade discrepancies with CONNECT problem sets and recitation scores on cemscores is the last day of class. The grade scale shown below is fixed, guaranteed, and will not be curved:

  • 1000 – 800 4.0: 739 – 680 3.0: 619 – 560 2.0: 499 – 440 1.0
  • 799 – 740 3.5: 679 – 620 2.5: 559 – 500 1.5: 439 – 0 0.0
Other help and motivation

• **Help Room**
  Help with the chemistry in CEM 141 is available from the instructors in the Help Room (Room 83 in the basement). The schedule will be posted outside the room. Use the Help Room as much as you like!

• **Learning Resources Center**
  Free tutoring is available at the Learning Resources Center in Bessey Hall and in several residence halls on campus. In each week preceding an examination, the Learning Resources Center will provide a mock examination on the Tuesday evening and a review on the Thursday evening.

• **General Chemistry Awards**
  Three awards will be given for the top three students enrolled in CEM 141 in the Fall Semester.
  - Top student will receive a $500 award;
  - Second highest will receive a $300 award
  - Third highest will receive a $200 award.
  All awards are funded by the faculty and personnel of the General Chemistry Office.