### Principles of Chemistry, Chemistry 1210, Fall 2014

**Section 1, M W F, 8:30-9:20 AM, Engineering 103**

Professor Scott A. Ensign, Widtsoe 239, 797-3969, scott.ensign@usu.edu.

<table>
<thead>
<tr>
<th><strong>Office Hours:</strong></th>
<th>Mon. and Wed., 1:00-2:30 PM, other times by appt.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prerequisite</strong></td>
<td>Previous or concurrent enrollment in Math 1050 or higher</td>
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<tr>
<td><strong>Course description</strong></td>
<td>Chemistry 1210 is the first of a two semester sequence of general chemistry for students in the physical and biological sciences and engineering. The course will cover topics presented in the first 13 chapters of the Brown, Lemay and Bursten text. Chemistry 1220 will cover the remainder of the material in the text.</td>
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<tr>
<td><strong>Recitation</strong></td>
<td>All students must register for and attend a section of recitation listed in the course schedule. Recitation sections consist of groups of about 30 students and are administered by teaching assistants. The recitation setting is designed to develop problem solving skills needed for the class examinations, and to assess your understanding of concepts covered during previous class sessions. For assessment, there is a graded component to recitations (see below). Recitation sections will begin during the second week of classes.</td>
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<tr>
<td><strong>iclickers</strong></td>
<td>USU has adopted a universal, campus wide interactive “personal response system” for classroom use called the “iclicker”. Students enrolled in the course will need to purchase one of these from the bookstore or otherwise obtain one from an on- or off-campus source. If you will be taking other USU courses using the iclicker, you will probably want to keep it beyond this semester (you may already have one for another course). The iclicker will be used for lecture and recitation participation, assessment, and student feedback. You will need to have your iclicker purchased and registered by beginning of class <strong>Friday, August 29</strong>. To register your iclicker, go to the following site: <a href="http://www.iclicker.com/registration/">www.iclicker.com/registration/</a>. <strong>Even if you registered your iclicker for a previous semester, you must reregister it for the fall semester.</strong> I will provide detailed instructions for registering your iclicker in a tutorial posted on Canvas.</td>
</tr>
<tr>
<td><strong>Learning Management System</strong></td>
<td>Canvas instruction will be used for the management of Chem. 1210. Importantly, you will take your chapter quizzes on line using Canvas. To log on to Canvas, go to the web address: canvas.usu.edu. Your USER and PASSWORD is your BANNER login and your default PASSWORD is your BANNER password. Canvas has many useful features (your assignment scores, a chat room, discussion page, mail, etc.) and you should take the time to explore them from within our course page. I will provide more instructions on using Canvas in class.</td>
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<tr>
<td><strong>Class resources</strong></td>
<td>My class resources, including chapter self tests, lecture overheads, lecture recordings, tutorials, recorded solutions, multimedia, practice exams, and current exam keys are posted on the following page (the link is also provided in Canvas): [<a href="http://ensignchemistry.com/chemistry">http://ensignchemistry.com/chemistry</a> 1210 preview/chemistry1210resources/resources.htm](<a href="http://ensignchemistry.com/chemistry">http://ensignchemistry.com/chemistry</a> 1210 preview/chemistry1210resources/resources.htm) The username and password for accessing the resources will be provided in class, and also posted on our Canvas course page. Accessing and using these resources is essential for your success in chemistry 1210.</td>
</tr>
</tbody>
</table>

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### Supplemental Instruction
Supplemental instruction (S.I.) will also be provided for this course. The S.I. instructors and their SI session times are:
Kyle Spackman, sec. 1 (spackman34@yahoo.com). T 4:30-5:30, R 6:30-7:30, ENGR 101
Sara Calicchia sec. 3 (alicchia@gmail.com) M 6:00, W 7:00 WIDT 007
Kyle and Sara are formally assigned to sections 1 and 3, respectively, but you are welcome to attend either or both of their SI sessions each week.

### Chapter self tests (non-graded)
There will be an end of chapter (non-graded) self test consisting of ~40-50 questions for each chapter. I provide both written and recorded solutions (tutorials) to these self tests. You should work each question of the self tests as homework, and watch my recorded solutions as necessary, in order to master the concepts from each chapter.

### On line Quizzes (graded)
There will be 12 graded on line quizzes offered throughout the semester. Each quiz counts 10 points and is open book. You will take the quizzes on line through Canvas. Quizzes are to be taken during the availability periods indicated on the class schedule and within canvas.
Quizzes will usually consist of 10 questions, worth 1 point each. You will have 30 minutes to take each quiz. You may repeat a given quiz up to four additional times to improve your grade on that particular quiz, if you wish. Your highest score for the five attempts will be recorded.
Note that each time you take a quiz you will receive a slightly different version, covering the same concepts but with different questions. I encourage you to take each quiz the full five times, as the problem solving skills you will gain from taking the quizzes multiple times will be very beneficial in preparing for the exams. Remember, there is no penalty for repeating a quiz; your highest score of all attempts is the one that will be entered into the gradebook. The quiz deadlines will be posted in canvas and you should make note of them. All attempts of a quiz must be taken by the quiz deadline.

### Recitation Quizzes (graded)
Multiple choice quizzes, consisting of 5 questions worth 5 points each, will be given at the conclusion of recitations in the weeks indicated with an asterisk on the class schedule. The quizzes will cover concepts covered in the previous week’s lectures, which will be reviewed in recitation. Your highest 10 of 11 recitation quizzes will be counted for 50 points total.

### Midterm Exams (graded)
Three hourly exams (100 points each) consisting of 25 multiple choice questions will be given during class on the dates indicated on the course schedule. The exams are based on material covered in class and closely match the difficulty level and content of the practice exams, chapter self tests, and graded quizzes. You are strongly encouraged to work the on-line chapter self tests, take the quizzes the full five times, and work the practice exams given in previous years.

### On line make-up exam (can substitute for lowest midterm score)
An optional “make-up exam”, covering all of the material covered on midterms 1-3 and worth 100 points, will be offered during the time interval indicated on the syllabus. If you score higher on this exam than on your lowest of three in-class midterms, the score will replace the lowest midterm score. If you score lower on the make-up exam than on all three of your in-class midterms, then this exam score will not count. The make-up exam must be scheduled and taken on line in the TAR computer lab in the ESLC during the time period indicated on the class schedule. More information about the make-up exam will be provided in class and in Canvas.

### Final exam
The final exam (200 points) will be given in class at the time indicated on the final exams schedule. The final exam will consist of 50 questions, and contain both a “new material” section (100 points, material covered since exam 3) and a “comprehensive portion” (100 points, material covered on exams 1-3).
### Missed exams
If you miss one of the three in-class midterms exams due to illness or emergency, I will offer you the opportunity to take an exam covering the same material to substitute for the missed exam. If at all possible I should be notified of the absence and reason before the scheduled midterm. Missed exams may require written documentation from a doctor or other authority at my discretion.

### Grading
A total of 670 points are possible in Chem. 1210 and are distributed as follows:
- Total of 3 in-class midterms, or best two midterms and the on-line make-up exam: 300 pts.
- 12 on-line quizzes @ 10 points each: 120 pts.
- Comprehensive Final Exam (M, December 8, 7:30-9:20 AM, ENG103): 200 pts.
- Recitation quizzes, best 10 of 11 @ 5 pts each: 50 pts.

Total points: 670 points

In addition, to encourage you to attend, prepare for, and be attentive during lectures, you may earn up to 10 points extra credit based on correct responses to the questions I will ask in lectures using the iclicker system.

Iclicker extra credit points: 10 points

In terms of final assignment of grades, you are guaranteed the following grades if your final class percentage lies within the indicated ranges:
- A/A-: 100 to 88.0% (93.0% or above is a guaranteed straight “A”)
- B+/B/B-: <88.0 to 77.0%
- C+/C/C-: <77.0 to 60.0%
- D+/D: <60.0 to 50.0%

Based on the overall class average, the percentage cuts for the various grades may shift lower than the above cuts. In other words, better grades may be assigned for lower percentages than those indicated above, a scenario that is to your favor. However, the percentages will never shift higher than the above, so you are assured the indicated or a higher grade, depending on the class average at the conclusion of the course.

### Course Withdrawal:
Withdrawal from the course after Sept. 15 will result in a “W” notation being placed on your transcript. No withdrawal is permitted after October 27.

### Provisions:
The administration of Chem 1210 will adhere strictly to the academic policies outlined in the most recent USU General Catalog, which can be found here: [http://catalog.usu.edu/content.php?catoId=8&navoid=1571](http://catalog.usu.edu/content.php?catoId=8&navoid=1571)

### Course assessment
Students in this class are expected to develop proficiency in the principles listed on the class schedule and the attached “Learning Objectives” list. Questions provided on midterms, quizzes, and through the use of the iclicker personal response system will be used to assess your understanding of these principles. The formats to be used for assessment will include instructor-designed questions. Please note that assessment is a tool used by the Department of Chemistry and Biochemistry to improve the quality of instruction and proficiency of our students. Your grade will be based on your performance on the assignments indicated above, some of which will be used for course assessment.

In accordance with the Americans with Disabilities Act, reasonable accommodations will be provided for all persons with disabilities in order to ensure equal participation in Chem 1210. In cooperation with the Disability Resource Center, reasonable accommodation will be provided for students with disabilities. Please meet with the instructor during the first week of class to make arrangements. Alternative format print materials, large print, audio, diskette or Braille, will be available through the Disability Resource Center.
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<th>Day</th>
<th>Date</th>
<th>Lecture</th>
<th>Topic</th>
<th>Chapter</th>
<th>Recitation</th>
<th>Quiz</th>
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<tr>
<td>F</td>
<td>8/29</td>
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<td>9/1</td>
<td>4</td>
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<td>9/3</td>
<td>5</td>
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<td></td>
</tr>
<tr>
<td>F</td>
<td>9/5</td>
<td>6</td>
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<td>2</td>
<td>M</td>
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<td>9/8</td>
<td>7</td>
<td>Balancing Equations</td>
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<td>all*</td>
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<td>Atomic/Molecular Wts.</td>
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<td>all*</td>
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<td>9/12</td>
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<td>Empirical Formulas</td>
<td>3</td>
<td>all*</td>
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<td>all*</td>
<td>4</td>
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<td>W</td>
<td>9/17</td>
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<td>Molarity, Electrolytes</td>
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<td>all*</td>
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<td>9/19</td>
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<tr>
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<td>9/24</td>
<td>14</td>
<td>catch up, Review for Exam 1</td>
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<td>10/10</td>
<td>21</td>
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<td>10/13</td>
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<td>Atomic sizes, energies</td>
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<tr>
<td>R</td>
<td>10/16</td>
<td>23</td>
<td>e- ioniz., afflin. (note THURSDAY date)</td>
<td>7</td>
<td>meet, except</td>
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<tr>
<td>F</td>
<td>10/17</td>
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<tr>
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<td>25</td>
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<td>W</td>
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<td>Lewis Structures</td>
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<td>F</td>
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<td>Covalent Bonds</td>
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<td>10/27</td>
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<td>Resonance, Octet violations</td>
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<td>all*</td>
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<td>W</td>
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<td>Bond Energies</td>
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<td>F</td>
<td>10/31</td>
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<td>VSEPR theory</td>
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<td>W</td>
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<td>F</td>
<td>11/7</td>
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<td>finish chapters 8 and 9</td>
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<td>Gases</td>
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<td>W</td>
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<td>12/8</td>
<td>Final Exam (Lectures 1-39) 7:30 - 9:20 AM</td>
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</table>

Note: Quiz 12, covering chapter 13, may be taken up until the day of the final.

*Recitation weeks with an asterisk have quizzes worth 5 points each.
Chemistry 1210 Syllabus, Fall 2014, Section 1, Dr. Scott Ensign

Chemistry 1210 Learning objectives

Define matter and classify it from the level of mixtures and compounds to elements.

Differentiate physical and chemical properties and changes and intensive and extensive properties.

List and define the base S.I. units of mass, length, time, temperature and amount of a substance, and manipulate the base units to give derived S1 units.

Use the principles of dimensional analysis and conversion factors to convert quantities expressed in one unit to another unit.

Express numbers in different units by using the prefix and exponential notation methods.

Explain the difference between precision and accuracy, and relate these terms to the concept and usage of significant figures in experimental measurements.

Explain the atomic theory of matter, emphasizing the composition of the atom, and what defines the identity of a given element.

Explain the relative sizes, masses, and charges of the proton, neutron, and electron, and how they assemble to form an atom.

Define the term isotope, and be able to discern the subatomic composition of an atom given its atomic and mass numbers. Represent the atom using the element symbol with superscript and subscript denoting the composition.

Use the Periodic Table to rationalize similarities and differences of elements, including physical and chemical properties and reactivity. Predict common ion charges of group 1A, 2A, 3A, 6A, and 7A elements based on position in the periodic table.

Name and predict ions formed from the elements, and recognize and be able to name common polyatomic cations and anions.

Differentiate between ionic and molecular compounds, and empirical and molecular formulas.

Given the chemical formula for an ionic compound or molecule, provide a proper unambiguous systematic name for the compound. Conversely, given the compound name, write the single chemical formula that matches the name.

Given the reactants and products for a chemical equation, balance the equation using whole number coefficients.

Recognize the following common chemical reactions: combustion, decomposition, combination.

Given the atomic weights and relative abundances of naturally occurring isotopes, calculate the average atomic weight of an element.

Use average atomic weights from the Periodic Table to calculate formula weights and molecular weights for compounds.

Use the concepts of the mol, molar mass and Avogadro’s number and conversion factors derived from their relationships to interconvert between mass, mols, and numbers of particles for atoms and molecules.
Explain the basis for the “mass defect” seen when an experimentally determined molar mass for an atom is compared to the sums of the masses of the subatomic particles in that atom.

Use the stoichiometric relationships between atoms in molecules, and the stoichiometric coefficients on reactants and products in chemical reactions, to interconvert between numbers of particles, mols, and masses within compounds and for chemical changes.

Given the molar mass of an unknown compound and its elemental composition in mass percent, determine the empirical and molecular formulas for the compound.

Given a chemical reaction and masses of reactants, determine the limiting reagent if the reaction goes to completion, and calculate the masses of products formed and excess reagent remaining at the conclusion of the reaction.

Understand solution composition and the terms solvent and solute

Differentiate between weak and strong electrolytes and nonelectrolytes

Define and differentiate strong and weak acids and bases

Define “solubility” and “miscibility” and understand the factors that make a solute soluble in water

Define and write representative equations for aqueous reactions involving neutralization, precipitation, gas generation, and oxidation/reduction.

Define and write representative equations for molecular equations, complete ionic equations, net ionic equations.

Recognize spectator ions in aqueous reactions

Define solution concentration in units of molarity and use dimensional analysis to interconvert molarity, mass, mols, and volume.

Define energy in terms of work and radiation (heat), and differentiate the following types of energy and the terms that relate to it: kinetic, potential, thermal, chemical energy; conservation of mass, system and surroundings, state function

Describe energies, energy changes and associated signs referenced relative to the system of interest

Define enthalpy and exothermic and endothermic reactions

Determine the enthalpy for a reaction given information from a standard table of enthalpies of formation or using specific heat and calorimetry data

Apply Hess’ law to determine enthalpies of reaction

Describe the properties of electromagnetic radiation, and use the appropriate equations that interrelate energy, frequency, wavelength, Planck’s constant, and the speed of light

Explain the concept of “photons” and “quanta” and the dual nature of radiant energy

Explain the Bohr model of the hydrogen atom and use the Rydberg equation to determine the energies associated with electronic transitions
Explain the dual nature of matter (wave and particle).

Explain how the Heisenberg uncertainty principle and Schrodinger models relate to electronic structure.

Describe electronic structure in terms of orbitals, with associated quantum numbers n, l, m_l, and m_s, and how these quantum numbers relate to the energies, shapes, orientations, and spins of electrons in atoms.

Use the above principles of quantum chemistry together with the Pauli exclusion principle and Hund's rule to predict the electronic configurations of multielectron atoms.

Predict periodic properties, including relative sizes of atoms, ionization energies, and electron affinities using the principles outlined in class.

Understand and describe chemical bonding at the level presented in class, with particular emphasis on understanding and applying the following terms/concepts: Lewis symbols and atoms, ionic bonding, lattice energy, isoelectronic series, covalent bonding, electronegativity and bond polarity, Lewis structures, formal charges, resonance, octet violations, bond strengths, oxidation numbers.

Apply valence shell electron pair repulsion theory to properly-drawn Lewis structures to predict bond angles and geometries about atoms in molecules.

Use valence bond theory to describe covalent bonding in terms of orbital overlaps and hybridizations.

Describe the properties of a gas in terms of the variables P, V, n, and T.

Use the Ideal gas law to interconvert between P, V, n, and T for a gas.

Understand and explain Kinetic-molecular theory.

Explain the factors that lead to non ideal behavior for a gas.

Understand and identify the intermolecular forces important in different solids and liquids.

Describe the processes by which states of matter are changed.

Define vapor pressure and boiling point.

Interpret heating curves and phase diagrams for a compound.

Understand the solution process in terms of thermodynamics.

Explain the factors that affect solubility of a solute.

Understand and explain the different colligative properties and use the proper mathematical equations to quantitatively describe these effects.
What is “Chemistry”?

The study of the properties of materials and the changes that materials undergo

The study of the composition, properties, and transformations of matter

Many societal issues require an understanding of chemistry to comprehend and evaluate

- Why do most scientists believe global warming is caused by the burning of fossil fuels? What is the greenhouse effect?
- What is the ozone layer, what results in its depletion, and why is it important?
- What is acid rain and what causes it?
- What health hazards are present in the air we breathe, water we drink, and food we eat? Should we be worried about them?
- What are the health benefits/risks of different diets and foods (oats, antioxidants, selenium, tomatoes, butter vs. margarine)?
- Should we fluoridate our water? What are the pros and cons?
- Are alternate medical practices beneficial, worthless, or dangerous? Will an ionic footbath remove toxins from our bodies? Will magnets align our energy fields?

How does chemistry relate to other sciences?

- Materials: properties and changes
- Some materials you may encounter in your profession:

<table>
<thead>
<tr>
<th>Computer chips- silicon and ceramics</th>
<th>Computer science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geologic specimens: rocks, fossils</td>
<td>Geology</td>
</tr>
<tr>
<td>Viruses, bacteria, monkeys</td>
<td>Biochemistry, biology, medicine</td>
</tr>
<tr>
<td>Polymers, ceramics</td>
<td>Engineering</td>
</tr>
<tr>
<td>Energy sources, petroleums</td>
<td>Chemistry, engineering</td>
</tr>
<tr>
<td>Air bag design</td>
<td>Engineering</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>Pharmacy, medicine</td>
</tr>
<tr>
<td>Pollutants, toxins, carcinogens</td>
<td>Toxicology, medicine</td>
</tr>
<tr>
<td>Fertilizers, pesticides</td>
<td>Agriculture</td>
</tr>
<tr>
<td>Explosives</td>
<td>Military, engineering</td>
</tr>
</tbody>
</table>

The hierarchy of scientific learning....

- What’s at the top?
- What’s at the bottom?
- What’s most important?
- What’s least important?
Chemistry is an "experimental science"
The "Scientific Process"

1. Make observations, design and perform experiments
2. Find patterns, trends, laws
3. Formulate and test "hypotheses"
4. Develop a "theory"

Lecture outline, Chapter 1
1. Introduction to matter
2. Substances and mixtures
3. Elements and compounds
4. Physical and chemical properties and changes
5. Units of measurement
6. Exponential notation and prefixes
7. Uncertainty in measurement
8. Dimensional analysis

The universe consists largely of matter and energy

\[ E = mc^2 \]

Matter - The physical material of the universe. Anything that occupies space and has mass.

Energy - Much more complicated with multiple levels of definitions.
- Potential to perform work (Ch. 5)
- Potential energy (Ch. 5)
- Kinetic energy (Ch. 5)
- Heat (Ch. 5)
- Radiant energy (Ch. 6)
- Chemical energy (Ch. 5)
- Free energy (Ch. 19)
- Electrical energy (Ch. 20)
- Nuclear energy (Ch. 21)
The three physical states of matter

<table>
<thead>
<tr>
<th>Physical state</th>
<th>Defined volume?</th>
<th>Defined shape?</th>
<th>Compress/expand?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solid</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Classifying matter: Substance

- Matter with fixed composition and distinct properties.
  - Water, sucrose, salt, oxygen, glycerol, aspirin, iron

Classifying matter: Mixture

- A combination of 2 or more substances
  - Kool-aid, air, salt water, steel
  - Each substance in the mixture retains its own chemical identity and properties
  - May be heterogeneous or homogeneous and in any physical state
    - Heterogeneous: non-uniform
    - Homogeneous: uniform throughout (a solution)
  - Can be separated into constituent substances by physical means (evaporation, heating, filtering, etc)

Subdividing matter

- Can pure substances be broken down further by other means?
  - Pure substance
  - Not separable by physical means
    - Matter
    - Separable by physical means
      - Mixture
      - Uniform throughout
        - Homogeneous mixture (solution)
          - Gatorade, air, salt water, antifreeze, gasoline, brass
        - Non-uniform throughout
          - Heterogeneous mixture
            - Ex: granite, oil and vinegar salad dressing, frozen mixed vegetables
The building blocks of matter

- All matter is comprised of very small, individual particles called "atoms"
- Atoms can be chemically connected (bonded) to each other
- Atoms are composed of smaller "subatomic" particles called protons, neutrons and electrons
- Atoms are distinguished from each other by the number of subatomic particles (more specifically, protons) they are built from
- A chemical element is a pure substance containing only one type of atom

Elements and their symbols

- ~114 known elements
- Some common elements, their one or two letter abbreviations ("symbols"), and the number of protons they contain:

<table>
<thead>
<tr>
<th>Element</th>
<th>Symbol</th>
<th>Protons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen</td>
<td>H</td>
<td>1</td>
</tr>
<tr>
<td>Helium</td>
<td>He</td>
<td>2</td>
</tr>
<tr>
<td>Carbon</td>
<td>C</td>
<td>4</td>
</tr>
<tr>
<td>Calcium</td>
<td>Ca</td>
<td>20</td>
</tr>
<tr>
<td>Chlorine</td>
<td>Cl</td>
<td>17</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>N</td>
<td>7</td>
</tr>
<tr>
<td>Oxygen</td>
<td>O</td>
<td>8</td>
</tr>
<tr>
<td>Sulfur</td>
<td>S</td>
<td>16</td>
</tr>
<tr>
<td>Silicon</td>
<td>Si</td>
<td>14</td>
</tr>
<tr>
<td>Iodine</td>
<td>I</td>
<td>53</td>
</tr>
<tr>
<td>Iron</td>
<td>Fe</td>
<td>26</td>
</tr>
</tbody>
</table>

Elements, atoms, and molecules

- The basic unit of an element is an atom, defined by the number of protons it was built from
- Atoms of the same or different type can be "bonded" (joined) together to form "molecules". A chemical bond is an attraction between two atoms that holds them together
- An element is a substance consisting of only one type of atom, whether individual or bonded atoms

Elemental composition (by mass) of:

The universe

- Hydrogen 74%
- Helium 24%

The earth's crust

- Potassium 2.6 %
- Sodium 2.8 %
- Calcium 3.6 %
- Iron 5.0 %
- Aluminum 8.1 %
- Oxygen 46.6 %
- Silicon 27.7 %

The human body

- Calcium 1.5 %
- Phosphorus 1.0 %
- Nitrogen 3.3 %
- Hydrogen 9.5 %
- Carbon 18.5 %
- Oxygen 65 %
Compound
• A substance composed of two or more different elements joined by chemical bond(s)
• The elemental composition (whole number ratio of atoms) is always the same for a pure compound

Physical and chemical changes

Physical change - changes that affect the state or form but not composition of a substance

Chemical change (reaction) - The combining or decomposing of substance(s), by breaking and forming chemical bonds, to form new substance(s) that have new compositions

Changes of state:

Changes of form by rearranging atoms:
Chemical decomposition:

\[ \text{H}_2\text{O} + \text{H}_2\text{O} \rightarrow \text{H}_2 + \text{O}_2 \]

Chemical combination:

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

Chemical combination:

\[ \text{H}_2\text{O} + \text{CO} \rightarrow \text{CO}_2 + \text{H}_2 \]

Elements cannot be decomposed into simpler substances by chemical means (chemical reactions)

Compounds

\[ \text{H}_2\text{O} \rightarrow \text{H}_2 + \text{O}_2 \]

Elements

\[ \text{H}_2\text{N} \rightarrow \text{H}_2 + \text{N}_2 \]
Physical and chemical properties are used to describe and differentiate different types of matter.

**Physical properties** - properties that can be measured without changing the basic identity of the substance.

**Chemical properties** - the way a substance may change or "react" to form other substances.

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**Physical properties**
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