The Components of Matter

Review: What is matter?

Recall: “Chemistry is the study of matter and its properties, the changes matter undergoes and the energy associated with those changes”

Recap: There are 3 stable states of matter – solid (s), liquid (l) and gas (g).
Specific *macro- and microscopic* physical properties define the three* states of matter.

<table>
<thead>
<tr>
<th>State of Matter</th>
<th>Macroscopic Description (observation)</th>
<th>Microscopic Description (chemical model)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The state of matter is determined by the strength of the forces (chemical bonds) between the individual microscopic particles within the matter.

Task: Rank the *intermolecular* forces present in steam, ice and water in order of increasing strength. Use the included figures as a guide.

**Ranking**
Changing between the 3 states of matter

Describe the relationship between the mpt. and bpt. of matter, with regard to microscopic processes, occurring at these specific temperatures

Example: The boiling of water to make steam (\( \text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{O}(g) \))

Water molecules change from liquid to gaseous state: physical change.
Physical and Chemical Properties – what’s the difference?

Analogy: We all possess ‘as is’ physical properties, or characteristics, that define us. For example, Dr. Mills is 5’11” and has green eyes.

As with people, each chemical also possesses a unique set of ‘as is’ physical properties that define it. For example, water is a clear, colorless, tasteless molecular material that has a fpt. of 0°C and a bpt. of 100 °C.

Chemical Properties, in contrast, are a function of change (usually associated with a chemical reaction). For example, Iron (Fe) reacts with oxygen gas to form rust:

\[ 4 \text{Fe (s)} + 3 \text{O}_2(g) \rightarrow 2 \text{Fe}_2\text{O}_3(s) \]

Task: Identify the flowing as either chemical or physical properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Chemical or Physical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diamond is the hardest known substance.</td>
<td></td>
</tr>
<tr>
<td>Charcoal burns to make CO(_2) (g)</td>
<td></td>
</tr>
<tr>
<td>The statue of liberty turned ‘green’</td>
<td></td>
</tr>
<tr>
<td>Copper is a good conductor of electricity</td>
<td></td>
</tr>
<tr>
<td>Sugar dissolves in water*</td>
<td></td>
</tr>
<tr>
<td>Melting of ice*</td>
<td></td>
</tr>
</tbody>
</table>

Think up two more chemical properties of your own
### Elements and Compounds – the further classification of pure matter

**Task:** State which of the following are *elements*, and which are *compounds*. When done, try to come up with a definition of what elements and compounds are.

<table>
<thead>
<tr>
<th>Material</th>
<th>Chemical Formula</th>
<th>Element or Compound?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>H₂O (l)</td>
<td></td>
</tr>
<tr>
<td>Oxygen gas</td>
<td>O₂ (g)</td>
<td></td>
</tr>
<tr>
<td>Pure silver coin</td>
<td>Ag (s)</td>
<td></td>
</tr>
<tr>
<td>Sugar crystals</td>
<td>C₆H₁₂O₆ (s)</td>
<td></td>
</tr>
<tr>
<td>Carbon dioxide gas</td>
<td>CO₂ (g)</td>
<td></td>
</tr>
</tbody>
</table>

**Elements:**

**Compounds:**
Compounds and elements can have either ‘giant’ or molecular structures:

**‘Giant’**: Repeating lattice of particles – usually strongly bound (high mpt.) solids.

Examples: sand (SiO$_2$), diamond (C), table salt (NaCl)

**Molecular**: a collection of independent molecular units (molecules will be discussed in more detail later). Usually (low mpt) liquids or gasses at room temp.

Definition: *Molecule* – a small, independent particle of matter made up from 2 or more atoms

Examples: water (H$_2$O), carbon dioxide (CO$_2$), Nitrogen gas (N$_2$)

Think of molecules like cars on the expressway – each car (molecule) is a separate, independent unit that contains a number of passengers (atoms). The cars (molecules) are free to move while the people (atoms) stay fixed inside.

‘Giant’ materials are like people (atoms) ‘locked’ in place at a very crowded concert, the DMV waiting room etc……
Review: A microscopic scale view of several materials is presented below. Label each using *elemental* or *compound* and *molecular* or ‘giant’ tags.

<table>
<thead>
<tr>
<th>Water (H$_2$O (l))</th>
<th>Silicon (Si (s))</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Water" /></td>
<td><img src="image2" alt="Silicon" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Steam (H$_2$O (g))</th>
<th>Sodium Chloride (NaCl)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3" alt="Steam" /></td>
<td><img src="image4" alt="Sodium Chloride" /></td>
</tr>
</tbody>
</table>

Details: Ice is a solid (crystalline) form of water (a molecular compound). How would you describe the structure of ice? Can you think of other similar examples?

More Details: Allotropes of an Element

Example: Carbon

- $C_{(\text{diamond})}$
- $C_{(\text{graphite})}$
- $C_{60}$
Pure Matter v Mixtures

**Recap:** Pure matter is classed as *either* an ELEMENT or a COMPOUND.

Elements can have *either* Molecular or ‘giant’ structures. **Examples:** N\(_2\) (g) (Nitrogen gas, molecular), Pb(s) (metallic lead, a ‘giant’ structure)

Compounds can also have *either* Molecular or ‘giant’ structures. **Examples:** H\(_2\)O(l) (water, molecular), Fe\(_2\)O\(_3\)(s) (‘rust’ (iron oxide), a ‘giant’ structure)

**Recall:** A molecule is an independent unit containing two or more atoms. Remember the car / passenger analogy. Molecules can exist as *either* elements or compounds

Mixtures

**ANY combination of different types of pure matter ‘placed together’** is defined as a mixture (eg. air, milk, pepsi).

**Mixtures are NOT** pure materials. eg. Pure gold (Au) vs ‘white’ gold (Au+ Ag), or water (H\(_2\)O) vs pepsi (H\(_2\)O + sugar….)

**Discussion:** Air contains a number of different components – what are they? How would you describe what air is made up from using words like element, compound, gas, molecular etc.?
Task: Assign generic labels that describe to microscopic scale matter shown on the slide (e.g. ‘gaseous atomic element’ etc.)

Mixture Types

As viewed from a macroscopic perspective, mixtures are classified as either HOMOGENEOUS or HETEROGENEOUS.

HOMOGENEOUS MIXTURES:

Examples:

HETEROGENEOUS MIXTURES:

Examples:
Discussion: Can you think of something that is both a homogeneous mixture and a solid?

Examples of Alloys:

Classification of Matter Flowchart
(Dr. Mills really likes this slide – why? Hint: Recall the fundamental job of a chemist)
Task: Use the ‘Classification of Matter’ flowchart (above) to classify the following:

1. The compressed gasses in a deep sea diver’s gas bottle (He(g) and O₂(g))

2. A ham and cheese omelet

3. An ice cube (made from pure water)

4. A ruby (Al₂O₃(s) with Cr³⁺ impurities)

Extra Credit: Ask me about the separation of mixtures assignment (based on background reading)
The following questions were taken from your 1\textsuperscript{st} practice midterm:

State whether the following are classified as elements, compounds or mixtures**:

- **Diamond:**
- **Carbon dioxide gas:**
- **Air:**
- **A cup of coffee:**
- **Water:**
- **Sand (SiO\textsubscript{2}):**
- **Oxygen gas:**

**include additional details for extra credit!