

Module 4: Classifying Matter and Its Changes

Mark Peever mpeever@gmail.com

August 12, 2025

1 Overview

1. **Mixtures** contain multiple types of elements and/or compounds.
2. Matter is made up of moving atoms and/or molecules: the higher its temperature, the faster those atoms and/or molecules are moving.
3. **Physical Changes** are when a substance is changed, but remains the same substance.
4. **Chemical Changes** are when a substance changes from one type of thing to another type of thing.

2 Classifying Matter

Definition 1 (Pure Substance) *A substance that contains only one element and/or compound*

Definition 2 (Mixture) *A substance that contains different elements and/or compounds*

- a mixture contains multiple elements and/or compounds, but they haven't lost their individual identities and properties
- *e.g.* air is a mixture of many different gases¹: each gas in air is still whatever kind of gas it would be without the others... air is not a compound
- it's possible to separate parts of a mixture *physically* (*e.g.* by filtering)

Definition 3 (Homogenous Mixture) *A mixture with a composition that is always the same, regardless of which part of the sample you are observing*

¹See the table in the textbook, p. 105

Definition 4 (Heterogenous Mixture) *A mixture with a composition that differs depending on which part of the sample you are observing*

- air *seems like* a homogeneous mixture: it pretty much looks the same everywhere. . . if you go past a dairy farm, you'll realize it's actually heterogeneous on a large enough scale
- paint is a heterogenous mixture, which is why you have to mix it up before you can use it

3 Classifying Changes in Matter

Definition 5 (Chemical Change) *a change that affects the type of atoms or molecules in a substance*

Definition 6 (Physical Change) *a change in which the atoms or molecules in a substance stay the same*

- the idea here is that if we physically alter a substance, that's not a chemical change
- dissolving one substance into another is a physical change², because we haven't actually changed the kinds of atoms and/or molecules involved
- chewing a steak is a physical change, but digesting a steak is a chemical change

4 Phase Changes

- one interesting type of physical change is the *phase change*
- in general, there are three phases of matter: solid, liquid, and gas³.
- we can convert matter between these phases with heat ⁴ (see Table)

5 The Kinetic Theory of Matter

Theory 1 (The Kinetic Theory of Matter) *Molecules and atoms are in constant motion, and the higher the temperature, the greater their speed.*

- we already know all matter is made of *atoms* and/or *molecules*

²I realize we could argue differently based on our definitions, but let's just go with it. Check out p. 107 for more.

³Let's not get hung up on plasma right now.

⁴And pressure!

| Name | Phase Change | Beginning Phase | Ending Phase |
|------------------------|-----------------|-----------------|--------------|
| freeze | add heat | liquid | solid |
| melt | take heat away | solid | liquid |
| evaporate | add heat | liquid | gas |
| condense | take heat away | gas | liquid |
| sublimate ⁵ | change pressure | solid | gas |

Table 1: Phase Changes for Matter

- those atoms and molecules are in constant motion:⁶
 1. in *solids*, they move more-or-less in place, vibrating
 2. in *liquids* they move faster, and don't really stay in place
 3. in *gases*, they move much faster, and are free to travel really far from each other
- since motion requires energy,⁷ we can say that the atoms and/or molecules in liquid have more energy than in a solid.
- so we can think of **thermal energy** as being the energy associated with the movement of the atoms and/or molecules in a substance
- similarly, we can think of **temperature** as being the average thermal energy of the substance

6 Chemical Reactions and Chemical Equations

Definition 7 (Homonuclear Diatomic) *Homonuclear diatomic molecules are made up of two atoms of the same type.*

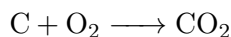
- homonuclear diatomic molecules are the natural form⁸ of several elements: N₂, O₂, Cl₂, F₂, Br₂, I₂, At₂, H₂
- you'll find all these at the right-hand side of the periodic table
- we only care about homonuclear diatomic molecules when we discuss the substances in terms of their natural form: we don't care about them when we deal with these substances in terms of their roles in molecules (*e.g.* water (H₂O) contains a *single* O, not two O atoms)

⁶This doesn't break the Law of Conservation of Momentum, as long as they all sort of cancel each other out.

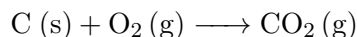
⁷Remember energy is the ability to do work, and work is related to force and distance moved.

⁸"Natural" here means, "found in nature."

- we think of chemical changes in terms of **chemical reactions**, *e.g.* “carbon plus oxygen yields carbon dioxide”
- we write chemical reactions like an equation in math:

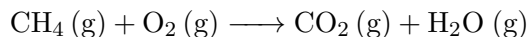


- when we write a chemical reaction as an equation, we call it a **chemical equation**
- we write the **reactants** on the left-hand side, and the **products** on the right-hand side
- we can add phase information too:

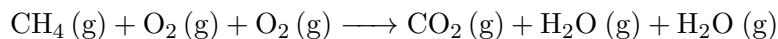


6.1 Balancing Chemical Equations

- let’s consider the burning of methane [Wile, 2003, p. 117ff]: “methane plus oxygen yields carbon dioxide plus water”
- we can write that one as:

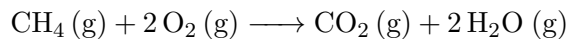


- written that way, we have matter both created and destroyed:
 1. we have one C atom on the left, and one on the right...that works, but
 2. we have four H atoms on the left, and two on the right...so, did we create atoms?
 3. we have two O atoms on the left, and three on the right...so once again, we’re creating atoms
- in order to tell the truth about not creating atoms, we need to conserve the atoms on each side
- so our equation is:



- now we have:
 1. one C atom on the left, and one on the right
 2. four H atoms on the left, and four on the right

3. four O atoms on the left, and four on the right
- so now we're not creating or destroying atoms!
 - we can write that more simply⁹:



- this is called a **balanced chemical equation**
- and notice what it tells us:
 1. CH₄ takes twice as many O₂ molecules to burn as CH₄ molecules
 2. for every CH₄ molecule we burn, we'll get one CO₂ molecule
 3. for every CH₄ molecule we burn, we'll get one H₂O molecule

Hint 1 (Balancing Chemical Equations) *A chemical equation is balanced when the same number of atoms of each type are on both the left-hand-side and the right-hand-side.*

References

- [Wile, 2003] Wile, D. J. L. (2003). *Exploring Creation with Chemistry*. Apologia Educational Ministries, Inc., 2 edition.

⁹Just like we would in a math equation.