



The Atomic Nature of Matter

Chapter 17

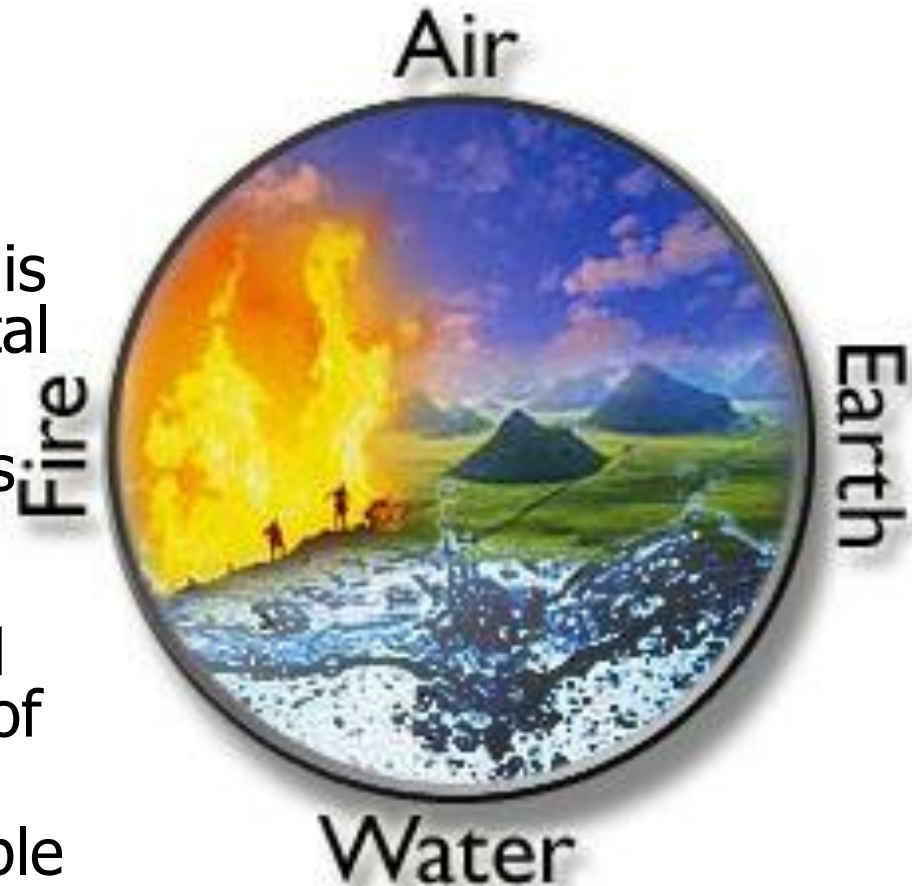


Eternal Questions

- **People have long asked,**
 - "What is the world made of?"
 - and
 - "What holds it together?"

What is the World Made of?

- People have come to realize that the matter of the world is made from a few fundamental building blocks of nature.
- The word "**fundamental**" is key here. By fundamental building blocks we mean objects that are **simple and structureless** -- not made of anything smaller.
- Even in ancient times, people sought to organize the world around them into fundamental elements, such as earth, air, fire, and water.





The Atom

Today we know that there is something more fundamental than earth, water, air, and fire...

But in reality there are atoms and space.

-Democritus (c. 400 BCE)

Around 1900, people thought of atoms as permeable balls with bits of electric charge bouncing around inside.

But is the atom fundamental?



Is the Atom Fundamental?



- People soon realized that they could categorize atoms into groups that shared similar chemical properties (as in the Periodic Table of the Elements).
- Moreover, experiments which "looked" into an atom using particle probes indicated that atoms had structure and were not just squishy balls. These experiments helped scientists determine that atoms have a tiny but dense, positive nucleus and a cloud of negative electrons (e^-).



Is the Nucleus Fundamental?

Because it appeared small, solid, and dense, scientists originally thought that the nucleus was fundamental.

So, then, are protons and neutrons fundamental?





17.1 Elements

- Atoms are the building blocks of matter
 - Not all atoms are alike;
 - Atoms of the same kind make up what we call elements
- To date approximately 115 elements have been discovered
- 90 occur naturally; the others are formed in laboratories



17.1 Elements

- More than 99% of the material on Earth is formed from only about a dozen elements
- Majority of elements are RARE
- Living things are composed of primarily 5 elements:
 - O, C, H, N & Ca

17.1 Elements

THE 16 MOST COMMON

- | | |
|-------|--------|
| 1. Al | 9. N |
| 2. Ca | 10. O |
| 3. C | 11. P |
| 4. Cl | 12. K |
| 5. F | 13. Si |
| 6. H | 14. Na |
| 7. Fe | 15. S |
| 8. Mg | 16. Ti |



17.2 Atoms Are Recyclable

- Atoms are extremely old; the atoms that compose our bodies have been around long before the solar system came into existence.
- They cycle & recycle between living & non-living things



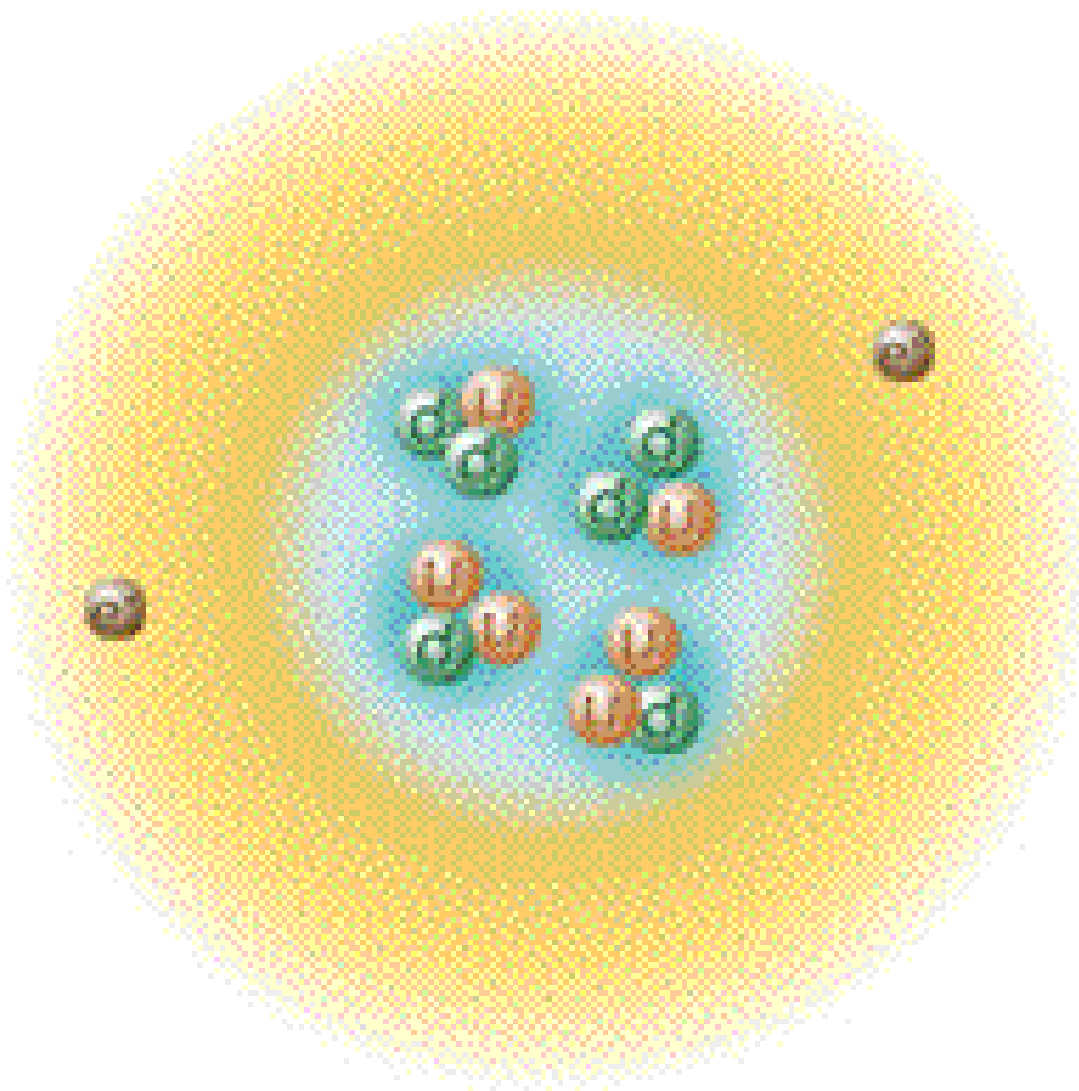
17.3 Atoms Are Small

- The number of atoms in a single human breath:

1,000,000,000,000,000,000,000,000

- The number of humans on the planet:

100,000,000,000



Electrons are in constant motion around the nucleus. protons and neutrons jiggle within the nucleus, and electrons orbit around it

This picture is quite distorted. If we drew the atom to scale and made protons and neutrons a centimeter in diameter, then the electrons would be less than the diameter of a hair and the entire atom's diameter would be greater than the length of **thirty football fields!**



17.4 Evidence for Atoms

- Robert Brown is credited with the first fairly direct proof of the existence of atoms, in 1827.
- He observed that pollen grains under a microscope were in a constant state of agitation (movement).
- This perpetual jiggling of particles that are just large enough to be seen is called Brownian motion.



17.5 Molecules

- Atoms can combine to form larger particles called molecules.
- Examples
 - Water, Carbon dioxide, Ammonia, Methane
 - H_2O CO_2 NH_3 CH_4



17.6 Compounds

- Compounds are substances that are made up of atoms of different elements combined in a fixed proportion.
- Chemical formulas of a compound tell the proportions of each kind of atom.
- Examples
 - Water, Carbon dioxide, Ammonia, Methane
 - H_2O CO_2 NH_3 CH_4



17.6 Compounds

- Compounds may or may not be made up of molecules.
- Compounds may be made up of ions
- Compounds have different properties from the elements of which they are made.
 - At room temp water is a liquid
 - H & O are gases



Arranging the Elements

- The periodic table of the elements represents a system of classifying all of the known elements.
- This arrangement of elements was a huge milestone because it helped chemists predict the existence of elements that had yet to be discovered.



Arranging the Elements

- Dmitri Mendeleev first arranged the 63 known elements of his time by comparing their chemical & physical properties in the mid 1800's.
- He designed a periodic table in which the elements were arranged in order of increasing atomic mass



Arranging the Elements

- Despite the importance of Mendeleev's work, his table was not completely correct.
- Henry Moseley determined for the first time the atomic numbers of elements should be how the elements are placed on the table.

Arranging the Elements



- Moseley's periodic law states that the physical and chemical properties of elements are functions of their atomic numbers.



Design of the Periodic Table: Columns

- Each column is numbered.
- Columns of elements are called groups or families. Elements within the same group or family have similar BUT NOT identical properties.
- Group 1 elements are all soft, white, shiny metals. They are all highly reactive, which means they readily form compounds.



Design of the Periodic Table: Rows

- Each horizontal row is numbered
- Rows are called periods.
- Unlike groups, elements in a period are not alike in properties.

- There is still a pattern however...



Design of the Periodic Table: Rows

- As you move across a period from the left to the right, the first element is ALWAYS an extremely active solid. The last element is ALWAYS a particularly inactive gas.

Design of the Periodic Table: Element Keys

6



Atomic #

C



Symbol

Carbon



Element Name

12.011



Atomic Mass

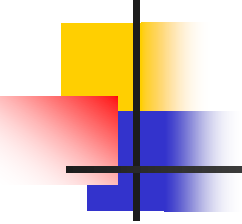


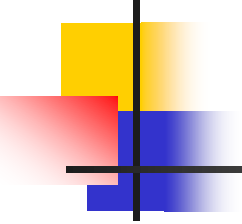
17.9 The Phases of Matter

- Solid, Liquid, Gas, & PLASMA

- Plasma

- Matter consists of positive ions & free electrons. This phase exists only at high temps. Although it is less common to our everyday life, it is the predominant phase of matter in the universe.

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- Solids
 - Have a definite shape & a definite volume
 - Fixed repeatable arrangement of atoms

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- Liquids
 - No definite shape but they do have a definite volume
 - Take the shape of its container

- 
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- Gases
 - No definite shape or definite volume