Introduction to Physical Science

- Introduction to Physical Science
- Matter
- Chemistry
- Force and Motion
- Energy
- Waves, Sound and Light
- Electricity and Magnatism
What is Science?

- Science is a method for studying the natural world.
- It is a process that uses and to gain knowledge about events in nature.
What is Science?

- Nature follows a set of rules
- many rules, such as those concerning how the human body works, are complex
What is Science?

- Other rules, such as the fact that Earth rotates about once every 24 h, are much simpler.
- Scientists ask questions to learn about the natural world.
Defining Science

- Life Science
  - the study of living organisms

- Earth Science
  - the study of Earth and space

- Physical Science
  - the study of matter and energy
  - chemistry & physics
Defining Science

• Sometimes, a scientific study will overlap the categories.
• One scientist, for example, might study the motions of the Human body to understand how to build better artificial limbs.
A. The Kinetic Theory

1. All matter is composed of small particles (atoms, molecules, or ions).
2. They are in constant, random motion.
3. They constantly collide with each other and with the walls of their container.
### Phase Properties

<table>
<thead>
<tr>
<th>Phase</th>
<th>Proximity</th>
<th>Energy</th>
<th>Motion</th>
<th>Volume</th>
<th>Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid</td>
<td>close</td>
<td>little</td>
<td>vibrational</td>
<td>definite</td>
<td>definite</td>
</tr>
<tr>
<td>Liquid</td>
<td>close</td>
<td>moderate</td>
<td>rotational</td>
<td>definite</td>
<td>indefinite</td>
</tr>
<tr>
<td>Gas</td>
<td>far apart</td>
<td>a lot</td>
<td>translational</td>
<td>indefinite</td>
<td>indefinite</td>
</tr>
</tbody>
</table>
Boyle’s Law. The volume of a gas varies inversely with its pressure if temperature remains constant.

Pushing the plunger down will increase the pressure.

Volume of the gas inside the cylinder will decrease.

Pressure increases inside the cylinder because the volume is smaller.
Charles’s Law
The volume of a gas varies \textit{directly} with its temperature if pressure remains constant.

A balloon shrinks when placed in cold water.
Why is the Periodic Table important to me?

- The periodic table is the most useful tool to a chemist.
- You get to use it on every test.
- It organizes lots of information about all the known elements.
Pre-Periodic Table Chemistry ...

- ...was a mess!!!
- No organization of elements.
- Imagine going to a grocery store with no organization!!
- Difficult to find information.
- Chemistry didn’t make sense.
Dmitri Mendeleev: Father of the Table

HOW HIS WORKED...
- Put elements in rows by increasing atomic weight.
- Put elements in columns by the way they reacted.

SOME PROBLEMS...
- He left blank spaces for what he said were undiscovered elements. (Turned out he was right!)
- He broke the pattern of increasing atomic weight to keep similar reacting elements together.
The Periodic Law

- Properties of elements are a periodic function of their Atomic Numbers.

- So...this means that when you arrange the elements according to their atomic numbers, you see a repetition of their physical and chemical properties.
Chemical elements are arranged in groups that have similar chemical and physical properties.
CHEMISTRY
Composition of Matter

- **Matter** - Everything in universe is composed of matter
  - Matter is anything that occupies space or has mass
- **Mass** - quantity of matter an object has
- **Weight** - pull of gravity on an object
Elements

- Pure substances that cannot be broken down chemically into simpler kinds of matter
- More than 100 elements (92 naturally occurring)
90% of the mass of an organism is composed of 4 elements (oxygen, carbon, hydrogen and nitrogen).

Each element unique chemical symbol
  - Consists of 1-2 letters
  - *First* letter is always *capitalized*
Atoms

- The simplest particle of an element that retains all the properties of that element
- Properties of atoms determine the structure and properties of the matter they compose
- Our understanding of the structure of atoms is based on scientific models, not observation
The Nucleus

- **Central core**
- Consists of **positive charged protons** and **neutral neutrons**
- Positively charged
- Contains most of the **mass of the atom**
The Protons

- **All atoms of a given element** have the same number of protons.
- **Number of protons** called the **atomic number**.
- **Number of protons** balanced by an equal number of negatively charged electrons.
The Neutrons

- The **number varies** slightly among atoms of the same element
- Different number of neutrons produces **isotopes** of the same element
Atomic Mass

- Protons & neutrons are found in the nucleus of an atom.
- Protons and neutrons each have a mass of 1 amu (atomic mass unit).
- The atomic mass of an atom is found by adding the number of protons & neutrons in an atom.
- \# of protons + \# of neutrons = atomic mass
The Electrons

- Negatively charged high energy particles with little or no mass
- Travel at very high speeds at various distances (energy levels) from the nucleus
- Are located around the nucleus
Periodic Table

- Elements are arranged by their atomic number on the Periodic Table
- The horizontal rows are called Periods & tell the number of energy levels
- Vertical groups are called Families & tell the outermost number of electrons
# Periodic Table of Elements

![Periodic Table Image]

## Legend - click to find out more...

- **H** - gas
- **Li** - solid
- **Br** - liquid
- **Tc** - synthetic
- **Non-Metals**
- **Transition Metals**
- **Rare Earth Metals**
- **Halogens**
- **Alkali Metals**
- **Alkali Earth Metals**
- **Other Metals**
- **Inert Elements**
Compounds

- Most elements do not exist by themselves
- Readily combine with other elements in a predictable fashion
A **compound** is a pure substance **made up of atoms of two or more elements**

- The proportion of atoms are always fixed

**Chemical formula** shows the kind and proportion of atoms of each element that occurs in a particular compound
Molecules are the simplest part of a substance that retains all of the properties of the substance and exists in a free state.

Some molecules are large and complex.
Chemical Formulas

- **Subscript** after a symbol tell the number of atoms of each element.
- \( \text{H}_2\text{O} \) has 2 atoms of hydrogen & 1 atom of oxygen.
- **Coefficients** before a formula tell the number of molecules.
- \( 3\text{O}_2 \) represents 3 molecules of oxygen or (3x2) or 6 atoms of oxygen.
The tendency of elements to combine and form compounds depends on the number and arrangement of electrons in their outermost energy level.

Atoms are most stable when their outermost energy level is filled (when it has 8 electrons).
Most atoms are not stable in their natural state.

Tend to react (combine) with other atoms in order to become more stable (undergo chemical reactions).

In chemical reactions bonds are broken; atoms rearranged and new chemical bonds are formed that store energy.
Covalent Bonds

- **Formed when two atoms share one or more pairs of electrons**

*Water (H₂O)*
Ionic Bonds

- Some atoms become stable by losing or gaining electrons.
- Atoms that lose electrons are called positive ions.
Atoms that **gain electrons** are called **negative ions**

Because **positive and negative electrical charges attract** each other ionic bonds **form**

![Diagram of sodium and chlorine atoms showing electron transfer to form ions and charge changes.](image)
Motion and Forces
Forces

- Push or pull that one object exerts on another
- Examples: hitting a baseball, throwing a basketball, etc.
- Forces aren’t always noticeable
- Floor pushes up on you - otherwise you’d fall
- Forces influence motion
- Changes the velocity - either the speed or direction
- Net Force: Total force on an object
  - If forces are balanced, no movement occurs - net force is zero
  - Balanced forces: forces equal in size but opposite in direction
  - Why don’t you fall through the floor??
    [http://www.teachersdomain.org/resources/phy03/sci/phys/mfw/goalstring/index.html](http://www.teachersdomain.org/resources/phy03/sci/phys/mfw/goalstring/index.html)
- Unbalanced force: force that is not balanced by another force
  - Results in movement
Motion and Forces

Physical Science 2.3
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- Unbalanced force: force that is not balanced by another force
- Results in movement
The forces on the person are balanced.

The floor pushes upward on the person.

Gravity pulls downwards on the person.
- Strong force to the right, weak force to the left = move to the right

- Inertia - the tendency of an object to resist any change in motion
  - If moving - stays moving unless acted on by unbalanced force
  - If stopped - stays stopped unless acted on by unbalanced force

- Car should stay in motion once it starts in motion
  - Problem: friction opposes motion
Inertia and injury

- In car crashes, you tend to remain in motion until you are acted on by a force (until you hit something that resists you).

Seatbelts

- Prevents people from being thrown from the car - provides unbalanced force to stop inertia.
- Increases time over which patient slows.
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A. Energy

- **ENERGY**
  - The ability to cause change

**THERMAL**
- internal motion of particles

**NUCLEAR**
- changes in the nucleus

**CHEMICAL**
- bonding of atoms

**MECHANICAL**
- motion of objects

**ELECTRICAL**
- motion of electric charges

joules (J)
A. Energy

- **Kinetic Energy (KE)**
  - energy in the form of motion
  - depends on mass and velocity

- Which has the most KE?
  - 80 km/h truck

- Which has the least KE?
  - 50 km/h motorcycle
A. Energy

- Potential Energy (PE)
  - stored energy
  - depends on position or configuration of an object

- Which boulder has greater gravitational PE?
- What other ways can an object store energy
C. Conservation of Energy

- **Law of Conservation of Energy**
  - Energy may change forms, but it cannot be created or destroyed under ordinary conditions.

- **EX:**
  - PE → KE
  - mechanical → thermal
  - chemical → thermal
C. Conservation of Energy

PE $\Leftrightarrow$ KE

View pendulum animation.

View roller-coaster animation.
C. Conservation of Energy

Mechanical $\Rightarrow$ Thermal

View rolling ball animations. View skier animation.