Atoms and Elements

Grade 9 Science
Physical Science Unit
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Matter

Matter is anything that has mass and takes up space (has volume).

It can be solid, liquid, gas or plasma.

The Particle Theory

1. All matter is made up of particles.
2. Particles are always moving, since they have energy.
3. There is empty space (nothing!) in between particles.
4. The particles of one substance are different from particles of other substances.

Particle Theory

Note that "particles" can mean:

Atoms, which are particles of an **element**;

OR

Molecules, which are particles of a **compound**;

OR

Ions, which are particles that have a positive or negative charge.

Theories and Laws

Theory:

- general explanation of a set of related observations, based on evidence and good arguments
- "WHY"
- Can be replaced or modified to fit new facts

Theories and Laws

Law:

- scientific description of the physical world
- considered to be fact, based on many observations and tests
- "what happens"

Theories are used to <u>explain</u> laws. They do not become laws over time.

History of Atomic Theory

Atomic theory:

- describes the nature of matter
- matter is made up of small units called **atoms**

Current Atomic Theory

- all matter is composed of atoms
- atoms of a specific element (like helium) are identical in size and mass
- atoms of different elements can combine together to make new substances

Subatomic Particles

Subatomic particles:

- components that make up an atom
- particles: electrons, protons and neutrons

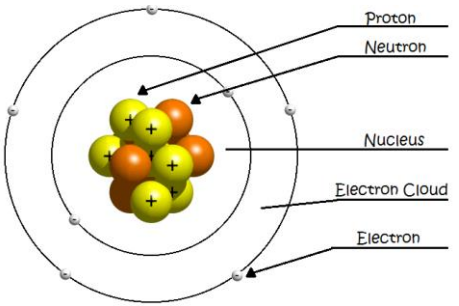
Subatomic Particles

Particle	Mass	Charge	Location
Electron	Very light	Negative	Electron cloud
Proton	Heavy (~2000 times heavier than an electron)	Positive	Nucleus
Neutron	Heavy (slightly heavier than a proton)	Neutral (no charge)	Nucleus

The Atomic Model

- protons and neutrons are in a ball in the centre of the atom (**nucleus**)
- electrons orbit in a (relatively) huge cloud around the nucleus

The Atomic Model



Periodic Law

Periodic law:

When arranged by increasing atomic number, the chemical elements display a regular and repeating pattern of chemical and physical properties.

This means that the periodic table isn't arranged randomly – it is very logical!

Classes of Elements

Metals – left side of the periodic table

General Properties of Metals
High lustre (shiny)
Malleable, ductile
Good conductors of heat and electricity
Solid at room temperature (except mercury)

Classes of Elements

Non-metals – right side of the periodic table

General Properties of Non-Metals
Low lustre (dull)
Brittle
Good insulators of heat and electricity
Some solids, many gases, one liquid

Classes of Elements

Semi-metals, or metalloids – along the edge of the "staircase"

General Properties of Semi-Metals
Properties between metals and non-metals
Brittle, poorer conductor of electricity and heat than metals

Structure of the Periodic Table

Period: horizontal row
There are seven periods of elements.

Group (family): vertical column
There are eighteen groups of elements.

Families of Elements

Alkali metals
- Group 1
- Soft, shiny metals
- Very reactive!

Alkaline earth metals
- Group 2
- Shiny, silvery metals
- Somewhat reactive

Families of Elements

Halogens
- Group 17
- highly reactive elements
- harmful to living things

Noble gases
- Group 18
- All gases
- Very stable and unreactive

Families of Elements

Transition metals
- centre block of the periodic table

Lanthanides and **actinides**
- separate two rows below the main part of the periodic table
- Fit into period 6 and 7 after the alkaline earth metals

Elements on the Periodic Table

For each element, you find:
- element symbol
- element name
- atomic number
- atomic mass

Sometimes more!

Atomic Number

Atomic number:
- number of protons in the nucleus
- also the number of electrons for an atom

The elements are arranged on the periodic table in order of increasing atomic number.

Atomic Mass

Atomic mass:
- mass of one atom of an element
- measured in amu (atomic mass units)
- number of protons and neutrons added together

Example: Periodic Table

How many protons, neutrons and electrons does a gold atom have?

Element Symbols

IMPORTANT

It's really important to use the correct element symbol, with the right capital and lowercase letters!

DON'T GUESS!!

Bohr-Rutherford Diagrams

- Electrons orbit in "shells", or orbits, around the nucleus
- Each shell can hold a specific number of electrons:

Shell	1	2	3	4
Electrons	2	8	8	18

Drawing Bohr-Rutherford Diagrams

1. Write the number of protons and neutrons in the centre.
2. Draw a circle around the "nucleus".
3. Add electrons on each side until the shell is full.
   - Add unpaired, then pair
   - When shell is full, add another

Example: Magnesium

Valence Electrons

Valence electrons:

- Electrons in outside shell
- "movable" – can add more or take some out of this shell
- Can be shared to make bonds

Lewis Diagrams

- Only chemical symbol and the valence electrons
- SUPER HANDY TRICK:

Number of valence electrons = <u>last</u> number of group

(How many valence electrons for Ca? Br? Xe? Al?)

Lewis Diagram Examples

1. H
2. Cl
3. Ne

Ions

Ions:

- Atom gains or loses electrons to become stable
- Gets a charge
- Metals lose electrons, non-metals gain

Ions look like noble gases!

Ion Notation

Written with the same symbol, but add charge (how many electrons it gained or lost) as a superscript

Examples:

Na^{+} (lost one electron)

N^{3-} (gained three electrons)

Naming Ions

Metals:

- _____ ion (sodium ion, aluminum ion)

Non-Metals:

- Ending changes to "-ide" (sulfide ion, chloride ion)

Non-Metal Prefixes

- –ine just becomes –ide
- Other use first syllable:
  carbide, nitride, oxide, phosphide, sulfide
- Selenium becomes selenide

Compounds

Compound:

- Two or more elements combine together
- Two main types: **ionic** and **covalent**

Ionic Compounds

- Have a **metal** and one or more **non-metals**
- **Valence electrons** of metal atoms are **transferred** to non-metal atoms
- Positive metal ions and negative non-metal ions are attracted – "bonded"

Ionic Compounds

Properties:

- High melting points
- Crystalline formation
- Dissolve in water to make solutions that conduct electricity
- Solids at room temperature

Covalent Compounds

- Also called molecular compounds
- Only non-metals
- Valence electrons are **shared** between atoms so each is stable (full valence shell)
- **Molecule** is formed

Covalent Compounds

- Most covalent compounds have properties that include:
  - Solids, liquids or gases at room temperature
  - Good insulators (poor conductors) of electricity
  - Lower boiling points

Formulas and Names

- Compounds can be written using a **name** or a **formula**, but when reading them, they would sound the same.
- For example, an ionic compound is **sodium chloride**, but it can also be written as **NaCl**. This is table salt!

Formulas and Names

The formula tells you:

- Elements in the compound, using the chemical symbol,
- Number of atoms of each element, using subscripts

Formulas and Names

KI	H_2O
CO_2	MgS
CaF_2	Li_2O

Classifying Matter

Pure substance:

Only one type of particle

Element:

Can be found on the periodic table

All the same type of atom

Compound:

Two or more elements bonded together

All the same type of particle

Classifying Matter

Mixture:

More than one type of particle

Mechanical mixture:

Mixture where different substances are visible and will not separate if left alone (heterogeneous)

Classifying Matter

Suspension:

Mixture in which one substance is "held" within another and will separate if left alone (homogeneous OR heterogeneous)

Solution:

Mixture in which separate parts are not visible, and will not separate if left alone (homogeneous)

Classifying Matter

Homo- means "same"

Hetero- means "different"

-geneous comes from the root *genus*, which means "category" or "type"

Physical and Chemical Properties

Physical properties:

- Characteristics of a substance that can be observed without changing chemical composition (using the senses or measurements)
- Include how a substance changes state

Chemical properties

- How a substance reacts when it interacts with another substance

Qualitative and Quantitative

Qualitative properties:

- Characteristics that can only be observed, not measured (no numbers)

Quantitative properties

- Measurable (have numbers and units)

Physical Properties

Colour
Lustre (shininess)
Melting point
Boiling point
Density
Ductility
Conductivity
Hardness
Texture
Malleability
Viscosity
Odour
Brittleness

Physical Properties

Other physical properties can include crystal shape, state, size, shape, volume, temperature and mass.

When describing physical properties of a substance, it is best to use as much detail as possible.

Chemical Properties

Solubility
Reactivity
Flammability
Toxicity
Heat of reaction
(energy released/absorbed)
Chemical stability

Chemical and Physical Properties

Chemistry is the study of chemical properties, and how different substances interact.

Physical and Chemical Properties

Physical and Chemical Changes

Physical and Chemical Changes

Physical Changes

- Size, shape, state or appearance changes
- Chemical composition of the substance stays the same (same type of particles)

Chemical Changes

- Particles are different, change in chemical composition

Chemical Changes

1. Production of a gas
2. Production of a precipitate (a solid)
3. Significant change in temperature
4. Production of light or fire
5. Significant change in colour

HAS TO BE A NEW SUBSTANCE!

Chemical Changes

- Also called **reactions**
- Can be written using names or formulas of the elements and compounds that are used and produced.
- The general form of a reaction is written as:

  Reactant A + Reactant B $\rightarrow$ Product C + Product D