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# Atoms and Elements

## In-Class Notes

### History of Chemistry

#### Empedocles

-He is best known for creating the cosmogonic theory

-coined the term "love" for when things come together and "strife" for when things separated

#### Cosmogonic Theory

-includes four classical elements: fire air  
water earth

#### Democritus

-was the first to propose that atoms exist and coined the term "Atomos" which means indivisible

#### Aristotle

-Believed that form and matter created the things in our world

-His philosophy included a fifth element called "Aether" which was a divine substance

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### Alchemists

- Were the first people to perform hands on experiments
- Attempted to change base metals into valuable ones such as gold
- They believed that they could find a substance that would give them eternal life. This was called the philosopher's stone

### Transmutation

- An act that changes the character of something

### Philosopher's Stone

- A legendary substance, capable of turning inexpensive metals into gold
- It was believed to be the elixir of life, useful for rejuvenation and possibly achieving immortality

### Modern Chemists

- Actually used scientific method to investigate the world around them

### Sir Francis Bacon

- One of the first scientists to develop new knowledge as a result of experimentation

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### Robert Boyle

- He published the skeptical chemist
- He recognized that air was not an element but was a mixture

### Antoine de Lavoisier

- He is considered the father of chemistry
- He defined the term "element" as a pure substance that cannot be chemically broken down into simpler substances
- He discovered and identified 23 elements

### Henry Cavendish

- He discovered that water was not an element

### Marie Curie

- Was a physicist, chemist and a pioneer in the study of radiation
- Discovered the elements Radium and Polonium
- Won the Nobel Prize for chemistry in 1911

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## Physical and Chemical Changes

### Properties of Matter

- Colour, Odour, Hardness, Melting/Freezing Point, Boiling Point, Luster, Malleability,
- Conductivity, Mass, Weight, Volume, Height, Density
- 

### Physical and Chemical Changes

#### Physical Change:

- No new substance is formed

just a change in physical appearance

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- New properties can appear
- Can be reversed
- Changing temperature or pressure is a common way to cause a physical change

#### Chemical Change:

- Always causes at least one new substance to be formed with new properties
- Difficult or impossible to change back

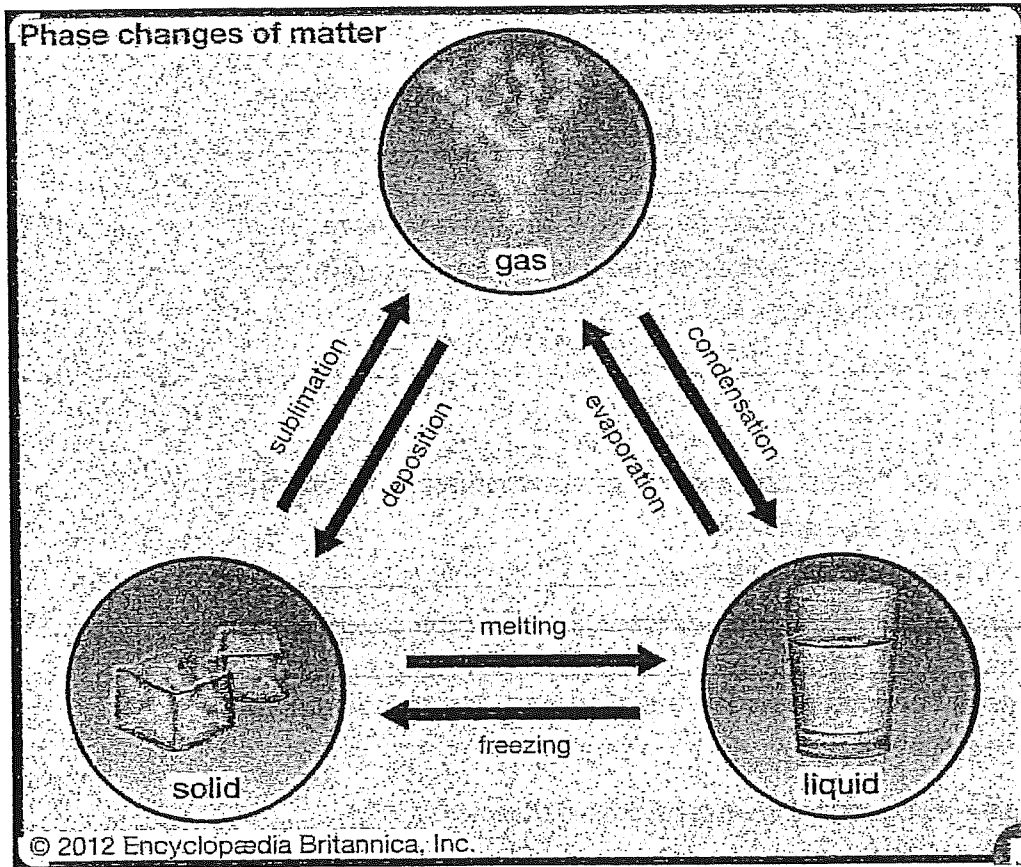
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### Indicators of change

List 3:

Heat loss/gain  
change in colour  
Precipitate forms



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## Atomic Theory and the History of the Atomic Model

### Atomic Theory

- The theory that all matter is composed of microscopic particles
- These particles contain three components called protons, neutrons, and electrons
- A pure substance is a term we use to call something that is composed entirely out of one substance or one element, such as pure gold
- Most elements do not occur naturally as pure substances but rather as compounds which contain multiple atoms from the same or different elements. An example is water (H<sub>2</sub>O)

### Protons

- Charge is +1
- The amount of protons a particular atom has is what defines it. In other words, determines what element it is
- The amount of protons an atom has is what defines it. In other words, determines what element it is
- When the amount of protons equals the amount of electrons in an atom, the atom is electrically neutral

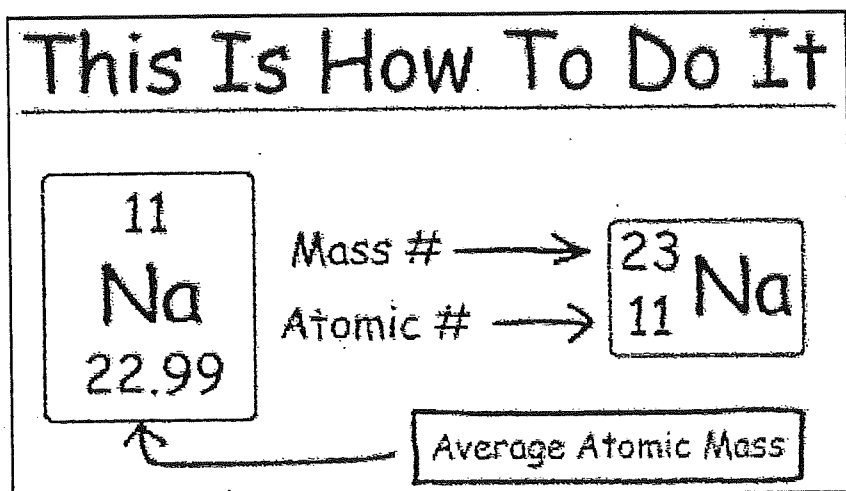
Note\*\*\* we will only be discussing neutral atoms in this class

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### Neutrons

- Charge = 0
- Located in the nucleus of the atom
- The number of Neutrons in an atom can change and the atom will remain the same element. This can occur to unstable atoms during nuclear decay
- Remember, the number of protons an atom has is its atomic number
- The number of neutrons that an element has can be calculated by this equation



Atomic Mass - Atomic Number = Number of Neutrons

$$23 - 11 = 12 \text{ Neutrons}$$

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## Electrons

- Mass is  $1/1836$  the mass of a proton/neutron (Much smaller!)
- Charge is  $-1$
- electrons reside in orbitals around the positive nucleus. We can never 100 percent know where they are, so we have them in clouds or orbitals of probability
- the first orbital always contains a maximum of two electrons
- the second orbital always contains a maximum of eight electrons
- the third orbital always contains a maximum of eight electrons

2:8:8 rule

- valence electrons are the number of electrons in the outer most orbital

## Dalton's Model of the Atom

- All elements are composed of atoms
- Atoms are indivisible and indestructible
- Atoms are not created or destroyed in a chemical reaction

## Thompson's Model of the Atom

-Atoms are Neutral

-Atom is a sphere or cloud of positivity with negative electrons scattered throughout it

- Overall charge is 0

No protons in this model



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### Rutherford's Model of the Atom

- Nucleus is positive, all protons are found here
- Electrons surround the Nucleus

### Bohr's Model of the Atom (We will Draw this One!)

- Electrons move around the Nucleus in circular paths called orbits (like planets around the Sun)
- electrons fill shells using the 2,8,8 Rule (2 in the first, 8 in the second, 8 in the third)

### Quantum Model of the Atom

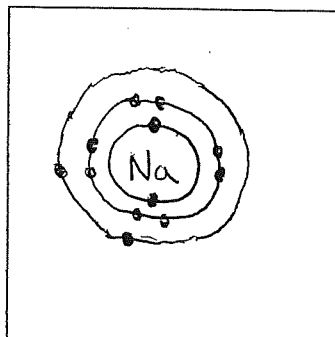
-electrons randomly move in electron clouds  
called orbitals

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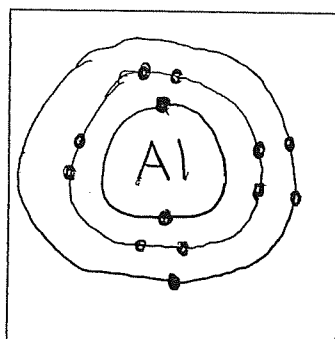
**Sodium:**

Bohr Diagram:



**Aluminum:**

Bohr Diagram:



**Metal's Metalloids and Non-Metals**

**Dimitri Mendeleev**

- Russian Chemist
- He is considered the father of the periodic table
- There was a limit to the number of elements that were discovered at this time
- However, with the creation of the periodic table of elements, Mendeleev was able to predict the existence and properties of elements that were yet to be discovered

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### Important Terms

**Ductile**- the ability to bend but not break

**Malleable**- the ability of something to be molded into various shapes or sheets

**Brittle**- something that breaks easily (opposite of ductile)

**Conduct**- to transmit a form of energy

### The Periodic Table

-The horizontal rows of the periodic table are called Periods (1-7)

The vertical columns are called families or groups (1-17)

Elements in the same family  
\_\_\_\_\_ have similar physical and  
chemical properties

### Metals

- Metals are on the left and in the center of the periodic table
- Metals have the following physical properties:
  - conduct heat and electricity
  - ductile and malleable
  - shiny
  - solid at room temperature (except mercury)

### Metals

- Metals have the following chemical properties:
  - can easily corrode/oxidize
  - react with acid to release hydrogen gas

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# Metals

## Non-Metals

- Non-metals are on the right side of the periodic table
- Non-metals have the following physical properties:
- poor conductors of heat and electricity
- Usually solid or gas at room temperature (only Bromine is liquid at room temperature)

## Non- Metals

- Non-metals have a wide range of chemical properties and reactivities
- Tend to gain electrons during a reaction

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# Non-Metals

The image shows a standard periodic table of elements. A staircase-shaped line is drawn across the table, separating metals (to the left and bottom) from non-metals (to the right and top). The elements in the shaded area, representing non-metals, include: Hydrogen, Helium, Boron, Carbon, Nitrogen, Oxygen, Fluorine, Neon, Silicon, Phosphorus, Sulfur, Chlorine, and Argon. The shaded area also includes some metalloids like Boron, Silicon, and Germanium.

## Metalloids

- Metals are separated from non-metals by a staircase of elements called metalloids
- Metalloids are elements with properties intermediate between metals and non-metals

## Metalloids

- Physical Properties:
  - solid at room temperature
  - can be shiny or dull
  - brittle not ductile
  - may conduct electricity, poor conductor of heat
- Chemical Properties:
- Vary

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# Metalloids

The image shows a standard periodic table of elements. A shaded region highlights the metalloids, which are elements that have properties intermediate between metals and nonmetals. The shaded elements are Boron (B), Silicon (Si), Germanium (Ge), Arsenic (As), Antimony (Sb), Tellurium (Te), and Astatine (At). The rest of the periodic table, including the lanthanide and actinide series, is shown in a smaller font below the main table.

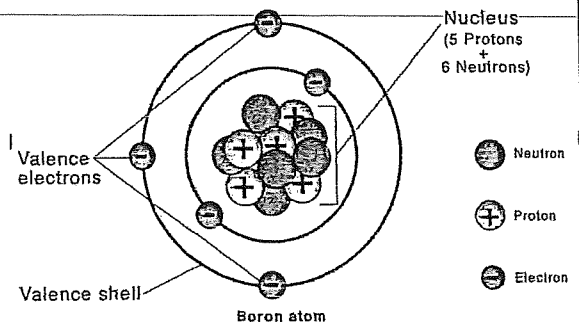
## Periodic Trends

- The reason that chemical reactions occur is based on the movement or sharing of electrons between different atoms or molecules-
- Valence electrons are the number of electrons that are in an atom's outermost shell
- -Atoms are stable if they have a full valence shell

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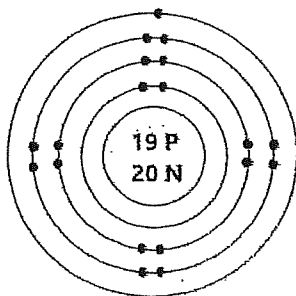
## Valence Electrons



## Period Trends

- As we move down the periodic table, we add more orbital rings
- you only need to be able to draw Bohr models of elements on the first three rows/periods but know that an additional orbital get added every row/period
- Remember the 2,8,8 rule

## Bohr model of Potassium atom



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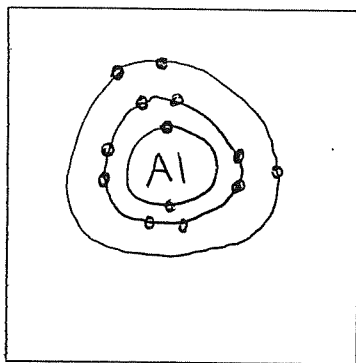
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## Periodic Trends

- Elements get heavier as we move down and to the right on the periodic table (atomic mass increases)
- This is because the proton number increases

## Aluminum:

Bohr Diagram:



Protons= 13  
Electrons= 13  
Neutrons= 14  
Atomic Number= 13  
Atomic Mass= 27  
Period Number= 13  
Valence Electrons= 3

## Periodic Table (Chemical) Families

### Chemical Families

- All atoms of elements in the same group have the same number of valence electrons
- For example, all elements in group 1 have one valence electron



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### Alkali Metals (Group 1)

Reactivity:

- React easily with water and air
- reacts easily with halogens

Physical Properties:

- Shiny Silvery
- Only found in nature as compounds
- Compounds are white solids soluble in water

### Alkaline Earth Metals (Group 2)

Reactivity:

- Less reactive than group one metals

Physical Properties:

- Shiny, silvery
- Forms compounds that are often insoluble in water

### Halogens (Group 17)

Reactivity:

- Reacts easily with alkali metals

Physical Properties:

- Poisonous
- Exists naturally as compounds ( $\text{Cl}_2$  is chlorine gas)

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## **Noble Gases (Group 18)**

Reactivity:

- Inert, stable, unreactive
- Can be excited by electricity to produce colors, but are chemically uncharged

Physical Properties

- colourless, odourless
- Gases at room temperature
- Does not form compounds

## **Elements Molecules and Compounds**

### **Elements and Compounds**

- Some substances are made up of only one element

-Lead Pb, Gold (Au)

-Neon (Ne), Silver (Ag)

-anything on the periodic table in pure form

- Most substances are made up of more than 1 element

- Salt (NaCl), Water (H<sub>2</sub>O)

- Sugar (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>)

-Caffeine

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## Elements and Compounds

- Element:

- the simplest form of a substance

- the smallest particle of an ~~at~~ element is  
an atom

- Compound:

- The simplest form of a material. That is made up of 2  
or more elements

- The smallest particle of a compound is a molecule. Which is composed of two or more atoms

Which are compounds? (Circle the ones that are compounds)

Water

Gasoline

Gold

Pizza

Potassium

Air

Oxygen Gas

Blood

Nitrogen

Salt

Liquid Mercury

Sugar

Argon

Coffee

even though its a pure gas, it is a compound because all  
gasses form compounds. ex.  $O_2$ ,  $F_2$

Compounds

- Elements will combine to form compounds through chemical reactions
- The process of an atom losing or sharing one or more electrons and another atom gaining one or more electrons

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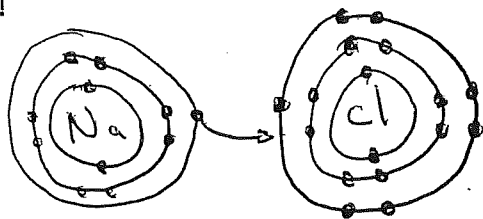
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### Examples

- Atoms can gain or lose electrons to form compounds:
- $\text{Na} + \text{Cl} \rightarrow \text{NaCl}$  (Salt)
- Na loses 1 electron
- Cl gains one electron

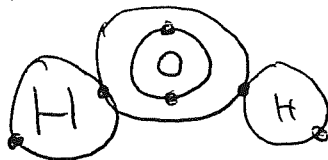
Goal is to have a full shell

Please draw it!



- Atoms can share electrons to form compounds:
- $2\text{H} + \text{O} \rightarrow \text{H}_2\text{O}$  (Water)
- H and O will share electrons

Please Draw it!



Goal is still to have a full shell

### What is a Chemical Formula?

- The number and kind of atoms that make up a molecule of material

Water's chemical formula = H<sub>2</sub>O

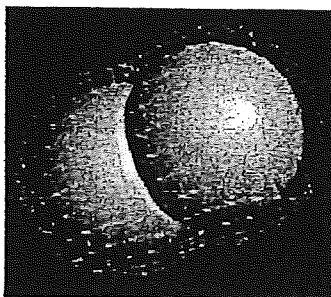
- Water consists of 2 atoms of Hydrogen H<sub>2</sub> and one atom of oxygen (O)

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## Worksheet

- ⊙ Identifying elements and number of atoms
- ⊙ Diatomic molecules = made of only two atoms.
- ⊙ Di means two in Greek
- ⊙ E.g.  $H_2$ ,  $O_2$



## Worksheet explained cont...

- ⊙ E.g.  $3AlCl_3$
- ⊙ The coefficient tells us how many molecules we have.
- ⊙ Here we have three molecules of  $AlCl_3$
- ⊙ The subscript tells us how many of each atom we have.
- ⊙ Each molecule has 1 Al and 3 Cl
- ⊙ We have to multiply that by the coefficient to get the total # of atoms.
- ⊙  $1 \times 3 = 3 \text{ Al}$     $3 \times 3 = 9 \text{ Cl}$

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Lets do this together

$4Pb(NO_3)_2$  How many molecules?  
How many Leads? Nitrogens? Oxygens?

$3H_2SO_4$  How many molecules?  
How many Hydrogens?  
Sulfurs? Oxygen?

### Classification of Matter

- Matter: Anything that has mass and takes up space
- Mixture: Two or more substances mixed together
- Pure Substance: A substance that contains only one kind of matter
- Mechanical Mixture: A mixture of two or more components that can be seen with the unaided eye

### Solutions

- Solution- a liquid mixture of two or more components (a solvent and a solute)
- Heterogenous Solution- a solution that has two very different components like a smoothie

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- Homogenous Solution- a solution that is consistent all the way through, like Kool-Aid
- Precipitate- When there is an excess of solute that collects and won't dissolve, like sugar at the bottom of coffee