**Chapter 3 – Atoms: The Building Blocks of Matter**

I. The Atom: From Philosophical Idea to Scientific Theory

# Performance-Based Objective #1 (Let’s Annotate!)

**SWBAT** compare and contrast the historical models of the atom (Dalton, Thomson, Rutherford) **IOT** illustrate how advances in technology and data collection lead to modifications and improvements to the current understanding of atomic theory**.**

1. The particle theory of matter was supported as early as \_\_\_\_\_ BC

by the Greek thinker (philosopher) \_\_\_\_\_\_\_\_\_\_\_\_. He called

nature’s basic particle an \_\_\_\_\_\_, based on the Greek word

meaning “indivisible.”

B. Three Basic Laws About Matter

1. In the 1790s, advances in technology (improved balances)

allowed chemists to study how compounds reacted.

2. Three Laws (Evidence for Atomic Theory)…

a. **Law of Conservation of Mass** – mass is neither \_\_\_\_\_\_\_\_\_nor \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ during ordinary chemical reactions or physical changes.

b. **Law of Definite Proportions** – a compound

contains the \_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_ in exactly the same \_\_\_\_\_\_\_\_\_\_\_\_\_ by mass regardless of sample size

or source of the compound.

c. **Law of Multiple Proportions** - if two or more compounds are composed of the same two elements, then the \_\_\_\_\_ of the masses of the

**\_\_\_\_\_\_\_\_** element combined with a certain mass of the \_\_\_\_\_\_\_ element is a ratio of \_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_

B. Compounds Contain Atoms in Whole-Number Ratios

1. John Dalton (1776-1884) - published his Atomic Theory in 1808

a. All matter is composed of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_ particles called \_\_\_\_\_\_\_\_\_

b. Atoms of a given element are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in

\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_, and other properties.

Atoms of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_ differ in these properties.

c. Atoms cannot be \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_,

or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

d. Atoms of different elements combine in simple \_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ to form chemical \_\_\_\_\_\_\_\_\_\_\_\_\_

e. In a chemical reaction, atoms are \_\_\_\_\_\_\_\_\_\_\_\_\_,

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. **Dalton’s Atomic Theory** easily explains the **Laws of**

**Conservation, Definite Proportions, and Multiple**

**Proportions of Mass**!

C. Atoms **CAN** be subdivided into smaller particles!

Two points of Dalton’s theory have been modified due to

technological advancements:

1. Atoms **CAN** be divided into smaller particles (protons,

neutrons, and electrons)

2. Atoms of the same element **CAN** have slightly

**DIFFERENT** masses

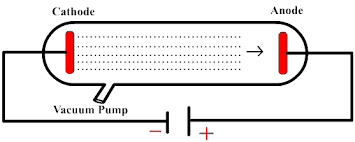
II. The Structure of the Atom

A. **Atom –** smallest particle of an \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ that retains the

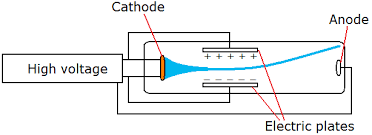
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of that element.

B. Atoms Contain Positive and Negative Particles

1. Cathode Ray Tube (Sir William Crookes - 1879)



* NOTE: When an electric or magnetic field was placed near the tube, the particles were affected in a strange way!



* These experiments led to the hypothesis that the particles in a cathode

rays are \_\_\_\_\_\_\_\_\_\_\_\_\_ charged.

2. John Joseph (“J. J.”) Thomson (1897)

1. Measured the ratio of the \_\_\_\_\_\_\_\_ of the cathode-ray particles to their \_\_\_\_\_ .
2. Concluded that all cathode rays are composed of

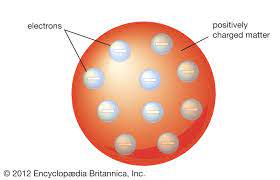
\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_ charged particles, which were named \_\_\_\_\_\_\_\_\_\_.

3. Robert Millikan (1909) – measured the \_\_\_\_\_\_\_\_\_\_ of the

electron (“Oil Drop Experiment”)

4. Since matter is neutral, there has to be positive material in

the atom to counteract the electrons

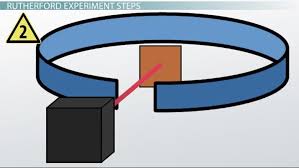
\* JJ Thomson proposed the Plum Pudding Model in 1904…but we now know it was **INCORRECT!!!**

C. Atoms have Small, Dense, Positively Charged Nuclei

1. The Gold Foil Experiment (Ernest Rutherford - 1911)

a. Experimental Design

1. A thin, gold foil was bombarded with \_\_\_\_\_\_ particles (positively-charged; four times the mass of the hydrogen atom)



2. The foil was

surrounded by a

screen that would

detect where the

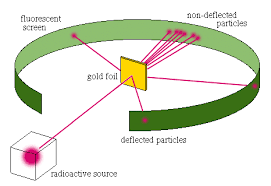
alpha particles

would hit once they

passed through the

foil

b. The Results



1. Most of the alpha

particles went straight

through the foil or were

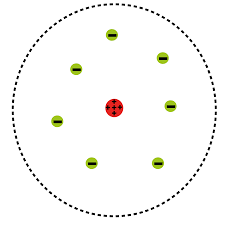
slightly deflected (this

was expected)

2. **HOWEVER** they were surprised when about 1 of 8000 particles deflected \_\_\_\_\_\_\_\_\_\_ toward

the source.

c. Rutherford’s Hypothesis



1. Small, densely packed bundles of matter with a

\_\_\_\_\_\_\_\_\_\_ charge must have caused the

backwards deflections.

2. Rutherford used the term \_\_\_\_\_\_\_\_\_\_ to

describe each bundle of matter.

3. Rutherford refined his model by including

positively charged particles in nucleus called

protons

4. For every proton an atom has in its nucleus,

the same number of \_\_\_\_\_\_\_ surrounds the nucleus

D. A Nucleus contains Protons and Neutrons

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Particle** | **Symbols** | **Relative Electric Charge** | **Mass**  **Number** | **Relative**  **Mass**  **(u\*)** | **Actual Mass**  **(kg)** |
| Electron |  |  |  | 0.0005486 | 9.109 x 10-31 |
| Proton |  |  |  | 1.007276 | 1.673 x 10-27 |
| Neutron |  |  |  | 1.008665 | 1.675 x 10-27 |

\* u = unified atomic mass unit or “amu”

III. Counting Atoms

**Performance-Based Objective #2 (Let’s Annotate!)**

**SWBAT** apply an understanding of isotopes, atomic number, and mass number **IOT** determine the number of protons, neutrons, and electrons in an isotope**.**

A. All atoms of an element must have the same number of protons but

not neutrons

1. **Atomic Number –** number of \_\_\_\_\_\_\_\_\_\_\_ in the nucleus

a. Every element has a **DIFFERENT** atomic number. This identifies the element!

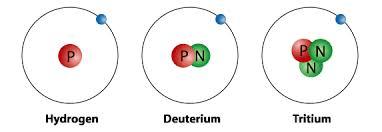
b. Found on the periodic table...in each element block near the symbol

c. In a neutral atom, there will be the \_\_\_\_\_\_\_\_ number of \_\_\_\_\_\_\_\_\_\_\_\_ as there are \_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. **Isotopes** – atoms of the \_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

that have \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ masses.

1. Isotopes of Hydrogen



|  |  |  |  |
| --- | --- | --- | --- |
| **# p+** |  |  |  |
| **# n0** |  |  |  |
| **p+ & n0** |  |  |  |

1. The atoms in any sample of an element most likely

will have a mixture of several isotopes in various

proportions.

3. **Mass Number** – total number of \_\_\_\_\_\_\_\_\_\_\_\_\_ and

\_\_\_\_\_\_\_\_\_\_\_\_\_ that make up the nucleus of an isotope.

1. MUST be given to you!!! NOT on the periodic table!!!

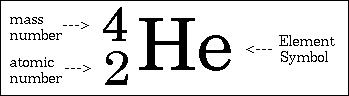
b. Isotopes have the same \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_

**BUT** different \_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_!

c. Although isotopes have different masses, they do NOT have different chemical behavior

4. Identifying Isotopes

a. Nuclear Symbol



1. Hyphen Notation



c. Using either notation, one can determine the number of protons, neutrons, and electrons the isotope possesses

1. # protons = atomic number (from periodic table) = # electrons

2. # neutrons =

d. Examples

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Nuclear Symbol** | **Hyphen**  **Notation** | **Number of protons** | **Number of neutrons** | **Number of electrons** |
| chlorine-35.png |  |  |  |  |
| Iodine-131.jpg |  |  |  |  |
|  | Uranium-235 |  |  |  |
|  |  | 20 | 21 | 20 |

B. Atomic mass is a **relative** measure

1. Carbon-12 (6 protons/6 neutrons) was assigned a mass of

12 **atomic** **mass units** (**amu**s)

2. One **atomic mass unit** (**amu**) is defined as \_\_\_\_\_\_\_\_\_\_\_\_\_

the mass of a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ atom

3. The mass of all other isotopes were determined by

comparing their mass to that of carbon-12

4. One amu is nearly, but not exactly, equal to one proton or

one neutron

C. Average atomic mass (or average atomic weight) is a **weighted**

value

1. Scientists determine the average atomic mass by

determining the abundance of each isotope and then

factoring in the mass of the isotope.

1. Most naturally-occurring elements have at least two

isotopes.

D. A **relative** mass scale makes counting atoms possible

1. The Mole

a. A **mole** is the amount of substance that contains as

many \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ as there are \_\_\_\_\_\_\_\_\_\_\_\_

in exactly 12 grams of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

b. The mole is a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ unit (a word that

indicates a number)

2. Avogadro’s Number

a. The number of particles in a mole has been

experimentally determined in a number of ways.

b. The best modern value is

6.02214179 x 1023

which means there are 6.02214179 x 1023 atoms of

carbon-12 in a 12 gram sample.

c. This number is called “Avogadro’s Number” in honor

of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_...

the Italian scientist whose ideas were crucial in

explaining the relationship between mass and

numbers of atoms.

d. This number is usually rounded to…