

You have mastered this topic when you can:

- 1) describe atomic models developed by **DEMOCRITUS** and **ARISTOTLE**.
 - 2) name and describe the atomic models developed by **DALTON**, **THOMSON** and **NAGAOKA**.
 - 3) describe the relative location and charge of an **ELECTRON**.
-

EARLY ATOMIC THEORIES OF MATTER [VIII.1.A.a), pgs. 139 – 142]

I) **A brief history of Atomic Structure:** For over 2500 years, people have been pondering the structure of *matter*. Below is a brief description of the development of several early *Atomic Models*.

II) **EARLY GREEK MODELS OF MATTER.** Early Greek philosophers created the first models of *matter*. A philosopher is a person who creates theories based on their personal observations, experiences, and logic. They do not perform experiments thus their models are not scientific models.

A) Empedocles (~ 450 B.C.E.) reasoned that *matter* is composed of four elementary substances: *air*, *earth*, *fire* and *water*.

B) **DEMOCRITUS** (~ 400 B.C.E.) reasoned that *matter* is composed of particles called *atoms*. He described *atoms* as tiny unbreakable particles having different sizes and shapes that are in constant motion in empty space (a void). To account for the vast variety of *matter*, he reasoned that each substance has its own unique *atom*. *Atoms* of different substances have different sizes and different shapes. **e.g.** The *atoms* of water have a different size and shape than the *atoms* of chocolate.

C) **ARISTOTLE** (~ 350 B.C.E.) disagreed with *Democritus* and supported an expanded version of the *four-element* model proposed by Empedocles. *Aristotle* reasoned that *matter* consists of unique combinations of four fundamental *elements*: *air*, *earth*, *fire* and *water*, each of which could be *hot* or *cold*, *moist* or *dry* [Diagram near the bottom of page 139 of Hebden]. **e.g.** Fog could be described as cold, moist air; a chili pepper could be described as hot, moist earth. Since *Aristotle* was more popular than *Democritus*, his four *element* model was accepted as fact for almost 2000 years.

II) **EARLY ATOMIC THEORIES** [pgs. 140 – 142]

A) **ROBERT BOYLE** (1600's) questioned the validity of *Aristotle's four-element theory*. If all *matter* is composed of combinations of the four *elements air*, *earth*, *fire* and *water*, then those *elements* must be the *fundamental particles* of which *matter* is composed. *Boyle* reasoned that since *elements* were the *fundamental particles* of *matter*, *elements must be pure substances composed of one kind of particles that cannot be chemically broken down into simpler substances*. Using this concept of an *element*, *Boyle* reasoned that *Aristotle's elements* were *pure substances*, which meant that each of *Aristotle's* four elements was composed of its own uniquely structured particle. Boyle's experiments and observations revealed that each of *Aristotle's elements (air, earth, fire and water)* can be broken down into simpler substances by chemical means. Earth can be broken down chemically through many different refining processes to produce substances such as gold, copper, oxygen, carbon, lead, mercury, uranium, iodine, aluminum, etc. Water can be broken down chemically through the process of electrolysis to produce hydrogen gas and oxygen gas. (Chemical electrolysis uses electricity to break apart a *compound*.) As a result of his experimentation, *Boyle* concluded that *Aristotle's four elements* were not the *fundamental particles* of *matter* known as *elements* because they can be broken down into simpler substances. This conclusion created a new definition of an *element*:

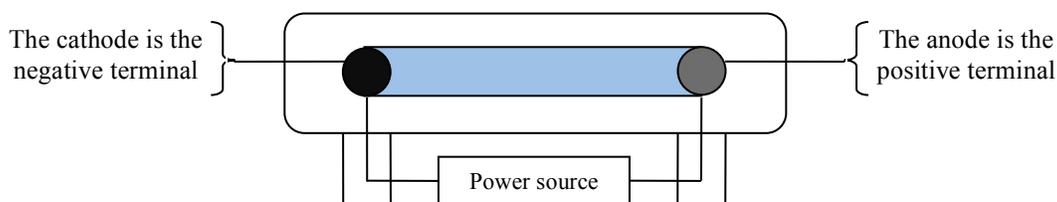
An ELEMENT _____

Boyle's theory of *elements* inspired other scientists, to further research which led to the development of much more accurate *models* of *matter*.

B) **JOHN DALTON** studied the existing research about the structure of *matter* and in 1803 he summarized his conclusions in the first scientifically accurate *ATOMIC THEORY*. *DALTON'S ATOMIC THEORY* is summarized in these five key points. ← **UNDERSTAND AND MEMORIZE ALL OF THEM!!**

- 1.
- 2.
- 3.
- 4.
- 5.

C) In 1870, William Crookes used cathode ray tubes to investigate atomic structure. A cathode ray tube is a sealed glass tube containing trace amounts of gaseous element. Two electrodes, an anode and a cathode, are inserted into opposite ends of the cathode ray tube and are connected to a power source, a source of electricity. When the power source is activated the cathode becomes negatively charged and the anode becomes positively charged.



1) When the power source was activated a glowing beam between the cathode and the anode was observed. This glowing beam came to be known as *cathode rays*. Crookes knew that the *cathode rays* were emitted by the cathode, and that they consisted of either light rays or glowing *particles*. He also knew that magnets have no effect on light rays while they cause *particles* to move. This knowledge led him to place a magnet near a beam of *cathode rays* to see if they moved. The magnet caused the *cathode rays* to bend, which led Crookes to conclude that *cathode rays* were composed of *particles* not light rays. To remind us of this fact we'll refer to the glowing beam as *cathode particles*. Crookes repeated these experiments using many different *elements* as the cathode with each experiment producing the same **results**: All the elements tested produced a glowing beam of *cathode particles* that was deflected when a magnet was brought near it. Crookes was not able to determine how the atoms of the elements used as a cathode produced the glowing beam of *cathode particles*; this inspired further research to identify the source of the *cathode particles*.

D) **J. J. THOMSON**: In the 1890's, *Thomson* repeated the experiments done by Crookes 20 years earlier. *Thomson* observed that every *element* used as a cathode produced a beam of *cathode particles* and that all beams of *cathode particles* behaved the exact same ways. **FIRST**: *Cathode particles* traveled in a straight line from the cathode, the negative terminal, to the anode, the positive terminal. **SECOND**: When he placed a positive charge next to the cathode ray tube, the *cathode particle* beam was deflected (bent) toward it a specific distance. **THIRD**: When he placed a negative charge next to the cathode ray tube, the *cathode particle* beam was deflected (bent) away from it a specific distance. *Thomson* knew that *opposite charges attract each other and like charges repel each other*. As a result he reasoned as follows: **FIRST**: Since the *cathode particle* beam was attracted to a positive charge and repelled from a negative charge he concluded that *cathode particles* carry a

negative charge. Since all *elements* he tested emitted a *cathode particle* beam and all *elements* are composed of *atoms*, all *atoms* contain these *negatively charged cathode particles*. **SECOND:** Every *element* tested produced *cathode particles* that deflected (bent) the same distance toward a given positive charge and the same distance away from a given negative charge placed next to the cathode ray tube. This meant that the *negatively charged cathode particles* released from every *element* tested *had identical mass and identical charge*. Thomson named these particles *corpuscles*. The negatively charged *corpuscles* were eventually named **ELECTRONS**, symbolized as e^- , and were the first **SUBATOMIC** particle to be discovered. **SUBATOMIC means under or smaller than the atom.** Since all *electrons* are identical and each carries the same amount of negative charge, it was decided that each *electron* carries a relative charge of negative one (-1). This means that an atom containing four *electrons* carries a negative four charge.

1) **Thomson** knew that *all atoms contained negatively charged electrons and that all atoms are electrically neutral*. This led him to develop the **MUFFIN MODEL (AKA: plum pudding model)** in 1903, which is summarized here.

- 1.
- 2.
- 3.
- 4.

E) **HANTARO NAGAOKA** developed the **SATURN MODEL** in 1904 using the same information **Thomson** used to develop his *Muffin Model*.

1) **Nagaoka's Saturn Model** is summarized here.

- 1.
- 2.
- 3.

C) **Required Practice 1:** Answer these questions on your own paper. {See your Teacher.}

1. Describe the *models* of *matter* developed by **Democritus** and **Aristotle**.
2. Draw and describe the *atomic model theorized* by **Dalton**.
3. Name, describe and draw the atomic models developed by **Dalton**, **Thomson** and **Nagaoka**.
4. How are the models of **Dalton**, **Thomson** and **Nagaoka** similar and how are they different?