Chapter 4

Atomic Structure

Warm – Up

We have not yet discussed this material, but what do you know already??

- What is an atom?
- What are electron, neutrons, and protons?
- Draw a picture of an atom from what you know today.

Today's Agenda

- QOTD: How did we come to understand the atom?

- Historical journey of the atom
- Scientists and experiments
- Atomic Structure

- No homework tonight, but warning, you'll have some this weekend…

History of the Atom

- 1. Democritus vs. Aristotle pg. 102-103
- 2. **John Dalton** and conservation of mass pg. 104-105
- 3. Cathode ray tube and Sir William Crookes pg. 107-108
- 4. Mass and charge of electron (J.J. Thompson) and oil drop experiment pg. 108-109
- 5. Plum pudding model vs. **Rutherford's experiment** pg. 110-112

Democritus

- Greek philosopher who asked questions about matter.
  - Can you divide matter infinitely?
    - Democritus says no!
  - Tiny particles called atoms, indivisible!

- Matter is composed of atoms,

  which move through empty space.
- Atoms are solid homogeneous, indestructible, and indivisible.
- Atoms have different sizes and shapes. These properties, and movement determine properties of matter

John Dalton

- Matter is composed of small particles called atoms that are indivisible and indestructible.
- Atoms of a given element are identical in size, mass, and chemical properties, and are different from those of another element.
- Different atoms combine in simple whole number ratios to form compounds.
- In a chemical reaction, atoms are separated, combined or rearranged.

The Atom

- EXTREMELY small particle of an element that retains the properties of that element is an atom.
- If atom is the size of an orange, an orange would be the size of the EARTH

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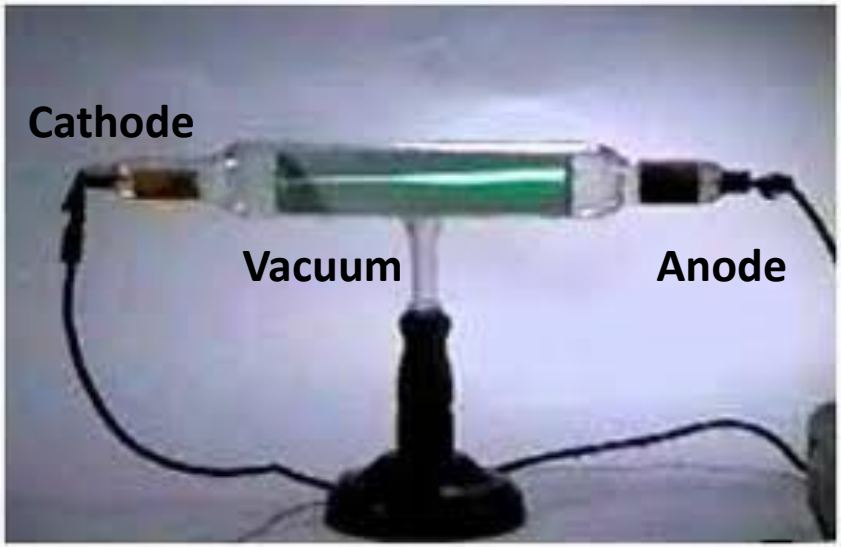
Subatomic Particles - Electron

- Cathode Ray Tube

Thin beam of electrons travels from cathode to anode!



- Cathode rays are a stream of charged particles. Particles carry a negative charge…now called electrons!

J.J. Thompson

- Determined that the mass of the charged particle (electron) was much less than that of the hydrogen atom.
  - Dalton was WRONG about the atom being the smallest particle!

Dalton's Inaccuracies

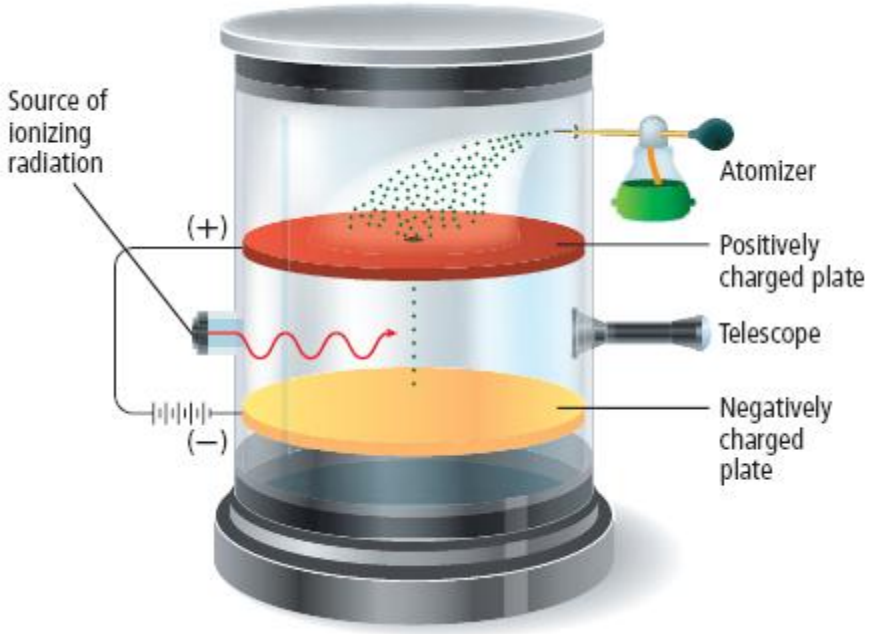
- Atoms are not the smallest type of matter!
  - Subatomic particles – electrons, protons, and neutrons
- Atoms of the same element can have slightly different masses! - isotopes

Millikan Oil-Drop Experiment

- Determined the charge of an electron.

Charge up the oil particles with electrons.

Change the electric field changes the rate of oil droplets! (MOVIE!)



Charge of electron 1.602×10^{-19} coulombs

Mass of electron = 9.1×10^{-28} grams

Plum Pudding Model

- Matter isn't all negatively charged, so how do we have negatively charged subatomic particles without positively charged ones??
- J.J. Thompson thought an atom was a positively charged sphere with electrons hanging out within.

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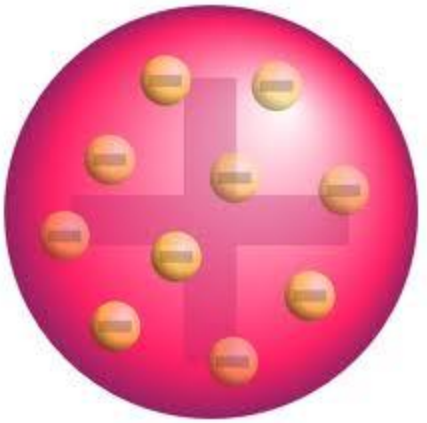


Warm Up

- What were Dalton's inaccurate theories. Why are they wrong?
- What were the correct ones?
- What was JJ Thompsons model for the atom?

Agenda

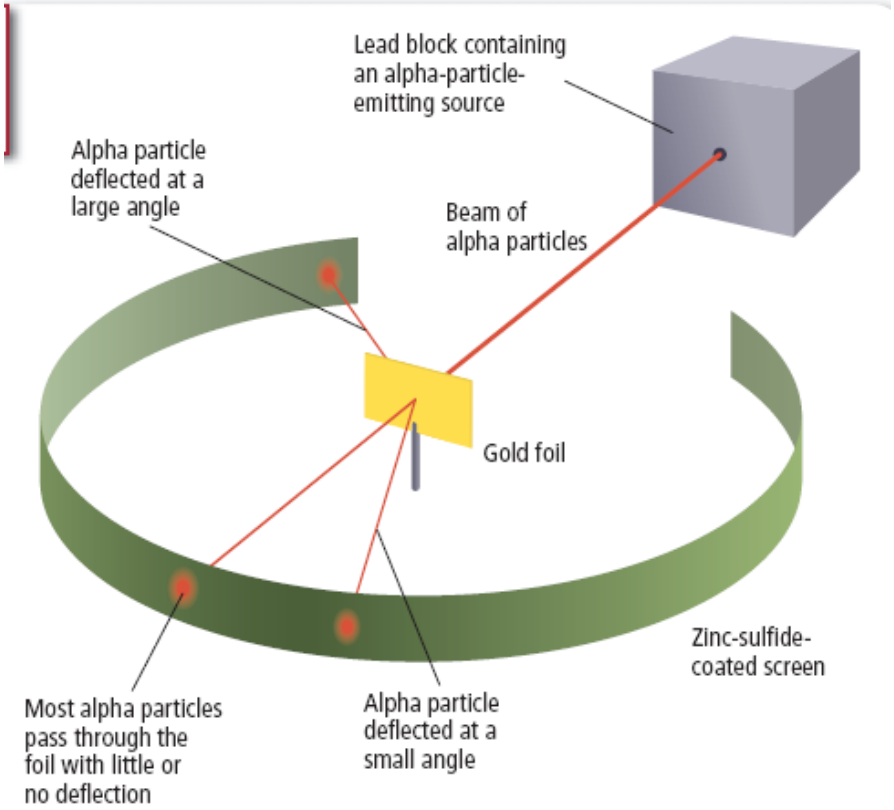
- Question of the Day: What is an isotope and how do we write an isotopic symbol?

- Finish history lesson
- Periodic table and isotopes
- Ions

- Homework is actually due tomorrow…I forgot that we started on a Tues…sorry!

Rutherford and the Nucleus

- Experiment proved that plum pudding model was incorrect!
- Atom is mostly empty space through which e^- can move. Almost all of the positive charge and atomic mass resides in the center – NUCLEUS!



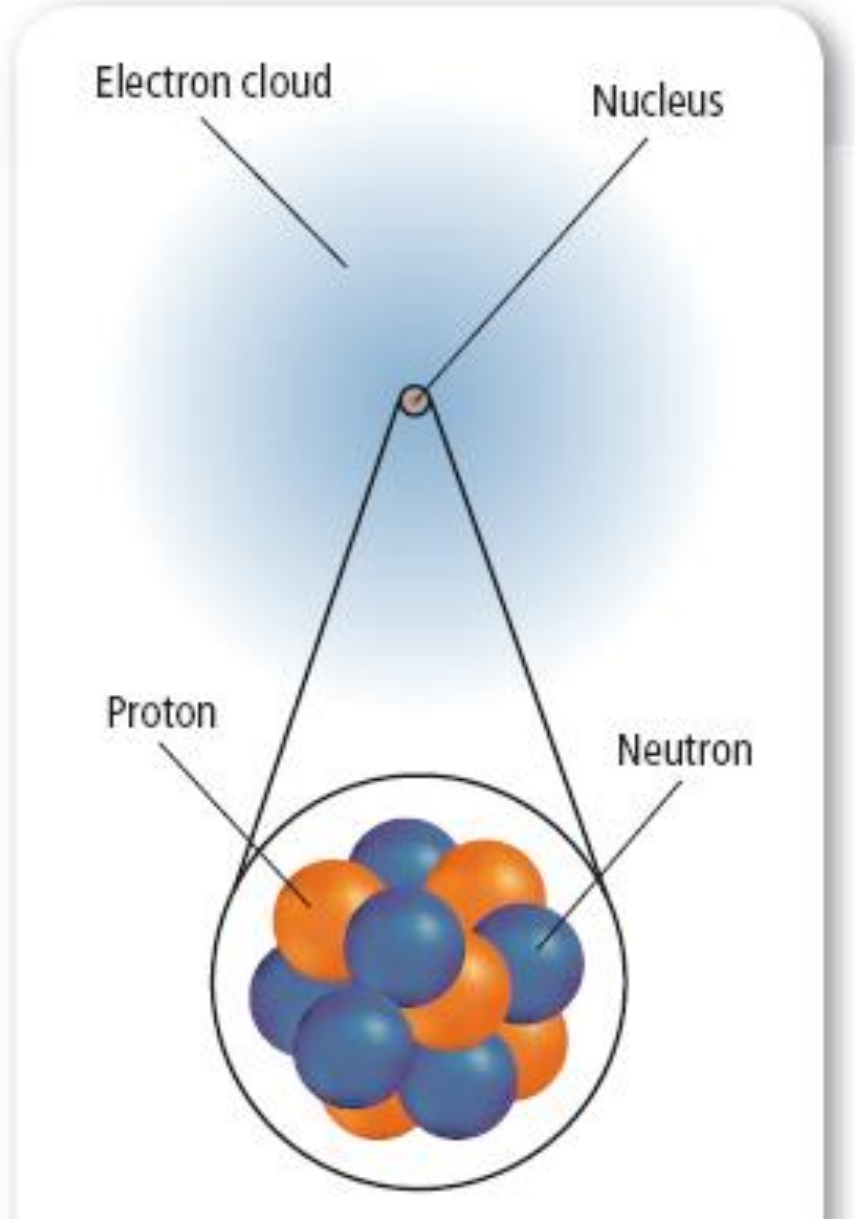
Nucleus is positively charged to deflect alpha particles and to balance electron charge.

Subatomic Particles

- Electron – VERY tiny, negatively charged
- Proton – located in the nucleus, charge opposite of an electron (positive!)
- Neutron – located in the nucleus, same mass as a proton, neutral!

Atomic Theory Today

- Quantum Mechanical Model
- All atoms are made up of electrons, protons, and neutrons. Electrons are located outside of the nucleus, protons and neutrons are located inside the nucleus.
- Electrons exist in a cloud surrounding the nucleus. Attracted to the nucleus so they hang around!
- Nucleus accounts for 99.97% of the atomic mass, and occupies a VERY small volume.
- A neutral atom has the same number of electrons and protons!



Current Atomic Model

Neutral atom:

Protons = # Electrons

Simulation!!

Summary

- What are John Dalton's 4 theorems
  - Which ones are wrong and why?
- How was the electron discovered?
- Who discovered the mass of an e^-?
  - HOW?
- What was Rutherford's contribution?
- Describe the structure of the atom.

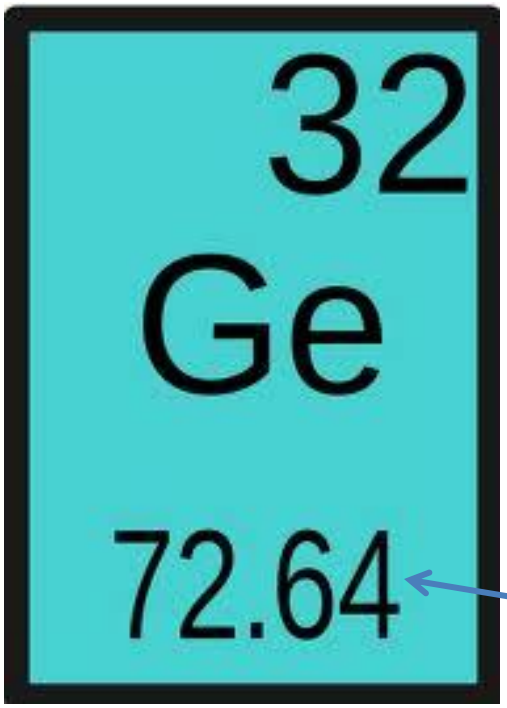
Periodic Table of the Elements

- hydrogen
- alkali metals
- alkali earth metals
- transition metals
- poor metals
- nonmetals
- noble gases
- rare earth metals

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Unq	105 Unp	106 Unh	107 Uns	108 Uno	109 Une	110 Unn								

58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Properties of Atoms



Atomic #
# of Protons =
# of Electrons
(in neutral atom)

Atomic mass
Protons + # neutrons

Practice

Atomic Number Complete the following table.

Composition of Several Elements				
	Element	Atomic Number	Protons	Electrons
a.	Pb	82		
b.			8	
c.				30

What is the isotopic symbol for each?

Isotopes and Ions

- Isotope – Atoms with the same number of protons but different number of neutrons.

- Things to remember –
  - The # of protons of an element **NEVER** changes, and is **ALWAYS** the same as the Atomic #.
  - If the # neutrons is different = ISOTOPE
  - If the # electrons is different = ION
    - + = cation Less electrons
    - - = anion More electrons

Isotopic symbol : $^{70}_{32}Ge$

Warm Up!

Element	Atomic #	Mass #
Calcium	20	46
Oxygen	8	17
Mercury	80	204

What is the number of protons, electrons, and neutrons for each?

What is the isotope symbol (shorthand notation) for each?

Today's Agenda

- Question of the day: How do we calculate the average mass of an element?

- Finish table from yesterday
- Shorthand notation
- Average atomic mass calcs!

- Ch 4 58-74 evens due tomorrow (they're not too bad) LEAVE LAB NTBKS tonight!! Al lab!

Fill in the table!

Name	Symbol	Atomic #	Atomic Mass	# protons	# neutrons	# electrons	Atom/ cation/ anion
	K		40				Atom
Boron					6	5	
	Br				45	36	
Sodium			24			10	
Nitrogen					8	10	

What is the shortand notation (isotopic symbol with charges if needed!)

Mass of Atoms

- Mass of electron = 1/1840th of a proton
- Mass of proton ≈ mass of neutron
- 1 atomic mass unit (amu) ≈ mass of proton

Carbon 12 atom = 12 amu

Why aren't the masses of elements in whole numbers?

Atomic Mass = Average of Isotopes

- Weighted average mass – mass of each isotope contributes to total mass according to *how much* of that isotope exists.

Amu = ((Mass of Isotope$_1$) x (Relative Abundance$_1$)) + ((Mass of Isotope$_2$) x (Relative Abundance$_2$))…

Amu = ((M_1) x (RA_1)) + ((M_2) x (RA_2)) + ((M_3) x (RA_3))…

Atomic Mass = Average of Isotopes

- Given info:

K

Potassium

Three isotopes = $^{39}_{19}K$ $^{40}_{19}K$ $^{41}_{19}K$

Percent Composition:	93.26%	0.01%	6.73%

What is the atomic mass (AMU)??

Calculate the Atomic Mass of K

1. Use % composition and convert to relative abundance decimal (divide by 100)

93.26% composition = .9326 relative abundance

2. Amu = ((Mass of Isotope$_1$)x(Relative Abundance$_1$)) + ((Mass of Isotope$_2$)x(Relative Abundance$_2$))…

((0.9326)x(39)) + ((0.0001)x(40)) + ((0.0673)x(41)) = 39.1347 amu

Practice

- What element is this?

Isotope	Mass of Isotope	Percent abundance
^{6}X	6.015 amu	7.59%
^{7}X	7.016 amu	92.41%

Find atomic mass and ID the element (from table)!

- Boron has two isotopes: Boron-10 (% abundance – 19.8%, mass = 10.013 amu) and Boron-11 (% abundance – 80.2%, mass – 11.009 amu). Calculate the atomic mass of Boron.

- Bromine has two isotopes with the first having a mass of 78.918336 amu and occupying 50.69% and the second isotope having a mass of 80.916289 amu and occupying 49.31%. What is the average atomic mass of bromine?

- Verify the atomic mass of Magnesium:

^{24}Mg = 23.985042 amu and percent abundance of 78.99% , ^{25}Mg = 24.985837 amu and percent abundance of 10.00%, ^{26}Mg = 25.982593 amu and percent abundance of 11.01%.

One more…

- Copper has two naturally occurring isotopes, Cu-63 and Cu-65. The atomic mass of Cu is 63.55 amu. Calculate the percent abundances of the two isotopes.