The Atom & Periodic Table

Unit 2

Topics 1-3

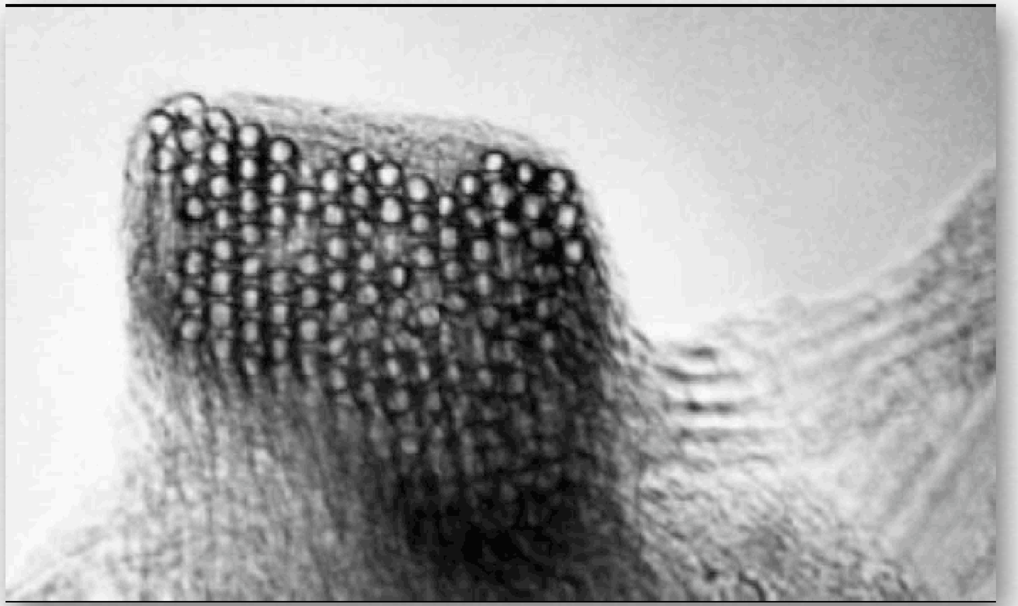
Development of the Atomic Model

Topic 1

- **What do you think of when you hear the word 'atom'?**

Lab: Black Box

How small is an atom?



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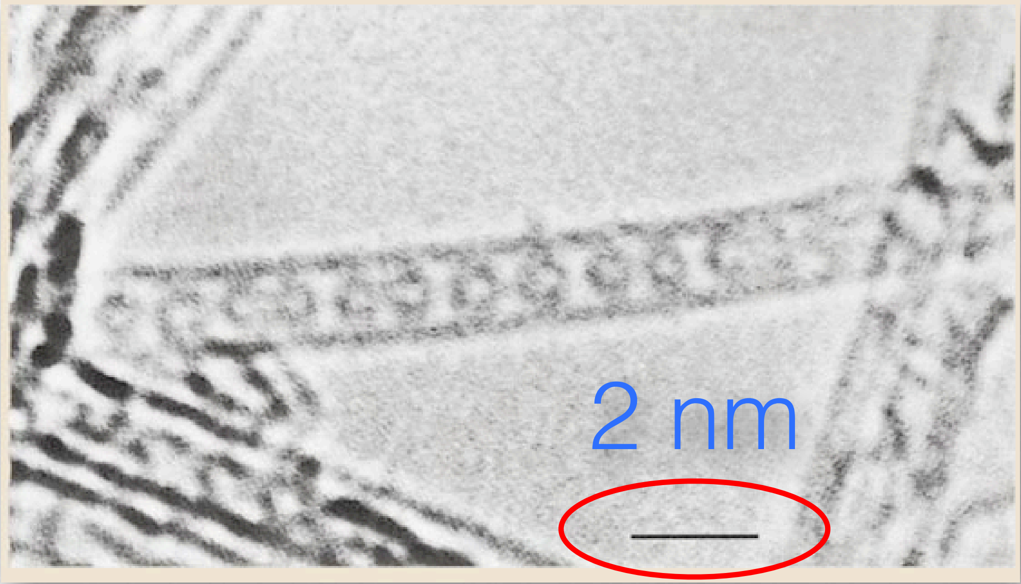
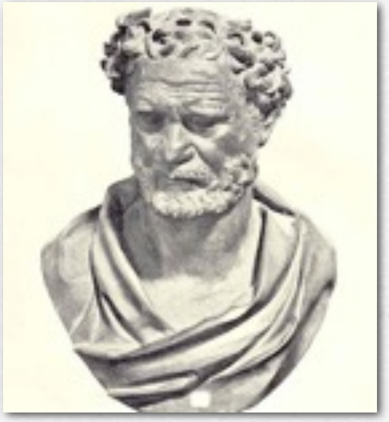


TEM

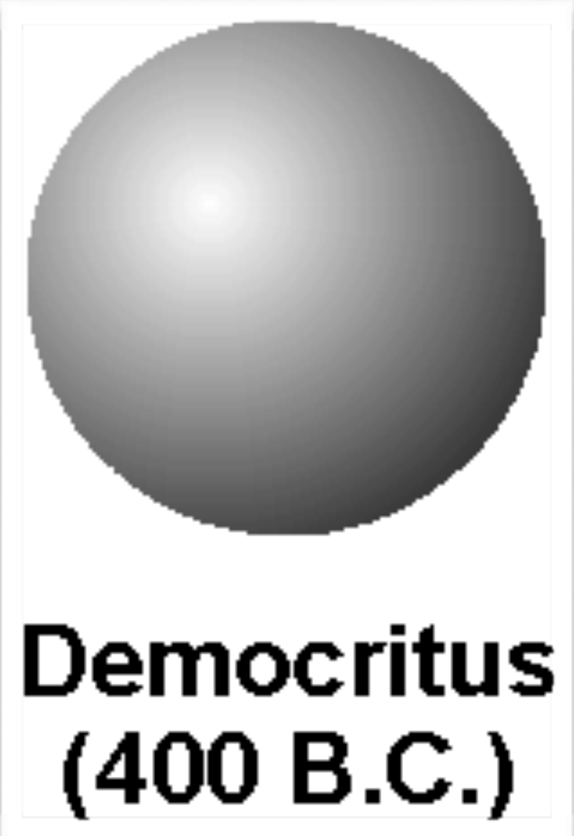
One nanometer equals 1x10^{-9} meters.

Then 62,500,000 of these pictures would fit in one meter!

Democritus's Atomic Theory



The smallest piece of matter is indivisible (atomos, which means 'not to be cut')



Atoms:

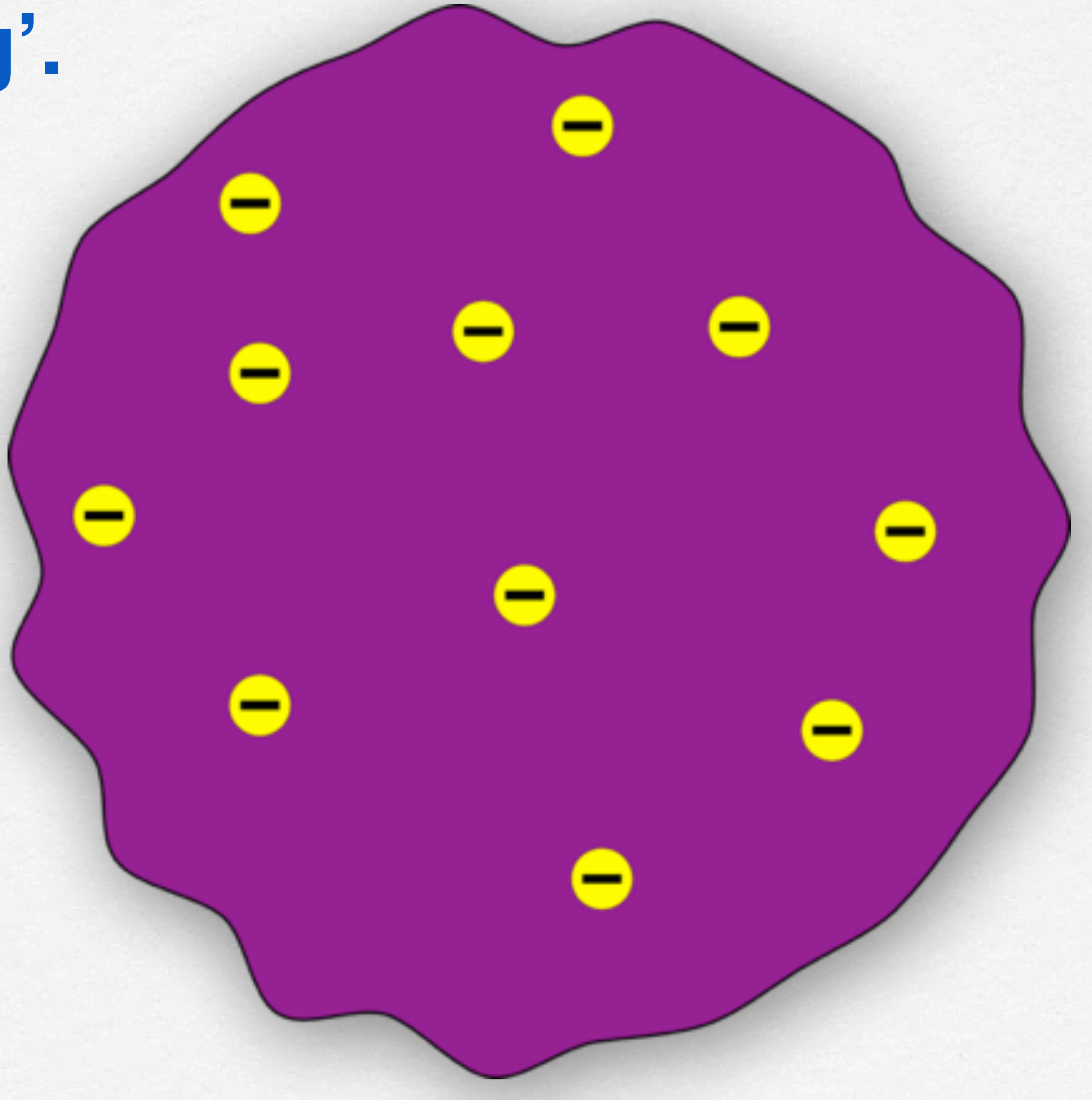
- small
- hard particles
- made of the same material
- always moving
- capable of joining together

Dalton’s Atomic Theory (1808)

Matter is composed of extremely small particles called atoms, which cannot be subdivided, created, or destroyed.

Thompson's Atomic Theory (1904)

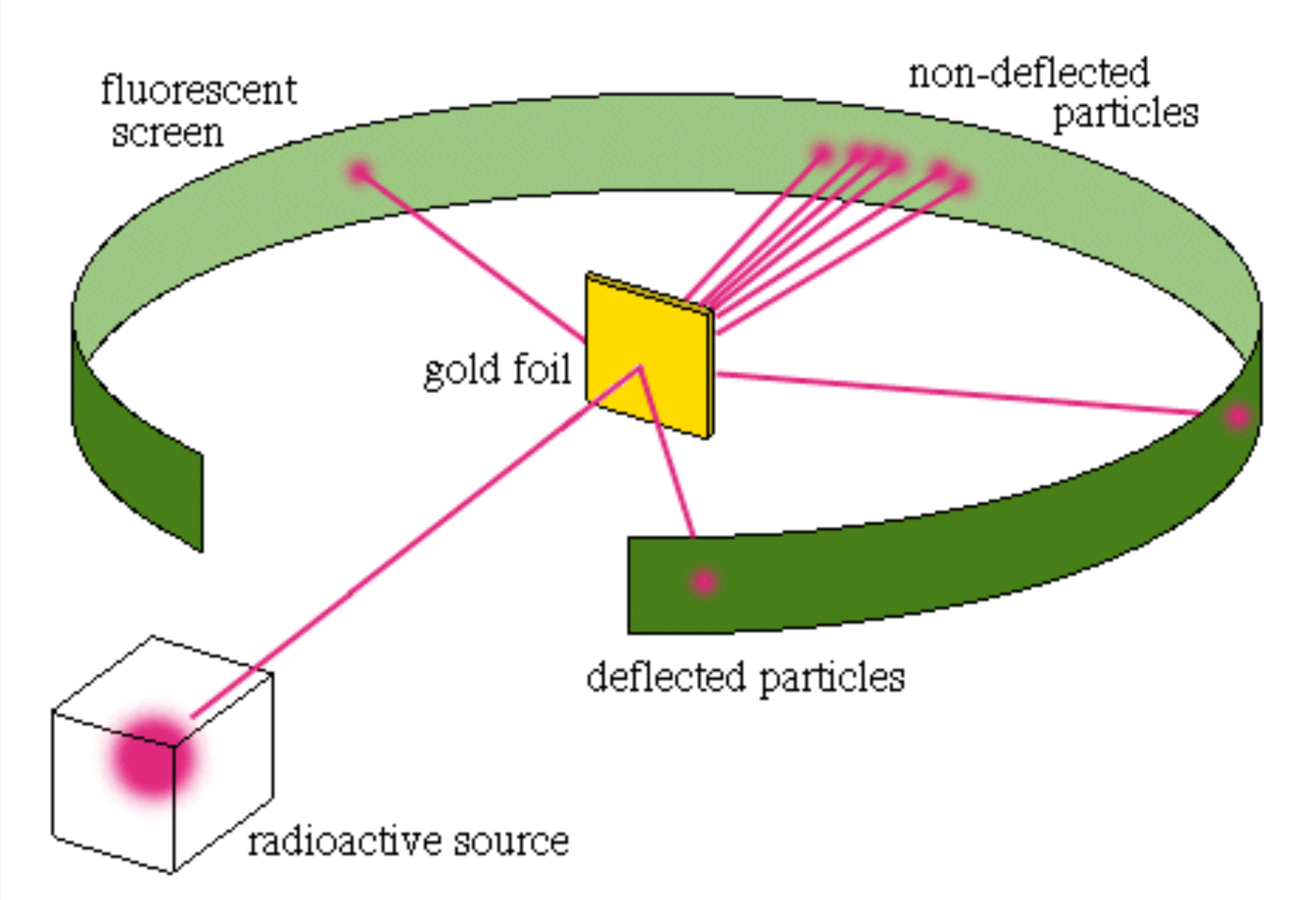
- electrons (plums) evenly distributed throughout a positively charged 'pudding'.



Rutherford's Atomic Theory (1911)

Gold Foil Experiment

Expected vs. Actual



Rutherford's Atomic Theory (1911)

Gold Foil Experiment - Results

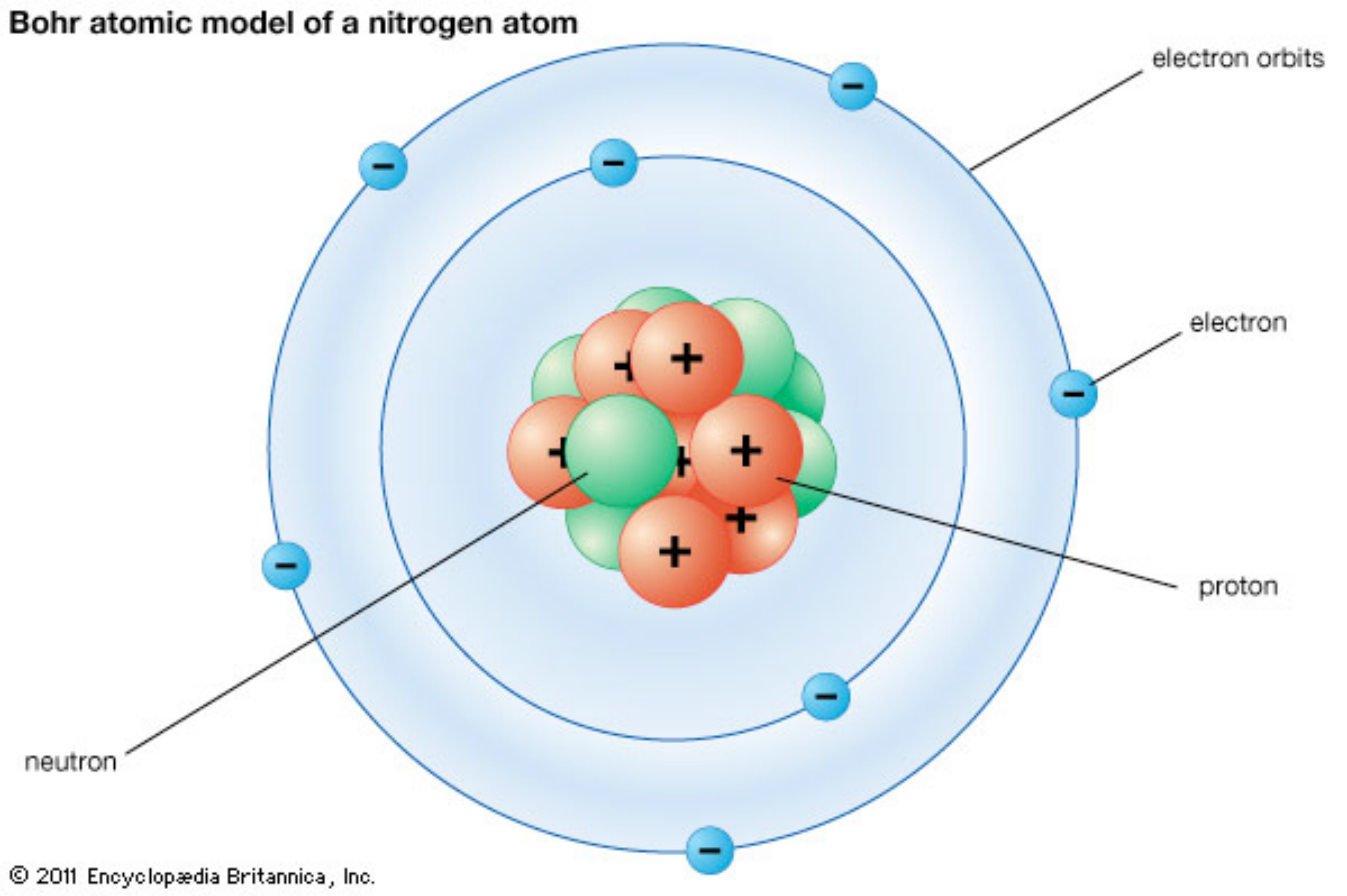
1. Atoms are MOSTLY EMPTY SPACE

2. In the atom is a DENSE, POSITIVELY CHARGED NUCLEUS

Bohr's Atomic Theory (1913)

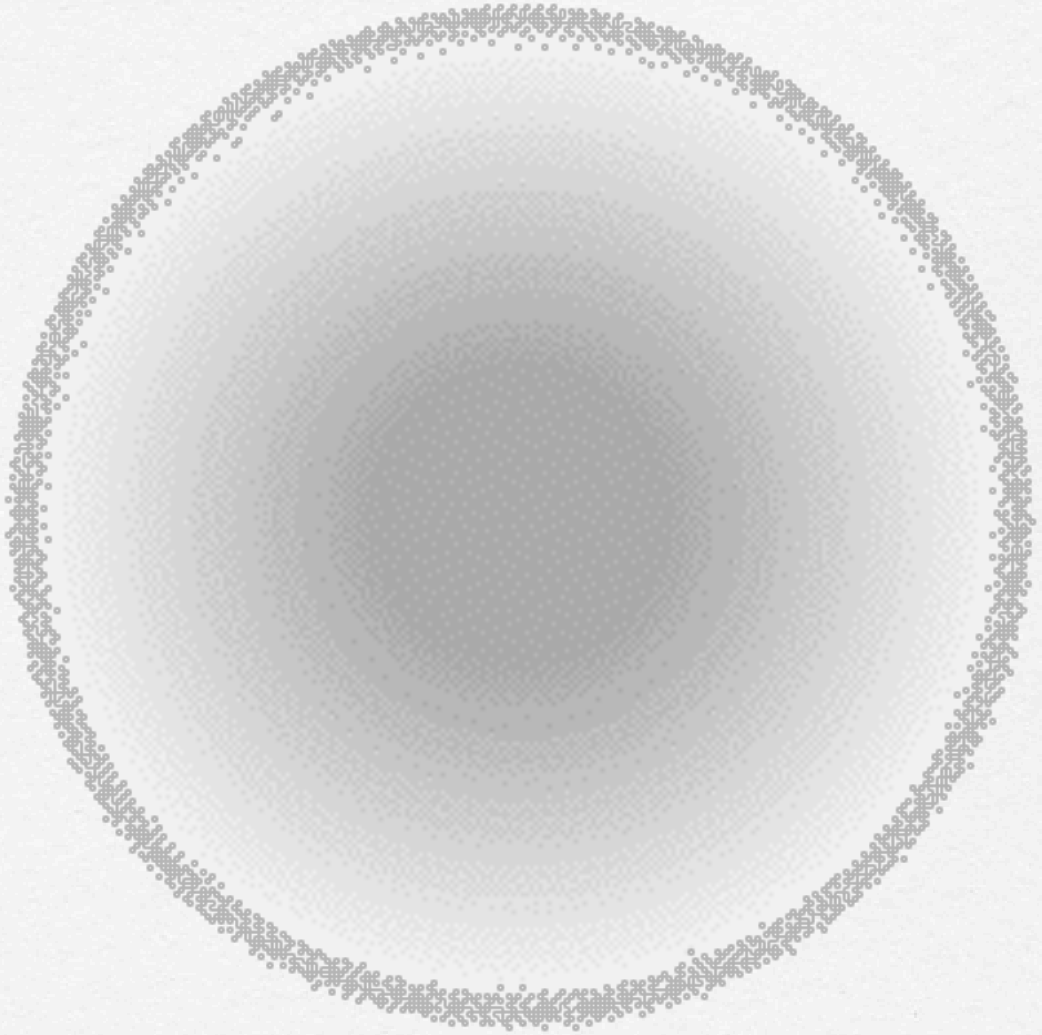
Planetary Model

Atoms travel in specific *orbits* around the nucleus.



Quantum Mechanical (Modern) Theory

Electrons travel in diffuse clouds around the nucleus (*orbitals*)



Regents Practice

The modern model of the atom shows that electrons are

1) found in regions called orbitals
2) orbiting the nucleus in fixed paths
3) located in a solid sphere covering the nucleus
4) combined with neutrons in the nucleus

Which conclusion is based on the "gold foil experiment" and the resulting model of the atom?

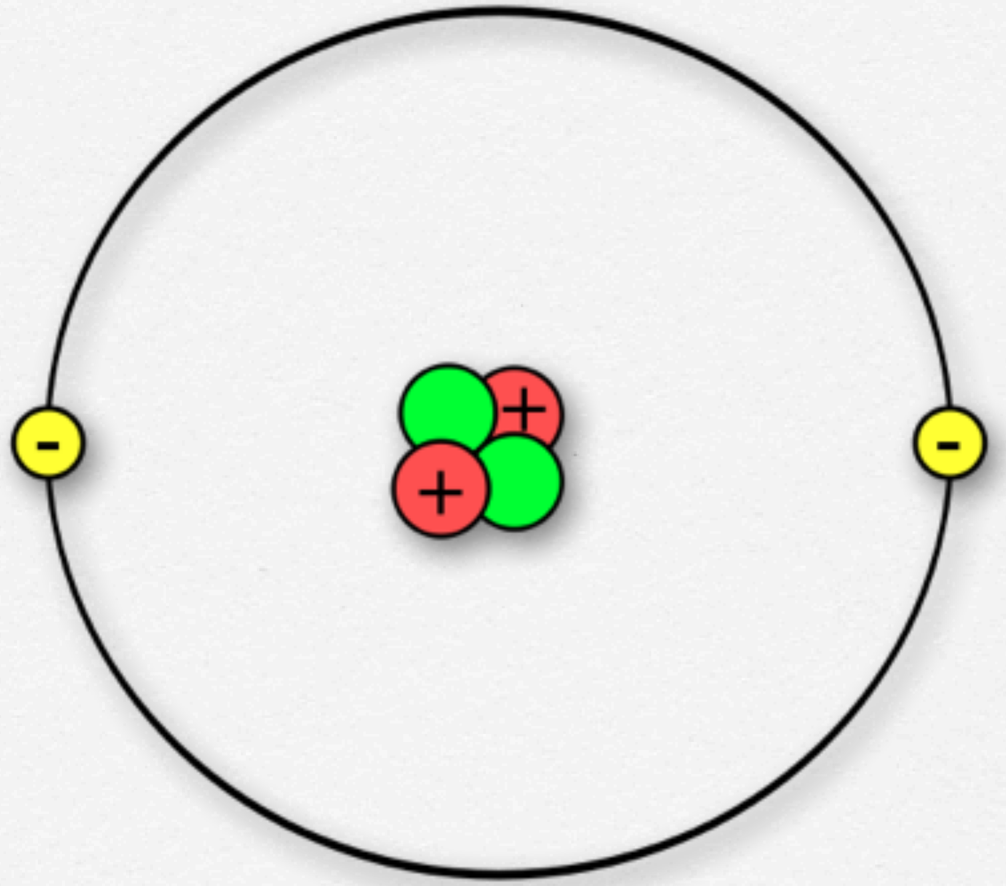
1) An atom has hardly any empty space, and the nucleus has a negative charge.
2) An atom is mainly empty space, and the nucleus has a negative charge.
3) An atom is mainly empty space, and the nucleus has a positive charge.
4) An atom has hardly any empty space, and the nucleus has a positive charge.

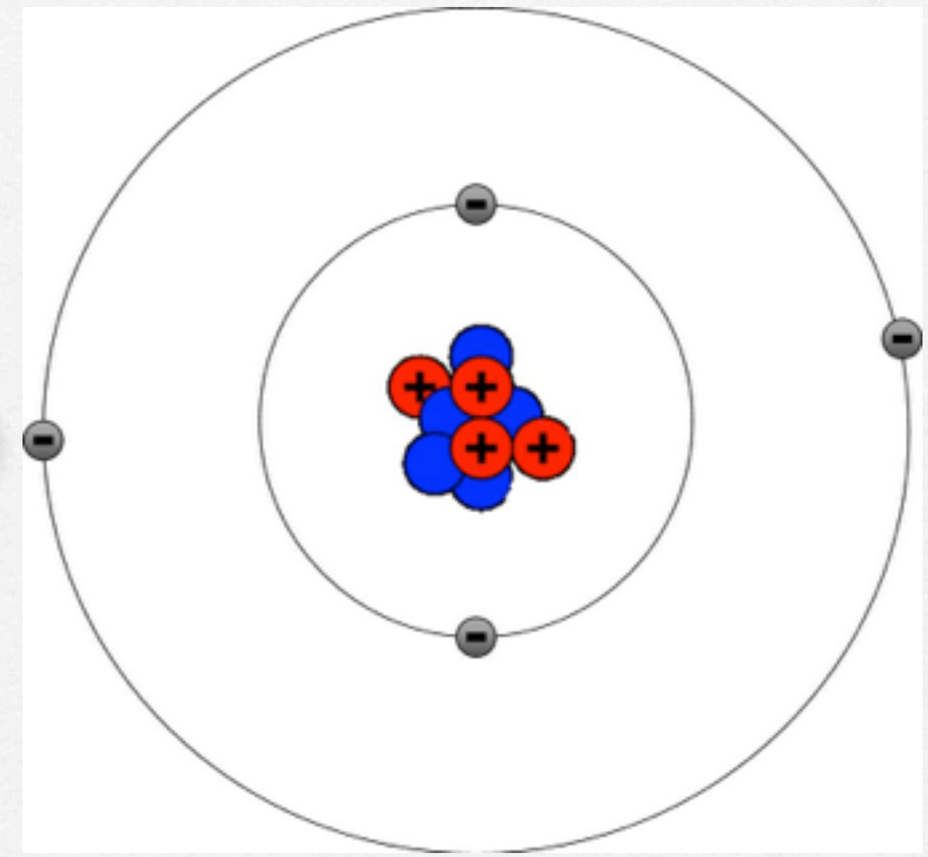
In the modern wave-mechanical model of the atom, the orbitals are regions of the most probable location of

1) electrons 2) protons 3) positrons 4) neutrons

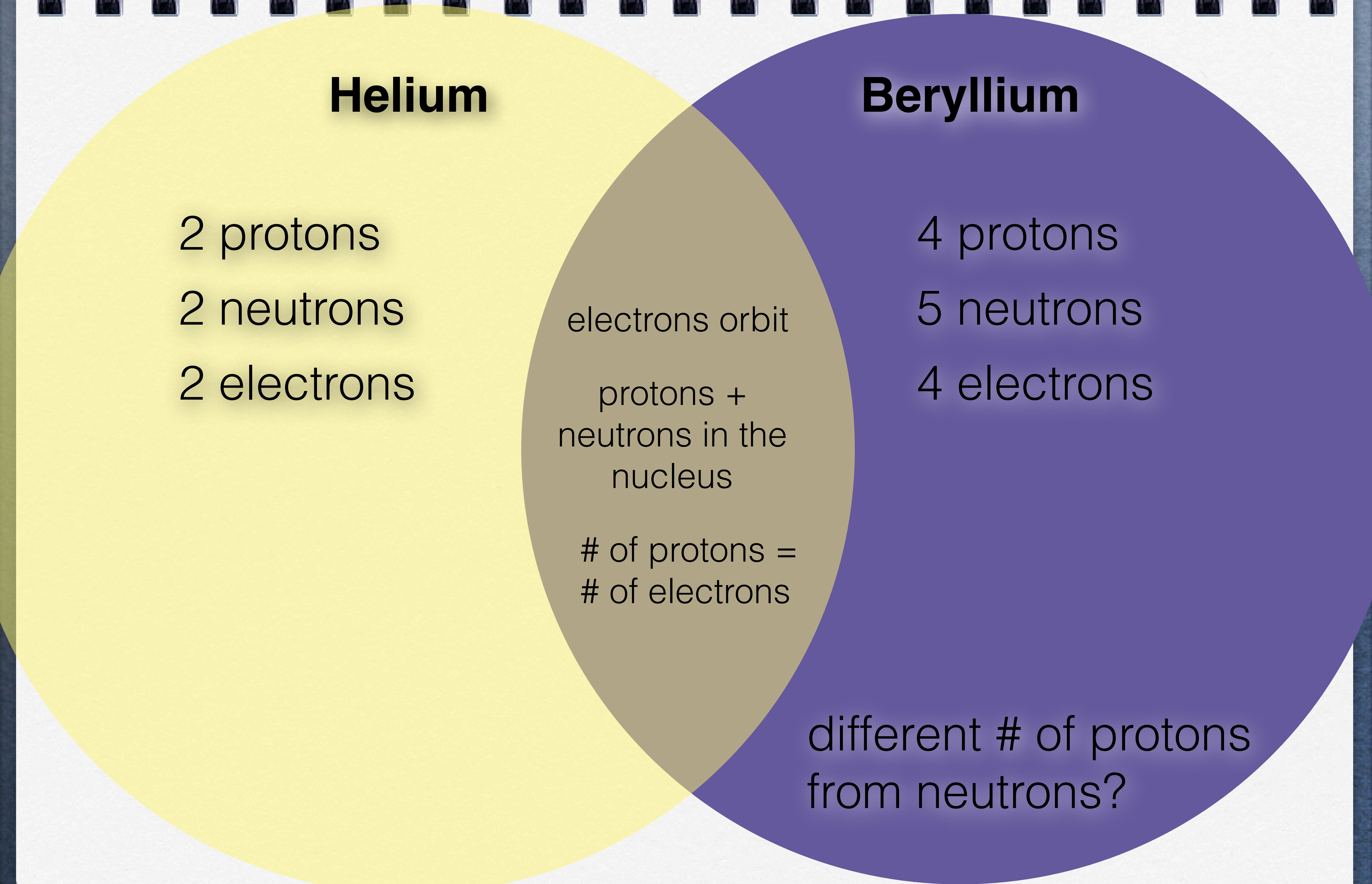
Subatomic Particles & Symbols

Topic 2





1. Compare the two models. List three similarities and three differences.
2. Based on the models, why do you think helium is number 2 (the second element) and beryllium number 4 (the fourth element) on the periodic table?


Helium
Beryllium
2 protons
2 neutrons
2 electrons
electrons orbit
protons + neutrons in the nucleus
# of protons = # of electrons
4 protons
5 neutrons
4 electrons
different # of protons from neutrons?

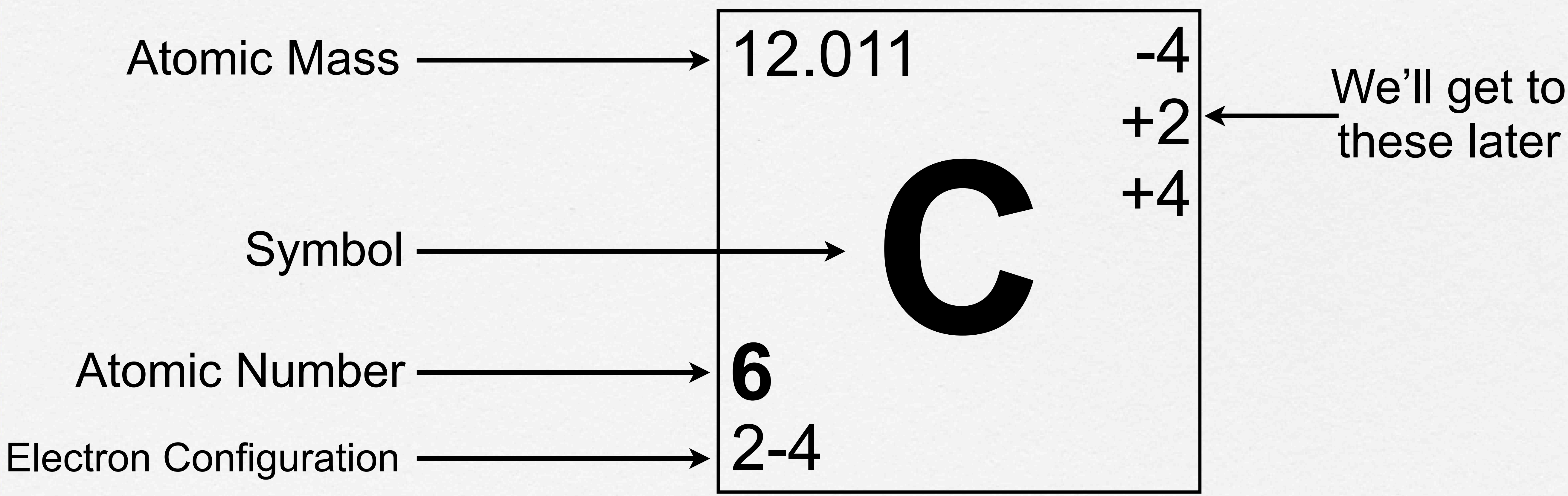
Subatomic Particles & Properties

Particle	Symbol	Location	Electrical Charge	Approximate Relative Mass (amu)	Actual Mass (g)
Electron	e^-	**Outside nucleus**	**1-**	**1/1840 (essentially 0)**	9.11×10^{-28}
Proton	p^+	**Inside nucleus**	**1+**	**1**	1.67×10^{-24}
Neutron	n^0	**Inside nucleus**	**0**	**1**	1.67×10^{-24}

- **What does the unit ‘amu’ mean?**
  atomic mass unit (1/12 of the mass of a carbon-12 atom)

- **ATOMS are electrically** neutral **. This means that the number of** protons **must equal the number of** electrons **.**

Get out your Reference Tables!!



Atomic Number: # of protons in the nucleus

Atomic Mass: # of protons + neutrons in the nucleus

Regents Practice

Which notation represents an atom of sodium with an atomic number of 11 and a mass number of 24?

1) $^{24}_{11}Na$ 2) $^{11}_{24}Na$ 3) $^{35}_{11}Na$ 4) $^{13}_{11}Na$

What is the mass number of the nuclear symbol $^{19}_{9}F$?

1) 28 2) 10 3) 19 4) 9

Which statement is true about a proton and an electron?

1) They have different masses and different charges.
2) They have different masses and the same charges.
3) They have the same masses and different charges.
4) They have the same masses and the same charges.

Regents Practice

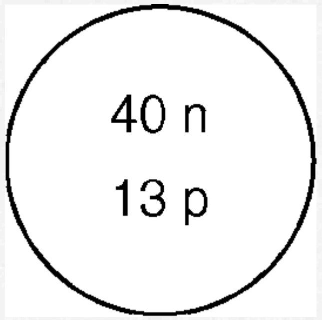
The atomic number of an atom is *always* equal to the number of its

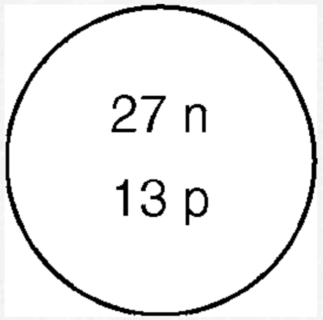
1) protons plus electrons
2) protons plus neutrons
3) neutrons, only
4) protons, only

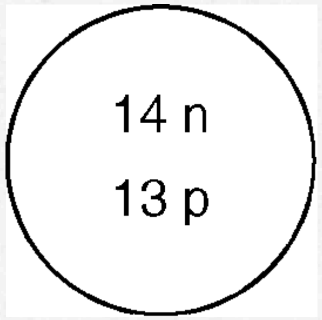
What is the total number of electrons found in an atom of sulfur?

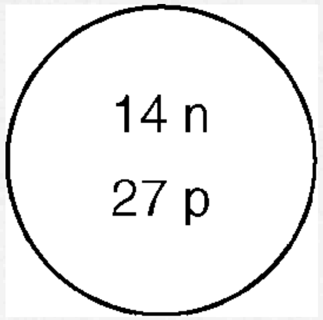
1) 16
2) 6
3) 32
4) 8

Which diagram represents the nucleus of an atom of $^{27}_{13}\text{Al}$?

1) 

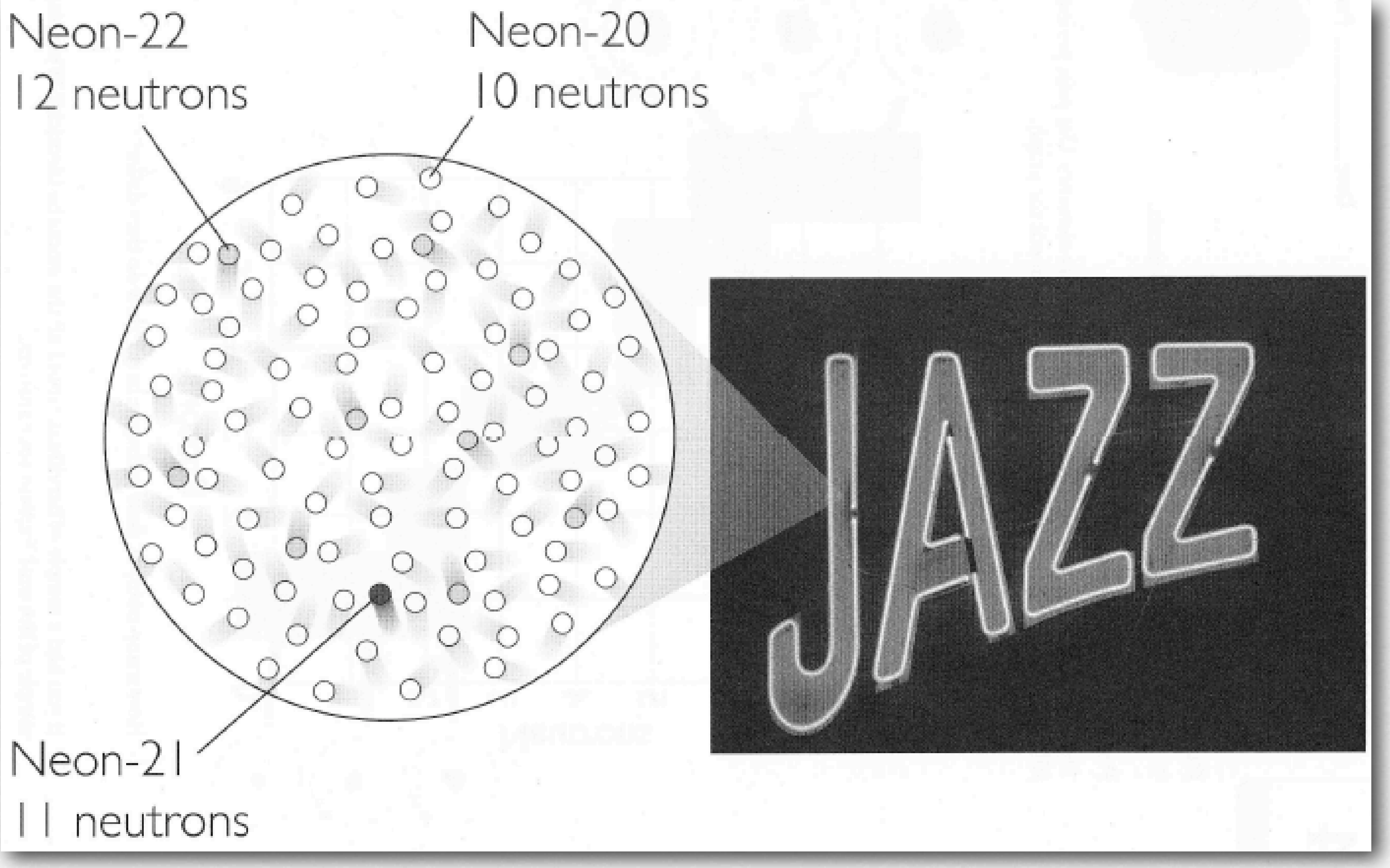
2) 

3) 

4) 

Isotopes

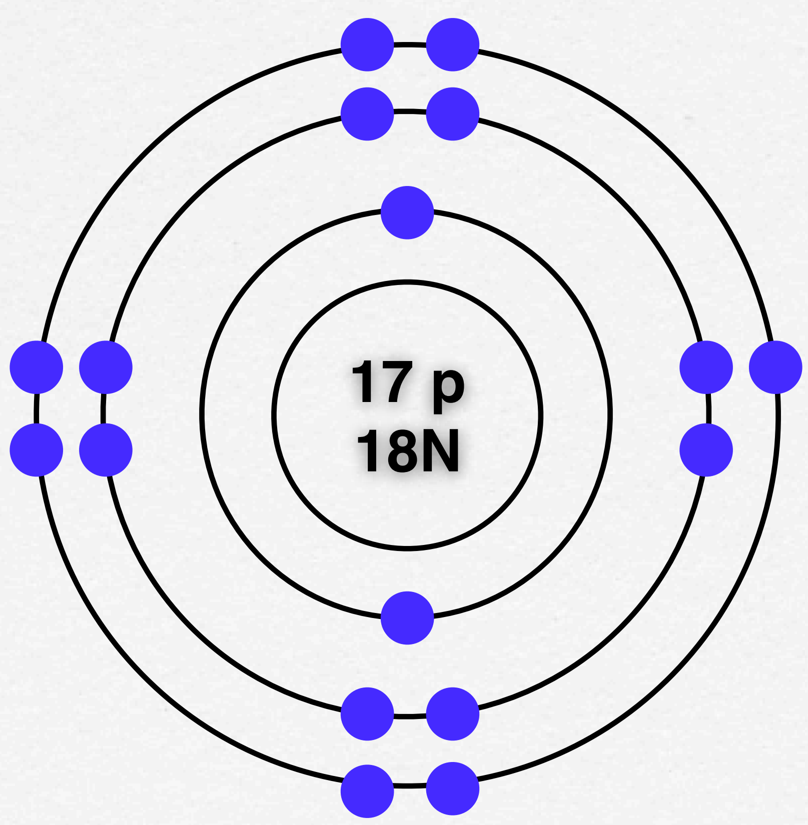
Topic 3



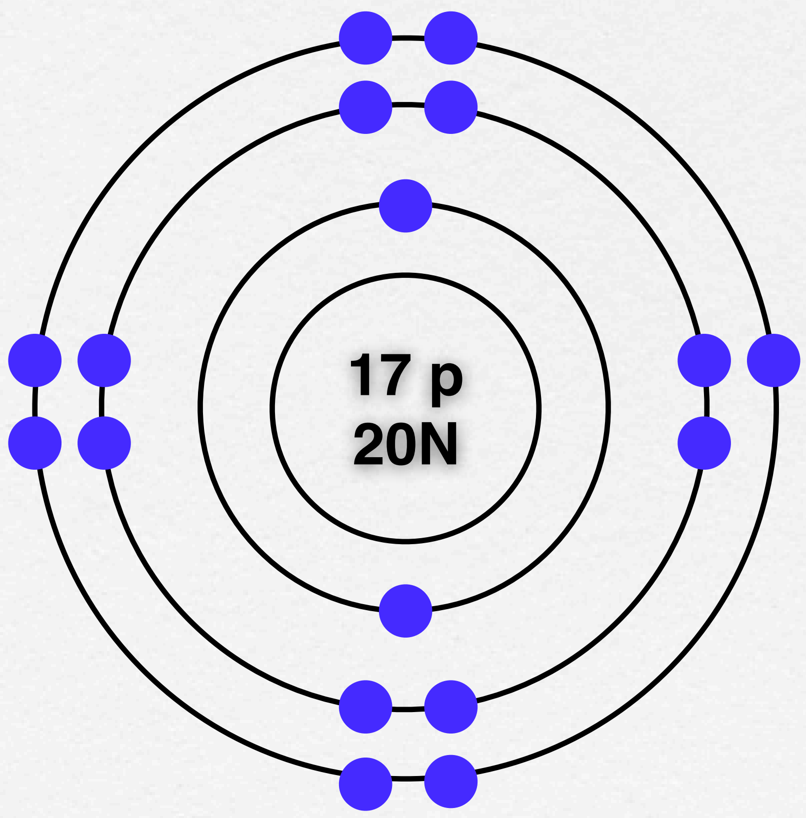
Notation of Atoms

^{35}Cl	Cl-35	Chlorine-35

Chlorine - 35



Chlorine - 37



Isotopes (*Iso-, meaning same)*

- **Atoms with same # of protons, different # of neutrons**

- What are three things that are the *same* between atoms that are isotopes?
  1. **Same chemical properties**
  2. **Same atomic number**
  3. **Same number of electrons**

- What are two things that are *different*?
  1. **Different number of neutrons**
  2. **Different mass numbers**

Remember!

- Number of protons defines the element.
- Number of neutrons determines the isotope

Lead's Isotopes

Table 4 The Stable Isotopes of Lead

Name of atom	Symbol	Number of neutrons	Mass number	Mass (kg)	Abundance (%)
Lead-204	${}^{204}_{82}Pb$	122	204	203.973	1.4
Lead-206	${}^{206}_{82}Pb$	124	206	205.974	24.1
Lead-207	${}^{207}_{82}Pb$	125	207	206.976	22.1
Lead-208	${}^{208}_{82}Pb$	126	208	207.977	52.4

***Atomic Mass*:** given to a number of decimal places. This is because, in most cases, there are a number of naturally occurring isotopes.

***Mass Number*:** the number of protons and neutrons in the isotope.

Atomic Mass vs. Mass Number

Isotope	Atomic Number	Number of Protons	Number of Neutrons	Number of Electrons	Mass Number (amu)
Hydrogen-1	1	1	0	1	1
Hydrogen-2 (deuterium)	1	1	1	1	2
Hydrogen-3 (tritium)	1	1	2	1	3

Hydrogen has three isotopes. (Atomic mass = 1.0079 amu)

Based on this information, which isotope must be the most abundant?

1.0079

H

1

Example

For example:
A natural sample of C (atomic mass = 12.011 amu) is a mixture of C-12 (98.89%) and C-14 (1.11%).

Carbon's atomic number is __6__, has an average atomic mass of __12.011__ amu, and carbon's most common isotope has a mass number of __12__ amu.

Therefore, the most common type of carbon atom has __6__ protons, __6__ neutrons and __6__ electrons. Another naturally-occurring isotope of carbon is C-14, but it is rare in comparison to the amount of C-12 in nature.

Regents Practice

What is the total number of neutrons in the nucleus of a neutral atom that has 19 electrons and a mass number of 39?

1) 19
2) 20
3) 58
4) 39

What is the mass number of an atom that has six protons, six electrons, and eight neutrons?

1) 6
2) 20
3) 14
4) 12

What is the total number of neutrons in an atom of aluminum-27? **14**

The atomic mass of an element is the weighted average of the masses of

1) all of its radioactive isotopes
2) its two least abundant isotopes
3) all of its naturally occurring isotopes
4) its two most abundant isotopes

Topic 3 - Review

- <u>Isotopes</u>: Same protons, different neutrons
- <u>Mass Number</u>: # of protons and neutrons in an isotope
- <u>Atomic Mass</u>: Given in decimal form, showing that more than one isotope can be present
- ***Bohr & Lewis Dot Structures for Electrons in Atoms***