Name:

Regents Chemistry: Dr. Mintz

Practice Packet

Chapter 1: Atomic Concepts

http://mintzchemistry.weebly.com

Chapter 1: Atomic Theory Vocabulary

Allotrope - one or more forms of an elementary substance.
    Ex 1: Graphite (the form of carbon in your pencils) and diamond (the form of carbon after millions of years of compression) are both allotropes of carbon.
    Ex 2: O_2 (oxygen gas) and O_3 (ozone) are allotropes of oxygen.

AnION – negatively charged atom; an atom that gains an electron

Atom – the basic unit of structure for all matter; can't be broken down any further by chemical means

Atomic Mass – the average mass of all naturally occurring isotopes for an element

Atomic Mass unit (a.m.u.) – 1/12th the mass of a Carbon-12 atom; the mass of one proton or one neutron

Atomic number – the number of protons in an atom of a given element
    Ex: The atomic # of carbon is 6, which means that every atom of carbon has 6 protons in its nucleus and carbon is the only element with the atomic # 6

Bohr model – atomic model constructed by Neils Bohr that proposes all electrons can be found in orbitals or paths; electrons must gain or lose energy to jump from one orbital to another

CatION – positively charged atom; an atom that loses an electron

Electron – virtually MASSLESS (teenie, tiny) NEGATIVELY CHARGED particle found OUTSIDE the nucleus

Electron Configuration – the arrangement of electrons in an atom or molecule

Element – particles that all have the same number of protons in the nucleus

Excited state – when an atom absorbs energy and one or more of its electrons "jump" to an orbital further from the nucleus

Ground state – when all electrons within an atom fill the lowest energy orbitals; when the electrons are where they would "normally" be

Ion – a charged atom; an atom that gains or loses an electron

Isotope – an atom of an element with the same number of protons (atomic #) but a different number of neutrons
    Ex: Carbon-12 (6 protons, 6 neutrons) and Carbon-14 (6 protons, 8 neutrons)

Lewis Dot Diagram – representation of an atom or molecule using only the element symbol and the valence electron arrangement

Mass number – the mass of a given isotope of an element; the sum of the masses of protons and neutrons
    Ex: The mass number for Carbon-12 is exactly 12 amu, even though the atomic mass (average mass) of all carbon isotopes is 12.0111

Neutron – subatomic particle with a MASS of 1 amu (atomic mass unit), and a CHARGE of zero found WITHIN THE NUCLEUS; (NEUTRAL)

Nuclear Charge – electric charge within the nucleus of an atom; equal to the # of protons (always positive!)

Nucleons – any (subatomic) particle found in the nucleus of an atom; a PROTON or a NEUTRON

Nucleus – the DENSE, POSITIVE, core of an atom

Orbital – a region where electrons of an atom can be found

Proton – subatomic particle with a MASS of 1 amu (atomic mass unit), and a CHARGE of +1 found WITHIN THE NUCLEUS

Valence electron(s) – the outermost electrons in an atom; there can NEVER be more than 8 valence electrons (OCTET RULE)

Wave-mechanical model – states that electrons don't travel in fixed orbits, but that we can use mathematic principals to predict where electrons are most likely to be found

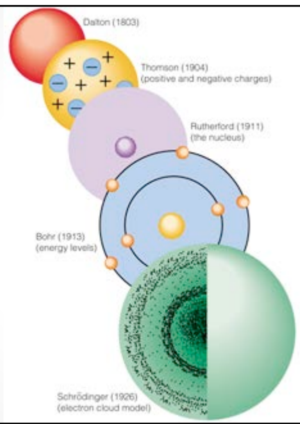
Atomic Theory

Chemistry 200

Video 1.1

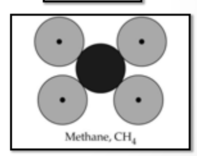
Objective

- Describe how the model of the atom has changed throughout history.
- Explain the structure of the atom according to Dalton, Thomson, Rutherford and Bohr.



John Dalton

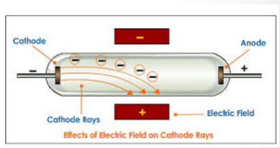
- He deduced that all <u>elements</u> are composed of atoms
- Atoms are indivisible and indestructible particles.
- Atoms of the <u>same</u> element are exactly alike.
- Atoms of <u>different</u> elements are <u>different</u>.
- <u>Compounds</u> are formed by the joining of atoms of two or more elements.



J.J. Thomson

- Thomson studied the <u>passage</u> of an electric current through a gas.
- As the current passed through the gas, it gave off rays of <u>negatively charged particles.</u>

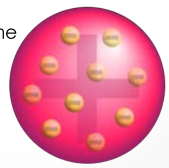
Cathode Ray Tube



Deflected beam with Magnet

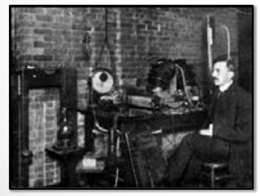
Thomson's Plum Pudding Model

- Atoms were made from a positively charged substance with negatively charged electrons scattered about, like raisins in a pudding.
- Thomson concluded that the negative charges came from *within* the atom.



Earnest Rutherford

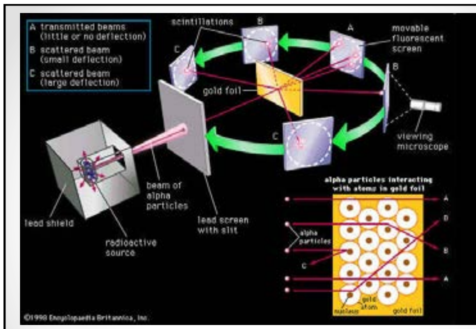
- In 1908, the English physicist Ernest Rutherford was hard at work on an experiment that seemed to have little to do with unraveling the mysteries of the atomic structure.



Rutherford's Gold Foil Experiment

Gold Foil

Aluminum Foil

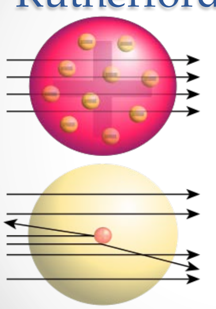


Gold Foil Experiment

Beam of alpha particles (positively charged) at a piece of thin gold foil

Beam was deflected or bounced back 1 in 8000 particles

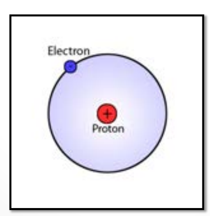
Rutherford's Conclusions



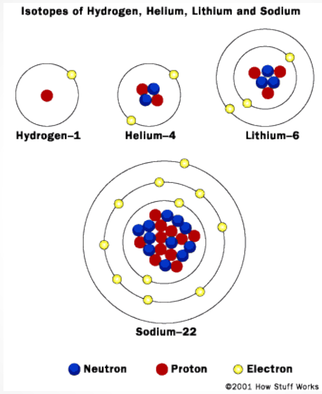
- The atom had a dense central core with a positive charge
  - Nucleus
  - Called positive charge particles protons
- **Atom is mainly empty space**

Neils Bohr

- According to Bohr's atomic model, electrons move in definite orbits around the nucleus, much like planets circle the sun. These orbits, or energy levels, are located at certain distances from the nucleus.



The Bohr Ring Model

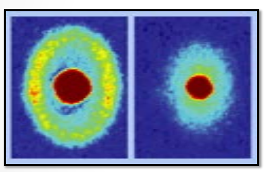


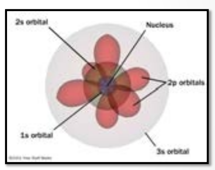
The Modern Atomic Model

- It is impossible to determine the exact location of an electron. The probable location of an electron is based on how much energy the electron has.
- According to the modern atomic model, at atom has a small positively charged nucleus surrounded by a large region in which there are enough electrons to make an atom neutral.
- Electrons whirl about the nucleus billions of times in one second
  - They are not moving around in random patterns.
  - Location of electrons depends upon how much energy the electron has.
  - Electrons are found in regions of space called orbitals

The Electron Cloud

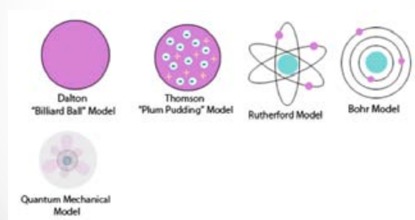
- Electrons with the lowest energy are found in the energy level closest to the nucleus
- Electrons with the highest energy are found in the outermost energy levels, farther from the nucleus.





Conclusions

- The model of the atom has changed throughout history as more particles were discovered.



Anatomy of the Atom

Chemistry 200
Video 1.2

Objective:

How do we determine the amount of protons, neutrons & electrons in an atom?

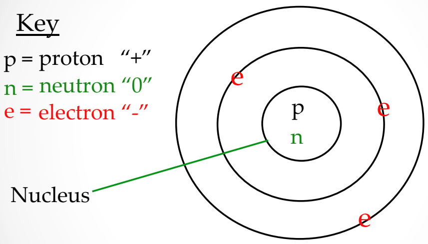
Bohr's atomic model describes the location of subatomic particles within an atom

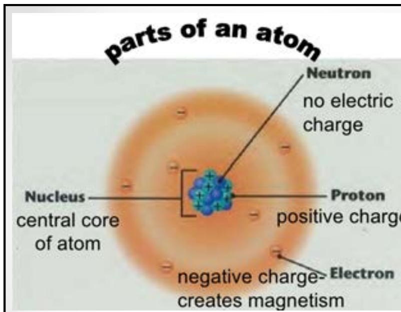
Key

p = proton "+"

n = neutron "0"

e = electron "-"





Subatomic Particles

Name	Symbol	Mass	Charge	Notation
Proton	p	1 amu	+1	^1_1H or $_1^1p$
Neutron	n	1 amu	0	^1_0n
Electron	β-	$\frac{1}{1836}$ amu	-1	$^0_{-1}e$

<u>Nucleons</u>: the subatomic particles in the nucleus (p + n)

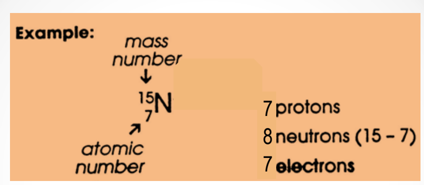
<u>Nuclear charge</u>: the charge of the nucleus (# of protons)

<u>Atomic Mass Unit</u>: 1/12 the mass of a carbon-12 atom (^{12}C or C-12)

<u>Determining Atomic Structure</u>

1. Mass # = Protons + neutrons
2. Atomic # = Protons = Electrons (if it's an atom)

An atom is neutral, same # of protons & electrons



$^{23}_{11}Na$

11 protons

12 neutrons (23 - 11)

11 electrons

Ions

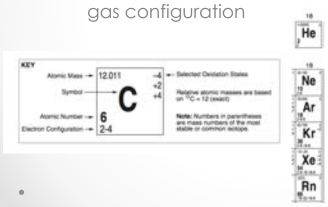
Chemistry 200
Video 1.3

Objective

- Describe ions in terms of electrons and charge.
- Explain how ions form.

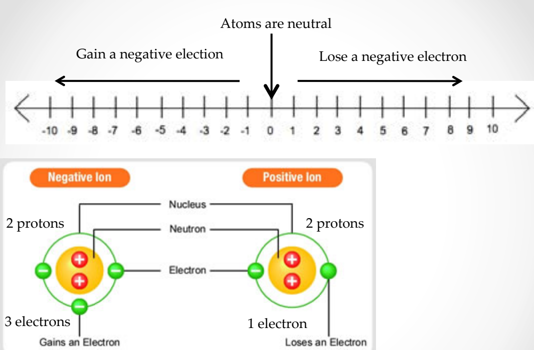
Ions

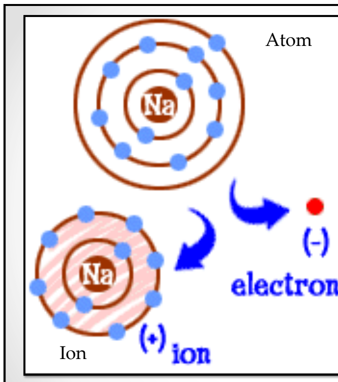
- Positively or Negatively Charged Atoms
  - Atoms gain or lose **electrons** to achieve a stable electron configuration
    - A stable electron configuration is the same as group 18 elements also known as the noble gas configuration



Ions

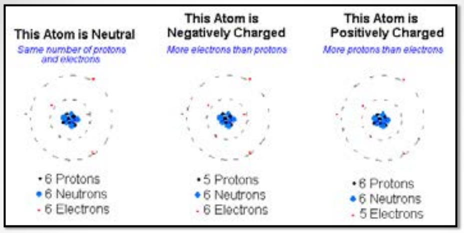
- Since Electrons carry a negative charge:
  - Positive Ion – lost electrons
    - Called Cations
  - Negative Ion – gained electrons
    - Called Anions





+11 Protons
-11 Electrons
Electrically Neutral

+11 Protons
-10 Electrons
Overall Charge is +1



+6 protons
6 neutrons
-6 electrons
C

+5 protons
6 neutrons
-6 electrons
B^{-1}

+6 protons
6 neutrons
-5 electrons
C^{+1}

Positively or negatively charged atom

★Remember: electrons carry a negative charge!★

Cation = positive ion
- Lost electrons
- Na^{+1}
  - 11 (+'s) protons & 10 (-'s) electrons
  - +11 – 10 = +1

Anion = negative ion
- Gained electrons
- F^{-1}
  - 9 (+'s) protons & 10 (-'s) electrons
  - +9 -10 = -1

Atom or Ion	Protons	Electrons
F		
F^{-1}		
C		
C^{+4}		
Mg		
Mg^{+2}		

Electron Configuration & The Bohr Model

Chemistry 200
Video 1.4

Objective:

How do we determine the electron configuration of an atom & draw it's Bohr model?

The Periodic Table of Elements can be used to determine the amount of electrons an atom or ion possess, as well as the order in which electrons fill the energy levels.

Electron Configuration
- shows how the electrons are distributed in an atom

look at bottom of the elements' box on periodic table

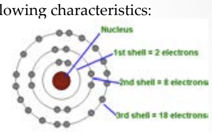
24.305 +2
Mg
12
2-8-2

Bohr & The Energy Levels of an Atom

The **Shells** or **Energy Levels** that orbit the nucleus of an atom possess the following characteristics:

1. Each Shell or Energy Level is a specific distance from the nucleus

2. Each Shell or Energy Level contain a specific # of electrons



$2(n)^2$ where "n" is the energy level #

$2(1)^2 = 2$ $2(2)^2 = 8$ $2(3)^2 = 18$ $2(4)^2 = 32$

3. The further the shell or energy level is from the nucleus, the more energy the electrons need to occupy that shell or energy level

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Bohr concluded that electrons follow a specific pattern when filling the energy levels of an atom:

1. The lowest energy level (closest to the nucleus) fills first

2. The next higher energy level will fill only after the lower level is filled

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Atom	Electron Configuration	Bohr Model
$^{1}_{1}H$		
^{12}C		
Argon-40		
Fe-59		

Excited vs. Ground States

Chemistry 200
Video 1.5

Objective:

How do we recognize the difference between the Ground & Excited states of an atom?

Ground vs Excited States

Ground State

- when electrons occupy the lowest available orbital within a shell

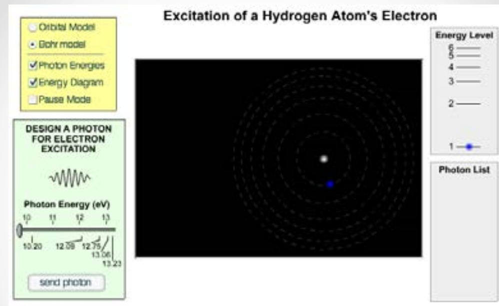
electrons are not always found in their ground state configurations

Excited State

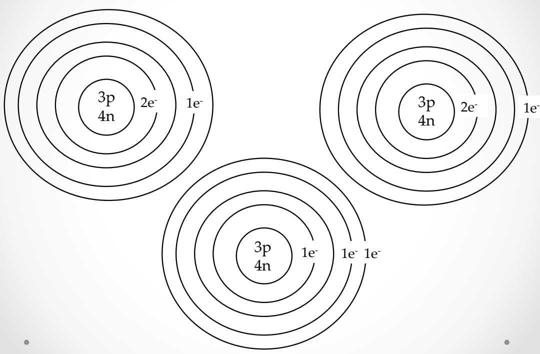
- when an electron absorbs energy (from heat, light, electricity), it temporarily moves to a higher energy level

- this state is unstable & electron(s) quickly return to the lower available level

- the amount of energy absorbed = energy emitted (may be in the form of infrared, U-V or visible light)



Possible excited state configurations of Lithium-7



Isotopes & Average Atomic Mass

Chemistry 200

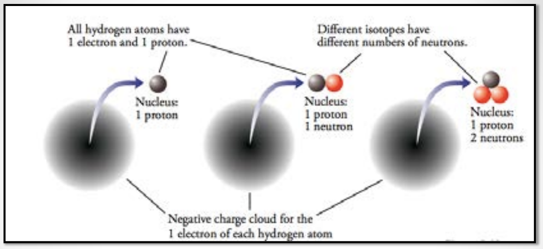
Video 1.6

Objective

- Explain what makes elements and isotopes different from each other.
- Calculate the average atomic mass of an element

Isotopes

- All atoms of a specific element have the same number of protons (and the same number of electrons in uncharged atoms), they don't necessarily have the same number of neutrons.



<u>Normal Hydrogen Gas Sample (5000 Atoms)</u>
4999 Atoms - 1 Proton 1 Electron
1 Atom – 1 Proton 1 Electron 1 Neutron (called deuterium)

Tritium – 1 Proton 1 electron 2 Neutrons (unstable)

Quick Review

- Atomic # - # of protons
- Mass # - # protons + # neutrons

Isotopes have the **SAME** atomic # but **DIFFERENT** mass numbers

Symbols
H – 1 (0 neutrons)
H – 2 (1 neutron)
H – 3 (2 neutrons)

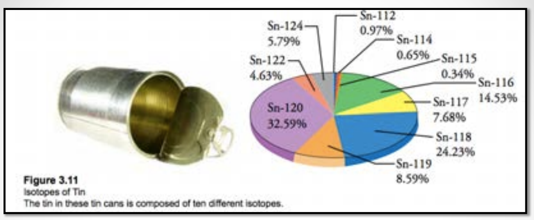


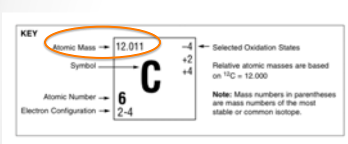
Figure 3.11
Isotopes of Tin
The tin in these tin cans is composed of ten different isotopes.

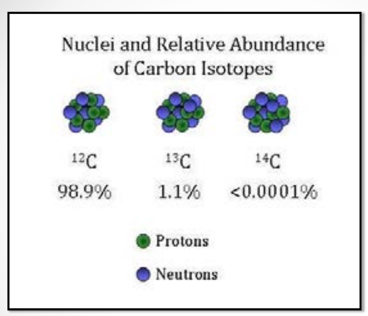
Atomic Mass Unit

- u or amu
- VERY small = 1.66 x 10^{-24} grams or **1/12th the mass of a carbon atom**
- Mass of proton is 1 amu and mass of a neutron is 1 amu.
- Mass = protons + neutrons
- So why is atomic mass on periodic table a decimal?

Average Atomic Mass

- **Weighted average** of the masses of the naturally occurring isotopes of the element





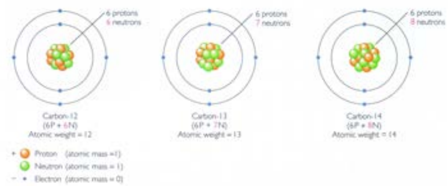


FIGURE 2.3 These three carbon isotopes all have the same number of protons and thus the same atomic number, 6. Their atomic masses differ, however, because they have slightly different numbers of neutrons. The atomic mass of any element is the average of the weighted sum of the atomic masses of its various isotopes. One isotope of an element—for example, carbon-12—is far more abundant than the others because natural processes favor that particular isotope.

Calculating Average Atomic Mass

- Element X has two natural isotopes. The isotope with a mass of 10 amu (^{10}X) has a relative abundance of 19.91%. The isotope with a mass of 11 amu (^{11}X) has a relative abundance of 80.09%. Calculate the atomic mass of this element.

$$\text{Atomic Mass} = \frac{(\text{mass})\ (\%\text{abundance}) + (\text{mass})\ (\%\ \text{abundance})\ldots}{100}$$

$$\text{Atomic Mass} = \frac{(10\ \text{amu})(19.91\%) + (11\ \text{amu})\ (80.09\%)}{100}$$

Atomic Mass = 10.8009 amu

Review

- Isotopes are the same elements with different numbers of neutrons
- An amu is 1/12th the mass of a carbon atom.
- Average atomic mass is the weighted average of all the naturally occurring isotopes of a given element

Atomic Emission Spectrum

Chemistry 200
Video 1.7

Objective:

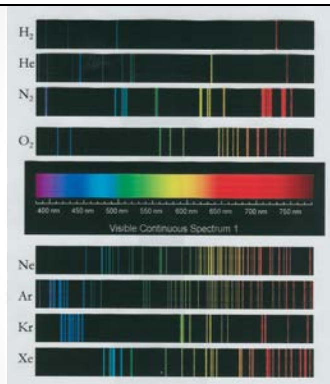
How does the Emission Spectrum relate to Ground & Excited states of an atom?

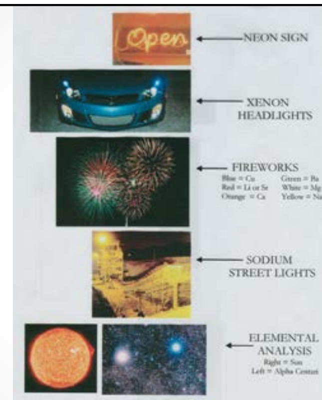
Since electrons can only absorb or release exact amts of energy to move btwn fixed energy levels, an element always produces the same **emission spectrum or spectral lines** when excited electrons return to their ground state configuration

Emission (Bright Line) Spectrum:

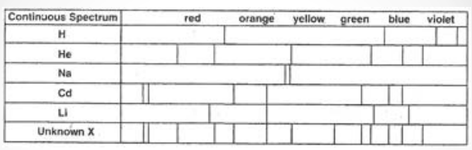
- a series of bright lines produced when excited electrons return to their original energy levels

each element has its own unique set of spectral lines which can be used to identify the elements' presence





Below are the visible light spectras for 5 elements & the continous spectrum of a white light bulb



a. Which 2 elements are in unknown X? Cd & He

b. Is there a 3rd element present in unknown X? Explain

Yes….there's a line that doesn't line up w/ any of the 5 elements presented

c. Stars are mostly hydrogen w/ small abundances of other elements. Is unknown X a likely spectrum for a star? Explain.

No….there aren't any spectral lines present for hydrogen

Video Lesson 1: Atomic Theory

John Dalton (1766 – 1844):

John Dalton was an English chemist. His ideas form the atomic theory of matter. Here are his ideas.

- All elements are composed (made up) of atoms. It is impossible to divide or destroy an atom.
- All atoms of the same elements are alike. (One atom of oxygen is like another atom of oxygen.)
- Atoms of different elements are different. (An atom of oxygen is different from an atom of hydrogen.)
- Atoms of different elements combine to form a compound. These atoms have to be in definite whole number ratios. For example, water is a compound made up of 2 atoms of hydrogen and 1 atom of oxygen (a ratio of 2:1). Three atoms of hydrogen and 2 atoms of oxygen cannot combine to make water.

1. What is the name of John Dalton's theory? ______________________________
2. What are elements made of? ______________________________
3. An atom of hydrogen and an atom of carbon are ______________________________.
4. What are compounds made of? ______________________________
5. The ratio of atoms in HCl is: a) 1:3 b) 2:1 c) 1:1

J. J. Thompson (Late 1800s):

J. J. Thompson was an English scientist. He discovered the electron when he was experimenting with gas discharge tubes. He noticed a movement in a tube. He called the movement cathode rays. The rays moved from the negative end of the tube to the positive end. He realized that the rays were made of negatively charged particles – electrons.

1. What did J.J. Thompson discover? ______________________________
2. What is the charge of an electron? ______________________________
3. What are cathode rays made of? ______________________________
4. Why do electrons move from the negative end of the tube to the positive end?
____
5. What was Thompson working with when he discovered the cathode rays?
____

Lord Ernest Rutherford (1871 – 1937):

Ernest Rutherford conducted a famous experiment called the gold foil experiment. He used a thin sheet of gold foil. He also used special equipment to shoot alpha particles (positively charged particles) at the gold foil. Most particles passed straight through the foil like the foil was not there. Some particles went straight back or were deflected (went in another direction) as if they had hit something. The experiment shows:

- Atoms are made of a small positive nucleus; positive nucleus repels (pushes away) positive alpha particles
- Atoms are mostly empty space

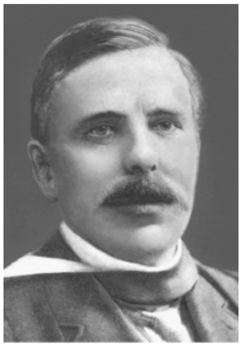
1. What is the charge of an alpha particle? ____________________________________
2. Why is Rutherford's experiment called the gold foil experiment? ____________________
   ____
3. How did he know that an atom was mostly empty space? ___________________________
   ____
4. What happened to the alpha particles as they hit the gold foil? ______________________
   ____
5. How did he know that the nucleus was positively charged? ___________________________
   ____

Niels Bohr (Early 1900s):

Niels Bohr was a Danish physicist. He proposed a model of the atom that is similar to the model of the solar system. The electrons go around the nucleus like planets orbit around the sun. All electrons have their energy levels – a certain distance from the nucleus. Each energy level can hold a certain number of electrons. Level 1 can hold 2 electrons, Level 2 - 8 electrons, Level 3 - 18 electrons, and level 4 – 32 electrons. The energy of electrons goes up from level 1 to other levels. When electrons release (lose) energy they go down a level. When electrons absorb (gain) energy, they go to a higher level.

1. Why could Bohr's model be called a planetary model of the atom? ________________
   ____
2. How do electrons in the same atom differ? ____
   ____
3. How many electrons can the fourth energy level hold? __________________________
4. Would an electron have to absorb or release energy to jump from the second energy level to the third energy level? ____
5. For an electron to fall from the third energy level to the second energy level, it must _________________________________ energy.

Understanding the Rutherford Model



Rutherford, E.

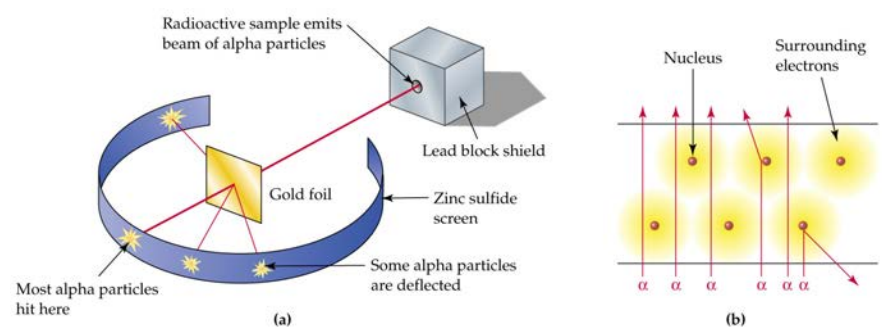
Ernest Rutherford performed an experiment in 1911 that helped him develop the solar system model of the atom. He probed the inside of the atom using small, positively charged particles called alpha particles. Based on his observations, he suggested that the atom is mostly empty space with a small, positively charged center and negatively charged electrons revolving around the outside like planets around the sun. This is the image that most people have of an atom, but how did it get that way? By answering a series of questions below and analyzing Rutherford's experiment, you will find out.

Answer the questions below based on your knowledge of the world and on the description of Rutherford's Alpha Scattering Experiment.

1. If you toss a tennis ball at a brick wall, what will happen?

2. If you toss a tennis ball at something that looks like a solid wall, but is actually smoke, what will happen?

Rutherford performed the following experiment: He aimed a beam of high speed, positively charged particles called alpha particles (similar to our tennis ball) at a piece of solid gold foil (similar to our wall). He set up a special screen all around the foil to help him see where the particles went.



3. According to Dalton's model, the atom is a solid sphere. What would the alpha particles do when they hit the gold foil if Dalton were correct?

4. According to Thomson, the atom is a positively charged cloud with electrons scattered throughout. What would the alpha particles do when they hit the foil if Thomson were correct?

5. When Rutherford performed his experiment, only 1 in 20,000 alpha particles bounced straight back or were deflected greatly. The rest went straight through the gold foil.

    a. What does this indicate about the probability of actually hitting anything?

    b. What does this indicate about the size of whatever has been hit compared to the size of the gold atoms in the foil?

    c. Is the atom mostly solid or mostly space? How do you know?

    d. Considering the fact that alpha particles are positively charged, what must the charge be on whatever deflected them?

    e. Based on this evidence, what is in an atom's center?

    f. Where might the negatively charged electrons be located?

Multiple Choice

1. _____ Which conclusion was a direct result of the gold foil experiment?
    1. An atom is mostly empty space with a dense, positively charged nucleus.
    2. An atom is composed of a least three types of subatomic particles.
    3. An electron has a positive charge and is located inside the nucleus.
    4. An electron has properties of both waves and particles.

2. _____ Which sequence represents a correct order of historical developments leading to the modern model of the atom?
    1. the atom is a hard sphere → electrons exist in orbital outside the nucleus → most of the atom is empty space
    2. the atom is a hard sphere → most of the atom is empty space → electrons exist in orbital outside the nucleus
    3. most of the atom is empty space →the atom is a hard sphere → electrons exist in orbital outside the nucleus
    4. most of the atom is empty space → electrons exist in orbital outside the nucleus → the atom is a hard sphere

3. _____ The gold foil experiment led to the conclusion that each atom in the foil was composed mostly of empty space because most alpha particles directed at the foil
    1. were deflected by the electrons in gold atoms
    2. were deflected by the nuclei in gold atoms
    3. passed through the foil
    4. remained trapped in the foil

4. _____ An orbital of an atom is defined as the most probable location of
    1. a positron
    2. a proton
    3. a neutron
    4. an electron

5. _____ Compared to the entire atom, the nucleus of the atom is
    1. Smaller and contains most of the atom's mass
    2. Larger and contains most of the atom's mass
    3. Larger and contains little of the atom's mass
    4. Smaller and contains little of the atom's mass

6. _____ Which statement describes the distribution of charge in an atom?
    1. A neutral nucleus surrounded by one or more negatively charged electrons.
    2. A neutral nucleus surrounded by one or more positively charged electrons.
    3. A positively charged nucleus is surrounded by one or more negatively charged electrons.
    4. A positively charged nucleus is surrounded by one or more positively charged electrons.

<u>Constructed Response:</u> *In these types of questions students are given a short paragraph containing some chemical information. Students are to use the information and their knowledge of chemistry to answer a series of questions.*

Base your answers to questions 1 through 4 on the information below and your knowledge of chemistry.

In the gold foil experiment, a thin sheet of gold was <u>bombarded</u> with alpha particles. Almost all the alpha particles passed straight through the foil. Only a few alpha particles were <u>deflected</u> from their original paths.

<u>Vocabulary First</u>

1. What does the term “bombarded,” mean in this context?

 ____

 ____

2. What does the term “deflected, “ mean is this context?

 ____

 ____

<u>Chemistry Next</u>

3. Explain, in terms of charged particles, why some of the alpha particles were deflected. **NOTE: “Explain in terms of” is a common formatted Regents question. This means to focus your answer using “charged particles”.*

 ____

 ____

 ____

4. State one conclusion about atomic structure based on the observation that most alpha particles passed straight through the foil.

 ____

 ____

 ____

Base your answers to questions 5 and 6 on the information below and your knowledge of chemistry.

In 1897, J. J. Thompson demonstrated in an experiment that cathode rays were deflected by an electric field. This suggested that cathode rays were composed of negatively charged particles found in all atoms. Thomson concluded that the atom was a positively charged sphere of almost uniform density in which negatively charged particles were embedded. The total negative charge in the atom was balanced by the positive charge, making the atom electrically neutral.

In the early 1900s, Ernest Rutherford bombarded a very thin sheet of gold foil with alpha particles. After interpreting the results of the gold foil experiment, Rutherford proposed a more sophisticated model of the atom.

5. State one aspect of the modern model of the atom that agrees with a conclusion made by Thomson.

____

____

____

6. State on conclusion from Rutherford's experiment that contradicts one conclusion made by Thompson.

*Before answering: What does the word "contradict" mean?

____

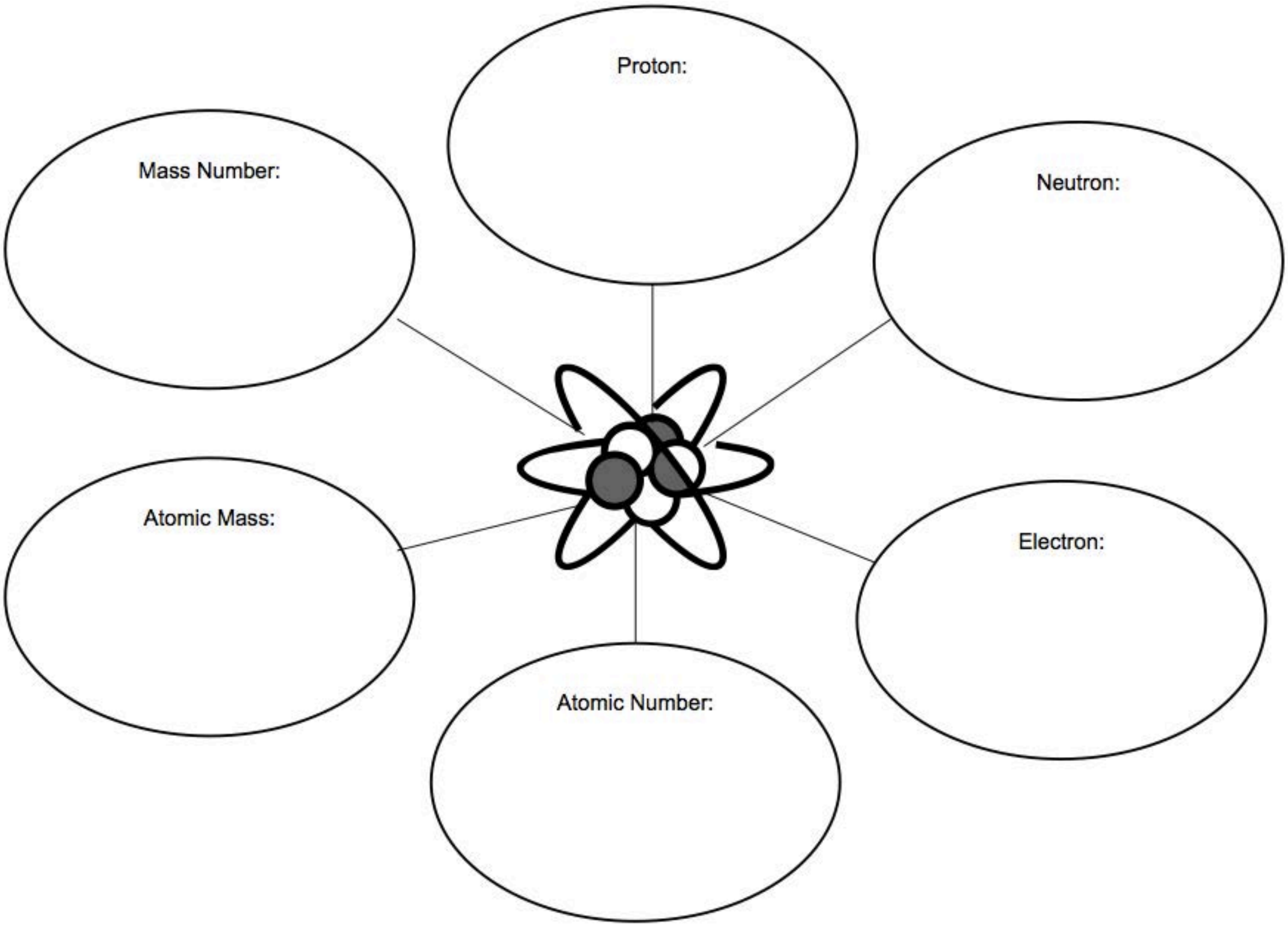
____

____

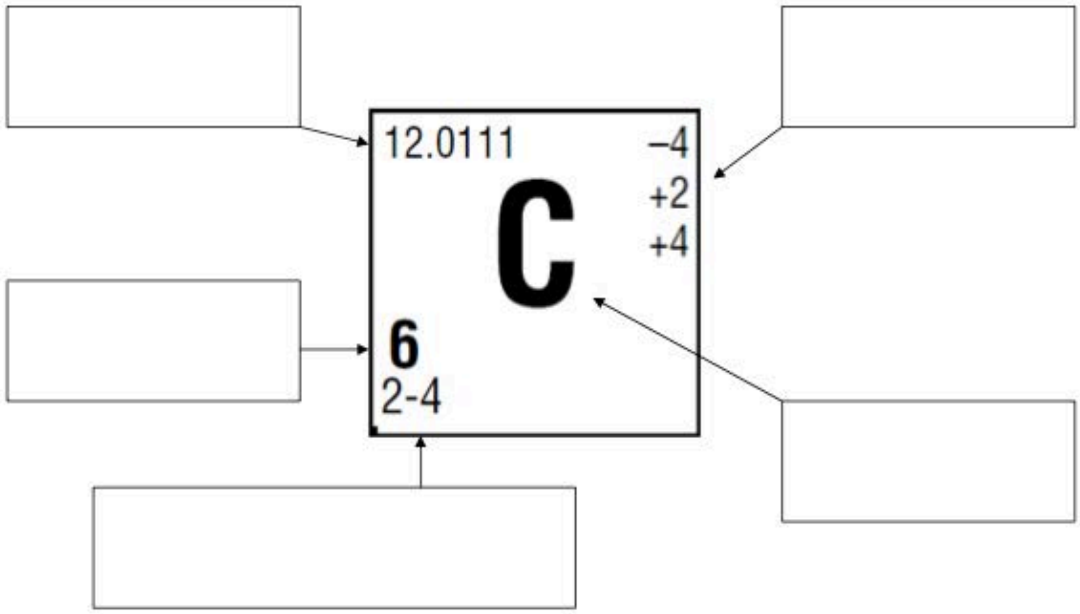
____

Video Lesson 2: Anatomy of an Atom

Directions: Using your notes, fill in the concept map with what you believe is important information about the structure of the atom.



Use your periodic table and Table O to fill in blanks.



SUBATOMIC PARTICLES

Subatomic Particle	Charge	Relative Mass	Location	Symbol	How to Calculate
Proton					
Neutron					
Electron					

What is the name of the element that has neutral atoms that contain?

1. 5 protons ______________________
2. 17 protons ______________________
3. 25 protons ______________________
4. 82 protons ______________________
5. 92 protons ______________________
6. 16 electrons ______________________
7. 32 electrons ______________________
8. 1 electron ______________________
9. 8 electrons ______________________
10. 2 electrons ______________________

Name:

D R . M In T Z

Video Lesson 2: Anatomy of an Atom

The Number of Protons Neutrons & Electrons

*Fill in the blanks in the following worksheet. Please keep in mind that the isotope represented by each space may **NOT** be the most common isotope or the one closest in atomic mass to the value on the periodic table.*

Atomic Symbol	Atomic Number	Protons	Neutrons	Electrons	Mass Number
B			6		
	11				24
		31	37		
				39	89
	29		35		
		43			100
Pb					207
			102	70	
		89			225
Mo			53		
	81				206
	100		159		
No					261
Yb					172
		106	159		

Multiple Choice:

1. _____ The mass of a proton is approximately equal to the mass of
   1. An alpha particle
   2. A beta particle
   3. A positron
   4. A neutron

2. _____ What is the number of electrons in an atom that has 3 protons and 4 neutrons
   1. 1
   2. 7
   3. 3
   4. 4

3. _____ Which statement compares the masses of two subatomic particles?
   1. The mass of an electron is greater than the mass of a proton.
   2. The mass of an electron is greater than the mass of a neutron.
   3. The mass of a proton is greater than the mass of an electron.
   4. The mass of a proton is greater than the mass of a neutron.

4. _____ Which two particles have opposite charges?
   1. An electron and a neutron
   2. An electron and a proton
   3. A proton and a neutron
   4. A proton and a positron

5. _____ Which part of a helium atom is positively charged?
   1. Electron
   2. Neutron
   3. Nucleus
   4. Orbital

6. _____ The notation for the nuclide $^{137}_{55}Cs$ gives information about
   1. mas number, only
   2. atomic number, only
   3. both mass number and atomic number
   4. neither mass number nor atomic number

7. _____ A sample of matter must be copper if
   1. Each atom in the sample has 29 protons
   2. Atoms of the sample react with oxygen
   3. The sample melts at 178 K
   4. The sample can conduct electricity

8. _____ Compared to an atom of phosphours-31, an atom of sulfur-32 contains
   1. one less neutron
   2. one less proton
   3. one more neutron
   4. one more proton

9. _____ What can be determined if only the atomic number of an atom is known?
    1. The total number of neutrons in the atom, only
    2. The total number of protons in the atom, only
    3. The total number of protons and the total number of neutrons in the atom
    4. The total number of protons and the total number of electrons in the atom

10. _____ Which quantity represents the number of protons in an atom?
    1. Atomic number
    2. Oxidation number
    3. Number of neutrons
    4. Number of valence electrons

11. ____ An atom of lithium-7 has an equal number of
    1. electrons and neutrons
    2. electrons and protons
    3. positrons and neutrons
    4. positrons and protons

12. _____ What is the mass number of ${}^{19}_{9}F$?
    1. 9
    2. 10
    3. 19
    4. 28

Ions

How are ions made from neutral atoms?

Why?

You have learned that not all atoms of an element are the same. Variation in the number of neutrons results in different isotopes of the element. In this activity we will explore another variation that can take place—the loss and gain of electrons. The exchange of electrons between atoms is a very common way for chemical change to take place. We will see it many times throughout the year.

1. Use Model 1 to complete the following table.

	Metal or Nonmetal	**Is the number of protons the same in the atom and the ion?**	**Is the number of neutrons the same in the atom and the ion?**	**Is the number of electrons the same in the atom and the ion?**	**Charge on the ion**
Lithium	metal				1+
Magnesium					2+
Aluminum		yes			3+
Fluorine				no	1–
Oxygen	nonmetal		yes	no	2–
Nitrogen					3–

2. Based on the table you completed in Question 1, what distinguishes a neutral atom from an ion?

3. Examine the isotope symbols in Model 1.

   a. Where is the ion charge located in the isotope symbol?

   b. Is a charge indicated on the neutral atoms? If yes, where is it located?

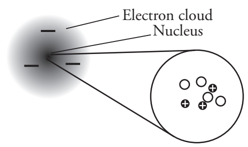
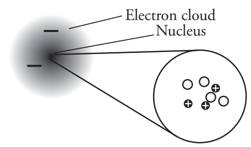
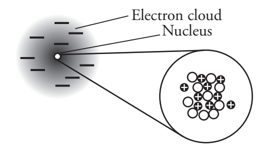
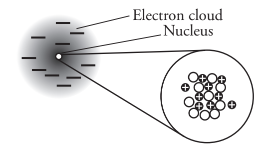
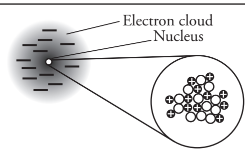
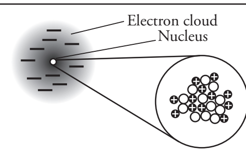
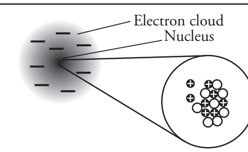
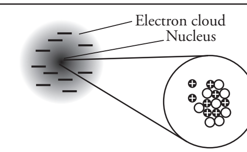
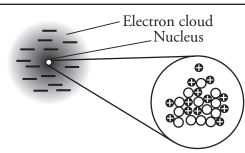
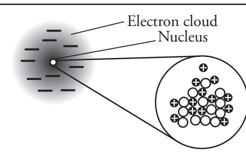
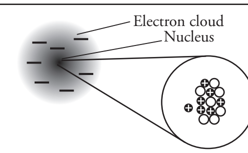
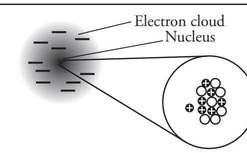
4. Which subatomic particle carries a positive charge?

5. Which subatomic particle carries a negative charge?

6. Propose a mathematical equation to calculate the charge on an ion from the number of protons and electrons in an ion. Confirm that your equation works using two positive ion examples and two negative ion examples from Model 1.

STOP

Model 1 – Atoms and Ions

	Neutral Atoms	**Ions**		**Neutral Atoms**	**Ions**
	Atom of Lithium	Ion of Lithium		Atom of Fluorine	Ion of Fluorine
Symbol	$^{7}_{3}\mathrm{Li}$	$^{7}_{3}\mathrm{Li}^{1+}$	**Symbol**	$^{19}_{9}\mathrm{F}$	$^{19}_{9}\mathrm{F}^{1-}$
Atomic Diagram			**Atomic Diagram**		
No. of Protons ⊕	3	3	**No. of Protons** ⊕	9	9
No. of Neutrons ○	4	4	**No. of Neutrons** ○	10	10
No. of Electrons ▬	3	2	**No. of Electrons** ▬	9	10
	Atom of Magnesium	Ion of Magnesium		Atom of Oxygen	Ion of Oxygen
Symbol	$^{24}_{12}\mathrm{Mg}$	$^{24}_{12}\mathrm{Mg}^{2+}$	**Symbol**	$^{16}_{8}\mathrm{O}$	$^{16}_{8}\mathrm{O}^{2-}$
Atomic Diagram			**Atomic Diagram**		
No. of Protons ⊕	12	12	**No. of Protons** ⊕	8	8
No. of Neutrons ○	12	12	**No. of Neutrons** ○	8	8
No. of Electrons ▬	12	10	**No. of Electrons** ▬	8	10
	Atom of Aluminum	Ion of Aluminum		Atom of Nitrogen	Ion of Nitrogen
Symbol	$^{27}_{13}\mathrm{Al}$	$^{27}_{13}\mathrm{Al}^{3+}$	**Symbol**	$^{14}_{7}\mathrm{N}$	$^{14}_{7}\mathrm{N}^{3-}$
Atomic Diagram			**Atomic Diagram**		
No. of Protons ⊕	13	13	**No. of Protons** ⊕	7	7
No. of Neutrons ○	14	14	**No. of Neutrons** ○	7	7
No. of Electrons ▬	13	10	**No. of Electrons** ▬	7	10

Read This!

Chemists refer to positively charged ions as **cations**. Chemists refer to negatively charged ions as **anions**.

7. Fill in the following table.

Symbol	$^{88}_{38}Sr^{2+}$	$^{32}_{16}S^{2-}$		
Atomic Number				35
Mass Number			70	
Number of protons			31	
Number of electrons			28	36
Number of neutrons				45
Cation or anion				

8. Could a +3 ion of aluminum be made by adding three protons to an aluminum atom? Explain.

9. One of your classmates is having trouble understanding ions. He explains the formation of a cation like this:

   "When you add an electron, you get a positive charge because adding is positive in math."

   a. As a group, explain in a grammatically correct sentence why this student is incorrect.

   b. Provide a better description of how math relates to electrons and ion formation.

Video Lesson 3: Ions

Write the full chemical symbol for the ion with:

1. 12 protons and 10 electrons:
2. 74 protons and 68 electrons:
3. 95 protons and 89 electrons:
4. 33 protons and 36 electrons:

Determine the number of protons, neutrons and electrons for the following ions:

Cu^{2+}
p =
n =
e =

Li^{+}

O^{2-}

Cl^{-}

Al^{3+}

I^{7+}

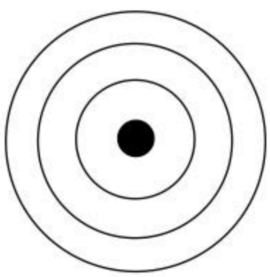
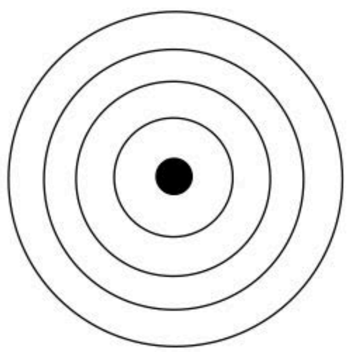
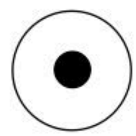
Atom	Atomic number	Mass number	Protons	Neutrons	Nucleons	Nuclear Charge	Atomic Charge	Electrons
$^{1}H^{+}$								
^{23}Na								
$^{35}Cl^{-}$								
Calcium- 41								
$^{48}Ti^{+2}$								
P-31								
$^{75}As^{-3}$								
$^{80}Br^{+5}$								
$^{24}Mg^{+2}$								

Video Lesson 4: Electron Configurations & The Bohr Model

1. Write the **ground** state electron configuration for the following neutral atoms.

    - Nitrogen:
    - Oxygen:
    - Arsenic:
    - Krypton:
    - Bromine:
    - Copper:

2. Write the electron configuration on the line and draw the Bohr Model of the following atoms

Sodium (Na) __________ Potassium (K) _________ Hydrogen (H) _________

3. Create Bohr model for the following particles

1) $^{41}_{20}Ca$

2) $^{32}_{16}S^{-2}$

3) $^{54}_{25}Mn$

4) $^{86}_{37}Rb^{+1}$

5) $^{18}_{9}F^{-1}$

6) $^{79}_{34}Se^{-2}$

Multiple Choice:

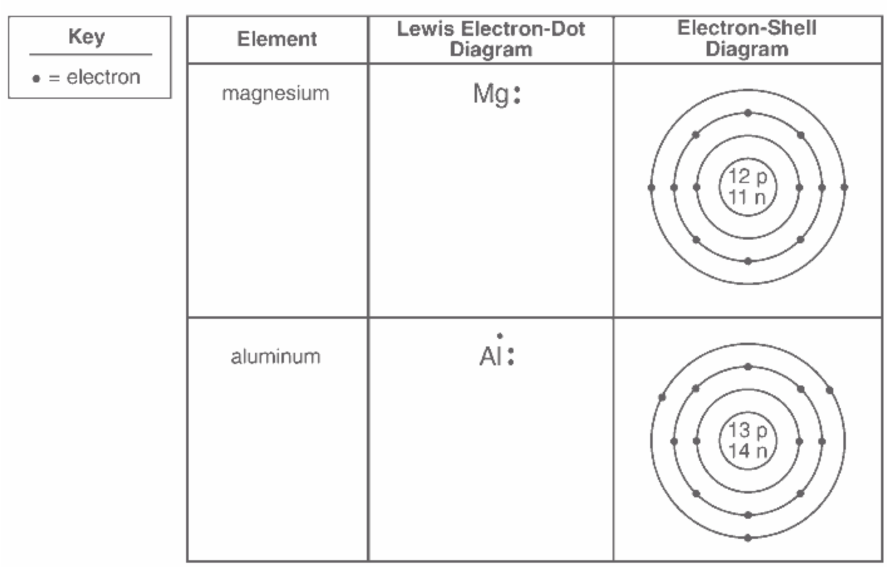
1. _____ Which statement describes the relative energy of the electrons in the shells of a calcium atom?
    1. An electron in the first shell has more energy than an electron in the second shell.
    2. An electron in the first shell has the same amount of energy as an electron in the second shell.
    3. An electron in the third shell has more energy than an electron in the second shell.
    4. An electron in the third shell has less energy than an electron in the second shell.
2. _____ What is the total number of valence electrons (electrons in outermost energy level) in an atom of germanium in the ground state?
    1. 8
    2. 2
    3. 14
    4. 4

3. _____ Which atom in the ground state has a partially filled second electron shell?
    1. Hydrogen atom
    2. Lithium atom
    3. Potassium atom
    4. Sodium atom

Constructed Response:

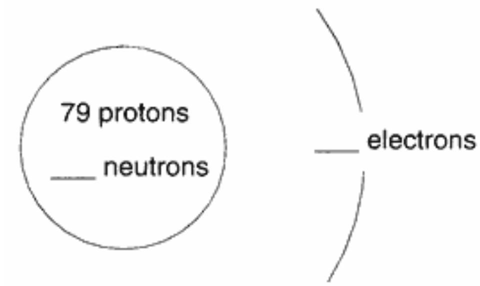
1. Determine the mass number of the magnesium atom represented by the electron-shell diagram. _______________________

Atomic Diagrams of Magnesium and Aluminum



In the early 1900's, evidence was discovered that atoms were not "hard spheres." It was shown that atoms themselves had an internal structure. One experiment involved gold metal foil.

2. Complete the simple model of an atom of gold-197 by placing the correct numbers in the two blanks.



Video Lesson 5: Ground State vs. Excited State Electron

For each of the following electron configurations of neutral atoms, determine the name of the element listed and determine if the configuration as written is in the ground state or the excited state.

	Name	Ground/Excited
• 2-8	______________	______________
• 2-7-2	______________	______________
• 2-8-11-2	______________	______________
• 2-8-7-2	______________	______________

Multiple Choice:

1. _____ Which atom in the ground state has an outermost electron with the most energy?
   1. Cs
   2. K
   3. Li
   4. Na

2. _____ When an excited electron in an atom moves from ground state, the electron
   1. Absorbs energy as it moves to higher energy state
   2. Absorbs energy as it moves to a lower energy state
   3. Emits energy has it moves to a higher energy state
   4. Emits energy has it moves to a lower energy state

3. _____ A bromine atom in the excited state could have an electron configuration of
   1. 2-8-18-6
   2. 2-8-18-7
   3. 2-8-17-7
   4. 2-8-17-8

4. _____ Which electron configuration could represent a strontium atom in an excited state?
   1. 2-8-18-7-1
   2. 2-8-18-7-3
   3. 2-8-18-8-1
   4. 2-8-18-8-2

5. _____ A specific amount of energy is emitted when excited electrons in an atom in a sample of an element return to the ground state. This emitted energy can be used to determine the
   1. Mass of the sample
   2. Volume of the sample
   3. Identity of the element
   4. Number of moles of the element

6. _____ What is the electron configuration of a sulfur atom in the ground state?
   1. 2-4
   2. 2-6
   3. 2-8-4
   4. 2-8-6

Constructed Response:
Base your answers to the next two questions on the information below.

An atom in an excited state has an electron configuration of 2-7-2

1. Write the electron configuration of this atom in the ground state. ___________________

2. Explain, in terms of subatomic particles, why this excited atom is electrically neutral.
   ____
   ____

Video Lesson 6: Isotopes and Average Atomic Mass

According to the *Periodic Table,* carbon has a mass of 12.0111amu. The mass of an atom comes from its protons and neutrons. Carbon has 6 protons. Subtracting the number of protons from the mass to get the number of neutrons gives 6.0111. This result is impossible. There are no fractions of neutrons. Nonsensical numbers such as these exist elsewhere. For example, the U.S. Census reports 2.59 people per household. This number is an average. The atomic mass listed on the *Periodic Table* is the average mass of the isotopes of carbon.

Calculate the average atomic mass of each example below.

1. An element recently discovered in Spring Valley High School called "valleyum" occurs in the following proportions: 81.75% Vm-500 and 18.25% Vm-502.

2. A new element, “schoolium”, found in only schools occurs in the following proportions: 9.750% Sl-750 and 90.25% Sl-752.

3. A new element “newium” has been discovered which occurs in the following proportions. 25.25% Nw-300; 15.25% Nw-301; and 59.50% Nw-302.

4. A new element found in the science department office called “departmentium” is found in the following proportions: 11.78% Dt-800; 1.850% Dt-801; and 86.37% Dt-803.

5. The element Levium, symbol Le, has the following naturally occurring isotopes:

^{296}Le = 50%
^{298}Le = 25%
^{299}Le = 25%

Calculate the average atomic mass

6. The element Chemisgreatium, symbol Cg, has the following naturally occurring isotopes:

^{601}Cg 65%
^{603}Cg = 35%

Calculate the average atomic mass

Multiple Choice:

1. _____ The table below gives the atomic mass and the abundance of the two naturally occurring isotopes of chlorine.

Naturally Occuring Isotopes of Chlorine

Isotopes	AtomicMassof theIsotopes (u)	Natural Abundance (%)
^{35}Cl	34.97	75.76
^{37}Cl	36.97	24.24

Which numerical setup can be used to calculate the atomic mass of the element chlorine?
   1. (34.97 u)(75.76) + (36.97 u)(24.24)
   2. (34.97 u)(0.2424) + (36.97 u)(0.7576)
   3. (34.97 u)(0.7576) + (36.97 u)(0.2424)
   4. (34.97 u)(24.24) + (36.97 u)(75.76)

2. _____ The atomic mass unit is defined as exactly 1/12th the mass of an atom of
   1. $^{12}_{6}C$
   2. $^{14}_{6}C$
   3. $^{24}_{12}Mg$
   4. $^{26}_{12}Mg$

3. _____ Atoms of different isotopes of the same element differ in their total number of
   1. Electrons
   2. Neutrons
   3. Protons
   4. Valence electrons

4. _____ Isotopes of an element must have different
   1. Atomic numbers
   2. Mass numbers
   3. Numbers of protons
   4. Number of electrons

5. _____ The table below shows the number of subatomic particles in atom X and in atom Z.

Subatomic Particles in Two Atoms

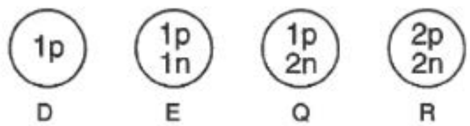
Atom	Number of Protons	Number of Neutrons	Number of Electrons
X	6	6	6
Z	6	7	6

Atom X and atom Z are isotopes of the element
   1. Aluminum
   2. Carbon
   3. Magnesium
   4. Nitrogen

6. _____ An atom that has 13 protons and 15 neutrons is an isotope of the element
   1. Nickel
   2. Silicon
   3. Aluminum
   4. Phosphorous

7. _____ The nucleus of an atom of cobolt-58 contains
   1. 27 protons and 31 neutrons
   2. 27 protons and 32 neutrons
   3. 59 protons and 60 neutrons
   4. 60 protons and 60 neutrons

8. _____ Each diagram below represents the nucleus of a different atom.



   Which diagrams represent nuclei of the same element?
   1. D and E, only
   2. D, E, and Q
   3. Q and R, only
   4. Q, R, and E

9. _____ Which notations represent different isotopes of the element sodium?
   1. ^{32}S and ^{34}S
   2. S^{2-} and S^{6+}
   3. Na^{+} and Na^{0}
   4. ^{22}Na and ^{23}Na

10. _____ The most common isotope of chromium has a mass number of 52. Which notation represents a different isotope of chromium?
   1. $^{52}_{24}Cr$
   2. $^{54}_{24}Cr$
   3. $^{24}_{52}Cr$
   4. $^{24}_{54}Cr$

11. _____ Which two notations represent different isotopes of the same element?
   1. $^{6}_{4}Be$ and $^{9}_{4}Be$
   2. $^{7}_{3}Li$ and $^{7}_{3}Li$
   3. $^{14}_{7}N$ and $^{14}_{6}C$
   4. $^{32}_{15}P$ and $^{32}_{16}S$

12. _____ The atomic mass of titanium is 47.88 atomic mass units. This atomic mass represents the
   1. total mass of all the protons and neutrons in an atom of Ti
   2. total mass of all the protons, neutrons, and electrons in an atom of Ti
   3. weighted average mass of the most abundant isotope of Ti
   4. weighted average mass of all the naturally occurring isotopes of Ti

Constructed Response:

Copper has two naturally occurring isotopes. Information about the two isotopes is shown in the table below.

Naturally Occurring Isotopes of Copper

Isotope	Atomic Mass (atomic mass units, u)	Percent Natural Abundance (%)
Cu-63	62.93	69.17
Cu-65	64.93	30.83

1. In the space provided, show the correct numerical setup for calculating the atomic mass of copper.

2. Average Atomic Mass = ________________________

Base your answers to the next 2 questions on the information below.

The accepted values of the atomic mass and percent natural abundance of each naturally occurring isotope of silicon are given in the data table below.

Naturally Occuring Isotopes of Silicon

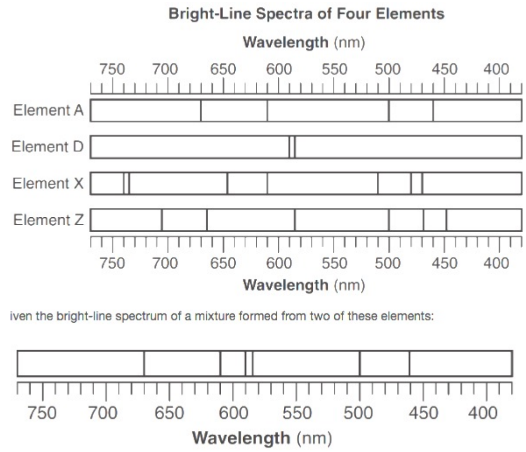
Isotope	Atomic Mass (atomic mass unit)	Percent Natural Abundance (%)
Si – 28	27.98	92.22
Si – 29	28.98	4.69
Si – 30	29.97	3.09

3. Show the correct numerical setup for calculating the average atomic mass of Si.

4. Determine the total number of neutrons in an atom of Si-29.

Video Lesson 7: Atomic Emissions Spectra

1. _____ The bright-line spectra produced by four elements are represented in the diagram below.

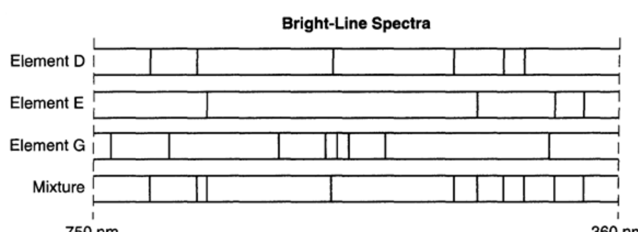


Given the bright-line spectrum of a mixture formed two of these elements:
   1. A and D
   2. A and X
   3. Z and D
   4. Z and X

2. _____ A specific amount of energy is emitted when excited electrons in an atom in a sample of an element return to the ground state. This energy can be used to determine the
   1. Mass of the sample
   2. Volume of the sample
   3. Identity of the element
   4. Number of moles of the element

3. _____ During a flame test, lithium salt produces a characteristic red flame. This red color is produced when electrons in excited lithium atoms
   1. Are lost by the atoms
   2. Are gained by the atoms
   3. Return to lower energy states within the atoms
   4. Move to higher energy states within atoms

4. _____ Given the bright-line spectrum of three elements and the spectrum of a mixture formed from at least two of these elements.

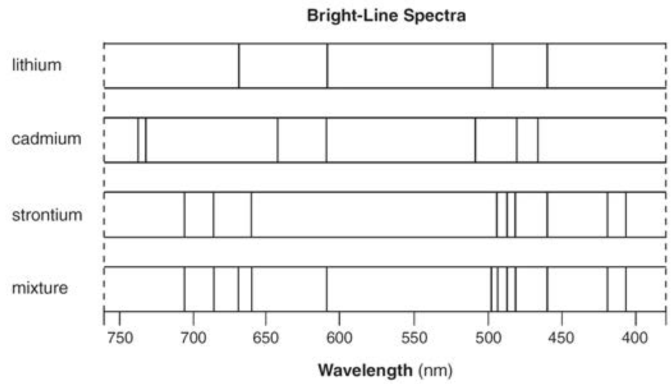


Which elements are present in the mixture?
   1. E and D, only
   2. E and G, only
   3. D and G, only
   4. D, E, and

Name:

Constructed Response:

Base your answers to the next 3 questions on the information below.
The Bright-Line spectra of three elements and a mixture of the elements are shown below.



1. State the total number of valence electrons in a cadmium atom in the ground state.
____

2. Identify all the elements in the mixture. ______________________________

3. Explain, in terms of both electrons and energy, how a bright-line spectrum of an element is produced.
____
____
____

Name: **Chapter 1: Atomic Review**

____ 1. According to the modern model of the atom, the nucleus of an atom is surrounded by one or more

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

____ 2. Compared to the charge of a proton, the charge of an electron has

1) a greater magnitude and the same sign
2) a greater magnitude and the opposite sign
3) the same magnitude and the same sign
4) the same magnitude and the opposite sign

____ 3. Which particle has *no* charge?

1) electron 3) positron
2) neutron 4) proton

____ 4. What is the approximate mass of a proton?

1) 1 u 3) 1 g
2) 0.0005 u 4) 0.0005 g

____ 5. What is the overall charge of an ion that has 12 protons, 10 electrons, and 14 neutrons?

1) 2– 2) 2+ 3) 4– 4) 4+

____ 6. Which phrase describes an atom?

1) a negatively charged nucleus surrounded by positively charged protons
2) a negatively charged nucleus surrounded by positively charged electrons
3) a positively charged nucleus surrounded by negatively charged protons
4) a positively charged nucleus surrounded by negatively charged electrons

____ 7. Which particles have approximately the same mass?

1) an electron and an alpha particle
2) an electron and a proton
3) a neutron and an alpha particle
4) a neutron and a proton

____ 8. As a result of the gold foil experiment, it was concluded that an atom

1) contains protons, neutrons, and electrons
2) contains a small, dense nucleus
3) has positrons and orbitals
4) is a hard, indivisible sphere

____ 9. The gold foil experiment led to the conclusion that each atom in the foil was composed mostly of empty space because most alpha particles directed at the foil

1) passed through the foil
2) remained trapped in the foil
3) were deflected by the nuclei in gold atoms
4) were deflected by the electrons in gold atoms

____ 10. Which conclusion was a direct result of the gold foil experiment?

1) An atom is mostly empty space with a dense, positively charged nucleus.
2) An atom is composed of at least three types of subatomic particles.
3) An electron has a positive charge and is located inside the nucleus.
4) An electron has properties of both waves and particles.

____ 11. All phosphorus atoms have the same

1) atomic number
2) mass number
3) number of neutrons plus the number of electrons
4) number of neutrons plus the number of protons

____ 12. Which electron configuration represents the electrons in an atom of Ga in an excited state?

1) 2-8-17-3 3) 2-8-18-3
2) 2-8-17-4 4) 2-8-18-4

____ 13. Which quantity represents the number of protons in an atom?

1) atomic number
2) oxidation number
3) number of neutrons
4) number of valence electrons

____ 14. What is the charge of the nucleus of an oxygen atom?

1) 0 2) –2 3) +8 4) +16

____ 15. An atom of any element must contain

1) an equal number of protons and neutrons
2) an equal number of protons and electrons
3) more electrons than neutrons
4) more electrons than protons

____ 16. In an atom of argon-40, the number of protons

1) equals the number of electrons
2) equals the number of neutrons
3) is less than the number of electrons
4) is greater than the number of electrons

____ 17. Which quantity can vary among atoms of the same element?

1) mass number
2) atomic number
3) number of protons
4) numbers of electrons

18. What is the mass number of a carbon atom that contains six protons, eight neutrons, and six electrons?

1) 6 2) 8 3) 14 4) 20

19. The mass of 12 protons is approximately equal to

1) 1 atomic mass unit
2) 12 atomic mass units
3) the mass of 1 electron
4) the mass of 12 electrons

20. The greatest composition by mass in an atom of $^{17}_{8}$O is due to the total mass of its

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

21. The numbers of protons and neutrons in each of four different atoms are shown in the table below.

Protons and Neutrons in Four Different Atoms

Atom	Number of Protons	Number of Neutrons
A	8	8
D	9	9
E	9	10
G	10	10

Which two atoms represent isotopes of the same element?

1) *A* and *D* 3) *E* and *D*
2) *A* and *G* 4) *E* and *G*

22. The table below indicates the stability of six nuclides.

Stability of Six Nuclides

Nuclide	Stability
C-12	stable
C-14	unstable
N-14	stable
N-16	unstable
O-16	stable
O-19	unstable

All atoms of the unstable nuclides listed in this table have

1) an odd number of neutrons
2) an odd number of protons
3) more neutrons than protons
4) more protons than neutrons

23. Atoms of different isotopes of the same element differ in their total number of

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

24. The nucleus of an atom of cobalt-58 contains

1) 27 protons and 31 neutrons
2) 27 protons and 32 neutrons
3) 59 protons and 60 neutrons
4) 60 protons and 60 neutrons

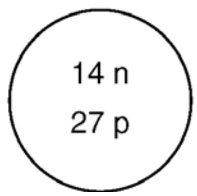
25. What is the total number of neutrons in an atom of O-18?

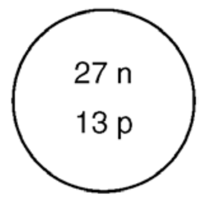
1) 18 2) 16 3) 10 4) 8

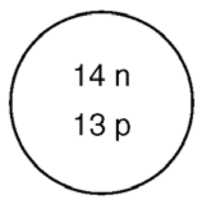
26. Which isotopic notation represents an atom of carbon-14?

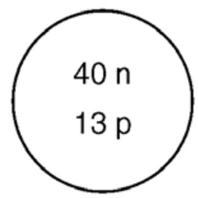
1) $^{6}_{8}C$ 2) $^{8}_{6}C$ 3) $^{6}_{14}C$ 4) $^{14}_{6}C$

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

1)


3)


2)


4)


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

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

29. What information is necessary to determine the atomic mass of the element chlorine?

1) the atomic mass of each artificially produced isotope of chlorine, only
2) the relative abundance of each naturally occurring isotope of chlorine, only
3) the atomic mass and the relative abundance of each naturally occurring isotope of chlorine
4) the atomic mass and the relative abundance of each naturally occurring and artificially produced isotope of chlorine

____ 30. The atomic mass of element *A* is 63.6 atomic mass units. The only naturally occurring isotopes of element *A* are *A*-63 and *A*-65. The percent abundances in a naturally occurring sample of element *A* are closest to

1) 31% *A*-63 and 69% *A*-65
2) 50% *A*-63 and 50% *A*-65
3) 69% *A*-63 and 31% *A*-65
4) 100% *A*-63 and 0% *A*-65

____ 31. The average isotopic mass of chlorine is 35.5. Which mixture of isotopes (shown as percents) produces this average mass?

1) 50% ^{12}C and 50% ^{13}C
2) 50% ^{35}Cl and 50% ^{37}Cl
3) 75% ^{35}Cl and 25% ^{37}Cl
4) 75% ^{12}C and 25% ^{13}C

____ 32. An orbital is defined as a region of the most probable location of

1) an electron
2) a neutron
3) a nucleus
4) a proton

____ 33. Which atom in the ground state has an outermost electron with the most energy?

1) Cs 2) K 3) Li 4) Na

____ 34. Compared to an electron in the first electron shell of an atom, an electron in the third shell of the same atom has

1) less mass
2) less energy
3) more mass
4) more energy

35. Given the table below that shows student's examples of proposed models of the atom:

Proposed Models of the Atom

Model	Location of Protons	Location of Electrons
A	in the nucleus	specific shells
B	in the nucleus	regions of most probable location
C	dispersed throughout the atom	specific shells
D	dispersed throughout the atom	regions of most probable location

Which model correctly describes the locations of protons and electrons in the wave-mechanical model of the atom?

1) *A* 2) *B* 3) *C* 4) *D*

36. An electron in a sodium atom gains enough energy to move from the second shell to the third shell. The sodium atom becomes

1) a positive ion
2) a negative ion
3) an atom in an excited state
4) an atom in the ground state

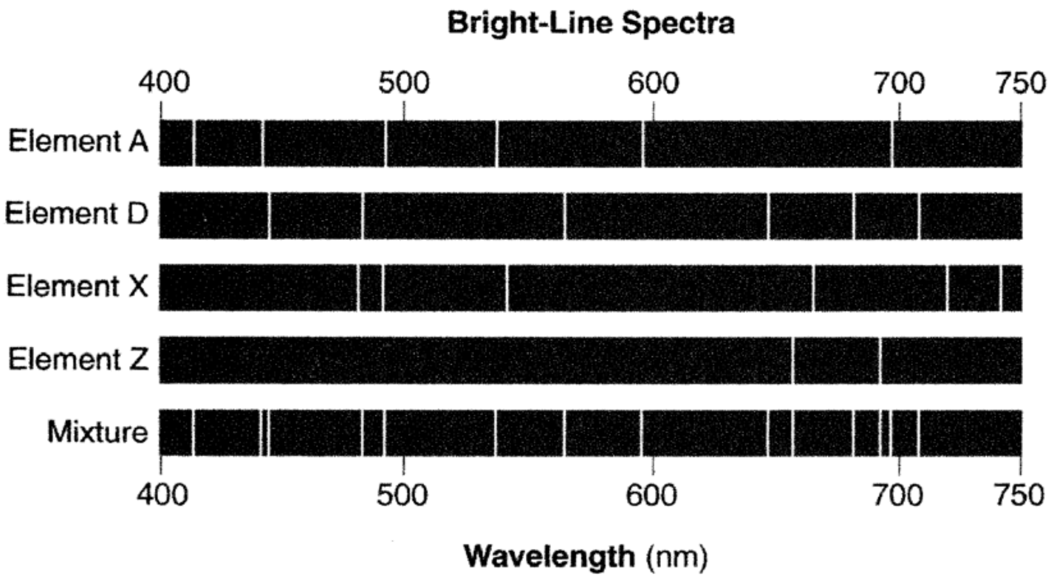
37. A bromine atom in an excited state could have an electron configuration of

1) 2-8-18-6
2) 2-8-18-7
3) 2-8-17-7
4) 2-8-17-8

38. Which electron configuration is possible for a nitrogen atom in the excited state?

1) 2-5 2) 2-4-1 3) 2-6 4) 2-4

39. The diagram below represents the bright-line spectra of four elements and a bright-line spectrum produced by a mixture of three of these elements.



Which element is *not* present in the mixture?

1) *A*
2) *D*
3) *X*
4) *Z*

40. The bright-line spectrum of an element in the gaseous phase is produced as

1) protons move from lower energy states to higher energy states
2) protons move from higher energy states to lower energy states
3) electrons move from lower energy states to higher energy states
4) electrons move from higher energy states to lower energy states

41. Which electron configuration represents the electrons of an atom in an excited state?

1) 2–8–1
2) 2–8–6
3) 2–8–17–6
4) 2–8–18–5

42. In the wave-mechanical model of the atom, an orbital is defined as

1) a region of the most probable proton location
2) a region of the most probable electron location
3) a circular path traveled by a proton around the nucleus
4) a circular path traveled by an electron around the nucleus

43. According to the electron-cloud model of the atom, an orbital is a

1) circular path traveled by an electron around the nucleus
2) spiral path traveled by an electron toward the nucleus
3) region of the most probable proton location
4) region of the most probable electron location

44. Compared to the energy and charge of the electrons in the first shell of a Be atom, the electrons in the second shell of this atom have

1) less energy and the same charge
2) less energy and a different charge
3) more energy and the same charge
4) more energy and a different charge

45. Which electron configuration represents a selenium atom in an excited state?

1) 2-7-18-6
2) 2-7-18-7
3) 2-8-18-6
4) 2-8-18-7

____ 46. Base your answer to the following question on the information below and on your knowledge of chemistry.

Illuminated **EXIT** signs are used in public buildings such as schools. If the word **EXIT** is green, the sign may contain the radioisotope tritium, hydrogen-3. The tritium is a gas sealed in glass tubes. The emissions from the decay of the tritium gas cause a coating on the inside of the tubes to glow.

State, in terms of neutrons, how an atom of tritium *differs* from an atom of hydrogen-1.

Base your answers to questions **47** through **50** on the information below and on your knowledge of chemistry.

A student compares some models of the atom. These models are listed in the table below in order of development from top to bottom.

Models of the Atom

Model	Observation	Conclusion
Dalton model	Matter is conserved during a chemical reaction.	Atoms are hard, indivisible spheres of different sizes.
Thomson model	Cathode rays are deflected by magnetic/electric fields.	Atoms have small, negatively charged particles as part of their internal structure.
Rutherford model	Most alpha particles pass straight through gold foil but a few are deflected.	An atom is mostly empty space with a small,dense,positively as part of their nucleus.
Bohr model	Unique spectral lines are emitted by excited gaseous elements.	Packets of energy are absorbed or emitted by atoms when an electron changes shells.

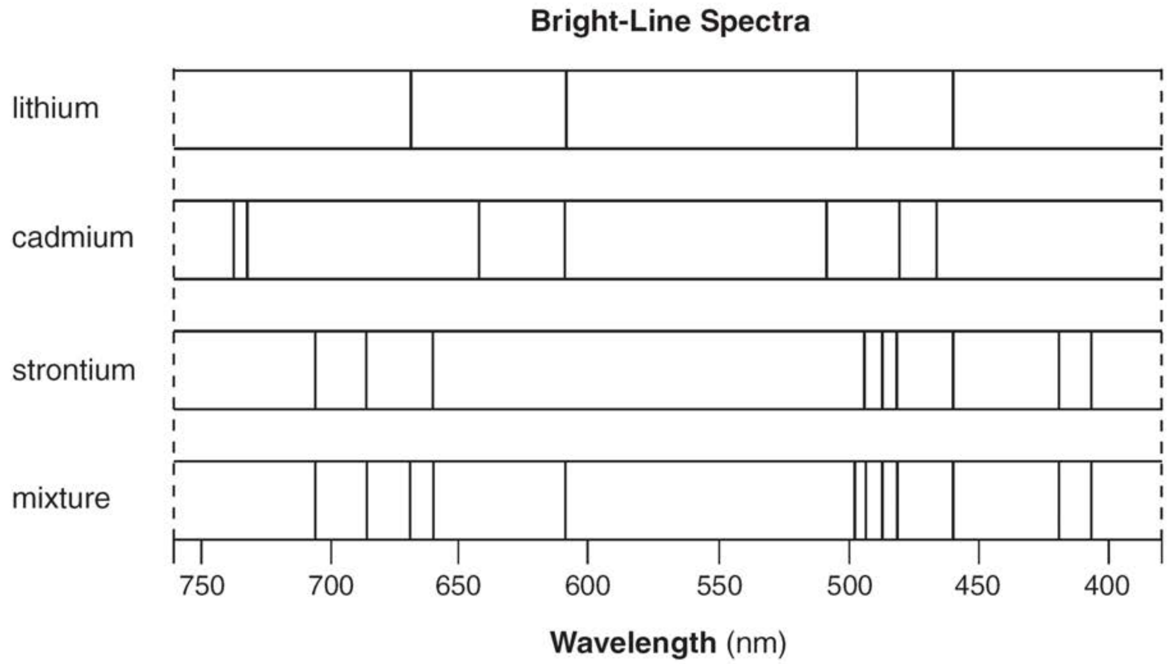
____ 47. State *one* way in which the Bohr model agrees with the Thomson model.

____ 48. Using the conclusion from the Rutherford model, identify the charged subatomic particle that is located in the nucleus.

____ 49. State *one* conclusion about the internal structure of the atom that resulted from the gold foil experiment.

____ 50. State the model that first included electrons as subatomic particles.

Base your answers to questions **51** through **53** on the information below.
The bright-line spectra for three elements and a mixture of elements are shown below.



____ 51. State the total number of valence electrons in a cadmium atom in the ground state.

____ 52. Identify *all the elements in the mixture.*

____ 53. Explain, in terms of *both electrons and energy, how the bright-line spectrum of an element is produced.*

____ 54. Explain, in terms of protons and neutrons, why U-235 and U-238 are different isotopes of uranium.

Base your answers to questions **55** and **56** on the information below.

In the gold foil experiment, a thin sheet of gold was bombarded with alpha particles. Almost all the alpha particles passed straight through the foil. Only a few alpha particles were deflected from their original paths.

____ 55. Explain, in terms of charged particles, why some of the alpha particles were deflected.

____ 56. State *one* conclusion about atomic structure based on the observation that almost all alpha particles passed straight through the foil.

____ 57. Naturally occurring boron is composed of two isotopes. The percent abundance and the mass of each isotope are listed below.

- 19.9% of the boron atoms have a mass of 10.013 atomic mass units.
- 80.1% of the boron atoms have a mass of 11.009 atomic mass units.

Calculate the atomic mass of boron. Your response must include *both* a correct numerical setup and the calculated result.

____________________ atomic mass units