NAME: ____

Chapter 5: Atomic Structure and the Periodic Table

Vocabulary:

alkali metals
alkaline earth metals
atom
atomic mass
atomic mass unit
atomic number
cathode ray
Dalton's atomic theory
electron
group
halogen
inner transition metal
isotope
mass number
metal
metalloid
neutron
noble gas
nonmetal
nucleus
period (on periodic table)
periodic law
periodic table
proton
representative element
transition metal

Notes: page 107 and (section 5.1)

1. In 1981 Gerd Binnig and Heinrich Rohrer produced an image of __________ using a scanning _________________ microscope.

2. What is Democritus credited with inventing? ________________________________

3. He believed that these were ________________ and _______________________ which means they couldn't be __________________ or _______________________.

Draw Atoms

a. monatomic	b. diatomic	c. Mixture of elements	d. Compounds

NAME: ____

Notes Section 5.1 Continued. page 2

1. How many copper atoms lined up side by side would form a 1.0 cm line? __________

Write that number in scientific notation: _________________________

2. How is the atom defined on page 108? An atom is…

3. How many copper atoms are in one copper penny? ________________

4. (REVIEW) Calculate how long a line of copper atoms could be formed with the copper atoms in the penny. (Show work)

2.4×10^{22} atoms

E.C. RESEARCH QUESTION (100 points e.c. possible). How are scanning tunneling microscopes and nanotechnology changing our world? 5 paragraph essay with three references.

Notes Section 5.2

1. What is a particle accelerator?

2. How fast do scientists move atoms in a particle accelerator?

3.What happens when atoms are smashed together in the particle accelerators?

4. What has been changed in Dalton's atomic theory?

5. How many fundamental particles have been identified (approximately)?

6. What negatively charged subatomic particle was found by J.J. Thomson in 1897?

7.In Thomson's experiment, he passed _____________ _____________ through gases at _________ pressure.. He sealed the gases in glass tubes fitted at each end with ____________. He then put high voltage through the tubes. The anode became positively charged. The cathode became ______________________. The beam is called a ______________________________

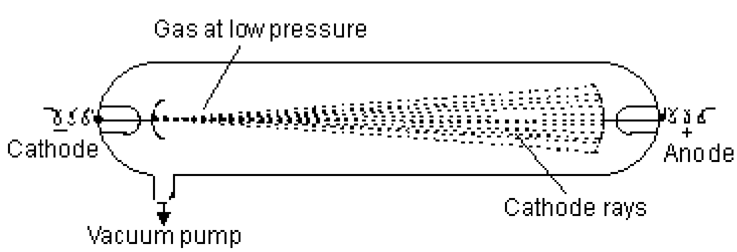


Fig. 1 Production of cathode rays

8. In the picture above, draw a negative sign. Show, using a colored pen/marker, how the path of the electrons would be affected.

9. What particles are in the cathode ray? ______________. This can be restated as: the cathode ray is composed of streams of electrons.

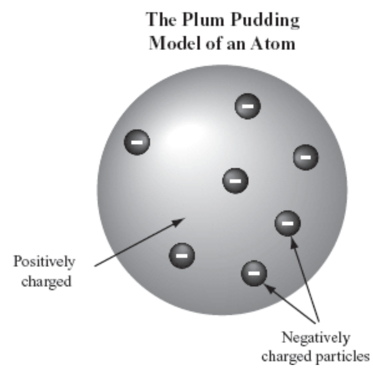
NAME: ____

Section 5.2 Continued: page 3

1. Since atoms are electrically neutral, E. Goldstein believed that for each negatively charged electron, there must be a ____________. He observed canal rays, which are ____.

2. In 1932, the English Physicist, James __________________ confirmed the existence of another nuclear particle, the ______________________. These particles have no charge, but have a mass nearly equal to that of a proton. The particles discovered by Chadwick are called ______________.

3. According to J.J. Thomson's view of the atom, Dalton was wrong about ______________, but correct about the rest of his atomic theory. J.J. Thomson's model looked like the picture:



http://www.google.com/imgres?imgurl=http://www.welsch.com/gallery/bitmap/Rosinenkuchen_nach__Thompson_077.jpg&imgrefurl=http://www.welsch.com/e/index.php5%3Fchap%3D5_1%26gid%3D581%26oldcat%3DPhysics%26dis%3D9%26oldType%3DBitmap&usg=__qIoMoSrsnTEq6nD-ER_1KeRoNNc=&h=460&w=460&sz=25&hl=en&start=6&zoom=1&itbs=1&tbnid=d_atPr1R90iR0M:&tbnh=128&tbnw=128&prev=/images%3Fq%3Dplum%2Bpudding%2Bmodel%2Bof%2Batom%26hl%3Den%26gbv%3D2%26tbs%3Disch:1

4. J.J. Thomsons's model was testable. Ernest Rutherford designed an experiment in 1911. Their test used relatively massive alpha particles, which are ___________ atoms that have lost their two ___________ and have a double ______________ charge because of the two remaining ________________.

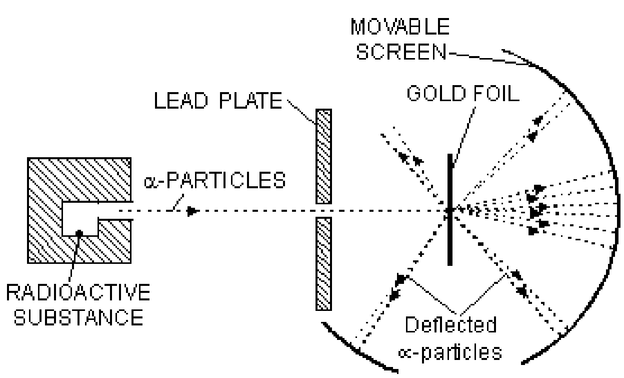


Fig. 3

5. Rutherford's apparatus consisted of gold foil surrounded by a fluorescent screen. The fluorescent screen lights up when hit by an alpha particle. If Thomson's model had been accurate, all of the particles would have ______ ________________________.

NAME: ____

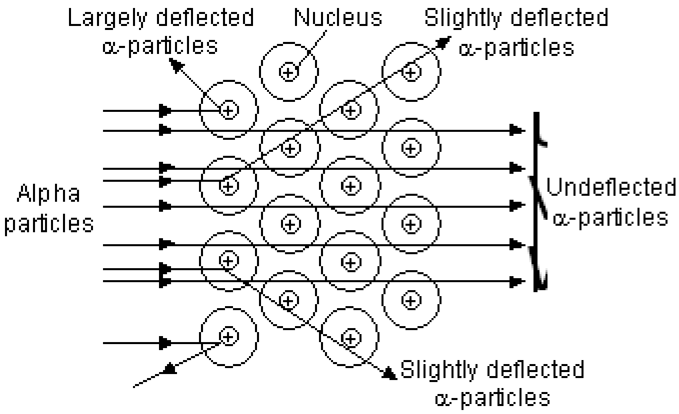


Fig. 4 (a)

6. Rutherford concluded:

7. Rutherford's quote about the particles which bounced straight back toward the source was:

"It was about as credible as if ____.

8.What can you conclude from the alpha particles which went straight through?

Section 5.3 Continued: page 4

1. What can you conclude from the alpha particles which were SLIGHTLY deflected?

2. What can you conclude from the alpha particles which bounced back?

3. What three subatomic particles are atoms made from?

4. Use table 5.2 to determine how the atoms of boron are different from the atoms of carbon?

5. How are the atoms of fluorine and neon different from each other (use table 5.2)?

6. Atomic number = number of ____________________ and _____________________

7. In a neutral atom, the number of _________________ equal the number of ______________.

8. In a positively charged atom the number of protons is ________than the number of electrons.

9. In a negatively charged atom the number of protons is __________ than the number of electrons.

10. When atoms obtain a charge, the number of electrons ______________ change.

11. The number of protons + neutrons = _______________________

12. The mass number minus the number of protons = __________________

13. What is the "mass number" of an isotope?

14. What must be true if two atoms are isotopes: They have the same number of __________ and different numbers of ______________ and their masses are _________.

NAME: ____

15. What equation is used to determine the number of neutrons?

16. What is a subscript?

17. What is a superscript?

18. Define isotope.

19. Are isotopes chemically alike? Explain why.

NAME: ____

Section 5.3 Continued: page 5

1. How does the discovery of isotopes contradict Dalton's atomic theory?

Dalton's Atomic Theory

1.) All matter is made up of tiny particles called atoms.
2.) All atoms of a given element are alike, but are different from the atoms of any other element.
3.) Compounds are formed when atoms of different elements combine in fixed proportions.
4.) A chemical reaction involves a rearrangement of atoms, not a change in the atoms themselves.

2. Look at figure 5.9 on page 117. How are the three neon atoms the same? ___________

3. How are the three neon atoms different? _____________________________________

4. What do all three isotopes of hydrogen share? _________________________________

5. What is deuterium? __________ How is it the same as hydrogen-1? ______________ How is it different from hydrogen-1? _________________

6. What is tritium?______________ _____ How is it the same as hydrogen-1? ________ How is it different from hydrogen-1? _____________________________________

7. What is the 16 in ${}^{16}_{8}O$? ____

8. What is the 8 in ${}^{16}_{8}O$? ____

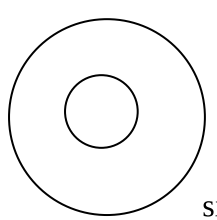
9. What is the O in ${}^{16}_{8}O$? ____

10. Why do ${}^{16}_{8}O$, ${}^{17}_{8}O$, and ${}^{18}_{8}O$ all exist? ___________________________________

11. How many neutrons are in ${}^{16}_{8}O$? (show work)_____________________________.

12. How many neutrons are in ${}^{17}_{8}O$? (show work) ____________________________

13. How many neutrons are in ${}^{18}_{8}O$? (show work)_____________________________.

Draw a diagram of ${}^{18}_{8}O$  similar to figure 5.9.

NAME: ____

<u>Section 5.3 Continued, page 6.</u> ______________________

In 1932, James Chadwick confirmed the existence of another subatomic particle: the neutron. Neutrons are subatomic particles with no charge but with a mass nearly equal to that of a proton. Thus, the fundamental building blocks of atoms are the electron, the proton, and the neutron.

1. What did James Chadwick discover? ____________________________

Protons and neutrons are large, and found in the nucleus, at the center of the atom. The sum of the number of protons and neutrons in an atom is called the **mass number**. Protons are positively charged. Neutrons are electrically neutral. On the other hand, electrons are negative. Electrons are very small, and are found far away from the nucleus.

2. What is the mass number?

3. Where does one find protons and neutrons in an atom?

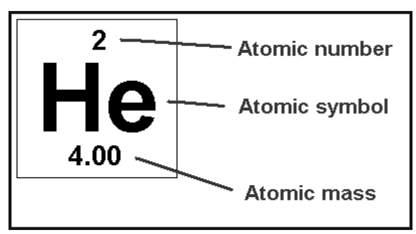
4. What are the charges on protons ______, neutrons _______, and electrons _____.

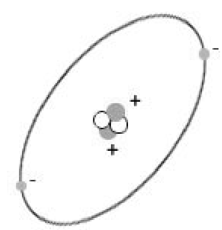
5. Where are electrons found?

6. Are electrons much larger or much smaller than protons and neutrons? _________.

7. What is the nucleus?

The atomic number is the number of protons in an atom's nucleus. In a neutral atom, it is also the number of electrons. The number of protons an atom has determines what type of atom it is. Every atomic number also corresponds with an atomic symbol. If an element has an atomic number of 2, each atom of that element has 2 protons, and it can then be identified with the symbol "He," which stands for helium. A helium atom may not have more or less than 2 protons. <u>The atomic number is always the smallest number in any periodic table entry</u>.





8. What is the atomic number?

9. If the atomic number is 2, the element must be ______. If the atomic number is 10, the atom is _______ if the atomic number is 18, the atom is _______.

10. For neon, the number of protons is ______, because the atomic number is _____.

The protons and neutrons are the heavier subatomic particles found in the nucleus of an atom. The mass number is the sum of the number of protons and the number of neutrons in an atom. <u>The atomic mass number is always the largest number in any periodic table entry</u>.

11. Which number is always larger, the atomic mass, or the atomic number?

12. To find the mass number you should….

13. How would you find the number of neutrons, if you were given the mass number and the atomic number?

NAME: ____

Section 5.3 Continued, page 7.

Fill in the chart:

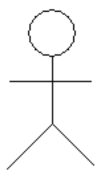
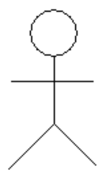
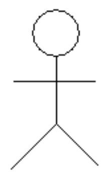
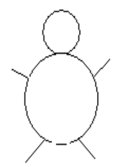
name	symbol	protons	neutrons	electrons
	$^{1}_{1}H$			
	$^{2}_{1}H$			
	$^{3}_{1}H$			
	$^{4}_{2}He$			
	$^{20}_{10}Ne$			
	$^{21}_{10}Ne$			
	$^{13}_{6}C$			
	$^{12}_{6}C$			
	$^{35}_{17}Cl$			
chlorine - 37				
	$^{67}_{30}Zn$			
zinc - 70				
	$^{67}_{30}Zn^{+2}$ Challenge!!!			
	$^{35}_{17}Cl^{-1}$ Challenge !!!			
sodium – 24				
	$^{24}_{11}Na^{+1}$ challenge!!!			
		7	7	7
		34	44	34
		80	120	80

NAME: ____

You may be wondering why some of the atomic mass numbers in the periodic table are expressed in decimal notation, and not whole numbers. After all, an atom's mass is the sum of its protons and neutrons, and it is impossible for an atom to have a fraction of a proton or a neutron. The reason why the periodic table contains decimals is because the atomic mass number in the periodic table represents the <u>average</u> mass of all of the known isotopes of a given element. Isotopes are atoms that have the same number of protons but different numbers of neutrons. Some atoms of an element can therefore be heavier than other atoms, due to an extra neutron in the nucleus.

Some of the carbon found in nature has a mass of 12 (6 protons and 6 neutrons in the nucleus). This isotope of carbon is called *Carbon-12*. Some of the carbon found in nature is heavier, due to the presence of an extra neutron. This type of carbon is called *Carbon-13*, and has 6 protons and 7 neutrons. The periodic table entry for carbon has an atomic mass of 12.011. Since this number is so close to 12, we can assume that most of the carbon found in nature is *Carbon-12*. How does a scientist calculate an average atomic mass? Well, let's consider the following problem.

A family contains the following four people. Find the average weight of the family members.

			
100 pounds	100 pounds	100 pounds	104 pounds

Traditionally, a math student will do this problem by adding up all four of the weights and then dividing by 4, the number of people in the family. This will get the correct answer, which is 101 pounds:

$$\frac{100 + 100 + 100 + 104}{4} = 101$$

Here's another way of looking at this question:

3 out of 4 people in the family are 100 pounds. 3 out of 4 is 75% of the family.
1 out of 4 people in the family are 104 pounds. 1 out of 4 is 25% of the family.

$$\begin{array}{rcrcl} 75\% \times 100 \text{ pounds} & = & 7500 & & \\ +\ 25\% \times 104 \text{ pounds} & = & +\ 2600 & & \\ \hline 100\% \times \text{Average weight} & = & 10100 & = & 100\% \times \underline{101 \text{ pounds}} \end{array}$$

By multiplying each percentage by the appropriate weight, and then adding them all up, we can determine what the average of 100% of the family members will be.

The first method is not useful for calculating average atomic mass because we don't have the necessary variables. You will find the second method to be far more convenient and effective when you are trying to find the average atomic mass. Remember to make sure that all percentages add up to 100%.

NAME: ____

Beanium Lab Preparation: Section 5.3 Continued.

1. Look at the table below, how is the mass of the most abundant element related to the average atomic mass?

Name	**Symbol**	**Natural percent abundance**	**Mass (amu)**	**"Average atomic mass.**
hydrogen	$^{1}_{1}H$	**99.985%**	**1.0078**	**1.0079 amu**
	$^{2}_{1}H$	**0.015 %**	**2.0141**	
	$^{3}_{1}H$	**aprox. 0**	**3.0160**	
Helium	$^{3}_{2}He$	**0.0001**	**3.0160**	**4.0026 amu**
	$^{3}_{2}He$	**99.9999**	**4.0026**	

2. Calculate the average atomic mass for the elements listed below?

Name	**Symbol**	**Natural percent abundance**	**Mass (amu)**	**"Average atomic mass.**
Carbon	$^{12}_{6}C$	**98.89**	**12.0**	
	$^{13}_{6}C$	**1.11**	**13.0**	
Chlorine	$^{35}_{17}Cl$	**75.77**	**35**	
	$^{37}_{17}Cl$	**24.23**	**37**	

3. The isotope of ________________ was assigned a mass of 12.00 amu. One amu – atomic mass unit is defined as 1/12 the mass of _______________.

4. Boron has two isotopes, Boron-10 and Boron-11. Which is more abundant, given that the atomic mass of boron is 10.81 amu? ________________

5. There are three isotopes of silicon: they have mass numbers of 28, 29, and 30. The atomic mass of silicon is 28.086 amu. Comment on the relative abundances of these three isotopes:

____

6. The element copper has naturally occurring isotopes with mass numbers of 63 and 65. The relative abundance and atomic masses are 69.2% for mass = 62.93 amu, and 30.8% for mass = 64.93 amu. Calculate the average atomic mass for copper. Show work.

7. Caculate the atomic mass of bromine given that the two isotopes have atomic masses and relative abundances of 78.92 amu (50.69%) and 80.92amu (49.31%). Show work.

NAME: ____

Isotopes of Beanium Lab

1. According to the book on page 118, what has a mass spectrometer been used for since the 1920s?____

We will be doing a lab called isotopes of beanium to mimic what the mass spectrometer does for scientists.

PURPOSE: In this lab you will calculate the average mass of the element "Beanium" by taking a sample of this element and taking a weighted average of its four isotopes – *black, red,* _____, and *pinto*.

PROCEDURE:

1. Take a cupful of beans from the mixed pile. This is the random sample.
2. Separate the beans by type.
3. In the meantime, have one person in the group measure and record the mass of each type of bean on the balance.
4. Count and record the number of each type of bean.
5. Calculate the percent abundance of each bean isotope – remember that all percentages must add up to 100%.
6. Finally, calculate the average mass of Beanium. Remember, the weighted average WILL be between the highest and lowest mass on your data table.

SUGGESTED DATA TABLE:

Type of Bean	Isotope #1 Black	Isotope #2 Red	Isotope #3 Pinto	Isotope #4
Qualitative Observations				
Mass of One Bean (g)				
Number of Beans of One Type				

Calculations

Ratio for this type of bean (# / TOTAL #)					Average Atomic Mass of Beanium?
Calculations $\sum$(ratio·mass)					

NAME: ____

<u>Beanium lab continued:</u>

Conclusions:

The mass of the four types of beans were ___________g, ___________g, ___________g, and ____________g. We had ______ black beans out of a total of ______ beans. The percent abundance, calculated here _____________________ was _______________________% black bean. The percent abundance for the red beans was _______%. The percent abundance for the pinto beans was ________%. The percent abundance for the black eyed peas was _________ %. Our average atomic mass for the "element" beanium was ____________________. You will notice that our average atomic mass was between __________g and __________g, as one would expect from an average. We had the greatest % abundance of ____________________, and therefore, our average atomic mass was closest to ________ (the mass of that type of bean).

This lab is a good **model** for finding the average atomic mass because

____

____

___________________. Errors in measurement include _________________

____

____.

Most elements have isotopes, so when you look at the periodic table, the atomic mass is a ______________ average of all of the __________________.

Additional observations or comments?

NAME: ____

Section 5.3 Continued, page 11. _____________________

1. A research team has just discovered a new element called Likhitium. Now, they need to determine the average atomic mass in order to complete an entry for the periodic table. Given the following relative abundances, calculate the average atomic mass of Likhitium.

   Likhitium-138: 44.7% Likhitium-140: 00.5%
   Likhitium-139: 52.3% Likhitium-141: 02.5%

2. Another new element, Thorsonium, has two isotopes. 67.52% of the Thorsonium isotopes have a mass of 256 amu. The rest of the sample is Thorsonium-257. Find the average atomic mass of Thorsonium. (100% - 67.52% = 32.48%)

3. There are four isotopes of lead. Data on their atomic structure can be found in the table. Find the average atomic mass of lead in the space below. Remember that the mass of **protons + neutrons** = mass # **= mass of an isotope**

Isotope	A	B	C	D
Protons	82	82	82	82
Neutrons	122	124	125	126
Percent Abundance	1.37%	26.26%	20.82%	51.55%

4. A new element, Albanesium, has been discovered. 43.2% of all naturally occurring Albanesium has a mass of 292 amu. 46.8% of all Albanesium has a mass of 293 amu. The rest of the Albanesium has a mass of 295 amu. Find the average atomic mass of Albanesium. (hint: all the percentages MUST add up to 100%)

5. There are two naturally occurring isotopes of Beinium, of respective masses 670 and 682. What percentage of a natural sample is of mass 670 if the periodic table entry reads 671.82? (Remember – all percentages have to add up to 100%.)

NAME: ____

<u>Section 5.4 page 13.</u> ____________________

The **periodic table** is an arrangement of all of the elements in the universe. The first periodic table was devised in the 1800s by a Russian chemist named Dimitri Mendeleev. He organized all of the known elements based on what **atomic mass** each one had. The elements in the modern table are organized according to their **atomic number**. There are always two numbers in every entry in the periodic table: the atomic number and the atomic mass.

1. What does the periodic table organize?

2. Why is Dimitri Mendeleev famous?

3. Did Mendeleev organize the periodic table based on atomic mass or atomic number?

4. How is the modern periodic table different?

Begin text review here:

5. How many elements had been discovered by the mid-1800s when Demitri Mendeleev was developing his periodic table?

6. What was Mendeleev able to do because he arranged element in order of increasing atomic _______________, in columns so the elements with the most similar _______________ were side by side? ____-.

7. Were Mendeleevs predictions found to be accurate?

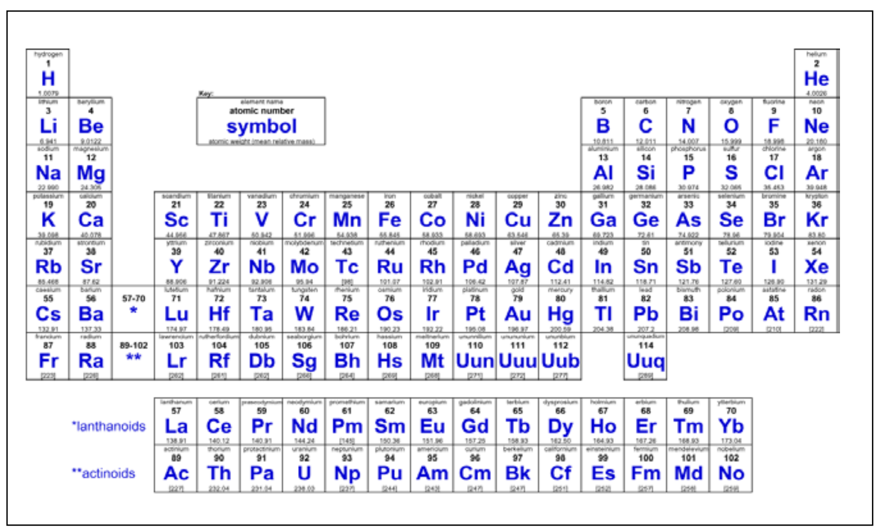
8. Henry Mosely (1887-1915) determined the atomic ___________ of the elements and rearranged the periodic table ____.

9. Whose periodic table is most similar to our current periodic table?

10.What is true about the symbols for the elements? The first letter is ________________, the second is always _________________.

11. Color in the periodic table as follows:

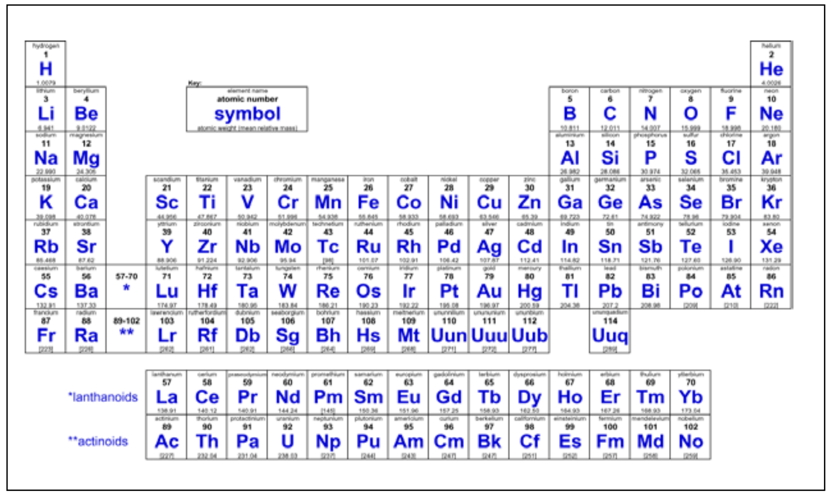
1. Orange: **Alkali metals**
2. yellow: **Alkaline Earth metals**
3. blue ***<u>transition elements</u>*** and ***<u>inner transition metals</u>***.
4. Green: **Other metals**.
5. Pink: **nonmetals** except for noble gases
6. Red: **Noble Gases**



NAME: ____

Section 5.4 page 14. ____________________

The horizontal rows of the modern periodic table are called **periods**. The properties of the elements within a period change as you move across it from element to element. The pattern of properties within a period repeats, however, when you move from one period to the next. This repetition is known as **periodic law**.



Each vertical column of the periodic table is called a **group** or **family**. The elements in any group of the periodic table have similar physical and chemical properties.

1. List the characteristics of metals:

*
*
*
*

2. List the characteristics of nonmetals:

*
*
*
*

Matching: Which type of element is described below:

noble gases, halogens, nonmetals, metalloids, transition metals, inner transition metals, alkaline earth metals, alkali metals	
	1. React vigorously with water, these are soft metals.
	2. React vigorously with acid, these metals are commonly found in rocks, bones, and as cofactors for enzymes.
	3. These metals are shiny, hard, and often are used for jewelry or construction
	4. These are always found as gases. They are very unreactive.
	5. These are NOT conductors of electricity or heat, they are either brittle solids, liquid, or gases. They are dull, lusterless when solid.
	6. These are often man-made and radioactive, some are used in nuclear explosives.
	7. These can behave as metals or non-metals. They are widely used in the semiconductor industry (i.e. they are used in computers and cell phones).

8. Identify these as metal, metalloid, or nonmetal:

a) gold b) silicon c) manganese d) sulfur e) barium

f) uranium g) sodium h) germanium i) phosphorous

9. Name two elements which have properties similar to sodium. __________ and __________.

10. Name two elements which have properties similar to chlorine. _________ and _________.

11. On your periodic table – above, make a dark line around the representative elements.

NAME: ____

Review for TEST

Complete the following passage by filling in the blanks with a term, short phrase, or number. Use your textbook, notes, and periodic table to help you.

Atoms of each element are ________________ from the atoms of all other elements. Dalton theorized that atoms are indivisible, but the discovery of ________________ particles changed this theory. We now know that atoms are made up of electrons, which have a ________________ charge; ________________, which have a positive charge, and ________________, which are neutral. The latter two particles are found in the ________________ of the atom.

It was ________________ who discovered the nucleus of the atom. The nucleus has a ________________ charge and it occupies a very small volume of the atom. In contrast, the negatively charged ________________ occupy most of the volume of the atom.

The number of ________________ in the nucleus of the atom is the atomic ________________ of that element. Because atoms are electrically neutral, the number of protons and ________________ in an atom are equal. The sum of the ________________ and neutrons is the mass number. Atoms of the same element are identical in most respects, but they can differ in the number of ________________ in the nucleus. Atoms that have the same number of protons but different mass numbers are called ________________.

The ________________ of an element is the weighted average of the masses of the isotopes of that element. Two isotopes of sulfur are ^{32}S and ^{34}S. An atom of the sulfur-32 isotope contains _____ protons and _____ neutrons. The sulfur-34 isotope has _____ protons and _____ neutrons.

Each of the three known isotopes of hydrogen has _____ protons in the nucleus. The most common hydrogen isotope has _____ neutrons. It has a mass of _____ amu and is called hydrogen-1.

Complete the following table.

Element	**Symbol**	**Atomic number**	**Mass Number**	**Number of protons**	**Number of Electrons**	**Number of Neutrons**
carbon			**12**		**6**	
	K	**19**				**21**
		12		**12**		**12**
helium		**2**	**4**	**2**		
		5		**5**		**6**

NAME: ____

<u>Review for TEST</u>

1. Given the relative abundance of the following naturally occurring isotopes of oxygen, calculate the average atomic mass of oxygen:

   oxygen-16: 99.760%

   oxygen-17: 0.037%

   oxygen-18: 0.204%

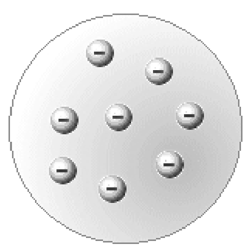
2. In a few sentences, describe the basic structure of an atom, as <u>Rutherford</u> would envision it. ____

____

____

____

3. Dalton, Thomson, and Rutherford had very different models of the atom. In the boxes below, explain what each scientist would think of an atom of oxygen. Also, include a drawing of what each scientist's model of oxygen would look like.

Scientist	Dalton	Thomson	Rutherford
Description	Small, indestructible piece of matter. Identical to every other atom of oxygen. Different from any other type of atom.		
Drawing			

_____________ proposed the existence of the electron.

The number of protons and ____________ in a neutral atom are equal.

NAME: ____

Review for TEST

_____________ are subatomic particles with no charge.

The first modern theory of the atom was proposed by _____________.

___________'s atomic theory states that all atoms are indivisible.

Atoms combine with one another in _____________________ ratios to form compounds.

_____________ used a cathode ray tube to discover the electron.

A neutral subatomic particle is called a ______________.

______________ used gold foil to discover the nuclear atom.

The ___________ number is the number of protons in an atom.

An atom of ____________ has 74 protons.

The atomic mass number is the number of __________ + ___________.

An atom of Beryllium-10 has ______ neutrons.

______________ are atoms that have the same number of protons but different numbers of neutrons.

Forensic chemists use a device called a ______________________ to identify small amounts of unknown materials.

The atomic mass of an element is expressed in __________________________.

2. Given the relative abundance of the following naturally occurring isotopes of Askium, calculate the atomic mass of Askium. Show work.

   Askium-238: 54.7%
   Askium-239: 32.3%
   Askium-245: 11.5%
   Askium-246: rest