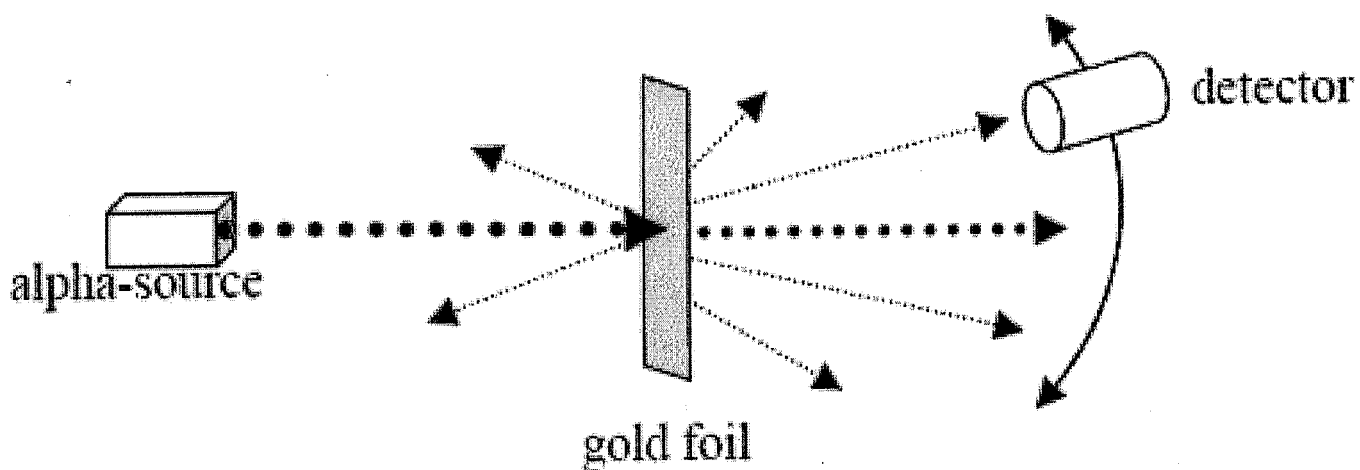
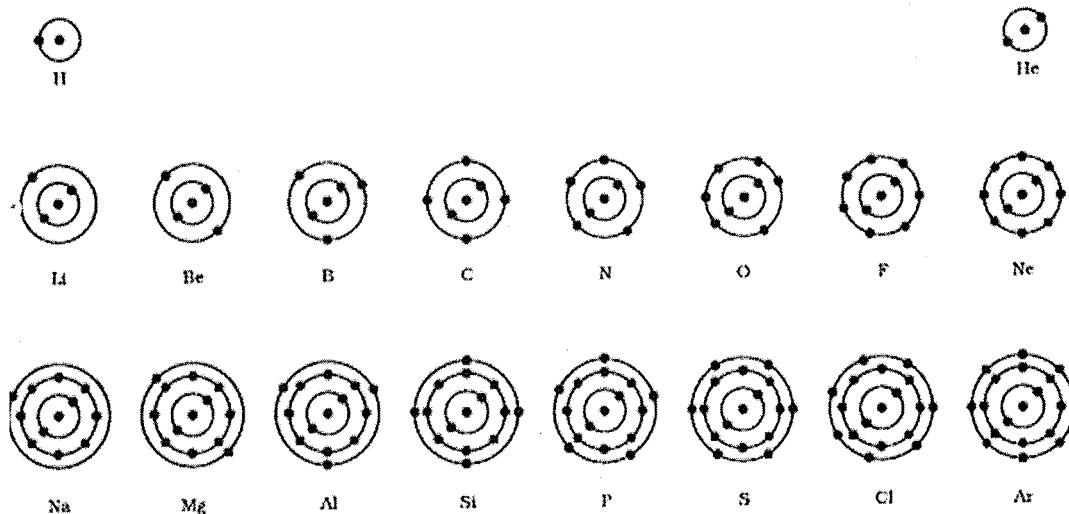


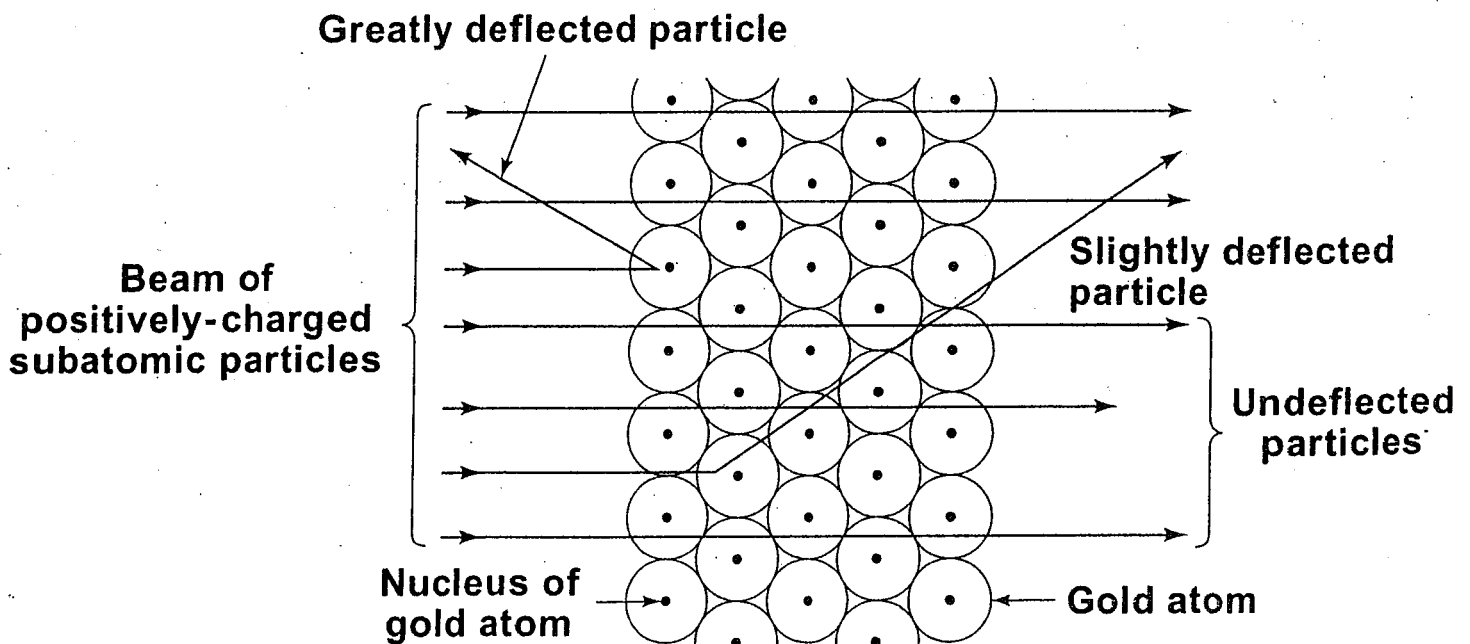
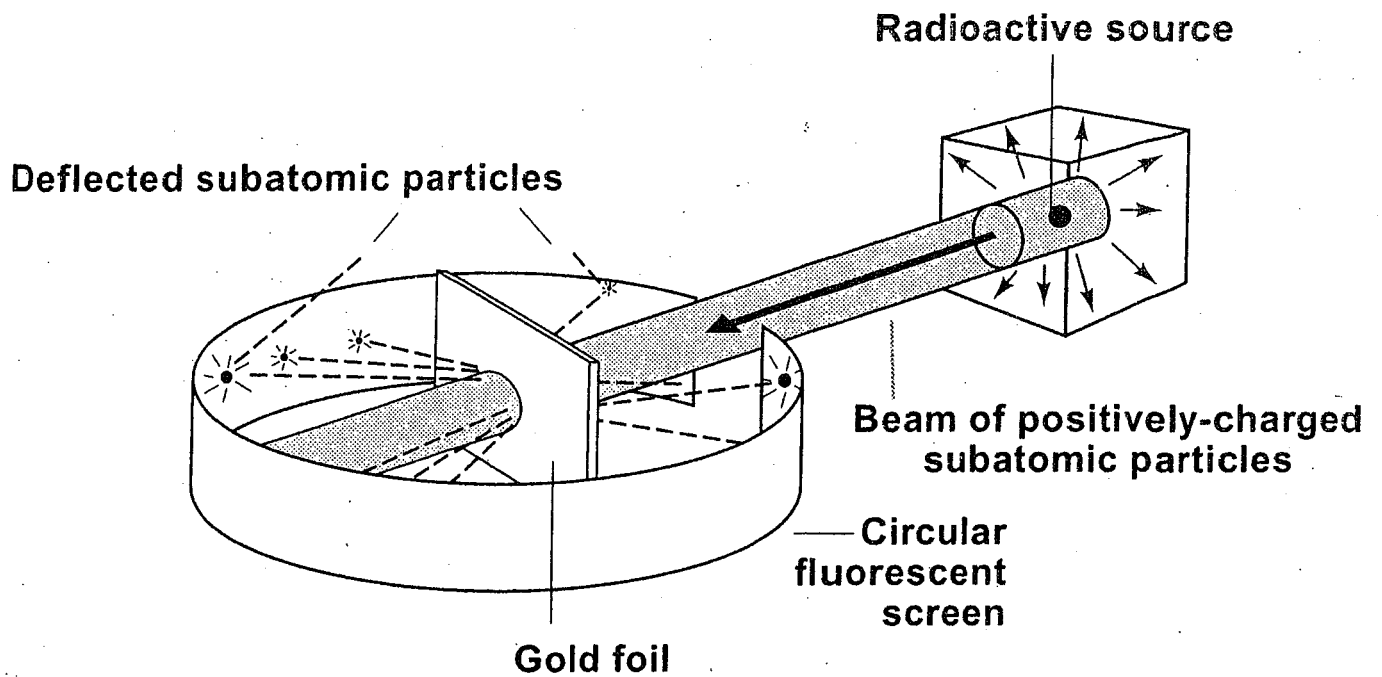
# Unit #3: Atomic Structure



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# 5 RUTHERFORD'S GOLD FOIL EXPERIMENT



1

## Some Key Vocabulary Terms for Atomic Structure Unit

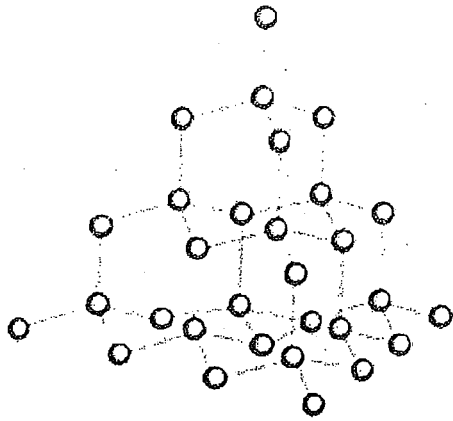
- atom** the smallest particle of an element that can enter into a chemical reaction
- atomic mass** the average mass of all the isotopes in a sample of an element
- atomic mass unit** one-twelfth the mass of a carbon-12 atom
- atomic number** the number of protons in the nucleus of an atom
- compound** a substance composed of two or more elements that are chemically combined in definite proportions by mass
- electron** a fundamental particle of matter having a negative charge
- electron configuration** the distribution of the electrons in an atom
- element** substances that cannot be broken down or decomposed into simpler substances by chemical means
- empirical formula** the simplest integer ratio in which atoms combine to form a compound
- excited state** the condition that exists when the electrons of an atom occupy higher energy levels while lower energy levels are vacant
- formula mass** the sum of the atomic masses of all atoms present
- formula** symbols and subscripts used to represent the composition of a substance
- ground state** the condition of an atom or ion in which the electrons occupy the lowest available energy levels
- heterogeneous** a mixture in which the substances are not uniformly mixed
- homogeneous** a substance in which the particles are uniformly mixed
- isotope** atom of an element that has a specific number of protons and neutrons
- Lewis dot diagram** a diagram that depicts valence electrons as dots around the atomic symbol (representing the nucleus and non-valence electrons) of the element
- mass number** the total number of protons and neutrons in the nucleus of an atom
- mole** the number of atoms of carbon present in 12.000 g of carbon-12
- molecular formula** the actual ratio of the atoms in a molecule
- molecule** the smallest unit of a covalently bonded substance that has the properties of that substance
- neutron** the uncharged particle in the nucleus of an atom
- nucleus** the dense, positively charged central core of an atom
- octet of electrons** the stable valence electron configuration of eight electrons
- orbital** a region in an atom in which an electron of a particular amount of energy is most likely to be located
- percentage composition** the composition of a compound as a percentage of each element compared with the total mass of the compound
- positron** particle identical to an electron except that it has a positive charge
- proton** the positively charged particle in the nucleus of an atom
- pure substance** a compound or an element; a material in which the composition is the same throughout
- quantum number** one of a set of four numbers that describes a property of an electron in an atom
- valence electrons** the electrons in the outer energy level of an atom
- wave-mechanical model** the current model of the atom that deals with the wave-particle duality of nature



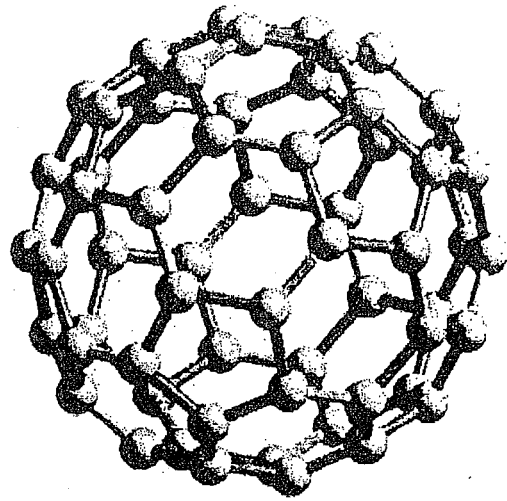
Particle	Symbols	Relative electric charge	Mass number	Relative mass (amu*)	Actual mass (kg)
Electron	$e^{-}$ , ${}_{-1}^0e$	-1	0	0.000 5486	$9.109 \times 10^{-31}$
Proton	$p^{+}$ , ${}_{1}^1H$	+1	1	1.007 276	$1.673 \times 10^{-27}$
Neutron	$n^0$ , ${}_{0}^1n$	0	1	1.008 665	$1.675 \times 10^{-27}$

\*1 amu (atomic mass unit) =  $1.660\ 540 \times 10^{-27}$  kg

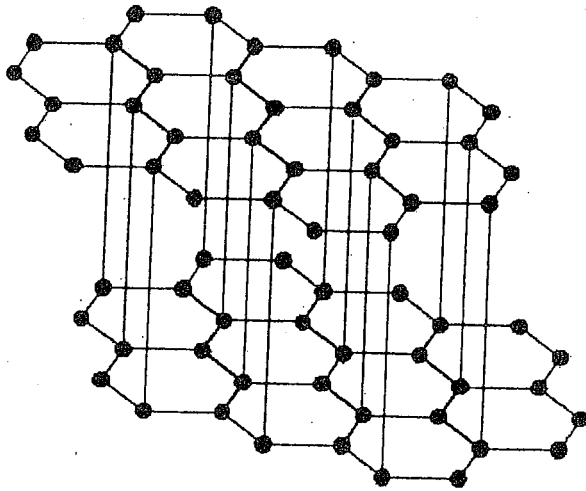
3



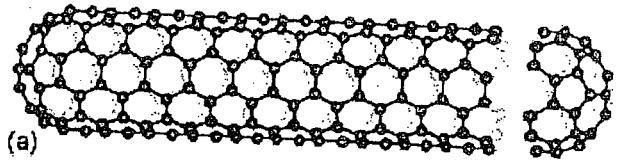
**Diamond**



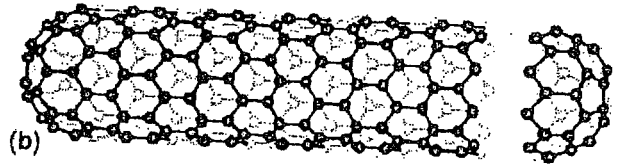
**Buckminsterfullerene**



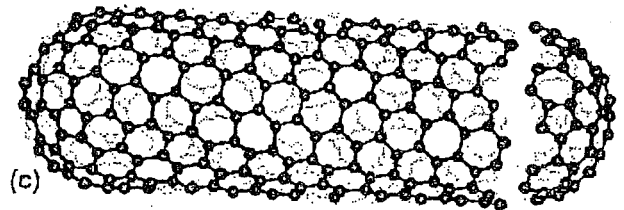
**Graphite**



(a)

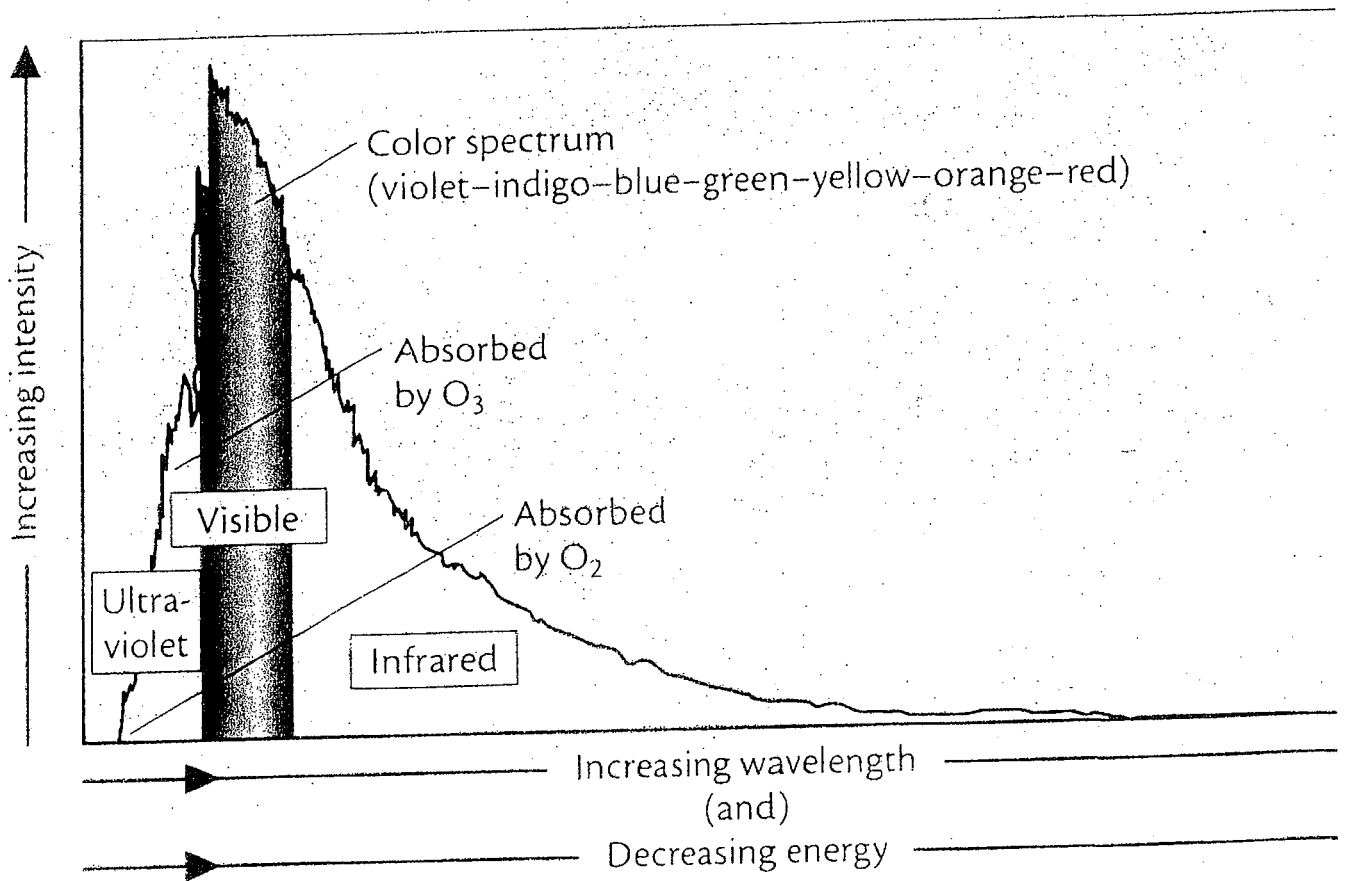
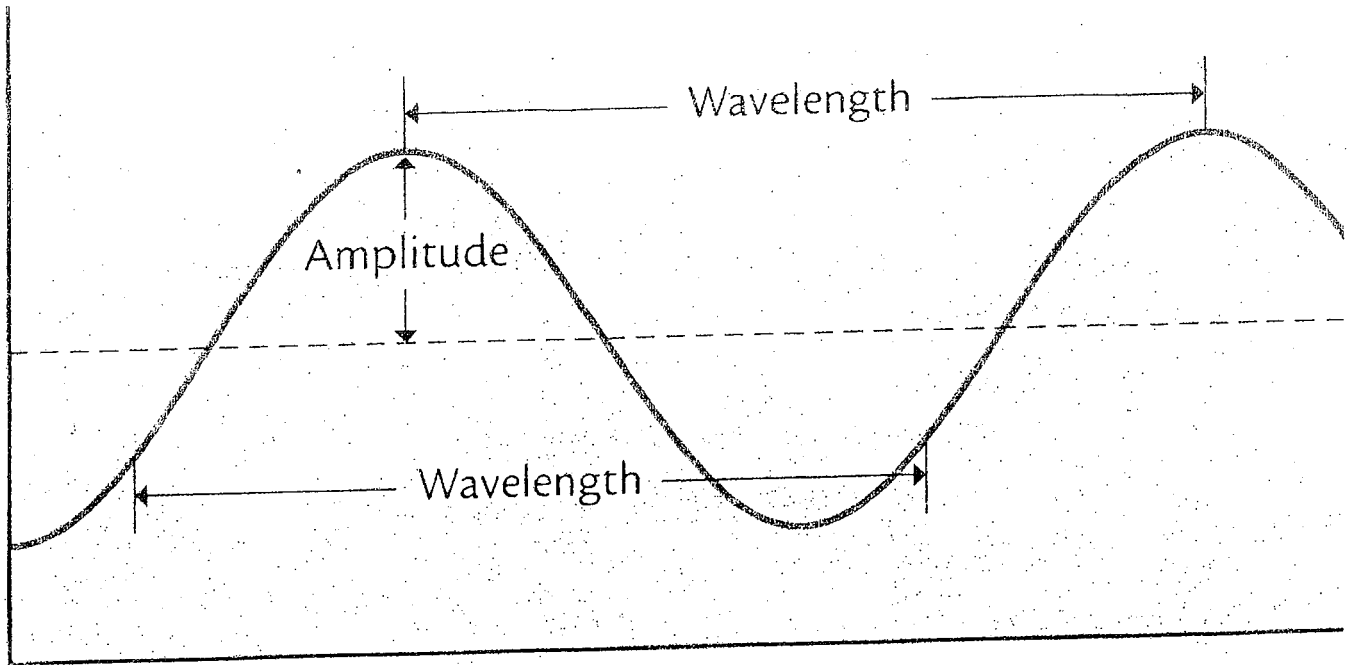


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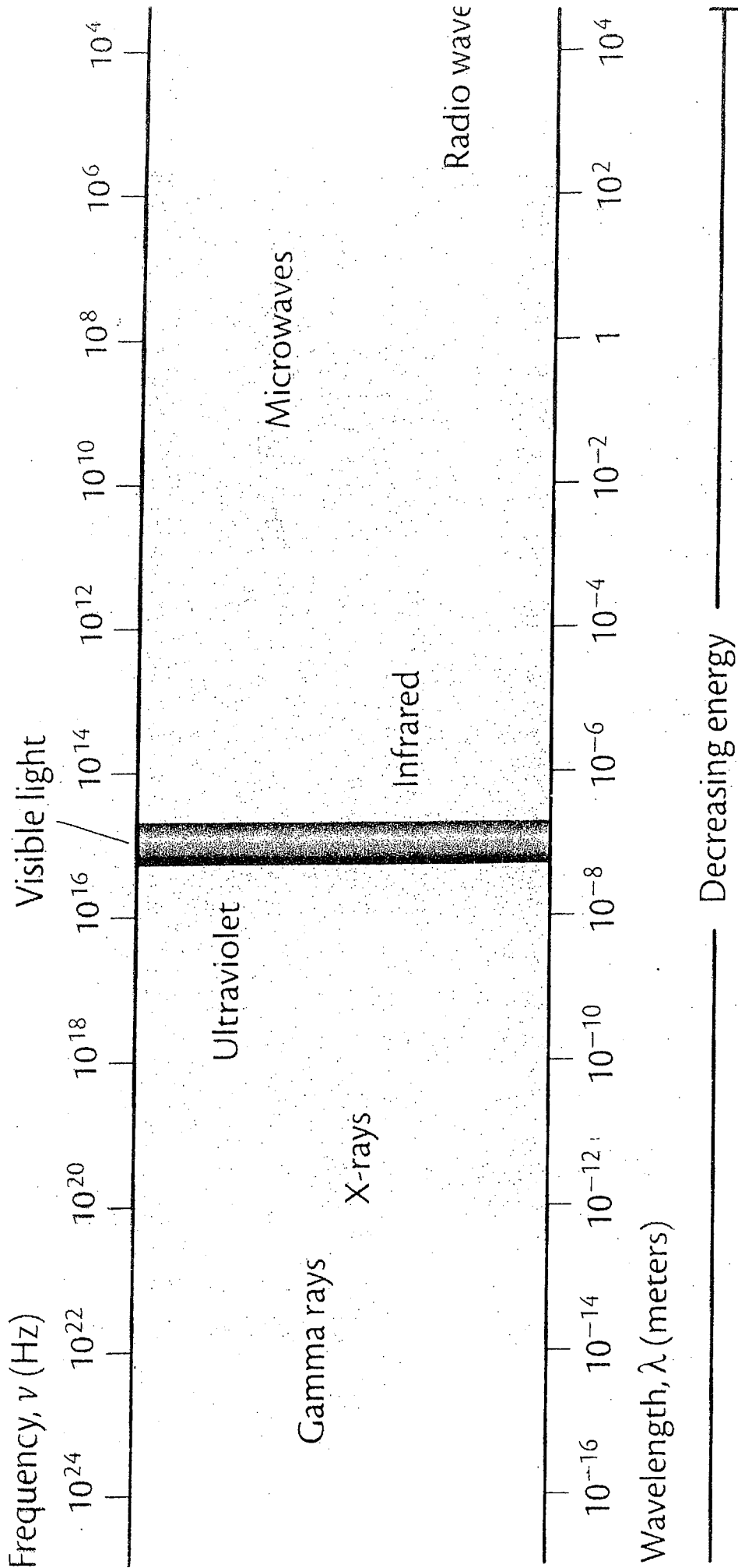


(c)

**Nanotubes**



Figures 4-20 and 4-21, American Chemical Society.



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Figure 4-19, American Chemical Society, CHEMISTRY IN THE COMMUNITY, Fourth Edition ©2001 by Pearson Education, Inc. and Company

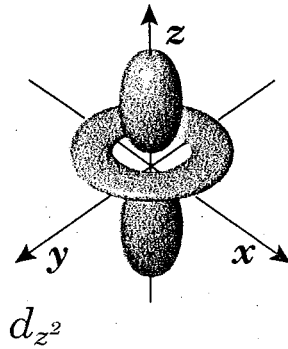
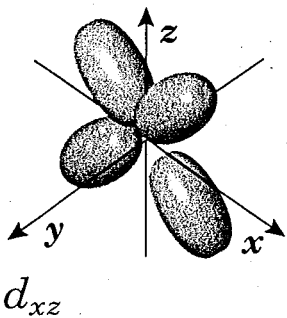
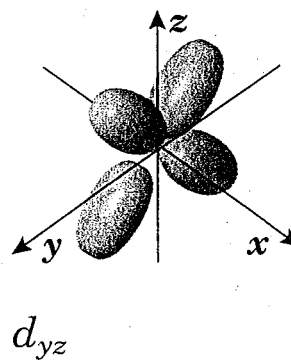
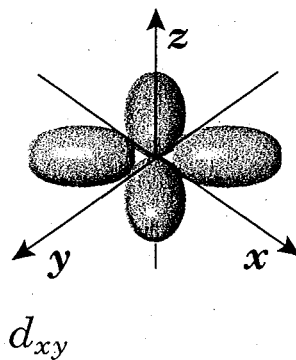
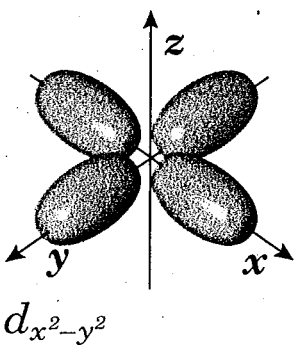
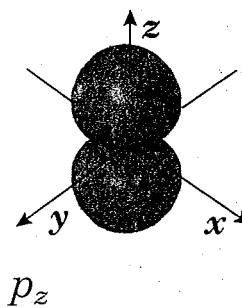
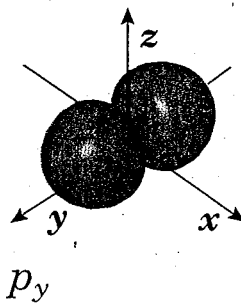
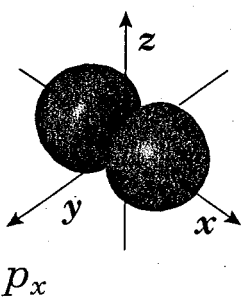
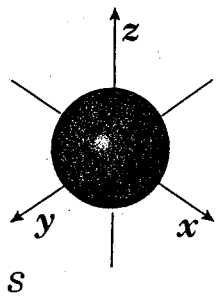


## Electrons Accommodated in Energy Levels and Sublevels

Principal energy level	Sublevels available	Number of orbitals in sublevel ( $2\ell + 1$ )	Number of electrons possible in sublevel [ $2(2\ell + 1)$ ]	Total electrons possible for energy level ( $2n^2$ )
1	<i>s</i>	1	2	2
2	<i>s</i> <i>p</i>	1 3	2 6	8
3	<i>s</i> <i>p</i> <i>d</i>	1 3 5	2 6 10	18
4	<i>s</i> <i>p</i> <i>d</i> <i>f</i>	1 3 5 7	2 6 10 14	32
5	<i>s</i> <i>p</i> <i>d</i> <i>f</i> <i>g</i> *	1 3 5 7 9	2 6 10 14 18	50
6	<i>s</i> <i>p</i> <i>d</i> <i>f</i> * <i>g</i> * <i>h</i> *	1 3 5 7 9 11	2 6 10 14 18 22	72

\*These orbitals are not used in the ground state of any known element.

# Shapes of $s$ , $p$ , and $d$ Orbitals



8

Name \_\_\_\_\_

Common Elements: place the correct symbol next to the element

<u>aluminum</u>	<u>antimony</u>	<u>argon</u>	<u>arsenic</u>	<u>astatine</u>
<u>barium</u>	<u>beryllium</u>	<u>bismuth</u>	<u>boron</u>	<u>bromine</u>
<u>cadmium</u>	<u>calcium</u>	<u>carbon</u>	<u>cesium</u>	<u>chlorine</u>
<u>chromium</u>	<u>copper</u>	<u>deuterium</u>	<u>fluorine</u>	<u>francium</u>
<u>germanium</u>	<u>gold</u>	<u>helium</u>	<u>hydrogen</u>	<u>iodine</u>
<u>iron</u>	<u>krypton</u>	<u>lead</u>	<u>lithium</u>	<u>magnesium</u>
<u>manganese</u>	<u>mercury</u>	<u>neon</u>	<u>nickel</u>	<u>nitrogen</u>
<u>oxygen</u>	<u>phosphorus</u>	<u>platinum</u>	<u>potassium</u>	<u>radium</u>
<u>radon</u>	<u>rubidium</u>	<u>silicon</u>	<u>silver</u>	<u>sodium</u>
<u>strontium</u>	<u>sulfur</u>	<u>tin</u>	<u>titanium</u>	<u>tritium</u>
<u>tungsten</u>	<u>uranium</u>	<u>xenon</u>	<u>zinc</u>	

Place the correct element name next to its symbol

He  
Li  
Be  
B  
C  
N  
O  
F  
Ne

Na  
Mg  
Al  
Si  
P  
S  
Cl  
Ar  
K

Ca  
Sc  
Ti  
V  
Cr  
Mn  
Fe  
Co  
Ni

9

Name \_\_\_\_\_

Element/Symbol Quiz

Give the name for the element symbol in the space provided

1) C

\_\_\_\_\_

2) S

\_\_\_\_\_

3) K

\_\_\_\_\_

4) P

\_\_\_\_\_

5) U

\_\_\_\_\_

6) Hg

\_\_\_\_\_

7) He

\_\_\_\_\_

8) Cl

\_\_\_\_\_

9) Ne

\_\_\_\_\_

10) Au

\_\_\_\_\_

Give the symbol for the element name in the space provided

1) Lead=

\_\_\_\_\_

2) Nickel=

\_\_\_\_\_

3) Bromine=

\_\_\_\_\_

4) Cobalt=

\_\_\_\_\_

5) Copper=

\_\_\_\_\_

6) Aluminum=

\_\_\_\_\_

7) Iron=

\_\_\_\_\_

8) Magnesium=

\_\_\_\_\_

9) Manganese=

\_\_\_\_\_

10) Zinc=

\_\_\_\_\_

BONUS: 1) Which 2 elements from the list above make up the penny? \_\_\_\_\_ and \_\_\_\_\_

2) Name the band that played at the fair this summer that has one of the above elements in its name. \_\_\_\_\_

10

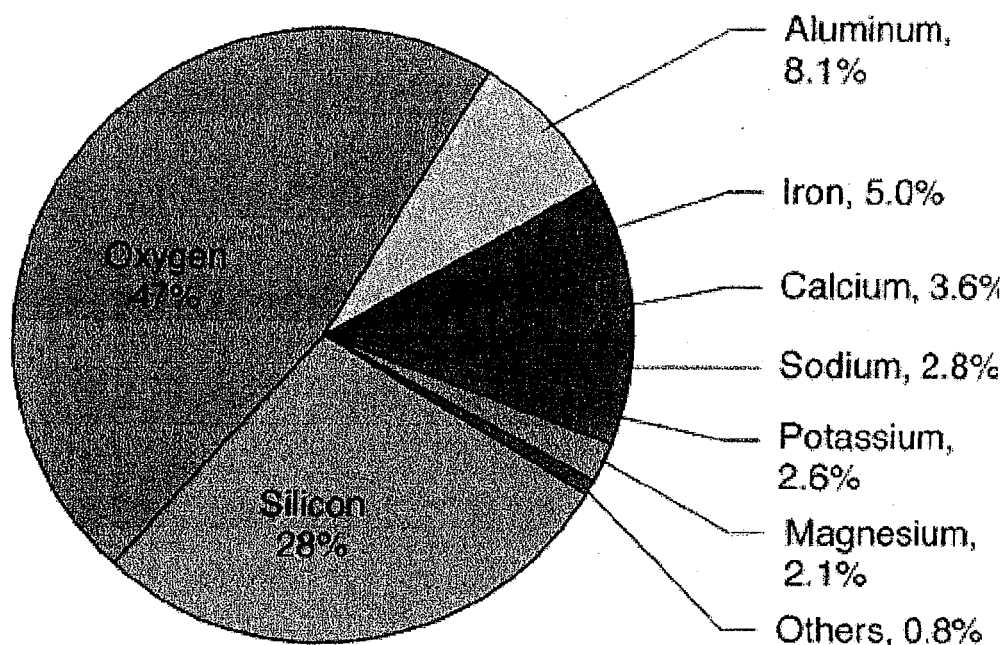
What is made of the following elements ?

1. Oxygen (65%)
2. Carbon (18%)
3. Hydrogen (10%)
4. Nitrogen (3%)
5. Calcium (1.5%)
6. Phosphorus (1.0%)
7. Potassium (0.35%)
8. Sulfur (0.25%)
9. Sodium (0.15%)
10. Magnesium (0.05%)
11. Copper, Zinc, Selenium, Molybdenum, Fluorine, Chlorine, Iodine, Manganese, Cobalt, Iron (0.70%)
12. Lithium, Strontium, Aluminum, Silicon, Lead, Vanadium, Arsenic, Bromine (trace amounts)

Reference: H. A. Harper, V. W. Rodwell, P. A. Mayes, *Review of Physiological Chemistry*, 16th ed., Lange Medical Publications, Los Altos, California 1977.

Most of the human body is made up of water, H<sub>2</sub>O, with cells consisting of 65-90% water by weight. Therefore, it isn't surprising that most of a human body's mass is oxygen. Carbon, the basic unit for organic molecules, comes in second. 99% of the mass of the human body is made up of just six elements: oxygen, carbon, hydrogen, nitrogen, calcium, and phosphorus.

Elements in the earth's crust



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The "nuclear notation" of an atom includes both the atomic number and the mass number of the atom. The atom's symbol is written with its mass number expressed as a superscript at the upper-left location and the atomic number written as a subscript at the lower-left location. For example:

Nuclear notation of sodium -23:  ${}_{11}^{23}\text{Na}$  means mass number = 23 and atomic number = 11

Here are a couple of others:

hydrogen-1:  ${}_1^1\text{H}$  means 1 proton and 0 neutrons in the nucleus  
(atomic number = 1, and mass number = 1)

hydrogen-1:  ${}_1^2\text{H}$  means 1 proton and 1 neutron in the nucleus  
(atomic number = 1, mass number = 2)

**Problem 1.** For practice, determine the number of electrons, protons, and neutrons in the atoms of aluminum and cesium listed below.

a. aluminum-27;  ${}_{13}^{27}\text{Al}$  protons: \_\_\_\_\_ electrons: \_\_\_\_\_ neutrons: \_\_\_\_\_

b. cesium-133;  ${}_{55}^{133}\text{Cs}$  protons: \_\_\_\_\_ electrons: \_\_\_\_\_ neutrons: \_\_\_\_\_

**Problem 2.** The element uranium has three different isotopes. In the blanks below, write the number of electrons, protons, and neutrons for each isotope of uranium.

a.  ${}_{92}^{234}\text{U}$  protons: \_\_\_\_\_ electrons: \_\_\_\_\_ neutrons: \_\_\_\_\_

b.  ${}_{92}^{235}\text{U}$  protons: \_\_\_\_\_ electrons: \_\_\_\_\_ neutrons: \_\_\_\_\_

c.  ${}_{92}^{238}\text{U}$  protons: \_\_\_\_\_ electrons: \_\_\_\_\_ neutrons: \_\_\_\_\_

**Problem 3.** Supply the missing information in the table below.

Isotope	Nuclear Notation	At.No.	Mass No.	No. e's	No. p's	No. n's
a. aluminum-27		_____	_____	_____	_____	_____
b. bismuth-209		_____	_____	_____	_____	_____
c. calcium-40		_____	_____	_____	_____	_____
d. copper-64		_____	_____	_____	_____	_____
e. _____		<u>2</u>	<u>4</u>	_____	_____	_____
f. _____		_____	<u>207</u>	<u>82</u>	_____	_____
g. _____		<u>8</u>	_____	_____	_____	<u>8</u>
h. _____		_____	_____	_____	<u>50</u>	<u>69</u>
i. _____		_____	_____	<u>30</u>	_____	<u>36</u>

Name \_\_\_\_\_

Element/Symbol Quiz

Give the name for the element symbol in the space provided

- 1) C \_\_\_\_\_
- 2) S \_\_\_\_\_
- 3) K \_\_\_\_\_
- 4) P \_\_\_\_\_
- 5) U \_\_\_\_\_
- 6) Hg \_\_\_\_\_
- 7) He \_\_\_\_\_
- 8) Cl \_\_\_\_\_
- 9) Ne \_\_\_\_\_
- 10) Au \_\_\_\_\_

Give the symbol for the element name in the space provided

- 1) Lead= \_\_\_\_\_
- 2) Nickel= \_\_\_\_\_
- 3) Bromine= \_\_\_\_\_
- 4) Cobalt= \_\_\_\_\_
- 5) Copper= \_\_\_\_\_
- 6) Aluminum= \_\_\_\_\_
- 7) Iron= \_\_\_\_\_
- 8) Magnesium= \_\_\_\_\_
- 9) Manganese= \_\_\_\_\_
- 10) Zinc= \_\_\_\_\_

BONUS: 1) Which 2 elements from the list above make up the penny? \_\_\_\_\_ and \_\_\_\_\_

2) Name the band that played at the fair this summer that has one of the above elements in its name. \_\_\_\_\_

Name \_\_\_\_\_

Unit 2A

What are the Mass Numbers of the following elements: (this is the atomic mass rounded to the nearest whole number based on the most abundant isotope)

Ex. Scandium (Sc) = 45amu (as 44.955 will be rounded up)

- 1) Lithium (Li) =
- 2) Phosphorous (P) =
- 3) Cobalt (Co) =
- 4) Zirconium (Zr) =
- 5) Rhodium (Rh) =
- 6) Silver (Ag) =
- 7) Platinum (Pt) =
- 8) Lead (Pb) =
- 9) Radon (Rn) =
- 10) Plutonium (Pu) =

PART II: Complete the following table using some of the data you determined above and the notes below

Element	Atomic #	Mass #	#Protons	#Nuetrons	#Electrons
Lithium					
Phosphorous					
Cobalt					
Zirconium					
Rhodium					
Silver					
Platinum					
Lead					
Radon					
Plutonium					

\*The atomic number is equal to the number of protons in an atom

\*A neutral atom will have the same number of electrons as protons

\* The number of neutrons is determined by subtracting the number of protons from the mass number

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## Atomic Structure

Fill in the below table for the following neutral atoms.

Element	Symbol	Atomic Number	Mass Number	Protons	Neutrons	Electrons	Isotope
					19		chlorine-36
		11	24				
			18			8	
			9		5		
			41	18			
		9			10		
	B				6		
		13	28				
neon			22				

Name \_\_\_\_\_

Calculating atomic mass

Be sure to show all your work on this assignment. **Notice: the answers are at the bottom. No credit for no work.**

1. The element boron consists of two isotopes,  $^{10}_5\text{B}$  and  $^{11}_5\text{B}$ . Their masses, based on the carbon scale, are 10.01 amu and 11.01 amu, respectively. The isotopic abundance of  $^{10}_5\text{B}$  is 20.0% and the abundance of  $^{11}_5\text{B}$  is 80.0%. What is the atomic mass of boron?

2. A sample of silicon was found to have 3 isotopes Si-28 (27.98 amu), Si- 29 (28.98 amu) and Si-30 (29.97 amu) with the percent abundances of 92.23%, 4.67% and 3.10% respectively. Calculate the atomic mass of this silicon sample.

3. Assume that the element  $_{111}\text{Uuu}$  is synthesized and that the sample contains 25.2%  $^{272}\text{Uuu}$  (271.4 amu), 30.8%  $^{273}\text{Uuu}$  (272.3 amu) and 44.0%  $^{275}\text{Uuo}$  (274.2 amu). Only one isotope has been found to date for Uuu – this example is just made up!) What is the value of the atomic mass for this made up sample?

(16)

4. Gallium is a metallic element found in small lasers used in compact disc players. In a sample of gallium, there is 60.2% of gallium-69 (68.9 amu) atoms and 39.8% of gallium-71 (70.9 amu) atoms. What is the atomic mass of gallium?

5. Magnesium occurs in nature in three isotopic forms: magnesium-24 (23.985 amu, 78.70% abundance), magnesium-25 (24.986 amu, 10.13 % abundance), and magnesium-26 (25.983 amu, 11.17 % abundance). Calculate the atomic mass of magnesium from this data.



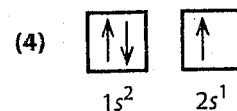
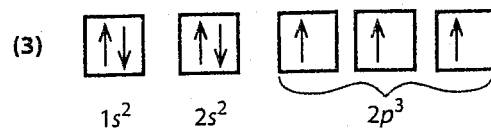
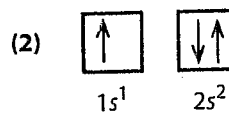
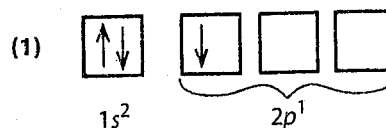
## Review Questions

- The concept that matter is composed of tiny, discrete particles is generally attributed to the (1) Greeks (2) Romans (3) English (4) Germans
- The first subatomic particle discovered was the (1) proton (2) neutron (3) electron (4) photon
- According to the law of the conservation of mass, if the products of a reaction have a mass of 64.0 g, then the total mass of the reactants (1) must be less than 64.0 g (2) must be equal to 64.0 g (3) must be more than 64.0 g (4) is not related to the mass of the products
- The gold-foil experiment led scientists to conclude that an atom's (1) positive charge is evenly distributed throughout its volume (2) negative charge is mainly concentrated in its nucleus (3) mass is evenly distributed throughout its volume (4) volume is mainly unoccupied
- The model of the atom that pictured the atom with electrons stuck randomly throughout the mass of the atom was called the (1) cannonball model (2) plum pudding model (3) planetary model (4) wave-mechanical model
- After bombarding a gold foil sheet with alpha particles, scientists concluded that atoms mainly consist of (1) electrons (2) empty space (3) protons (4) neutrons
- Experimental evidence indicates that the nucleus of an atom (1) contains most of the mass of the atom (2) contains a small percentage of the mass of the atom (3) has no charge (4) has a negative charge
- Dalton's atomic theory states that (1) all atoms of an element are positively charged (2) different elements can have the same mass (3) atoms of a given element must be identical (4) all the atoms in a compound are identical
- Modern theory pictures an electron as (1) a particle only (2) a wave only (3) both a particle and a wave (4) neither a particle nor a wave
- What are the major differences between the plum pudding and planetary models of the atom?
- Why did Rutherford conclude that the atom was mostly empty space?
- What is a major difference between the Rutherford and the wave-mechanical models of the atom?
- The atomic mass of an element is defined as the weighted average mass of that element's (1) most abundant isotope (2) least abundant isotope (3) naturally occurring isotopes (4) radioactive isotopes
- Element X has two isotopes. If 72.0% of the element has an isotopic mass of 84.9 amu and 28.0% has an isotopic mass of 87.0 amu, the average atomic mass of element X is numerically equal to (1)  $(72.0 + 98.9)(28.0 + 87.0)$  (2)  $(72.0 - 84.9)(28.0 - 87.0)$  (3)  $(0.720)(84.9) + (0.280)(87.0)$  (4)  $(72.0)(84.9) + (28.0)(87.0)$
- A neutral atom with 6 electrons and 8 neutrons is an isotope of (1) carbon (2) silicon (3) nitrogen (4) oxygen
- The average isotopic mass of chlorine is 35.5 amu. Which mixture of isotopes (shown as percents) produces this mass? (1) 50% C-12 and 50% C-13 (2) 50% Cl-35 and 50% Cl-37 (3) 75% Cl-35 and 25% Cl-37 (4) 75% C-12 and 25% C-13
- The major portion of an atom's mass consists of (1) electrons and protons (2) electrons and neutrons (3) neutrons and positrons (4) neutrons and protons
- Which atoms have the same number of neutrons? (1) H-1 and He-3 (2) H-2 and He-4 (3) H-3 and He-3 (4) H-3 and He-4
- Atoms of  $^{16}\text{O}$ ,  $^{17}\text{O}$  and  $^{18}\text{O}$  have the same number of (1) neutrons but a different number of protons (2) protons but a different number of neutrons (3) protons but a different number of electrons (4) electrons but a different number of protons
- A neutron has approximately the same mass as (1) an alpha particle (2) a beta particle (3) an electron (4) a proton
- The total number of protons and neutrons in the nuclide  $^{35}_{17}\text{Cl}$  is (1) 52 (2) 35 (3) 18 (4) 17
- The nuclides  $^{14}_6\text{C}$  and  $^{14}_7\text{N}$  are similar in that they both have the same (1) mass number (2) atomic number (3) number of neutrons (4) nuclear charge
- What is the nuclear charge of an atom with a mass of 23 and an atomic number of 11? (1) 11+ (2) 12+ (3) 23+ (4) 34+
- Compared to the charge and mass of a proton, an electron has (1) the same charge and a smaller mass (2) the same charge and the same mass (3) an opposite charge and a smaller mass (4) an opposite charge and the same mass

25. Which of the following statements is correct?  
 (1) A proton is positively charged; a neutron is negatively charged. (2) A proton is negatively charged; a neutron is positively charged. (3) A proton is positively charged; an electron is negatively charged. (4) A proton is negatively charged; an electron is positively charged.
26. Which symbols represent atoms that are isotopes of each other? (1)  $^{14}\text{C}$  and  $^{14}\text{N}$  (2)  $^{16}\text{O}$  and  $^{18}\text{O}$  (3)  $^{131}\text{I}$  and  $^{131}\text{I}$  (4)  $^{222}\text{Rn}$  and  $^{222}\text{Ra}$
27. When electrons in an excited state fall to lower energy levels, energy is (1) absorbed (2) released (3) neither absorbed nor released (4) both released and absorbed

The Atom 7

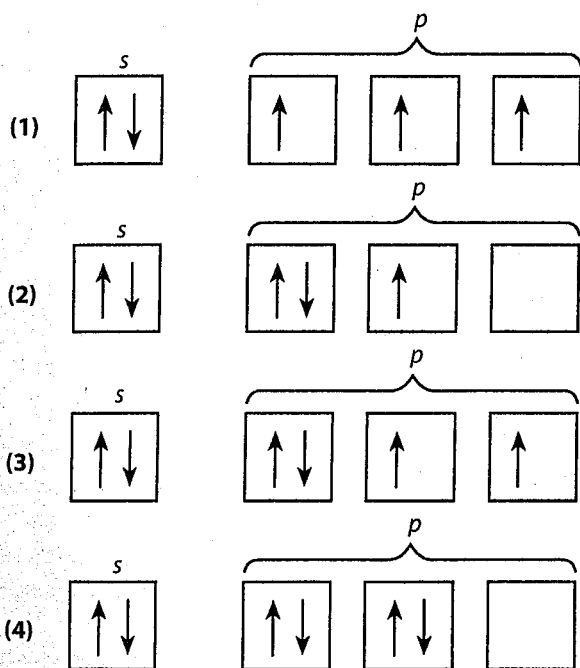
37. Which is the electron configuration of an atom in the excited state? (1)  $1s^2 2s^2 2p^2$  (2)  $1s^2 2s^2 2p^1$  (3)  $1s^2 2s^2 2p^5 3s^2$  (4)  $1s^2 2s^2 2p^6 3s^1$
38. Which atom in the ground state contains one completely filled  $p$  orbital? (1) Ne (2) O (3) He (4) Be
39. What is the total number of electrons in the second principal energy level of a calcium atom in the ground state? (1) 6 (2) 2 (3) 8 (4) 18
40. Which is the correct orbital notation of a lithium atom in the ground state?



41. The atom of which element in the ground state has two unpaired electrons in the  $2p$  sublevel?  
 (1) fluorine (2) nitrogen (3) beryllium (4) carbon
42. What is the total number of occupied  $s$  orbitals in an atom of nickel in the ground state? (1) 1 (2) 2 (3) 3 (4) 4

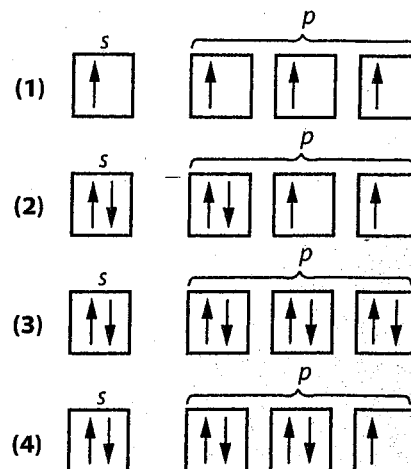
19

43. Which atom in the ground state has only three electrons in the  $3p$  sublevel? (1) phosphorus (2) potassium (3) argon (4) aluminum
44. What is the total number of occupied principal energy levels in a neutral atom of neon in the ground state? (1) 1 (2) 2 (3) 3 (4) 4
45. Which is the electron configuration of an atom in the excited state? (1)  $1s^1 2s^1$  (2)  $1s^2 2s^1$  (3)  $1s^2 2s^2 2p^1$  (4)  $1s^2 2s^2 2p^2$
46. Which orbital notation correctly represents the outermost principal energy level of a nitrogen atom in the ground state?



47. Which electron configuration represents a potassium atom in the excited state? (1)  $1s^2 2s^2 2p^6 3s^2 3p^3$  (2)  $1s^2 2s^2 2p^6 3s^1 3p^4$  (3)  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$  (4)  $1s^2 2s^2 2p^6 3s^2 3p^5 4s^2$
48. In an atom of lithium in the ground state, what is the total number of orbitals that contain only one electron? (1) 1 (2) 2 (3) 3 (4) 4
49. What is the total number of completely filled principal energy levels in an atom of argon in the ground state? (1) 1 (2) 2 (3) 3 (4) 4
50. What is the total number of electrons needed to completely fill all the orbitals in an atom's second principal energy level? (1) 16 (2) 2 (3) 8 (4) 4
51. An atom in the excited state can have an electron configuration of (1)  $1s^2 2s^2$  (2)  $1s^2 2p^1$  (3)  $1s^2 2s^2 2p^5$  (4)  $1s^2 2s^2 2p^6$

52. What is the total number of sublevels in the fourth principal energy level? (1) 1 (2) 2 (3) 3 (4) 4
53. Which electron configuration represents an atom in the excited state? (1)  $1s^2 2s^2 2p^6 3s^2$  (2)  $1s^2 2s^2 2p^6 3s^1$  (3)  $1s^2 2s^2 2p^6$  (4)  $1s^2 2s^2 2p^5 3s^2$
54. Which element has atoms in the ground state with a sublevel that is only half filled? (1) helium (2) beryllium (3) nitrogen (4) neon
55. Which sublevel contains a total of five orbitals? (1)  $s$  (2)  $p$  (3)  $d$  (4)  $f$
56. What is the maximum number of electrons that can occupy the fourth principal energy level of an atom? (1) 6 (2) 8 (3) 18 (4) 32
57. What is the total number of unpaired electrons in an atom of oxygen in the ground state? (1) 6 (2) 2 (3) 8 (4) 4
58. Which of the following sublevels has the highest energy? (1)  $2p$  (2)  $2s$  (3)  $3p$  (4)  $3s$
59. What is the maximum number of electrons in an orbital of any atom? (1) 1 (2) 2 (3) 6 (4) 10
60. What is the electron configuration of a Mn atom in the ground state? (1)  $1s^2 2s^2 2p^6 3s^2$  (2)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2$  (3)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1 4p^1$  (4)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7$
61. Which orbital notation correctly represents a noble gas in the ground state?



62. Which atom in the ground state has three half-filled orbitals? (1) P (2) Si (3) Al (4) Li
63. What is the total number of completely filled sublevels found in an atom of krypton in the ground state? (1) 10 (2) 2 (3) 8 (4) 4

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Atomic Structure problems

1) Describe what happens when an atom goes into the excited state.

2) If 75% of an isotope has a mass of 35.0 amu, and 25% of the isotope has a mass of 37.0 amu, what is the average atomic mass of this element?

3) Complete the following for Cesium

Symbol	Bohr configuration	Atomic mass	Most abundant isotope	Protons	Neutrons	Electrons	Nuclear Notation

4) Describe Rutherford's gold foil experiment.

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Name \_\_\_\_\_

Lewis Structure Practice

Complete Lewis structures of the following elements in the boxes provided.

1) Boron

9) Bromine

2) Phosphorous

10) Tin

3) Silicon

11) Radon

4) Iodine

12) Oxygen

5) Argon

13) Gold

6) Sulfur

14) Sodium

7) Aluminum

15) Barium

8) Nitrogen



## STUDENT VIEWING GUIDE

## The Atom

Write the answer in the space provided.

1. Scientists view objects that are too small to see with the naked eye by using \_\_\_\_.
2. Like charges \_\_\_\_.
3. A neutral atom has \_\_\_\_ numbers of positive protons and negative electrons.
4. In the Rutherford experiment positively charged particles were deflected because they approached the \_\_\_\_.
5. Subatomic particles that are found in the nucleus of the atom are \_\_\_\_ and \_\_\_\_.
6. The fuzzy cloud in the video graphic represents the space around the nucleus occupied by the \_\_\_\_.
7. The nucleus is \_\_\_\_ times smaller than the atom.
8. The source of most of the lead in the atmosphere is \_\_\_\_.
9. List two ways that knowledge of the atom is applied in the real world.
10. The scanning tunneling microscope shows images of the \_\_\_\_.

Name \_\_\_\_\_

# History of Fireworks

## NOVA Activity **Fireworks!**

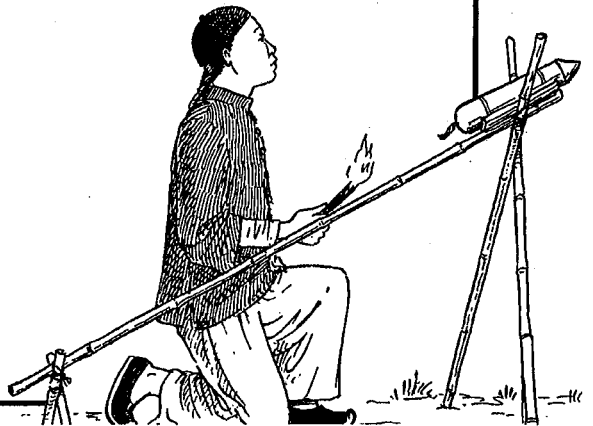
Fireworks have been around for more than 1,000 years, and have been used and thought about in many different ways during that time. In this activity, find out some of the ways that fireworks have evolved.

### Procedure

- ① As you watch the program, take notes on your assigned group topic.
- ② After watching, discuss your notes with your other group members. Once you do additional research, work with other members to create a summary page of all your findings.

Notes

- ①
- ②
- ③
- ④
- ⑤
- ⑥
- ⑦
- ⑧
- ⑨
- ⑩



Name: \_\_\_\_\_

~~Reagent~~ Chemistry

Quiz: Atomic Structure

- 1) Write the number of protons, the number of neutrons, and the number of electrons for each of the elements listed below.
- a) Sodium-23
  - b) Carbon-12
  - c) Boron-11
  - d) Oxygen-16
  - e) Oxygen-18
  - f) Phosphours-31
  - g) Silver-108
  - h) Iron-56
  - i) Iron-58
  - j) Argon-38

- 2) Write the nuclear notation for each of the following elements.

Element	Nuclear Notation	Number of Protons	Number of Neutrons	Number of Electrons
S		16	20	16
Ne		10	12	10
Mg		12	13	12
Ni		28	32	28
Cl		17	20	17
K		19	20	19

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- 3) A certain element exists as three natural isotopes as shown in the table below.

Isotope	Mass (amu)	% abundance	Mass number
1	19.99244	90.51	20
2	20.99395	0.27	21
3	21.99138	9.22	22

Calculate the average atomic mass of the element.

- 4) An element consists of two isotopes. Isotope A has an abundance of 75% and its mass is 14.00 atomic mass units. Isotope B has an abundance of 25% and its mass is 15.00 atomic mass units. What is the atomic mass of the element?

- 5) Element A exists in three isotope forms. The isotope mixture consists of 10.0%  $^{22}\text{X}$ , 20.0%  $^{23}\text{X}$ , and 70.0%  $^{24}\text{X}$ . What is the atomic mass of this element?

- 6) If 75% of an isotope has a mass of 35.0 atomic mass units, and 25% of an isotope has a mass of 37.0 atomic mass units, what is the atomic mass of this element?

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Name: \_\_\_\_\_

Regents Chemistry

**Worksheet: Atomic Structure**

1) Describe Rutherford's gold foil experiment. Explain the significance of his findings.

2) Be able to complete the following chart:

Principal energy level (n)	Sublevels	# orbitals per sublevel	# electrons per sublevel	# electrons per principal energy level $2n^2$
1				
2				
3				
4				

3) Energy is released when an electron moves in which direction?

- a) higher energy to lower energy sublevel
- b) lower energy to higher energy sublevel

4) From the following nuclear notation  $^{32}_{15}\text{P}$ , determine the mass number, atomic #, number of protons, number of electrons, and number of neutrons.

5) Which particle in the atom has the least mass? What is this mass?  
Which particle in the atom has the greatest mass? What is this mass?

6) a) Define isotope.

b) Calculate the average atomic mass for various isotopes.

Ex. Calculate the average atomic mass of the following element.

Isotope	Mass (amu)	% Abundance	Mass #
1	19.99244	90.51	20
2	20.99395	0.27	21
3	21.99138	9.22	22

7) All atomic mass units on the periodic table are compared to the atomic mass of what atom?



Atomic Structure Review Sheet

Name \_\_\_\_\_

- 1) Calculate the average atomic mass for Boron given the following data for the isotopes of Boron.

<u>Isotope</u>	<u>abundance</u>	<u>isotopic mass (amu)</u>
Boron-10	19.78%	10.013
Boron-11	80.22%	11.009

- 2) What is the number 11 in boron-11?

- 3) Complete the following table:

Element	Symbol	Number of protons	Number of electrons	Mass number	Number of neutrons
Molybdenum				96	
	Kr				48
		14		28	
	Hg <sup>+</sup>				121
	Cu <sup>+</sup>			64	

- 4) Complete the following table:

Principal energy level	Maximum number of electrons
1	
2	
3	
4	
5	

- 5) 1 amu is equal to 1/12 of the mass of an atom of which element?
- 6) Compare the masses and charges of protons, neutrons and electrons.

10) Explain why elements have characteristic bright line spectra. Use the terms "energy level" and "excited state" in your answer.

11) Define quanta

12) Give the Lewis electron dot diagram for the following:

Be

Si

Se

Br

13) Indicate if the following elements with the associated electron configurations are in the ground state or an excited state.

Br 2-8-7

P 2-8-5

K 2-8-7-2

O 2-5-1

14) Draw a Bohr diagram for the following :

$^{35}\text{Cl}^-$

$^{59}\text{Ni}^{2+}$

30



Name \_\_\_\_\_

**Part I: Complete the following chart**

<u>Particle</u>	<u>Charge</u>	<u>Relative atomic mass</u>
Proton		
Neutron		
Electron		

**Part II: Determine the average atomic mass of Mercury. Show all work for each part of the equation. HINT → remember to use  $\sum(\% \text{ abundance})(\text{Mass Number})$**

**Isotopes of the Element Mercury with a Known Natural Abundance**

Mass Number	Natural Abundance
196	0.15%
198	9.97%
199	16.87%
200	23.10%
201	13.18%
202	29.86%
204	6.87%

Answer \_\_\_\_\_

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Over please

**Part III: Match the appropriate term on the left with the definitions below.**

- \_\_\_\_\_ 1) Atom
- \_\_\_\_\_ 2) electron configuration
- \_\_\_\_\_ 3) isotope
- \_\_\_\_\_ 4) mass number
- \_\_\_\_\_ 5) orbital

- A) atom of an element that has a specific number of protons and neutrons
- B) the smallest particle of an element that can enter into a chemical reaction
- C) region in an atom in which an electron of a particular amount of energy is most likely to be located
- D) the distribution of the electrons in an atom
- E) the total number of protons and neutrons in the nucleus of an atom

**Part IV: Complete the following**

<u>Isotope</u>	<u>Protons</u>	<u>Neutrons</u>	<u>Nuclear Notation</u>
Iron-56			
Hydrogen-1			
	109		

**Bonus**

- 1) You are in a cold house in the winter. It is dark. You have one match. There is a candle and there is a wood burning stove. Which do you light first? \_\_\_\_\_
- 2) What occurs once in a minute, twice in a moment and never in a thousand years? \_\_\_\_\_
- 3) What grows down when it grows up? \_\_\_\_\_

- 1) An element consists of three isotopes. 42% are X-18, 22% are X-19 and 36% are X-20.  
a. What is the average atomic weight of this element?

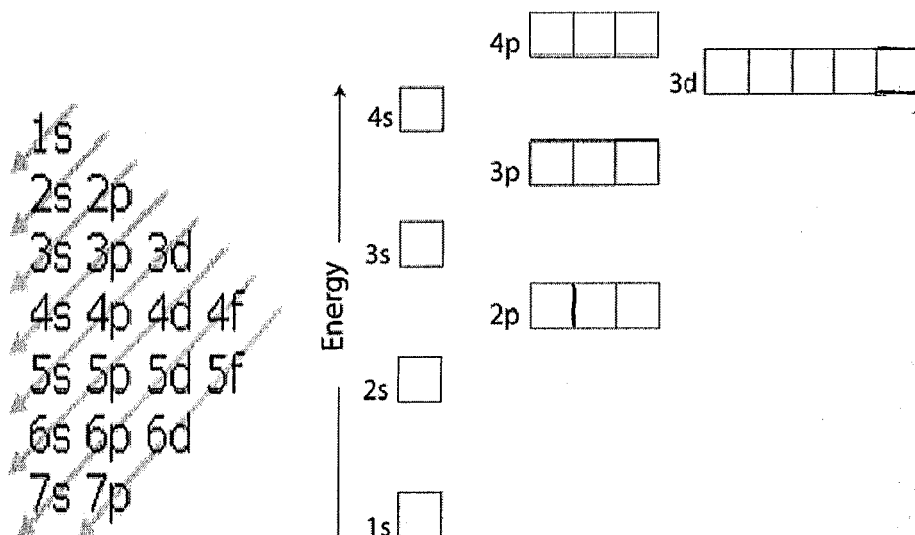
b. What element could this possibly represent?

- 2) Draw a Bohr model of nitrogen

- 3) For the element Chromium:

a. list the electron configuration notation using s/p/d following the diagonal rule

b. Show orbital filling with arrows as necessary. Some may not be used.



- 4) Draw a Lewis structure for Sulfur.

- 5) Make a table and compare the mass/charge of the parts of an atom.

**Phases of Matter and Atomic Structure Quiz****Multiple Choice**

Identify the choice that best completes the statement or answers the question.

- \_\_\_\_\_ 1. The smallest particle of an element that retains the properties of that element is a(n) \_\_\_\_\_.  
a. atom b. electron c. proton d. neutron
- \_\_\_\_\_ 2. Which of the following is true about subatomic particles?  
a. Electrons are negatively charged and are the heaviest subatomic particle. b. Protons are positively charged and the lightest subatomic particle. c. Neutrons have no charge and are the lightest subatomic particle. d. The mass of a neutron nearly equals the mass of a proton.
- \_\_\_\_\_ 3. All atoms are \_\_\_\_\_.  
a. positively charged, with the number of protons exceeding the number of electrons b. negatively charged, with the number of electrons exceeding the number of protons c. neutral, with the number of protons equaling the number of electrons d. neutral, with the number of protons equaling the number of electrons, which is equal to the number of neutrons
- \_\_\_\_\_ 4. The particles that are found in the nucleus of an atom are \_\_\_\_\_.  
a. neutrons and electrons b. electrons only c. protons and neutrons d. protons and electrons
- \_\_\_\_\_ 5. As a consequence of the discovery of the nucleus by Rutherford, which model of the atom is thought to be true?  
a. Protons, electrons, and neutrons are evenly distributed throughout the volume of the atom. b. The nucleus is made of protons, electrons, and neutrons. c. Electrons are distributed around the nucleus and occupy almost all the volume of the atom. d. The nucleus is made of electrons and protons.
- \_\_\_\_\_ 6. The atomic number of an element is the total number of which particles in the nucleus?  
a. neutrons b. protons c. electrons d. protons and electrons
- \_\_\_\_\_ 7. The sum of the protons and neutrons in an atom equals the \_\_\_\_\_.  
a. atomic number b. nucleus number c. atomic mass d. mass number
- \_\_\_\_\_ 8. All atoms of the same element have the same \_\_\_\_\_.  
a. number of neutrons b. number of protons c. mass numbers d. mass
- \_\_\_\_\_ 9. Isotopes of the same element have different \_\_\_\_\_.  
a. numbers of neutrons b. numbers of protons c. numbers of electrons d. atomic numbers
- \_\_\_\_\_ 10. How many protons, electrons, and neutrons does an atom with atomic number 50 and mass number 125 contain?  
a. 50 protons, 50 electrons, 75 neutrons b. 75 electrons, 50 protons, 50 neutrons c. 120 neutrons, 50 protons, 75 electrons d. 70 neutrons, 75 protons, 50 electrons
- \_\_\_\_\_ 11. If E is the symbol for an element, which two of the following symbols represent isotopes of the same element?  
1.  ${}^{20}_{10}\text{E}$                       2.  ${}^{20}_{11}\text{E}$                       3.  ${}^{21}_9\text{E}$                       4.  ${}^{21}_{10}\text{E}$
- a. 1 and 2 b. 3 and 4 c. 1 and 4 d. 2 and 3

- \_\_\_\_\_ 12. How is the number of neutrons in the nucleus of an atom calculated?  
a. Add the number of electrons and protons together. b. Subtract the number of electrons from the number of protons. c. Subtract the number of protons from the mass number. d. Add the mass number to the number of electrons.
- \_\_\_\_\_ 13. What is one standard atmosphere of pressure in kilopascals?  
a. 0 kPa b. 760 kPa c. 101.3 kPa d. 1 kPa
- \_\_\_\_\_ 14. The average kinetic energy of the particles of a substance \_\_\_\_\_.  
a. is not affected by the temperature of the substance b. increases as the temperature of the substance is lowered c. is directly proportional to the temperature of the substance d. is equal to the total energy absorbed by the substance
- \_\_\_\_\_ 15. The direct change of a substance from a solid to a gas is called \_\_\_\_\_.  
a. evaporation b. sublimation c. condensation d. solidification
- \_\_\_\_\_ 16. If a balloon is squeezed, what happens to the pressure of the gas inside the balloon?  
a. It increases. b. It stays the same. c. It decreases. d. The pressure depends on the type of gas in the balloon.
- \_\_\_\_\_ 17. When the Kelvin temperature of an enclosed gas doubles, the particles of the gas \_\_\_\_\_.  
a. move faster b. strike the walls of the container with less force c. decrease in average kinetic energy d. decrease in volume
- \_\_\_\_\_ 18. Boyle's law states that \_\_\_\_\_.  
a. the volume of a gas varies inversely with pressure b. the volume of a gas varies directly with pressure c. the temperature of a gas varies inversely with pressure d. the temperature of a gas varies directly with pressure
- \_\_\_\_\_ 19. Charles's law states that \_\_\_\_\_.  
a. the pressure of a gas is inversely proportional to its temperature in kelvins b. the volume of a gas is directly proportional to its temperature in kelvins c. the pressure of a gas is directly proportional to its temperature in kelvins d. the volume of a gas is inversely proportional to its temperature in kelvins
- \_\_\_\_\_ 20. A gas occupies a volume of 2.4 L at 14.1 kPa. What volume will the gas occupy at 84.6 kPa?  
a. 497 L b. 2.5 L c. 14 L d. 0.40 L
- \_\_\_\_\_ 21. A sample of gas occupies 17 mL at  $-112^{\circ}\text{C}$ . What volume does the sample occupy at  $70^{\circ}\text{C}$ ?  
a. 10.6 mL b. 27 mL c. 36 mL d. 8.0 mL
- \_\_\_\_\_ 22. The tendency of molecules to move toward areas of lower concentration is called \_\_\_\_\_.  
a. suffusion b. suspension c. effusion d. diffusion
- \_\_\_\_\_ 23. Which of the following statements is NOT true?  
a. Protons have a positive charge. b. Electrons are negatively charged and have a mass of 1 amu. c. The nucleus of an atom is positively charged. d. Neutrons are located in the nucleus of an atom.
- \_\_\_\_\_ 24. In Bohr's model of the atom, where are the electrons and protons located?  
a. The electrons move around the protons, which are at the center of the atom. b. The electrons and protons move throughout the atom. c. The electrons occupy fixed positions around the protons, which are at the center of the atom. d. The electrons and protons are located throughout the atom, but they are not free to move.

**Atomic Structure****Matching: place the answers for questions 1-28 on the scan tron sheet***Match each item with the correct statement below.*

- |            |             |
|------------|-------------|
| a. proton  | d. electron |
| b. nucleus | e. neutron  |
| c. atom    |             |

- \_\_\_\_\_ 1. the smallest particle of an element that retains the properties of that element  
\_\_\_\_\_ 2. a positively charged subatomic particle  
\_\_\_\_\_ 3. a negatively charged subatomic particle  
\_\_\_\_\_ 4. a subatomic particle with no charge

*Match each item with the correct statement below.*

- |                     |                |
|---------------------|----------------|
| a. mass number      | d. atomic mass |
| b. atomic mass unit | e. isotope     |
| c. atomic number    |                |

- \_\_\_\_\_ 5. atoms with the same number of protons, but different numbers of neutrons in the nucleus of an atom  
\_\_\_\_\_ 6. the total number of protons and neutrons in the nucleus of an atom  
\_\_\_\_\_ 7. the number of protons in the nucleus of an element  
\_\_\_\_\_ 8. the weighted average of the masses of the isotopes of an element

**Multiple Choice***Identify the letter of the choice that best completes the statement or answers the question.*

- \_\_\_\_\_ 9. Which of the following is NOT a part of Dalton's atomic theory?  
a. All elements are composed of atoms. b. Atoms are always in motion. c. Atoms of the same element are identical. d. Atoms that combine do so in simple whole-number ratios.
- \_\_\_\_\_ 10. Dalton hypothesized that atoms are indivisible and that all atoms of an element are identical. It is now known that \_\_\_\_\_.  
a. all of Dalton's hypotheses are correct b. atoms of an element can have different numbers of protons  
c. atoms are divisible d. all atoms of an element are not identical but they must all have the same mass
- \_\_\_\_\_ 11. Which of the following is true about subatomic particles?  
a. Electrons are negatively charged and are the heaviest subatomic particle. b. Protons are positively charged and the lightest subatomic particle. c. Neutrons have no charge and are the lightest subatomic particle. d. The mass of a neutron nearly equals the mass of a proton.
- \_\_\_\_\_ 12. All atoms are \_\_\_\_\_.  
a. positively charged, with the number of protons exceeding the number of electrons b. negatively charged, with the number of electrons exceeding the number of protons c. neutral, with the number of protons equaling the number of electrons d. neutral, with the number of protons equaling the number of electrons, which is equal to the number of neutrons

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Name: \_\_\_\_\_

ID: A

- \_\_\_\_\_ 13. As a consequence of the discovery of the nucleus by Rutherford, which model of the atom is thought to be true?  
a. Protons, electrons, and neutrons are evenly distributed throughout the volume of the atom. b. The nucleus is made of protons, electrons, and neutrons. c. Electrons are distributed around the nucleus and occupy almost all the volume of the atom. d. The nucleus is made of electrons and protons.
- \_\_\_\_\_ 14. An element has an atomic number of 76. The number of protons and electrons in a neutral atom of the element are \_\_\_\_\_.  
a. 152 protons and 76 electrons b. 76 protons and 0 electrons c. 38 protons and 38 electrons d. 76 protons and 76 electrons
- \_\_\_\_\_ 15. The sum of the protons and neutrons in an atom equals the \_\_\_\_\_.  
a. atomic number b. nucleus number c. atomic mass d. mass number
- \_\_\_\_\_ 16. What does the number 84 in the name krypton-84 represent?  
a. the atomic number b. the mass number c. the sum of the protons and electrons d. twice the number of protons
- \_\_\_\_\_ 17. All atoms of the same element have the same \_\_\_\_\_.  
a. number of neutrons b. number of protons c. mass numbers d. mass
- \_\_\_\_\_ 18. Isotopes of the same element have different \_\_\_\_\_.  
a. numbers of neutrons b. numbers of protons c. numbers of electrons d. atomic numbers
- \_\_\_\_\_ 19. In which of the following sets is the symbol of the element, the number of protons, and the number of electrons given correctly?  
a. In, 49 protons, 49 electrons b. Zn, 30 protons, 60 electrons c. Cs, 55 protons, 132.9 electrons d. F, 19 protons, 19 electrons
- \_\_\_\_\_ 20. How many protons, electrons, and neutrons does an atom with atomic number 50 and mass number 125 contain?  
a. 50 protons, 50 electrons, 75 neutrons b. 75 electrons, 50 protons, 50 neutrons c. 120 neutrons, 50 protons, 75 electrons d. 70 neutrons, 75 protons, 50 electrons
- \_\_\_\_\_ 21. If E is the symbol for an element, which two of the following symbols represent isotopes of the same element?  
1.  ${}_{10}^{20}\text{E}$                       2.  ${}_{11}^{20}\text{E}$                       3.  ${}_{9}^{21}\text{E}$                       4.  ${}_{10}^{21}\text{E}$   
a. 1 and 2 b. 3 and 4 c. 1 and 4 d. 2 and 3
- \_\_\_\_\_ 22. How is the number of neutrons in the nucleus of an atom calculated?  
a. Add the number of electrons and protons together. b. Subtract the number of electrons from the number of protons. c. Subtract the number of protons from the mass number. d. Add the mass number to the number of electrons.
- \_\_\_\_\_ 23. What unit is used to measure weighted average atomic mass?  
a. amu b. gram c. angstrom d. nanogram
- \_\_\_\_\_ 24. Which of the following statements is NOT true?  
a. Protons have a positive charge. b. Electrons are negatively charged and have a mass of 1 amu. c. The nucleus of an atom is positively charged. d. Neutrons are located in the nucleus of an atom.

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Name: \_\_\_\_\_

ID: A

- \_\_\_\_\_ 25. The atomic mass of an element depends upon the \_\_\_\_\_.  
a. mass of each electron in that element b. mass of each isotope of that element c. relative abundance of protons in that element d. mass and relative abundance of each isotope of that element
- \_\_\_\_\_ 26. How does the energy of an electron change when the electron moves closer to the nucleus?  
a. It decreases. b. It increases. c. It stays the same. d. It doubles.
- \_\_\_\_\_ 27. Emission of light from an atom occurs when an electron \_\_\_\_\_.  
a. drops from a higher to a lower energy level b. jumps from a lower to a higher energy level c. moves within its atomic orbital d. falls into the nucleus
- \_\_\_\_\_ 28. The quantum mechanical model of the atom \_\_\_\_\_.  
a. defines the exact path of an electron around the nucleus b. was proposed by Niels Bohr c. involves the probability of finding an electron in a certain position d. has many analogies in the visible world

**Short Answer: place all answers for questions 29-40 on this test paper**

29. Chlorine has two naturally occurring isotopes, Cl-35 and Cl-37. The atomic mass of chlorine is 35.45. Which of these two isotopes of chlorine is more abundant?
30. Consider an element Z that has two naturally occurring isotopes with the following percent abundances: the isotope with a mass number of 19.0 is 55.0% abundant; the isotope with a mass number of 21.0 is 45.0% abundant. What is the average atomic mass for element Z?
31. Give the electron configuration for a neutral atom of selenium.
32. A gas occupies a volume of 140 mL at 35.0°C and 97 kPa. What is the volume of the gas at STP?



Name: \_\_\_\_\_

ID: A

### Numeric Response

33. How many protons are present in an atom of Be-9?
34. Determine the number of electrons in an atom of iridium.
35. What is the atomic number for an element with 41 neutrons and a mass number of 80?
36. How many protons are present in the nuclei of the three known isotopes of hydrogen?
37. Calculate the number of neutrons in  $^{210}\text{Pb}$ .
38. What is the total number of subatomic particles in the nucleus of an atom of  $^{209}_{83}\text{Bi}$ ?

### Essay

39. What observations by Rutherford led to the hypothesis that atoms are mostly empty space, and that almost all of the mass of the atom is contained in an atomic nucleus?
40. Explain how the atoms of one element differ from those of another element.

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**Atomic Structure****Matching**

Match each item with the correct statement below.

- |            |             |
|------------|-------------|
| a. proton  | d. electron |
| b. nucleus | e. neutron  |
| c. atom    |             |

- \_\_\_\_\_ 1. the smallest particle of an element that retains the properties of that element
- \_\_\_\_\_ 2. a positively charged subatomic particle
- \_\_\_\_\_ 3. a negatively charged subatomic particle
- \_\_\_\_\_ 4. a subatomic particle with no charge
- \_\_\_\_\_ 5. the central part of an atom, containing protons and neutrons

**Multiple Choice**

Identify the choice that best completes the statement or answers the question.

- \_\_\_\_\_ 6. All atoms are \_\_\_\_\_.  
 a. positively charged, with the number of protons exceeding the number of electrons  
 b. negatively charged, with the number of electrons exceeding the number of protons  
 c. neutral, with the number of protons equaling the number of electrons  
 d. neutral, with the number of protons equaling the number of electrons, which is equal to the number of neutrons
- \_\_\_\_\_ 7. As a consequence of the discovery of the nucleus by Rutherford, which model of the atom is thought to be true?  
 a. Protons, electrons, and neutrons are evenly distributed throughout the volume of the atom.  
 b. The nucleus is made of protons, electrons, and neutrons.  
 c. Electrons are distributed around the nucleus and occupy almost all the volume of the atom.  
 d. The nucleus is made of electrons and protons.
- \_\_\_\_\_ 8. An element has an atomic number of 76. The number of protons and electrons in a neutral atom of the element are \_\_\_\_\_.  
 a. 152 protons and 76 electrons  
 b. 76 protons and 0 electrons  
 c. 38 protons and 38 electrons  
 d. 76 protons and 76 electrons
- \_\_\_\_\_ 9. What does the number 84 in the name krypton-84 represent?  
 a. the atomic number  
 b. the mass number  
 c. the sum of the protons and electrons  
 d. twice the number of protons
- \_\_\_\_\_ 10. All atoms of the same element have the same \_\_\_\_\_.  
 a. number of neutrons  
 b. number of protons  
 c. mass numbers  
 d. mass
- \_\_\_\_\_ 11. Which of the following sets of symbols represents isotopes of the same element?  
 a.  ${}_{42}^{91}\text{J}$   ${}_{42}^{92}\text{J}$   ${}_{40}^{93}\text{J}$  b.  ${}_{19}^{50}\text{L}$   ${}_{20}^{50}\text{L}$   ${}_{21}^{50}\text{L}$  c.  ${}_{38}^{84}\text{M}$   ${}_{38}^{86}\text{M}$   ${}_{38}^{87}\text{M}$  d.  ${}_{59}^{138}\text{Q}$   ${}_{55}^{133}\text{Q}$   ${}_{54}^{133}\text{Q}$

Name: \_\_\_\_\_

ID: A

- \_\_\_\_\_ 12. In Bohr's model of the atom, where are the electrons and protons located?  
a. The electrons move around the protons, which are at the center of the atom. b. The electrons and protons move throughout the atom. c. The electrons occupy fixed positions around the protons, which are at the center of the atom. d. The electrons and protons are located throughout the atom, but they are not free to move.
- \_\_\_\_\_ 13. How does the energy of an electron change when the electron moves closer to the nucleus?  
a. It decreases. b. It increases. c. It stays the same. d. It doubles.
- \_\_\_\_\_ 14. What is the number of electrons in the outermost energy level of an oxygen atom?  
a. 2 b. 4 c. 6 d. 8
- \_\_\_\_\_ 15. Emission of light from an atom occurs when an electron \_\_\_\_\_.  
a. drops from a higher to a lower energy level b. jumps from a lower to a higher energy level c. moves within its atomic orbital d. falls into the nucleus

### Short Answer

16. List the number of protons, neutrons, and electrons in  $^{13}_6\text{C}$ .
17. Consider an element Z that has two naturally occurring isotopes with the following percent abundances: the isotope with a mass number of 19.0 is 55.0% abundant; the isotope with a mass number of 21.0 is 45.0% abundant. What is the average atomic mass for element Z?
18. Give the electron configuration for a neutral atom of selenium.

### Numeric Response

19. What is the relative charge carried by an electron?
20. Draw a Bohr Model and a Lewis structure for Gold

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Name: \_\_\_\_\_

- 1) What Greek philosopher was the first person to propose the idea that matter is made of tiny individual particles called atoms?  
 A) Dalton                                      B) Rutherford                                      C) Democritus                                      D) Bohr
- 2) Experimental evidence indicates that the nucleus of an atom  
 A) has a negative charge                                      C) contains a small percentage of the mass of the atom  
 B) has no charge                                      D) contains most of the mass of the atom
- 3) In an experiment, alpha particles were used to bombard gold foil. As a result of this experiment, the conclusion was made that the nucleus of an atom is  
 A) smaller than the atom and positively charged                                      C) smaller than the atom and negatively charged  
 B) larger than the atom and negatively charged                                      D) larger than the atom and positively charged
- 4) After bombarding a gold foil sheet with alpha particles, scientists concluded that atoms consist mainly of  
 A) neutrons                                      B) protons                                      C) electrons                                      D) empty space
- 5) Which particle has the *least* mass?  
 A) a proton                                      B) a neutron                                      C) an electron                                      D) a deuteron
- 6) What particle has a mass of approximately one atomic mass unit and a unit positive charge?  
 A) a neutron                                      B) an alpha particle                                      C) a proton                                      D) a beta particle
- 7) What particle is electrically neutral?  
 A) proton                                      B) electron                                      C) neutron                                      D) positron
- 8) What particle has approximately the same mass as a proton?  
 A) beta                                      B) electron                                      C) alpha                                      D) neutron
- 9) How many protons are in the nucleus of an atom of beryllium?  
 A) 9                                      B) 2                                      C) 5                                      D) 4
- 10) All atoms of an element have the same  
 A) number of nucleons                                      C) atomic mass  
 B) atomic number                                      D) number of neutrons
- 11) All atoms in a given sample of an element contain the same number of  
 A) nucleons and electrons                                      C) protons and electrons  
 B) protons and neutrons                                      D) nucleons and neutrons
- 12) As the number of neutrons in the nucleus of an atom increases, the nuclear charge of the atom  
 A) remains the same                                      B) decreases                                      C) increases
- 13) Which atom contains exactly 15 protons?  
 A) nitrogen-15                                      B) phosphorus-32                                      C) sulfur-32                                      D) oxygen-15
- 14) The nucleus of an atom consists of 8 protons and 6 neutrons. The total number of electrons present in a neutral atom of this element is  
 A) 14                                      B) 2                                      C) 6                                      D) 8
- 15) What is the symbol for an atom containing 20 protons and 22 neutrons?  
 A)  ${}_{22}^{40}\text{Ti}$                                       B)  ${}_{20}^{42}\text{Ca}$                                       C)  ${}_{22}^{42}\text{Ti}$                                       D)  ${}_{20}^{40}\text{Ca}$
- 16) Compared to an atom of C-12, an atom of C-14 has  
 A) fewer neutrons                                      B) fewer protons                                      C) more neutrons                                      D) more protons
- 17) What is the mass number of the atom below?  
 ${}_{1}^3\text{H}$   
 A) 1                                      B) 2                                      C) 3                                      D) 4

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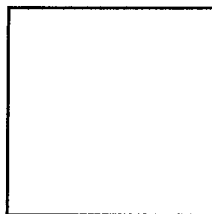
- 18) What is the total number of nucleons (protons and neutrons) in the atom below?



- A) 113                                      B) 45                                      C) 79                                      D) 34
- 19) A sample of element  $X$  contains 90. percent  ${}^{35}X$  atoms, 8.0 percent  ${}^{37}X$  atoms, and 2.0 percent  ${}^{38}X$  atoms. The average isotopic mass is *closest* to
- A) 32                                      B) 35                                      C) 38                                      D) 37
- 20) Which pair of nuclei represent isotopes of the same element?
- A)  $\begin{pmatrix} 5p \\ 6n \end{pmatrix}$  and  $\begin{pmatrix} 7p \\ 6n \end{pmatrix}$                                       C)  $\begin{pmatrix} 1p \\ 2n \end{pmatrix}$  and  $\begin{pmatrix} 2p \\ 1n \end{pmatrix}$
- B)  $\begin{pmatrix} 10p \\ 10n \end{pmatrix}$  and  $\begin{pmatrix} 11p \\ 11n \end{pmatrix}$                                       D)  $\begin{pmatrix} 3p \\ 3n \end{pmatrix}$  and  $\begin{pmatrix} 3p \\ 4n \end{pmatrix}$
- 21) What is the atomic number of an atom with six valence electrons?
- A) 12                                      B) 8                                      C) 10                                      D) 6
- 22) What is the total number of valence electrons in an atom of phosphorus in the ground state?
- A) 5                                      B) 2                                      C) 3                                      D) 7
- 23) An atom has the electron configuration 2-8-7. The electron-dot symbol for this element is
- A)  $\cdot\overset{\cdot}{\underset{\cdot}{\text{X}}}\cdot$                                       B)  $\overset{\cdot}{\underset{\cdot}{\text{X}}}\cdot$                                       C)  $\overset{\cdot}{\text{X}}\cdot$                                       D)  $\text{X}\cdot$
- 24) The characteristic spectral lines of elements are caused when electrons in an excited atom move from
- A) higher to lower energy levels, releasing energy                                      C) lower to higher energy levels, releasing energy
- B) higher to lower energy levels, absorbing energy                                      D) lower to higher energy levels, absorbing energy
- 25) What is the electron configuration of a gold atom in the ground state?
- A) 2-8-18-32-18-1                                      B) 2-8-18-32-18-2                                      C) 2-8-18-31-18-2                                      D) 2-8-18-18-1
- 26) Which electron configuration represents an atom in an excited state?
- A) 2-8-2                                      B) 2-8-1                                      C) 2-7-1                                      D) 2-7
- 27) Which statement correctly describes the charge of the nucleus and the charge of the electron cloud of an atom?
- A) The nucleus is negative and the electron cloud is negative.
- B) The nucleus is negative and the electron cloud is positive.
- C) The nucleus is positive and the electron cloud is negative.
- D) The nucleus is positive and the electron cloud is positive.
- 28) What is the total number of neutrons in an atom of  ${}_{26}^{57}\text{Fe}$ ?
- A) 26                                      B) 31                                      C) 83                                      D) 57

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- 29) The questions below refer to an atom that has 13 protons, 14 neutrons, and 13 electrons.
- (a) What is the atomic number of this atom?
  - (b) What is the mass number of this atom?
  - (c) Write the electron configuration for this atom.
  - (d) Identify the atom.
  - (e) Draw a correct Lewis electron-dot diagram for the atom.



- 30) Find the average mass of a sample of magnesium which contains 78.7% Mg-24, 10.1% Mg-25, and 11.2% Mg-26. [Show all work. Round answer to the nearest hundredth.]

Questions 31 and 32 refer to the following:

The information below describes the proposed discovery of element 118.

In 1999, a nuclear chemist and his team announced they had discovered a new element by crashing krypton atoms into lead. The new element, number 118, was assigned the name ununoctium and the symbol Uuo. One possible isotope of ununoctium could have been Uuo-291.

However, the discovery of Uuo was not confirmed because other scientists could not reproduce the experimental results published by the nuclear chemist and his team. In 2006, another team of scientists claimed that they produced Uuo. This claim has yet to be confirmed.

‡‡Adapted from *Discover*, January 2002

- 31) What would be the total number of neutrons present in a theoretical atom of Uuo-291 described in the reading passage?
- 32) What would be the total number of electrons present in a theoretical atom of Uuo-291 described in the reading passage?
- 33) State, in terms of subatomic particles, how an atom of C-13 is different from an atom of C-12.

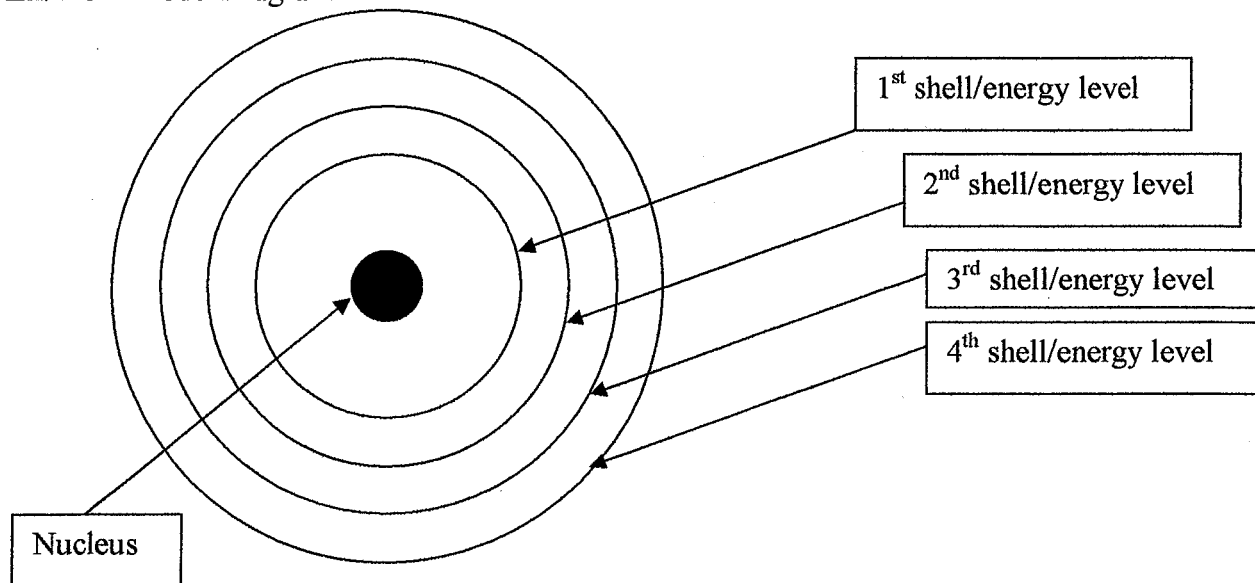
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### Building an Atomic Model from a Bohr Diagram

INTRO: Scientists' perception of the structure of the atom has evolved over a period of many years. Neils Bohr proposed his model of the atom in 1913. Although the quantum mechanical model has replaced the Bohr model as the accepted model of the atoms, Bohr diagrams are useful to show the number and arrangement of electrons in various energy levels. For this lab, you will build a Bohr model for an atom of an element that your instructor assigns. (This will be for a multiple lab grade)

The Bohr model proposed electrons revolving around the nucleus in concentric, circular orbits (also called shells or energy levels), which are numbered from 1 to 7. Each orbit has a unique energy; the lowest energy is associated with the orbit closest to the nucleus and the highest energy with the orbit farthest from the nucleus.

Ex. Bohr Model Diagram



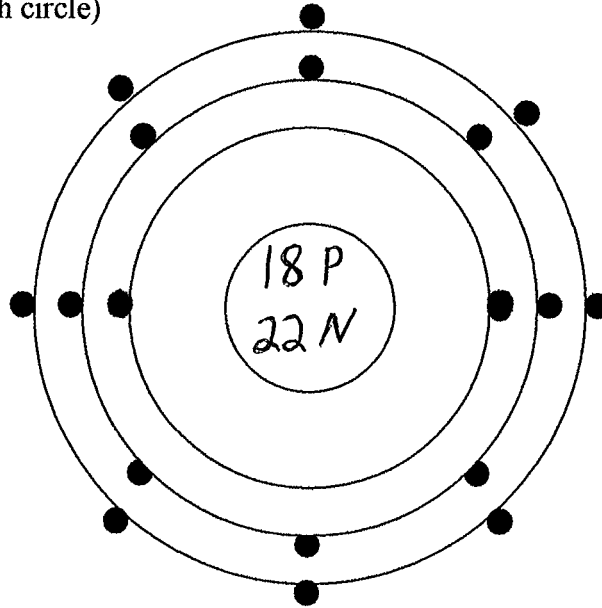
On the Periodic table of your Reference Table, the number of electrons in the principal energy level is listed below the element's atomic number. For instance, Ar, 2-8-8, indicates that there are 2 electrons in the 1<sup>st</sup> (or closest) principal energy level, 8 electrons in the 2<sup>nd</sup> energy level and 8 electrons in the 3<sup>rd</sup> (or outermost) principal energy level. The electrons in the outermost energy level of an atom are called the valence electrons. Argon, therefore has 8 valence electron.

- TASK I) Draw Bohr diagram for the element that was giving to/selected by you  
II) Complete the following pieces of information for your element  
III) Build a 3-Dimensional model of this element  
IV) Present your model to the class

I: Drawing a Bohr Diagram: \*Obtain a compass from the teacher for this exercise\*

1. Draw a center circle representing the nucleus and write the number of protons and neutrons in the center of this circle
2. Draw concentric circles for each occupied energy level.
3. Draw the correct number of electrons in each principal energy level (try to spread them out as evenly as possible for each circle)

Example for Argon:



**Draw Your Bohr Diagram in the space below:**

Element Name \_\_\_\_\_

Electron Configuration \_\_\_\_\_

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## II: Atomic information

1. Element Name \_\_\_\_\_
2. Atomic Symbol \_\_\_\_\_
3. Atomic mass \_\_\_\_\_
4. Mass Number for most abundant isotope  
(Round the atomic mass to the nearest whole number) \_\_\_\_\_
5. Number of Protons \_\_\_\_\_
6. Number of Electrons \_\_\_\_\_
7. Number of Neutrons (for this isotope) \_\_\_\_\_
8. Electron configuration \_\_\_\_\_
9. Number of valence electrons  
(Re-read intro again if necessary) \_\_\_\_\_
10. 2 interesting facts about your element  
\_\_\_\_\_  
\_\_\_\_\_

## III: Build a 3-Dimensional model of this element

Construct a 3-dimensional Bohr model for your assigned element. You may use any non-perishable (non-food etc.) materials that you choose. The dollar store has many things you can use that are inexpensive and easy to obtain, or you may use materials from home. Your model will be graded on creativity and effort as well as the following:

1. Must have the correct number of protons and neutrons in the nucleus
2. Must have the correct number of electrons in the correct energy levels according to the electron configuration on your periodic table
3. Must have a way to distinguish between the different sub-atomic particles (ex. different color beads or materials for the protons, neutrons and electrons)
4. Must have a label including at least the elements name, symbol and atomic number as well as a key to distinguish between protons, neutrons and electrons

## IV: Present your model to the class

You will present your models to the class and will discuss the following information:

1. Element name
2. Symbol
3. Atomic Number
4. Number of protons, neutrons and electrons
5. Number of occupied energy levels
6. Number of valence electrons
7. 2 interesting facts about your element

See the Rubric on the following page to meet model and presentation requirements, if necessary.

Name \_\_\_\_\_

Rubric for Bohr Model Lab: This lab packet and your model must be turned in/ready on the due date in order to not be penalized the 10pts per lab period. Remember this is a multiple lab grade.

I: Drawing of your Bohr diagram for the element that was giving to/selected by you: 15 points \_\_\_\_\_

II: Complete the following pieces of information for your element: 25 points \_\_\_\_\_

III: Model: 50 points

- Correct protons (6) \_\_\_\_\_
- Correct Neutrons (6) \_\_\_\_\_
- Correct electrons in proper energy level (6) \_\_\_\_\_
- Distinguished between sub-atomic particles (6) \_\_\_\_\_
- Label with name, symbol, atomic number and key (6) \_\_\_\_\_
- Effort (used class time wisely/completed outside work) (10) \_\_\_\_\_
- Creativity (goes beyond basic materials and is unique etc.) (10) \_\_\_\_\_

Total for Model \_\_\_\_\_

IV: Presentation of your model to the class: 10 points

The following were stated: (1 point each)

- Element Name \_\_\_\_\_
- Symbol \_\_\_\_\_
- Atomic Number \_\_\_\_\_
- # Protons \_\_\_\_\_
- #Neutrons \_\_\_\_\_
- #Electrons \_\_\_\_\_
- Occupied Energy levels \_\_\_\_\_
- Valence Electrons \_\_\_\_\_
- Interesting Fact #1 \_\_\_\_\_
- Interesting Fact #2 \_\_\_\_\_

Total for Model \_\_\_\_\_

Final Score \_\_\_\_\_

48

## History of Atomic Models

