Chemistry

Unit 2

Atomic Theory & Structure

Name:______________________________ Date:__________ Per:__________

Protons, Neutrons, and Electrons Practice Worksheet

Name of the element	Atomic symbol	Atomic number	Protons	Neutrons	Electrons	Atomic mass
Boron	**B**					
Sodium	**Na**					
Gallium	**Ga**					
Yttrium	**Y**					
Copper	**Cu**					
Technetium	**Tc**					
Lead	**Pb**					
Ytterbium	**Yb**					
Actinium	**Ac**					
Molybdenum	Mo					
Thallium	**Tl**					
Fermium	**Fm**					
Nobelium	No					
Hydrogen	**H**					
carbon	**C**					
Nitrogen	**N**					
Barium	**Ba**					
helium	**He**					
calcium	**Ca**					
silicon	Si					
argon	**Ar**					
magnesium	**Mg**					
Chloride [redacted]	**Cl**					
Seaborgium	**Sg**					

Isotopes Worksheet

1. What is an isotope? ____

____

2. What does the number next to isotopes signify? ______________________

____

3. How can you tell isotopes apart? ______________________________

____

For each of the following isotopes, write the number of protons, neutrons, and electrons.

	Chromium-58	Chromium-63
# of protons		
# of neutrons		
# of electrons		

	Carbon-12	Carbon-14
# of protons		
# of neutrons		
# of electrons		

	Nitrogen-14	Nitrogen-15
# of protons		
# of neutrons		
# of electrons		

	Sulfur-32	Sulfur-35
# of protons		
# of neutrons		
# of electrons		

	Sodium-23	Sodium-20
# of protons		
# of neutrons		
# of electrons		

	Selenium-79	Selenium-85
# of protons		
# of neutrons		
# of electrons		

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Ions and Isotopes worksheet

Complete the following:

1. For each of the following ions, indicate the **total number of protons and electrons in** the ion.

Ion	Number of Protons	Number of Electrons
Co^{+2}		
Co^{+3}		
Cl^{-1}		
K^{+1}		
S^{-2}		
Sr^{+2}		
Al^{+3}		
P^{-3}		

2. For each of the ions listed, identify the total number of electrons for each
   - ____ 1. B^{+3}
   - ____ 2. Fe^{+3}
   - ____ 3. Mg^{-2}
   - ____ 4. Sn^{+2}
   - ____ 5. Hg^{+1}
   - ____ 6. Hg^{+2}
   - ____ 7. Li^{+1}
   - ____ 8. Cr^{+3}
   - ____ 9. Rb^{-1}
   - ____ 10. Pt^{+2}

3. Here are three isotopes of an element: $_{6}^{12}C$ $_{6}^{13}C$ $_{6}^{14}C$
   a. The element is: ____________________
   b. The number 6 refers to the ____________________________
   c. The numbers 12, 13, and 14 refer to the ___________________________
   d. How many protons and neutrons are in the first isotope? ___________________
   e. How many protons and neutrons are in the second isotope? ___________________
   f. How many protons and neutrons are in the third isotope? ___________________

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4. Complete the following chart:

Isotope name	atomic #	mass #	# of protons	# of neutrons	# of electrons
uranium-235					
uranium-238					
boron-10					
boron-11					

Part I: Fill in the following chart

Element/Ion	Atomic Number	Number of Protons	Number of Neutrons	Number of Electrons	Mass Number
$^{1}_{1}H$					
$^{1}_{1}H^{+}$					
$^{12}_{6}C$					
$^{7}_{3}Li$					
$^{35}_{17}Cl^{-}$					
$^{39}_{19}K$					
$^{24}_{12}Mg^{2+}$					
$^{75}_{33}As$					
$^{108}_{47}Ag^{+}$					
$^{32}_{16}S^{2-}$					
		30		28	66
	76		114		

Part II: Answer the following questions:

1. a. How can you tell if an atom has a negative charge? What has happened to the atom?

   b. How can you tell if an atom has a positive charge? What has happened to the atom?

2. Define an isotope.

3. What would happen if the number of protons were to change in an atom?

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Average Atomic Mass

Calculate the average atomic masses. Round all answers to two decimal places.

1. Iodine is 80% ^{127}I, 17% ^{126}I, and 3% ^{128}I. Calculate the average atomic mass of iodine.

2. Calculate the average atomic mass of gold with the 50% being gold-197 and 50% being gold-198.

3. Calculate the average atomic mass of lithium, which occurs as two isotopes that have the following atomic masses and abundances in nature: 6.017 u, 7.30% and 7.018 u, 92.70%.

4. Hydrogen is 99% ^{1}H, 0.8% ^{2}H, and 0.2% ^{3}H. Calculate its average atomic mass.

5. What is the atomic mass of hafnium if, out of every 100 atoms, 5 have a mass of 176, 19 have a mass of 177, 27 have a mass of 178, 14 have a mass of 179, and 35 have a mass of 180.0?

6. Calculate the average atomic mass of magnesium using the following data for three magnesium isotopes.

Isotope	*mass (u)*	*relative abundance*
Mg-24	24.0	78.7
Mg-25	25.0	10.13
Mg-26	26.0	11.17

7. Calculate the average atomic mass of iridium using the following data for two iridium isotopes.

Isotope	***mass (u)***	***relative abundance***
Ir-191	191.0	37.58
Ir-193	193.0	62.42

8. Lithium has two naturally occurring isotopes: lithium-6 and lithium-7. If the average atomic mass of lithium is6.941 amu, which isotope is the most abundant? How do you know?

The History of the Atom Webquest

Instructions: Using google docs under your school account, create a document that answers the following questions. Use any reputable website (which means Wikipedia is out), research the answers to these questions. Type out each question and then type your researched answer below it and insert anything that it may be asking for. Once finished, share your document with me @ ________________________________@frco.k12.va.us and print out a copy for you to keep in your notebook. If you do not finish it today, this will become your homework and needs to be shared with me by Monday!

Questions:

1. The Greek philosophers Aristotle and Democritus had ideas about what the makeup of matter was. What were those ideas and how did they differ from each other? Insert a picture that relates to the Greeks thoughts on matter.
2. Model # 1 – The Greek Model – The Greeks developed the first model of the atom called the solid sphere model (or bowling ball model, billiard model as it became to be known as later). What did this model of the atom look like? Insert a picture of it.
3. Who was John Dalton and what were the five parts to his atomic theory?
4. What did Joseph John Thomson discover about the atom? Write a brief description of the experiment (cathode ray experiment) that he conducted to discover this. Insert a picture that shows the experiment.
5. Model # 2 – The Plum Pudding Model – With the discovery of the electron by J.J. Thomson, the Greek Model was no longer correct so he developed a new one. Describe what the plum pudding model of the atom looks like and insert a picture of it.
6. Robert Millikan was able to run experiments on the electron. What did Millikan determine regarding the electron? What was his famous experiment called? Include a brief description and picture.
7. What did Ernest Rutherford discover in the gold foil experiment? Write a brief description of the experiment and insert a picture.
8. Model # 3 – The Planetary Model – With Rutherford's discovery, the plum pudding model was proven incorrect. Rutherford developed a new model called the planetary model. Write a brief description of his model and insert a picture of it.
9. Who was James Chadwick and what did he discover about the atom? Insert a picture that helps you remember who he was and what his contribution in the history of the atom was.
10. Neils Bohr had a different view than Rutherford did about the location of electrons around the nucleus. How did Bohr think the electrons were arranged around the atom? Give a brief description of what his research showed.
11. Model # 4 – The Bohr Model – Write a brief description of the Bohr Model for an atom and insert a picture of what it looked like.
12. Erwin Schrodinger took the Bohr model a little further. What did Schrodinger say about an atom's electrons that differed from Bohr?
13. Model # 5 – The Quantum Mechanical Model – Write a brief description of the Quantum Mechanical Model and insert a picture of what it looks like.

Electron Configurations, Orbital Notations & Quantum Numbers

Chemical properties depend upon the number and arrangement of electrons in an atom. Usually, only the valence or outermost electrons are involved in chemical reactions. The electron cloud is compartmentalized. We model this compartmentalization through the use of electron configurations and orbital notations. The compartmentalization is as follows: energy levels have sublevels which have orbitals within them. We can use an apartment building as an analogy. The atom is the building, the floors of the apartment building are the energy levels, the apartments on a given floor are the orbitals and electrons reside inside the orbitals. There are two governing rules to consider when assigning electron configurations and orbital notations. Along with these rules, you must remember electrons are lazy and they "hate" each other since they find each other quite repulsive, they will fill the lowest energy states first AND electrons repel each other since like charges repel.

PART I: ELECTRON CONFIGURATIONS

Electron configurations are nothing more than a detailed way to show the addition of electrons around the nucleus of an atom. An electron configuration can quickly show the reader which electron orbitals have been filled and which are not. The periodic table is your map for determining the correct electron configuration and knowing how to use it is imperative to obtain the correct configuration for each atom.

Rule 1: Aufbau's Rule – a new element is created by adding a proton to the nucleus and an electron to the lowest energy level available

1. Each main energy level has *n* sublevels, where *n* equals the number of the energy level. That means the first energy level has one sublevel, the second has two, the third has three and so on.

2. The sublevels are named s, p, d, f, g . . . and continue alphabetically. The modern periodic table does not have enough elements to necessitate the use of sublevels beyond f.

3. It may be easier for you to understand this by studying the table presented below:

Energy Level	Number of Sublevels	Names of Sublevels
1	1	s
2	2	s, p
3	3	s, p, d
4	4	s, p d, f
5	5	s, p, d, f, g

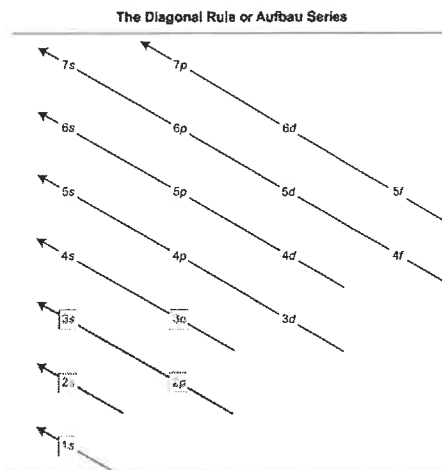
Sublevel Name	s	p	d	f
Number of orbitals	1	3	5	7
Maximum number of electrons	2	6	10	14

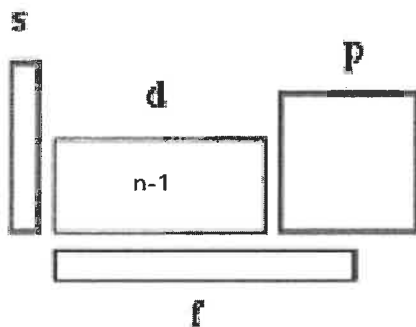
4. Each sublevel has increasing odd numbers of orbitals available. s = 1, p = 3, d = 5, f = 7. Each orbital can hold *only two electrons* and they *must be of opposite spin.* An s-sublevel holds 2 electrons, a p-sublevel holds 6 electrons, a d-sublevel holds 10 electrons, and an f-sublevel holds 14 electrons.

5. The filling of the orbitals is related to energy. Remember, electrons are lazy, much like us! Just as you would place objects on a bottom shelf in an empty store room rather than climb a ladder to place them on a top shelf, expending more energy—electrons fill the lowest sublevel available to them. Use the diagonal rule as your map when determining electron configurations for any of the elements.

6. Use this periodic table to help you…

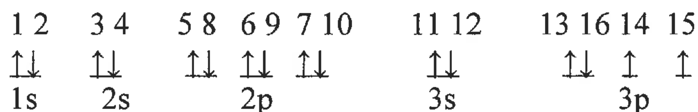
Aufbau Slide Rule





PART II: ORBITAL NOTATIONS

Orbital notation is a drawing of the electron configuration. It is very useful in determining electron pairing and thus predicting oxidation numbers. The orbital notation for sulfur would be represented as follows:

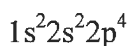


The electrons are numbered as to the filling order. Notice electrons 5, 6, and 7 went into their own orbitals before electrons 8, 9, and 10 forced a pairing to fill the 2p sublevel. This is an application of Hund's rule which minimizes electron-electron repulsions. The same filling order is repeated in the 3p sublevel.

Rule 2: Hunds Rule (Bus Seat Rule)
The *most stable* arrangement of electrons is one with the maximum number of unpaired electrons. It *minimizes electron-electron repulsions* and thus stabilizes the atom. Here is an analogy. In large families with several children, it is a luxury for each child to have their own room. There is far less

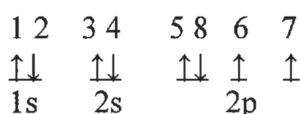
fussing and fighting if siblings are not forced to share living quarters. The entire household experiences a lower, less frazzled energy state. Electrons find each other very repulsive, so they too, are in a lower energy state if each "gets their own room" or, in this case, orbital. Electrons will fill an orbital singly, before pairing up in order to minimize electron-electron repulsions. All of the electrons that are single occupants of orbitals have parallel (same direction) spins and are assigned an up arrow. The second electron to enter the orbital, thus forming an electron pair, is assigned a down arrow to represent opposite spin.

Electron configurations
Group the 1's, 2's, etc. TOGETHER and it looks like this:


$1s^2 2s^2 2p^4$

Which element has this electron configuration?

Orbital notations
Use blanks to represent orbitals and arrows to represent electrons and it looks like this:



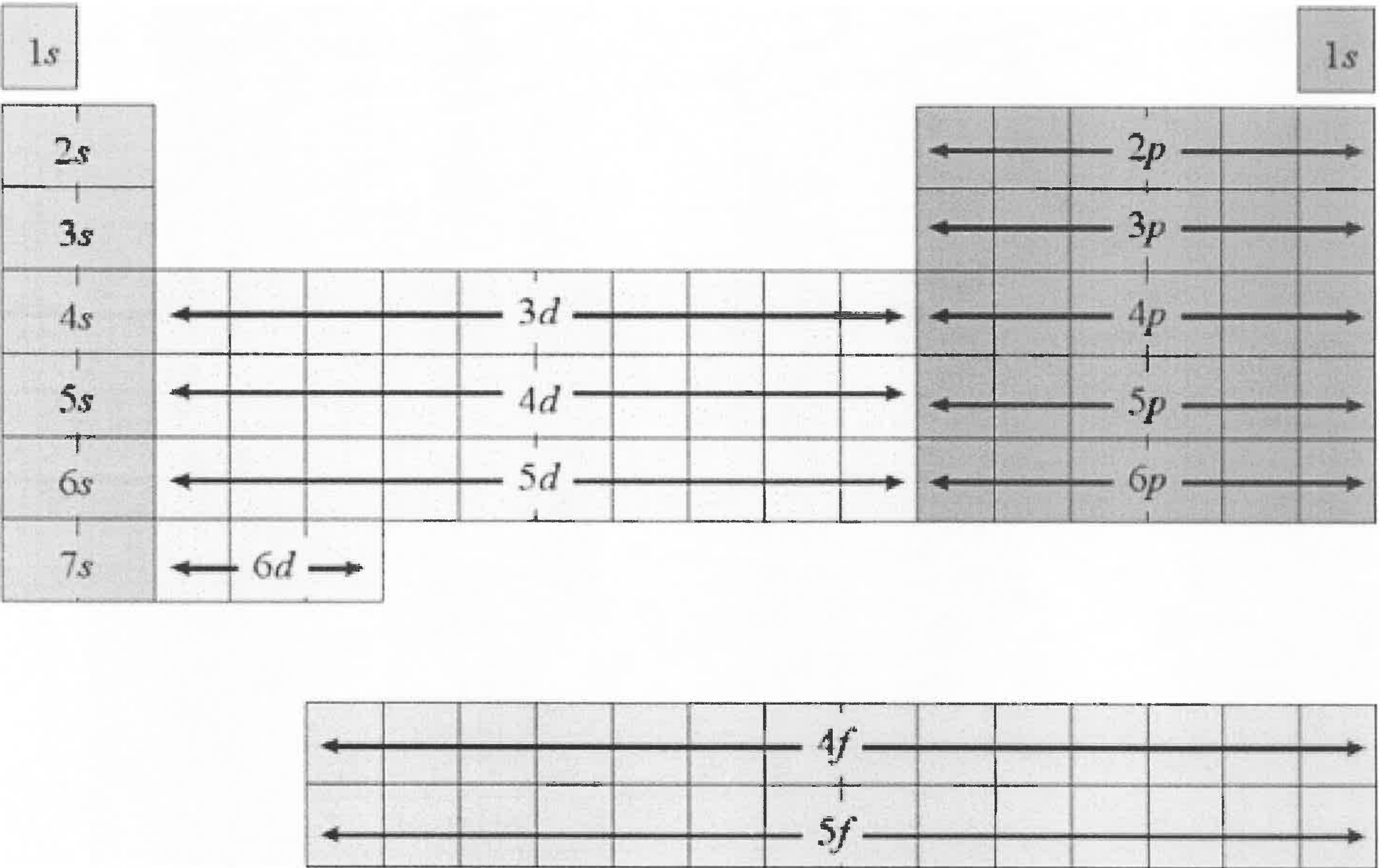
The electrons are numbered as to the filling order. Notice electrons 5,6,7 went into their own orbitals before electron 8 forced a pairing. This minimizes repulsion.

Which element has this orbital notation?

PART III: QUANTUM NUMBERS AND ATOMIC ORBITALS

1. Energy Level of the Electron **1, 2, 3, 4, 5, etc.**	Describes the energy level of the electron and refers to the average distance of the electron from the nucleus. $2n^2$
2. Sublevel of the Electron **s,p,d,f**	Refers to the sublevels that occur within each principal level and determines the shape of the orbital. **0, 1, 2, 3…** **S=0, p=1, d=2, f=3**
3. Orbital Location of the Electron	Specifies which orbital within a sublevel you are likely to find the electron **…−2, −1, 0, 1, 2, …**
4. Spin of the Electron **+ ½ or −½**	Specifies the value for the spin. Only two possibilities exist: +½ and −½. No more than two electrons can occupy an orbital.

Rule 3: The Pauli Exclusion Principle
In 1925, Wolfgang Pauli stated: *No two electrons in an atom can have the same set of four quantum numbers*. This means no atomic orbital can contain more than TWO electrons and the electrons must be of opposite spin if they are to form a pair within an orbital.



1s
1s
2s
2p
3s
3p
4s
3d
4p
5s
4d
5p
6s
5d
6p
7s
6d
4f
5f

Name ______________________________ Date ____________ Period ________

Table: Orbital Notation - Complete the missing information on the table below.

Z	*Symbol*	*Configuration*	*Orbtial Notation*				
			1s	*2s*	*2p*		
1		**1s1**	___	___	___	___	___
2	**He**		___	___	___	___	___
3		**$1s^1 2s^1$**	___	___	___	___	___
4	**Be**		___	___	___	___	___
5	**B**		___	___	___	___	___
6	**C**		___	___	___	___	___
7	**N**		___	___	___	___	___
8	**O**		___	___	___	___	___
9	**F**		___	___	___	___	___
10	**Ne**		___	___	___	___	___

QUESTIONS

1. Identify the following atoms by their electron configurations:

a. $1s^2 2s^2 2p^5$ ____________________

b. $1s^2 2s^2 2p^6 3s^2 3p^2$ ____________________

c. $1s^2 2s^2 2p^6 3s^2 3p^6$ ____________________

d. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^5$ ____________________

2. How does Hund's Rule help you determine the electron configuration of an atom?

3. Write the ortbial diagram for the element chlorine in the space below.

4. What is the electron configuration for aluminum?

5. Is there anything unusual about the electron configuration of chromium (Z=24) [Ar] $3d^5 4s^1$? Explain

Electron Configuration Practice Worksheet

In the space below, write the unabbreviated electron configurations of the following elements:

1) sodium ______________________
2) iron ______________________
3) bromine ______________________
4) barium ______________________
5) neptunium ______________________

In the space below, write the abbreviated electron configurations of the following elements:

6) cobalt ______________________
7) silver ______________________
8) tellurium ______________________
9) radium ______________________
10) lawrencium ______________________

Determine what elements are denoted by the following electron configurations:

11) $1s^2 2s^2 2p^6 3s^2 3p^4$ ______________
12) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^1$ ______________
13) [Kr] $5s^2 4d^{10} 5p^3$ ______________
14) [Xe] $6s^2 4f^{14} 5d^6$ ______________
15) [Rn] $7s^2 5f^{11}$ ______________

Determine which of the following electron configurations are not valid:

16) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 4d^{10} 4p^5$ ______________
17) $1s^2 2s^2 2p^6 3s^3 3d^5$ ______________
18) [Ra] $7s^2 5f^8$ ______________
19) [Kr] $5s^2 4d^{10} 5p^5$ ______________
20) [Xe] ______________

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Electron Configurations Worksheet

Write the complete ground state electron configurations for the following:

1) lithium ______________________________

2) oxygen ______________________________

3) calcium ______________________________

4) titanium ______________________________

5) rubidium ______________________________

6) lead ______________________________

7) erbium ______________________________

Write the abbreviated ground state electron configurations for the following:

8) helium ______________________________

9) nitrogen ______________________________

10) chlorine ______________________________

11) iron ______________________________

12) zinc ______________________________

13) barium ______________________________

14) polonium ______________________________

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Show the full and the abbreviated electron configuration for each element below:

Oxygen

Sulfur

Calcium

Krypton

Chromium

Show the abbreviated version of each of the following

Mercury

Uranium

Iodine

Name ________________________________

Period ________________________________

Electron Configurations, Orbital Notations and Quantum Numbers
Understanding Electron Arrangement and Oxidation States

ANALYSIS

Complete this table:

Question Number	Element	Electron Configuration	Non Core Orbital Notation [only the outermost orbitals are drawn]	Set of Quantum Numbers for the LAST Non Core Electron to Fill
1.			↿ 4s	
2.	Fe			
3.		$1s^2 2s^2 2p^3$		
4.			↿⇂ 5s ↿⇂ ↿⇂ ↿⇂ ↿⇂ ↿⇂ 4d ↿ ↿ _ 5p	
5.	Br			
6.			↿⇂ 6s	
7.		[Ar] $4s^2 3d^8$		
8.	P			
9.			↿⇂ 5s ↿ ↿ _ _ _ 4d	
10.	U			
11.		[Kr] $5s^2 4d^9$		
12.			↿⇂ 3s	
13.		[Ar] $4s^2 3d^{10} 4p^6$		
14.			↿⇂ 4s ↿⇂ ↿⇂ ↿⇂ ↿⇂ ↿⇂ 3d ↿ ↿ ↿ 4p	
15.	W			
16.		[Rn] $7s^1$		
17.	Pu			
18.		$1s^2 2s^2 2p^1$		
19.			↿⇂ 4s ↿ ↿ ↿ ↿ ↿ 3d	
20.	I			

STUDY: ATOMIC STRUCTURE

1. For each of the following, indicate what each is credited for discovering—
   a. Aristotle
   b. Democritus
   c. Dalton
   d. Thomson
   e. Rutherford
   f. Bohr
   g. Chadwick
   h. Millikan

2. What information does each of the following give you?
   a. Atomic#

   b. Atomic Mass

3. What does the term atomic mass unit (AMU) mean? What is this unit based upon?

4. How many protons, electrons, and neutrons are contained in an atom of element 44?

5. Complete the following:

Atom	Atom Name	A#	M#	#P	$\#e^-$	#N
Mn						
S						
O^{-2}						
Be^{+2}						

6. ____________ is anything that has both mass and volume.
7. ____________ is the study of matter and energy
8. ____________ is the central part of the atom
9. subatomic particles contained in the nucleus that have NO apparent charge are called ___________
10. subatomic particles found OUTSIDE the nucleus, having little mass, and a negative charge are called ___________
11. subatomic particles found in the nucleus that have a positive charge are called ___________
12. The current model of the nature of the atom indicates that electrons are not in definite orbits. The older model is called the ______________________ model.
13. Atoms of the SAME element that have the same number of protons BUT different number of neutrons are called ________________
14. Atoms that have an apparent charge because of a loss or gain of electrons are called __________________.

Use the following diagram to answer 15-17. Assume the atom has a NEUTRAL charge.

22.989
Na
11

15. What is the element represented above? ___
16. Atomic# _______ Mass#__________
17. #protons ___ #electrons ___ #neutrons ___

18. The electrons located in the LAST shell of an atom are known as ___________ electrons.
19. The period (row) number gives you the number of _________________.
20. The group (column) number gives you the number of __________________.
21. What are the max # of electrons in each shell?
    a. n=1 ____ c. n=3 ____

b. n=2 ____ d. n=4 ____

22. Isotopes of an element have different—
    a. atomic numbers
    b. atomic masses
    c. number of protons
    d. number of outer-shell electrons

23. The data in the table below indicate that—

substance	#protons	#neutrons	#electrons
A	8	8	8
B	8	9	8

A. A and B are isotopes of the same element.
B. A and B are different elements.
C. A has a greater charge than B.
D. A is more reactive than B.

24. Silver (Ag) has two naturally occurring isotopes: Ag-107 occurs 52.0% and Ag-109 occurs 48.0%. Which calculations will determine the average atomic mass of silver (Ag)?

A. $\frac{107+109}{2}$ C. $\frac{(107\times 3)+109}{3}$

B. $\frac{(107\times 3)+109}{2}$ D. (107 x 0.52) + (109 x 0.48)

25. How does the radioactive isotope C-14 differ from its stable counterpart C-12?
    a. it has a different number of protons and two less neutrons that C-12
    b. it has the same number of protons and two more electrons than C-12
    c. it has the same number of protons but two more neutrons than C-12
    d. it has a different number of protons and two more neutrons than C-12

26. Neon has three isotopes of masses 22, 21 and 20. If the isotopes have the abundance 8%, 2% and 90% respectively, what is the average relative atomic mass of neon?

27. Carbon has three different isotopes: C-12, C-13. and C-14. When looking at the periodic table, the average atomic mass is 12.011 amu. Which of the following isotopes occurs the most. Justify your answer.

28. Nitrogen forms a –3 ion. How many electrons does the nitrogen ion have?
    a. 3 c. 8
    b. 9 d. 10

29. Chlorine forms a -1 ion. How many electrons does a chloride ion have?

30. A neutral atom of potassium has 19 electrons. Potassium forms a +1 ion. How many electrons does a potassium ion have?

31. Sulfur forms a -2 anion. This means that an sulfur ion—

32. Complete the electron configuration, orbital filling diagrams, and quantum numbers for the following atoms

Na

Ti

Te

Dy

34. the space occupied by one pair (2) of e^- is called a(n) _______________
35. electron in an orbital have ____________ spins
36. What are the 4 sublevels? ________________

37. Fill in—

n	Max #electrons
1	
2	
3	
4	

38. How many electrons are held in—
s-____; p-____; d- ____; f- ____

39. Fill in—

n	$\#e^-$	sublevels	#orbitals
1			
2			
3			
4			

40. State the Pauli Exclusion Principle.

41. State Hund's Rule.

42. State the Aufbau Rule.

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