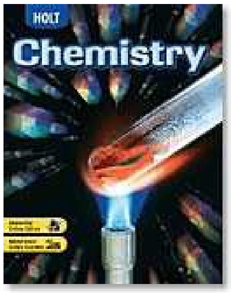
Unit 3: The periodic table

reading



major topics

1. An improved, modern atomic model
2. Configuration of electrons within atoms
3. Evidence for the relative energy of electrons in each atomic orbital
4. Patterns and reasons for periodic variations in atomic properties

objectives

6.1 Define, apply and distinguish among the following key terms:

1. proton
2. electron
3. neutron
4. isotope
5. atomic number
6. mass number
7. isotopic notation
8. electron configuration
9. orbital configuration
10. energy level
11. ground state
12. excited state
13. ionization energy
14. valence electrons
15. family of elements
16. group of elements
17. alkali metals
18. alkaline earth metals
19. transition elements
20. noble gases
21. halogens

6.2 Determine the number of protons, neutrons and electrons in any atom given its atomic number, mass number, and charge; and vice versa.

6.3 Determine the electron configuration for any atom or ion in its ground state.

6.4 State the general trends in ionization energies, electronegativity, and atomic size across rows and down columns in the periodic table.

6.5 State the relationship between the size of a neutral atom and the size of that atom's cations or anions.

6.6 Explain trends in an atom's first ionization energy and its successive ionization energies based on its electron configuration and its position in the periodic table.

6.7 Explain trends in atoms' electronegativities and sizes based on their electron configurations and their positions in the periodic table.

6.8 Relate an atom's valence electron configuration to its typical ionic state and its position in the periodic table.

1. Using the periodic table where appropriate, complete the following table. [6.1]
Note that:
- nuclear charge can be determined from the number of protons since each proton has a charge of +1
- the *average molar mass* in the periodic table is <u>not</u> the same as the exact (integer) *mass number* of each isotope

element	atomic number	number of protons	number of electrons	number of neutrons	mass number	total charge	nuclear charge
nitrogen	7				14	neutral	+7
chromium					52	+3	
fluorine					19	–1	
	25				55	neutral	
cobalt					59	+2	
	36				84	neutral	
iodine					127	–1	

2. Based on the information presented below using isotopic notation, determine the number of protons, neutrons, and electrons present in each of the following atoms or ions. [6.2]

symbol	number of protons	number of neutrons	number of electrons
$^{3}_{1}H$			
$^{143}_{56}Ba^{2+}$			
$^{90}_{36}Kr$			
$^{32}_{16}S$			
$^{33}_{16}S$			
$^{33}_{16}S^{2-}$			
$^{1}_{1}H^{+}$			

3. Using an arrow (↑ or ↓) to represent each electron, show the electron configuration for each of the following neutral atoms in its ground state. Each box represents an orbital in which electrons may reside. Phosphorus is already done as an example. [6.3]

	1s	2s	2p			3s	3p			4s	3d	4p
ex: $_{15}P$	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑	↑	↑			

a. $_{7}N$

b. $_{12}Mg$

c. $_{6}C$

d. $_{13}A\ell$

e. $_{18}Ar$

f. $_{20}Ca$

g. $_{17}C\ell$

h. $_{8}O$

i. $_{10}Ne$

j. $_{26}Fe$

k. $_{14}Si$

l. $_{34}Se$

4. For each electron configuration above, express it in written form. Write your answers in the spaces above. [6.4]

For the phosphorus example, the answer is: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$

5. Write the <u>complete</u> electron configuration (e.g. $1s^2\ 2s^2\ 2p^6$...) for each the following neutral elements. [6.5]

a. $_{28}$Ni

b. $_{49}$In

c. $_{74}$W

d. $_{37}$Rb

e. $_{35}$Br

f. $_{27}$Co

g. $_{87}$Fr

h. $_{85}$At

i. $_{36}$Kr

j. $_{42}$Mo

k. $_{62}$Sm

l. $_{54}$Xe

m. $_{19}$K

6. Write the <u>short-cut</u> electron configuration (e.g. [Ne] $3s^2\ 3p^3$) for each the following neutral elements. [6.6]

a. $_{82}$Pb

b. $_{16}$S

c. $_{84}$Po

d. $_{56}$Ba

e. $_{76}$Os

f. $_{26}$Fe

g. $_{81}$Tℓ

7. Complete the following table detailing how the principal quantum number (n) relates to the subshells and orbitals associated with that quantum number. Shell 3 has already been completed for you. [6.7]

n principal quantum number	number of subshells within shell n	name(s) of subshells(s)	total number of orbitals in shell	maximum number of electrons in shell
1				
2				
3	3	s, p, d	1 + 3 + 5 = 9	2 × 9 = 18
4				
5				
6				
7				
10 (theoretical)				

❑ Look at your answers above for the "total number of orbitals in shell." How does each of these answers relate mathematically to the principal quantum number, n ?

8. Write the short-cut electron configuration and then the valence electron configuration for each of the following neutral elements. Two samples are completed for you. [6.8]

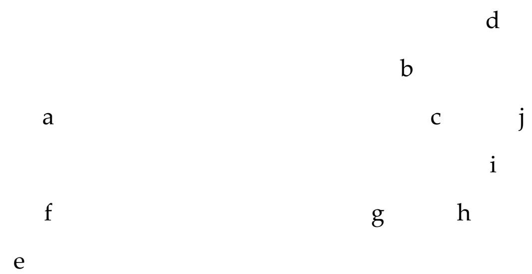
	electron configuration	valence
$_{15}$P	[Ne] $3s^2\ 3p^3$	$3s^2\ 3p^3$
$_{56}$Ba		
$_{35}$Br		
$_{83}$Bi		
$_{88}$Ra		
$_{52}$Te		

	electron configuration	valence
$_{31}$Ga	[Ar] $4s^2\ 3d^{10}\ 4p^1$	$4s^2\ 4p^1$
$_{82}$Pb		
$_{14}$Si		
$_{53}$I		
$_{36}$Kr		
$_{32}$Ge		

❑ Which lettered orbitals generally are *not* considered to contain valence electrons?

❑ Describe how to identify the valence electrons in terms of the principal quantum number (n).

9. Write the valence electron configuration for each element indicated by letter in the table below. Note that it is not necessary to determine which specific element is indicated; seeing its position in the table is sufficient. [6.9]



a.

b.

c.

d.

e.

f.

g.

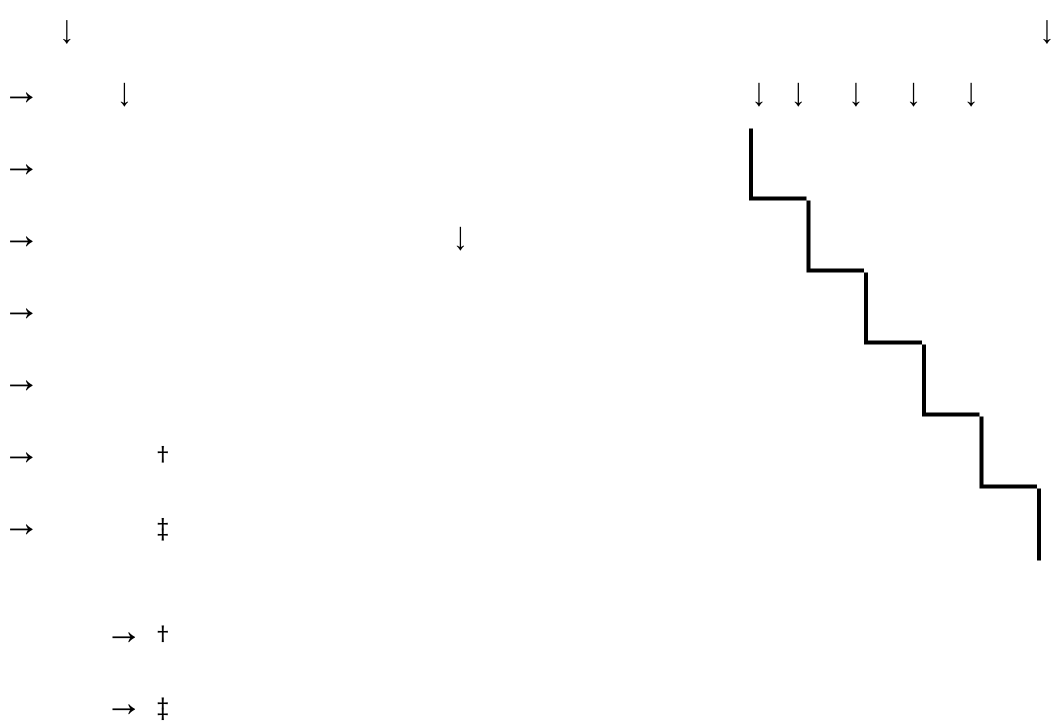
h.

i.

j.

10. Annotate the periodic table below by writing each of the following terms beside the appropriate arrow. In some cases more than one description should be placed beside the same arrow. [6.10]

- ❏ row 2
- ❏ alkali metals
- ❏ halogen family
- ❏ group 5
- ❏ valence electrons $ns^2\ np^1$
- ❏ noble gases
- ❏ energy level 4
- ❏ column 6
- ❏ valence electrons $ns^2\ np^5$
- ❏ transition metals
- ❏ chalcogens
- ❏ rare-earth elements
- ❏ period 7
- ❏ nitrogen family
- ❏ alkaline earth metals



11. Use an arrow (↑ or ↓) to represent each electron in the electron configurations of the following ions. Then write the shortcut electron configuration for each. The phosphide ion is done as an example. [6.11]

	1s	2s	2p	3s	3p	4s	3d	
ex: $_{15}P^{3-}$	↑↓	↑↓	↑↓ ↑↓ ↑↓	↑↓	↑↓ ↑↓ ↑↓			= [Ar]

a. $_{12}Mg^{2+}$

b. $_{13}Al^{3+}$

c. $_{16}S^{2-}$

d. $_{7}N^{3-}$

e. $_{28}Ni^{2+}$

f. $_{8}O^{2-}$

g. $_{21}Sc^{3+}$

h. $_{9}F^{-}$

i. $_{11}Na^{+}$

j. $_{19}K^{+}$

12. Complete the table for each of the following ions. You may use shortcut notation for electron configurations.

	atomic number	charge of ion	# of electrons	ion symbol	electron configuration
	11	+2	9	Na^{+2}	$[He]\ 2s^2\ 2p^5$
a.	12	+2			
b.	12	+1			
c.	16	+1			
d.	16	–3			
e.	17	–1			
f.	20	+2			
g.	13	+3			
h.	8	–2			
i.	3	+2			
j.	7	–1			

k. Place a ✱ to the right of each configuration above that can be expected to be especially stable. [6.12]

13. Identify the neutral element having each of the following electron configurations. [6.13]

a. $1s^2$

b. $1s^2\ 2s^2\ 2p^5$

c. $1s^2\ 2s^2\ 2p^3$

d. $1s^2\ 2s^2\ 2p^6\ 3s^2$

e. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$

f. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^3$

g. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$

h. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$

14. Noble gases are benchmarks of stability. An ion with the same electron configuration as a noble gas also exhibits unusual stability. Complete the following tables identifying some of the ions having the same electron configurations as noble gases. (Each of these tables shows an *isoelectronic* group, i.e. a group of atoms and ions with the same electron configuration.) [6.14]

–3 ion		–2 ion		–1 ion		noble gas		+1 ion		+2 ion		+3 ion	
p	e	p	e	p	e	p	e	p	e	p	e	p	e
	10	8	10		10	10	10		10		10	13	10
		O^{2-}				Ne						Al^{3+}	

The complete electron configuration for all seven atoms or ions above is:

$1s^2\ 2s^2\ 2p^6$

–3 ion		–2 ion		–1 ion		noble gas		+1 ion		+2 ion		+3 ion	
p	e	p	e	p	e	p	e	p	e	p	e	p	e
	18		18		18	18	18		18		18		18
						Ar							

The complete electron configuration for all seven atoms or ions above is:

–3 ion		–2 ion		–1 ion		noble gas		+1 ion		+2 ion		+3 ion	
p	e	p	e	p	e	p	e	p	e	p	e	p	e
	54		54		54	54	54		54		54		54
						Xe							

The complete electron configuration for all seven atoms or ions above is:

S T U

V Y

Z

W X

Use the periodic table above to answer questions 15 through 17. You do not need to consider which actual element corresponds to each letter. (And the letters do not stand for their usual elements.) The general **periodic trends** in the properties of elements are sufficient to answer these questions.

15. Which element from each pair has a larger atomic size (or radius)? [6.15]

a. V or Y

b. U or Z

c. W or U

16. Which element from each pair has a greater first ionization energy? [6.16]

a. S or U

b. V or W

c. U or Y

17. Which element from each pair has a larger electronegativity? [6.17]

a. W or X

b. U or Z

c. U or X

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18. For each of the following pairs, circle the neutral atom that has the larger size (or radius). Then briefly explain the reason for each choice. [6.18]

a. Na or Cs

b. I or Br

c. F or S

d. Aℓ or Cℓ

e. B or Ba

19. For each of the following pairs, circle the atom or ion that has the larger size (or radius). Then briefly explain the reason for each choice. [6.19]

a. Aℓ or $A\ell^{3+}$

b. S or S^{2-}

c. K or K^{+}

d. Mg^{2+} or Ca^{2+}

e. I^{-} or Br^{-}

f. Ca^{2+} or K^{+}

g. S^{2-} or $C\ell^{-}$

20. Because of the patterns in properties of elements in the periodic table, it is possible to estimate an unknown value of a property of element based on the known values of that property for other nearby elements. The following table shows the **first ionization energy** (in units of kJ/mol) for some elements. Make a reasonable estimate of the missing ionization energies of the other elements based on the patterns in the values that are given. (You are not expected to figure out exactly the real values, just ones that fit the general pattern.) [6.20]

Li	Be
	899
Na	Mg
496	738
K	Ca
419	590
Rb	Sr
403	
Cs	Ba

B	C	N	O	F	Ne
		1402			2081
Aℓ	Si	P	S	Cℓ	Ar
578	786		1000		1521
Ga	Ge	As	Se	Br	Kr
	762	947		1140	
In	Sn	Sb	Te	I	Xe
558		834		1008	
Tℓ	Pb	Bi	Po	At	Rn
589			812		1037

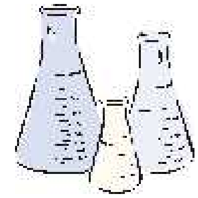
21. The following table lists the first several ionization energies of several elements. (Each consecutive ionization energy identifies how much energy it will take to remove another electron from that atom or ion.) The names of the elements have been disguised so that you cannot tell where they lie in the periodic table. Yet you can still figure out which family each one belongs to, and thus the charge of its most stable positive ion. Use the given data to make this prediction for the elements below. [6.21]

	ionization energies (in kJ/mol)				
element	first	second	third	fourth	element's most stable cation
Wt	502	962	4853	5606	Wt^{2+}
Wu	514	7209	7698	– – –	
Wv	573	1803	2724	11485	
Ww	498	4531	4686	5201	
Wx	732	1443	7698	8201	
Wz	414	3046	4477	5272	

❏ What do each of these most-stable cations have in common in terms of electron configuration?

Lab 3 A

The periodic table and properties of elements



background

In the 1800s when scientists were examining properties of different elements, they noticed similarities, and that there was a pattern to which chemicals were similar. One of these scientists was Dmitri Mendeleev. He arranged the elements by their atomic weight and noticed that there was a repeating (periodic) pattern to their chemical properties. In 1869, he published his first periodic table of elements. At that time there were only about sixty known elements, and there were some blank spots in his table. He was so confident that his table was correct, even with the missing elements, that he predicted scientists would discover these elements and he predicted the new elements' atomic weights and properties. In the years that followed, when three of the elements he predicted were discovered, scientists knew that Mendeleev was correct.

purpose

The purpose of this lab is to observe different properties of chemicals and to use this knowledge and the periodic table to identify unknowns. Your unknowns are: **calcium, iodine, and zinc**.

procedure

To conserve supplies, use only small amounts of each element for testing. If it is not altered by the test, please return it to the container. Devise methods to test the following properties. Check with your teacher for safety before beginning. Do not touch any of the elements; use tweezers or gloves. As a group, divide up the tasks and show each other your results. Include a brief description of each test procedure in your table.

1. Appearance
2. Reaction with water (watch for a while)
3. pH of water after mixing with element
4. Relative melting point (must do samples G and B in hood)
5. Conductivity (teacher has device for this; use wires or large chunks, not powder; for sample A, break a piece apart and test a fresh surface)
6. Reaction with hydrochloric acid
7. One more of your own choosing

samples

A	?
B	sulfur*
C	?
D	magnesium
E	silicon
F	copper
G	?**
H	carbon
I	aluminum
J	sodium***

* only heat in hood
** keep covered; only heat in hood
*** will be tested together as a class

data

Make a neat table. Plan it out before you begin so that it has room for the data you will collect.

analysis

On separate paper, using full sentences (other than for lists of information), complete the following analysis questions.

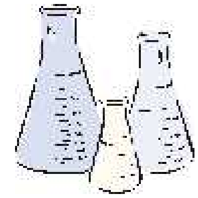
1. Make a three-column table. In the first column write the letter of each unknown element. In the second column list its properties. In the third column state which actual element it is (calcium, iodine, or zinc) and explain how its properties show that it fits in that spot on the periodic table.
2. Annotate the blank periodic table (on the back of this page) to neatly show:
   a. where each 'known' and 'unknown' sample belongs on the table
   b. the properties you observed for each sample (these may need to be inserted neatly outside the actual table grid)
   c. where metals and non-metals are located on the table
   d. any other patterns or trends you notice among the elements you tested
3. What properties do the metals have in common?
4. What properties do the non-metals have in common?
5. For the metalloid, describe which of its properties are similar to the metals and which of its properties are similar to the non-metals.
6. Find two metals you tested that are in the same row on the periodic table. What pattern exists in their chemical properties across the row?
7. Find two metals you tested that are in the same column on the periodic table. What pattern exists in their chemical properties down the column?

The periodic table and properties of elements

1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1																		2
3	4												5	6	7	8	9	10
11	12												13	14	15	16	17	18
19	20		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
37	38		39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
55	56	57 to 70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
87	88	89 to 102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118

Lab 3 B

Name that element



introduction

On the following pages, the characteristics of many real elements are described. But each element's real symbol has been replaced with a two-letter alias. You must match each alias with its correct element.

The aliases are not assigned completely randomly. The same initial upper-case letter is used for all elements within the same *family* (a.k.a. *group* or *column*) in the periodic table. For example, aliases **Fa**, **Fb**, and **Fc** are all for elements in the same family.

The main point of this lab is for you to become more familiar with the properties and uses of some of the most common and/or most important elements and compounds of those elements. It also will help you see further evidence of the significant similarities that exist among the elements within a family and the patterns that exist throughout the periodic table.

procedure

Read the element descriptions on the following pages. Use your existing knowledge and the information in the CRC Handbook to help you identify which real element each alias matches. When you find a match, record the alias in the real element's spot on the blank periodic table at the end of this lab. Continue to branch out from the elements you have figured out to match additional elements.

Helpful hints:

- ❏ Section B in the CRC Handbook has detailed element "biographies."
- ❏ You must cite the handbook in each completed cell in your periodic table, e.g. **56^{th} ed., p. B-37**.
- ❏ Each family of aliases (e.g. Ab, Ac, Ad, Ae...) belongs in a single column.
- ❏ Aliases are not the same as actual element symbols (e.g. aliases Ga and Ca are not gallium and calcium).
- ❏ You will not necessarily fill a column (e.g. you may be given only 4 elements from a column of 7).

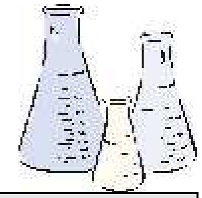
element **X**
This element does not exactly belong to any group in the periodic table. Element **X** has the second lowest boiling point of any element and is the least dense of all gaseous elements. It is not the most abundant element on earth, but it is the most abundant element in the universe.

group **A**
• These elements all have an extremely stable electronic structure. They are extremely unreactive.
• Element **Ab** is found in small amounts in earth's atmosphere and is used in incandescent lamps to decrease the rate of filament evaporation and deterioration. Its name comes from a Greek word meaning inactive.
• Element **Ac** is the second least dense of all gases and is the second most abundant element in the universe. It has the lowest boiling point of all of the elements and behaves more like an ideal gas than any other element. Much of the supply of this element is obtained from wells in Texas, Oklahoma, and Kansas. A mixture of this gas is also used in treatment of acute asthma and other constrictive respiratory problems.
• Elements **Ad**, **Ag**, and **Af** naturally occur in much smaller amounts than the other **A** members.
• Element **Ag** is used in high-speed photographic flash tubes and has a melting point and boiling point in between those of **Af** and **Ad**.
• Element **Ae** is used in electric advertising signs to produce a brilliant red-orange light.
• Element **Af** is radioactive, making it a health concern when found in homes. In the liquid state, it has the highest density of the elements in this group.

group **B**
Some of these elements are gases at room temperature. The general name for this group comes from the Greek word for "salt-forming." They all form diatomic molecules. The four most common of the group exhibit non-metallic properties. • Element **Ba** is the only liquid non-metal at room temperatures. Its name comes from a word that means stench. The silver salt of this element is used to make photographic enlarging paper. Its gas is reddish-brown in color. • Element **Bb** is used to produce safe drinking water and is more reactive than **Ba**. • Element **Bc** is the most reactive of all of the elements. Water will burn with a bright flame in this gas. An acid of this element is used to etch the glass of light bulbs. • Element **Bd** is extremely rare. Less than thirty grams of this element may be present in all of the earth's crust. All known isotopes of element **Bd** are radioactive. • Element **Be** is solid at room temperature and its alcohol solution is used as an antiseptic. The lack of this element in the human diet causes the condition known as *goiter*. Dried seaweed and deposits in Chile were formerly important sources of this element.

group **C**
These are all active metals. All react with water and dilute acid to make hydrogen gas and a basic solution. • Element **Ca** has the smallest atomic radius and is the least dense of all of the metals. Its name comes from the Greek word for stone. It gives a crimson color to a flame. The stearate of this element is used as an all-purpose and high-temperature lubricant. An alloy of **Ca** and lead is used for cable sheath. • Element **Cb** ranks second in abundance within the group and has a boiling point less than that of **Cc**. Element **Cb** reacts more vigorously with water than does **Cc**. It is an essential constituent for plant growth. The carbonate of **Cb** was originally extracted from wood ashes and is used in making soap and hard glass. • Element **Cc** is the most abundant of the group and is the sixth most abundant on earth. The stearate of this element is useful when bathing. • Element **Cd** is the least abundant of the elements in this family. No measurable quantity of this element has ever been prepared or isolated. • The name for element **Ce** comes from the Latin word meaning "deepest red." It melts to a liquid slightly above room temperature. • Element **Cf** has a greater density than **Ce** but is less dense than **Cd**. Element **Cf** is one of the three elements that is liquid at normal room temperature and pressure. It produces a blue flame in flame tests.

group **D**
• Element **Da** and its compounds exhibit luminescence. It is a radiological hazard and can cause cancer. • Element **Db** occurs abundantly in limestone and is an essential constituent of bones, teeth, and shells. Its oxide is an important ingredient in making cement used in concrete. Its sulfate occurs in enormous deposits of gypsum. • Compounds of element **Dc** produce a scarlet color in a flame test. Element **Dc** is named after a Scottish town. Its hydroxide is used in the sugar-refining process. • Element **Dd** forms an ionic compound with chlorine that has the empirical formula **Dd**$C\ell_2$. It is alloyed with aluminum and used to construct airplanes. Hydroxides, sulfates, and citrates of this element are commonly used as medicines. • Element **De** is found in emeralds. It was formerly called *glucinium* because of the sweet taste of some of its compounds. It is brittle, yet it is hard enough to scratch glass. Compounds of this element do not ionize sufficiently to impart color to a Bunsen flame. • A sulfate of element **Df** is sometimes called *permanent white*. It is used in x-ray diagnostic work. Its flame test produces green flames. Its nitrate is the least soluble of the nitrates formed by cations in group D.



group E

These elements are sometimes referred to as the *chalcogens*.

- Elements **Ea** and **Eb** are non-metals that form hydrides with the formulas H_2**Ea** and H_2**Eb**.
- Element **Ea** is more active than element **Eb** and forms a diatomic molecule. Element **Ea** and its compounds makes up over 49% of the mass of the earth's crust. One allotrope of this element screens the earth's surface from harmful ultraviolet rays yet is itself a dangerous air pollutant. Recently a dangerous deficiency of this allotrope has developed in the outer atmosphere over Antarctica.
- Element **Eb** forms a molecule that has a larger number of atoms than the diatomic molecule that **Ea** forms. Millions of tons of this element are used annually to produce the compound that is most-produced by the chemical industry. H_2**Eb** is a gas at room temperature, is very poisonous, and is found in some water supplies.
- Element **Ec** shows distinct metallic properties, unlike elements **Ea** and **Eb**. It is the poorest electrical conductor of all of the metals, however. It used to be known as "the useless metalloid," but it has been shown to impart free-cutting properties to steel.
- Element **Ed** also conducts electrical current poorly, but its conductivity is increased by the presence of light. This property makes element **Ed** useful for constructing devices that measure light intensity. Depending on its atomic arrangement, it may appear red or gray. Its largest commercial use is in the glass industry, for making ruby red glass.
- Element **Ee** is extremely rare, unstable, and radioactive. It is the heaviest element in this group.

group F

Elements in the **F** group include metalloids that form chlorides with the empirical formula of $\mathbf{F}C\ell_3$.

- Element **Fa** is often used as a household metal foil and is the most abundant metal in earth's crust. Oxides of element **Fa** occur in rubies and sapphires. It is extremely light, conducts electricity relatively well, and possesses high tensile strength.
- An acid of element **Fb** is used as a mild antiseptic. Another compound of **Fb** is used to make glass. It is the only element of this group that shows virtually no metallic characteristics.
- Element **Fc** melts at room temperature and expands as it cools or turns solid; for this reason it can break its storage container when it cools or freezes, just as ice does. Its name comes from the Latin word for France.

group G

- One allotrope of element **Ga** is the hardest naturally-occurring substance. Another form of this element is mined in large quantities in Pennsylvania, Illinois, and Wyoming. **Ga** forms network solids.
- Hyper-pure samples of element **Gb** are used to make computer chips. Its oxide is commonly known as quartz. It is the second-most abundant element on earth, making up about 25% of the mass of the crust.
- The oxide of element **Gc** is known as cassiterite. **Gc** metal is a major component in various alloys, including pewter, britannia, solder, and antifriction. Its foil is very malleable and resistant to corrosion. Older people sometimes mistakenly call a common household metal product "**Gc** foil," but now it is actually made of **Fa**.
- Element **Gd** is the least-abundant of the elements in group **G**. It is greyish-white and rather brittle. It is sometimes used in the diodes of hobbyist crystal radios.
- Galena is the principal ore of element **Ge**. **Ge** is used to make cable coverings and storage batteries for cars. Pipes used to be made from **Ge**, and the Latin name for **Ge** is still reflected in the word "plumber."

group **H**
These elements all have five valence electrons.

- Element **Ha** forms a diatomic molecule which is extremely stable. In liquid form, it is used as a refrigerant. This element's primary commercial use is in fertilizers. Four-fifths of earth's atmosphere is composed of this element. Although it is always diatomic on earth, it exists as distinct atoms on the surface of the sun and other stars.
- Element **Hb** exists in both a yellow crystalline form and a gray metalloid form. The yellow form is very volatile and poisonous. This element's oxides and acids are used in weed killers, glass manufacturing, rodent poisoning, and preserving wood.
- Element **Hc** forms a molecule of four atoms. It is the only element of this group that is almost never found in nature as a free element. It burns spontaneously in air. A sodium compound of **Hb** is used as a cleaning agent. The pure element exists in both "white" and "red" form.

group **W**
These elements all have six fewer electrons than the nearest noble gas.

- Element **Wa** is used in making an older type of rechargeable battery.
- Element **Wb** is used in common "alkaline" batteries and also is used to coat iron to prevent the iron from rusting. Iron or steel with this coating is called *galvanized*. **Wb** has been found in the prehistoric ruins of Transylvania.
- Element **Wc** is the only metal that is liquid at 20°C. An Illinois doctor alloyed this metal with silver to develop the most widely-used tooth filling alloy.

group **Y**
These elements are known as the "coinage metals." Although they would be predicted to have electron configurations ending $s^2\ d^9$, due to electron "promotion" their configurations actually end $s^1\ d^{10}$.

- **Ya** is the most malleable and ductile of all metals. It is yellow in color. Its price reached $900 to $1000 per ounce during the financial crisis in 2008-2009.
- **Yb** is rust-colored and is used in plumbing and electrical wiring. It is used in many alloys including German silver, gunmetal, brass, manganin, and bell metal.
- **Yc** is the best metallic conductor of electricity, but the rapid formation of tarnish on its surface generally makes it a poor choice for use in electrical connections. It is used in coins, dinnerware plating, and as a constituent in tooth fillings. Unlike many other cations, the cation of **Yc** forms insoluble compounds with many halides.

Lab 3 B

Name that element

Name Period

Place each element's alias into the proper spot in the periodic table. Element "X" (hydrogen) has already been done.

You must <u>cite your source</u> in every cell, as shown in the hydrogen example. List the edition number of the <u>CRC Handbook</u> in which you read about that particular element and the page number on which that article appears.

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1. Summarize the principle concepts of the Bohr model and the Wave Mechanical model; particularly note the points on which they agree and the points on which they differ.

2. Explain in detail the steps by which a bright-line atomic spectrum is generated. Particularly focus on electrons, energy, and photons. Also explain why each element has a unique spectrum or "fingerprint."

3. Name the periodic "family" or "families" which fit(s) the following descriptions. Answers may be repeated.

- **a.** d-block
- **b.** s-block
- **c.** have the valence electron configuration ns^2np^6
- **d.** usually charged –1
- **e.** usually charged –2
- **f.** usually charged +1
- **g.** usually charged +2
- **h.** have the smallest atomic radius in a period
- **i.** have the largest atomic radius in a period

4. Name the period which fits each of the following descriptions:

- **a.** the first period having elements with electrons in d-orbitals
- **b.** the period in which the 4d orbital is being filled
- **c.** the period which has no p-orbital
- **d.** the first period having elements with electrons in f-orbitals
- **e.** the period in which the 5f orbital is being filled

NOTE: The "reasons" you give for questions 5 and 8 must focus on electrons, orbitals, protons, attractive forces, and similar ideas. "Because it is farther to the right" and similar statements are not reasons, but merely describe a pattern. They are not sufficient as reasons.

5. In each of the following pairs, choose the atom or ion having the largest radius AND explain the reason it is larger.

- **a.** P and S
- **b.** Mg and Ca
- **c.** Ca^{2+} and K^{+}
- **d.** Br^{-} and I^{-}
- **e.** S and S^{2-}
- **f.** Mg and Mg^{2+}

6. Rank the following four atoms from smallest to largest: As, S, Cℓ, and Se

7. Rank the following atoms and ions from smallest to largest: S, P, P^{3-}, As^{3-}, F, O

8. In each of the following pairs, choose the atom having the largest ionization energy AND explain the reason the ionization energy is larger.

- **a.** F and Cℓ
- **b.** Se and Br
- **c.** K and Mg
- **d.** P and Ga

9. Rank the following four atoms from smallest to largest ionization energy: As, S, Cℓ, and Se

10. Choose the more electronegative atom in each of the following pairs. (No reason need be given.)

- **a.** Na and Cℓ
- **b.** Ca and S
- **c.** F and Li
- **d.** Si and O

11. For each of the following, write the electron configuration in the first column; "shortcut" notation is acceptable. In the second column write the valence electron configuration.

	electron configuration	valence electron configuration
a. Si		
b. Sr		
c. Re		X
d. Sb		
e. Po		

12. Consider the formation of barium arsenide from the reaction of barium metal with pure arsenic.

a. Using the periodic table as your guide, identify the most likely charge each element has as an ion.

Ba○ As○

b. Complete the following table showing the electron configurations before and after ionization.

neutral atom e⁻ configuration	change in # of e⁻ (mark a box & write #)	ion e⁻ configuration
Ba	❏ gained ❏ lost _______ e⁻	Ba○
As	❏ gained ❏ lost _______ e⁻	As○

c. It is known that neutral atoms of barium have a radius of 222 pm; those of arsenic have a radius of 120 pm. Comment on the sizes of the two ions in comparison to these given original radii of the neutral atoms and explain the reason for this pattern.

d. [This will take some thought.] Given that krypton has a radius of 112 pm and xenon has a radius of 131 pm, comment on the sizes of the two ions in comparison to atoms of these noble gases (whose electron configuration they share). Explain the reason for these comparative sizes.

13. The successive ionization energies of several period 3 elements are shown below. Identify which element each of the following sets of data correspond to AND identify the charge of the ion it commonly forms.

	IE_1	IE_2	IE_3	IE_4	element	typical charge
a.	10.5	33.0	49.9	210.5		
b.	9.02	82.9	125.7	173.5		
c.	13.4	26.4	140.6	191.6		

d. Looking only at the first column—the first ionization energies—examine your conclusions for the list of elements and explain what additional evidence the first ionization energies provide for your conclusions.

