EXPERIMENT #4 — THE PERIODIC LAW

Discussion: The present organization of the elements is a product of the first periodic table published by Dmitri Mendeleev in 1869. The amazing accuracy of his predictions has been very important to chemists in this century. However, the basis of his arrangement was the atomic masses of the elements. This approach proved incorrect as it would have placed some elements in a family with dissimilar properties. Henry Moseley rearranged the table on the basis of atomic numbers of the elements. In accordance with Moseley's revision, the periodic law states: *the properties of the elements are periodic functions of their atomic number.*

Each of the known elements has its own set of characteristic properties. These range from solid to gas, lustrous to dull, low to high melting points, various colors and so on. The elements are arranged with in the periodic table into groups or families (vertical columns) and periods or rows. This arrangement reflects the periodic or repeating nature of the properties of the elements.

In this experiment, you will use your knowledge of periodic properties and a list of clues to correctly arrange the elements from a scrambled periodic table. You will also predict values for information missing from the table.

Reference: Laboratory Chemistry (TAE), "Experiment 17: The Periodic Law," Carmichael, L. N., Haines, D. F. and Smoot, R. C., Charles E. Merrill Publishing Co, 1983, p. 85-88.

Procedure:

1. Locate Table 1. Each block on this blank periodic table represents different main group elements from Groups IA-VIIIA.

2. Locate Table 2. The elements A-Z are main group elements with the various properties (atomic radii, oxidation (charge) number, density, phase, melting point, electronegativity, ionization energy) indicated in each block. Cut out blocks A-Z. Use the following clues and arrange the elements in their proper order in Table 1. When you have placed these 26 elements in their correct position, glue or tape them in place.

Clues: The following sets of elements belong in the same groups (families):
ZRD, PSIF, JXBE, LHT, QKA, WOV, GUN, YMC.

J has an atomic number 3 times that of **T**.
U has a total of six electrons.
$\mathbf{I_2A}$ is the simple formula for an oxide.
P is less dense than **S**.
S is an alkali metal.
E is a noble gas.
W is a liquid.
Z has the smallest atomic mass in its set.
B has ten protons.
O has an atomic number larger than **V**.
D has the largest atomic mass in its set.
C has 5 electrons in its outer principal energy level.
F is a gas.
X has an atomic number one higher than **F**.
L is an alkaline earth metal with atomic mass of 40.
Y is a metalloid.
O is a halogen.
The atomic mass of **T** is more than that of **H**.
Q has an atomic mass 2 times that of **A**.
Atoms of **I** are larger that those of **S**.
M has an atomic number one less than **A**.
The electrons of atom **N** are distributed over three principal energy levels.
The atomic radius of **K** is the largest of the set.

3. Cut out the remaining 16 blocks. Use the information provided in each block and your knowledge of the periodic properties of the elements to arrange these elements in their proper position in Table 1. Glue or tape these blocks in place.

4. Some information is missing from each block. Predict the values for the missing items from the location of the element on the periodic table. Place your predictions on the table. (You may use the periodic table in lab or in your text only to determine the symbol of each element.)

Questions:

1. What are the general trends within the rows and groups for electronegativity? For those elements that are missing electronegativity values, predict the expected values.

2. What are the general trends within the rows and groups for ionization energy? In particular, look carefully at the second period (Li to Ne). What elements appear to be exceptions to the general trend? Explain why these elements behave in this fashion.

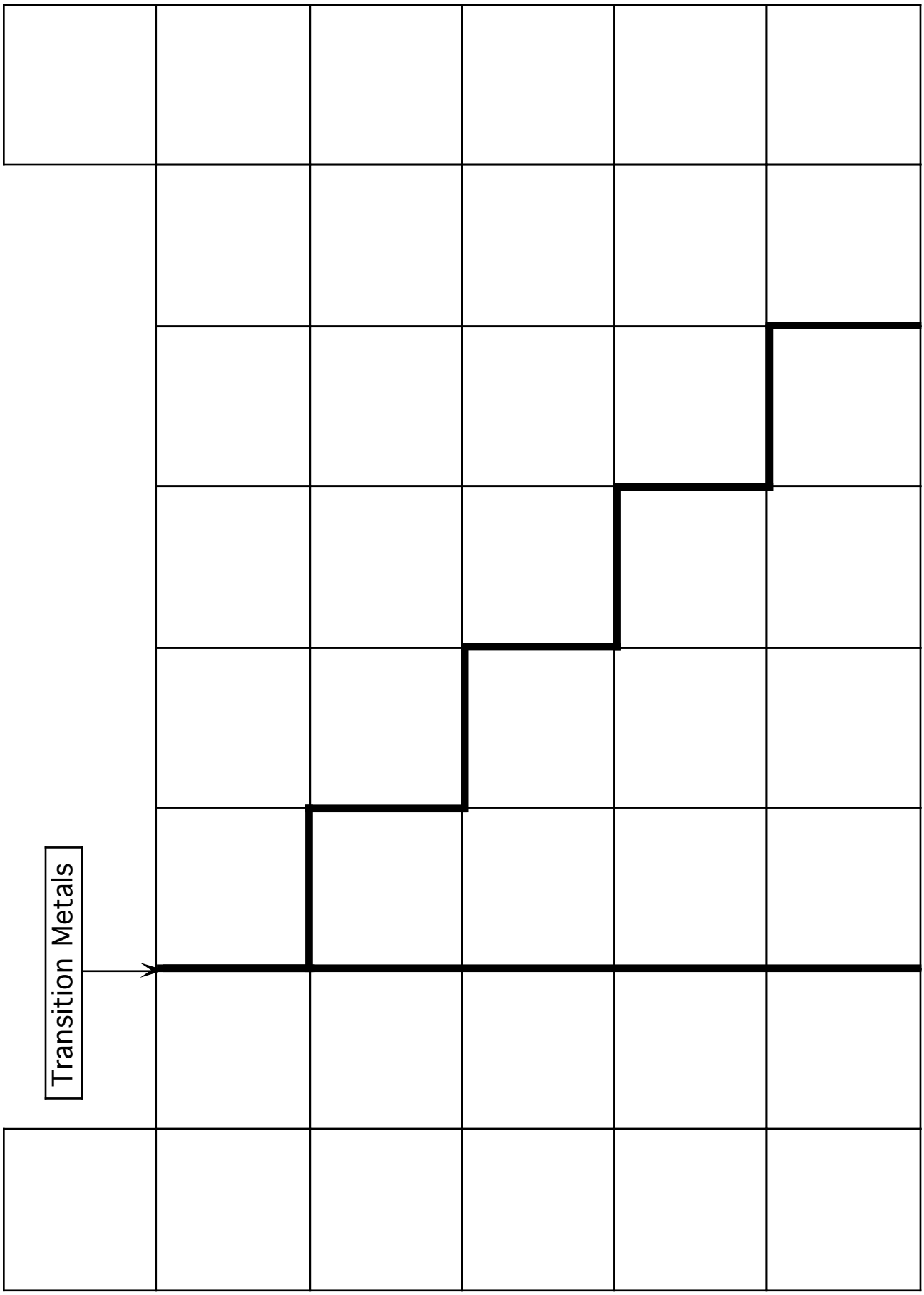
3. Examine your completed table. What general trends can be made of trends within rows and groups for the following properties:
   a. density
   b. atomic radii
   c. melting point

4. Where are the heavy metals located? Give three examples.

5. List four physical properties that distinguish metals from non-metals

6. List the reason for the location of sodium in the periodic table.

7. Explain the relationship of oxidation number to electron configuration for Groups IA through VIIIA. How can an atom's electron configuration be predicted on the basis of its location in the periodic table?


Transition Metals

0.014	**3.5**	0.0009		1.82	**2.1**	5.9	**1.7**	0.0018		0.00009	**2.1**
A		**B**		**C**		**D**		**E**		**F**	
66	1312	*70*	2084	*110*	1013	*122*	579	*95*	1525	*53*	1312
gas	-218°C	gas	-249°C		44°C		29.8°C	gas	-189°C	gas	-259°C
5.32	**1.9**	1.85	**1.5**	0.862	**0.9**	0.0037		4.79		1.55	**1.0**
G		**H**		**I**		**J**		**K**		**L**	
122	762	*111*	897	*231*	415	*110*	1351	*117*	946	*197*	589
	937°C		1278°C		64°C	gas	-157°C		217°C		839°C
0.0013		2.33		0.003		0.534	**1.0**	0.207	**2.5**	2.07	**1.5**
M		**N**		**O**		**P**		**Q**		**R**	
70	1400	*117*	782	*99*	1254	*152*	521	*104*	1004	*143*	577
gas	-210°C		1410°C	gas	-101°C		181°C		113°C		660°C
0.971	**1.0**	1.74		2.27	**2.5**	0.0016	**4.0**	3.12	**2.8**	0.00018	
S		**T**		**U**		**V**		**W**		**X**	
192	496	*160*	738	*77*	1090	*64*	1680	*114*	1139	*50*	2374
	98°C		649°C		3550°C	gas	-219°C	liq	-7°C	gas	-272°C
				+1		+2,+4		+3,+5		0	
5.7	**2.1**	2.43	**2.0**	1.53	**0.9**	7.31		6.69	**1.9**	0.0059	
Y		**Z**		*		*		*		*	
121	946	*88*	801		405	*140*	740	*141*	830	*130*	1168
	817°C		2079°C		39°C		232°C		631°C	gas	-112°C
-1		+2,+4		+3,+5				–2,+4,+6		+1,+3	
	2.1	9.4	**1.9**	9.75		1.87	**0.8**	6.24	**2.1**	7.31	**1.6**
*		*		*		*		*		*	
140	897	*150*	811	*146*	704	*262*	376		869	*162*	560
	302°C		254°C		271°C		28°C		450°C		157°C
–1		+1,+3		0		+2		+2,+4			
4.93	**2.5**	11.85		0.0097		3.5		11.3	**1.7**	2.54	**1.0**
*		*		*		*		*		*	
133	1013	*171*	589		1030		502	*175*	714	*215*	550
			304°C	gas	-71°C		725°C		328°C		769°C

KEY	Oxidation (charge) #	Atomic Number
	Density (g/cc)	**Electronegativity**
	LETTER	**Atomic Symbol**
	Atomic Radius (pm)	Ionization Energy (kJ/mol)
	Phase (solid unless indicated)	Melting Point (°C)