The Periodic Table

In 1869, aware of the need to organize elements in a meaningful way, Dmitri Mendeleev developed a classification scheme based upon increasing molar mass. Elements that demonstrated similar patterns of chemical behavior were placed into one of eight groups. Members of these groups were displayed in vertical columns of his periodic table. Even though his chart was incomplete, Mendeleev was able to predict the properties of elements yet to be discovered. Over the next two years, Mendeleev published modified versions of his original periodic table.

Today's periodic table accommodates at least 49 additional elements. Although the scheme is based upon increasing atomic number, the arrangement of elements within the chart is similar in organization to the table published by Mendeleev in 1871. Trends in the chemical and physical properties of elements may be seen as a periodic function of electron configuration.

In this exercise, you will examine several properties of elements and observe how these properties may be interpreted in respect to periodic law. Your knowledge of the modern periodic table and facts about the elements will then allow you to construct the periodic table published by Mendeleev in 1871.

OBJECTIVES

1. to understand the relationship between electron configuration and the location of an element within the periodic table
2. to examine and graph periodic trends in atomic radii and the first ionization energies
3. to construct the periodic table published by Mendeleev in 1871 according to a list of clues and your knowledge of the modern periodic table

MATERIALS

Apparatus

pencil
ruler
textbook

PRELAB

Answer questions 1-5 on the Report Sheet.

PROCEDURE

Part I

1. Locate the upper section of the periodic table illustrated in Part I of the Report Sheet. For each of the elements listed, write its electron configuration within the appropriate box.

Part II

1. Using the data listed in Table 1 and the first grid supplied in Part II of the Report Sheet, plot the atomic radius of each element against increasing atomic number. The atomic radii shown here are given in nanometers.

$$1 \text{ nm} = 1 \times 10^{-9} \text{ m}$$

2. Plot the first ionization energy of each element against increasing atomic number on the second grid supplied in Part II of the Report Sheet.

Table 1

ELEMENT	ATOMIC NUMBER	ATOMIC RADIUS (nm)	FIRST IONIZATION ENERGY (kJ/mol)
hydrogen	1	0.037	1312
helium	2	0.05	2372
lithium	3	0.152	519
beryllium	4	0.111	900
boron	5	0.088	799
carbon	6	0.077	1088
nitrogen	7	0.070	1406
oxygen	8	0.066	1314
fluorine	9	0.064	1682
neon	10	0.070	2080
sodium	11	0.186	498
magnesium	12	0.160	736
aluminum	13	0.143	577
silicon	14	0.117	787
phosphorus	15	0.110	1063
sulfur	16	0.104	1000
chlorine	17	0.099	1255
argon	18	0.094	1519
potassium	19	0.231	418
calcium	20	0.197	590

Part III

1. The positions of the 59 elements found on Mendeleev's 1871 version of the periodic table are coded for the chart shown in Part III of the Report Sheet. The following clues are taken from various places throughout your text (Heath Chemistry). You will be expected to use your text as a reference in using the clues given to identify the coded elements. The index of your text will be very useful in your search. Identify each element and write the name in the correct position on this chart.

1A has a single electron in the 1*s* sublevel.
1B derived its name from the Latin word for stone *lithos.*
1C can be collected as a silver liquid in the electrolysis of table salt.
1D has a first ionization energy of 418 kJ/mol.
1E has a density of 8.96 g/cm^3.
1F is the first alkali metal with a completed 3*d* sublevel.
1G was originally identified by its Latin name, *argentum.*
1H is an alkali metal located in period 6 of the modern periodic table.
1I derived its name from the Latin word for shining dawn, *aurum.*
2A was used as a target substance in the experiments by Irene Joliot-Curie.
2B is an alkaline earth metal located in period 3.

2C is the metallic component of the substance limestone.
2D is a transition metal with 30 protons.
2E is represented by the symbol Sr.
2F possesses a nuclear charge of +48.
2G is an alkaline earth metal found in period 6 of the modern periodic table.
2H is a liquid metal, originally called *hydragyrum.*
3A has a single electron in the 2*p* sublevel.
3B is a lightweight metal with a molar mass of 26.98 grams.
3C is a transition metal with an atomic number of 39.
3D is a metal represented by the symbol In.
3E is the first member of the rare earth metals.
3F is found in group 13 and period 6 of the modern periodic table.
4A is the element whose common isotopic form is the basis of the atomic mass unit.
4B has a second ionization energy of 1577 kJ/mol.
4C is located between scandium and vanadium on the modern periodic table.
4D is represented by the symbol Zr.
4E derives its symbol from the Latin word *stannum.*
4F is a very dense metal with an atomic mass of 207.2 amu.
4G is the second member of the actinide series.
5A is the most abundant element in the atmosphere.
5B has 3 electrons in the 3*p* sublevel.
5C is a byproduct of fossil-fuel oxidation and represented by the symbol V.
5D is a period 4 nonmetal known since 1650.
5E is a member of both group 5 and period 5 of the modern periodic table.
5F was originally called *stibium.*
5G is located in period 6 of the modern periodic table, beneath niobium.
5H is a metal with atomic number 83.
6A is the most abundant element in Earth's crust.
6B is a member of group 16, known during the time of the Roman empire.
6C is the first member of group 6 on the modern periodic table.
6D is represented by the symbol Se.
6E has 42 protons within its nucleus.
6F is a halogen whose crystals sublime.
6G was originally called wolfram.
6H is the fourth member of the actinide series.
7A has an atomic radius of 0.099 nm.
7B is represented by the symbol Mn.
7C forms a diatomic gas with a molar mass of 160 amu.
7D has a molar mass of 127.6 grams.
8A is a group 8 metal known during the time of the Roman empire.
8B is an element named after the German word for Satan.
8C has an average atomic mass of 59 amu.
8D is located between iron and osmium on the modern periodic table.
8E has a nuclear charge of +44.
8F has an atomic mass of 106.4 amu.
8G has 114 neutrons within its nucleus.
8H is named after the Latin word for rainbow, *iris.*
8I is an inert metal often used in electrodes and has an atomic number of 78.

The Periodic Table

Name _____

Class _____ Date _____

EXPERIMENT 11A REPORT SHEET

PRELAB QUESTIONS

1. Why was the periodic table developed? _____

2. How was Mendeleev's scheme for listing elements different from that used in the modern periodic table? _____

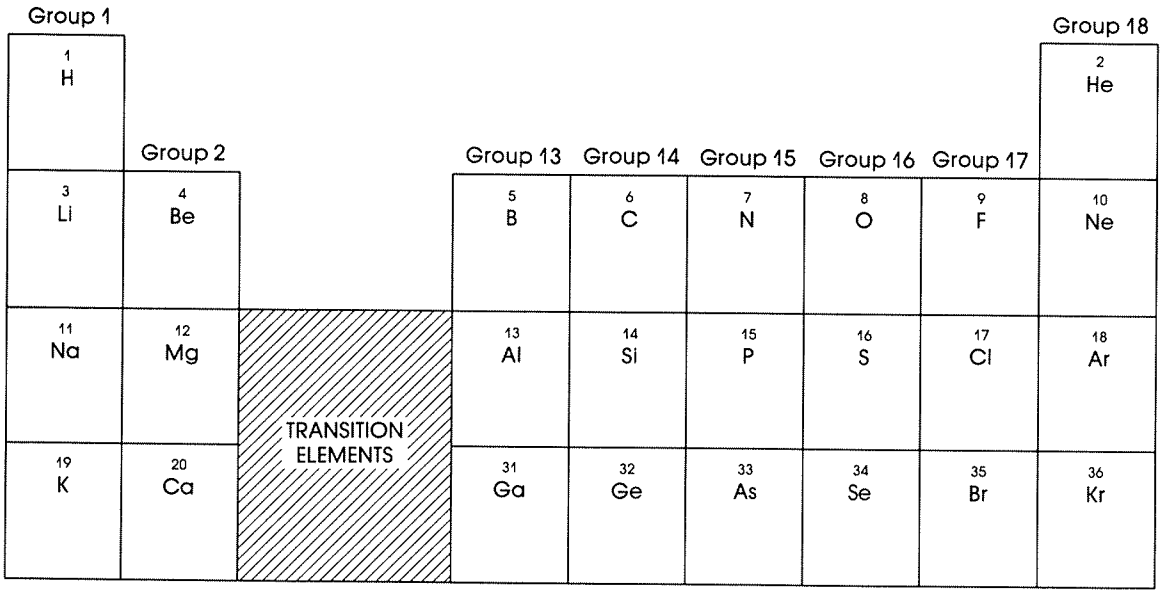
3. What is meant by the term first ionization energy? _____

4. Which version of Mendeleev's periodic table will you construct in Part III of this exercise? _____

5. Which two atomic properties will you examine for periodic trends? _____

DATA AND OBSERVATIONS

Part I



Representative Elements of Periods 1–4

Figure 11A-1 *Representative elements of periods 1-4*

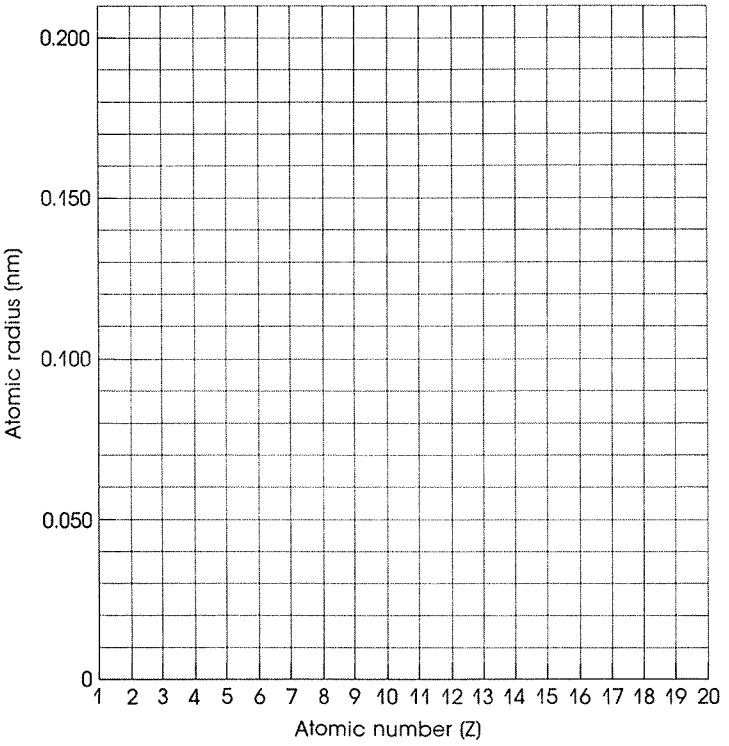


Figure 11A-2 *Atomic radius graph*

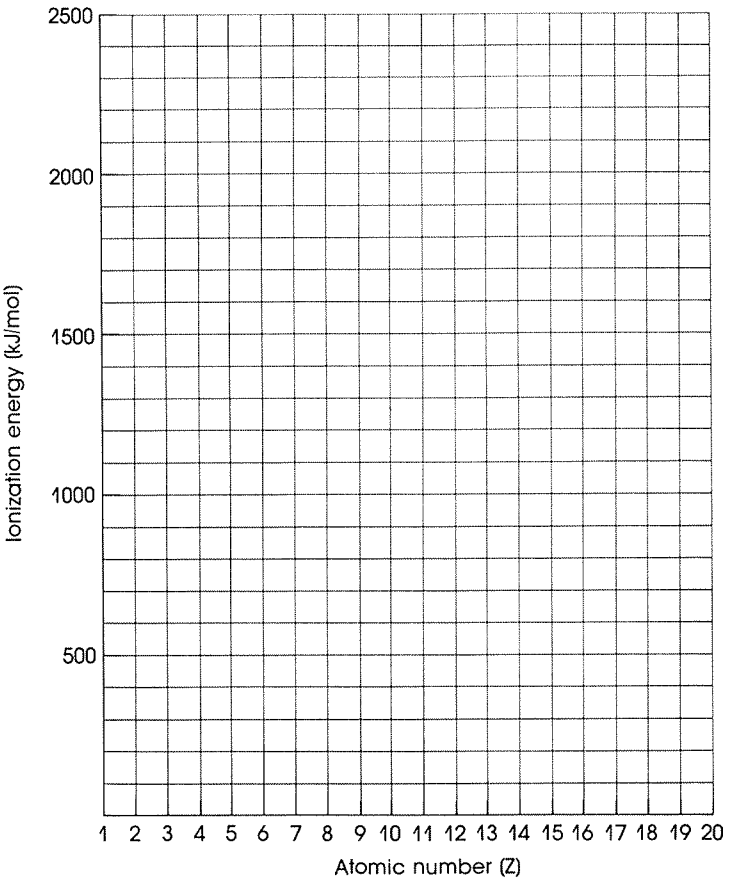
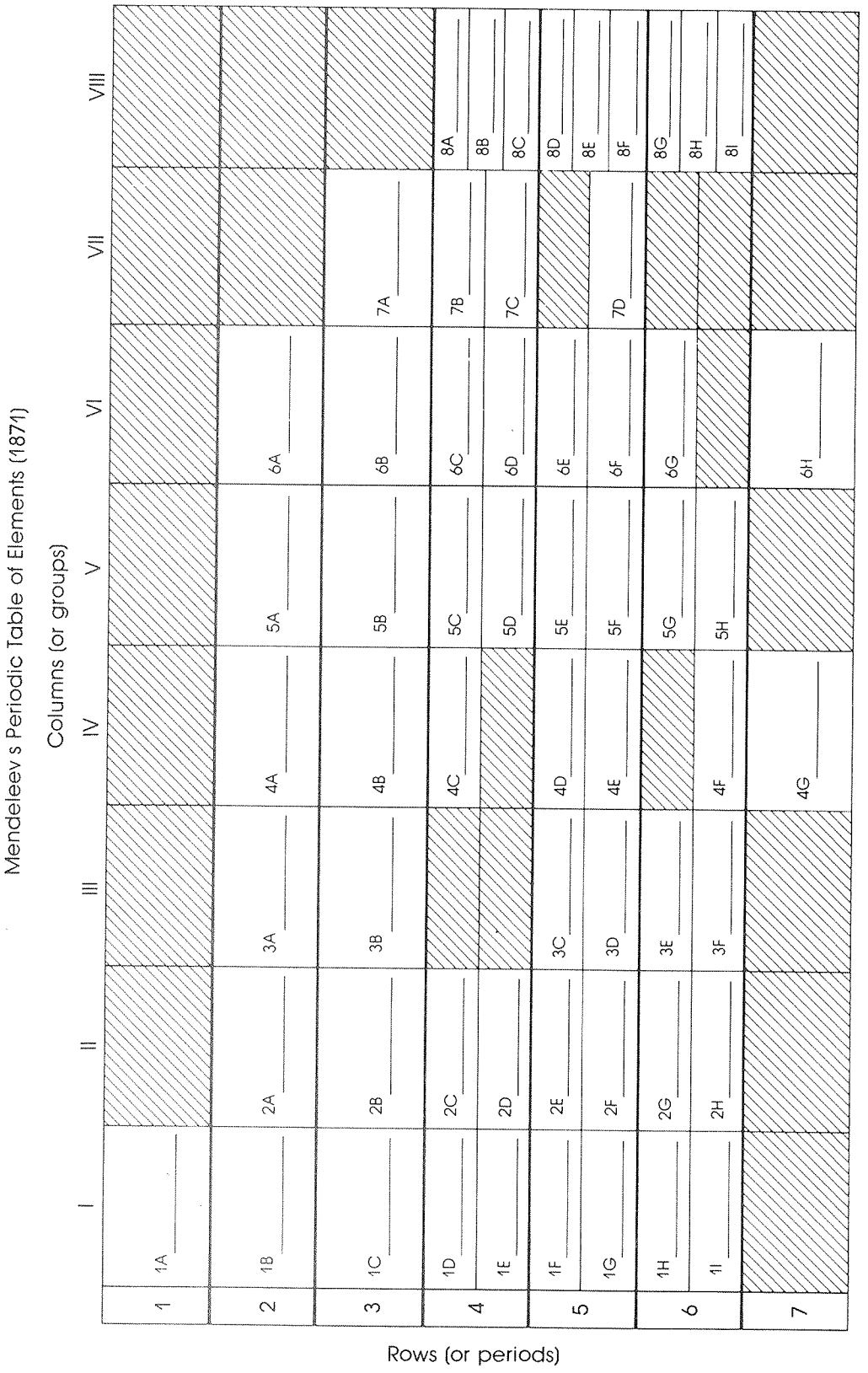


Figure 11A-3 *Ionization energy graph*

Figure 11A-4



CONCLUSIONS

1. Examine the placement of electron configurations in Part I of the Report Sheet. What relationship can be seen in an element's placement within a group and its electron configuration? _____

2. Examine the graph form of atomic radius plotted against increasing atomic number (Part II, Step 1). Can a periodic tendency be observed? If so, describe the indicated trend. _____

3. Which group appears to have members of the largest atomic radii for a given period? Which group has the smallest radii? _____

4. Examine the graph form of ionization energy plotted against increasing atomic number (Part II, Step 2). Can a periodic tendency be observed? If so, describe the indicated trend. _____

SYNTHESIS

1. No members of group 18 of the modern periodic table can be found on Mendeleev's classification chart. Suggest a reason for their absence. _____

2. What factor may account for the observed trend in atomic radii as one proceeds across the period? _____