

Experiment 4

Elements and the Periodic Table

Purpose

- To become familiar with the periodic table, and its organization, and the properties of elements including subatomic particles.
- To observe the characteristic colors produced by certain metallic ions when vaporized in a flame and then to identify an unknown metallic ion by means of a flame test.
- To combine two metals together to make an alloy.

Background

In this experiment, you will be looking at some elements in the laboratory. Some look different from each other, while others look similar. Elements can be categorized in several ways. In this experiment, you are going to group elements by similarities in their physical properties. Elements that appear shiny or lustrous are called **metals**. Metals are also usually good conductors of heat and electricity. Other elements called **nonmetals** are not good conductors of heat and electricity, are brittle, and appear dull (not shiny).

Certain groups of elements have common names that you should become familiar with. These include the alkali metals (Group 1A), the alkali earth metals (Group 2A), the halogens (Group 7A), and the noble gases (Group 8A). These groups, like all vertical groups on the periodic table, contain elements that are similar to one another.

Atoms are made of even smaller particles of matter called subatomic particles. A large number of subatomic particles are now known, but we are primarily interested in protons (p^+), neutrons (n), and electrons (e^-). Protons are positively charged particles ($1+$), electrons are negatively charged particles ($1-$), and neutrons are neutral (charge = 0). Within the atom, the protons and neutrons are tightly packed together in the **nucleus**. Electrons are outside of the nucleus and occupy the rest of the atom, which is mostly empty space. Atoms of a particular element always contain the same number of protons in the nucleus. The number of protons in an atom is called the **atomic number** (Z). For example, atoms of the element hydrogen always have one proton in their nuclei, while atoms of the next element, helium, always have two protons in their nuclei. Atoms of the element carbon similarly contain six protons, and atoms of iron have 26 protons. In a neutral atom, the number of protons is equal to the number of electrons. The sum of the number of protons and neutrons in the nucleus of an atom is called the **mass number** (A) of the atom.

For an atom:

$$\text{Atomic number } (Z) = \text{number of protons} = \text{number of electrons}$$

$$\text{Mass Number } (A) = \text{number of protons} + \text{number of neutrons}$$

In this activity you will also investigate the colors of flame produced by solutions of metallic ions. When a metallic ion is excited by heating it in a flame, the metal ions will begin to emit light. We will use our flame test to identify what metal ion is in an unknown sample. This technique of using certain metallic ions to color flames is widely used in pyrotechnics to produce the range of colors seen in a firework display.

We will also be creating an alloy in this experiment. An alloy is a mixture of metals. For example, brass is a mixture of zinc and copper while bronze is a mixture of copper and tin

Procedure

Part A. Comparison of Physical Properties of Elements.

1. Gather samples of the elements below and then complete the table below by writing the name, atomic number, and color for each element. Also indicate whether the element is shiny or dull, and whether it is a metal, nonmetal or metalloid.

Element	Symbol	Atomic number	Color	Luster (Shiny or dull)	Metal, nonmetal or metalloid
Aluminum					
Carbon					
Copper					
Iron					
Magnesium					
Nickel					
Nitrogen					
Oxygen					
Phosphorus					
Silicon					
Silver					
Sulfur					
Tin					
Zinc					

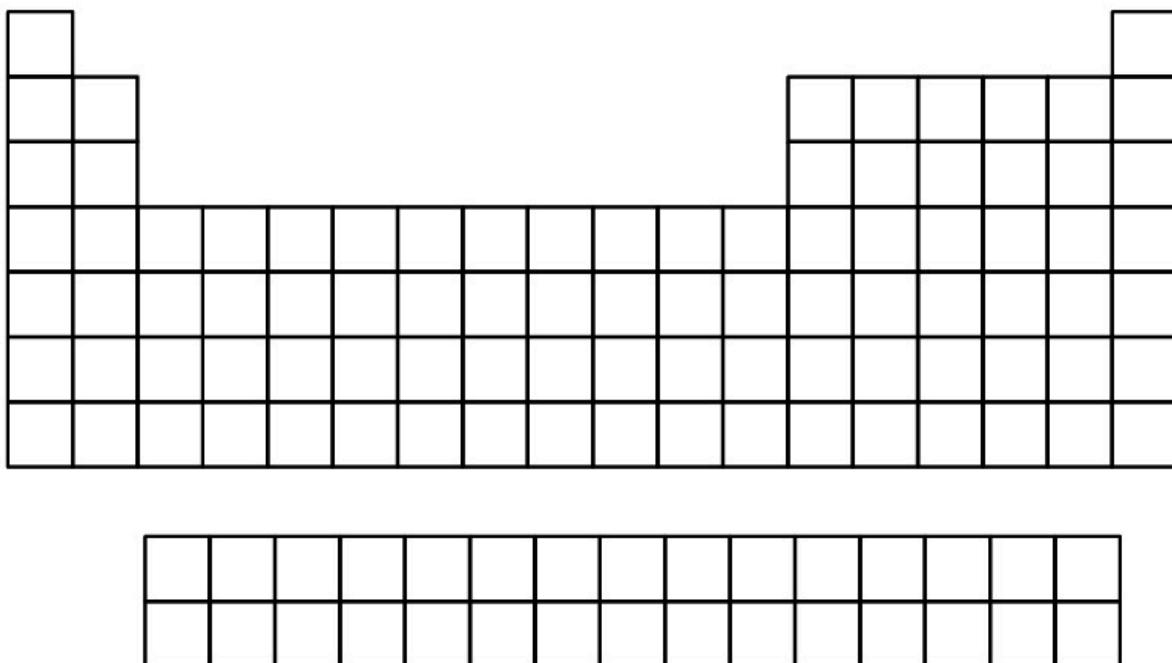
Predicting Properties Based on Location in the Periodic Table

2. Use the location of the given elements in the periodic table to predict whether the elements listed below would be a metal or non-metal and shiny or dull. After you have completed your predictions, observe those same elements on the front counter to see if your predictions are correct.

Element	Metal or Nonmetal?	Prediction: Shiny or Dull?	Prediction Correct? Yes or No
Chromium			
Gold			
Lead			
Cadmium			

Parts of the Periodic Table

3. Using the colored pencils provided in the lab, shade.
- the halogens blue
 - the alkali metals red
 - the noble gases purple
 - the alkali earth metals orange
 - the transition metals yellow
- d. Draw a dark line to separate the metals from the nonmetals



Part B. Atoms and Subatomic Particles

1. Using your known regarding the parts of an atom, complete the following table with the correct atomic numbers, mass numbers, and number of protons, electrons, and neutrons for the neutral atom of each element

Note: This table deals with atoms only- not ions.

Element	Symbol	Atomic Number	Mass number	Protons	Neutrons	Electrons
	Cu				34	
			33			16
				11	23	
Iron			58			
	Ti		47			

2. Complete the table below with the number of protons, electrons, neutrons, and complete atomic notation (showing the mass number and atomic number) for each neutral atom

Isotope name	Atomic notation (symbol with mass number and atomic number)	Protons	Neutrons	electrons
	$^{39}_{19}\text{K}$			
	$^{80}_{35}\text{Br}$			
		33	42	
Sulfur-31				

Part C. Flame test of metals and identification of an unknown metal

SAFETY: Students must wear safety goggles at all times.

WASTE DISPOSAL: All chemicals used must go in the proper waste container for disposal.

Procedure:

1. Place 10 drops of the solutions listed in the table below in a spot plate.
2. Light the Bunsen Burner and adjust it so that it has a hot blue flame which may appear almost colorless.
3. Clean a nichrome testing wire with cork handle by dipping it in hydrochloric solution (1.0 M HCl) for one minute.
4. Dip the cleaned nichrome wire in the solutions to be tested. You should see a thin film or bubble of the solution adhering to the wire.
5. Place the wire with sample in the hottest part of the flame (tip of the inner blue cone), and record the color produced. The color may not last long so look carefully. Element should produce only one major color. Clean the wire after each test by dipping it in the HCl solution.
6. When you have tested all the known solutions and can distinguish the color of each metal ion, obtain unknown solutions and determine which metal ions are present by performing a flame test and comparing your observations to your previous data.

Solution	Metallic element that is producing color	Color of Flame
SrCl_2		
BaCl_2		
CaCl_2		
KCl		
NaCl		
CuCl_2		

Unknown number	Color of Flame	Identity of metallic element that is producing color

Part D. Conversion of a penny into an alloy.

Safety: Zinc chloride solution and granular zinc are severe skin irritants. Zinc metal dust is very flammable; there may be zinc dust present at the bottom of the granular zinc container. Do not use zinc dust in this procedure.

Wear goggles, chemical resistant gloves and a chemical-resistant apron.

Wash hands thoroughly with soap and water before leaving the laboratory.

Waste: Put used zinc solution in the waste container.

Procedure

1. Weigh out and place 2.5–3.0 g of sodium chloride and 15 mL of vinegar in a clean, 100-mL beaker.
 2. Clean two pennies by placing them in the sodium chloride/vinegar solution until they are shiny.
 3. Remove the pennies using tongs and rinse them thoroughly with water. Dry completely with a towel.
- Note: Do not handle the clean pennies with your hands. The oils from your skin may interfere with the zinc-plating reaction.*
4. In a clean 100-mL beaker, mix together 1.0 g of granular zinc and 20 mL of 1.0 M zinc chloride solution.
 5. Place the beaker with the ZnCl_2 and zinc on a hot plate set to a medium heat setting.
 6. Carefully and gently heat the mixture until the solution boils.
 - 7.. Using tongs, immerse two pennies in the mixture until they appear “silver.”
 8. Use tongs to remove the pennies from the solution. Caution: The pennies will be very hot.
 9. Carefully dip the pennies into a beaker of distilled water to cool them.
 10. Using tongs, place one of the treated penny on the hot plate until the penny turns to a golden color. Using tongs, flip the penny every 30 seconds to avoid burning.
 11. Use tongs to remove the penny from the hot plate and immediately dip the penny into a fresh beaker of distilled water. The penny will be extremely hot and should be handled with tongs until it has cooled for several minutes.

Questions

- 1a. What metal is on the outside of a normal penny?

- b. Is this metal an element, compound or alloy?

- 2a. When you were done with this part of the experiment you created an alloy. What is an alloy?

- b. What is the name of the alloy you created?

Post-Lab Questions

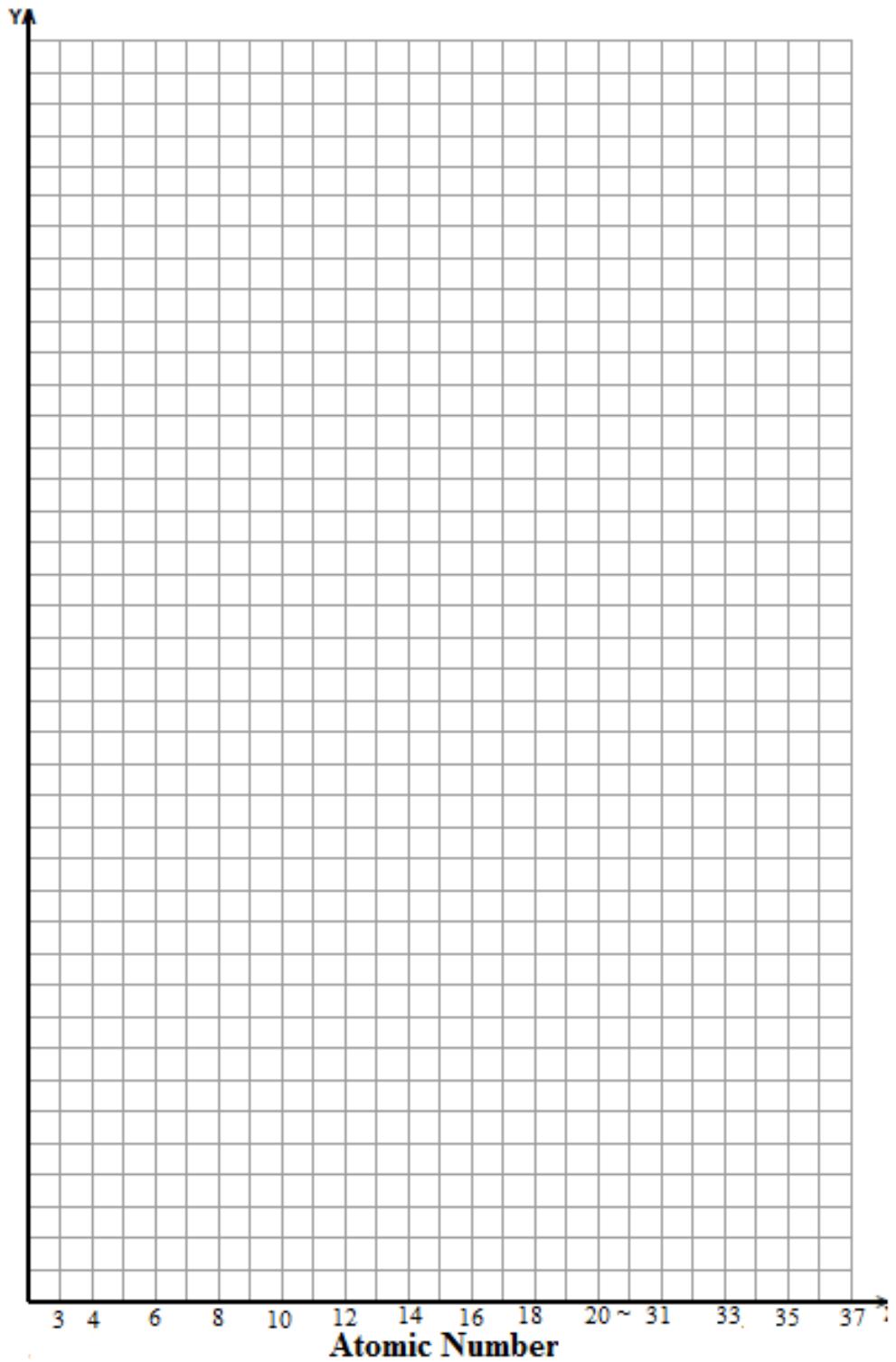
1. Write the name and symbols of

- a. the halogen in period 4 _____
- b. the alkali metal in period 2 _____
- c. the metalloid in period 3 _____
- d. the noble gas in period 1 _____

2. Calculate the average atomic mass of sulfur if 95.00% of all sulfur atoms have a mass of 31.972 amu, 0.76% has a mass of 32.971 amu and 4.22% have a mass of 33.967 amu. Show work.

3. On the graph paper on the next page, plot the atomic radius (y- axis) for elements 1-24 versus atomic number (x- axis) and then answer the question that follow.

Symbol	Atomic Number	Atomic Radius (Picometers)	Symbol	Atomic Number	Atomic Radius (Picometers)
H	1	53	Al	13	118
He	2	31	Si	14	111
Li	3	167	P	15	98
Be	4	112	S	16	88
B	5	87	Cl	17	79
C	6	67	Ar	18	71
N	7	56	K	19	243
O	8	48	Ca	20	194
F	9	42	Sc	21	184
Ne	10	38	Ti	22	176
Na	11	190	V	23	171
Mg	12	145	Cr	24	166



- a. What trend do you notice in atomic radius as you go across a period on the periodic table?

Name _____

Pre-Lab Assignment for Periodic Table and Elements

1. What is the symbol for the following elements?

a. Magnesium _____

b. Phosphorus _____

c. Iron _____

d. Copper _____

2. For the following elements, give their name and their atomic number.

Name	Atomic Number
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a. F	_____	_____
b. P	_____	_____
c. K	_____	_____
d. Co	_____	_____

3. What is the **name** of the **group** that contains the following elements (*halogens, noble gases, alkali metals, alkali earth metals*) ?

a. lithium _____ b. Ca _____

c. chlorine _____ d. Ar _____

4. Classify each of the following as a metal, nonmetal, or metalloid.

a. sodium _____ b. silicon _____

c. nitrogen _____ d. copper _____

5. **Circle** the metals in the following group.

C Ca Br Co Ni Ar Li Al O

6. Are the following statements regarding electrons true or false?

- (True/False) Electrons have a charge of 1-.
- (True/False) If an atom has an equal number of protons and electrons, it will be neutral.
- (True/False) Electrons are found in the nucleus of the atom.

7. Are the following statement regarding protons true or false?

- (True/False) Protons have the same mass as electrons.
- (True/False) Protons are positively charged.
- (True/False) Protons are found in the nucleus of the atom.

8. Determine the number of protons and neutrons and each of the following

	Protons	Neutrons	Electrons
a. $^{41}_{20}\text{Ca}$	_____	_____	_____
b. $^{55}_{26}\text{Fe}$	_____	_____	_____
c. $^{23}_{11}\text{Na}$	_____	_____	_____
d. $^{18}_8\text{O}$	_____	_____	_____

9. Define the term "atomic radius"