

The Periodic Table

Pre-Lab Assignment

Before coming to lab:

- Read the lab thoroughly.
- Answer the pre-lab questions that appear at the end of this lab exercise.

Purpose

Periodic trends in reactivity and other physical properties will be determined by qualitative observation. A variety of inorganic compounds, including predictable and unpredictable ionic compounds, binary molecular, acids, and polyatomic ions will be named systematically.

Background

In 1869 Russian chemist Dmitri Mendeleev published the forefather to the modern periodic table in which he arranged the known elements by increasing atomic mass, leaving gaps where he predicted elements not yet discovered would be found. While doing so, Mendeleev noted that elements in close proximity to one another often shared predictable chemical and physical properties, known as periodic trends.

On the periodic table, horizontal rows are known as periods while columns are known as groups or families. Some groups are known by their common names. Group 1A is also known as the Alkali Metals, Group 2A as the Alkaline Earth Metals, Group 7A as the Halogens and Group 8A as the Noble Gases. Main Group elements are designated with an "A" in their group name and are on the edges of the table while transition metals have a "B" and are in the middle. Metals are located on the left of the periodic table and nonmetals on the right, with metalloids straddling the line in between.

When multiple atoms combine, they create a molecule that is held together by chemical bonds. Ionic bonds involve the exchanging of electrons between a metal and a nonmetal. Covalent bonds involve the sharing of electrons between a nonmetal and another nonmetal. The Law of Constant Compositions states that every molecule of a given compound has exactly the same ratio of elements. Thus standardized rules for identifying compounds, called nomenclature, can and has been established.

Ionic compounds are divided into two categories: those with predictable cations, meaning metals from Groups 1A-3A or polyatomic ions, and those with unpredictable cations, meaning transition metals. The format for naming these compounds is shown below.

For predictable:

full name of cation _ *base name of anion + ide*

For unpredictable:

cation(charge) _ *base name of anion + ide*

the charge is written in Roman Numerals

Polyatomic ions are groups of atoms that behave as a single unit and carry a shared overall charge. Some common polyatomic ions are included in Table 1. They can be substituted for any cation or anion in an ionic compound. Oxyanions (polyatomic ions that include oxygen and carry negative charges) can change the number of oxygens present and thus change their prefix and/or suffix in a predictable pattern while their overall charge is maintained.

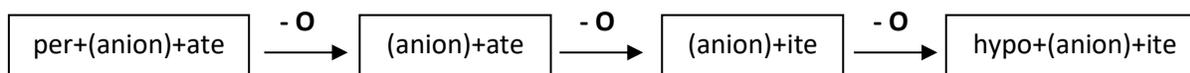


Table 1: Common Polyatomic Ions

4 oxygens	3 oxygens	2 oxygens	1 oxygen	0 oxygens
PO ₄ ³⁻ , phosphate	PO ₃ ³⁻ , phosphite	PO ₂ ³⁻ , hypophosphite		
	CO ₃ ²⁻ , carbonate	CO ₂ ²⁻ , carbonite	CO ²⁻ , hypocarbonite	
SO ₄ ²⁻ , sulfate	SO ₃ ²⁻ , sulfite	SO ₂ ²⁻ , hyposulfite		
		CH ₃ COO ⁻ or C ₂ H ₃ O ₂ ⁻ , acetate		
	NO ₃ ⁻ , nitrate	NO ₂ ⁻ , nitrite	NO ⁻ , hyponitrite	
ClO ₄ ⁻ , perchlorate	ClO ₃ ⁻ , chlorate	ClO ₂ ⁻ , chlorite	ClO ⁻ , hypochlorite	
	BrO ₃ ⁻ , bromate	BrO ₂ ⁻ , bromite	BrO ⁻ , hypobromite	
	IO ₃ ⁻ , iodate	IO ₂ ⁻ , iodite	IO ⁻ , hypoiodite	
			OH ⁻ , hydroxide	
				NH ₄ ⁺ , ammonium

Binary molecular compounds are named with the most metallic (furthest left and down on the periodic table) listed first with the exception of oxygen, which is always listed last. Since molecular compounds do not contain charges, the exact number of atoms of each element must be explicitly included in the name through the addition of Greek numerical prefixes, as seen in Table 2.

(prefix*+)first element name _ (prefix+)second element base

no prefix of "mono-" is used for the first element

Table 2: Prefixes for Molecular Compounds

Number	Prefix	Number	Prefix
1	mono-	6	hexa-
2	di-	7	hepta-
3	tri-	8	octa-
4	tetra-	9	nona-
5	penta-	10	deca-

Acids are molecular compounds that produce H^+ (hydrogen ion) when dissolved in aqueous solution. They contain charges and their name is dependent on the suffix of the anion included.

For "-ide": (hydro)anion base name(+ic) _ acid

For "-ite": anion base name(+ous) _ acid

For "-ate": anion base name(+ic) _ acid

Example Exercise: Naming Compounds

Name the following: (1) $CaCl_2$, (2) AgO , (3) P_2O_4 , and (4) $HClO_2$.

(1) $CaCl_2$ is an ionic compound with a predictable cation (Ca is in Group 2A, +2).

→ **calcium chloride**

(2) AgO is an ionic compound with an unpredictable cation (Ag is a transition metal)
O is in Group 6A so -2, thus Ag must be +2 to balance its charge

→ **gold(II) oxide**

(3) P_2O_4 is a molecular compound (both nonmetals)

→ **diphosphorous tetroxide**

(4) $HClO_2$ is an acid with an "-ite" suffix (ClO_2^- = chlorite)

→ **chlorous acid**

Procedure

Part I: Metals with Water

Instructor Demonstration: Your laboratory instructor will demonstrate the reaction of sodium metal in water. Note your observations on your Data Sheet.

Caution! These reactions may be vigorous and produce flammable $\text{H}_2(\text{g})$!

1. Obtain one small piece of calcium and one small piece of magnesium. Store these on a plastic weigh boat until use.
2. Fill a 250 mL beaker approximately half full with tap water. Find a watchglass that will fit on top of the beaker and set it aside.
3. Carefully put the piece of calcium into the beaker of water and immediately cover the top with the watchglass. Observe any changes that take place and record your observations in your data sheet.
4. After the reaction has completed, dispose of the beaker's contents in the specified waste container and refill the beaker halfway with tap water.
5. Carefully put the piece of magnesium into the beaker of water and immediately cover the top with the watchglass. Observe any changes that take place and record your observations in your data sheet.
6. After the reaction has completed, dispose of the beaker's contents in the specified waste container.
7. Summarize your observations about their reaction with water into a periodic trend for the three metals observed: sodium, magnesium, and calcium.

Part II: Observations of Elements

1. Take observations of the elements listed and complete the table on your data sheet.

Part III: Nomenclature of Compounds

1. Complete pages 5-5 to 5-7.

Experiment 4—Data Sheet

Name: _____

Part I: Metals with Water

1. Sodium with water Observations:

2. Calcium with water Observations:

3. Magnesium with water Observations:

4. Summarize metals' reactivity with water

Part II: Observations of Elements

Element	Symbol	Metal, Metalloid, or Nonmetal	Description
Aluminum			
Carbon			
Copper			
Iron			
Magnesium			
Nickel			
Nitrogen			
Oxygen			
Phosphorous			
Silicon			
Silver			
Sulfur			
Tin			
Zinc			

Part III: Nomenclature of Compounds

Name the following compounds appropriately.

1. NaCl _____
2. AgNO₃ _____
3. Ca(OH)₂ _____
4. Na₂SO₄ _____
5. CdBr₂ _____
6. KNO₂ _____
7. Fe(NO₃)₃ _____
8. (NH₄)₃PO₄ _____
9. MgS _____
10. (NH₄)₂S _____
11. HgCl₂ _____
12. H₂SO₄(aq) _____
13. Cr(BrO₃)₃ _____
14. Cu₂CO₃ _____
15. HCl(aq) _____
16. CO₂ _____
17. H₂O₂ _____
18. KIO₂ _____
19. V₂O₅ _____
20. Na₂SO₃ _____
21. Ta(NO₂)₅ _____
22. Ag₂CO₃ _____
23. CrF₃ _____
24. ZrS₂ _____
25. H₂CO₂(aq) _____
26. Au(ClO₃)₃ _____
27. HC₂H₃O₂(aq) _____

Give the balanced ionic or molecular formulas for the following compounds.

1. barium chloride _____
2. lead(II) iodide _____
3. ammonium hydroxide _____
4. bismuth(III) chloride _____
5. magnesium nitrate _____
6. iron(III) chloride _____
7. calcium bromite _____
8. copper(I) sulfide _____
9. silver phosphite _____
10. nickel(II) phosphate _____
11. sodium sulfite _____
12. tin(IV) oxide _____
13. zinc nitrite _____
14. titanium(IV) iodate _____
15. manganese(IV) sulfide _____
16. phosphoric acid _____
17. hypochlorous acid _____
18. ammonium cyanide _____
19. hydrobromic acid _____
20. barium hydroxide _____
21. carbon tetrachloride _____
22. sulfur dioxide _____
23. carbonic acid _____
24. zinc phosphite _____
25. yttrium(III) oxide _____
26. nitrous acid _____
27. chromium(III) sulfite _____
28. carbon disulfide _____

Experiment 4—Post-Lab Assignment

1. Using the trend you observed in Part I, predict and explain whether the following elements would be reactive with water:

a. Barium, Ba

b. Aluminum, Al

c. Argon, Ar

2. Using the trend you observed in Part II, predict and explain whether the following elements would be reactive with HCl:

a. Strontium, Sr

b. Sodium, Na

3. Generally, metals are able to conduct electricity while nonmetals do not. What would you expect for metalloids? Explain.

Experiment 4—Pre-Lab Assignment

Name: _____

1. Consider the element silicon, Si.

- a. Is it a metal, nonmetal, or metalloid? _____
- b. What group is it in? _____
- c. What period is it in? _____
- d. Is it a main group element or transition metal? _____
- e. When bonded with O, would it form an ionic or covalent compound?

2. Consider the element rubidium, Rb.

- a. Is it a metal, nonmetal, or metalloid? _____
- b. What group is it in? _____
- c. What period is it in? _____
- d. Is it a main group element or transition metal? _____
- e. What charge would it have as an ion? _____
- f. When bonded with O, would it form an ionic or covalent compound?

3. Label the following compounds as molecular or ionic and name them appropriately.

