

PERIODIC TRENDS IN THE PROPERTIES OF ELEMENTS

The Alkaline Earth Metals

NAME: _____

INTRODUCTION:

The periodic table is the most recognized symbol of chemistry across the world. It is a valuable tool that allows scientists not only to classify the elements but also to explain and predict their properties. Similarities and differences among the elements give rise to so-called **periodic trends**, both across rows and within columns of the periodic table. Recognizing periodic trends in the physical and chemical properties of the elements is key to understanding the full value of the periodic table.

BACKGROUND:

The modern periodic table lists more than 112 elements, of which 92 are naturally occurring. Of these 92 elements, the eight most abundant elements together account for more than 98 percent of the mass of the Earth's crust, oceans, and atmosphere. Two of the eight most abundant elements on Earth are calcium and magnesium, which are present in both mountains and minerals, seawater and seashells. Calcium and magnesium are members of the Group 2A family of elements, the alkaline earth metals. Elements that share similar properties are arranged together within vertical columns, called groups or families, in the periodic table.

The alkaline earth metals—beryllium, magnesium, calcium, strontium, barium, and radium—are a reactive group of metals. Because they combine easily with many other elements, the alkaline earth elements are not found on Earth in the form of their free metals. They exist in nature in the form of ionic compounds, such as calcium carbonate, CaCO_3 . Calcium carbonate occurs naturally in limestone, marble, and seashells.

The alkaline earth metals react with water, acids and bases, and many nonmetals, including oxygen, sulfur, and the halogens. The ease with which a metal reacts is called the **activity** of the metal. By comparing how fast or how vigorously different metals react, it is possible to rank the metals in order from most active to least active. This ranking—called the **activity series** of the metals—shows clear periodic trends, both within a group and across a period of elements in the periodic table.

Periodic trends are also observed in the **solubility** of alkaline earth metal compounds. Although their compounds with **halide anions** (negative ions of F, Cl, Br, and I) are all water-soluble, alkaline earth metal compounds with other anions do not always dissolve in water. The solubility of alkaline earth metal compounds with different anions can be tested by carrying out so-called **double replacement** reactions. Reaction of calcium chloride with sodium carbonate, for example, leads to an exchange of anions between the two metals to give calcium carbonate, which is insoluble in water and precipitates out as a solid when the two solutions are mixed. The **word equation** for this reaction is the following:

calcium chloride + sodium carbonate \rightarrow sodium chloride + calcium carbonate
(clear solution) (clear solution) (clear solution) (solid white precipitate)

EXPERIMENT OVERVIEW:

The purpose of this experiment is to identify periodic trends in the activity and solubility of the alkaline earth metals. In Part A, the reactions of magnesium, calcium, and aluminum with water and acids will be compared in order to determine the trend in metal activity within a group (Mg vs. Ca) and across a period (Mg vs. Al) in the periodic table. In Part B, the solubility of magnesium, calcium, strontium, and barium compounds will be studied and used to identify an unknown alkaline earth metal.

PRE-LAB QUESTIONS:

1) Locate the metals calcium, magnesium, potassium, sodium, and strontium on the periodic table and arrange them in order of increasing first ionization energy.

2) Describe the periodic trend in the ionization energy of elements as you proceed down a group on the periodic table. Give a reason for this trend.

3) Describe the periodic trend in the ionization energy of elements as you proceed across a period on the periodic table. Give a reason for this trend.

SAFETY PRECAUTIONS:

- 1) Calcium and magnesium are reactive, flammable solids and possible skin irritants. Use forceps or a spatula to handle these metals.
- 2) Hydrochloric acid is toxic by ingestion and inhalation and is corrosive to skin and eyes; avoid contact with body tissues.
- 3) Strontium and barium compounds are toxic by ingestion. Potassium iodate solution is moderately toxic and a strong irritant. Avoid contact of all chemicals with eyes and skin.
- 4) Wear chemical splash goggles and chemical-resistant gloves and apron.
- 5) Always wash hands thoroughly before leaving the laboratory.

PROCEDURE:**Part A. Activity of Metals**

- 1) In a small beaker, obtain 2 small pieces of calcium turnings, 2 small pieces of magnesium ribbon, approximately 1-cm each, and a short piece of aluminum foil.
- 2) Place a reaction plate on top of a sheet of white paper. Add 15 drops of distilled water to the first three wells of the reaction plate. Test the water in wells A1-A3 with a piece of red litmus paper and record the initial color for this "litmus test" in Data Table A.
- 3) Use forceps to add one piece of calcium (step 1) to the first well.
- 4) Use forceps to add one piece of magnesium ribbon to the second well.
- 5) Tear off a 2-cm piece of aluminum foil and roll it into a loose ball. Add the aluminum metal to the third well.
- 6) Observe each well and record all immediate observations in Data Table A. If no changes are observed in a particular well, write NR (No Reaction) in the data table.
- 7) Test the water in wells A1-A3 with a piece of red litmus paper and record the color changes for this litmus test in Data Table A.

- 8) Continue to watch each well for 1-2 minutes. Record any additional observations comparing the rates of reaction in Data Table A.
- 9) Add 15 drops of HCl (hydrochloric acid) to the first three wells in the next row of the reaction plate. Measure the initial temperature of the solutions in these wells and record the values as an "observation" in Data Table A.
- 10) Use forceps to add one piece of calcium turnings (Step 1) to the first well, one piece of magnesium ribbon to the second well, and a 2-cm piece of aluminum foil rolled it into a loose ball to the third well.
- 11) Observe each well and record all immediate observations in Data Table A. If no changes are observed in a particular well, write NR in the data table.
- 12) Using a thermometer, measure the temperature of each solution in the three wells. Record the temperature of each solution as an observation in Data Table A.
- 13) Bring a lit match to the space just above each of the three wells in the second row. Record any observations for this "match test" in Data Table A.
- 14) Continue to watch each well for 1~2 minutes. Record any additional observations comparing the rates of reaction in Data Table A.
- 15) Pour the well contents into the "waste beaker" under the hood. Rinse the reaction plate with distilled water before using the plate again in Part B.

DATA TABLE A. ACTIVITY OF METALS

Calcium + water	Magnesium + water	Aluminum + water
Observations:		
Litmus Test Before:		
Litmus Test After:		
Calcium + HCl	Magnesium + HCl	Aluminum + HCl
Observations:		
Match Test:		

PART B: SOLUBILITY OF ALKALINE EARTH METAL COMPOUNDS

- 1) Place the reaction plate on a black desktop.
- 2) Referring to Data Table B as a guide, use add 15 drops of alkaline earth metal solutions to the appropriate wells, as follows:
 - Magnesium chloride to wells A1-C1
 - Calcium chloride to wells A2-C2
 - Strontium chloride to wells A3-C3
 - Barium chloride to wells A4-C4.
- 3) Add 15 drops of the unknown alkaline earth metal solution to wells A5-C5.
- 4) Referring to Data Table B as a guide, add 15 drops of testing solution to the appropriate wells, as follows:
 - Sodium carbonate to wells A1-A5
 - Sodium sulfate to wells B1-B5
 - Potassium iodate to wells C1-C5
- 5) Record observations in Data Table B as follows: if a solid forms in a well, write PPT (precipitate) in the appropriate space in the data table. If no solid is observed, write NR (no reaction) in the appropriate space in the data table.
- 6) Dispose of the contents of the reaction plate in the "waste" beaker. Rinse the reaction plate with distilled water.

DATA TABLE B: Solubility of Alkaline Earth Metal Compounds:

	Magnesium Chloride (1)	Calcium Chloride (2)	Strontium Chloride (3)	Barium Chloride (4)	Unknown (5)
A)Sodium Carbonate					
B)Sodium Sulfate					
C)Potassium Iodate					

Post-Lab Questions (Use a separate sheet of paper to answer the following questions.)

1. Which group II metal, magnesium or calcium, is more active? Cite your evidence.
2. Which period 3 metal, magnesium or aluminum, is more active? Cite your evidence.
3. Rank the three metals tested in Part A from most active to least active.
4. Write a general statement that describes the periodic trend in metal activity from top to bottom in a group (vertical column) of the periodic table.
5. Write a general statement that describes the periodic trend in metal activity as you read left to right within a period of the periodic table.
6. Locate the following metals on the periodic table: magnesium, potassium, and sodium. Based on your answers to Questions #4 and 5, rank these metals in order of their expected activity, from most active to least active.
7. Litmus paper changes color in acidic (red) and basic (blue) solutions. The word alkaline is a synonym for basic. Why are the two words "alkaline" and "earth" used to name the Group II metals?
8. In Part B, which alkaline earth metal formed the most precipitates? The fewest?
9. Write a general statement that describes the periodic trend in the solubility of alkaline earth metal compounds.
10. Use the solubility pattern observed for the known and unknown alkaline earth compounds in Part B to deduce the identity of the unknown alkaline earth metal. Explain your reasoning.