

Lab 8.2a

Types of Chemical Reactions

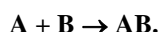
BACKGROUND

What is a chemical reaction?

A chemical reaction is a change in the arrangement of atoms. Atoms typically rearrange so that the system can achieve a more stable arrangement of electrons within its chemical structures. This will involve the breaking of existing bonds, (an endothermic process), and the formation of new bonds, (an exothermic process). There are many types of chemical reactions, but the most common classifications for first year chemistry are: synthesis, decomposition, single replacement, double replacement, and combustion. The type of chemical reaction may be determined easily by evaluating the chemical equation. Determining the type of reaction in the lab, however, is more involved.

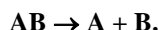
Synthesis Reactions (Direct Combination Reaction)

In synthesis reactions reactants combine to form a single, more complex chemical product. Usually two or more reactants will combine, but it possible for multiple units of the same reactant to combine to form the product ($2\text{NO}_2 \rightarrow \text{N}_2\text{O}_4$). Typically a synthesis reaction will take the form:



Decomposition Reactions

Decomposition reactions occur when a single reactant decomposes, or breaks, into multiple products. While the reactant chemical will usually produce two or more unique product chemicals, it is possible for a reactant to break into multiple units of a single chemical structure ($\text{N}_2\text{O}_4 \rightarrow 2\text{NO}_2$). Decomposition reactions have the standard format:



Single Replacement Reactions (Single Displacement or Substitution Reaction)

Single replacement reactions occur when one ion of one compound is replaced by another element. The replaced ion in the compound must be replaced by a similar element (anions are replaced by non-metals, cations are replaced by metals). The standard format of a single replacement reaction is:



For cation replacement, an activity series chart may be used to determine if a replacement will occur. An activity series is a chart that ranks reactivity of metals. Metals occurring at the top of the chart will replace metals below them on the chart. For anion replacement, halogens will replace other halogens that are below them on the periodic table.

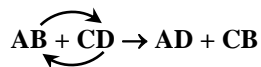
Table J
Activity Series**

Metals	Nonmetals
Li	F ₂
Rb	Cl ₂
K	Br ₂
Ca	I ₂
Ba	
Sr	
Ca	
Na	
Mg	
Al	
Tl	
Mn	
Zn	
Cr	
Fe	
Co	
Ni	
Sn	
Pb	
**H ₂	
Cu	
Ag	
Au	

Most ← | | → Least

Double Replacement Reactions (Double Displacement, Exchange, or Metathesis Reaction)

Double replacement reactions occur when two reactants exchange ions forming two new compounds. Frequently these reactions are reactions of aqueous solutions in which one of the new products forms a precipitate (solid) or complex ion. Acid-base neutralization reactions are a common type of double replacement reaction.



Combustion Reactions

Combustion reactions occur when a substance reacts with an oxidant (commonly oxygen) releasing energy in the form of heat or light. Common substances that undergo combustion would be hydrocarbons (C_xH_y) and carbohydrates ($\text{C}_x\text{H}_y\text{O}_z$). H_2 is another substance combusts by way of the reaction $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$. This reaction could be classified as synthesis or combustion, but the combustion classification provides more information about what is happening in the reaction (i.e., heat being evolved). The products of combustion reactions are generally CO_2 and H_2O .



Safety

- The hydrochloric acid solution is concentrated and will be corrosive to skins and eyes.
- Copper (II) carbonate and copper (II) sulfate are eye and lung irritants and may be toxic if ingested.
- Spills should be neutralized and cleaned up immediately. Any solutions that contact skin should be rinsed off with plenty of water.
- Standard fire precautions should be taken (hair tied back, loose clothing secured or removed, etc.)
- Goggles and aprons must be worn.
- Wash hands with soap and water before leaving the laboratory.

Lab 8.2a

Types of Chemical Reactions

I. PURPOSE

To observe basic types of chemical reactions and learn to recognize types by looking at equations.

II. MATERIALS

- | | | | |
|---------------------|-------------------|--|---|
| 1. Bunsen burner | 6. chemical scoop | 11. mossy zinc | 16. 1 M Na ₂ SO ₃ |
| 2. evaporating dish | 7. test tubes | 12. copper wire | 17. 6 M HCl |
| 3. ring stand | 8. test tube rack | 13. magnesium ribbon | 18. 1 M CuSO ₄ |
| 4. utility clamp | 9. wood splints | 14. CuCO ₃ (cr) | 19. 0.1 M Na ₃ PO ₄ |
| 5. crucible tongs | 10. sand paper | 15. 0.1 M Zn(C ₂ H ₃ O ₂) ₂ | |

III. PROCEDURES

Make observations before, during, and after each step of the lab.

Part A

1. Clean a piece of copper wire with sandpaper. Using crucible tongs, hold the copper wire in the hottest part of flame (top of inner cone). Observe during and after heating.
2. Clean a piece of magnesium ribbon with sandpaper. Put an evaporating dish near the burner. Using crucible tongs, hold the magnesium ribbon in the hottest part of flame (top of inner cone). **CAUTION: DO NOT STARE AT THE FLAME.** When the ribbon starts to burn, place it in the evaporating dish. Examine the remains carefully.

Part B

1. Place about 1 cm of CuCO₃ in a clean dry test tube. Place the test tube in a utility clamp on the ring stand at a 45° angle and heat with the burner in your hand for 2 to 3 minutes.
2. Remove burner from test tube, light a wooden splint and insert the splint into the test tube. Note any other changes.

Part C

1. Place a clean test tube in the test tube rack and add about 5 mL of 6 M HCl. **CAUTION: HANDLE ACIDS WITH CARE.** Drop a small piece of zinc into the acid and observe.
2. Place another test tube over the first and collect the gas. The second test tube should be held firmly with the utility clamp.
3. Light a wooden splint and place the lit end into the upper test tube with the gas. Note any other observations.
4. Add about 5 mL of 1 M CuSO₄ to a clean test tube. Place a small piece of zinc in the solution and observe. Leave the test tube in the rack for at least 5 minutes.

Part D

1. Add about 2 mL (2 pipets full) of 0.1 M Zn(C₂H₃O₂)₂ to a clean test tube.
2. Now, add about 2 mL of 0.1 M Na₃PO₄ to the same test tube and observe.
3. Add about 5 mL of 1 M Na₂SO₃ to a clean test tube. Now add about 1 mL of 6 M HCl to the same test tube and observe the odor given off by wafting some of the gas to your nose with care. **CAUTION: DO NOT SMELL THE GAS DIRECTLY.**

IV. PRE-LAB QUESTIONS

1. What is the purpose of cleaning the metals in Part A?
2. What is the purpose of keeping the test tube at an angle in Part B?
3. What types of changes should be expected in a chemical reaction?
4. How do chemical changes differ from physical changes?

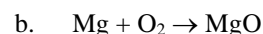
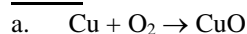
V. DATA & CALCULATIONS

A. DATA

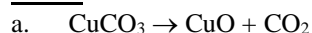
B. CALCULATIONS

1. The equations below represent the reactions that occurred in each part of the lab. For each equation, balance the equation, write the names of each substance below the formula in the equation, and write a description for each of the substances as observed in lab.

Part A



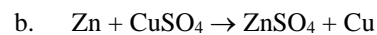
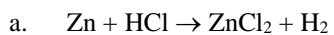
Part B



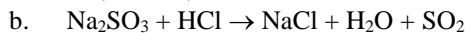
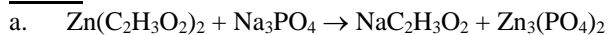
Part C

Lab 8.2a

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Part D



VI. POST-LAB QUESTIONS

1. Using the equation from the calculations for Part B, describe why the splint goes out in Part B?
2. Explain the sound generated in Part C.
3. List five observable changes that indicate a chemical reaction has taken place.
4. Describe the relationship between synthesis and decomposition reactions, and between single replacement and double replacement reactions.

VII. CONCLUSION