OBJECTIVE
To observe some typical chemical reactions, identify some of the products, and summarize the chemical changes in terms of balanced chemical equations.

APPARATUS AND CHEMICALS

| Bunsen Burner | 6 M HCl | copper-oxide |
| crucible and cover | 0.01 M CuSO₄ | mossy zinc |
| ring stand, ring, wire triangle | 6 M H₂SO₄ | |
| powered sulfur | conc. HNO₃ | |
| 0.1 M sodium oxalate, Na₂C₂O₄ | 3 M (NH₄)₂ CO₃ | |
| 0.1 M KMnO₄ | KMnO₄ (solid) | |
| 10 M NaOH | Na₂CO₃ (solid) | |
| 0.1 M Pb(NO₃)₂ | Na₂SO₃ (solid) | |
| 0.1 M BaCl₂ | ZnS (solid) | |
| 1 M K₂CrO₄ | 6-in. test tube | |
| 0.1 M NaHSO₃ (freshly prepared) | glass tubing | |
| thistle tube or long-stem-funnel | 6 M NH₃ | |
| 6 M HCl | 2-in. length of copper wire, 14, 16 or 18 gauge | |

DISCUSSION
Chemical equations represent what transpires in a chemical reaction. For example, the equation

\[ 2\text{KClO}_3(s) \rightarrow 2\text{KCl}(s) + 3\text{O}_2(g) \]

means that potassium chlorate, KClO₃, decomposes on heating (Δ is the symbol used for heat) to yield potassium chloride, KCl, and oxygen, O₂. Before
Sulfur, colorless; rotten-egg odor (Toxic)

Cl₂, pale yellow-green; H₂, colorless; odorless

Cu(NO₃)₂, blue

CuS, black; MnO₄⁻, purple

KCl, white (colorless solution); CuS, very dark blue or black; MnO₄²⁻, dark green

NH₄Cl, white (colorless black); MnO₄⁺, dark green

BaCO₃, white; MnO₄³⁻, dark blue

BaCrO₄, yellow; Mg, pale yellow-green;

K₂Cr₂O₇, purple; H₂S, colorless; rotten-egg odor (TOXIC)

Cu₂O, black; PbCl₂, white

Mn₃O₄, black or brown; NO, colorless, slight, pleasant odor

Ba(NO₃)₂, white; NO₂, brown; pungent odor (TOXIC)

Cu(NO₃)₂, blue; CO₂, colorless; odorless

MgO, white; Cl₂, pale yellow-green; pungent odor (TOXIC)

KMnO₄, purple; SO₂, colorless; choking odor (as from milk (TOXIC)

Ba(OH)₂, white; H₂S, colorless; rotten-egg odor (TOXIC)
in a test tube and add 2 mL of 6 M NH₃ in the hood. Heat gently with a Bunsen burner.

5 Does your product react with NH₃?
6 Suggest possible formulas for the product.
7 Write a reaction showing the formation of your proposed product:

\[ \text{Cu}(s) + \text{S}_8(s) \rightarrow ? \]

C. Oxidation-Reduction Reactions

Many metals react with acids to liberate hydrogen and form the metal salt of the acid. The noble metals do not react with acids to produce hydrogen. Some of the unreactive metals do react with nitric acid, HNO₃; however, in these cases gases that are oxides of nitrogen are formed rather than hydrogen.

Add a small piece of zinc to a test tube containing 2 mL of 6 M HCl and note what happens.

12 Record your observations.
13 Suggest possible products for the observed reactions: \( \text{Zn}(s) + \text{HCl}(aq) \rightarrow ? \)

Place a 1-in. piece of copper wire in a clean test tube; add 2 mL of 6 M HCl and note if a reaction occurs.

14 Record your observations.
15 Is Cu an active or an inactive metal?

While holding a clean test tube in the hood, place a 1-in. piece of copper wire in it and add 1 mL of concentrated nitric acid, HNO₃.

16 Record your observations.
17 Very cautiously note the odor of the gas produced. (\( \text{Fe}^{(III)} \))
18 Is the gas colored?
19 Suggest a formula for the gas.
20 Based upon the color of the solution (after the reaction has proceeded for 5 min, dilute with 5 mL of water), what substance is present in solution?

Potassium permanganate, KMnO₄, is an excellent oxidizing agent in acidic media. The permanganate ion is purple and is reduced to the manganous ion, Mn²⁺, which has a very faint, pink color. Add 10 drops of 6 M sulfuric acid, H₂SO₄, and then 1 or 2 drops of 0.1 M KMnO₄ solution to 1 mL of 0.1 M
sodium oxalate, Na$_2$C$_2$O$_4$, solution. If there is no obvious indication that a reaction has occurred, warm the test tube gently.

21 Record your observations. Was the KMnO$_4$ reduced to Mn$^{2+}$?

Place 3 mL of 0.1 M sodium hydrogen sulfite, NaHSO$_3$, solution in a test tube. Add 1 mL of 10 M sodium hydroxide, NaOH, solution and stir. To the mixture in the test tube add 1 drop of 0.1 M KMnO$_4$ solution.

22 Record your observations. Was the KMnO$_4$ reduced? Identify the manganese compound formed.

Add additional 0.1 M KMnO$_4$ solution, one drop at a time, observing the effect of each drop until 10 drops have been added.

23 Record your observations.

24 Suggest why the effect of additional potassium permanganate changes as more is added.

WHILE HOLDING A TEST TUBE IN THE FUME HOOD, add one or two crystals of potassium permanganate, KMnO$_4$, to 1 mL of 6 M HCl.

25 Record your observations.

26 VERY CAUTIOUSLY note the odor of the gas evolved. In this reaction the products must have H, Cl, Na, and O atoms in some new combinations, but no other elements can be present.)

27 Based on the odor and the color of the gas, what is the gas?

Additional observations are needed before equations can be written for the reaction above, but we see that we can identify some of the products. The remaining reactions are simple, and you will be able, from available information, not only to identify products but also to write equations. A number of reactions may be represented by equations of the following type:

$$AB + CD \rightarrow AD + CB$$

These are called double-decomposition, or metathesis, reactions. This type of reaction involves the exchange of atoms or groups of atoms between interacting substances. The following is a specific example:

$$\text{NaCl(aq)} + \text{AgNO}_3(\text{aq}) \rightarrow \text{AgCl(s)} + \text{NaNO}_3(\text{aq})$$

Place a small sample of sodium carbonate, Na$_2$CO$_3$, in a test tube and add several drops of 6 M HCl.

28 Record your observations.

29 Note the odor and color of the gas that forms. In this reaction the products must have H, Cl, Na, and O atoms in some new combinations, but no other elements can be present.)

30 What is the evolved gas?

31 Write an equation for the reaction HCl(aq) + Na$_2$CO$_3$(s) → ? (NOTE: In this reaction the products must have H, Cl, Na, and O atoms in some new combinations, but no other elements can be present.)

Note that H$_2$CO$_3$ and H$_2$SO$_3$ readily decompose as follows:

$$\text{H}_2\text{CO}_3(\text{aq}) \rightarrow \text{H}_2\text{O}(l) + \text{CO}_2(g) \quad \text{H}_2\text{SO}_3(\text{aq}) \rightarrow \text{H}_2\text{O}(l) + \text{SO}_2(g)$$
IN THE HOOD, repeat the same test with sodium sulfite, \( \text{Na}_2\text{SO}_3 \).

32 Record your observations.
33 VERY CAUTIOUSLY note the odor of the gas evolved. \( \text{ recorder}\) \( \text{ odor}\)
34 What is the gas?
35 Write an equation for the following reaction (note the similarity to the equation above): \( \text{HCl(aq)} + \text{Na}_2\text{SO}_3(s) \rightarrow ? \)

Repeat this test with zinc sulfide, \( \text{ZnS} \).

36 Record your observations.
37 VERY CAUTIOUSLY note the odor of the gas evolved. \( \text{ odor}\)
38 What is the gas?
39 Write an equation for the reaction \( \text{HCl(aq)} + \text{ZnS(s)} \rightarrow ? \)

To 1 mL of 0.1 M lead nitrate, \( \text{Pb(NO}_3)_2 \), solution in a clean test tube add a few drops of 6 M HCl.

40 Record your observations.
41 What is the precipitate?
42 Write an equation for the reaction \( \text{Pb(NO}_3)_2(aq) + \text{HCl(aq)} \rightarrow ? \)

To 1 mL of 0.1 M barium chloride, \( \text{BaCl}_2 \), solution add 2 drops of 1 M potassium chromate, \( \text{K}_2\text{CrO}_4 \), solution.

43 Record your observations.
44 What is the precipitate?
45 Write an equation for the reaction \( \text{BaCl}_2(aq) + \text{K}_2\text{CrO}_4(aq) \rightarrow ? \)

To 1 mL of 0.1 M barium chloride, \( \text{BaCl}_2 \), solution add several drops of 3 M ammonium carbonate, \( \text{(NH}_4)_2\text{CO}_3 \), solution in a test tube.

46 What is the precipitate?
47 Write an equation for the reaction \( \text{(NH}_4)_2\text{CO}_3(aq) + \text{BaCl}_2(aq) \rightarrow ? \)

After the precipitate has settled somewhat, carefully decant (that is, pour off) the excess liquid. Add 1 mL of water to the test tube, shake it, allow the precipitate to settle, and again carefully pour off the liquid. To the remaining solid, add several drops of 6 M HCl.

48 Record your observations.
49 Note the odor. \( \text{ odor}\)
50 What is the evolved gas? (Recall the reaction in step 31 of this experiment.)

REVIEW QUESTIONS

Before beginning this experiment in the laboratory, you should be able to answer the following questions:

1. Before a chemical equation can be written, what must you know? \( \text{(Be specific!)} \)
2. Why should you test the gas that is given off by your hydrogen generator by burning it? What might happen if you did not test it?
3. How could you distinguish between NO$_2$ and NO?
5. What is a precipitate?
6. Balance these equations:
   \[
   \text{KBrO}_3(s) \xrightleftharpoons[\Delta]{\text{KBr}}(s) + \text{O}_2(g)
   \]
   \[
   \text{ZnCl}_2(aq) + \text{AgNO}_3(aq) \rightarrow \text{Zn(NO}_3)_2(aq) + \text{AgCl}(s)
   \]
7. How could you distinguish between the gases H$_2$ and H$_2$S?
8. Using water, how could you distinguish between the white solids NaCl and PbCl$_2$?
9. Write equations for the decomposition of H$_2$CO$_3(aq)$ and H$_2$SO$_3(aq)$. 

Review Questions
REPORT SHEET FOR EXPERIMENT 4

CHEMICAL REACTIONS

A. A Reaction Between the Elements Copper and Sulfur

1. 
2. 
3. 
4. 
5. 

The rest of these numbers should be listed in order and answered in the analysis section.

6. 
7. \( \text{Cu(s)} + \text{S}_8(\text{s}) \rightarrow \)

B. The Formula of an Oxide of Copper

8. 
9. 
10. 
11. \( \text{CuO}(\text{g}) + \text{H}_2(\text{g}) \rightarrow \)

C. Oxidation-Reduction Reactions

12. 
13. \( \text{Zn(s)} + \text{HCl(aq)} \rightarrow \)
14. 
15. 
16. 
17. 
18. 

D. Metathesis Reactions

19. 
20. 
21. 
22. 
23. 
24. 
25. 
26. 
27. 
28. 
29. 
30.
HCl(aq) + Na₂CO₃(s) →

HC₁(aq) + Na₂SO₃(s) →

HCl(aq) + ZnS(s) →

Pb(NO₃)₂(aq) + HCl(aq) →

BaCl₂(aq) + K₂CrO₄(aq) → (46)

(NH₄)₂CO₃(aq) + BaCl₂(aq) →

QUESTIONS:
COMPLETE AND BALANCE THE FOLLOWING CHEMICAL REACTIONS

HBr(aq) + MgCO₃(s) →

HI(aq) + K₂SO₃(s) →

Pb(NO₃)₂(aq) + CuCl₂(aq) →

Ba(NO₃)₂(aq) + Na₂(CrO₄)(aq) →

K₂CO₃(aq) + Ba(NO₃)₂(aq) →

Foul formu[...]

Conclusion needed!