Student Investigation Sheet

Percent Dissociation of Acids and Bases

Acids and bases dissociate in water to different degrees. A strong acid or base will completely dissociate into ions, while a weak acid or base will dissociate only partially. The percent dissociation of an acid or a base is calculated using the following equations:

$$\text{percent dissociation of an acid} = \frac{[H^+]}{[\text{initial concentration of acid}]} \times 100$$

$$\text{percent dissociation of an base} = \frac{[OH^-]}{[\text{initial concentration of base}]} \times 100$$

You will investigate one weak acid, one strong acid, one weak base, and one strong base. You will measure the pH and conductivity of a weaker solution (0.01 M) and a stronger solution (0.1 M) of each acid and base. You will use your data to calculate the percent dissociation of each acid and base, and to identify strong and weak acids and bases.

Safety Precautions:

- HCl, NaOH, CH_3COOH and other acids and bases can burn if splashed in eyes or on skin. If you get any on your skin, rinse it off immediately and notify your teacher. If you get any in your eyes, use the eyewash station immediately.
- Wear safety equipment including goggles, gloves, and lab aprons.
- Assume any spills are acid or base spills. Have your teacher handle them.
- Treat the pH electrodes carefully, and don't let them dry out.

- Wear closed-toe shoes, tie back your hair, and do not eat or drink anything in the lab.
- Never leave the lab area unattended with chemicals sitting out.
- Follow all instructions for disposal and cleaning of the chemicals and their containers.
- Report any broken glass immediately and do not try to clean up any glass by yourself.

Objective(s):
In this investigation, you will examine the relative dissociations of strong and weak acids and bases and calculate the percent dissociations of acids and bases at different concentrations.

Materials:
Per group of 4:

- safety goggles, one pair per student
- lab apron, one per student
- disposable gloves, one pair per student
- metal stand with clamp for conductivity electrode
- stir bar and magnetic stirrer
- beakers, 250 mL, 8, dry and clean
- test tubes, 8
- beaker, 400 mL, for waste
- droppers
- material safety data sheets (MSDS) for HCl, NaOH, CH_3COOH, $NaHCO_3$
- pH paper
- conductivity meter or probeware with conductivity probes
- pH meter or probeware with pH probes (optional)
- instructions for the use of the conductivity electrodes
- wash bottle containing distilled water
- 0.01 M and 0.1 M solutions of the following acids and bases: HCl, NaOH, CH_3COOH, $NaHCO_3$
- paper towels

Safety Concerns

Identify any safety equipment and concerns that need to be observed in this lab.

Key Question

What is the question you want to answer?	
	Directions: Write the question for the investigation. The question should be specific and investigable.
	Key Components • Specific (one general thought, does not combine two or more questions) • Is able to be investigated

Hypothesis

What do you predict will be the result of the investigation?	
	Directions: Develop a claim about what you think is going to happen.
	Key Components • Expresses a cause-and-effect relationship • Is testable • Incorporates prior knowledge

Plan

How will you investigate the question?

Part 1: Using pH to Assess Degree of Dissociation

1. Work in groups of 4. Start by reading through the plan given here. Check the MSDS sheets provided by your teacher to identify any safety concerns for the chemicals you will be using in this lab.
2. You will be testing two concentrations of each solution, a 0.01 M concentration and a 0.1 M concentration. You will test two bases (two concentrations each) and two acids (two concentrations each).
3. Start by testing pH. Place about 1 mL of each solution in a clean, dry test tube. Use pH paper to determine the pH of each solution. Record all data.
4. (optional) Place about 100 mL of each solution in a beaker and use the pH meter or probeware to determine the pH of each solution. Record all data.

Part 2: Using Conductivity to Assess Degree of Dissociation

5. Your teacher will instruct you in the use of the conductivity meters or probeware being used. The meter may come with a temperature compensation feature, or you may need to input the temperature.
6. Clamp the conductivity probe to the stand and move the stand over the magnetic stirrer.
7. For each solution in turn, clean and dry the stir bar, and place it in a clean, dry beaker. Add about 100 mL of the solution. Position the beaker with the solution under the probe so that the probe is submerged in the solution but not in the way of the stir bar.
8. Wait for about a minute until the conductivity measurement has stabilized, and then record the measurement. Repeat for each solution.

Part 3: Clean-Up

Directions: Read and then follow the plan that you will use to study your question and analyze your hypothesis.

Key Components

- Plan is easily repeatable by others
- Plan describes the use of materials
- Plan is in a logical order

9. Turn off the meter or probeware after you have measured the conductivity of each solution. Rinse the probe with distilled water and put the cap back on. 10. Do NOT mix your used acids and bases together. Your teacher will collect your acids and bases and neutralize them.	

Data

What evidence was gathered during the investigation?	
	Directions: Record all of the evidence that has been collected. Use graphic organizers, tables, and graphs when appropriate.
	Key Components • Data (from an investigation and/or other sources, such as observations, reading material, archived date, etc.) • Appropriate (data applies directly to the question) • Sufficient (uses enough data to completely answer the question and determine a finding on the hypothesis)

Conclusion

What did you learn from this investigation?	
	Directions: Develop a conclusion for your investigation. The conclusion should contain clear thoughts and proper vocabulary. This section focuses on the answer to your question. It should support or refute the hypothesis by using logical reasoning to link the hypothesis to the data.
	Key Components • Use precise and accurate language • Use scientific vocabulary • Provide clear logical thoughts • Use evidence and reasoning to support or refute the hypothesis

Analysis and Conclusions

1. (a) Calculate the percent dissociation (% dissociation) for each solution of acid and base.

Acid or Base	% dissociation of 0.1 M solution	% dissociation of 0.01 M solution
HCl		
CH_3COOH		
NaOH		
$NaHCO_3$		

(b) How does concentration affect the percent dissociation? Explain your answer.

2. Which compound is the weaker acid, HCl or CH_3COOH? Explain your answer.

3. Which compound is the weaker base, NaOH or $NaHCO_3$? Explain your answer.

4. How did concentration affect the pH of each acid? of each base? Explain why.

5. How did concentration affect the conductivity of each acid? of each base? Explain why.

6. (a) Compare the degree of dissociation of a strong acid with that of a weak acid. Give an example of each.

(b) Compare the degree of dissociation of a strong base with that of a weak base. Give an example of each.

Inquiry and Nature of Science Skills in this Lab:

- Identify Questions
  - Develop a question that:
    - asks a question about a specific science concept or process
  - Recognize and develop testable questions that:
    - Specify a cause-effect relationship
    - Require the changing of one variable at a time
    - Can be answered with a science investigation or observational study
  - Develop predictions/hypotheses that:
    - State what may happen in an investigation based on prior knowledge or experience (prediction)
    - State the expected cause and effect (if-then statement) in an investigation based on prior knowledge and experience (hypothesis)
- Design Investigations
  - Design and conduct investigations using:
    - Fair test-changing only one variable at a time makes comparisons valid
    - Independent variable-the one variable the investigator chooses to change
    - Dependent variables-what changes as a result of, or in response to, the change in the independent variable
    - Constant-identify variables that must remain unchanged in
    - Multiple trials-repeated tests with the same variables to check for variability of results
  - Explain the investigative processes by:
    - Describing the logical sequence that was used to conduct the investigation
    - Properly citing all equipment and materials
    - Describing it so that it can be easily repeated by a fellow scientist
  - Practice lab safety by:
    - Following lab safety procedures
    - Recognizing safety equipment and materials and knowing their proper use

        - Incorporating laboratory safety practices into the investigation design
- Gather Data
    - Use tools and the SI (metric) system to accurately measure:
        - Volume
        - Mass
    - Choose appropriate tools to conduct an investigation:
        - Glassware (beakers, flasks, watch glass, etc.)
        - Balance
        - Pipette
        - Erlenmeyer flask
        - Graduated cylinder
        - Other Laboratory equipment
    - Use senses to observe:
        - Seeing (color, shape, size, texture, motion)
    - Use the appropriate format to record data:
        - Different explanations can be given for the same evidence, and it is not always possible to tell which one is correct without further inquiry.
        - What people expect to observe can affect how they perceive what they observe.
        - Scientific investigations lead to the development of scientific explanations.
    - Scientific Data and Outcomes:
        - Results of similar scientific investigations may turn out differently because of inconsistencies in methods, materials, and observations.
        - Comparisons of data are not accurate when some of the conditions are not kept the same.
        - Accurate recordkeeping, openness, and replication are essential for maintaining an investigator’s credibility with other scientists and society.
        - It is important in science to keep honest, clear, and accurate records.
        - When similar investigations give different results, it often takes further studies to decide what is right.
        - Arguments and conclusions are invalid if based on very small samples of data, biased samples, or samples for which there was no control sample.

- Scientific Endeavor
  - Characteristics of Science:
    - Science is based on factual knowledge.
    - Scientists are curious about wanting to know how things work.
    - Scientific claims can be substantiated using data and observation.
    - Scientific theories are based on accumulated evidence.
    - Scientific knowledge is subject to modification as new information challenges prevailing theories and as a new theory leads to looking at old observations in a new way.
    - An important part of science is the critical review and analysis of any idea or conclusion.
- Engineering and Technology
  - Uses of Technology:
    - Not every problem has a technological solution.