

Electrolyte versus Non-Electrolyte Solutions

Driving Questions

Sports drinks are often advertised as “Electrolyte Replacement Drinks”. These drinks are generally mixtures of water, sugars, and salt. Which of these ingredients is responsible for the electrolytic nature of sports drinks?

Background

We use physical properties to identify and describe matter. Physical properties of matter include color, density, odor, boiling point, melting point, solubility, and conductivity (among others). This investigation uses conductivity to differentiate between different types of matter.

Electrical conductivity is a measure of how easily electric current can flow through a substance. Solutions that conduct electricity are called electrolyte solutions. These solutions conduct electricity because they contain a solute that has dissociated into ions (charged particles). Solutions that do not conduct electricity are called non-electrolyte solutions. The solutes in these solutions dissolve as molecules (neutral particles, neither positively nor negatively charged).

A conductivity probe measures the conductivity of a solution. We measure the electrical current created in units of microsiemens per centimeter ($\mu\text{S}/\text{cm}$). The more ions present in the solution, the greater the conductivity values. We use a conductivity versus concentration plot to determine the electrolyte concentration of an unknown solution.

Materials and Equipment

For each student or group:

- ◆ Data collection system
- ◆ Conductivity sensor
- ◆ Test tube (6), 20-mm x 150-mm
- ◆ Beaker to collect rinse water
- ◆ Test tube rack
- ◆ Funnel
- ◆ Wash bottle filled with distilled (deionized) water
- ◆ Sucrose solutions (0.02 M, 0.04 M, 0.06 M, 0.08 M, 0.10 M), 25 mL of each concentration
- ◆ Sodium chloride solutions (0.02 M, 0.04 M, 0.06 M, 0.08 M, 0.10 M), 25 mL of each concentration
- ◆ Distilled (deionized) water, 50 mL
- ◆ Sports drink, 25 mL

Safety

Add these important safety precautions to your normal laboratory procedures:

- ◆ Do not eat, drink, or taste materials in the lab.

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Sequencing Challenge

The steps below are part of the Procedure for this lab activity. They are not in the right order. Determine the proper order and write numbers in the circles that put the steps in the correct sequence.

○	○	○	○	○
Dispose of the sodium chloride solutions, clean out each test tube, and repeat steps 1 and 2 using sucrose solutions.	Pour each sodium chloride solution into a test tube with the concentration clearly labeled.	Determine the concentration of electrolytes in the sports drink by comparing it to the conductivity versus concentration data.	Test the conductivity of each sodium chloride solution.	Dispose of the sucrose solutions, clean the test tubes, and then test the conductivity of a sample of sports drink.

Procedure

After you complete a step (or answer a question), place a check mark in the box () next to that step.

Note: When you see the symbol "♦" with a superscripted number following a step, refer to the numbered Tech Tips listed in the Tech Tips appendix that corresponds to your PASCO data collection system. There you will find detailed technical instructions for performing that step. Your teacher will provide you with a copy of the instructions for these operations.

Part 1 – Sodium chloride (salt) solutions

Set Up

- Label the test tubes "0.00 M NaCl", "0.02 M NaCl", "0.04 M NaCl", "0.06 M NaCl", "0.08 M NaCl", and "0.10 M NaCl".
- Use a funnel to pour 25 mL of distilled water into the test tube labeled 0.00 M.
- Use a funnel to pour 25 mL of 0.02 M NaCl into its labeled test tube.
- Rinse the funnel with distilled water.
- Continue to fill each test tube with the appropriate solution, and rinse the funnel between each solution.

6. Why do you have to rinse the funnel with distilled water before using it again?

7. Start a new experiment on the data collection system. ♦ (1.2)

8. Connect the conductivity sensor to the data collection system. ♦ (2.1)

9. Configure the data collection system to manually collect conductivity and concentration data in a table. Define concentration as a manually entered data set with units of molarity (M). ♦ (5.2.1)


10. What do you expect to happen to the conductivity as the concentration of sodium chloride increases?

11. Identify the dependent and independent variables as well as their units used in this part of the experiment.



Collect Data

12. Start a new manually sampled data set. ♦ (6.3.1)

13. Test the conductivity of each salt solution starting with 0.00 M and moving up in concentration. To test the conductivity follow these steps:

- Set the range of the conductivity sensor to its lowest setting (0 to 1,000 $\mu\text{S}/\text{cm}$) by pressing the green button marked with .
- Place the conductivity sensor in the test tube containing the sample you are testing.

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- c. If the conductivity sensor is saturated (reads 1,000 $\mu\text{S}/\text{cm}$), then change to the middle setting  (0 to 10,000 $\mu\text{S}/\text{cm}$). If the conductivity sensor is saturated at the middle setting (reads 10,000 $\mu\text{S}/\text{cm}$), then change to the highest setting  (0 to 100,000 $\mu\text{S}/\text{cm}$).
- d. Record the conductivity of the sample. $\diamond^{(6.3.2)}$
- e. Remove the conductivity sensor from the sample and clean the sensor by thoroughly rinsing it with distilled water.
- f. Repeat the steps above to test the conductivity of the next sample.
14. Why do you have to rinse the conductivity sensor with distilled water before using it again?

15. When you have recorded all of your data, stop the data set. $\diamond^{(6.3.3)}$
16. Copy the salt solutions conductivity data from your data collection system to Table 1 in the Data Analysis section.
17. Dispose of your solutions according to your teacher's instructions.
18. Clean all of your test tubes by rinsing them thoroughly with distilled water so that they can be used in the next part of this investigation.

Analyze Data

19. Create a graph of Conductivity ($\mu\text{S}/\text{cm}$) versus Concentration (M) on your data collection system. $\diamond^{(7.1.1)}$
20. Name the data run "salt solutions". $\diamond^{(8.2)}$
21. Explain what happens to the conductivity of the sodium chloride solution as the concentration of sodium chloride increases.

Part 2 – Sucrose (sugar) solutions**Set Up**

22. Label the test tubes “0.00 M sucrose”, “0.02 M sucrose”, “0.04 M sucrose”, “0.06 M sucrose”, “0.08 M sucrose”, and “0.10 M sucrose”.
23. Use a funnel to fill each test tube with 25 mL of the indicated sucrose solution.
24. What do you expect to happen to the conductivity as the concentration of sucrose increases?

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25. Identify the dependent and independent variables as well as their units used in this portion of the experiment.

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26. Return to the table display on your data collection system.

Collect Data

27. Start a new manually sampled data set. $\diamond^{(6.3.1)}$
28. Record the conductivity of each salt solution. Be sure to rinse the conductivity sensor with distilled water after each test. $\diamond^{(6.3.2)}$
29. When you have recorded all of your data, stop the data set. $\diamond^{(6.3.3)}$
30. Copy the sucrose solutions conductivity data from your data collection system to Table 1 in the Data Analysis section.
31. Dispose of your solutions according to your teacher’s instructions.
32. Clean all of your test tubes by rinsing them thoroughly with distilled water so that they can be used in the next part of this investigation.

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Analyze Data

33. Return to your graph of Conductivity ($\mu\text{S}/\text{cm}$) versus Concentration (M) on your data collection system.
34. Name the run “sugar solutions”. $\diamond^{(8.2)}$
35. Explain what happens to the conductivity of the sucrose solution as the concentration of sucrose increases.
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Part 3 – Sports drink

Set Up

36. Use a funnel to fill a test tube approximately halfway with a sports drink (at room temperature).
37. Why does the procedure specify that the sports drink should to be at room temperature?
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38. Configure your data collection system to monitor live conductivity data in a digits display. $\diamond^{(6.1)}$

Collect Data

39. Place the conductivity sensor in the test tube containing the sports drink and allow the conductivity reading to stabilize.
40. Record the brand and flavor of sports drink tested and its conductivity below.

Sports Drink: _____

Conductivity ($\mu\text{S}/\text{cm}$): _____

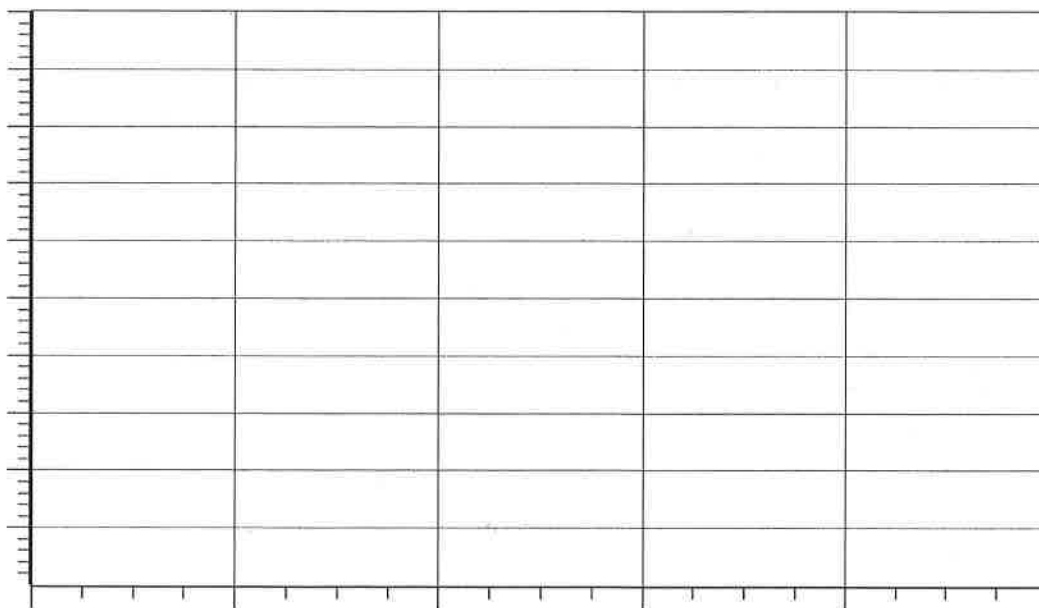
41. Save the data file and clean up your lab station according to the teacher's instructions. $\diamond^{(11.1)}$

Data Analysis

Table 1: Measured conductivity of salt and sucrose solutions

Concentration of Salt and Sugar Solutions (M)	Conductivity of Salt Solutions ($\mu\text{S}/\text{cm}$)	Conductivity of Sucrose Solutions ($\mu\text{S}/\text{cm}$)
0.00		
0.02		
0.04		
0.06		
0.08		
0.10		

- Return to your graph of Conductivity ($\mu\text{S}/\text{cm}$) versus Concentration (M) on your data collection system and display both the salt solutions data set and the sucrose solutions data set on the graph. $\diamond(7.1.3)$
- Plot or print a graph of Conductivity ($\mu\text{S}/\text{cm}$) versus Concentration (M). Include both the salt solutions data set and the sucrose solutions data set on the same set of axes (clearly label each). Label the overall graph, the x -axis, the y -axis, and include units on the axes.



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3. Where does the sports drink you tested fit on the graph of Conductivity ($\mu\text{S}/\text{cm}$) versus Concentration (M)? Place an "X" on the graph to mark this location and label it "Sports drink".

Analysis Questions

1. Explain the difference between an electrolyte solution and a non-electrolyte solution.

2. Which compounds in a sports drink are electrolytes? Which compounds in a sports drink are non-electrolytes?

3. What is the approximate concentration of electrolytes in the sports drink you tested? Explain how you determined this concentration.

4. Which effect does concentration have on the conductivity of an electrolyte solution?

Synthesis Questions

Use available resources to help you answer the following questions.

1. Explain the difference at the molecular level between what happens when salt and sugar dissolve.

2. Does crystalline table salt (sodium chloride) conduct an electric current?

3. Which type of compounds (ionic or covalent) generally makes better electrolyte solutions? Why?

4. Is human blood an electrolyte or non-electrolyte solution? Explain your answer.

Multiple Choice Questions

Select the best answer or completion to each of the questions or incomplete statements below.

1. What are solutions that conduct electricity called?

- A. Electrolyte solutions
- B. Non-electrolyte solutions
- C. Dilute solutions
- D. Concentrated solutions

2. What do solutions that conduct electricity contain that differentiates them from solutions that do not conduct electricity?

- A. Molecules
- B. Atoms
- C. Free-moving ions
- D. Solutes

3. Which of the following solutions would conduct electricity the best?

- A. A sugar solution
- B. A salt solution
- C. Distilled water
- D. All of the above

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4. What would you expect to happen as the concentration of electrolytes in a solution increases?

- A. An increase in the conductivity of the solution
- B. A decrease in the conductivity of the solution
- C. A decrease followed by an increase in the conductivity of the solution
- D. The conductivity of the solution will remain the same

5. What forms of sodium chloride will conduct electricity?

- A. In a solid crystalline state
- B. In a molten liquid state
- C. When dissolved in water
- D. Both B and C
- E. A, B, and C will all conduct electricity

Key Term Challenge

Fill in the blanks from the list of words in the Key Term Challenge Word Bank.

1. We use physical properties to observe and describe matter. _____ of matter include color, density, odor, boiling point, melting point, solubility, and conductivity (among others). This investigation uses conductivity to differentiate between different types of matter. _____ is the ability of an electric current to pass through a substance. An electric current is the flow or movement of charged particles (either electrons or ions).

2. Just as some solid substances, like metal wires, are good conductors of electricity, some liquids can also conduct electrical current. Such liquids are called _____. In order to be conductive, a solution must contain charged particles, or _____, which are free to move. Ions are formed if a solute _____, or splits into ions, when dissolved in a solvent (usually water). The free-moving ions enable an electric current to pass through the solution.

3. Not all substances ionize when they _____ into solution. Many substances dissolve as molecules. Because there are no charged particles, the solution will not conduct electricity. Solutions that do not conduct an electric current are known as _____. Substances such as pure water, oil, phenol, and alcohol are examples of substances that are non-electrolytes.

Key Term Challenge Word Bank

Paragraph 1

chemical properties

conductivity

physical properties

solubility

Paragraph 2

dissociates

electrolyte solutions

ions

molecules

non-electrolyte solutions

Paragraph 3

dissolve

electrolyte solutions

non-electrolyte solutions

melt