SI Chemistry - Full Discipline Demo

Water, pH, and Buffers

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Chemistry - Full Discipline Demo
Course	SI Chemistry - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Arrange the substances from most acidic to most basic.

≡ Apple
pH = 2.8

1 **Correct answer:** Apple
pH = 2.8

≡ Baking soda
pH = 8.5

2 **Correct answer:** Beer
pH = 4.0

≡ Beer
pH = 4.0

3 **Correct answer:** Tomato
pH = 4.5

≡ Bleach
pH = 12.5

4 **Correct answer:** Milk
pH = 6.6

≡ Blood
pH = 7.4

5 **Correct answer:** Blood
pH = 7.4

≡ Milk
pH = 6.6

6 **Correct answer:** Baking soda
pH = 8.5

≡ Milk of Magnesia
pH = 10.5

7 **Correct answer:** Milk of Magnesia
pH = 10.5

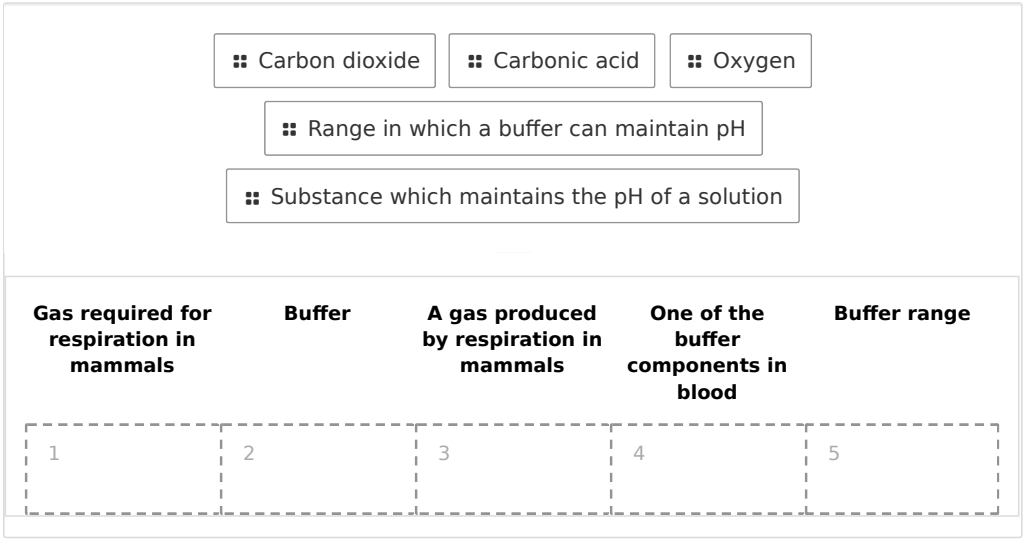
≡ Tomato

pH = 4.5

8 **Correct answer:** Bleach

pH = 12.5

Match the terms with the best definition by moving items to the correct bin.



Correct answers:

1 Oxygen 2 Substance which maintains the pH of a solution

3 Carbon dioxide 4 Carbonic acid

5 Range in which a buffer can maintain pH

Complete each statement.

Adhesion | Cohesion | Hydrogen | pH | pH indicator

Solutions are described as acidic, basic, or neutral based on their 1 values.

The greater the number of 2 ions in a solution, the more acidic the solution.

The tendency of water molecules to stick to other water molecules is 3.

4 is the tendency of water molecules to stick to other surfaces.

5 changes color and suggests the pH of a substance.

Correct answers:

1 pH 2 Hydrogen 3 Cohesion 4 Adhesion 5 pH indicator

Exploration

Many of the unique physical properties of water are the result of its polar covalent molecular structure, and its ability to form intermolecular hydrogen bonds with other water molecules.

- True ✔
- False

_____ is the tendency of like molecules to stick to one another, while _____ is the tendency of molecules to stick to something else, such as a container.

- Adhesion; cohesion
- Cohesion; adhesion ✔

The greater the number of _____ ions in a solution, the more acidic the solution.

- hydroxide
- hydrogen ✔
- base

A pH indicator will change color when a solution has a pH within its specific range.

- True ✔
- False

The range in which a buffer maintains a constant pH is called a buffer capacity.

- True
- False ✔

Exercise 1

How did the experiment in Part 1 demonstrate surface tension? Use your experiment observations when answering this question.

The experiment in Part I demonstrated surface tension as the surface tension of the water was strong enough to support the needle when the needle was placed horizontally. When the needle was placed vertically, it pierced through the surface tension of the water.

In Part 1, when adding the needle to water, which approach worked best to balance the needle on the water- the vertical or horizontal placement? Explain your answer.

The horizontal placement of the needle worked to balance the needle on the water due to the strength of the hydrogen bonds when compared to the pressure of the needle. Pressure is weight divided by area. The pressure is lower on the needle when it is horizontally positioned, because there is a larger surface area of the needle touching the water and the weight of the needle is spread out over that area. The surface tension was enough counter-pressure to hold the needle in place. The vertical placement of the needle has a higher pressure because the weight is distributed over a very small area (the tip of the needle), causing the needle to sink to the bottom of the container

In Part 2, how did your paperclip estimation compare to your paperclip results?

The answer will depend on the student’s estimation. When the experiment was conducted at HOL, the estimation was 15 paper clips less than the actual result.

In Part 3, how were the properties of adhesion and cohesion demonstrated in the experiment?

Cohesion is the tendency of water to stick to other water molecules (due to the surface tension, or hydrogen bonds between water molecules). Adhesion is the tendency of water to stick to molecules other than water molecules. The properties of adhesion and cohesion were well-demonstrated in the experiment when water was dropped on a coin one drop at a time. One would expect that the water would drip over the side of the coin as it was added drop-by-drop. However, as the water was dropped on the coin, it tended to stick to other water molecules more than sticking to the side of the coin, which is why the drops were visible on the coin. This demonstrated a stronger cohesion than adhesion to the coin.

In Part 4, how did the activity demonstrate capillary action? Explain your answer using your experiment results and observations.

The colored water being drawn into the plant demonstrated capillary action. The forces of cohesion and adhesion of the colored water caused the colored water to travel up the roots of the plant, resulting in a color change. If capillary action were not present in this experiment, then the changes in color of the plant would not have occurred. This experiment demonstrates the ability of plants to draw water into the plant from an outside source and carry the moisture throughout the plant.

Data Table 1: Surface Tension Observations with a Needle
(SAMPLE ANSWER BELOW)

Vertical:	The needle simply slides into the water. The water does not appear to move in reaction to the needle being placed through the surface of the water.
Horizontal:	The needle floats on the top of the water. As the needle is slowly placed horizontally into the water, you can observe the surface tension of the water as it surrounds the needle.

Data Table 2: Number of Paper Clips to Break Surface Tension
(SAMPLE ANSWER BELOW)

Prediction:	Student answers will vary.
Results:	The number of paper clips will depend on the volume of water in the student's glass and the size of the paper clips. For a 100-mL (3.4-oz) volume of water, 24 paper clips were needed.

Data Table 3: Drops of Water on a Coin
(SAMPLE ANSWER BELOW)

Prediction:	Student answers will vary.
Results:	The answer will depend on the coin chosen by the student. Quarter = approximately 48 drops of water; Penny = approximately 31 drops of water; Dime = approximately 46 drops of water; Nickel = approximately 45 drops of water

Panel 1: Observations: Capillary Action
(SAMPLE ANSWER BELOW)

As incubation time continued, the colored water was drawn up to the top of the celery or flower, causing the item to become the color of the food coloring. The color of the item changed as the water was drawn up and into the item.

Exercise 3

Compare and contrast the results between the commercial and homemade pH test strips. Which test strips were more accurate? Explain your answer.

The commercial pH strips were specific enough (when matched with the pH range color guide) to not only describe a solution as acidic, neutral, or basic, but to allow a quantitative number to be assigned to the solution. The homemade pH strips allowed a solution to be defined within a pH range, but did not allow for specific numerical differentiation between solutions. Both strips were generally accurate as they provided the same range of results. However, as the commercial strips allowed a quantitative number on the pH scale to be defined, the commercial strips were more specific.

Why is the pH scale important in science? Give several examples of scientific applications.

The pH reading of substances is used in many different fields on a daily basis. For example, blood should have a pH reading of 7.4. If a patient was not feeling well and their blood pH showed a reading above or below the normal value, medical personnel would know to treat the patient.
If you had an upset stomach or acid-reflux and chose to take an antacid to settle your stomach, you are ingesting a basic substance to help neutralize an acid build-up in your stomach.
If a chemical spill occurs that needs to be neutralized, knowing the pH of the spilled chemical allows scientists to determine how much (and at what pH) of another chemical would be need to be added to neutralize and clean up the spill.

What information about a chemical solution can be inferred from knowing its pH value?

Knowing a pH value for a solution, one can calculate the hydrogen ion and hydroxide ion concentrations for the solution. One can also use pH information to determine an equilibrium constant for an acid.
$pH = -\log [H^+]$

If a chemical has a pH of 3, how could you alter its pH value to be more basic?

If a chemical has a pH of 3, adding an amount of a base, such as NaOH, would change the pH value to be more basic.

Data Table 4: Testing pH of Household Items
(SAMPLE ANSWER BELOW)

Item Tested	Commercial pH Strip Color and Value	Homemade pH Strip Color and Value	Acid/ Base/ Neutral?	Explanation
1- HCl (hydrochloric acid)	Bright pink; 2.0	Pink; 1-3	Acid	Both the homemade and commercial pH strips showed a color in the acidic range.
2- NaOH (sodium hydroxide)	Dark blue; 10.0	Green; 9-12	Base	Both the homemade and commercial pH strips showed a color in the basic range.
3- Distilled Water	Yellowish green; 6.0-7.0	Purple: No change; 4-8	Neutral	Both the homemade and commercial pH strips showed a color in the basic range.
4-Student answers will vary.	No sample answer	No sample answer	No sample answer	No sample answer
5-No sample answer	No sample answer	No sample answer	No sample answer	No sample answer
6-No sample answer	No sample answer	No sample answer	No sample answer	No sample answer
7-No sample answer	No sample answer	No sample answer	No sample answer	No sample answer
8-No sample answer	No sample answer	No sample answer	No sample answer	No sample answer
9-No sample answer	No sample answer	No sample answer	No sample answer	No sample answer
10-No sample answer	No sample answer	No sample answer	No sample answer	No sample answer
11-No sample answer	No sample answer	No sample answer	No sample answer	No sample answer

12-No sample answer	No sample answer	No sample answer	No sample answer	No sample answer

Exercise 4

Analyze the results of your experiment. Did the buffer resist changes in the pH? Explain your answer using your experiment results.

The buffered solution resisted a change in pH. This was shown when the pH for the buffered solution remained constant at 8. But without the unbuffered solution, this result would not be conclusive. The unbuffered solution began to change pH with the first set of 3 drops of HCl. If the pH of the buffered solution changed in the same way as the unbuffered solution, then the buffer would not have been successful at maintaining a constant pH. As the buffered solution did not begin to show a change in pH, even after 18 drops of HCl, this suggests that the buffering capacity of the buffer was not exceeded.

Research the bicarbonate buffering system found in the bloodstream. Write a paragraph or two discussing this system and how your breathing rate can cause acidosis and alkalosis.

Bicarbonate ions can help maintain the pH of the blood. Acidosis occurs when the blood pH drops below 7.35. Alkalosis occurs when the blood pH increases above 7.45. Carbon dioxide causes a chemical change when mixed with water to make the blood more acidic. As people breathe in, oxygen is transferred into their system. As people breathe out, they exchange carbon dioxide from their lungs to the outside air. As the breathing rate increases or decreases, this constant flushing of carbon dioxide occurs at different rates, so the blood may become less or more acidic, respectively, if the buffering system is overwhelmed.

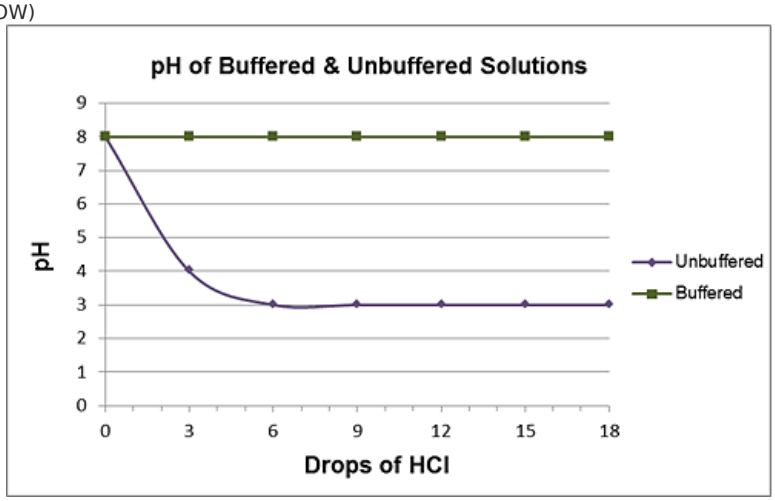
Data Table 5: pH Change of Buffered and Un–buffered Solutions

(SAMPLE ANSWER BELOW)

HCl Drops	Un-buffered Solution	Buffered Solution
Initial pH	8	8
+3 Drops HCl	4	8
+6 Drops HCl	2-4	8
+9 Drops HCl	2-4	8
+12 Drops HCl	2-4	8
+15 Drops HCl	2-4	8

+18 Drops HCl	2-4	8

Graph 1: pH Changes for Un-buffered and Buffered Solutions
(SAMPLE ANSWER BELOW)



Competency Review

Water has the ability to form intermolecular _____ bonds with other water molecules.

- electrostatic
- hydrogen ✔
- oxygenated

_____ is the unique property of water that allows insects to walk on water.

- Cohesion
- Adhesion
- Surface tension ✔

Water forms into droplets because of _____.

- adhesive forces
- cohesive forces ✔
- capilary action

Basic solutions have a greater number of _____ ions.

- hydroxide ✔
- hydrogen

Based on the logarithm for pH, a pH of 1 is _____ times more acidic than a pH of 5.

- 1000
- 10000 ✔
- 100000

A given pH indicator turns orange or yellow in the presence of solutions with the pH 1-3; this indicator would be most useful in detecting _____.

- acidic solutions ✔
- basic solutions
- neutral solutions

The pH of blood in the human body does not fluctuate due to buffers.

- True ✔
- False

A buffer is a chemical substance that maintains the pH of a solution by binding to, or releasing _____.

- acidic compounds
- basic compounds
- hydrogen ions ✔

What is an example of a naturally occurring pH indicator?

- Phenolpthalein
- Anthocyanin ✔
- Sodium hypochlorite

Which process is essential to determining pH with commercially available pH paper?

- The substance tested should be an acid or a base, and not a neutral substance.
- The paper must be used in the appropriate quantity; the paper may need to be cut.
- The color results must be compared to a color chart. ✔
- The appropriate volume of liquid must be tested.

NaOH has a(n) _____ pH.

- acidic
- neutral
- basic ✔

If a solution has a pH of 9, how can you lower its pH value?

- Add an amount of strong acid. ✔
- Add an amount of distilled water.
- Both of the above

If a buffered solution has a pH of 8, and a volume of acid is added within the buffering range of the solution, the pH of the solution will _____.

- increase to10
- decrease to 4
- remain near 8 ✔

A needle placed on top water is held on the surface of the water. This phenomenon is due to _____.

- capillary action
- surface tension ✔
- adhesion
- buoyancy

Extension Questions

Due to its strong tendency to form hydrogen bonds, solid water forms a crystalline structure with holes in it which leads to its lower density as compared to liquid water. This property makes ice float on liquid water.
Explain how life on Earth would be different if ice did not float on water.
(SAMPLE ANSWER BELOW)

If ice were denser than liquid water, then water, ponds, lakes, and rivers, would freeze from the bottom up. Fish and other aquatic life could not survive in cold weather because they would not be insulated from the cold, the water would freeze solid, and they would not get oxygen. As the Earth

was once mostly covered in ice, much of the aquatic life that we have today would not be present. Many scientists believe that all life on Earth originated from the water. Therefore, most if not all life on Earth would not exist today.