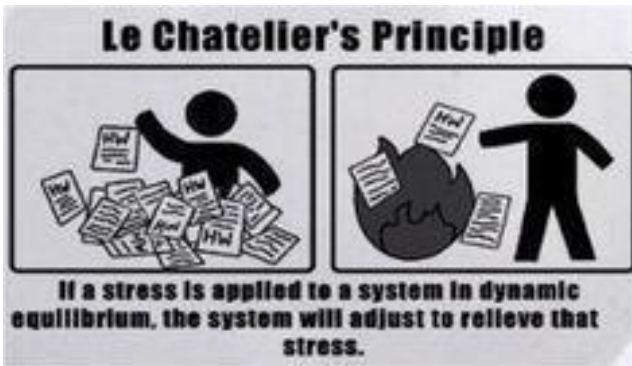


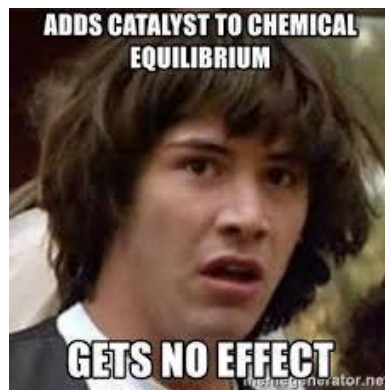
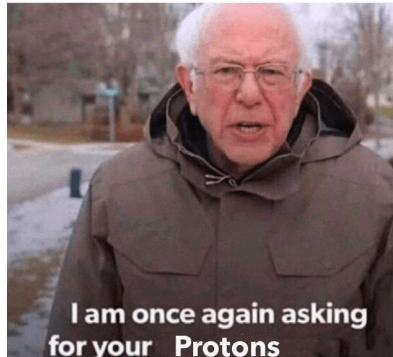
UNIT 7: HOW DOES THE BODY REGULATE pH



Bronsted-Lowry when you accept a proton



Bases be like:



People who can spell Phenolphthalein



when you realize you forgot to put the phenolphthalein indicator and your groupmate is still titrating after 45 minutes



247

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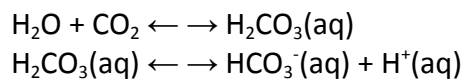
UNIT 7: HOW DOES THE BODY REGULATE pH

Introduction to Body System Equilibrium

Your blood needs to maintain a pH between 7.35 and 7.45 to remain healthy in homeostasis.

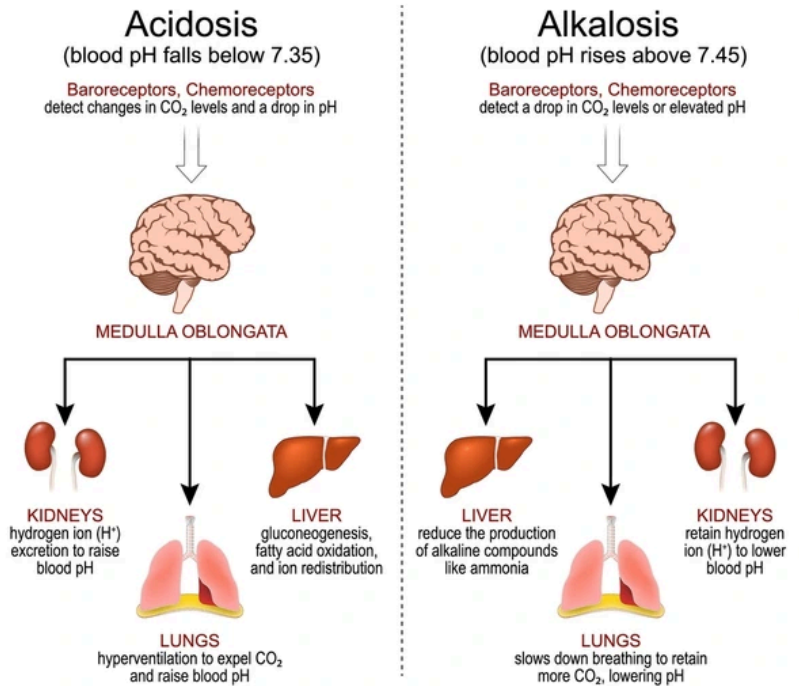
- **Acidosis** occurs when the pH of the blood becomes lower than 7.35 due to too much CO₂ in the body. The causes can include issues with respiratory systems (i.e. lung diseases), kidney malfunction, or buildup of lactic acid in the body (caused by cancers, CO poisoning, etc.). Symptoms can include extreme confusion, fatigue, lethargy, and shortness of breath.
- **Alkalosis** occurs when the blood pH rises higher than 7.45 due to excess basic substances in the body. Causes can include kidney, liver or lung disease, extreme vomiting leading to the loss of Cl⁻ and K⁺ electrolytes, or extreme use of aspirin. Symptoms can include extreme confusion, hand tremors, lightheadedness, muscle twitching, nausea, vomiting, numbness or tingling in the face, hands, or feet, and prolonged muscle spasms.

The blood pH is primarily regulated by the carbonic acid, H₂CO₃, and bicarbonate, HCO₃⁻ buffer system. This system utilizes chemical reactions to neutralize excess acids or bases. Additionally, the respiratory system regulates the amount of CO₂ in the body and the kidneys can manage the amount of bicarbonate in the body to maintain stability. The reactions that control this system are:

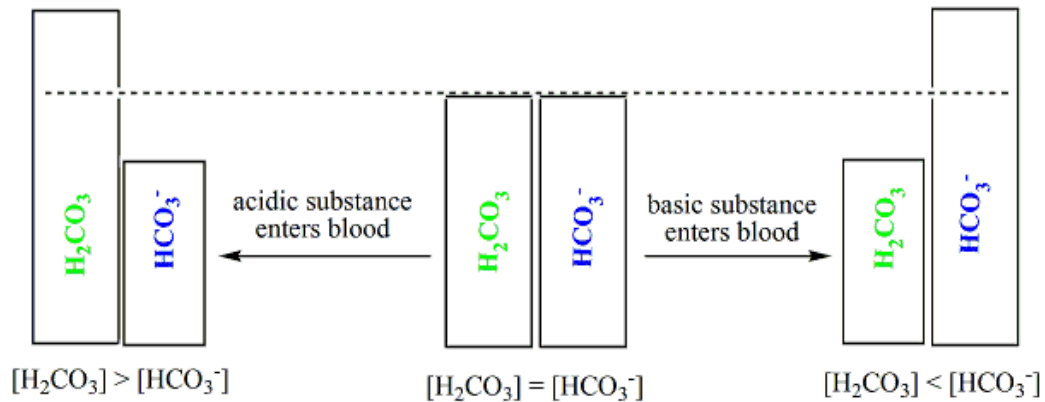


1. What is homeostasis?
2. What does each pH range mean in terms of acids, bases, and neutrality?
 - a. pH lower than 7:
 - b. pH higher than 7:
 - c. pH close to 7:

HOMEOSTASIS



UNIT 7: HOW DOES THE BODY REGULATE pH



- Describe briefly what acidosis means in terms of pH in the body.
- According to the image above, which chemical is the most abundant during acidosis?
- Describe briefly what alkalosis means in terms of pH in the body.
- According to the image above, which chemical is the most abundant during alkalosis?
- What types of elements are probably involved in “alkalosis”?
- What do you notice about the arrows in the reactions given? What might they mean?
- What questions do you have so far about how the body regulates these substances in order to maintain homeostasis?

UNIT 7: HOW DOES THE BODY REGULATE pH

Dynamic Equilibrium Activity

SEP: Analyzing and Interpreting Data CCC: Stability and Change

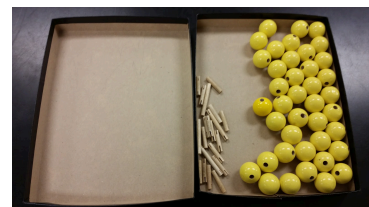
At the grocery store on a Saturday, there comes a point when there are constantly 200 people inside and 25 people in the parking lot. It's not the *same* people inside and outside all day, but there is a *constant exchange* of people coming in and out, so the amounts *look* constant. This is called "dynamic equilibrium" and can be written as: People Arriving \rightleftharpoons People Leaving. Dynamic equilibrium happens when we have two opposite processes occurring at the same rate. Today you'll be experiencing dynamic equilibrium by modeling the formation and breakdown of H_2 .

Experiment #1 Roles:

- Competitor #1: _____ will join single H atoms (yellow balls) to make H_2 for 4 min.
- Competitor #2: _____ will break apart H_2 molecules into single H atoms for 4 min.
- Counter of Forward Rate: _____ will report the rate (# of times) H_2 is made every 30s.
- Counter of Reverse Rate: _____ will report the rate (# of times) H_2 is broken every 30s.

Experiment 1: ($2H \rightleftharpoons H_2$)

Begin with the model kits set up like this (nothing bonded).



Data for Experiment 1:

Time	$2H \rightleftharpoons H_2$		$2H \rightleftharpoons H_2$	
	Forward Rate (# forward reactions that happened in this window)	Reverse Rate (# reverse reactions that happened in this window)	Concentration of H (# H present at this time- <i>single yellow spheres</i>)	Concentration of H_2 (# H_2 present at this time- <i>pair of yellow spheres bonded with stick</i>)
.5 min				
1 min				
1.5 min				
2 min				
2.5 min				
3.0 min				
3.5 min				
4.0 min				

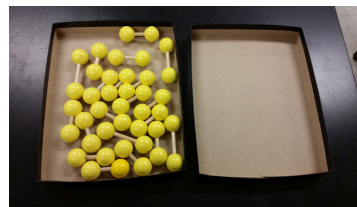
UNIT 7: HOW DOES THE BODY REGULATE pH

Experiment #2 Roles: *CHANGE ROLES!!!!*

- Competitor #1: _____ will join single H atoms (yellow balls) to make H₂ for 4 min.
- Competitor #2: _____ will break apart H₂ molecules into single H atoms for 4 min.
- Counter of Forward Rate: _____ will report the rate (# of times) H₂ is made every 30s.
- Counter of Reverse Rate: _____ will report the rate (# of times) H₂ is broken every 30s.

Experiment 2: (2H ⇌ H₂)

Begin with the model kits set up like this (everything bonded).



Data for Experiment 2

Time	2H ⇌ H ₂		2H ⇌ H ₂	
	Forward Rate (# forward reactions that happened in this window)	Reverse Rate (# reverse reactions that happened in this window)	Concentration of H (# H present at this time- <i>single yellow spheres</i>)	Concentration of H ₂ (# H ₂ present at this time- <i>pair of yellow spheres bonded with stick</i>)
.5 min				
1 min				
1.5 min				
2 min				
2.5 min				
3.0 min				
3.5 min				
4.0 min				

UNIT 7: HOW DOES THE BODY REGULATE pH

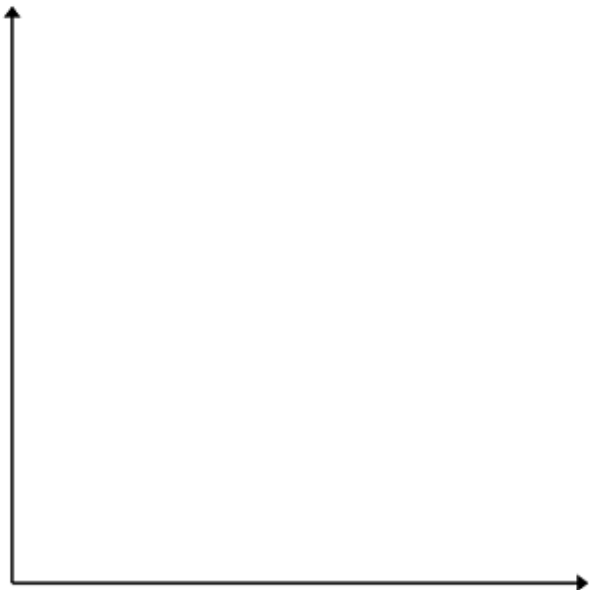
Make 4 Graphs:

Pick a color for H and another color for H_2 . Graph BOTH H and H_2 amounts on this graph.

Pick a color for Forward and another color for Reverse. Graph BOTH forward and reverse rates on this graph.

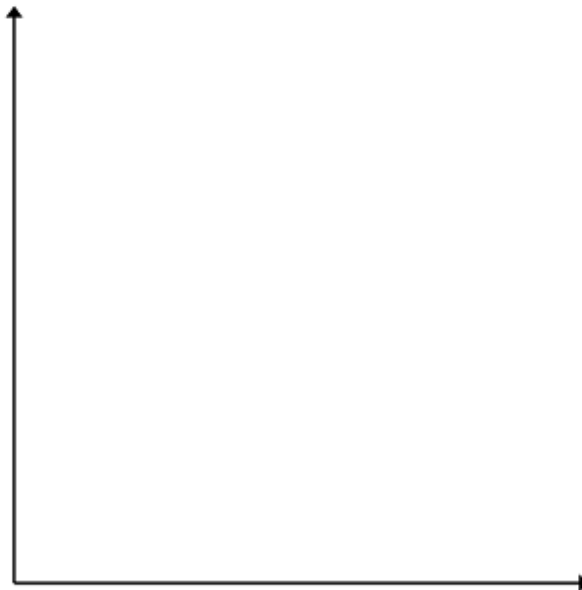
Graph 1:

Experiment #1: Time (x) vs Concentration (y)



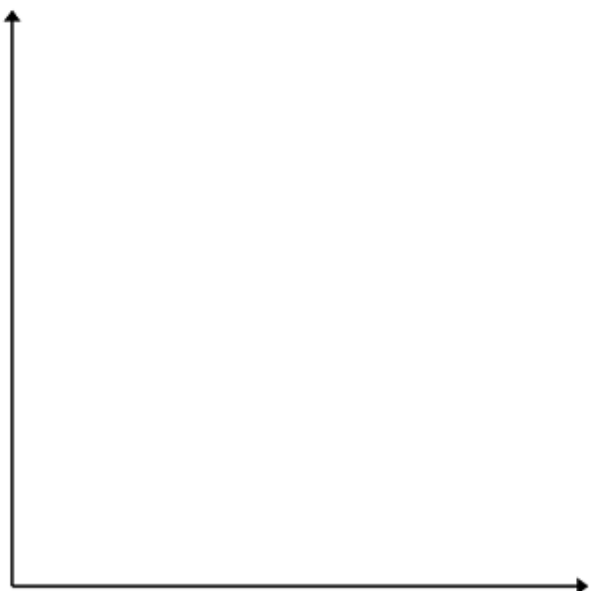
Graph 2:

Experiment #1: Time (x) vs Rate (y)



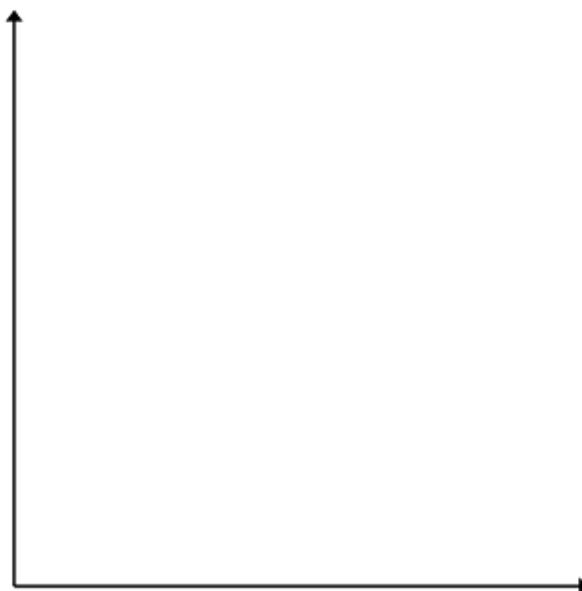
Graph 3:

Experiment #2: Time (x) vs Concentration (y)



Graph 4:

Experiment #2: Time (x) vs Rate (y)

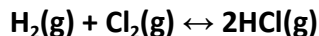


UNIT 7: HOW DOES THE BODY REGULATE pH

Equilibrium Simulation

SEP: Developing and Using Models CCC: Stability and Change

1. Hydrogen gas and chlorine gas react to form hydrogen chloride in an equilibrium reaction, represented below. At room temperature, the **ratio of moles of reactants to moles of product will always be 2:1.**



Create models to represent the equilibrium condition in which the reaction will contain 2 molecules of hydrogen, 2 molecules of chlorine, and 2 molecules of hydrogen chloride.

- a. Draw a representation of the model below. Count the number of each molecule and record.



Number of H₂: _____

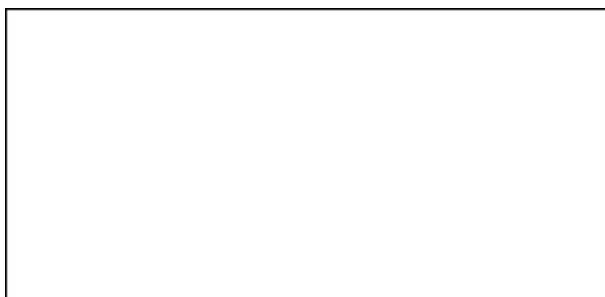
Number of Cl₂: _____

Number of HCl: _____

- b. Explain why the equilibrium ratio is 2:1. Use the definition above.

The initial equilibrium reaction is stressed by the addition of 6 molecules of H₂. Add these models to your simulation.

- c. Redistribute the atoms to create the 2:1 ratio needed to restore equilibrium. Draw a representation of the new equilibrium model below. Count the number of each molecule at equilibrium and record.



Number of H₂: _____

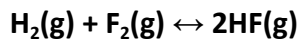
Number of Cl₂: _____

Number of HCl: _____

- d. Explain why the equilibrium ratio is 2:1.
- e. Describe what happened to the amount of Cl₂ molecules as the reaction shifted to restore equilibrium.
- f. Describe what happened to the amount of HCl molecules as the reaction shifted to restore equilibrium.

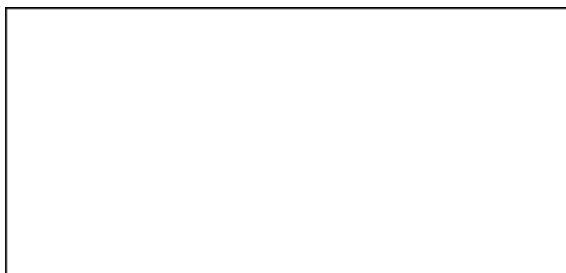
UNIT 7: HOW DOES THE BODY REGULATE PH

2. In a different reaction at equilibrium, H_2 gas and F_2 gas react to form HF in an equilibrium reaction. At room temperature, **the ratio of moles of reactants to moles of product will always be 1:2.**



Create models to represent the equilibrium condition in which the reaction will contain 1 molecule of hydrogen, 1 molecule of fluorine, and 4 molecules of hydrogen fluoride.

- a. Draw a representation of the model below. Count the number of each molecule and record.



Number of H_2 : ____

Number of F_2 : ____

Number of HF: ____

- b. Explain why the equilibrium ratio is 1:2.

The initial equilibrium reaction is stressed by the addition of 6 molecules of hydrogen fluoride. Add these models to your simulation.

- c. Redistribute the atoms to create the 1:2 ratio needed to restore equilibrium. Draw a representation of the new equilibrium model below. Count the number of each molecule at equilibrium and record.



Number of H_2 : ____

Number of F_2 : ____

Number of HF: ____

- d. Explain why the equilibrium ratio is 1:2.
- e. Describe what happened to the amount of H_2 and F_2 molecules as the reaction shifted to restore equilibrium.

3. For each reaction simulated above, sketch a graph depicting the number of molecules at the initial equilibrium and the final equilibrium. Connect the initial and final conditions with a line. Use different colors, shapes, or labels to depict the different substances in the reaction.



initial

final



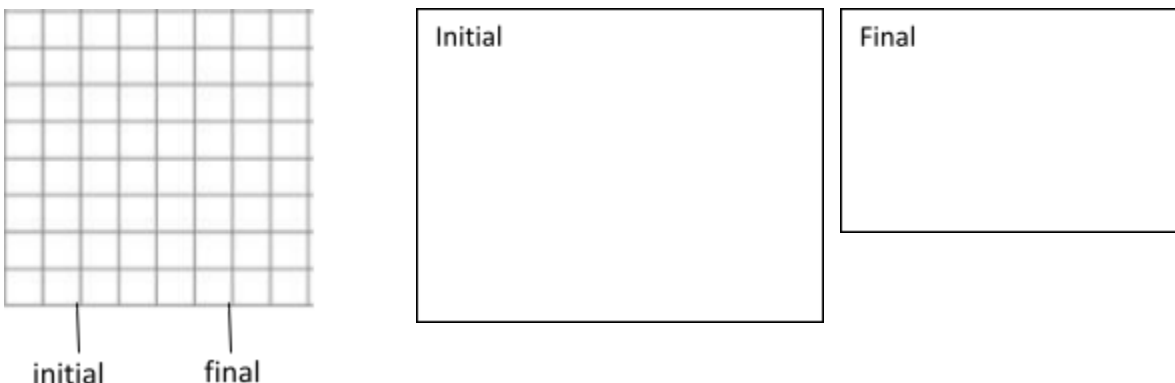
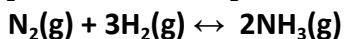
initial

final

UNIT 7: HOW DOES THE BODY REGULATE pH

4. Extend the initial equilibrium plot to the y axis with a straight horizontal line. Extend the final equilibrium plot to the end of the graph with a straight horizontal line. These lines depict the equilibrium states that would occur indefinitely when a reaction is not stressed. Based on the definition of “dynamic equilibrium” and collision theory, are reactions still taking place during the horizontal lines?

5. Consider the Haber Process, a reaction shown below that creates ammonia. Sketch the initial equilibrium conditions, like the graphs above, where $N_2 = 2$ molecules, $H_2 = 6$ molecules, and $NH_3 = 4$ molecules.



6. As pressure is increased on the system at the initial equilibrium, the reaction shifts to restore a new, final equilibrium in which NH_3 increases to 6 particles.

- Fill in the blank based on **molar** quantities: If NH_3 increases by ____ particles, the N_2 must decrease by ____ particles, and the H_2 must decrease by ____ particles.
 - Plot the new, final equilibrium conditions based on your answer to part a. Connect the lines as you did in question 4.
 - Draw a model of the initial and final conditions in the boxes marked above.
 - If pressure is increased, what happens to the volume the gas takes up?
- e. Why will the increase in pressure make the reaction shift to create more NH_3 , rather than H_2 and N_2 ?

UNIT 7: HOW DOES THE BODY REGULATE pH

Types of Equilibrium

SEP: Analyzing & Interpreting Data CCC: Stability and Change

Model 1: Chemical Equilibrium

Data from a reversible reaction in a closed container: **Reaction: $A \rightleftharpoons B$**

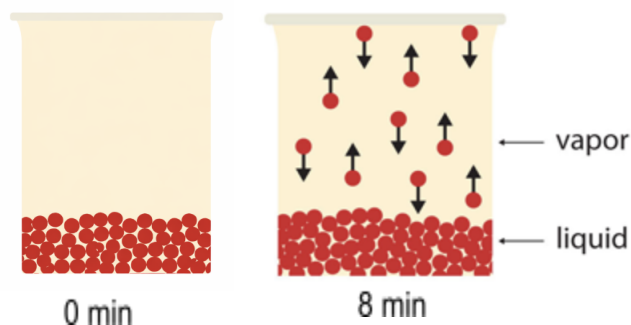
Time (min)	Concentration of A (mol/L)	Concentration of B (mol/L)	Rate $A \rightarrow B$ (mol/L-min)	Rate $B \rightarrow A$ (mol/L-min)
0	1.00	0.00	0.80	0.00
2	0.60	0.40	0.50	0.30
4	0.45	0.55	0.38	0.38
6	0.45	0.55	0.38	0.38
8	0.45	0.55	0.38	0.38

Questions

1. At what time do the forward and reverse rates become equal?
2. When the rates are equal, do the concentrations stop changing? Use data to support your answer.
3. Are the concentrations of A and B equal at equilibrium? Explain using Table 1.
4. Write a definition of chemical equilibrium based on the model.

Model 2: Physical Equilibrium (Phase Change)

The model and data below represent a simulation of a sealed container filled with water. The container is kept at a constant temperature. The number of molecules in each state are counted for 8 minutes.



Time (min)	Molecules in liquid	Molecules in gas
0	1000	0
2	820	180
4	760	240
6	750	250
8	750	250

247

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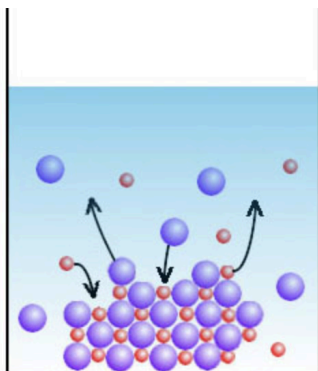
Dr. Palermo

Questions

5. At what time do the numbers in each phase become constant?
6. Does “constant numbers” mean molecules stop moving between liquid and gas? Explain.
7. Identify the two opposing processes happening at the same time in this system.
8. In one sentence, define physical equilibrium using this example.

Model 3: Solution Equilibrium

A beaker contains water and a large amount of solid sugar. The temperature stays constant and the beaker is covered.



Time (min)	Dissolved sugar (g per 100 mL water)
0	0
2	18
4	30
6	36
8	36

9. When does the solution become saturated?
10. At saturation, is the sugar still “dissolving”? Explain what must also be happening.
11. Define solution equilibrium in your own words.

Model 4: Comparing Types of Equilibrium

UNIT 7: HOW DOES THE BODY REGULATE pH

Card Sort (do as a group): Sort each situation into the correct category: Check with Dr. Palermo and then write in the table below.

Chemical equilibrium • Physical equilibrium • Solution equilibrium • Not at equilibrium

- A. A closed soda bottle: CO₂ bubbles form when opened.
- B. A sealed bottle of perfume where smell is present but liquid remains.
- C. A pot of boiling water with the lid off.
- D. Saltwater with salt crystals still sitting on the bottom (covered, constant temp).
- E. A glow stick that gradually fades over hours.
- F. A sealed container with ice and liquid water at 0°C.
- G. $N_2 + 3H_2 \rightleftharpoons 2NH_3$

Chemical Equilibrium	Physical Equilibrium	Solution Equilibrium	Not at equilibrium

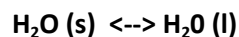
UNIT 7: HOW DOES THE BODY REGULATE pH

Equilibrium Check Your Understanding

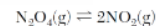
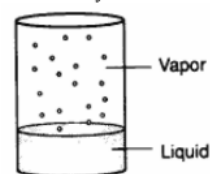
SEP: Constructing Explanations CCC: Stability and Change

- Given the equation representing a system at equilibrium: $N_2O_4 \rightleftharpoons 2NO_2$
Which statement describes this reaction at equilibrium?
 - The concentration of the reactant and the product must be equal.
 - The concentration of the reactant and the product must be constant.
 - The rates of the forward and reverse reactions are increasing.
 - The rates of the forward and reverse reactions are decreasing.
- Which statement represents a reaction at equilibrium?
 - The mass of the products must equal the mass of the reactants.
 - The entropy of the reactants must equal the entropy of the products.
 - The rate of formation of the products must equal the rate of formation of the reactants.
 - The number of moles of the reactants must equal the number of moles of the products.
- A solution at equilibrium must be
 - unsaturated
 - supersaturated
 - concentrated
 - saturated
- Some solid KNO_3 remains at the bottom of a stoppered flask containing a saturated $KNO_3(aq)$ solution at $22^\circ C$.
Which statement explains why the contents of the flask are at equilibrium?
 - The rate of dissolving is equal to the rate of crystallization.
 - The rate of dissolving is greater than the rate of crystallization.
 - The concentration of the solid is equal to the concentration of the solution.
 - The concentration of the solid is greater than the concentration of the solution.

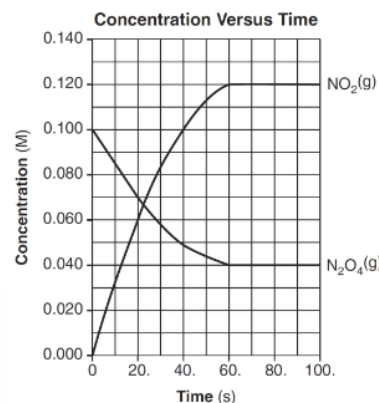
- Given the equation representing a system at equilibrium:
At which temperature does this equilibrium exist at 101.3 kilopascals?
 - 0K
 - 0C
 - 273K
 - 100K



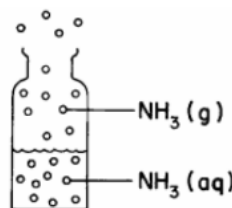
- A closed system is shown in the diagram. The rate of vapor formation is
 - less than the rate of liquid formation
 - greater than the rate of liquid formation
 - equal to the rate of liquid formation



- A reaction reaches equilibrium at $100^\circ C$. The equation and graph representing this reaction are shown. The graph shows that the reaction is at equilibrium after 60 seconds because the concentration of both $NO_2(g)$ and $N_2O_4(g)$ are
 - increasing
 - constant
 - decreasing
 - zero



- The diagram below shows a bottle containing $NH_3(g)$ dissolved in water. How can the equilibrium, $NH_3(g) \rightleftharpoons NH_3(aq)$, be reached?
 - Add more water.
 - Cool the contents.
 - Add more $NH_3(g)$.
 - Stopper the bottle.



UNIT 7: HOW DOES THE BODY REGULATE PH

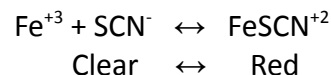
LeChatelier's Principle Inquiry Lab

SEP: Constructing Explanations CCC: Stability and Change

Background Information: Equilibrium exists when the rates of the forward and reverse reactions are equal. When stress is added to the reaction, the rates are no longer equal. The reaction will proceed in such a way to make the rates back to equal and establish a new equilibrium. This is known as LeChatelier's principle.

Guiding Questions: What changes stress equilibrium reactions and how can you determine the shift in equilibrium using observations?

Changing Concentration (reactants): Equilibrium of Complex Ions



1. Pour SCN^{-} equilibrium solution into 3 separate test tubes, 1/5 way filled.
2. Into the first test tube add 1 scoop of solid SCN^{-} . Record observations.
3. Into the second test tube add 6 drops of Fe^{+3} solution. Record observations.
4. Into the third test tube add 1 scoop of HPO_4^{-2} . Record observations.
5. Dispose of chemicals down the drain with lots of water.
6. Place test tubes in the tray upside down to dry.

Observations:

Step 2: _____

Step 3: _____

Step 4: _____

Conclusions:

- When SCN^{-} (a stress) was added in step 2, the reaction shifted to the _____ and creates more _____.
- When Fe^{+3} (a stress) was added in step 3, the reaction shifted to the _____ and creates more _____.
- When HPO_4^{-2} (a stress) was added in step 4, the reaction shifted to the _____ and creates _____.

Summary

Stress	Shift
Increasing Concentration	<i>Away From Stress or Towards Stress</i>
Decreasing Concentration	<i>Away From Stress or Towards Stress</i>

UNIT 7: HOW DOES THE BODY REGULATE pH

Changing concentration (products): Equilibrium of Acid Base Indicator(HIN) $\text{HIN(aq)} \leftrightarrow \text{H}^+ + \text{IN}^-$
 Yellow \leftrightarrow blue

1. Fill a test tube halfway with water.
2. Add 5 drops of bromothymol blue indicator.
3. Add 5 drops of 0.1M H^+ solution to the solution and record observations.
4. Add 0.10M OH^- solution drop wise until a reaction is observed. Record observations.
5. Dispose of chemicals down the drain with lots of water.
6. Place test tubes in the tray upside down to dry.

Observations:

Step 2: _____
 Step 3: _____
 Step 4: _____

Conclusions:

When H^+ (a stress) was added in step 3, the reaction shifted to the _____ and forms more _____.

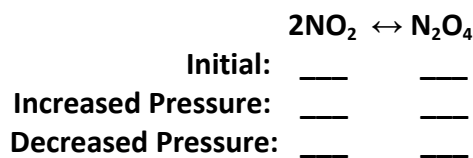
When the H^+ concentration was decreased (a stress) in step 4 (this was done by adding OH^-), the reaction shifted to the _____ because decreasing the H^+ concentration creates more _____.

Summary

Stress	Shift
Increasing Concentration	<i>Away From Stress or Towards Stress</i>
Decreasing Concentration	<i>Away From Stress or Towards Stress</i>

Changing Pressure: Pressure Equilibrium:

Observe the simulation https://javalab.org/en/le_chateliers_principle_pressure_en/ Count the number of each particle and write the before and after below the reaction:



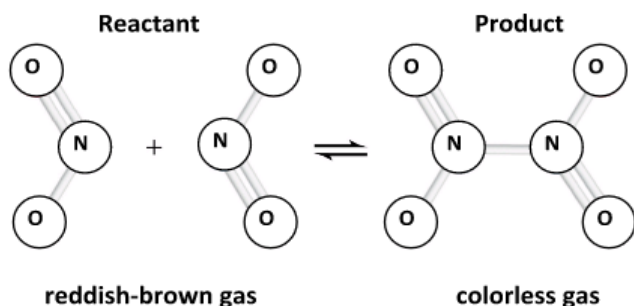
Which side of the reaction has more moles of gas particles?

Summary

Stress	Shift
Increasing Pressure	<i>Away from side with more moles or Towards side with more moles</i>
Decreasing Pressure	<i>Away from side with more moles or Towards side with more moles</i>

Le Chatelier's Principle: Changing Temperature

The tubes contain the following:



Questions:

1. Is the tube at equilibrium? How do you know?

2. Do you think the forward reaction is endothermic or exothermic based upon the chemical reaction above? What side would the energy be written on?

3. How could you test this system to determine if the reaction is endothermic or exothermic?

Observe: Write down what you observe:

Two identical equilibrium tubes containing both reddish-brown $\text{NO}_2(g)$ and colorless $\text{N}_2\text{O}_4(g)$ are placed in two different temperature (cold and hot) water baths. A third equilibrium tube is left out at room temperature.

Temperature of Water Bath	Observations/ Evidence
Room	
Cold	
Hot	

Questions:

UNIT 7: HOW DOES THE BODY REGULATE PH

1. What happened to the mass as you heated and cooled the system? Explain your answer.
2. Based on your observations, how does a decrease in temperature affect the $2\text{NO}_2(g) \leftrightarrow \text{N}_2\text{O}_4(g)$ equilibrium reaction in the tube? Does it shift equilibrium to the reactant side or product side?
3. Based on your observations, how does an increase in temperature affect the $2\text{NO}_2(g) \leftrightarrow \text{N}_2\text{O}_4(g)$ equilibrium reaction in the tube? Does it shift equilibrium to the reactant side or product side?
4. Was the reaction endothermic or exothermic based upon the demonstration? Explain.
5. Write the balanced chemical equation. Be sure to include heat in the reaction.

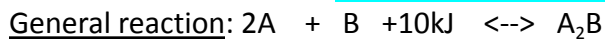
Summary

Stress	Shift
Increasing temperature	<i>Away from side with heat or Towards side with heat</i>
Decreasing temperature	<i>Away from side with heat or Towards side with heat</i>

UNIT 7: HOW DOES THE BODY REGULATE pH

LeChatelier's Principle Think Tank

SEP: Developing and Using Models CCC: Stability and Change



Equilibrium	Stress	New Equilibrium	Shift
	Add B 		
	Add A 		
	Add A ₂ B 		
	Remove A 		
	Remove B 		
	Remove A ₂ B 		
	Increase temperature 		
	Decrease temperature 		
	Increase pressure 		
	Decrease pressure 		

UNIT 7: HOW DOES THE BODY REGULATE pH

LeChatelier's Principle Check Your Understanding

SEP: Developing and Using Models CCC: Stability and Change

1. An increase in the temperature of a system at equilibrium favors the
 - a. endothermic reaction and decreases its rate
 - b. endothermic reaction and increases its rate
 - c. exothermic reaction and decreases its rate
 - d. exothermic reaction and increases its rate
2. The addition of a catalyst to a system at equilibrium will increase the rate of
 - a. the forward reaction, only
 - b. the reverse reaction, only
 - c. both the forward and reverse reactions
 - d. neither the forward nor reverse reaction

Given the equation representing a gaseous reaction at equilibrium: $2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{SO}_3 + \text{heat}$

3. Which change causes the equilibrium to shift to the right?
 - a. adding a catalyst
 - b. adding more $\text{O}_2(\text{g})$
 - c. decreasing the pressure
 - d. increasing the temperature
4. In the same reaction above, which will cause the reaction to shift to the right?
 - a. increasing the kinetic energy
 - b. increasing the pressure
 - c. decreasing the amount of $\text{SO}_2(\text{g})$
 - d. decreasing the amount of $\text{O}_2(\text{g})$

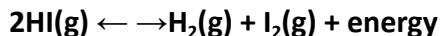
Given the equation representing a reaction at equilibrium: $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g}) + 92\text{kJ}$

5. What occurs when the concentration of $\text{H}_2(\text{g})$ is increased?
 - a. The equilibrium shifts to the left, and the concentration of $\text{N}_2(\text{g})$ decreases.
 - b. The equilibrium shifts to the left, and the concentration of $\text{N}_2(\text{g})$ increases.
 - c. The equilibrium shifts to the right, and the concentration of $\text{N}_2(\text{g})$ decreases.
 - d. The equilibrium shifts to the right, and the concentration of $\text{N}_2(\text{g})$ increases
6. What occurs when the concentration of $\text{NH}_3(\text{g})$ is increased?
 - a. The rate of the reverse reaction increases and the concentration of $\text{N}_2(\text{g})$ decreases.
 - b. The rate of the reverse reaction decreases and the concentration of $\text{N}_2(\text{g})$ increases.
 - c. The rate of the reverse reaction and the concentration of $\text{N}_2(\text{g})$ both increase.
 - d. The rate of the reverse reaction and the concentration of $\text{N}_2(\text{g})$ both decrease.
7. Increasing the concentration of $\text{N}_2(\text{g})$ will increase the forward reaction rate due to
 - a. a decrease in the number of effective collisions
 - b. an increase in the number of effective collisions
 - c. a decrease in the activation energy
 - d. an increase in the activation energy

UNIT 7: HOW DOES THE BODY REGULATE pH

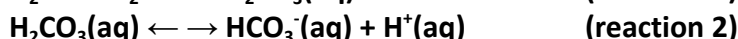
8. The formation of ammonia is favored by
- | | |
|----------------------------|------------------------|
| a. an increase in pressure | c. removal of $N_2(g)$ |
| b. a decrease in pressure | d. removal of $H_2(g)$ |

Given the equation representing a system at equilibrium in a sealed, rigid container:



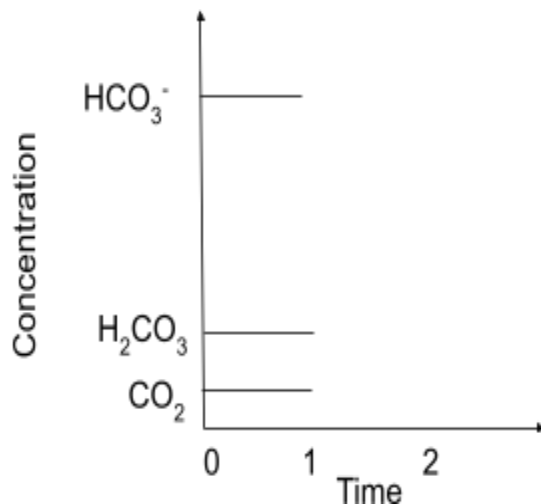
9. Increasing the temperature of the system causes the concentration of
- | | |
|----------------------|-----------------------------|
| a. HI to increase | c. HI to remain constant |
| b. H_2 to increase | d. H_2 to remain constant |
10. As the pressure increases at constant temperature, the mass of $H_2(g)$
- | | | |
|-------------|-------------|--------------------|
| a. increase | b. decrease | c. remain the same |
|-------------|-------------|--------------------|
11. If the volume of the container increases, what happens to the reaction?
- | | | |
|------------------------|-----------------------|---------------------|
| a. shifts to the right | b. shifts to the left | c. remains the same |
|------------------------|-----------------------|---------------------|

Recall the equilibrium system in the body:



12. If a buildup of CO_2 occurs in the body,
- a. Which way will reaction 1 shift?
 - b. How will it affect the concentration of carbonic acid, H_2CO_3 ?
 - c. Explain why this leads to acidosis.

13. Use the graph to answer the following questions:
- a. Why is the system at equilibrium from time 0-1?
 - b. HCO_3^- remains the most abundant of the three chemicals in the body at all times. If the CO_2 concentration increases, sketch a graph to show how it would affect all species in the system starting at time 1, and arriving at equilibrium at time 2.



UNIT 7: HOW DOES THE BODY REGULATE pH

Haber Process- The Making of Ammonia

SEP: Constructing Explanations CCC: Stability and Change

Watch this! <https://www.youtube.com/watch?v=tdEE5uvFhOM>

Humans have become champions at developing new strategies for increasing the amount of energy - and food - they capture from the environment. The harnessing of fire, the domestication of plants and animals, developments that occurred over tens of thousands of years - all served this end.

1. What new strategies can you think of that humans have developed for increasing energy & food?

By the nineteenth century, famine and hunger had long been common throughout even the wealthiest regions of the planet. European farmers realized the need for a new nitrogen source in order to continue feeding. In 1909, two German chemists named Fritz Haber and Carl Bosch invented a process to synthesize ammonia from atmospheric nitrogen and the hydrogen in fossil fuels. The process initially used coal as a feedstock, though later it was adapted to use natural gas. After the end of the Great War, nation after nation began building Haber-Bosch plants; today the process produces 150 million tons of ammonia-based fertilizer per year, equaling the total amount of available nitrogen introduced annually by all natural sources combined.

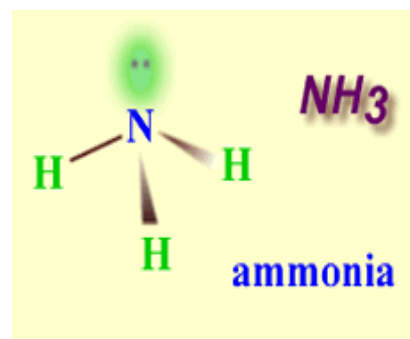
2. What does it mean to synthesize ammonia?

The raw materials for making ammonia fertilizer are readily available. Hydrogen can be generated from natural gas, and nitrogen is the largest component of the atmosphere. Central to the problem of creating ammonia are the strong triple bonds in the diatomic nitrogen molecule. Catalysts lower the molecules' activation energy so that these bonds can be broken, allowing the process to proceed faster. As the reactants enter the catalytic chamber, there are many more nitrogen and hydrogen molecules than ammonia molecules, a situation that, according to LeChatelier's Principle, favors the forward reaction. As the reaction proceeds, the percentage of ammonia molecules increases, and this rising concentration tends to favor the reverse process. Normally, the process would reach equilibrium and stop at a fixed amount of ammonia. However, the gas is not stationary, and as the ammonia is produced, it is removed by the cooling process. This restores the original imbalance that favors the creation of more ammonia, and so more is created when the reactants in the closed loop are recirculated through the reaction chamber.

3. How is the reaction stressed to make it shift to the right and continue to make ammonia?

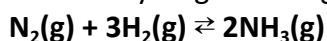
The nitrogen is needed by plants to make proteins. Some types of bacteria "fix" nitrogen from the air, forming nitrates, which plants can use. But large-scale farming requires more abundant nitrates, which can be made from ammonia. However, because ammonia could not be produced in abundance, most nitrates had to be imported from mined deposits, mainly in Chile.

Nitrates are also used in the manufacture of explosives. In 1913, as World War 1 was approaching, Germany was under pressure to obtain ammonia needed to make such explosives. These factors led researchers to investigate methods of producing ammonia on an industrial scale. Fritz Haber, a German chemist, learned that ammonia could be produced by



UNIT 7: HOW DOES THE BODY REGULATE pH

the direct combination of nitrogen from the air and hydrogen through the following reaction:



4. Does the above reaction satisfy the law of conservation of mass? What do the double arrows mean?

To occur at a reasonable rate, the reaction requires the presence of a catalyst, high temperature, and high pressure. Because the reaction is reversible, the ammonia must be removed as it is produced to keep the reaction moving to the right, in favor of the product. Karl Bosch, an engineer from a German company interested in Haber's work, designed equipment that could operate at temperatures up to 550°C and up to 200 atmospheres, making the large-scale production of ammonia possible. This process developed to produce ammonia is known as the Haber-Bosch process.

5. What is a catalyst? What does the author mean by the reaction is reversible?

Today, ammonia ranks as one of the most important industrial substances. Modern chemical plants that produce ammonia manufacture thousands of tons per day. The ammonia is then used in the manufacture of explosives, plastics, soap, and many other common products. However, the greatest percentage of ammonia is used in the production of fertilizers. The nitrogen in fertilizers is supplied directly or indirectly by ammonia. Fertilizers replenish nitrogen and other substances, particularly potassium and phosphorus that have been reduced or exhausted in soils. Ammonia is used as a fertilizer in both gaseous and liquid form. The gas is pumped directly into the soil. The liquid form, called anhydrous ammonia, is also added directly to the soil. Plants are able to absorb some of the ammonia, using it to make proteins. Bacteria in the soil convert much of the ammonia to nitrites (NO_2^-) and then to nitrates (NO_3^-). Plants absorb the nitrates and also utilize the source of nitrogen in making proteins.

6. What makes Ammonia so important to the plants?

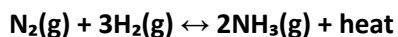
Fertilizers can be used to tailor soils for specific crops, to enrich poor soils and to increase crop yield. However, runoff is a problem with these fertilizers because they are highly soluble in water. Contamination of bodies of water by nitrogen fertilizers is a serious form of pollution. Increased plant growth in the affected body of water can lead to oxygen depletion and the "death" of the body of water. Controlled-release fertilizers are under development, but are currently used only in non-farming applications, due to their costs.

7. What problem does runoff create?

UNIT 7: HOW DOES THE BODY REGULATE pH

Design Investigation

A company produces ammonia, NH_3 , for fertilizer using the reversible reaction below:



The company wants to increase the amount of ammonia formed at equilibrium so it can collect more product and increase profit. However, any change in conditions must also be practical and cost-effective.

Your task is to recommend **one change in conditions** that would increase the amount of product and help the company earn more profit.

Design Constraints:

- You may change only **one variable at a time**
- Your recommendation must be based on **evidence and scientific reasoning**
- You must explain the change at both the **macroscopic and molecular** levels
- Your recommendation should consider **profit**, not just product yield

Planning Sheet

1. What condition will you change?
2. Why did you choose this condition?
3. How do you predict the system will respond?
4. What evidence from class investigations supports your recommendation?
5. What happens at the particle level?

Write a scientific recommendation to the company.

UNIT 7: HOW DOES THE BODY REGULATE pH

Identifying Acid, Bases, and Salts Think Tank Questions

SEP: Asking Questions CCC: Patterns

1. Read Table K provided. Which ion is common for all the acids listed?
2. Common household acids include lemon juice, sour candy, and vinegar. What properties do these chemicals have in common?
3. Read Table L provided. Which ion is common for the first three bases listed?
4. Common household bases include ammonia (floor cleaner), borax soap, and detergent. What properties do these chemicals have in common?

Table K
Common Acids

Formula	Name
HCl(aq)	hydrochloric acid
HNO ₂ (aq)	nitrous acid
HNO ₃ (aq)	nitric acid
H ₂ SO ₃ (aq)	sulfurous acid
H ₂ SO ₄ (aq)	sulfuric acid
H ₃ PO ₄ (aq)	phosphoric acid
H ₂ CO ₃ (aq) or CO ₂ (aq)	carbonic acid
CH ₃ COOH(aq) or HC ₂ H ₃ O ₂ (aq)	ethanoic acid (acetic acid)

Table L
Common Bases

Formula	Name
NaOH(aq)	sodium hydroxide
KOH(aq)	potassium hydroxide
Ca(OH) ₂ (aq)	calcium hydroxide
NH ₃ (aq)	aqueous ammonia

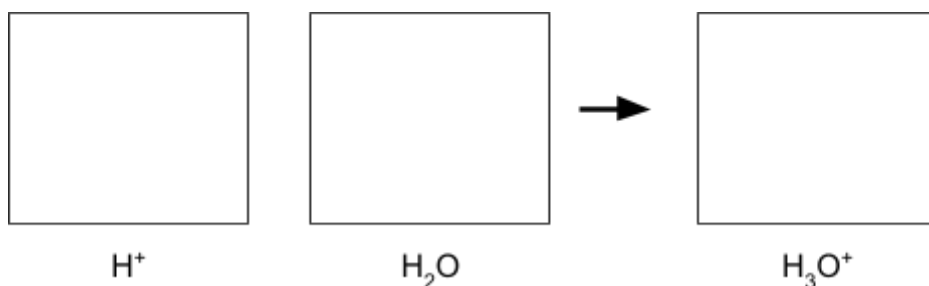
5. An acid can be neutralized with a base and both substances will lose their properties. They react to form water and salt.
 - a. What is the formula for water?
 - b. What bonds does water have?
 - c. Table salt is one type of salt that can be formed. What is the formula of table salt?
 - d. What bonds does table salt have?
 - e. A common acid base reaction is provided below. Label the acid, base on the reactant side and the salt on the product side.
$$\text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O}$$
 - f. Where do the atoms in water molecules come from in this reaction?

Arrhenius Acids are defined as a substance that dissociates in aqueous solution (water) to increase the concentration of **hydrogen ions (H^+)**. When an acid dissolves in water, the H^+ ion is attracted to the water molecules and forms the **hydronium ion H_3O^+**

6. Why is the hydrogen ion (H^+) attracted to water?

7. Is the H^+ attracted to the O or H in a water molecule?

In the boxes below, show how a hydrogen ion combines with water to form the hydronium ion.



Arrhenius bases are defined as a substance that increases the concentration of **hydroxide ions (OH^-)** when dissolved in water.

Salts: Recall that salts are ionic compounds.

8. Identify which are acids, bases and salts

HF	NaCl	$Ca(OH)_2$	H_2SO_4	H_3PO_4
LiOH	HCl	Na_2SO_4	HNO_3	$HC_2H_3O_2$

UNIT 7: HOW DOES THE BODY REGULATE pH

Properties of Acids and Bases Lab

SEP: Carrying Out Investigations CCC: Patterns

Background Information: Some of our everyday household items are known to be acidic or basic. We learned acids have pH values below 7 and bases have pH values above 7. But what other properties do they have?

Materials: test tubes and racks, pipettes, spatulas, spot plates, 1M HCl, 1M HC₂H₃O₂, 1M NaOH, 1M LiOH, 2M NaOH, phenolphthalein, litmus paper, pH paper, zinc, magnesium, copper, iron, CaCO₃, household chemicals.

Guiding Question: What properties do acids, bases, and salts have? Compare and contrast.

Procedure:

1. Test each solution at this lab station with red and blue litmus paper and pH paper. You must record either "red" or "blue" for the litmus and a number for the pH.

Household chemical	Non-neutral Ingredient	Red litmus	Blue litmus	pH paper	Acid or Base
Vinegar	HC ₂ H ₃ O ₂				Acid
Soda	H ₂ CO ₃				Acid
Juice	HC ₆ H ₇ O ₇				Acid
Soap	KOH				Base
Milk of magnesia	Mg(OH) ₂				Base
Draino	NaOH				Base

2. Add about five drops of each of the following to separate depressions on a spot plate. Test them all with litmus paper (record "red" or "blue" only) and phenolphthalein (record colorless or pink). Then decide if they are acids or bases. Clean and dry your spot plate.

Substances	Red litmus	Blue litmus	phenolphthalein	Acid or Base?
1M NaOH				
1M LiOH				
1M HCl				
1M HC ₂ H ₃ O ₂				



UNIT 7: HOW DOES THE BODY REGULATE pH

3. Add small pieces of Zn, Mg, Cu and Fe to separate depressions on your plate. Add a few drops of 1M HCl to each depression. Observe and record their reactivity. Scale their reactivity 0 (not reactive) to 4 (most reactive). Clean and dry your spot plate.

Metals	Observations	Reactivity
Zn		
Mg		
Cu		
Fe		

4. Add small pieces of Zn, Mg, Cu and Fe to separate depressions on your plate. Add a few drops of 1M $\text{HC}_2\text{H}_3\text{O}_2$ to each depression. Observe and record their reactivity. Scale their reactivity 0 (not reactive) to 4 (most reactive). Clean and dry your spot plate.

Metals	Observations	Reactivity
Zn		
Mg		
Cu		
Fe		

5. Place a small amount of CaCO_3 to a test tube. Then add a few drops of HCl. Record your observations. Clean and dry your test tube.

Observations:	
----------------------	--

6. Add about 10 drops of **6M HCl** to a clean, dry test tube. Also add one drop of phenolphthalein. To the same test tube, add **0.5 M NaOH** slowly, drop by drop, while swirling until the solution turns pink. When it turns pink, the solution is neutralized. Count how many drops you needed to add to obtain the pink color throughout the test tube.

Drops needed:	
----------------------	--

Post Lab Questions:

- Based on parts 1 and 2. what color will red and blue litmus paper turn
 - in an acidic solution?
 - in a basic solution?
 - in a neutral solution?
- The table 1 provides the “non-neutral ingredient” of the household chemicals. What similarities can you find in the formula of
 - all acids?
 - all bases?
- Using table 2, create a rule for testing acidic and basic solutions with phenolphthalein?
- Predict why the HCl reacts more vigorously with the metals than the $\text{HC}_2\text{H}_3\text{O}_2$ as seen in parts 3 and 4.



5. Which metals were least reactive with acids? Is that confirmed with what we have learned previously? Justify your answer.
6. Write a balanced reaction for HCl reacting with the most reactive metal that we used in part 3 and 4.
7. Write a balanced double replacement equation for the reaction of HCl and CaCO_3 that occurred in Pt. 5.
8. H_2CO_3 is very unstable and breaks down into water and carbon dioxide. Is this fact supported by your observations in step 5? Explain your answer.
9. Write a balanced double replacement reaction for the reaction of HCl and NaOH that occurred in Pt. 6.
10. Recall how phenolphthalein indicates acidic and basic solutions in part 2. Explain what occurred during this reaction to the acidity and basicity of this solution and NaOH was added to the HCl in part 6.
11. Explain why the reaction between the acid and the base is called a **neutralization** reaction in terms of pH values.
12. Explain, in terms of Molarity and concentration, why more drops of NaOH were needed than drops of HCl.



UNIT 7: HOW DOES THE BODY REGULATE pH

Identifying Arrhenius Acids and Bases Check Your Understanding

SEP: Developing and Using Models CCC: Structure and Function

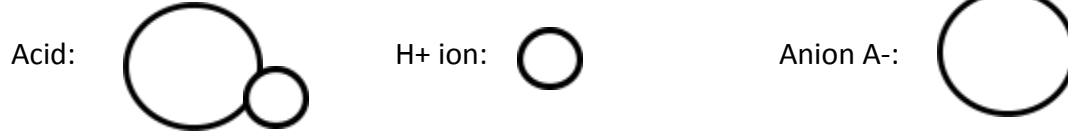
- The Arrhenius theory explains the behavior of
 - acids and bases
 - isomers and isotopes
 - alcohols
 - esters
- An Arrhenius base yields which ion as the only negative ion in an aqueous solution?
 - hydride ion
 - hydrogen ion
 - hydronium ion
 - hydroxide ion
- According to the Arrhenius theory, an acid is a substance that
 - changes litmus from red to blue
 - changes phenolphthalein to pink
 - produces hydronium ions as the only positive ions in an aqueous solution
 - produces hydroxide ions as the only negative ions in an aqueous solution
- Which formula represents a hydronium ion?
 - H_3O^+
 - OH^-
 - NH_4^+
 - HCO_3^-
- Which compound is an Arrhenius acid?
 - H_2SO_4
 - NaOH
 - KCl
 - NH_3
- Which substance is an Arrhenius base?
 - $\text{Ba}(\text{OH})_2$
 - H_3PO_4
 - CH_3COOH
 - NaCl
- Which compound releases hydroxide ions in an aqueous solution?
 - CH_3COOH
 - HCl
 - CH_3OH
 - KOH
- Which two compounds are electrolytes?
 - $\text{C}_6\text{H}_{12}\text{O}_6$ and $\text{CH}_3\text{CH}_2\text{OH}$
 - $\text{C}_6\text{H}_{12}\text{O}_6$ and HCl
 - NaOH and HCl
 - NaOH and CH_3CHOH
- Given the equation, which ion is X?
$$\text{HCl}(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{X}(\text{aq}) + \text{Cl}^-(\text{aq})$$
 - hydroxide
 - hydronium
 - hypochlorite
 - perchlorate
- When one compound dissolves in water, the only positive ion produced in the solution is $\text{H}_3\text{O}^+(\text{aq})$. This compound is classified as
 - a salt
 - an Arrhenius acid
 - a hydrocarbon
 - an Arrhenius base
- An aqueous solution of lithium hydroxide contains hydroxide ions as the only negative ion in solution. Lithium hydroxide is classified as an
 - aldehyde
 - alcohol
 - Arrhenius acid
 - Arrhenius base
- Which two formulas represent Arrhenius acids?
 - CH_3COOH and $\text{CH}_3\text{CH}_2\text{OH}$
 - $\text{HC}_2\text{H}_3\text{O}_2$ and H_3PO_4
 - KHCO_3 and KHSO_4
 - NaSCN and $\text{Na}_2\text{S}_2\text{O}_3$
- The only positive ion found in $\text{H}_2\text{SO}_4(\text{aq})$ is the
 - ammonium ion
 - hydroxide ion
 - hydronium ion
 - sulfate ion

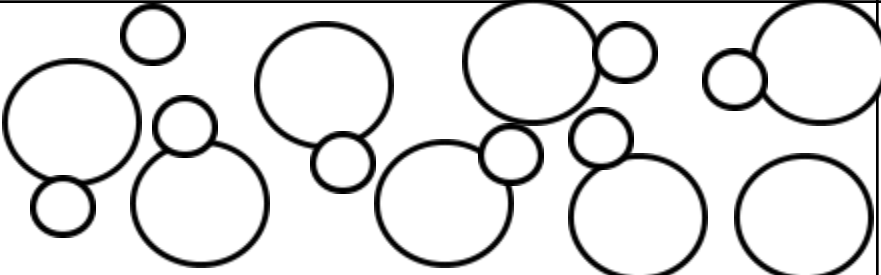
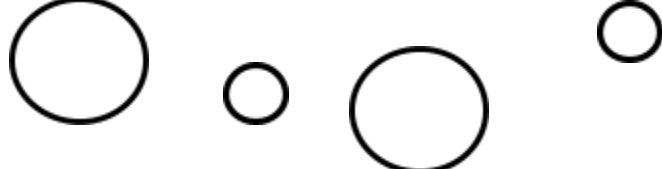
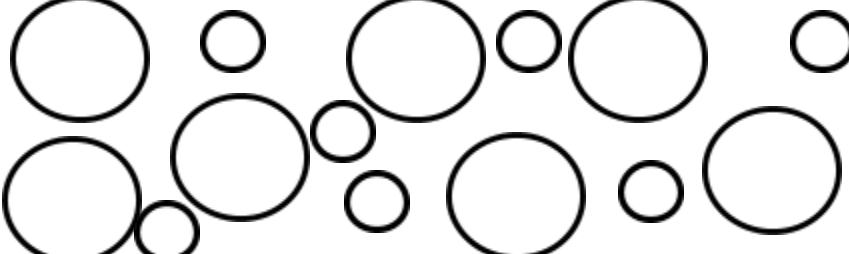

UNIT 7: HOW DOES THE BODY REGULATE pH

Strong or Weak, Concentrated or Dilute? Think Tank Questions

SEP: Developing and Using Models CCC: System Models

Directions: For each case, decide if the picture shows a weak or strong, and concentrated or dilute solution.



		W/S and C/D	Example
Case 1			
Case 2			
Case 3			
Case 4			

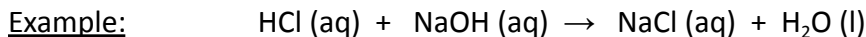
5. What does concentrated mean in terms of the amount of particles? _____
6. What does dilute mean in terms of amount of particles? _____
7. What does strong mean in terms of ions? _____
8. What does weak mean in terms of ions? _____

UNIT 7: HOW DOES THE BODY REGULATE PH

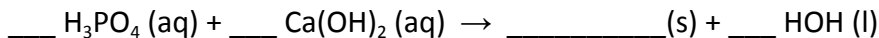
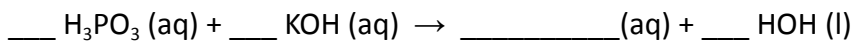
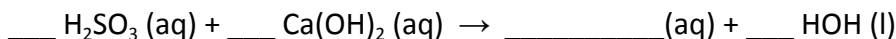
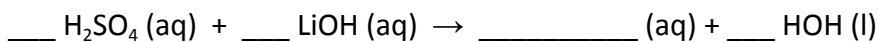
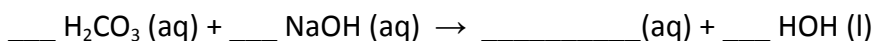
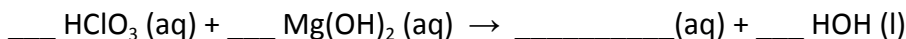
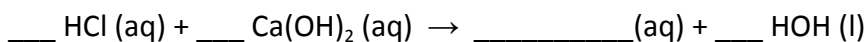
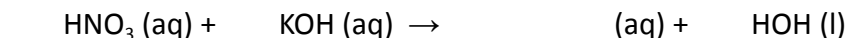
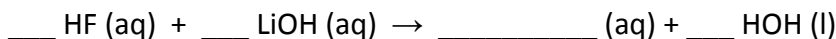
Reactions Involving Acids & Bases Check Your Understanding

SEP: Using Mathematical and Computational Thinking CCC: Patterns

Neutralization Reactions: If equal mole amounts of acid and base are added together, the resulting solution is NEUTRAL!



Predict the products of and balance the following reactions:

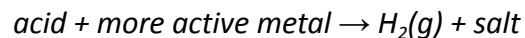


Neutralization reactions are a type of **DOUBLE REPLACEMENT** reaction like in the Granny Lab.

UNIT 7: HOW DOES THE BODY REGULATE pH

Reactions Involving Acids & Bases Think Tank Questions

SEP: Using Mathematics and Computational Thinking CCC: Structure and Function

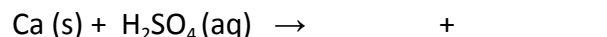
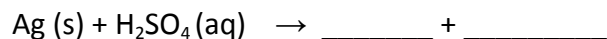
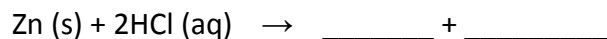


Reactions of Acids with Metals

Only 3 metals do NOT react with acids: Cu, Au, Ag

When metals react with acids, this is an example of a SINGLE REPLACEMENT reaction.

Predict the products of the following reactions:

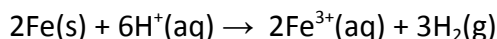


Reactions Involving Acids & Bases Check Your Understanding

1. Under standard conditions, which metal will react with 0.1 M HCl to liberate hydrogen gas?

- (1) Ag (2) Au (3) Cu (4) Mg

3. Because tap water is slightly acidic, water pipes made of iron corrode over time, as shown by the balanced ionic equation below. Explain, in terms of chemical reactivity, why copper pipes are less likely to corrode than iron pipes.



4. Many ancient cultural statues and buildings were made out of marble. Marble is a type of rock which contains the metal calcium in it. Explain why marble statues are damaged by acid rain.

5. During a laboratory activity, a student reacted a piece of zinc with 0.1 M HCl(aq).

(a) Complete the equation below by writing the formula of the missing products.



(b) Identify one metal that does not react spontaneously with HCl(aq). _____.

UNIT 7: HOW DOES THE BODY REGULATE pH

Acid Base Reactions Practice

SEP: Developing and Using Models CCC: Structure and Function

1. What are the products of a reaction between KOH(aq) and HCl(aq)?

- (1) H₂ and KClO (3) H₂O and KCl
 (2) KH and HClO (4) KOH and HCl

2. Which word equation represents a neutralization reaction?

- (1) base + acid → salt + water
 (2) base + salt → water + acid
 (3) salt + acid → base + water
 (4) salt + water → acid + base

3. Which compound could serve as a reactant in a neutralization reaction?

- (1) NaCl (3) CH₃OH
 (2) KOH (4) CH₃CHO

4. Which substance is always a product when an Arrhenius acid in an aqueous solution reacts with an Arrhenius base in an aqueous solution?

- (1) HBr (3) KBr
 (2) H₂O (4) KOH

5. Which reactants form the salt CaSO₄(s) in a neutralization reaction?

- (1) H₂S(g) and Ca(ClO₄)₂(s)
 (2) H₂SO₃(aq) and Ca(NO₃)₂(aq)
 (3) H₂SO₄(aq) and Ca(OH)₂(aq)
 (4) SO₂(g) and CaO(s)


6. Sulfuric acid, H₂SO₄(aq), can be used to neutralize barium hydroxide, Ba(OH)₂(aq). What is the formula for the salt produced by this neutralization?

- (1) BaS (3) BaSO₃
 (2) BaSO₂ (4) BaSO₄

7. Which chemical equation represents the reaction of an Arrhenius acid and an Arrhenius base?

- (1) HC₂H₃O₂(aq) + NaOH(aq) → NaC₂H₃O₂(aq) + H₂O(l)
 (2) C₃H₈(g) + 5 O₂(g) → 3 CO₂(g) + 4 H₂O(l)
 (3) Zn(s) + 2 HCl(aq) → ZnCl₂(aq) + H₂(g)
 (4) BaCl₂(aq) + Na₂SO₄(aq) → BaSO₄(s) + 2 NaCl(aq)

When an acid dissolves it dissociates or ionizes (breaking up into two ions). The ions are separated due to the polarity of water, as shown below. Draw what happens to the other acid, base, and salt in water.

<p>HCl(g) + H₂O(l) → HCl(aq)</p> 	<p>HNO₃(g) + H₂O(l) → HNO₃(aq)</p>	<p>NaOH(s) + H₂O(l) → NaOH(aq)</p>	<p>NaCl(s) + H₂O(l) → NaCl(aq)</p>
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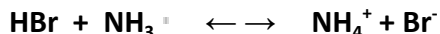
Explain why they are known as electrolytes when in solution but not when they are in solid or gas phases.

UNIT 7: HOW DOES THE BODY REGULATE pH

Bronsted Lowry Theory Think Tank Questions

SEP: Developing and Using Models CCC: Patterns

Acids are defined as **proton (H⁺) donors**. They donate protons to the base. **Bases** are defined as **proton acceptors**. They accept protons from the acid.



In the reaction above, HBr is the acid and NH₃ is the base. According to the Bronsted Lowry theory, why is HBr classified as an acid and NH₃ classified as a base? Use evidence from the reaction in your explanation.

According to Bronsted-Lowry theory, acid-base reactions involve a transfer of a proton. Above, the acid on the left, _____, transfers (donates) a proton (H⁺) and becomes a base on the right, _____. The donating acid and the base it becomes are called *conjugate acid - base pairs*. The base on the left, _____, accepts a proton (H⁺) and becomes an acid on the right, _____. This is also a conjugate pair.

1. $\text{HCl}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_3\text{O}^+(\text{aq}) + \text{Cl}^-(\text{aq})$
2. $\text{HI}(\text{aq}) + \text{NH}_3(\text{aq}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{I}^-(\text{aq})$
3. $\text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightleftharpoons \text{NH}_3(\text{aq}) + \text{H}_2\text{O}(\text{l})$
4. $\text{HSO}_4^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{SO}_4^{2-}(\text{aq}) + \text{H}_3\text{O}^+(\text{aq})$

1. In the reactions above, list the acids in the reactants and explain what they all have in common.
2. In the reactions, list the bases in the first half of the equation and explain what they all have in common.
3. Did you notice these are reversible equilibrium reactions? If you reverse the equations (starting on the product side), list the new acids and bases in the reverse reactions.
Acids: _____ Bases: _____
4. Now you can see that each acid on the left hand side produces a corresponding base on the right hand side. The base is called the **conjugate base**. Similarly, a base on the right hand side will produce a **conjugate acid**. These pairs are known as **conjugate acid-base pairs**. List the conjugate acid-base pairs for equations (1) and (2).
5. Write the acid-base reaction for NH₃ reacting with HClO₂ and identify the acid, the base, the conjugate acid and the conjugate base.

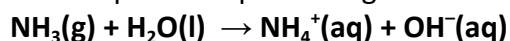
UNIT 7: HOW DOES THE BODY REGULATE pH

Bronsted Lowry Theory Check Your Understanding

SEP: Developing and Using Models CCC: Structure and Function

- One acid-base theory defines a base as an
(1) H^+ donor (2) H donor (3) H^+ acceptor (4) H acceptor
- One alternate acid-base theory states that an acid is a(n)
(1) H^+ donor (2) OH^- donor (3) H^+ acceptor (4) OH^- acceptor
- According to one acid-base theory, a water molecule acts as an acid when the water molecule
(1) accepts an H^+ (2) accepts an OH^- (3) donates an H^+ (4) donates an OH^-

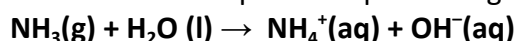
- Given the equation representing a reaction at equilibrium:



The H^+ acceptor for the forward reaction is

- $H_2O(l)$ (2) $NH_4^+(aq)$ (3) $NH_3(g)$ (4) $OH^-(aq)$
- Which formula represents a hydronium ion?
(1) H_3O^+ (2) OH^- (3) NH_4^+ (4) HCO_3^-

- Given the balanced equation representing a reaction:



According to one acid-base theory, the $NH_3(g)$ molecules act as

- an acid because they accept H^+ ions
 - an acid because they donate H^+ ions
 - a base because they accept H^+ ions
 - a base because they donate H^+ ions
- Which statement describes an alternate theory of acids and bases?
(1) Acids and bases are both H^+ acceptors.
(2) Acids and bases are both H^+ donors.
(3) Acids are H^+ acceptors, and bases are H^+ donors.
(4) Acids are H^+ donors, and bases are H^+ acceptors.
 - What major similarities and differences can you identify between Arrhenius and Bronsted Lowry (alternative) acid base theories?

Similarities

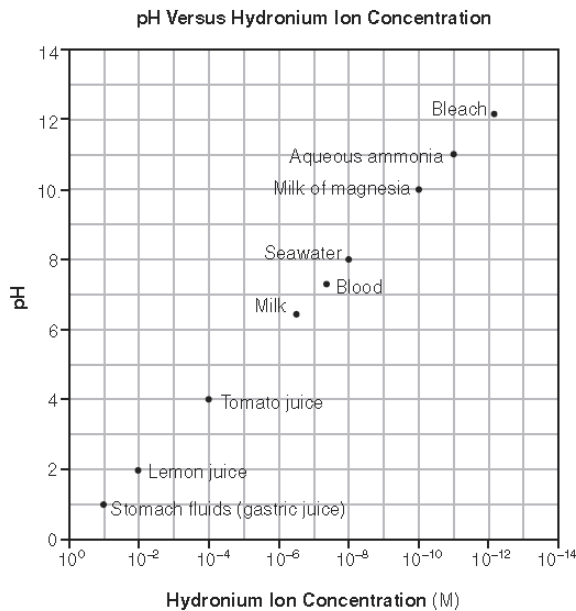
Differences

UNIT 7: HOW DOES THE BODY REGULATE pH

The pH Scale Think Tank Questions

SEP: Analyzing and Interpreting Data CCC: Patterns

The pH scale is a measure of the H^+ or H_3O^+ concentration in a solution. "pH" stands for "potential to ATTRACT Hydrogen ions" "potential to ATTRACT Hydrogen ions. The pH scale is logarithmic, which means that a change of *one* pH unit will change the concentration of H^+ by a factor of 10.



1. What is the relationship between pH value and hydrogen ion concentration?

2. Which substance is 10000 times more acidic than seawater?

3. What substance is 100 times more basic than lemon juice?

3. Complete the table below using the grid above:

	Hydronium Ion Concentration (M)	pH	Acid or Base?
Stomach fluids			
Lemon Juice			
Tomato Juice			
Seawater			
Milk of Magnesia			

4. Find the pH of the following solutions and determine if its acidic or basic:

Acid Concentration	pH	Acid or Base? (or neutral 😊)
$[H_3O^+] = 1 \times 10^{-2}$		
$[H_3O^+] = 1 \times 10^{-7}$		
$[H^+] = 1 \times 10^{-11}$		
$[H^+] = 1 \times 10^{-5}$		
$[H_3O^+] = 0.0010$		
$[H_3O^+] = 0.0000010$		
$[H^+] = 0.0000000010$		

UNIT 7: HOW DOES THE BODY REGULATE pH

pH Check Your Understanding

SEP: Analyzing and Interpreting Data CCC: Patterns

Recall the following:

- increasing or decreasing the pH by 1 changes the $[H^+]$ by a factor of 10^1 (10 times, ten-fold)
- increasing or decreasing the pH by 2 changes the $[H^+]$ by a factor of 10^2 (100 times, hundred-fold)
- increasing or decreasing the pH by 3 changes the $[H^+]$ by a factor of 10^3 (1000, thousand-fold)

- Describe what happens to the concentration of hydrogen ions in a solution if the pH is changed from 7 to 5.
- Describe what is happening to the concentration of hydrogen ions in a solution if the pH is changed from 5 to 8.

3. Complete the table below:

pH Change	$[H_3O^+]$ increase or decrease?	$[OH^-]$ increase or decrease?	Does the solution become more acidic or basic?	By a factor of... (ex. 100x)
6 to 8				
8 to 5				
3 to 7				
11 to 9				
14 to 13				
4 to 8				

4. Which of these pH numbers indicates the highest level of acidity?

- (1) 5 (2) 10 (3) 8 (4) 12

5. Which change in pH represents a hundredfold increase in the concentration of hydronium ions in a solution?

- (1) pH 1 to pH 2 (3) pH 2 to pH 1
(2) pH 1 to pH 3 (4) pH 3 to pH 1

6. The pH of a solution changes from 4 to 3 when the hydrogen ion concentration in the solution is

- (1) decreased by a factor of 100
(2) decreased by a factor of 10

- (3) increased by a factor of 100
(4) increased by a factor of 10

7. Solution A has a pH of three and solution Z has a pH of six How many times greater is the hydronium ion concentration in solution A than the hydronium ion concentration in solution Z?

- (1) 100 (2) 3 (3) 2 (4) 1000

8. What is the pH of a solution that has a hydronium ion concentration 100 times greater than a solution with a pH of 4?

- (1) 5 (2) 3 (3) 2 (4) 6

UNIT 7: HOW DOES THE BODY REGULATE pH

Indicators Lab

SEP: Carrying Out Investigations

CCC: Patterns

Part A: Determining pH Range of Indicators

- Test all pH solutions with methyl orange and record the color you observe. Rinse the spot plate.
- Repeat the tests with bromothymol blue, phenolphthalein, and litmus and record the color you observe. Rinse the spot plate between each test.

pH	1	3	5	7	9	11	13
Methyl orange							
Bromothymol Blue							
Phenolphthalein							
Litmus paper							

- Do your results from Part A agree with the pH ranges listed on table? Explain.

Common Acid–Base Indicators

Indicator	Approximate pH Range for Color Change	Color Change
methyl orange	3.1–4.4	red to yellow
bromthymol blue	6.0–7.6	yellow to blue
phenolphthalein	8–9	colorless to pink
litmus	4.5–8.3	red to blue
bromcresol green	3.8–5.4	yellow to blue
thymol blue	8.0–9.6	yellow to blue

- Complete the table below by shading each color of each indicator in the specific pH regions:

pH	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Methyl Orange															
Bromothymol Blue															
Phenolphthalein															
Litmus															
Bromcresol Green															
Thymol Blue															



Part B: Determining the identity of an unknown solution.

UNIT 7: HOW DOES THE BODY REGULATE pH

- Use the indicators to test the unknown solution. Record your observations below.
- Use the table provided to determine each pH range that color represents.

Indicator	Color	pH range
Litmus		
Phenolphthalein		
Methyl Orange		
Bromothymol Blue		

- Provide a possible pH for your unknown.
- Using the table provided, predict what color this unknown solution would turn if bromocresol green was added.
- Using the table provided, predict what color this unknown solution would turn if thymol blue was added.



UNIT 7: HOW DOES THE BODY REGULATE pH

Natural Indicators

Phenomenon: Butterfly pea tea

Fill 3 small beakers with butterfly pea tea. Beaker one will serve as the control. In a second beaker place a few drops of hydrochloric acid (HCl). In a third beaker, place a few drops of sodium hydroxide (NaOH). Record your observations below:

Beaker		Color
1	Control	
2	Acid added	
3	Base added	

This shift in color represents Le Chatelier's principle as shown below:



- Using evidence from the experiment and the reaction above, explain the color change that occurred in beaker 2.

Hydrangeas can produce different flower colors depending on soil conditions. In general, hydrangeas are more likely to produce **blue flowers in more acidic soil** and **pink flowers in more basic soil**. A student tests soil from two gardens.

Garden	Soil pH	Hydrangea Color
A	5.2	Blue
B	7.8	Pink

- Which garden has a greater concentration of hydronium ions?



UNIT 7: HOW DOES THE BODY REGULATE pH

Indicators Check Your Understanding

SEP: Analyzing and Interpreting Data CCC: Patterns

Common Acid–Base Indicators

Indicator	Approximate pH Range for Color Change	Color Change
methyl orange	3.1–4.4	red to yellow
bromthymol blue	6.0–7.6	yellow to blue
phenolphthalein	8–9	colorless to pink
litmus	4.5–8.3	red to blue
bromocresol green	3.8–5.4	yellow to blue
thymol blue	8.0–9.6	yellow to blue

1. Which indicator, when added to a solution, changes color from yellow to blue as the pH of the solution is changed from 5.5 to 8.0?

- (1) bromocresol green (3) litmus
(2) bromothymol blue (4) methyl orange

2. Which indicator would best distinguish between a solution with a pH of 3.5 and another with a pH of 5.5?

- (1) bromothymol blue (3) litmus
(2) bromocresol green (4) thymol blue

3. In which solution will bromocresol green appear blue?

- (1) 1 M NaCl (2) 1 M NH₃
(3) 1 M H₂CO₃ (4) 1 M CH₃COOH

4. In which solution will the thymol blue indicator appear blue?

- (1) 0.1 M CH₃COOH (2) 0.1 M KOH (3) 0.1 M HCl (4) 0.1 M H₂SO₄

5. What is the color of the indicator methyl orange in a solution that has a pH of 2?

- (1) blue (2) yellow (3) orange (4) red

6. In a solution with a pH of 3, what color is bromocresol green?

- (1) yellow (2) green (3) blue (4) red

7. At what pH will bromothymol blue be yellow and bromocresol green be blue?

- (1) 10.5 (2) 5.7 (3) 7.0 (4) 14

8. A student used blue litmus paper and phenolphthalein paper as indicators to test the pH of distilled water and five aqueous household solutions.

Then the student used a pH meter to measure the pH of the distilled water and each solution. The results of the student's work are recorded in the table below.

Testing Results

Liquid Tested	Color of Blue Litmus Paper	Color of Phenolphthalein Paper	Measured pH Value Using a pH Meter
2% milk	blue	colorless	6.4
distilled water	blue	colorless	7.0
household ammonia	blue	pink	11.5
lemon juice	red	colorless	2.3
tomato juice	red	colorless	4.3
vinegar	red	colorless	3.3

a) Identify the liquid tested that has the lowest hydronium ion concentration.

b) Explain, in terms of the pH range for color change on the table provided, why litmus is not appropriate to differentiate the acidity levels of tomato juice and vinegar.

c) Based on the measured pH values, identify the liquid tested that is 10 times more acidic than vinegar.

UNIT 7: HOW DOES THE BODY REGULATE pH

Sample Regents Question:

A Profitable Blueberry Field

Optimal blueberry growth occurs within a soil pH of 4.5 to 5.0. A blueberry farmer had the soil from a field tested. The results indicated that the soil had a hydronium ion concentration of 1.0×10^{-8} M. Figure 1 shows indicators that could be used to test soil pH.

One way farmers can optimize the soil for blueberry growth is by adding elemental sulfur. Equation 1 shows the process when bacteria in the soil oxidizes the sulfur.

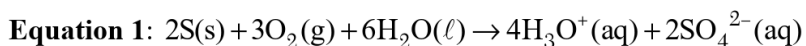


Figure 1: Indicators

Indicator	pH Range for Color Change	Color Change
alizarine yellow	10.2 – 12.0	yellow to red
bromcresol purple	5.2 – 6.8	yellow to purple
bromphenol blue	3.0 – 4.6	yellow to purple
congo red	3.0 – 5.0	blue-violet to red
methyl red	4.4 – 6.2	red to yellow

Which two indicators, when used independently, would provide results that, together, are suitable for evaluating soil pH to ensure optimal blueberry growth?

- (1) alizarine yellow and bromcresol purple
- (2) bromcresol purple and bromphenol blue
- (3) bromphenol blue and congo red
- (4) methyl red and alizarine yellow

Which row in the table completes the claim describing a possible cause and effect of adding elemental sulfur to the soil? Adding elemental sulfur to the soil cause, resulting in the effect.

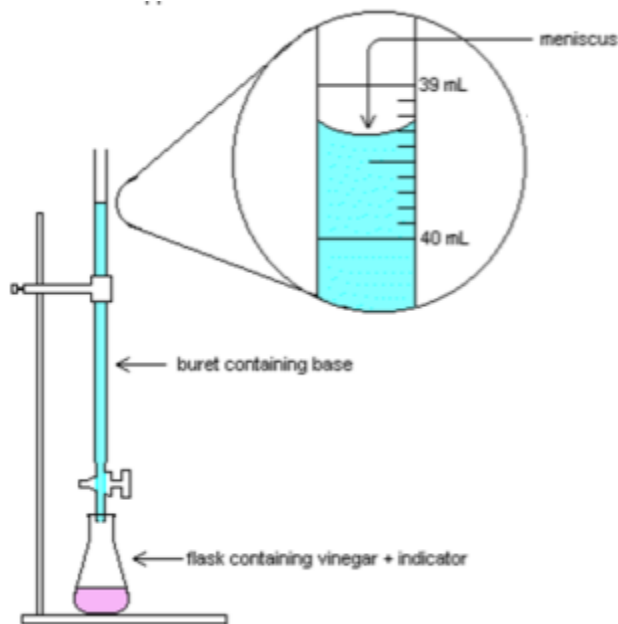
	Cause	Effect
(1)	increases the pH by 3	hydronium ion concentration decreasing by 1000
(2)	decreases the hydronium ion concentration by 1000	pH increasing by 3
(3)	decreases the pH by 3	hydronium ion concentration increasing by 1000
(4)	increases the hydronium ion concentration by 1000	pH decreasing by 3

UNIT 7: HOW DOES THE BODY REGULATE pH

Titration Think Tank Questions

SEP: Developing and Using Models CCC: Scale, Proportion, Quantity

Titration is a procedure used to determine the concentration (M) of an acid or a base. You combine together an acid and a base knowing the volume of each and the concentration of only one of them.



What number would be at the top of the buret?

Read the volume of the base in the buret.

If the buret holds 50mL, how much base is actually in the buret?

If a student started at 2.0mL and released base until it was at the level shown, how much bases was added?

Why is it not necessary to subtract all your volumes from 50mL?

1. A 25.0-milliliter sample of $\text{HNO}_3(\text{aq})$ is neutralized by 32.1 milliliters of 0.150 M $\text{KOH}(\text{aq})$. What is the concentration of the acid?
2. How many milliliters of 0.200 M NaOH are needed to neutralize 100. mL of 0.100 M HCl ?
3. In a titration, 20.0 milliliters of 0.15 M $\text{HCl}(\text{aq})$ is exactly neutralized by 18.0 milliliters of $\text{KOH}(\text{aq})$.
 - (a) Complete the equation below for the neutralization reaction by writing the formula of *each* product.
$$\text{KOH}(\text{aq}) + \text{HCl}(\text{aq}) \rightarrow \underline{\hspace{2cm}} + \underline{\hspace{2cm}}$$
 - (b) Compare the number of moles of $\text{H}^+(\text{aq})$ ions to the number of moles of $\text{OH}^-(\text{aq})$ ions in the titration mixture when the $\text{HCl}(\text{aq})$ is exactly neutralized by the $\text{KOH}(\text{aq})$.

UNIT 7: HOW DOES THE BODY REGULATE PH

(c) Determine the concentration of the KOH(aq).

(d) What is the new pH of the solution?

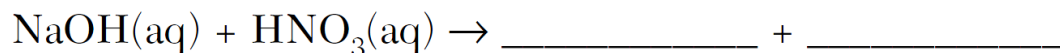
4. In a laboratory activity, 0.500 mole of NaOH(s) is completely dissolved in distilled water to form 400. milliliters of NaOH(aq). This solution is then used to titrate a solution of HNO₃(aq).

(a) Identify the negative ion produced when the NaOH(s) is dissolved in distilled water.

(b) Calculate the molarity of the NaOH(aq). Your response must include *both* a correct numerical setup and the calculated result.

(c) If 26.4 milliliters of the NaOH solution is needed to exactly neutralize 44.0 milliliters of the HNO₃ solution, what is the molarity of the HNO₃ solution?

(d) Complete the equation below representing this titration reaction by writing the formulas of the products.



UNIT 7: HOW DOES THE BODY REGULATE pH

Acid Base Titration Lab

SEP: Planning and Carrying Out Investigations CCC: Scale, Proportion, Quantity

Guiding Question: What is the molarity of the household vinegar?

Materials: Burettes, stands, flasks, graduated cylinders, .100M HCl, unknown NaOH, phenolphthalein, vinegar.

Pre-Lab Questions:

1. Why is it important to allow a small amount of the acid and base to pour out of the burette?
2. Why is it important to place a white piece of paper beneath the flask?
3. Why is it important to go slowly while adding the base drops?
4. Write the neutralization reaction for HCl reacting with NaOH.
5. What is the pH of each reactant and at the end point of the titration?

Procedure: **WARNING: Wear your goggles at ALL times.**

Part A: Titration of NaOH

1. Fill burette B with the base. Let about 2-3 mL drain out of each burette and discard. Record the initial base volumes. You may choose to start exactly at 0.00mL.
2. Measure 10.0ml of acid in a graduated cylinder. Transfer to the flask. Record the volume of the acid in your data table.
3. Add one drop of phenolphthalein to the flask. (Too much could ruin the lab.)
4. Place a sheet of white paper under the flask and place the flask under burette B. Place the tip of the burette in the flask.
5. Begin the titration by SLOWLY adding the base, drop by drop, while carefully swirling the flask.
6. Continue adding the base until a faint pink color appears for at least 15 seconds while stirring.
7. Record the burette B reading as the final reading of the base.
8. Empty and rinse the flask thoroughly.
9. Repeat the procedure for trial 2, using 20mL of acid instead of 10mL.

Part A	Trial 1		Trial 2	
	HCl	NaOH	HCl	NaOH
Initial				
Final				
Volume used				

Part B	
Vinegar volume:	___
Initial Base reading:	___
Final Base reading:	___
Total Base volume:	___



UNIT 7: HOW DOES THE BODY REGULATE PH

Part B: Titration of Vinegar

1. Measure out 10mL of white vinegar and place it into a flask. Add 1 drop of phenolphthalein.
2. Carefully titrate with the base until the solution turns faint pink for at least 30 seconds. Be sure to write down the initial and final burette readings.

Calculations: SHOW ALL WORK!

1. Calculate the molarity of NaOH in part A using the volumes of **trial 1** and the known molarity of HCl (0.100M).
2. Calculate the molarity of NaOH in part A using the volumes from **trial 2** and the known molarity of HCl (0.100M).
3. Write a scientific statement explaining if the molarity of the base changes greatly when the volume of the known acid changes.
4. Use the average molarity of the base calculated in calculations 1 and 2 to find the molarity of the vinegar in Part B.
5. Write a scientific statement comparing the molarities of the HCl and vinegar. Include a claim, evidence from the lab, and reasoning to support your claim.
6. Another titration is set up below. The concentration of the acid is unknown.
 - a. HCl is in the flask. For simplicity, model just the H^+ ions dissolved in solution: draw **five** H^+ ions in the flask. Record the volume of the acid in mL in the table below.
 - b. A 1.00M NaOH solution is added to the burette. For simplicity we are going to model just the OH^- ions. Draw **ten** OH^- ions in the burette. Record the concentration of the base in the table.
 - c. Record the initial burette volume of NaOH in mL in the data table.
 - d. The base (OH^-) is added dropwise into the flask until all of the acid (H^+) is neutralized by the base. Record the final volume of base in the burette.
 - e. Subtract to get the total volume of base used to neutralize the acid and record.
 - f. Draw a final model of the flask when neutralization occurs. Consider conservation of mass!
 - g. Using the titration formula, determine the unknown concentration of the acid used and record.

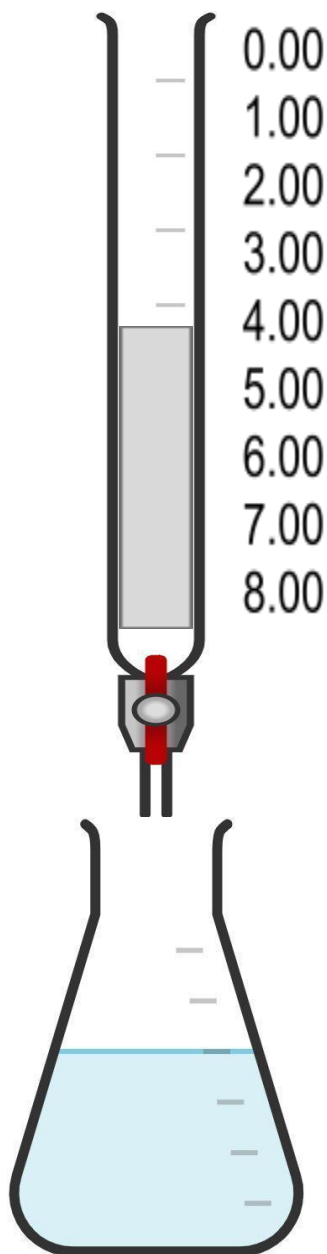
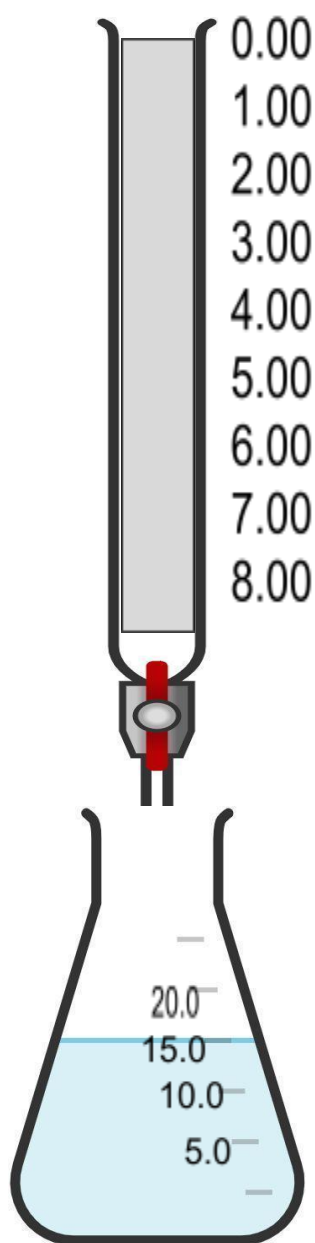


UNIT 7: HOW DOES THE BODY REGULATE pH

Volume of acid in flask	Concentration of Base (NaOH)	Initial volume of NaOH in buret	Final volume of NaOH in buret	Total Volume of Base Used	Molarity of the Acid

Initial:

Final:



UNIT 7: HOW DOES THE BODY REGULATE pH

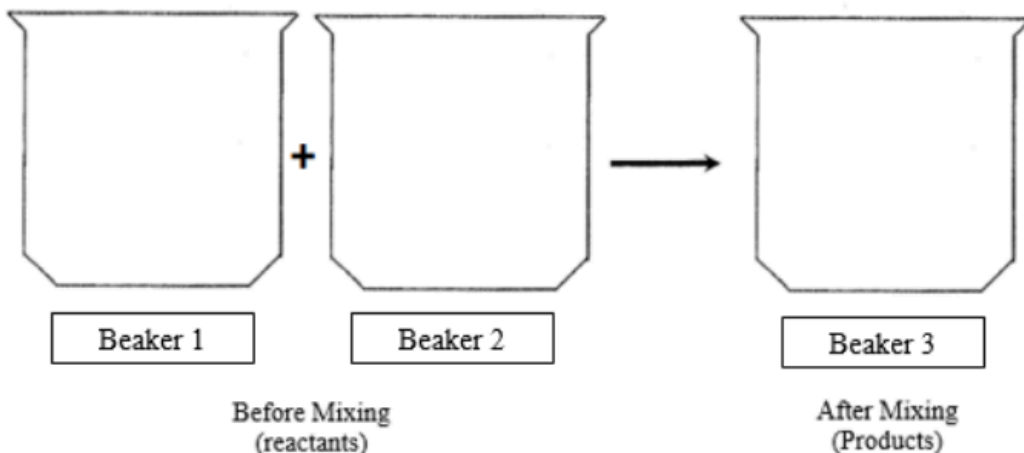
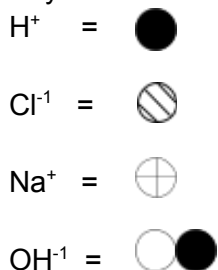
Neutralization Particle Diagrams

SEP: Developing and Using Models CCC: Structure and Function

Activity:

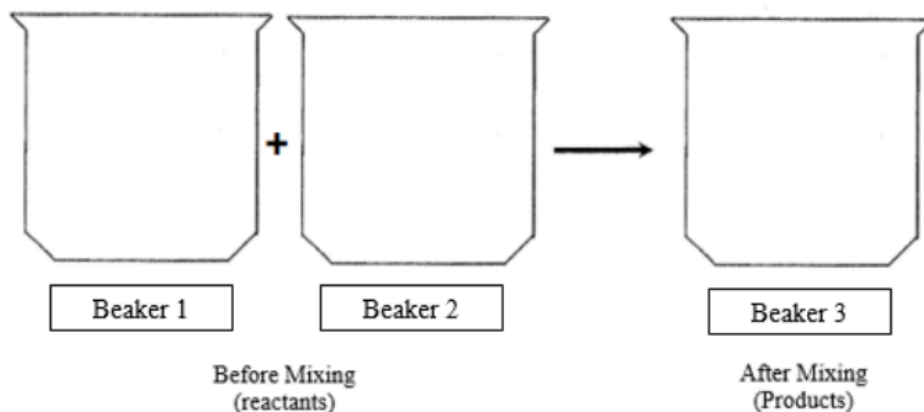
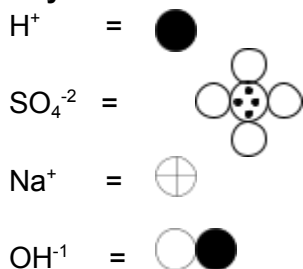
1. Write the balanced neutralization reaction for the reaction of HCl and NaOH under the beakers.
2. Using the key, draw particle models to represent the reaction before and after mixing. Draw five dissociated acid particles in beaker 1 and five dissociated base particles in beaker 2.
3. Match each hydrogen ion in beaker one with one hydroxide ion in beaker two. Then draw the number of water molecules that form in beaker three.

Key:



4. What was the pH of the resulting solution?
5. In a second neutralization reaction H_2SO_4 and $NaOH$ are mixed. Using the key below, draw three dissociated acid particles in beaker one and three dissociated base particles in beaker two.
6. Match each hydrogen ion in beaker one with one hydroxide ion in beaker two. Then draw the number of water molecules that form in beaker three. Draw the remaining ions in beaker three.

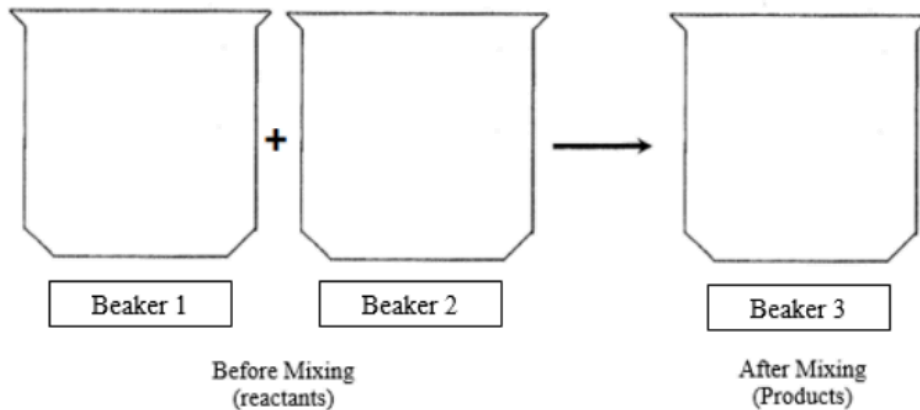
Key:



UNIT 7: HOW DOES THE BODY REGULATE pH

7. What additional ion(s) would be needed to neutralize the solution? How many more would you need?

8. Draw a model below to justify that neutralization has occurred.

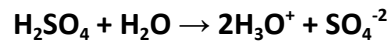
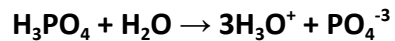


8. Write the **balanced** equation for the complete neutralization of H_2SO_4 and NaOH .

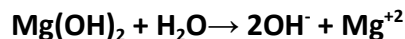
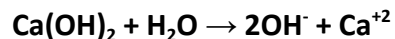
UNIT 7: HOW DOES THE BODY REGULATE pH

Neutralization by Titration Check Your Understanding

SEP: Using mathematics and Computational Thinking CCC: Scale, Proportion, Quantity



What happens when an acid has two or more hydrogen atoms? Do they just lose one? Strong acids completely ionize leaving no hydrogen atoms in the anion or conjugate base. This means we need to amend our titration formula for these special acids to include all the acidic ions that come off.



Similarly, what happens when a base has two or more hydroxide ions? Do they just lose one? Strong bases completely ionize leaving no hydroxide ions in the cation. This means we need to amend our titration formula for these special bases to include all the basic ions that come off.

1. If 65.0mL of 1.50M H_3PO_4 is neutralized by 25.0mL of $\text{Ca}(\text{OH})_2$, what is the molarity of the base?
2. If 15.0mL of 3.50M H_2SO_4 is neutralized by 25.0mL of $\text{Mg}(\text{OH})_2$, what is the molarity of the base?
3. If 150.0mL of 4.50M HNO_3 is neutralized by 3.00M $\text{Mg}(\text{OH})_2$, what is the volume of the base added?
4. If 25.5mL H_3PO_4 is neutralized by 50.0mL of 2.00M LiOH , what is the molarity of the acid?
5. If 35.0mL of H_2CO_3 is neutralized by 50.0mL of 1.50M KOH , what is the molarity of the acid?
6. If 6.00M HI is neutralized by 50.0mL of 4.50M RbOH , what is the volume of the acid added?

UNIT 7: HOW DOES THE BODY REGULATE pH

Titration Practice

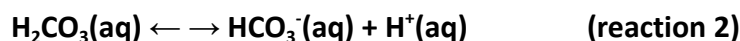
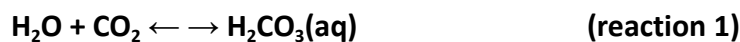
SEP: Using mathematics and Computational Thinking CCC: Scale, Proportion, Quantity

- What are the products of a reaction between $\text{LiOH}(\text{aq})$ and $\text{HCl}(\text{aq})$?
 - H_2 and LiClO
 - H_2O and LiCl
 - LiH and HClO
 - LiOH and HCl
- Which word equation represents a neutralization reaction?
 - salt + acid \rightarrow base + water
 - base + salt \rightarrow water + acid
 - base + acid \rightarrow salt + water
 - salt + water \rightarrow acid + base
- Which compound could serve as a reactant in a neutralization reaction?
 - HCl
 - HOH
 - CH_3OH
 - H_2O
- Which substance is always a product when an Arrhenius acid in an aqueous solution reacts with an Arrhenius base in an aqueous solution?
 - HF
 - H_2O
 - KBr
 - LiOH
- Which reactants form the salt $\text{MgSO}_4(\text{s})$ in a neutralization reaction?
 - $\text{H}_2\text{S}(\text{g})$ and $\text{Mg}(\text{ClO}_4)_2(\text{s})$
 - $\text{H}_2\text{SO}_3(\text{aq})$ and $\text{Mg}(\text{NO}_3)_2(\text{aq})$
 - $\text{H}_2\text{SO}_4(\text{aq})$ and $\text{Mg}(\text{OH})_2(\text{aq})$
 - $\text{SO}_2(\text{g})$ and $\text{MgO}(\text{s})$
- Sulfuric acid, $\text{H}_2\text{SO}_4(\text{aq})$, can be used to neutralize barium hydroxide, $\text{Ca}(\text{OH})_2(\text{aq})$. What is the formula for the salt produced by this neutralization?
 - CaS
 - CaSO_2
 - CaSO_3
 - CaSO_4
- Which chemical equation represents the reaction of an Arrhenius acid and an Arrhenius base?
 - $\text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O}$
 - $\text{C}_3\text{H}_8 + 5 \text{O}_2 \rightarrow 3 \text{CO}_2 + 4 \text{H}_2\text{O}$
 - $\text{Zn} + 2 \text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2$
 - $\text{Ba}(\text{OH})_2 + \text{Na}_2\text{SO}_4 \rightarrow \text{BaSO}_4 + 2 \text{NaOH}$
- Which volume of 0.10 M $\text{NaOH}(\text{aq})$ exactly neutralizes 15.0 milliliters of 0.20 M $\text{HNO}_3(\text{aq})$?
 - 1.5 mL
 - 7.5 mL
 - 3.0 mL
 30. mL
- In which laboratory process could a student use 0.10 M $\text{NaOH}(\text{aq})$ to determine the concentration of an aqueous solution of HBr ?
 - chromatography
 - decomposition of the solute
 - evaporation of the solvent
 - titration
- The data collected from a laboratory titration are used to calculate the
 - rate of a chemical reaction
 - heat of a chemical reaction
 - concentration of a solution
 - boiling point of a solution
- Which volume of 0.10 M $\text{NaOH}(\text{aq})$ exactly neutralizes 15.0 milliliters of 0.020 M $\text{HNO}_3(\text{aq})$?
 - 1.5 mL
 - 7.5 mL
 - 3.0 mL
 30. mL
- What volume of 0.120 M $\text{HNO}_3(\text{aq})$ is needed to completely neutralize 150.0 milliliters of 0.100 M $\text{NaOH}(\text{aq})$?
 - 62.5 mL
 - 125 mL
 180. mL
 360. mL
- A 25.0-milliliter sample of $\text{HNO}_3(\text{aq})$ is neutralized by 32.1 milliliters of 0.150 M $\text{KOH}(\text{aq})$. What is the molarity of the $\text{HNO}_3(\text{aq})$?

14. A 25.0 mL sample of 5.00 M HCl is required to neutralize 34.5 mL of NaOH solution, what is the concentration of the NaOH solution?
15. A total of 50.0 mL of 0.50 M KOH solution completely neutralizes 125 mL of hydrobromic acid solution (HBr). Calculate the concentration of the HBr solution.
16. What volume of 0.10 M NaOH(aq) exactly neutralizes 15.0 milliliters of 0.20 M HNO₃(aq)?
17. What volume of 0.05 M HI is required to neutralize 50 ml of 0.01 M NaOH solution?
18. What volume of 0.500 M HNO₃(aq) must completely react to neutralize 100.0 milliliters of 0.100 M KOH(aq)?
19. In a titration, 15.65 milliliters of a KOH(aq) solution exactly neutralized 10.00 milliliters of a 1.22 M HCl(aq) solution.
- Write the balanced equation for the titration reaction.
 - Show a correct numerical setup for calculating the molarity of the KOH(aq) solution.
20. In performing a titration, a student adds three drops of phenolphthalein to a flask containing 25.00 milliliters of HCl(aq). Using a buret, the student slowly adds 0.150 M NaOH(aq) to the flask until one drop causes the indicator to turn light pink. The student determines that a total volume of 20.20 milliliters of NaOH(aq) was used in this titration.
- The concentration of the NaOH(aq) used in the titration is expressed to what number of SF?
 - Calculate the molarity of the HCl(aq) used in this titration. Your response must include both a correct numerical setup and the calculated result.

Assessment Task

Recall the equilibrium system in the body:

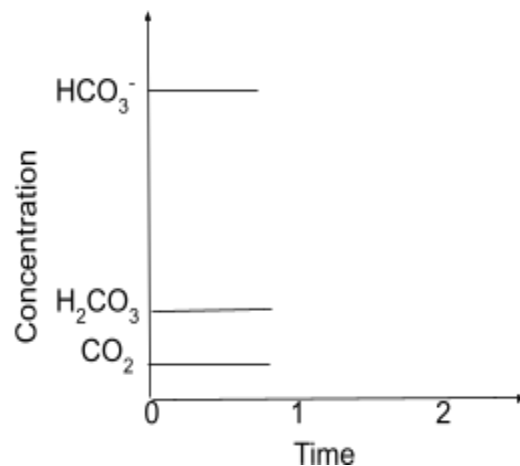


1. Identify the acid and base conjugate pairs in each reaction above.

Buffers are solutions of chemicals that work together to maintain a constant pH. Blood is considered a buffer because it has the carbonate buffer system shown above and maintains a pH close to 7.40.

2. During a carbon monoxide poisoning, CO will get stuck (bonded) to the blood and allow less O₂ to circulate. This will lead to a build up of lactic acid that consumes the HCO₃⁻. When HCO₃⁻ is removed from the body during this time, explain...
 - a. How does this shift reaction 2?
 - b. How does that affect the acidity of the body?
 - c. Based on what you read about the blood buffer, if only a small amount of CO is inhaled, will the pH drastically change? explain your answer using the reactions and LeChatelier's principle.
 - d. Does too much CO poisoning lead to acidosis or alkalosis?
3. If a body is in a state of alkalosis and bases are present in extreme amounts, they will remove H⁺ in the body.
 - a. What is the name of the type of reaction when bases remove H⁺ ions?
 - b. If H⁺ is removed from the body, what happens to the pH of the body?
 - c. Based on what you read about the blood buffer, if only a small amount of base is ingested, will the pH drastically change? explain your answer using the reactions and LeChatelier's principle.

4. Use the graph to answer the following questions:
- Why is the system at equilibrium from time 0-1?



- HCO_3^- remains the most abundant of the three chemicals in the body at all times. If the H_2CO_3 concentration increases, sketch a graph to show how it would affect all species in the system starting at time 1, and arriving at equilibrium at time 2.
- How would this shift affect the pH of the body?
- Would too much of this shift lead toward alkalosis or acidosis?

Phenolphthalein is also used in forensic science during the **Kastle–Meyer Test**, which helps investigators determine whether blood might be present at a crime scene.

Sometimes blood is not visible because it has been cleaned or diluted, so investigators rely on chemical tests to detect possible traces. Hydrogen peroxide is added to the tested area and oxidizes any blood present to form a solution with a pH of 8.2. If blood is not present, the hydrogen peroxide maintains its neutral pH.



Because many substances, such as certain cleaning products, are also basic, they can cause the test to show a false positive. For this reason, a positive color change does not prove that blood is present.

Instead, it signals that more testing is needed. Tests like the Kastle–Meyer test are called **presumptive tests**. A presumptive test provides an initial indication but does not confirm the identity of a substance. This is similar to using an indicator in class to estimate pH without knowing exactly what chemicals are in a solution.

- If the blood is present at a crime scene, what color will the phenolphthalein become?
- If a person uses cleansers often in the crime scene, what color will the phenolphthalein become and what might that indicate? (Why is this a presumptive test?)
- If no blood or cleaner is present, what color will the phenolphthalein become?