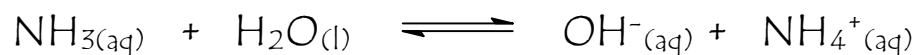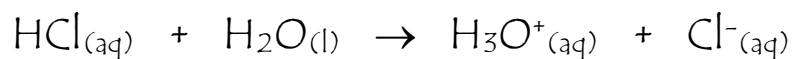Take notes while watching the following video tutorials to prepare for the "Acids & Bases Part 2 Activity".

Acids & Bases part 5: Kw, $[H_3O^+]$ & $[OH^-]$ Calculations

Water – Is it an Acid or a Base?

Identify the conjugate acid/base pairs in the following reactions.

$$HCl_{(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$$

$$NH_{3(aq)} + H_2O_{(l)} \rightleftharpoons OH^-_{(aq)} + NH_4^+_{(aq)}$$

Water is amphoteric.

Self-ionization of water:

Neutral

Acidic

Basic

Using Kw to Calculate $[H_3O^+]$ & $[OH^-]$

$$Kw = [H_3O^+][OH^-] = 1.0 \times 10^{-14}$$

Acidic $[H_3O^+] > [OH^-]$ $[H_3O^+] \geq 1.0 \times 10^{-7}$

Neutral $[H_3O^+] = [OH^-]$ $[H_3O^+] = 1.0 \times 10^{-7}$

Basic $[H_3O^+] < [OH^-]$ $[H_3O^+] \leq 1.0 \times 10^{-7}$

Coffee has a $[H_3O^+]$ of 1×10^{-5} M. Calculate the $[OH^-]$ of coffee.
Is coffee acidic or basic?

Digestive solution in our stomach has a $[OH^-]$ of 1×10^{-12} M. What is the $[H_3O^+]$ of this solution? Is it acidic or basic?

Liquid soap has a $[H_3O^+]$ of 1×10^{-9} M.   What is the $[OH^-]$ of liquid soap?
Is liquid soap acidic or basic?

Acids & Bases Part 6: pH Calculations

These concentration values for $[H_3O^+]$ are awkward numbers.
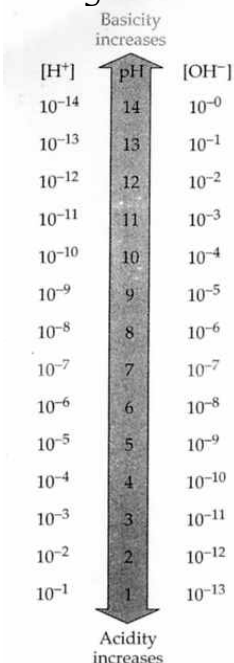
$$Kw = [H_3O^+][OH^-] = 1.0 \times 10^{-14}$$

Acidic	$[H_3O^+] > [OH^-]$	$[H_3O^+] \geq 1.0 \times 10^{-7}$
Neutral	$[H_3O^+] = [OH^-]$	$[H_3O^+] = 1.0 \times 10^{-7}$
Basic	$[H_3O^+] < [OH^-]$	$[H_3O^+] \leq 1.0 \times 10^{-7}$

We will use logarithms to simplify the concentration values and create the concept of pH.

In H_2O, the pH ranges from 1 to 14

pH values of some Common Materials

Material	pH	Material	pH
Battery acid	0.5	Saliva	6.5 – 7.5
Stomach acid	1.0 – 3.0	Pure water	7.0
Lemon juice	2.2 – 2.4	Blood	7.35 – 7.45
Vinegar	2.4 – 3.4	Bile	6.8 – 7.0
Tomato juice	4.0 – 4.4	Pancreatic fluid	7.8 – 8.0
Carbonated drinks	4.0 – 5.0	Sea water	8.0 – 9.0
Black coffee	5.0 – 5.1	Soap	8.0 – 10.0
Urine	5.5 – 7.5	Milk of Magnesia	10.5
Rain (unpolluted)	6.2	Household ammonia	11.7
Milk	6.3 – 6.6	Lye (1.0 M NaOH)	14.0

4

Using pH and $[H_3O^+]$ in Calculations

$$pH = -\log[H^+] = -\log[H_3O^+]$$

$$[H^+] = [H_3O^+] = 10^{-pH}$$

Pancreatic fluid has a $[H_3O^+]$ of 10^{-8} M. What is the pH?
Is pancreatic fluid acidic or basic?

Blood has pH of 7.4. What is the $[H_3O^+]$ of blood?
Is blood acidic or basic?

Kw calculations can be combined with pH when $[OH^-]$ are involved.

$$Kw = [H^+][OH^-] = 1.0 \times 10^{-14}$$

$$pH = -\log[H^+] \quad and \quad pOH = -\log[OH^-]$$

$$-\log\{ Kw = [H^+][OH^-] = 1.0 \times 10^{-14}\} = pH + pOH = 14$$

$$pH + pOH = 14$$

Combing Kw, $[H_3O^+]$, $[OH^-]$, pH & pOH in Calculations

$$Kw = [H^+][OH^-] = 1.0 \times 10^{-14}$$
$$pH = -\log[H^+]$$
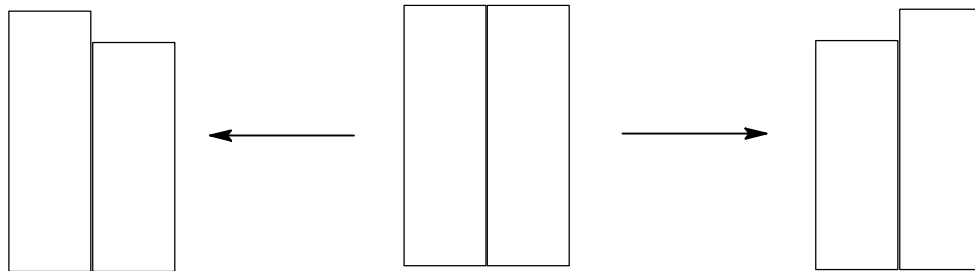$$[H^+] = 10^{-pH}$$
$$pOH = -\log[OH^-]$$
$$pH + pOH = 14$$

Complete the table.

$[H_3O^+]$	$[OH^-]$	pH	Acid, base or neutral?
	1.0×10^{-10} M		
		9.00	
5.0×10^{-3} M			

Acids & Bases Part 7: Buffers

Buffers are a combination of substances that act together to prevent drastic changes in pH.

Generic Buffer System

Buffer Capacity: the greatest amount of acid or base that a buffer can accommodate while maintaining the pH

Buffering Systems in the Body

Explain your answers to the following questions using the concepts of equilibrium and acid/base chemistry.

1. Hyperventilation is a condition where the breathing is too fast from anxiety, hysteria, altitude sickness, intense exercise.

$$CO_{2\,(g)} + H_2O_{(l)} \rightleftharpoons H_2CO_{3(aq)} \rightleftharpoons H^+_{(aq)} + HCO_3^-_{(aq)}$$
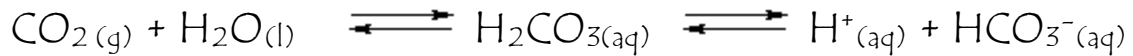
    a) Would you expect a patient's blood carbon dioxide concentration to increase or decrease with hyperventilation?

    b) What happens to the $[H^+]$?

    c) Would hyperventilation cause the blood pH to increase or decrease?

2. The phosphate buffer system is used to help regulate the pH inside our cells. Renal failure prevents the excretion of $H_2PO_4^-$.

$$H_2PO_4^-_{(aq)} \rightleftharpoons H^+_{(aq)} + HPO_4^{2-}_{(aq)} \rightleftharpoons H^+_{(aq)} + PO_4^{3-}_{(aq)}$$

    a) According to the phosphate buffer system, what happens to the $[H^+]$?

    b) Does the pH increase or decrease?

Acids & Bases Part 8:
    The Effects of Cellular pH on Carboxylic Acids, Amines, & Phosphates

Carboxylic acids, phosphate esters and amines are ionized at physiological pH. Use this information to complete the table below.

Group	Neutral Form	Ionized form at Physiological pH
Carboxylic acid		
Phosphate ester		
Amine		

The ionized forms are important to our health because the charges enable these groups to bind to enzymes and chemically react or the charge on these molecules enables them to stay inside the cell because the cell membrane is non-polar.

Many medical conditions (kidney disease, stroke & exposure to poisons) can raise or lower the pH within the cell. Changes in pH disrupt cell function by causing key molecules to change from their neutral to their ionized form or vice versa.

Acids & Bases Part 9: Serial Dilutions and pH

Dilution Calculation Review

1:10 Dilutions simplify the calculation.

The logarithmic nature of pH lends itself to 1:10 serial dilutions.
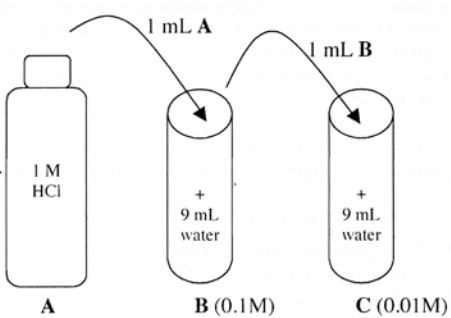
We will use a 1.0×10^{-3} M HCl solution to begin the following questions.

a) Write the acid dissociation reaction for HCl.

b) Complete the table below when we perform a series of 1:10 serial dilutions.

Solution	$[H_3O^+]$	pH
original A		
1st dilution B		
2nd dilution C		
3rd dilution D		

What is the $[OH^-]$ of Solution D?