

## Acid-Base Equilibrium BUFFERS

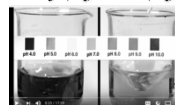
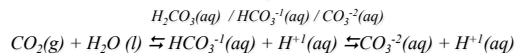
Dr. Ron Rusay

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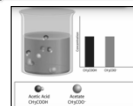
## BUFFERS

Weak Acid-Weak Base Systems

Example:



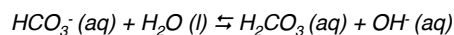
[https://www.youtube.com/watch?v=XR\\_0k8JlawY](https://www.youtube.com/watch?v=XR_0k8JlawY)



<https://www.youtube.com/watch?v=ZLKEjXbCU30>

## QUESTION

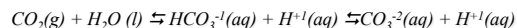
In the following equilibrium:



- $HCO_3^{-}$  is an acid and  $H_2CO_3$  is its conjugate base.
- $H_2O$  is an acid and  $OH^{-}$  is its conjugate base.
- $HCO_3^{-}$  is an acid and  $OH^{-}$  is its conjugate base.
- $H_2O$  is an acid and  $H_2CO_3$  is its conjugate base.
- $H_2O$  is an acid and  $HCO_3^{-}$  is its conjugate base.



## Two VERY IMPORTANT Buffer Systems "Bicarbonate"



- Blood:** a human's blood serum volume is relatively small, 4-6 Liters with a narrow pH range, pH = 7.35 – 7.45; pH is maintained through buffering (homeostasis)  
Have you ever had respiratory alkalosis during an exam?
- Oceans:** an extraordinarily large volume of a "salt water" solution with a pH ~ 8.1; maintained through buffering

## Human & Oceanic Bicarbonate Buffer Systems

**Acid-Base Disorders**

Stephen W. Smith, M.D.  
Department of Emergency Medicine  
Hennepin County Medical Center

Cartoons Courtesy of Dr. Rock

Resource: [www.acid-base.com/Tinimilli](http://www.acid-base.com/Tinimilli)

<http://chemconnections.org/general/chem121/Buffers/Buffer-Med-Pics.htm>

**Overview of Marine Carbon System**

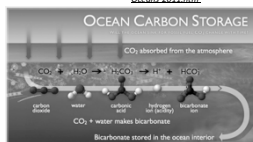
Christopher L. Sabine (NOAA/PMEL)

The carbon dioxide system in sea water: equilibrium chemistry and measurements

Andrew G. Dickson

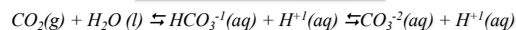
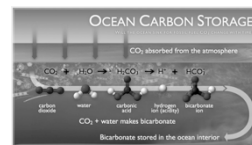
Scripps Institution of Oceanography, University of California, San Diego,  
9500 Gilman Drive, La Jolla, CA 92093-0241, USA adickson@ucsd.edu

<http://chemconnections.org/general/chem121/Buffers/Buffer-CO2-Oceans-2011.htm>



## EQUILIBRIUM

$CO_2$  & Oceanic Bicarbonate Buffering



**Oceans:** pH ~ 8.1 and falling

[http://www.tos.org/oceanography/issues/issue\\_archive/22\\_4.html](http://www.tos.org/oceanography/issues/issue_archive/22_4.html)

Increasing  $CO_2$  is decreasing ocean pH; long term effects?

[http://sos.noaa.gov/datasets/Ocean/ocean\\_acidification.html](http://sos.noaa.gov/datasets/Ocean/ocean_acidification.html)

### Bicarbonate Buffer Systems

Which is the buffer?

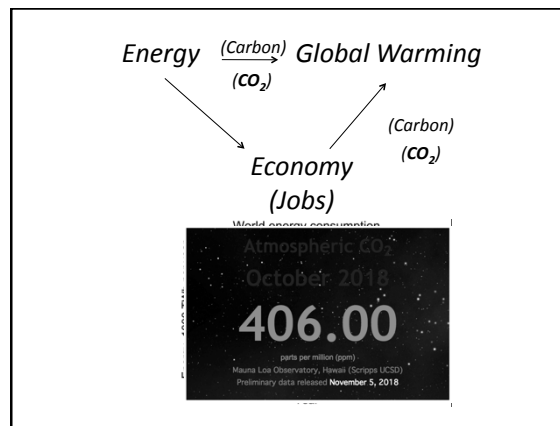
One is bicarbonate buffer to pH ≈ 8 - 9.  
One is water plus sodium hydroxide, pH ≈ 8 - 9.

Volunteers to experiment and find out which is which?

The diagram illustrates the bicarbonate buffer system in three states:

- Buffer after addition of  $\text{OH}^-$ :** Shows the reaction  $\text{HCO}_3^- + \text{OH}^- \rightleftharpoons \text{CO}_3^{2-} + \text{H}_2\text{O}$ . A molecular model shows a decrease in  $\text{HCO}_3^-$  and an increase in  $\text{CO}_3^{2-}$ .
- Buffer with equal concentrations of weak acid and its conjugate base:** Shows the reaction  $\text{HCO}_3^- \rightleftharpoons \text{CO}_3^{2-} + \text{H}^+$ . A molecular model shows equal concentrations of  $\text{HCO}_3^-$  and  $\text{CO}_3^{2-}$ .
- Buffer after addition of  $\text{H}^+$ :** Shows the reaction  $\text{HCO}_3^- + \text{H}^+ \rightleftharpoons \text{CO}_3^{2-} + \text{H}_2\text{O}$ . A molecular model shows an increase in  $\text{HCO}_3^-$  and a decrease in  $\text{CO}_3^{2-}$ .

Chemical structures shown:  $\text{HCO}_3^-$  (bicarbonate),  $\text{CO}_3^{2-}$  (carbonate),  $\text{H}_2\text{O}$  (water),  $\text{H}^+$  (proton),  $\text{OH}^-$  (hydroxide).



### Your Future?

#### Global Warming & Your Carbon Footprint

<http://chemconnections.org/general/chem108/Global%20Warming%20Bonus.html>

The map shows the distribution of carbon footprints across the world, with higher concentrations in developed countries.

The United Nations' Nobel Prize winning International Panel on Climate Change (IPCC: <http://www.ipcc.ch/>) of more than 1,000 scientists have concluded that "human influence on the climate system is clear, and recent anthropogenic (man made) emissions of greenhouse gases are the highest in history. The atmospheric concentration of key greenhouse gases — carbon dioxide, methane, and nitrous oxide — is unprecedented in at least the last 800,000 years, and our fossil-fuel driven economies and (mankind's) ever-increasing population are to blame."