Blood and Buffers

How the bicarbonate buffer system in your bloodstream keeps cells at a happy pH during metabolism

Last updated:

Age: Elementary School,Middle School,High School

Format: Stage Show

Category: Biology

Scientific Concepts: ph,Acids and Bases,Buffers,Metabolism,Indicators,Homeostasis

Materials: (printable checklist?)

- At least two 100 mL graduated cylinders or beakers
- Bromthymol blue or universal indicator solution
- Phosphate buffer solution, pH 7
- Dry ice Keep in a cooler!
- Water DI or tap water
- Pasteur pipettes and bulbs (or eye dropper / plastic transfer pipette)
- Safety Goggles, Thermal Gloves, Nitrile Gloves, Lab Coats, Poster!

Safety Precautions: Science Theatre demonstrators must keep the safety of themselves and their audience in mind at all times. All Science Theatre demonstrators must have read through the Safety Training page. The ST Safety Box with first aid kit, fire extinguisher, etc. should always be available to demonstrators. Always wear safety gloves, glasses, and a labcoat if handling chemicals; always perform potentially dangerous demonstrations at a safe distance from the audience; and always keep a very close eye on any volunteers you call from the audience. Demonstrators should wear goggles and lab coats, and the ST general safety box should be available to them. Dry ice is extremely cold! Please wear thermal gloves or AT LEAST nitrile gloves when placing pieces into beaker. Although the buffer solution is at pH 7, it still contains chemicals that we want to keep away from skin. Do not allow children to inhale any vapors or touch any solutions with their bare hands.

Preparation:

- Prepare enough pH 7 phosphate buffer solution as described below, plan on using 100 mL s of buffer for each run through the experiment.
- Purchase dry ice and keep in cooler
- Prepare Phenolphthalein or universal indicator solution as described below. You will only need a few drops for each trial run, so if you make a lot, you can keep it and store it for the next acid/base demonstration
- Try to acquire DI water it contains less dissolved CO_2 and therefore your control beaker will be closer to neutral pH. If not possible, tap water should be okay, just be aware its pH may range from 6 to 7.4, depending on the dissolved ions.

PHOSPHATE BUFFER, pH 7 Make 0.2 M NaH_2PO_4 solution 137.9 g/mol *0.2 mol/L = 27.6 g/L Make 0.2 M Na_2HPO_4 141.96 g/mol*0.2 mol/L = 28.4 g/L Mix together 500 mL of NaH_2PO_4 + 500 mL Na_2HPO_4 to make 1 L of

phosphate buffer. Check the pH. Should be approximately 7. Bring up or down to 7 with NaOH or HCl, depending on the original pH.

BROMTHYMOL BLUE ALCOHOL SOLUTION

Add 0.5g of Bromthymol blue into 500ml of 95% ethanol and dissolve Add 500ml of distilled water Filter and store at room temperature

Demonstration:

- Put out two identical beakers, next to signs indicating BUFFERED or UNBUFFERED
- To the unbuffered beaker, add 100 mL of DI water. To the buffered beaker, add 100 mL of the pH 7 phosphate buffer
- Add 10 -20 drops of indicator solution approximately 2 ml s, the solutions should both be homogeneously green if using bromthymol blue, this indicates a pH somewhere between 6 and 7.6
- Using thermal gloves, break off a small chunk of dry ice and drop it into both beakers at the same time
- Have the kids notice the difference in time it takes for a color change to occur in the two beakers. The buffered solution will change colors much more slowly than the unbuffered. If using bromthymol blue, acidic solution is indicated by a bright yellow color. If using universal indicator, once the solution acidifies the color may be yellow, orange or red, depending on how acidic the solution gets.
- " The chemicals used in the demonstration are safe to be poured down the drain of a sink a hazardous waste container is not necessary.

What to Say: Partner 1: Our cells are constantly undergoing chemistry. Cells must react oxygen with glucose from food to make energy to fuel all of your daily activities. (Ask what kind of things they do to need energy ie running, playing basketball, swimming&.) In this process, carbon dioxide is released in the following reaction: (Point to the reaction on the poster)

$C_6H_{12}O_6 + 6O_2$ ’ $6CO_2 + 6H_2O$ +~38ATP

Partner 2: So every time you go for a run, your body breaks down the food you ate for breakfast, releasing carbon dioxide. The carbon dioxide, like we breathe out, can combine with water in the blood to form an acid carbonic acid. (Point to this reaction on the poster) $H_2O + CO_2$ Ô H_2CO_3

Partner 1: Having all of this acid in our blood might start to hurt! Cells like to live in a very narrow pH range: from 6.8 to 7.4 either just above or just below neutral pH (pH=7). (Depending on the age, you may need to state that pH is just a scale of how acidic or basic a solution is. Point to the pH scale on the poster). So how do we keep our cells happy and out of danger from all this acid when you go for a run?

Partner 2: The key is buffers! Remember, a buffer is something that can resist a large change in pH when we add an acid or base. We have a bicarbonate buffer system in our blood, so when cells produce acid while working hard, the change in pH is absorbed rather than hurting our cells.

Partner 1: Take, for example, these two cylinders. Both have water, an indicator (to tell us what the pH of the solution is), and are at approximately pH = 7. Now, I will add some dry ice, solid CO_2. (Ask if anyone can hypothesize what will happen when we add the dry ice) Compare what happens to the beaker on the left

versus the right. See how fast the color changes? That means that the pH is changing quickly those cells are not happy! The other cylinder, however, is buffered, and any change in pH is being absorbed.

Diagrams:

Why It Is: The term pH is a simple way of expressing how acidic (or basic) a solution is. The standard pH scale runs from 0 to 14. If the pH is less than 7, the solution has more H+ than OH- and the solution is acidic. The lower the pH, the more H+ is present and the more acidic the solution is said to be. If the pH is greater than 7, the solution has more OH- than H+ and the solution is basic. The higher the pH, the more OH- is present and the more basic the solution is said to be. If the pH is equal to 7, the solution has the same amount of OH- as H+ and the solution is said to be neutral.

A buffer solution is a solution that will resist large pH changes upon the addition of an acid or base. Buffers resist pH change because there is an acid component to neutralize added base and a base component to neutralize added acid. The most common type of buffer in the chemistry laboratory is the combination of a weak acid like acetic acid and its conjugate base, an acetate salt. The conjugate acid-base pair differs by an H+ ion.

Indicators can be used to determine how acidic or basic a solution is. The one we are using today is a bromthymol blue, which turns blue in the presence of a base. As more acid is added to the solution, the indicator will change color to green at neutral pH and then is bright yellow at acidic pH s, letting us know that the solution has changed its pH. Indicators change color due to the color of the different forms the chemical can take on. When it is protonated (say, in an acidic solution) the indicator turns yellow.

Real Life Examples: Alka seltzer tablets contain weak acids and their conjugate bases. When dissolved in water, you ve made your own little buffer system! In biology labs, cells are often grown in buffers to keep them happy. Indicators are added to the solution to let the scientist know when he needs to change the media.

References:

- http://www.csmate.colostate.edu/cltw/universalindicatorrecipe.doc?
- http://www.thelabrat.com/protocols/BromthymolBlue.shtml?
- http://www.chemistry.wustl.edu/~edudev/LabTutorials/Buffer/Buffer.html?

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