

Experiment #3 Lab Report

Equilibrium Observational Lab

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Introduction

In this lab we experimented with the concept of Le Chatelier's principle, and observed the changes that occurred in each different type of reaction. Le Chatelier's principle states that if a dynamic equilibrium is altered by a change in conditions, the equilibrium will shift in an attempt to counteract these changes. Another concept that was explored during this lab was the equilibrium constant "K". The equilibrium constant is the value that reaction quotient will be when a reaction has reached equilibrium. A reaction quotient helps us better identify the way that a reaction will shift after a change has occurred in the system. Additionally, this lab let us work on qualitative assessments of pH. The change in pH of a substance can be determined by the concentration of reactants and the shift this reaction will undergo in order to counteract these changes. All these reactions can be used in a practical sense when studying how the body regulates blood pH.

<http://www.chemguide.co.uk/physical/equilibria/lechatelier.html> , April 2013, Chem Guide.

Procedure

Refer to lab manual for experiment 3.

Observations and Discussion

Part One: Equilibrium Shift

- After 1 drop of NH_3 , Ammonia, was added to 0.1mol/L CuSO_4 solution, the substance changed from a light blue, translucent colour to a darker shade of blue that which possessed much less clarity. Once this step was complete, 20 drops of HCl were added to the dark blue substance, causing it to return to its initial colouring, a light blue translucent substance.
- We observed a colour change. With the following reaction, $(\text{Cu}(\text{H}_2\text{O})_4) + 4\text{NH}_3 \rightarrow (\text{Cu}(\text{NH}_3)_4) + 4\text{H}_2\text{O}$, the observations made pertaining to the change in colour from light blue to dark blue can be explained by an equilibrium shift to the right. With the addition of NH_3 , ammonia, a single displacement reaction occurs and the strength of the metal-ammonia bond in comparison to the metal-water bond causes a swap of H_2O and NH_3 . This is what causes a shift to the right of the equilibrium. $[\text{Cu}(\text{H}_2\text{O})_4]^{2+}$ was the light blue solution, and with the addition of NH_3 became $[\text{Cu}(\text{NH}_3)_4]^{2+}$, the dark blue substance formed.
- After approximately 20 drops of HCl was added a change was observed in the colour of the substance, as it returned back to its original colour and clarity. The addition of NH_3 dropwise after this step caused the substance to go "streaky" with dark blue strands and eventually turn a turquoise, sky blue colour. After this step, any addition HCL added would cause the substance to return to it's original clear blue state.

- d) In step 4, we experienced the same change in colour when NH_3 and HCl were added. With the addition of NH_3 the substance changed to a dark blue, less clear substance, and when HCl was added the substance returned to a clear blue state.

Part 2: Multiple Equilibria

d) To begin, 0.5 mL of Na_2CO_3 were added to a clear test tube, the solution was a clear liquid with no bubbles. After 10 drops of AgNO_3 was added to the clear solution, it turned into a cloudy off-white colour. The silver ion is causing a colour change and a precipitate to be formed. Then, when 10 drops of HNO_3 were added, the solution turned clear once again.

e) A change in colour is presented. This equation is a double displacement reaction; the two products in this equation produce the cloudy solution, the precipitate. The cloudy precipitate created is Ag_2CO_3 , which caused the opacity in the solution.

f) When the HNO_3 was added, the solution cleared, which indicates that it reacted with the products causing a reverse reaction. Therefore the reaction is reversible. If you look at the chemical equation for this reaction it is shown that a new product is formed, and there are double sided arrows demonstrating that the reaction in both ways.

g) After adding 1 drop of 0.1 mol/L of HCl , the solution turned an opaque/milky white colour. After adding one drop of KI , the solution turned a yellowish colour, and then after one drop of Na_2S , the solution turned into a dark brown colour. The solution turns yellow because the iodide ions are oxidized to make I_2 , which could be yellow in colour.

Part Three: Buffers

k) The pH of the water was approximately 4.89 after 1 minute. Initially, we assumed the pH of this substance would be 7 as pure water is basic, and the average range for ground water systems is anywhere between a pH of 6 and 8.5. This substance had a pH in such a low range because once it was extracted from the tap, it reacted with the CO_2 that was in the air and one of the products created was a diluted carbonic acid, which ultimately caused the pH of the water to become much more acidic.

l) With the addition of 2.5 g of NaHCO_3 , sodium bicarbonate, the water began to raise sufficiently in pH up to 8.30 after one minute. The effect of sodium bicarbonate on water occurs due to its amphoteric characteristics. This substance reacts with acids produce a CO_2 gas in order to neutralize undesired acidity. In the reaction of $\text{NaHCO}_3 + \text{H}_2\text{O} \rightarrow \text{Na}^+ + \text{H}_2\text{CO}_3 + \text{OH}^-$,

sodium bicarbonate and water react to produce a basic solution of sodium, carbonic acid and hydroxide ions.

m) Once the acid HCl is added to the Hydrogen Carbonate solution, the solution begins to become slightly more acidic. When 30mL of HCl is added to the solution, the pH drops from 8.30 to 7.54 after approximately one minute. The addition of this acid allows the pH levels to drop and attempts to regulate them to be within the acceptable limits for water.

n) As 30 mL of HCl was added to the solution of H_2CO_3 , bubbles began to form within. This is a result of Carbon dioxide gas, CO_2 , bubbling when carbonate ions are present. The pH of the substance dropped from 8.30 to 7.54 after approximately one minute. This resulted due to the acidic properties of HCl acting on the pH of the substance, causing it to become more acidic. The pH of distilled water is 7, where as the pH of blood is tightly regulated between the levels of 7.35 and 7.45 which are very close to the approximate pH of the new substance, 7.54. The species that are present in this reaction are HCl and HCO_3 .

o) With the addition of 0.85% Lactic Acid, the number of bubbles being produced increased rapidly. The pH of the substance dropped to 7.40, which brought the pH into the ranges for that of normal blood.

p) When 0.50g of NaHCO_3 is added the pH became more basic and raised to a pH of 7.43. This produced more bubbles and sodium bicarbonate crystals were present until dissolved into the solution.

q) After this, another 0.50g of NaHCO_3 was added to the solution, the crystal of this substance dissolved slowly into the solution and caused a lack of clarity throughout. This reaction with sodium bicarbonate caused the pH to increase to 7.65. This is too basic for blood as it is .20 outside the range of 7.35 and 7.45. Having blood that is too basic is a disorder known as Alkalosis, which can lead to arrhythmia. Arrhythmia is a disorder where a person experiences an irregular heartbeat. If a person's blood has a high pH level, their sodium bicarbonate levels will be high and their carbon dioxide levels will be too low. These factors lead to arrhythmia as they are a cause for shortness of breath.

r) A small CO_2 pellet was added to the solution next, instantly causing smoke to expel from the top of the beaker. The pellet had no effect on the colour or clarity of the substance, but rather began to shrink at a very slow pace and produce bubbles that would travel to the top of the beaker and release smoke into the surrounding environment. The initial pH of the substance was 7.65, and after this pellet was added the pH dropped once again to 7.35 after approximately one minute.

s) Before 0.40g of NH_4Cl was added, the pH of the substance was approximately 7.32. Once this substance was added, bubbles of greater size and quantity began to be produced and expelled through the top of the beaker. Additionally, the CO_2 pellet began to shrink at a much faster rate, thus resulting in less smoke over time. Throughout the duration of these observations, the pH of the substance remained the same, and eventually the substance stopped releasing a gas out the top of the beaker.

Answers to Questions

1. a) In one step, ammonium is used as the acid source instead of Cl because although it is a weak base, it is the conjugate acid of NH_3 and will react with H_2O to produce hydronium ions. Whereas HCl is a strong acid, but its chloride ion will not hydrolyze, or break down, in this substance.

b) NH_4Cl is used in this system instead of NH_4NO_3 and NH_4I because it is much less toxic. Unlike NH_4Cl , Ammonium nitrate (NH_4NO_3) is capable of causing acidosis when present in the blood, as well as preventing oxygen absorption. Metabolic acidosis is a disorder that results in an overproduction of acid in the blood or an extreme loss of bicarbonate. These symptoms can be life-threatening and even fatal. Ammonium Iodide, (NH_4I), is also an example of a toxic substance and cannot be placed in the blood as high levels can be fatal due to symptoms of “iodism”.

2) Through the duration of this experiment, each time an acid was added to the substance its pH would experience a drop and become more acidic. This can be proved through the example of equilibrium through the following. As an acid is added to a system it will increase the concentration of the reactants. As a result, the equilibrium of this system will shift to the right to counteract this. Thus causing the acid and hydronium concentrations to increase, and therefore decreasing the pH.

3) Our blood contains hemoglobin which is used to transport oxygen to our cells and tissues. If blood pH became too low, causing acidosis, then oxygen would not be able to bind as well to the hemoglobin and therefore our tissues and organs would slowly die from hypoxia.

4) The tube on the left contains a red coloured substance because the blood within is able to receive oxygen (it is oxygenated). Whereas the tube on the left is not able to receive oxygen due to its acidic properties preventing it from binding oxygen to hemoglobin. This lack of oxygen causes the substance to turn blue.

5) If the soda started off slightly acidic and then went flat the pH of the soda should eventually go up, slowly becoming more basic. The gas that is being released from the soda making it “flat” is carbon dioxide (CO_2), which is acidic, by getting rid of this gas you are making the solution more basic, therefore causing a raise in pH.

6) As chickens pant, they eliminate carbon dioxide and the concentration of carbonate that is dissolved in their blood decreases. When they pant (hyperventilate) too much, CO_2 is released and H_3O^+ becomes imbalanced, causing carbonate to be used. For this reason, chickens have egg shells that are thinner and more fragile.

Conclusion

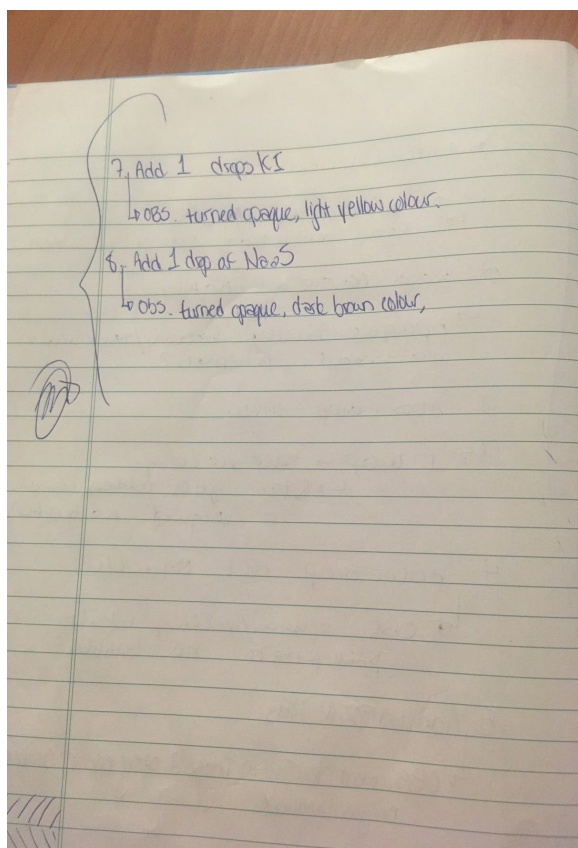
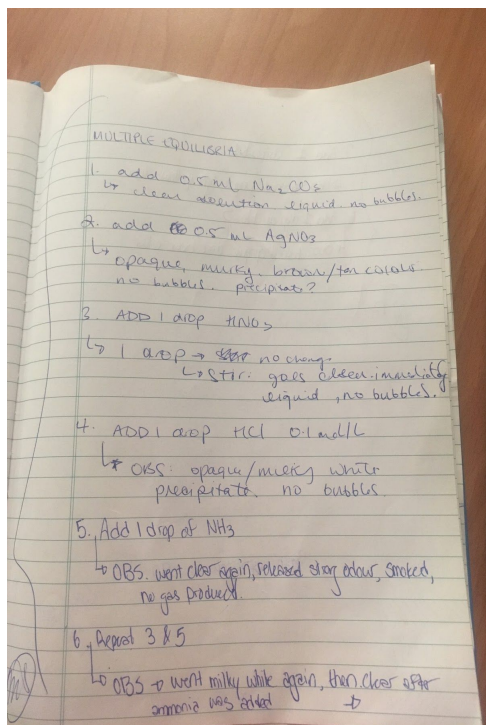
This lab demonstrated many practical levels of equilibrium, and how these shifts and changes in a system can be used to understand real life situations. The equilibrium principle demonstrated how reverse reactions work, and how certain ions help pertain different observational changes in solutions. The pH equation demonstrated how blood pH works in the blood, and how we as humans regulate our blood pH at around 7.4. Overall, this lab was very effective with demonstrating equilibrium, Le Chatelier’s principle, and observational skills.

Citations

1. Dl.clackamas.edu. (2017). *CH105: Lesson 7 Equilibria & Le Chatelier's Principle*. [online] Available at: http://dl.clackamas.edu/ch105/lesson7equilibria_lechatelier.html [Accessed 18 Oct. 2017].
2. Chemistry.wustl.edu. (2017). *pH Buffers in the Blood*. [online] Available at: <http://www.chemistry.wustl.edu/~edudev/LabTutorials/Buffer/Buffer.html> [Accessed 17 Oct. 2017].
3. Labtestsonline.org. (2017). *Acidosis/Alkalosis*. [online] Available at: <https://labtestsonline.org/understanding/conditions/acidosis/> [Accessed 17 Oct. 2017].
4. <http://www.chemguide.co.uk/>. (2013). Chem Guide [online] Available at: <http://www.chemguide.co.uk/physical/equilibria/lechatelier.html> [Accessed 17 Oct. 2017]

Peer Evaluation

Raw Data



Buffer Solution & Blood pH

1. 100 ml of water in beaker - clear/translucent.
2. put in magnet, create smooth vortex w/ magnetic stirrer.
3. → insert probe to read pH.
4. → observations: pH initial: ~~4.89~~ 4.89.
pH after 3 min: 4.85
↳ probe/magnet/vortex are aligned

5. Add 25g of NaHCO_3 .
↳ obs: crystals are being mixed in solvent.
↳ pH: up to 8.30. after 1 min
↳ "crystals" ^{mixture} dissolved into solution
↳ pH after 2 min: 8.37.

initial pH: 8.59 when HCl added (30 ml)
bubbles forming in solution and around magnet also around the tip of the probe.

↳ pH drops to 7.54 after 1 min.

initial pH: 7.54 → add lactic acid: bubbles building up on beaker. pH drops to 7.40 after 1 min.

18. → Increase speed: 7.40. no change pH remains same. still clear, no change in substance immediately.
↳ more bubbles accumulating in beaker. pH remains same throughout.

19. → Add 0.50g NaHCO_3 .
↳ crystals mixing, more bubbles in solution. slightly less clear as you can see mixture. Initially.
↳ ~~constant~~ more gas

20. → add another 0.50g NaHCO_3
pH → 7.65.

21. Add CO_2 pellet:
smoke emitting from top of beaker. pellet becomes clear on the outside. looks like an ice cube. magnet surrounded by large bubble.

pH = 7.35
↳ pellet is slowly shrinking

↳ after 3 min: 7.32

0.40 g NH_4Cl added,
pH drops to 7.28.

↳ large bubbles coming out of
pellet. (filled w/ the smoke)

↳ shrinking @ a much faster rate.
↳ less smoke.

↳ pH remains same entire time (constant).

↳ no smoke after few minutes -

- pellet is gone.

- ~~lots~~ bubbles, one large bubble
between pellet & probe.

* #1 20 drops - light blue CuSO_4 0.1 M/L
liquid. ~~to~~ almost translucent.

#2 dropwise, NH_3 . 1 drop - dark blue
slightly perthy

#3 HCl, 1 mol = after 20 drops, mostly opaque
went back to original
colour [translucent

#4 NH_3 dropwise: streaky, when mixed
colour bleeds" (blue)
Slightly opaque, darker shade of blue

add HCl, goes clean again