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Partner's Name and Student #: Julia Hancott

Demonstrator's Name: Joel

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Lab Day (T/W/Th/F): Tuesday

Lab Week (even/odd): odd

Lab time (10:00, 2:30, 6:30): 6:30

Laboratory Report Form

Experiment 2.

Equilibria

Checklist:

- o Raw Data Sheet written in pen, signed by TA and attached**
- o Completed Report Form attached**

Student's Initials AT

Table 1. Observations and Discussion

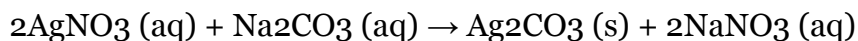


Initial : CuSO₄ – light blue, transparent solution

NH₃ – clear liquid with strong smell

HCl – clear liquid with strong acidic smell

- a) In the experiment, the CuSO₄ was in an aqueous form thus, the ions in CuSO₄ disassociate. In the equation above, the Cu ion forms an ion-water complex of [Cu(H₂O)₄]²⁺. This solution has been observed to be a transparent, light blue solution.
 - b) The reaction between [Cu(H₂O)₄]²⁺ and NH₃ created an immediate reaction of a transparent, dark blue solution. In this reaction, a single displacement reaction with [Cu(H₂O)₄]²⁺ and NH₃ occur. The Cu ion reacts with the NH₃ ion. This produces the products listed above in the equation.
 - c) As HCl was added, the colour of the solution became lighter until it was a shade of light blue. The HCl present in the aqueous solution initially dissociates to form H⁺ and Cl⁻. The H⁺ reacted with NH₃ in the reactants side to produce NH₄. This ultimately caused the NH₃ concentration to decrease which then caused an equilibrium shift towards the reactants. Therefore, an increased amount of [Cu(H₂O)₄]²⁺ formed which created the light blue colour seen initially in just [Cu(H₂O)₄]²⁺ alone.
1. By repeating steps 2 and 3, it demonstrated the equilibrium shift favouring the products with the addition of NH₃. This is seen by the solution turning a dark blue once again. The addition of NH₃ causes an influx in reactants. The equilibrium then shifts to the products side to obey Le Chatelier's Principle of opposing the change in a reaction with an opposite reaction. In step 3, the equilibrium shift occurs once to the reactants side and this is indicated by the light blue solution colour.



←

Initials: Na₂CO₃ – clear , no odour

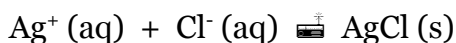
AgNO₃ – clear liquid, no odour

d) The colours that were observed was a clear liquid. Na_2CO_3 disassociates in water to produce Na^{+1} and CO_3^{-2} . These ions caused the solution to appear clear.

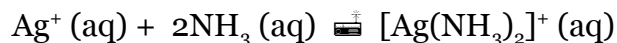
e) As AgNO_3 is added to the Na_2CO_3 , the solution turned orange tinted at first then beige and opaque. A double displacement reaction is occurring and the change in colour indicates the presence of products. The opaque colour was the Ag ion and CO_3 ion reacting to form a precipitate.



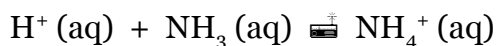
f) The addition of HNO_3 initially created a precipitate and then transitioned into a clear solution with fog being visible throughout the solution. HNO_3 is a strong acid therefore, it dissociates completely when reacted with water. Therefore, since HNO_3 is in an aqueous solution, it dissociates. The H^+ ion reacted with CO_3^{2-} ion from the products of the previous reaction. A reaction occurred to balance the influx of reactants which resulted in the productions of the products. Since this is a 3 part equilibria, all three reactions must have equal rate of reactions. According to the observations that we made, there was no noticeable gas that had formed therefore, the reaction consisted of bicarbonate. This is reversible since all reactions demonstrate La Chatlier's Principle.



g) The HCl ions disassociate when put into a water solution to form an aqueous solution. The HCl addition turned the previous solution white and opaque after 10 drops. The chloride ion from HCl and the silver from the AgCO_3 (from product of original reaction) formed a precipitate that appeared white and opaque. (It was not observed in the raw data sheet that a precipitate had formed but, it was observed that the solution was white and opaque.)

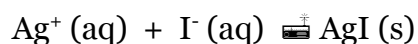


h) The addition of NH_3 to the current solution caused all molecules in the solution to become soluble as the Ag ion (in the previous reaction) from the precipitate reacted with NH_3 to form the soluble $[\text{Ag}(\text{NH}_3)_2]^+$. This caused the observations of a formation of a white substance on the bottom (precipitate) then disappeared as the test tube was gently tapped.

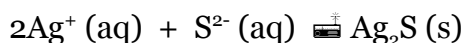


Repeating steps 7 & 9 : The same changes was not observed.

2. As HNO₃ is added to the previous solution, the test tube became very warm and it appeared as if gas was forming. The reaction that occurred was exothermic and it was caused by the disassociation of HNO₃. As HNO₃ dissociated, it caused the release of hydrogen as well as the reaction with the ammonia from the product ([Ag(NH₃)₂]⁺) in the previous reaction. This created NH₄. The decreasing concentration of NH₃ causes the Ag⁺ to react with the Cl⁻ that is present. As a result, the reaction Ag⁺+Cl⁻=AgCl takes place and a precipitate forms. Ammonium was then added to the previous solution. It was observed more gas had appeared to form, the test tube was cold to the touch and the reaction produced a lot of odour (may have been caused by use of ammonia). The reaction increased the amount of NH₃ that was available. Therefore, the aqueous solution for [Ag(NH₃)₂]⁺ formed and the precipitate disappeared.



i) The addition of KI to the solution caused a white precipitate to form with clear liquid underneath. The KI dissociated to form K⁺ and I⁻. The Ag from [Ag(NH₃)₂]⁺ reacted with I to produce the AgI precipitate.



j) The addition of Na₂S to the previous solution created a brown precipitate that formed and clear liquid that formed underneath. This occurred from the reaction of the Ag ion from the previous product of the reaction (AgI (s)) with the dissociated S²⁻. This formed the brown precipitate of Ag₂S.



k&l) The universal indicator containing the acetic acid was red. The red colour indicates an acidic solution is present. The pH colour was red/orange which meant the pH was 2.5. Both pH's correspond to the solution being acidic.

m) The universal indicator containing acetic acid and NaCH₃COO was red. This meant that the acidic solution was still present.

n) The pH paper turned orange which indicated that the pH was approximately a 3. This corresponded to the universal indicator because both exhibited acidic solutions present.

o) The universal applicator containing H₂O was red which meant that an acidic solution was present. The pH paper turned yellow which meant that it had a pH of 6.

p&q) The addition of HCl to the distilled water created a solution that was more acidic. The universal indicator of the H₂O and HCl was red which meant an acidic solution was present. The pH paper corresponded with a yellow/orange therefore, it

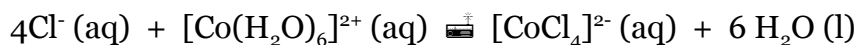
had a pH of approximately 3-6. The pH level was significantly lower than the original pH of the water.

The addition of HCl to the buffer caused the pH to remain constant. The buffer and HCl solution appeared light red with the addition of universal applicator. This implied that an acidic solution was present. The pH paper corresponded with an orange colour which implied that the pH level stayed constant.

r) The buffer and NaOH appeared orange with the presence of the universal indicator. This implied that the solution was still acidic. The pH of the solution remained constant even though a base was added. The H₂O and NaOH created a purple solution with the presence of the universal applicator. This indicated a basic solution was present. The pH of the solution increased.

s) The pH paper of the buffer and NaOH was a green/blue colour which indicated a pH of 11-12. This may have been brought on by an error because the universal applicator and pH does not correspond. The pH of the H₂O and NaOH was blue colour which indicated that the pH was approximately a 13-14. This corresponded with the universal applicator.

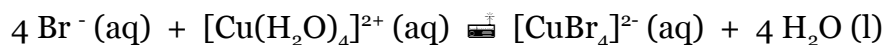
3) is done in calculations area.



t) Initial observation of CoCl₂ at room temperature was red/violet colour and odourless.

u) After the 3 drops of HCl to CoCl₂, the solution turned blue and fumed. Initially, the CoCl₂ reacted with water because it was in aqueous form. This caused CoCl₂ to dissociate into Co²⁺ and Cl⁻ forming [Co(H₂O)₆]²⁺. The HCl is also a strong acid in aqueous form therefore, it dissociates into H⁺ and Cl⁻. When both reactants are added, a single displacement reaction occurs forming the above products. The blue colour is produced by the formation of the products.

v) The addition of H₂O causes equilibrium to shift towards the reactants because of the influx in the product H₂O. This occurs in order to achieve equal rate of reaction for reactants and products by opposing the imbalance. The addition of water created a light red solution which indicated the presence of the reactants.



w) The appearance of CuBr₂ is a glittery obsidian.

x&y) The solid and H₂O became a solution (dissolved CuBr₂). This solution appeared to be a mint colour after H₂O was added. The solution stayed a mint colour throughout.

z) The addition of water caused the solution to remain a mint colour. The equilibria involved is the reaction stated above because it exhibits the Cu ionizing and reacting with H₂O forming [Cu(H₂O)₄].

aa) The initial appearance of KBr was observed to be white, snow-like crystals. When dissolved in H₂O, it became a clear solution. This implied that the dissociation of KBr formed K⁺ and Br⁻ which caused the colour of the solution to be clear.

bb) As CuBr₂ was added to the KBr solution, the solution changed to a green colour. This exhibited the common ion effect because the green colour was previously seen in the CuBr₂ which implied that the solubility of the CuBr₂ decreased in the aqueous environment.

Hot water bath

(cc) As the previous solution was heated, the solution turned a dark, green colour with a murky appearance. There was also observed to be a precipitate that had formed. To explain this, the reaction may have shifted its equilibrium towards its products which was indicated in the precipitate forming.

(dd) The CoCl₂ solution did not appear to change as it was heated.

Calculations:

K_a of CH₃COOH = 1.8 X 10⁻⁵

Initial :pH of H₂O: Assumed to be 7 because it's a neutral solution

Initial :pH of buffer: C₁V₁=C₂V₂

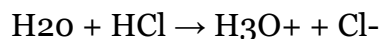
$$C_2 = (10 \text{ dr/g})(0.1\text{M}) / (20\text{dr/g})$$

$$C_2 = 0.05\text{M}$$

$$\text{pH} = -\log 1.8 \times 10^{-5} + \log (0.05/0.1)$$

$$= 4.74$$

3a) **pH of H₂O + HCl:**



$$C_1V_1 = C_2V_2$$

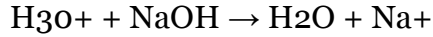
$$C_2 = (0.1\text{M})(5\text{dr/g}) / (25\text{dr/g})$$

$$C_2 = 0.02M$$

$$\begin{aligned} \text{pH} &= -\log(0.02) \\ &= 1.7 \end{aligned}$$

$$\begin{aligned} \text{pH change from H}_2\text{O to H}_2\text{O with addition of acid} \\ 7 - 1.7 = 5.3 \text{ drop in pH} \end{aligned}$$

pH of H₂O + NaOH:



$$C_1V_1 = C_2V_2$$

$$C_2 = (5\text{dr/g})(0.1M)/(25\text{dr/g})$$

$$C_2 = 0.02M$$

$$\begin{aligned} \text{pOH} &= -\log(0.02) = 1.7 & \text{pH} &= 14.00 - 1.7 \\ & & &= 12.3 \end{aligned}$$

pH change from H₂O to H₂O and NaOH

$$7 - 12.3 = 5.3 \text{ increase in pH}$$

b) **pH of buffer + HCl:**



I	0.04M	0.02M	0.04M
C	-0.02M	-0.02M	+0.02M
E	0.02M	0	0.06M

$$C_1V_1 = C_2V_2$$

$$\begin{aligned} C_2 &= (10\text{dr/g})(0.1M)/(25\text{dr/g}) \\ [\text{CH}_3\text{COO}^-] &= 0.04M \end{aligned}$$

$$C_1V_1 = C_2V_2$$

$$\begin{aligned} C_2 &= (0.1M)(5\text{dr/g})/(25\text{dr/g}) \\ [\text{HCl}] &= 0.02M \end{aligned}$$

$$\begin{aligned} \text{pH} &= 4.74 + \log(0.02/0.06) \\ &= 4.26 \end{aligned}$$

pH change from buffer to buffer and HCl

$$4.74 - 4.26 = 0.48 \text{ drop in pH}$$

pH of buffer + NaOH:



I	0.04 M	0.02M	0.04M
C	-0.02M	-0.02M	+0.02M
E	0.02M	0	+0.06M

$$C_1V_1 = C_2V_2$$

$$\begin{aligned} C_2 &= (0.1M)(10\text{dr/g})/(25\text{dr/g}) \\ [\text{CH}_3\text{COO}^-] &= 0.04 M \end{aligned}$$

$$C_1V_1 = C_2V_2$$

$$\begin{aligned} C_2 &= (5\text{dr/g})(0.1M)/(25\text{dr/g}) \\ [\text{NaOH}] &= 0.02M \end{aligned}$$

$$\begin{aligned} \text{pH} &= 4.74 + \log(0.02/0.06) \\ &= 4.26 \end{aligned}$$

pH change from buffer to buffer and NaOH

$$4.74 - 4.26 = 0.48 \text{ drop in pH}$$

Additional Discussion (if desired...otherwise, discussion can be combined with the observations in the table):

The noticeable source of error was seen in the pH paper when measuring the buffer solution with the addition of the base. The pH was supposed to remain somewhat constant which was demonstrated in the calculations. This may have been brought on by other solutions that travelled/was absorbed down the length of the pH paper. This could have resulted in contaminations and altered the pH level of the solution being measured. For instance, the solution of water and base could have contaminated the results for the buffer and base creating an illusion that the buffer and base were basic.

Conclusion

Equilibrium Shift

La Chatelier's Principle was effectively demonstrated in the reactions. This was achieved by observing the reaction minimizing the change in equilibrium by either favouring the reactants or products. The addition of HCl favoured the reactants and the addition of NH₃ favoured the products.

Multiple Equilibria

The use of numerous reactants provided the demonstration of equilibria acting for sub parts of a reaction that were all linked together (usually with the use of the products from the previous reaction reacting with the addition of a chemical). Equilibria can be achieved through numerous reactions.

Buffer system

The changes of pH in buffer system and the base and acid were extremely small (-0.48). This demonstrates the characteristics of buffer systems as they are in constant equilibrium and does not change with the addition of other substances. The changes in pH of the water and the pH with the addition of base (+5.3) and acid (-5.3) was extremely large because the strong acid and base dissociated completely therefore favouring the products.

Common Ion Effect

The common ion was Br⁻. The solution returned to a similar colour of the original CuBr₂ which implied that the solubility of it decreased causing the solution to change into a green colour. This resulted in an equilibrium shift to the products [Cu(Br)₄](aq).

Temperature Effect

The solution exhibited equilibrium shift as underwent temperature change. It favoured its products which was indicated in the precipitate form that was observed.

⑤ If steps 2 & 3 repeated,
sol'n turns dark blue then
sol'n turns light blue

Eq. Shift

① Before
 $CuSO_4$ - light blue sol'n, transparent
 NH_3 - basic strong smell, clear

③ HCl:
strong, acidic;
smell clear,
liquid

② After \approx 2 drops
- dark blue ~~transparent~~,
immediate rxn

④ w HCl
w every drop,
color becomes
lighter, shades
of blue until
total light blue

⑥ $CuSO_4 + NH_3$ sol'n 2/10/16

~~④~~ w HCl
⑦ \rightarrow white, opaque

dark blue, transparent,
immediate rxn

~~NH_3~~
~~10 drops~~

w HNO_3
- precipitate formed
- clear, foggy, liquid

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Sept. 27 2016
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① Before



- no odour
- clear



- clear liquid
- no odour

② After

→ orange tinted

⊙ first turn beige & opaque

③ w/ HNO₃

→ precipitate formed

→ clear, foggy liquid

④ w/ HCl ≈ 10 drops

→ white opaque

⑤ w/ NH₃

→ white substance formed on bottom then disappeared when gently

⑦ when steps 7-9 repeated

→ w/ HNO₃

- test tube heated

up

- gas formed / firmed

⊙ top

→ w/ NH₃

- alot of gas firmed

- test tube cooled

- alot of odour

⑧ w/ KI

→ precipitate formed

⊙ top

- white in colour

- rest of liquid

clear

Multiple Equilibria

⑨ w/ Na₂S

- precipitate turns

brown

- precipitate floating

⊙ top

→ rest of liquid

clear

~~top 2d~~
2/09/16

Ayda
The
Sept. 27th

2016
8581091

CH_3COOH	Ph colour = red red / orange (red)
CH_3COOH + H_2O NaCH_3COO	orange (red)
H_2O	yellow (red)
Buffer + HCl	orange (red light)
Buffer + NaOH	green / blue (orange)
H_2O + HCl	yellow / orange (red)
H_2O + NaOH	blue (purple)

Buffer System

Anjali Thoms
Sept 27th 2016
87810°(1)

Example Common Ion Effect

$\text{CuBr}_2 + \text{KBr}$ sol'n

Before

CuBr - light green liquid KBr - clear liquid

After
 KBr - darker green liquid

$\text{CuCl}_2 + \text{KBr}$ in hot bath

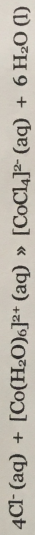
- dark, murky green
- almost opaque
- black line
- liquid splashed on tattoo = black/green dots

CoCl_2
Before

- light red

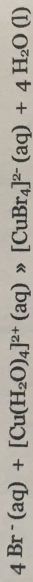
CoCl_2 in hot water bath

- darker red



→ HCl strong scent, clear
→ CoCl_2 red / violet color, odorless

→ after ≈ 3 drops, the solution turned blue + fumed
→ after ≈ 10 drops H_2O , solution turned to light red



→ CuBr_2 : glittery, obsidian

↳ w/ H_2O : turned mint solution

→ KBr: white, snow-like crystals, clear when added to solution
 CuBr_2 (green)

→ Hot water bath

↳ w/ solution: clear, may have
to ~~turn water~~ dark, milky green, precipitate seen

↳ w/ ~~CuCl_2~~ . No change

2/9/16