REPORT

EXPERIMENT 1: CHEMICAL REACTIONS

Group: 4 **Section:** 1 **Date:** 15/07/2022

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I. Introduction:

Experiment 1 is aimed to test and observe the chemical changes of the reactants to form chemical reactions among different solutions. Seven experiments will be conducted in this experiment 1. The first is a process involving copper (Cu^{2+}), iron (Fe^{2+} and Fe^{3+}), and aluminum (Al^{3+}). The reactions of silver halides, H_2O_2, and $KMnO_4$ are the following. The flame test is the final experiment**.**

II. Experimental:

1. Reactions of Cu^{2+}:

a. Mix 10 drops of 0.5M $CuSO_4$ with 10 drops of 2M NaOH → Observe
→ Add 10 drops of 2M NaOH → Observe.

b. Mix 10 drops of 0.5M $CuSO_4$ with 10 drops of 2M NH_4OH → Observe
→ Add 10 drops of 2M NH_4OH → Observe.

2. Reactions of silver halides:

a. KCl: Mix and wait for 2 minutes: 10 drops of 0.5M KCl with 10 drops of 0.1M AgNO3 → Observe.
Mix and wait for 2 minutes: 10 drops of 0.5M KCl with 10 drops of 0.1M $AgNO_3$ and 10 drops of 2M NH_4OH → Observe.

b. KBr: Mix and wait for 2 minutes: 10 drops of 0.5M KBr with 10 drops of 0.1M $AgNO_3$ → Observe.
Mix and wait for 2 minutes: 10 drops of 0.5M KBr with 10 drops of 0.1M $AgNO_3$ and 10 drops of 2M NH_4OH → Observe.

3. Reactions of H_2O_2:

a. Mix and wait for 2 minutes: 1 drop of 0.1M $KMnO_4$ with 5 drops of 2M H_2SO_4 and 5 drops of 3% H_2O_2 → Observe.

b. Mix and wait for 2 minutes: 5 drops of 0.1M KI with 5 drops of 2M H_2SO_4 and 5 drops of 3% H_2O_2 → Observe.

c. Mix and wait for 2 minutes: 10 drops of 3% H_2O_2 with a pinch of MnO_2
→ Observe.

4. **Reactions of $KMnO_4$:**
    a. Mix 10 drops of 0.5M Na_2SO_3 with 5 drops of 2M H_2SO_4 and 5 drops of 0.1M $KMnO_4$ → Observe.
    b. Mix 10 drops of 0.5M Na_2SO_3 with 5 drops of 6M NaOH and 5 drops of 0.1M $KMnO_4$ → Observe.
    c. Mix 10 drops of 0.5M Na_2SO_3 with 5 drops of distilled water and 5 drops of 0.1M $KMnO_4$ → Observe.
5. **Reactions of Fe^{2+} and Fe^{3+}:**
    a. Reactions of Fe^{3+}:
        i. Mix 10 drops of 0.5M $FeCl_3$ with 5 drops of 2M KOH → Observe.
        ii. Mix 10 drops of 0.5M $FeCl_3$ with 5 drops of 2M NH_4OH → Observe.
    b. Reactions of Fe^{2+}:
        i. Mix 10 drops of 0.5M $FeSO_4$ with 5 drops of 2M KOH → Observe.
        ii. Mix 10 drops of 0.5M $FeSO_4$ with 5 drops of 2M NH_4OH → Observe.
6. **Reactions of Al^{3+}:**
    a. Mix 10 drops of 0.5M $Al_2(SO_4)_3$ with 5 drops of 2M NaOH → Observe → Add 20 drops of 2M HCl → Observe.
    b. Mix 10 drops of 0.5M $Al_2(SO_4)_3$ with 5 drops of 2M NaOH → Observe → Add 20 drops of 2M NaOH → Observe.
7. **Flame test:**
    a. Light the Bunsen burner.
    b. Clean the loop with distilled water.
    c. Dip the loop into the tested solution.
    d. Hold it in flame.
    e. Record the dominant flame color.
    f. Clean the loop for the next solution.
    g. Repeat the same process for other tested solutions.

- Tested solution: LiCl, NaCl, KCl $CaCl_2$, $BaCl_2$.

III. Results and discussion:

1. Reactions of Cu^{2+}:

Table 1: Reactions of Cu^{2+}

Reaction	Observation	Chemical Equation
0.5M $CuSO_4$ + 2M NaOH	Before adding NaOH to the test tube, the solution has a blue color ($CuSO_4$). After adding NaOH, a pale blue precipitate starts forming.	$CuSO_4$ (aq) + 2NaOH (aq) → $Cu(OH)_2$ (s) + Na_2SO_4 (aq)
0.5M $CuSO_4$ + 2M NH_4OH	At first, the pale blue precipitate of $Cu(OH)_2$. Then, on passing the excess NH_4OH, the pale blue color precipitate will turn into a deep blue solution. This is due to the formation of a soluble complex tetra amine copper [II] sulfate ($[Cu(NH_3)_4]SO_4$)	$CuSO_4$ (aq) + $2NH_4OH$ (aq) → $Cu(OH)_2$ (s) + $(NH_4)_2SO_4$ (aq) $Cu(OH)_2$(s) + $(NH_4)_2SO_4$ (aq) + $2NH_4OH$ (aq) → $[Cu(NH_3)_4]SO_4$ (aq) + $4H_2O$ (aq)

Comments: In the first reaction, the precipitate is $Cu(OH)_2$, it is a double displacement reaction, and requires a precipitate in order to form a chemical reaction. In the second reaction, first, it forms a dark blue precipitate $Cu(OH)_2$, then the precipitate dissolves and forms a dark blue solution is a complex salt $[Cu(NH_3)_4]SO_4$.

Figure 1.1: Reaction 1.1

Figure 1.2: Reaction 1.1

Figure 1.3: Reaction 1.2

Figure 1.4: Reaction 1.2

2. Reactions of silver halides:

Table 2: Reactions of silver halides

Reaction	Observation	Chemical Equation
0.5M KCl **+ 0.1M $AgNO_3$**	Forming a white precipitate (AgCl) from two colorless solutions (KCl and $AgNO_3$)	KCl (aq) + $AgNO_3$ (aq) → KNO_3 (aq) + AgCl (s)
0.5M KCl **+ 0.1M $AgNO_3$** **+ 2M NH_4OH**	First, the reaction of KCl and $AgNO_3$ form white precipitate. Then the precipitate will turn into a colorless solution due to the soluble complex $[Ag(NH_3)_4]Cl$	KCl (aq) + $AgNO_3$ (aq) → AgCl (s)+ KNO_3 (aq) AgCl (s) + 2NH4OH (aq) → $[Ag(NH_3)_4]Cl$ (aq) + $2H_2O$ (aq)
0.5M KBr **+ 0.1M $AgNO_3$**	Light yellow precipitate appears.	KBr (aq) + AgNO3 (aq) → AgBr (s) + KNO3 (aq)
0.5M KBr **+ 0.1M $AgNO_3$** **+ 2M NH_4OH**	First, the reaction of KBr and $AgNO_3$ forms light yellow precipitate. Then the precipitate will	KBr (aq) + AgNO3 (aq) → AgBr (s) + KNO3 (aq)

	remain stable since AgBr does not form a soluble complex.	

Comments: Ion Ag^{+} can combine with halogens to form a precipitate with different colors. Moreover, these precipitates are dissolved in NH_4OH and form complex salts.
In the last picture on the right, we did not put enough NH_4OH into the solution, so it is still a little yellow in the solution.


Figure 2.1: Reaction 2.1

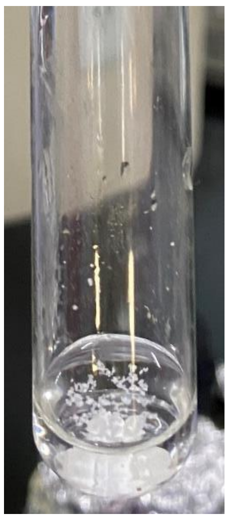
Figure 2.2: Reaction 2.1


Figure 2.3: Reaction 2.2


Figure 2.4: Reaction 2.2

3. Reactions of H_2O_2:

Table 3: Reactions of H_2O_2

Reaction	Observation	Chemical Equation
0.1M $KMnO_4$ + 2M H_2SO_4 + H_2O_2	The purple of KMnO4 faded into a clear liquid and released gas.	$2KMnO_4$ (aq) + $3H_2SO_4$ (aq) + $5H_2O_2$ (aq) → K_2SO_4 (aq) + $2MnSO_4$ (aq) + $8H_2O$ (aq) + $5O_2$ (g)
0.1M KI + 2M H_2SO_4 + H_2O_2	The orange liquid turned into yellowish-brown liquid and after 2 minutes dark purple precipitate appeared.	2KI (aq) + H_2SO_4 (aq) + H_2O_2 (aq) → K_2SO_4 (aq) + I_2 (s) + $2H_2O$ (aq)

H_2O_2 + MnO_2	The solution effervesces and has black precipitate.	MnO_2 (s) + H_2O_2 (aq) → MnO (s) + H_2O (aq) + O_2 (g)

Comments: All 3 reactions are oxidation-reduction reactions because there is a change in oxidize number in each reaction. O_2 is the gas released in the first and last reaction. I_2 is the dark purple precipitate. The yellow solution is the color of KI. The black precipitate in the last reaction is MnO. We can conclude that H_2O_2 can be both the oxidation and reduction chemical substance because it can raise its oxidization number in the first reaction to become O_2 or lower it in the second reaction to become H_2O.
The dark purple of I_2 was so dark that we consider it black.

Figure 3.1: Reaction 3.1

Figure 3.2: Reaction 3.2

Figure 3.3: Reaction 3.3

4. Reactions of $KMnO_4$:

Table 4: Reactions of $KMnO_4$

Reaction	Observation	Chemical Equation
0.5M Na_2SO_3 + 2M H_2SO_4 + 0.1M $KMnO_4$	The purple color of potassium permanganate was changed into a clear liquid (transparent).	$5Na_2SO_3$ (aq) + $3H_2SO_4$ (aq) + $2KMnO_4$ (aq) → K_2SO_4 (aq) + $2MnSO_4$ (aq)+ $5Na_2SO_4$ (aq) + $3H_2O$ (aq)
0.5M Na_2SO_3 + 6M NaOH + 0.1M $KMnO_4$	Forming dark green precipitation.	$2KMnO_4$ + Na_2SO_3 + 2NaOH → K_2MnO_4 + Na_2SO_4 + H_2O + Na_2MnO_4

0.5M Na_2SO_3 + H_2O + 0.1M $KMnO_4$	Forming a transparent liquid and brown precipitation.	$3Na_2SO_3$ (aq) + H_2O (aq) + $2KMnO_4$ (aq) → $3Na_2SO_4$ (aq) + $2MnO_2$ (s) + 2KOH (aq)

Comments: $KMnO_4$ can react with a salt such as Na_2SO_3 in many different conditions like acid (H_2SO_4), base (NaOH), or even distilled water (H_2O). Mangan (Mn) is an oxidized substance as it reduces oxidation number from +7 to +2 or +4.

In the second reaction, the dark green was so dark that we consider it black. In the last reaction, there should be some dark red precipitation of MnO_2 that appeared after the solution turned transparent, but we put so little $KMnO_4$ and too much distilled water, so it was quite difficult to see.

Figure 4.1: Reaction 4.1

Figure 4.2: Reaction 4.2

Figure 4.3: Reaction 4.3

5. A. Reactions of Fe^{3+}:

Table 5: Reactions of Fe^{3+}

Reaction	Observation	Chemical Equation
0.5M $FeCl_3$ + 2M KOH	Forming brown-red precipitation.	$FeCl_3$ (aq) + 3KOH (aq) → $Fe(OH)_3$ (s) + 3KCl (aq)
0.5M $FeCl_3$ + 2M NH_4OH	Forming yellow-brown precipitation.	$FeCl_3$ (aq) + $3NH_4OH$ (aq) → $Fe(OH)_3$ (s) + $3NH_4Cl$ (aq)

Comments: $FeCl_3$ reacts with base compounds in order to create ion Fe^{3+}, forming brown precipitation $Fe(OH)_3$.

Figure 5.A.1: Reaction 5.A

Figure 5.A.2: Reaction 5.A

5. B. Reactions of Fe^{2+}:

Table 6: Reactions of Fe^{2+}

Reaction	Observation	Chemical Equation
0.5M $FeSO_4$ + 2M KOH	Dark green precipitate appears.	$FeSO_4$ (aq) + 2KOH (aq) → $Fe(OH)_2$ (s) + K_2SO_4 (aq)
0.5M $FeSO_4$ + 2M NH_4OH	A yellow aqueous solution of $FeSO_4$ turn to dark green and appears dark	$FeSO_4$ (aq) + $2NH_3$ (aq) + $2H_2O$ (aq) → $Fe(OH)_2$ (s) + $(NH4)_2SO_4$ (aq)

	green precipitate.	

Comments: FeSO4 reacts with base compounds in order to create ion Fe2+, forming moss-green precipitation $Fe(OH)_2$.

Figure 5.B.1: Reaction 5.B

Figure 5.B.2: Reaction 5.B

6. Reactions of Al^{3+}:

Table 7: Reactions of Al^{3+}

Reaction	Observation	Chemical Equation
0.5M $Al_2(SO_4)_3$ + 2M NaOH	Form an opaque, white precipitate $Al(OH)_3$	$Al_2(SO_4)_3$ (aq) + 6NaOH (aq) → $2Al(OH)_3$ (s) + $3Na_2SO_4$ (aq)
0.5M $Al_2(SO_4)_3$ + 2M NaOH + 2M HCl	The precipitate Al(OH)3 slowly disappears and results in a clear liquid product	$Al_2(SO_4)_3$ (aq) + 6NaOH (aq) → $2Al(OH)_3$ (s) + $3Na_2SO_4$ (aq) $2Al(OH)_3$ (s) + 6HCl (aq) → $2AlCl_3$ (aq) + $6H_2O$ (aq)

0.5M $Al_2(SO_4)_3$ + 2M NaOH + 2M NaOH	White precipitate appears, and the precipitate dissolves.	$Al_2(SO_4)_3$ (aq) + 6NaOH (aq) → $2Al(OH)_3$ (aq) + $3Na_2SO_4$ (aq) $Al(OH)_3$ (aq) + NaOH (aq) → $NaAlO_2$ (aq) + $2H_2O$ (aq)

Comments: The result of the reaction between aluminum sulfate $Al_2(SO4)_3$ and sodium hydroxide is the white-colored precipitate aluminum hydroxide $Al(OH)_3$ and sodium sulfate Na_2SO_4. If using the products in the previous reaction as reactants and adding hydrochloric acid HCl, the precipitate aluminum hydroxide $Al(OH)_3$ dissolves and aluminum chloride is the new product. Following the same procedure, but replacing hydrochloric acid HCl with sodium hydroxide NaOH, the precipitate aluminum hydroxide $Al(OH)_3$ continuously accumulates and ultimately dissolves.

Figure 6.1.1: Reaction 6.1

Figure 6.1.2: Reaction 6.1

Figure 6.2.1: Reaction 6.2

Figure 6.2.2: Reaction 6.2

7. Flame test:

Solution	Dominant flame color	Wavelength (nm)	Frequency (s^{-1})	Photon energy (J)
LiCl	red-orange	622	4.823×10^{14}	3.196×10^{-19}
NaCl	orange	609	4.926×10^{14}	3.264×10^{-19}
KCl	violet	423	7.092×10^{14}	4.699x10-19
CaCl2	red-orange	622	4.823×10^{14}	3.196x10-19
BaCl2	orange-yellow	597	5.025×10^{14}	3.330x10-19

Comments: The purpose of this experiment is to show the differences displayed in color of the flame when various salts and metals react with fire. By translating the flame color into frequency, wavelength and energy per photon can be calculated by using the correct formulas.

Figure 7.1: Flame LiCl

Figure 7.2: Flame NaCl

Figure 7.3: Flame KCl

Figure 7.4: Flame $CaCl_2$

Figure 7.5: Flame $BaCl_2$

IV. Conclusions:

After this experiment, we had the opportunity to do many types of reactions such as synthesis, decomposition, single displacement, double displacement, combustion, acid-base, complex compound formation, and oxidation-reduction. Following the preceding trials, we can distinguish between several sorts of events such as color change, precipitation formation, and gas formation. In addition, we saw the physical characteristics of various chemicals alter through a flame test.