Experiment 7 – "The Halogen Family: Some Colorful Non-Metals"

Reagents -	Each Student	100 Students
iodine, I_2	0.5 g	50 g
methylene chloride, CH_2Cl_2	2 ml	200 ml
sodium iodide, NaI	0.7 g	70 g
commercial liquid swimming pool hypochlorite solution	1 ml	100 ml
sulfuric acid, H_2SO_4, 36% or 4.6 M	2 ml	200 ml
starch-iodide paper	1 piece	100 pieces
distilled water	20 ml	2000 ml
sodium bromide, NaBr	0.2 g	20 g
sodium chloride, NaCl	0.2 g	20 g
silver nitrate, $AgNO_3$, solution, 1%	5 ml	500 ml
ammonium hydroxide, NH_4OH, 6 M	2 ml	200 ml
commercialized iodized table salt	5.5 g	550 g
potassium iodide, KI	0.1 g	10 g
starch indicator solution	1 ml	100 ml

- prepare starch indicator by adding sufficient water to 5 g of soluble starch to make paste. Pour the paste into a liter of boiling water and heat until a clear solution results.

chlorine water	1 ml	100 ml

- prepare a saturated solution of chlorine in water by passing Cl_2 gas into water with gas disperser for 15–20 minutes, with stirring to insure good mixing. The chlorine water must be a very faint yellow - the faintest yellow that can be observed. If it is too concentrated, I_2 will be oxidized to iodate.

Special Equipment -

None

Suggestions and Precautions -

Note above that the chlorine solution must be very weak. The swimming pool solution must be an aqueous sodium hypochlorite solution, preferably of the concentration obtained from commercial pool suppliers rather than the bleach sold in grocery stores.

Prelaboratory Questions –

1. Ag^+, I^-, Cs^+

2. 

3.

ionic bonding occurs $2Na + :\ddot{\underset{..}{F}}:\ddot{\underset{..}{F}}: \longrightarrow 2Na^{+} + 2\ :\ddot{\underset{..}{F}}:^{-}$

4. a. $Ag^{+} + Cl^{-} \rightarrow AgCl\ (s)$

b. $2NaI + Br_2 \rightarrow 2NaBr + I_2$

5. KCl, $Mg(ClO_3)_2$, $Ca(OCl)_2$, $Fe(ClO_4)_3$

6. goiter

Observations and Results

Part 1- The attractive forces between the ions in NaI are greater than those between I_2 molecules.

Part 2- Possibly unable to observe color of gaseous Cl_2 because its concentration is too low. Color of gaseous chlorine less intense because it is not as concentrated as in CH_2Cl_2 solution. Fungicide, bactericide. $NaOCl + NaCl + H_2SO_4 \rightarrow Cl_2 + Na_2SO_4 + H_2O$.

Part 3- It is possible if one examines carefully the different shades of color. In trace amounts or in mixtures, such as KI in table salt, the yellow AgI cannot be detected.

$NaCl + AgNO_3 \rightarrow AgCl + NaNO_3$; $NaBr + AgNO_3 \rightarrow AgBr + NaNO_3$;

$NaI + AgNO_3 \rightarrow AgI + NaNO_3$.

Part 4- $2KI + Cl_2 \rightarrow 2KCl + I_2$.

Questions and Problems

1. The body needs a source of iodide ion to make thyroxine.
2. Fluorine gas would not be found in fluoridated water - the fluoride anion is present and since its outer electronic shell is complete, it is no longer highly reactive as is the free halogen.
3. Dissolve the bromoseltzer in water and test a sample of that solution with $AgNO_3$. Absence of the pale yellow AgBr would indicate bromide's absence.

Experiment 8 – "Analysis of Commercial Bleaches: Comparison of Two Competing Products"

Reagents -	Each Student	100 Students
potassium iodide, KI	2.1 g	210 g
distilled water	400 ml	40,000 ml
acetic acid, $HC_2H_3O_2$, 17 M	6 ml	600 ml
2 brands of liquid commercial bleach	6 ml	600 ml
(3 ml of each - example, Purex or Clorox)		
sodium thiosulfate, $Na_2S_2O_3$, solution, 0.10 M	120 ml	12,000 ml
starch solution (optional) - see Experiment 7 for preparation	12 ml	1200 ml

Special Equipment -

50 ml burette, burette brush, burette clamp

1 ml pipette, pipette bulb

Suggestions and Precautions -

If this is the students' first experience with a burette or pipette, a demonstration of the equipment is essential. Students can be referred to Experiment 14 for a discussion on titration.

Prelaboratory Questions -

1. A substance which, in a titration, changes color at the endpoint. Starch solution is the indicator in this experiment.
2. When an amount (volume) of one reactant, sufficient to react with all of the other, has been added.
3. A standard solution is one whose concentration is known so that it may be used to determine the concentration of another. $Na_2S_2O_3$.
4. $I_2 + 2Na_2S_2O_3 \rightarrow Na_2S_4O_6 + 2NaI$.
5. Cl_2.

Observations and Results -

None

Questions and Problems –

2. Yes, if the percentage were listed.

Experiment 9 – "How Fast Are Chemical Reactions?"

Reagents -	Each Student	100 Students
lead nitrate, $Pb(NO_3)_2$, solution, 0.1 M	2 ml	200 ml
potassium chromate, K_2CrO_3, solution, 0.1 M	1 ml	100 ml
sodium oxalate, $Na_2C_2O_4$, solution, 0.1 M	2 ml	200 ml
sulfuric acid, H_2SO_4, 1 M	0.7 ml	70 ml
potassium permanganate, $KMnO_4$, solution, 0.1 M	0.3 ml	30 ml
manganous sulfate, $MnSO_4$, solution, 0.1 M	0.3 ml	30 ml
acidified sodium sulfite starch solution	200 ml	20,000 ml
- 0.01 M: 1.3 g of Na_2SO_3, 10 ml of 6 M H_2SO_4, and 5 g of boiled soluble starch per liter of water.		
potassium iodate, KIO_3, solution, 0.02 M	200 ml	20,000 ml
distilled water	1200 ml	120,000 ml
ice		

Special Equipment -

time piece with second hand

10 ml pipettes (2)

thermometer °C

Suggestions and Precautions -

Students will enjoy the dramatic clock reaction. If desired, try doubling all concentrations to get sharper reactions. The reaction of $C_2O_4^{2-}$ with MnO_4^- is definitely faster at higher temperatures. Also note how the reaction speeds up as Mn^{2+} is formed to catalyze the reaction.

Prelaboratory Questions –

1. a. slow; b. fast; c. slow; d. fast; e. fast.
2. $\frac{2\text{moles}}{8\text{ L}} = 0.25$ moles/L or 0.25 M
3. a. gas is no longer evolved, and solid is dissolved; b. the purple-colored solution becomes colorless.
4. It speeds up the rate of a reaction; Mn^{2+}.
5. The appearance of intense blue-black color.

Observations and Results -

Part 1- a. Molecular equation: $Pb(NO_3)_2 + K_2CrO_4 \rightarrow PbCrO_4 + 2KNO_3$

Net ionic: $Pb^{2+} + CrO_4^{2-} \rightarrow PbCrO_4$.

b. Explain any time difference: As the reaction proceeded, forming Mn^{2+}, it went faster - took less time.

What role is played by Mn^{2+}? Catalyst.

Could the effect have been caused by SO_4^{2-}? No.

Explain: SO_4^{2-} was also present during the first reactions in large concentrations and did not affect the rate; therefore, addition of an additional small amount would not appreciably affect the rate.

Part 2- Which mixtures... IO_3^-. 4, 5 are the ones in which IO_3^- concentration is varied.

Questions and Problems-

1. By lowering the temperature, the reaction rate (bacterial) is decreased.
2. Increased temperatures increase reaction rates - cooking is a chemical reaction.
3. Oils have higher boiling points than water, so by increasing the boiling temperature at which the reaction occurs, the cooking rate is increased.
4. Rusting, tarnishing, dental decay, and aging.

Experiment 10- "Chemical Reactions Can Go Both Ways"

Reagents -	Each Student	100 Students
potassium chromate, K_2CrO_4, solution, 0.3 M	2 ml	200 ml
sulfuric acid, H_2SO_4, 2 M	1 ml	100 ml
sodium hydroxide, NaOH, 2 M	2 ml	200 ml
cupric nitrate, $Cu(NO_3)_2$, solution, 0.1 M	2 ml	200 ml
ammonium hydroxide, NH_4OH, 2 M	2 ml	200 ml
red litmus paper (or other pH paper)	4/student	400 pieces
blue litmus paper (or other pH paper)	4/student	400 pieces
magnesium chloride, $MgCl_2$, solution, 1 M	1 ml	100 ml
ammonium chloride, NH_4Cl	0.3 g	30 g
bismuth chloride, $BiCl_3$	0.4 g	40 g
sodium sulfide, Na_2S	0.5 g	50 g

Special Equipment -

None

Suggestions and Precautions –

There is nothing easy about equilibrium to a beginning student. Simple, even "homey" terminology is probably best. It may be wise to not overwork the term "concentration." We use "strength" occasionally.

Prelaboratory Questions -

1. A static or dynamic state of balance between opposing forces or actions; going both ways at equal speeds in the case of dynamic equilibrium; settling down to a steady state. It is in static equilibrium.

2. A reaction which stops short of completion because the products formed react with each other to reform the reactants; yes, equilibrium is achieved when the reverse reaction rate equals the forward reaction rate.

3. Since concentration affects rate, an increase in the concentration of a reactant would increase its reaction rate (forward or reverse) - therefore, the forward and reverse rates would no longer be equal and the "equilibrium" would shift.

4. Neutralization is the reaction of equivalent amounts of H_3O^+ ions and OH^- ions to form water and a salt. Hydrolysis is the reaction of salts or other compounds with H_2O. Hydrolysis is the reverse reaction of neutralization.

Observations and Results –

Part 1- Equation: $2CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{2-} + H_2O$

Explain how the addition of H_2SO_4… -It shifted the equilibrium to the right (see above equation) by increasing the concentration of the H^+ (H_3O^+) ions. H^+ (H_3O^+) is responsible for the change in color. Explain: The SO_4^{2-} is not involved in the equilibrium reaction; it is a spectator ion. How did OH^- cause a color change? $OH^- + H^+ \rightarrow H_2O$; it removed or lowered H^+, thus shifting the equilibrium to the left.

Part 2- Explain: Yes, Cu^{2+} indicated NH_3 is present because ammonia, NH_3, molecules are needed to form the blue complex ion, $Cu(NH_3)_4^{2+}$. Suggest a way to shift equilibrium to the left - add acid. How did it work: $H^+ + NH_3 \rightarrow NH_4^+$; the acid reacts with NH_3, lowering its concentration and bringing the equilibrium to the left in order to compensate for the decreased NH_3 concentration. Equation: $Mg^{2+} + 2NH_4OH \rightarrow Mg(OH)_2 + 2NH_4^+$. Which ions actually reacted with each other: NH_4^+ and OH^-. Equations: $NH_4^+ + OH^- \Leftrightarrow NH_3 + H_2O$; $Cu^{2+} + 4NH_3 \Leftrightarrow Cu(NH_3)_4^{2+}$. What ion was formed when NH_3 came in contact... - OH^-. How does the presence of this ion... - From the above equation, it can be seen that NH_3, $+ H_2O \Leftrightarrow NH_4^+ + OH^-$, the base, causes the litmus paper to change color.

Part 3- Equation: $BiCl_3 + H_2O \Leftrightarrow BiOCl + 2HCl$

How does this equation account for... - One of the products formed is H^+. Equation: $S^{2-} + 2H_2O \Leftrightarrow H_2S + 2OH^-$. Solution turned basic.

Questions and Problems-

1. a. $TiCl_4 + 4H_2O \rightarrow Ti(OH)_4 + 4HCl$; b. $Ba(OH)_2 + H_2SO_4 \rightarrow BaSO_4 + 2H_2O$

2. a. increase; b. increase; c. increase; d. decrease; e. no change; f. decrease.

3. a. $\frac{[2][x]}{[2][2]} = 4$; x = 8 M b. Yes; $\frac{[2][2]}{[1][1]} = 4.0$

c. They would react (shift to the right) until the concentrations were changed to obey the equilibrium law.

d. To the right.