Basic Skills for Chemistry
CHEM-1020
Experiment No. 5
<u>Physical and Chemical Changes</u>
(Revised 04/11/2016)

<u>Introduction:</u> Matter may undergo two types of transformations, classified by chemists as *Physical Changes* or *Chemical Changes*. In this experiment, you will treat several samples of matter in ways to cause them to undergo physical or chemical changes. Your task will be to make careful observations of what takes place, to classify the changes as either physical or chemical and to explain the reasons for each choice.

Physical changes may involve changes in size and shape or changes of state but with *no loss of identity*. No new substances form during physical changes. One type of physical change is the process of solution where a substance classed as a solute dissolves in another substance, called the *solvent*, typically, but not always a liquid. One can recover the solute simply by evaporating the solvent. Cutting a substance into small pieces is a physical change. Heating or cooling a substance to melt, vaporize or condense it produces a physical change. Freezing is also an example of a physical change. When two colored substances such as blue and yellow paint mix and produce the intermediate color green, the change is physical, since no new substance is created.

During chemical changes, the identity of reacting substances is lost and entirely different substances form. Chemical changes are typically more difficult to reverse although some can be reversed easily. Chemical changes occur when a substance decomposes into simpler substances or when two chemicals combine to form entirely new substances. Evidence of a chemical reaction may be the appearance of a new physical state such as a gas even when the system is not heated. When mixing two clear solutions results in a solid precipitate* even though the system is not cooled, the change is likely chemical. Further evidence of a chemical change may be an unexpected color change or a new odor from a new gas. Formation of a new color, even if the color change is reversible, usually indicates chemical change. Many chemical changes are also accompanied by the release of heat, light or electrical energy. In a chemical change, bonds that hold atoms together are broken and new bonds form. The new substances have different compositions and different chemical and physical properties from the original starting materials. However, mass is always conserved. Even though identity loss occurs in chemical changes, *no atoms are ever created or destroyed*. Two examples of chemical change are rusting and photosynthesis. When iron rusts, its appearance changes completely and the system gains mass. Mass gain does not mean that matter is created, however. The added mass comes from oxygen atoms in the air that combined chemically with the iron atoms. In rust (iron oxide), the iron and oxygen atoms have combined in a new way. In photosynthesis, carbon dioxide (CO_2) and water (H_2O) combine under the influence of chlorophyll, using the energy of sunlight, to form glucose ($C_6H_{12}O_6$) and oxygen (O_2) gas. Every C, H and O atom in the oxygen gas and glucose products was present in the original starting materials. The French scientist Antoine Lavoisier proved the law of conservation of mass by showing that in *closed* systems, chemical and physical changes never result in any change in total mass. We now recognize that the numbers and types of atoms before and after a change remain the same.

* A precipitate may appear as a dense solid at the bottom of a test tube, a bulky flocculent solid interspersed with the liquid or a cloudy suspension that does not settle out immediately.

In this experiment, you will note the initial appearances of twelve chemical systems, then heat or mix the substances with other reagents as directed. From your observations and interpretation of the results, you will classify each process as a chemical or physical change. The procedures in this experiment are simple and easy to perform. However, you must be prepared to do them in a safe and efficient manner, without wasting time. Otherwise, you may not finish working in the allotted two-hour lab period. Read the procedures and try to understand them a few days before and then immediately before you come to lab to enable you to work safely and effectively.

Safety: You must wear chemical splash goggles and a waterproof apron for the entire duration of this experiment. Do not handle *any* chemicals or equipment in the laboratory until you put on your goggles. When you remove your goggles at the end of the experiment, you must leave the laboratory immediately. Observe all the safe chemical handling and disposal procedures you were taught. In a previous experiment, you learned proper procedures for lighting and adjusting a Bunsen burner. For your safety and the safety of others, and to do this experiment in an efficient manner, review the instructions for lighting a burner and heating solids and liquids.

Proper Chemical Handling Procedures: In this and in all subsequent chemistry experiments, be careful to handle all chemicals properly. Your instructor will review the guidelines given at the start of the semester for handling chemicals. Some key points are:

a) To avoid contamination or inadvertent mixing of two incompatible substances, *never* return any chemical to its container. This can result in contamination of the chemical supply, or even a violent reaction if two incompatible substances are accidently mixed.

b) If you need to measure out a liquid or solution, use a graduated cylinder of the appropriate size. If you dispense too much liquid, save the excess for later, give it to someone else, or discard it properly. (See item f.) *Never* pour any excess back into a laboratory supply container.

c) Never put *your* dropper into a laboratory supply bottle. If a supply bottle does not have a dropper cap and you wish to measure out its contents with a dropper, pour some of the liquid into a small beaker and take it to your workstation.

d) You may use your own clean metal spatula to remove a granular or caked solid from a bottle.

e) Never set a bottle stopper down on a table or bench surface. This will leave a drop of solution on the bench top and possibly contaminate the stopper. Your instructor will demonstrate the proper technique for holding a stopper top between your fingers as you pour.

f) Dispose of used or unneeded chemicals only in an approved, environmentally safe manner. Some chemicals in this experiment are toxic or harmful to the environment and may not be legally thrown in the trash or poured down any sink drain. So-called heavy metals (most metals beyond iron in the periodic table) are toxic and interfere with the action of bacteria in sewage treatment plants and are environmentally harmful in other ways. The disposal of toxic organic chemicals, flammable liquids and concentrated acids and bases down the drain is also legally prohibited. Proper disposal instructions are in parentheses at the end of every procedure. Always consult your instructor if you have any questions.

g) Toxic or irritant chemicals such as concentrated hydrochloric acid, concentrated nitric acid and flammable or toxic organic solvents must be dispensed in a fume hood. This minimizes your exposure to potentially harmful vapors and reduces the chance of a dangerous spill or fire.

h) After you dispense a chemical for your use, return the supply bottle <u>immediately</u> to the laboratory supply area to make it available to other students.

Test Tube Handling Procedures: Read the instructions below for heating and handling test tubes safely before you attempt any procedure in this laboratory requiring the use of test tubes.

a) When working with several test tubes at once, place them in a test tube rack and label the white patch on each one in pencil. Do not use ballpoint ink. It does not work well on glass and is hard to erase.

b) When shaking is required to mix solutions or dissolve a solid, hold the test tube near its top with your fingers and shake gently from side to side. Do not shake so vigorously that liquid splashes out. Do *not* shake up and down or use your thumb to keep the liquid in the test tube.

c) When heating test tubes, hold them with a wire test tube holder, not a clamp or metal forceps. For liquids, use a small, soft blue flame and have the flame contact the side of the test tube just above the bottom. Heating the very bottom of a test tube may cause liquids to "bump" or spurt out. Hold the test tube at an angle and point it *away from anyone* in your vicinity. Do not squeeze the handle of the wire test tube holder in a way that loosens its grip on the test tube.

d) Solids may be heated with a strong flame since solids are less likely to spurt out of a test tube.

e) If an experiment is expected to produce a sudden or noisy reaction, you will be instructed to place the test tube in a rack, rather than hold it with the wire holder.

Experimental: Carry out the twelve procedures as directed and immediately record your observations in the data table before and after you do the procedures. To avoid waiting in line for laboratory reagents, *do not* perform the experiments in numerical order. Everyone in the class should start doing a different procedure. Dovetail your procedures and do not waste time waiting for a system to cool or for other slow changes to occur. *Do not* keep chemical bottles at your workstation when you are done using them. These twelve experiments can be time consuming if you are not prepared for this lab. Be sure to read the instructions beforehand and be prepared to work in a smooth, efficient manner.

Note: Do not confuse acid and base reagent concentrations. Hydrochloric acid solutions for this experiment comes in two concentrations, six molar (6 M) and one-tenth molar (0.1 M). The sodium hydroxide solutions likewise come in 6 M and 0.1 M concentrations. The properties and actions of the different concentrations are very different. Use only the concentration specified for each procedure.

Procedures:

1. a) Place one zinc pellet in a clean, dry porcelain crucible and poke it with a metal spatula. b) Place the crucible in the clay triangle on a ring stand. Position the iron ring so the bottom of the crucible is about 4 cm above the top of the Bunsen burner chimney. c) Heat the crucible strongly for two minutes with a hot, blue Bunsen burner flame. d) Poke the zinc again while it is still hot. What is its consistency? Go on to different procedure and let the crucible and zinc cool to room temperature. e) After the system has cooled, poke the zinc with the spatula again. Dispose of the zinc in the heavy metal hazardous waste container.

2. Weigh about 1 g of paraffin wax granules into a dry crucible. Place the crucible in a clay triangle on a ring stand and heat *gently* with a small soft blue burner flame. What happens to the wax? *Do not overheat. Keep a wire gauze square handy to place on top of the crucible if the wax catches fire. Do not use water to put out a wax fire.* b) Stop heating and let the crucible cool to room temperature while you do another procedure. What happens to the molten wax? (Carefully scrape the wax out with your metal spatula before it hardens completely and dispose of it as ordinary trash.) Caution: Do not drop any wax granules on the floor. Wax will make the floor dangerously slippery. Inform your instructor if you spill any wax on the floor.

3. Light a wooden splint with a match or with the Bunsen burner flame. (Extinguish the flame and wet the splint under the faucet before you dispose of the splint in the trash.)

4. Put an ice cube on a watch glass and observe what happens over a 30-minute period.

5. Place a small piece of solid carbon dioxide (CO_2), commonly called dry ice, on a piece of paper and observe it over a 30-minute period.

6. In a 15 cm (medium) test tube, place about 1 mL of 0.1 M or 0.5 M iron(III) chloride (also known as ferric chloride or $FeCl_3$) solution and 4 drops of 0.1 M potassium thiocyanate (KSCN) solution. Shake the test tube gently from side to side. (Flush the mixture down the drain and rinse the test tube with tap water.)

7. a) Pour about 1 mL of 0.1 M NaOH (sodium hydroxide) solution (be sure to use 0.1 M, not 6 M NaOH) into a 15 cm (medium) test tube. b) Add one drop of phenolphthalein indicator dye solution and shake the test tube gently from side to side to mix the solutions. c) Add about 1 mL of 6 M HCl, (not 0.1 M HCl) and shake again. (Discard the mixture in the heavy metal waste collection container and rinse the test tube with tap water.)

8. Place one zinc pellet in a medium test tube and add about 2 mL of 6M HCl (dilute hydrochloric acid). Let the system stand for five minutes. (Afterwards, discard the zinc and acid in the heavy metal waste collection container. Rinse the crucible with a little tap water and pour this water into the heavy metal waste container.)

9. Place a pea-sized amount of solid $NaHCO_3$ (sodium bicarbonate) into a 15 cm test tube and add about 2 mL of 6M HCl. Shake the test tube gently from side to side. (Discard the mixture in the heavy metal waste container. Rinse the test tube with tap water before you reuse it.)

10. Pour about 1 mL of 0.1M HCl into a 15 cm (medium) test tube. Add one drop of 0.1 M or 0.01 M silver nitrate ($AgNO_3$) solution and shake the test tube gently from side to side. (Discard the mixture in the heavy metal waste collection container. Rinse the test tube with a few mL of tap water and pour this water into the heavy metal waste collection container. Then rinse the test tube with tap water before you reuse it.)

11. a) Use a hanging pan balance to weigh about 0.1 g of sodium acetate into a large (2 cm wide) test tube. b) Add about 4 mL of tap water and shake the test tube from side to side. c) After the solid dissolves, hold the test tube with a wire test tube holder and heat the solution <u>gently</u> with a small, cool, blue burner flame until all the water is gone. What do you see? d) Allow the test tube to cool and add about 5 mL of tap water. e) Shake the test tube from side to side until the solid redissolves. (Discard the resulting solution down the sink drain and rinse the test tube with tap water before you reuse it.)

12. Add about 1 mL of 6M HCl to a 15 cm (medium) test tube and feel the bottom of the test tube. Add about 1 mL of 6M NaOH (sodium hydroxide solution) and gently shake the test tube from side to side. Feel the bottom of the test tube again. (Discard this mixture in the heavy metal waste collection container. Rinse the test tube with tap water.)

Observations: On the data page, record only <u>what</u> <u>you</u> <u>see</u>. Be sure to include all your observations before and after you cause each system to undergo a change. Your instructor will check and approve your data entries as you work. Do not leave the lab until the instructor initials or approves your data sheet

Waste Disposal: Follow the specific disposal instructions given in parentheses at the end of each experimental procedure. (It is extremely important to discard all acidic solutions and all heavy metal solutions and solid residues in the heavy metal waste collection container.) Rinse each test tube and crucible with tap water and shake out the excess water before you reuse it. For especially toxic or corrosive wastes, be sure to also pour the first rinse liquid into the hazardous waste container.

Cleanup: After you have disposed of all wastes and excess chemicals properly, according to the waste handling guidelines above, rinse all your glassware and put it back in your laboratory locker. Remove the rubber bulbs from your droppers and rinse them separately under running water. Wipe down all your work areas with a damp sponge before you leave the laboratory. Do not leave any puddles, drops of water or solid chemicals on the benchtops or floor. Pay particular attention chemical spills near the balances and to any possibility of wax granules on the laboratory floor.

Report: On pages 7 and 8, summarize your observations in the report tables and state whether your observed changes are chemical or physical. For full credit, state the reason for each conclusion in the right hand column. For instance, many chemical changes are easily identified by the production of a new solid or a new gas that was not present before you carried out the experiment. Anytime you see evidence of a new gas or a new solid forming, be sure to indicate that in your report.

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Data Page

Exp. No.	System	Observations Before Each Procedure	Observations During and After Each Procedure
1	Zinc Metal		
2	Paraffin Wax	mass of empty crucible __________ mass of crucible and wax ________ mass of wax _________	
3	Wood Splint		
4	Ice Cube		
5	Dry Ice		
6	$FeCl_3$ Solution and KSCN Solution		
7	NaOH and HCl Solutions w/Indicator		
8	Zinc Metal and HCl Solution		
9	Solid $NaHCO_3$ and HCl Solution		
10	HCl Solution and $AgNO_3$ Solution		
11	Solid Sodium Acetate and Water	mass of empty test tube _________ mass test tube & sodium acetate______ mass of sodium acetate__________	
12	HCl Solution and NaOH Solution		

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Report

Summarize your observations below. State what kind of change took place for each procedure (physical or chemical) and give a *reason* for each conclusion. (12 points)

Exp No.	System	Summary of Observations Before Procedure	Summary of Observations After Procedure	Conclusion (Physical or Chemical Change)	Reason for Conclusion
1	Zinc Metal				
2	Paraffin Wax				
3	Wood Splint				
4	Ice Cube				
5	Dry Ice				
6	$FeCl_3$ and KSCN Solutions				
7	NaOH and HCl Solutions w/ Indicator				
8	Zinc Metal and HCl Solution				
9	Solid $NaHCO_3$ and HCl Solution				

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Exp No.	**System**	**Summary of Observations Before Experiment**	**Summary of Observations After Experiment**	**Conclusion (Physical or Chemical Change)**	**Reason for Conclusion**
10	HCl and $AgNO_3$ Solutions				
11	Solid Sodium Acetate and Water				
12	HCl and NaOH Solutions				

Questions:

1) Indicate which of the following are chemical changes and which are physical changes. (3 points)
   - Iodine subliming ____________________
   - Leaves turning red in the autumn ____________________
   - Water boiling ____________________
   - Paper set on fire ____________________
   - Hydrogen peroxide bubbling when poured onto a wound ____________________
   - Sugar dissolving in water ____________________

2) Describe three chemical changes and three physical changes <u>not</u> discussed in this experiment. Be specific about the substances involved in each change. (3 points)

3) Describe an experiment you can do to demonstrate and prove that matter is never created or destroyed during a chemical change. (2 points)