Chemistry of Concrete

Rates of Accelerators in Concrete

Subject Area: Chemistry Grade Levels:10-12 Date: November 14, 2011

Lesson Overview

Students will look at a few principles of concrete. Last year we added an accelerator, calcium chloride and watched to see how fast it helped the reaction progress. But, we only did this from a qualitative perspective and the data collected was minimal. This year we will be adding some components to the activity. Students will pre-measure the mass of all concrete, water, and accelerator. This will allow for consistent results. Students will measure the temperature over time during the first five minutes and create a temperature vs. time graph. Students will then weigh the sample before it reacts and then after it is hard. They will notice the amount of water evaporated is negligible. Most of the water is still present. Additionally, the two samples (one with accelerator and one without) will be tested for "dryness" based on a the touch test. The time it takes to "dry" will be recorded and compared for each. Students will be asked to take the pH of the concrete as an extension into our next unit on acids and bases. As an additional skill, students will be allowed to color and finish the concrete to their own liking and take the sample home with them.

Materials Included in this Lesson

- Worksheet
- Reading on concrete
- How to write up a lab report

Other Materials for this Lesson

- Ready-mix concrete
- calcium chloride accelerator
- water
- weigh boats
- styrofoam cups
- color hardener
- stamp and release
- sealer
- balances
- graduated cylinders
- thermometers
- stopwatches
- pH paper
- stir rods
- scoopulas

Skills the Student will Learn

- How to mix concrete
- How to finish concrete
- How to apply color and sealer
- How to take the temperature of concrete
- How to take the pH of concrete

Student Deliverables

- Time vs. Temperature graph
- Lab Report
- Concrete sample

Length of Lesson: 3 Days

Activity Day One

Introduction to concrete and the chemistry behind the reaction. Allow students time to prep their lab report in their notebooks and to write the background paragraphs.

Activity Day Two

Students mix concrete. Measure pH, mass, temperature, and time. Data is collected. Samples are colored.

Activity Day Three

Concrete samples are sealed and data is analyzed. Students work on analysis and conclusion of their lab report.

Enrichment Suggestions

Students will be encouraged to look at how acetone helps evaporate off water so that the concrete can dry faster. Additionally students will be encouraged to look at why the concrete is so alkaline and why stains tend to be more acidic in nature.

Student Resources

Students will use their chemistry textbook, the chemistry workbook. An article I have written about the chemistry of concrete.
Additionally, they will be asked to use 2 outside resources online to help write their background paragraphs.

Foundation Academic Standards

1.2. Science: Specific applications of Investigation & Experimentation standards

- ✓ ü (1.a) Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.
- ✓ ü (1.d) Formulate explanations by using logic and evidence.
- ✓ ü(5.1) Apply appropriate problem-solving strategies and critical thinking skills to work-related issues and tasks.

Chemistry Standards:

- ✓ ü 7b. Students know chemical processes can either release (exothermic) or absorb (endothermic) thermal energy.
- ✓ ü 8b. Students know how reaction rates depend on such factors as concentration, temperature, and pressure.
- ✓ ü IE1d. Formulate explanations by using logic and evidence

CTE Pathway Standards

B. Engineering and Heavy Construction Pathway

C. Machine and Forming Technology Pathway

Technology:

4.5 Understand manufacturing-related concepts and the applications of technological (systems) literacy and technical (craft) skill.

Technical Knowledge & Skills:

10.7 Understand how graphic arts processes produce visual images to inform, educate, and serve manufacturing and personal needs.

10.8 Understand how manufacturing systems and processes transform and add value to industrial materials.

Lesson Plan Relevance To Externship

This lesson is directly related to my externship. I spent time mixing concrete. Some of the samples we used accelerator to help it dry faster. I spent much of my time coloring and sealing samples and looking at different coloring methods.

Grading Rubric for Concrete Lab Report

Title:
1 point = correct

Purpose:
0 points = misunderstood the purpose
1 point= clearly stated the purpose

Background
0 points = no information or sources were not cited
2 points = most topics are addressed

3 points = topic adequately addressed but no connections are made
4 points = adequately covered the topic with connections made
5 points = well organized, clear and scientifically written

Hypothesis

1 points = hypothesis present but incorrect
2points = hypothesis makes sense but is not appropriate for the purpose
3 points = clearly states an appropriate hypothesis for the purpose

Materials and Procedures

0 points = was incomplete
2 points = was complete

Results

0 points = data was not present
3 points = data was incomplete
5 points = data was complete, clear and accurately reflected the lab.

Analysis

0 points = no data analysis
3 points = incomplete or incorrect data analysis
5 points = data analysis is complete, correct, understandable and well presented.

Conclusion

0 points = no conclusion
2 points = included a restatement of the hypothesis
3 points = included the above but also used some supporting data
4 points = included the above but also included relevant information
5 points = restated hypothesis with supporting data, accurate error analysis, scientific language that includes relevant information

Quality Grade

0 points= grammar and spelling errors, disorganized and illegible
3 points= organized and legible with no spelling or grammar errors

Concrete Lab:

How does an additive accelerate the rate of reaction in concrete?

There are a series of many complicated chemical reactions involved in the "hardening" of concrete. Two of those reactions are below:

$$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$$

$$CaCO_3(aq) + 6H_2O(l) \rightarrow CaCO_3 \quad 6H_2O(s)$$

The top reaction takes calcium from parts of the cement in the concrete and it reacts in the water to form calcium hydroxide. Calcium hydroxide precipitates out as a solid surrounding the water and causing the solution to appear as if the water has disappeared. The second reaction shows how calcium carbonate and water forms a hydrate, which also takes the water and makes it part of its solid matrix. As a result we see that very little of the water actually evaporates and yet the "solution" now seems more solid than liquid, and therefore dry.

Today we will look at 2 processes:

1. What percentage of the water placed in the concrete actually evaporates during the "drying" process?
2. How much faster will the concrete dry when an "accelerator" is added?

The assumption will be that most of the water will not evaporate and when the sample is "hard" we will weigh the sample and it should weigh almost the same as it did when it was wet. We will experiment by taking the mass before and after and assuming only water is lost, what % of the water was lost.

The second process we will look at is how we can speed up the rate of the reaction. It is known that increasing the temperature can increase the rate of a reaction. We know that when calcium chloride is added to the water, the dissociation is exothermic. This extra heat will provide a catalyst to speed up the chemical reactions. As a result the solid precipitate and solid hydrate will form faster, enveloping the water molecules faster and therefore causing the concrete to harden faster.

Procedure:

1. Take the mass of a sample of dry concrete. (Approx. 160 grams). Be sure to weigh it in its reaction cup. Label it sample A. Take the mass of another sample of dry concrete (same mass) and label it sample B.
2. Take the mass of water you will be adding. This should be about 17mL. Use the same amount of water for both samples.
3. Add the water to the concrete samples.
4. Begin timing. Now mix the concrete and water.
5. To sample B add 5.0 grams of $CaCl_2$ (calcium chloride). Mix well.
6. After the concrete is well mixed, let it sit and dry.

7. Take the temperature of both samples. Then wash off the thermometer with water.
8. Every 10 minutes do a "touch" test to see if it is dry. When it is dry to the touch, record the time.
9. Mass out the sample and record the mass.

Data:

Cell #	Type	Sample A	Sample B
#1	Mass of cup + dry concrete		
#2	Mass of water added		
#3 (add #1 + #2)	Mass of cup + concrete + water		
#4	Time Concrete was mixed		
	Temperature after a few minutes of mixing		
#5	Time Concrete was deemed "hard"		
#6 (difference between #4 & #5)	Total time elapsed		
#7	Mass of cup + dry concrete		
#8 (#3 - #7)	Mass of water evaporated		
#9 (#8/#2 x 100)	% of water lost		

Analysis:

1. Which sample took longer to dry? By how much?
2. Did adding the calcium chloride speed up the "drying" process? Explain.
3. What was the difference in temperatures?
4. Which sample had a faster rate of reaction?
5. How did the temperature difference compare to the rate of the reaction?
6. What percentage of water was lost in the drying process for each sample?
7. Does that match the theory that most water stays in the sample of concrete?
8. Discuss possible sources of error in this experiment.

Conclusion:

Discuss how temperature played a role in the increased rate of a reaction. Also discuss how much water evaporated in the "drying process".