OVERVIEW-An Engineering Design Project Approach to Learning Chemistry

Addressing many of the challenges in the field of medicine requires an understanding of chemistry, biology and engineering. These challenges allow an opportunity for students to apply their emerging understanding of chemistry concepts, to be introduced to engineering concepts and to improve their 21st century skills. Design problems in pharmaceutical science are one avenue for integrating engineering in the high school chemistry class while demonstrating the interdisciplinary nature of chemical or biomedical engineering. While high school students are not expected to know pharmaceutical science, a fundamental understanding of bonding, periodicity and properties allows students to suggest solutions to problems in this area and to further their understanding of these concepts.

The module is intended to engage students in an ENGINEERING DESIGN activity that requires them to apply and synthesize concepts within the physical science standards as well as engineering concepts. Students will engage in an extended design activity over 17 days throughout the year that also addresses social perspectives, technology and the engineering standards and objectives. Some activities will take place in class while other work will be assigned for completion at home.

OBJECTIVES – Physical Science & Technology:

Structure & Properties of Matter

- ***Valence electrons*** (outer shell electrons) govern chemical properties
- The ***Periodic Table*** demonstrates ***Periodicity*** of numerous properties
- ***Physical properties*** of ***compounds*** reflect the nature of the atoms they contain
- Carbon atoms ***bond*** to one another in chains, rings & branches
- Important reactions involve the ***transfer (ionic bond)*** of or ***sharing (Covalent bond)*** of electrons to create a bond

Outcome

- Predict the ***Ionic compounds*** formed when a metal or non-metal/polyatomic ions
- Generate an ***Activity series of metals*** through experimentation of reactions between metals and metal ***salt*** solutions.
- Predict the ***products*** when 2 aqueous, salt solutions are combined
- Compare & contrast ionic compounds with carbon-containing compounds

Practices and 21st Century Skills

- Science involves practicing productive social interactions with peers (***collaboration***)
- Use the design process to systematically approach problem solving
- Effectively work in a group to share knowledge and ideas to solve a problem by proposing possible solutions to a problem, and/or critique proposed solutions.

CONTENT and ACTIVITIES – This module is designed to be presented over a 17 day period. It can be taught as a "stand-alone" module, i.e., a chapter in the textbook, or integrated throughout the curriculum between October and May when related concepts are being presented. We will use the integrated approach. The "Days" listed below are the sequence that will be followed. However, some "Days" will be skipped while those that are highlighted & have an asterisk (*) are considered essential to the module and will be completed.

*Day 1-2: Pre-test and introduce the problem to be solved (*Memorandum*)

Day 3-4: *"Like Dissolves Like"* lab activity-students will perform a lab activity to understand the relationship between ***Polarity*** and ***Solubility***

Day 5: *"Tooth and Notch"* activity-students will use this exercise to explore ***Ionic bonding*** and formula writing of ionic compounds

Day 6-7: *Relative Reactivity of Metals* – Wet Lab-Part 1/Virtual Lab-Parts 2&3-students will construct an activity series for metals based on the lab using metals and their metal salt solutions. This is a study in ***single replacement*** reactions.

*Day 8: *Engineering Design*, *An introduction*-student will view the Nightline® episode *"Deep Dive"* in order to develop a design process through collaboration and communication which are required for a successful engineering design.

*Day 9-10: *Applying engineering design* concepts-students will solve a brief design problem involving ***double replacement*** reactions.

Day 11-12: *Bonding revisited: Covalent bonds, carbon and hydrocarbons*. 2 video clips are used to clarify the differences between ***ionic*** and ***covalent bonding*** and compounds. ***Hydrogel*** demos will introduce these unique ***polymers***.

*Day 13-15: *Solving the Problem*: Synthesizing a hydrogel for drug delivery-Utilizing the design process, students will design a hydrogel from sodium alginate and a salt that meets specified project constraints including OSHA, FDA and EPA restrictions and regulations. I call this getting in touch with the real world!

*Day 16: Post-test and Final Reflections

*Day 17: Performance Assessment

RESEARCH WEBSITES – The following sources contain information that may be helpful in providing background on the various topics throughout the module:

Engineering: US Department of Labor (2010) **www.bls.gov/oco/ocos027.htm**

http://www.futuresinengineering.com/what.php

www.top-engineering-schools.com/biomedial-engineering.html

Hydrogels: **http://pslc.ws/macrog//gel.htm**

http://www.sep.org.uk/catalyst/articles/catalyst_18_1_335.pdf

Chemistry of Superabsorbant Polymers (SAPs):

http://www.functionalpolymers.basf.com/portal/streamer?fid=286901

Memorandum

To: Engineering department

From: H. Rogel

Date: 7/26/2011

Re: Project AB delivery

A promising new antibiotic is being developed that targets **antibiotic resistant** strains of bacteria. It is hoped that the antibiotic will be able to be taken orally by patients. But in order for it to be effective it must pass through the stomach intact.

Beginning immediately, we will be exploring the possibility of producing a hydrogel that could be used to carry the antibiotic through the stomach so it can be absorbed in the small intestine. Based on our prior research, we expect to be able to us a reaction between **sodium alginate** and a **salt** to produce the **hydrogel**. Your assignment is to determine which salt is the best candidate for producing the hydrogel.

As a team you are being asked to design, produce, and test a hydrogel for this application. We are counting on you to select a salt that will be used to produce the hydrogel that will carry the antibiotic. Your **proposal** will be compared to all competing proposals and should address the following aspects of this delivery material:

- Indicate both the salt and the concentration of the solution to be used in the synthesis procedure
- The hydrogel produced should be **flexible**
- The hydrogel produced should be **stable** in a **1M** hydrochloric acid solution which is similar to our stomach acid
- Both the procedure used to synthesize the hydrogel and the hydrogel itself should be safe. Consider the risks that may affect the individuals manufacturing the hydrogel (**OSHA** considerations), patients taking it (**FDA** standards) and the environmental impact (**EPA** restrictions)
- Consider the price of supplies and chemicals needed to produce your hydrogel

Your team should engage in effective collaboration and communication skills when proposing a solution to this design problem. Attention to developing and using these skills will benefit your team and your design.

Your department manager (teacher) will provide details regarding the timeline and other details. I look forward to seeing your creative solutions to this challenge.

CONFIDENTIAL

"Like Dissolves Like" Lab – Polar & Non-polar Substances

It is common knowledge that oil and water don't mix, but the reason they don't mix is not. The video at the link shown below demonstrates how different types of substances behave when they are mixed. (**VIEW VIDEO) @**

http://jchemed.chem.wisc.edu/JCESoft/CCA/pirelli/pages/cca2like.html

Some substances dissolve in each other and some do not. The purpose of this lab demonstrates how a characteristic of substances called ***Polarity*** affects whether substances dissolve in each other. It will provide you with the basis for classifying substance with respect to their polarity by knowing only that water is a polar substance.

EQUIPMENT:
- 2 – 50mL beakers
- Spatula or spoon
- Stirring-rod
- Disposable pipettes/dropper bottles
- Paper towels
- Goggles and Aprons

CHEMICALS:
- Water, H_20
- Vegetable Oil
- Sodium chloride, Table Salt, NaCl
- Potassium iodide, Sea Salt, KI
- Isopropyl alcohol, Rubbing Alcohol, C_3OH
- Sodium bicarbonate, Baking Soda, $NaHCO_3$
- Sucrose, Table Sugar, $C_{12}H_{22}O_{11}$
- Urea, NH_2CONH_2

PRINCIPLES: Determining polar nature

Chemists say that 'like dissolves like,' meaning that substances with similar chemical characteristics will dissolve in each other. Specifically, polar solvents tend to dissolve polar solutes, and non-polar solvents tend to dissolve non-polar solutes, while non-polar and polar substances are ***Immiscible*** (do not mix). For now, we will only identify (ID) whether substances are polar or non-polar. In a few days, you will learn what it means chemically for a substance to be polar or non-polar.

You may have notice common solubility problems in your everyday life. If you get bike chain grease on your pants, sap from a pine tree on your shirt, or wax from a candle on the table top, these substances are hard to remove with just water. Why do you think this demonstrates a solubility problem? What is the polarity of these substances, and how do you eventually get the stain out of your clothes?

It is possible to determine the polar nature of various substances knowing that 'like dissolves like.' Polar substances WILL DISSOLVE in WATER (a polar solvent), while non-polar solutes DO NOT. Non-polar substances dissolve only in other non-polar materials. Determine the polarity of each item in the table by testing its solubility in water and in oil.

PROCEDURE:
1. Carefully add 5-10mL of water to one beaker using a water bottle or a graduated cylinder.
2. Carefully add 5-10mL of vegetable oil to the second beaker using a graduated cylinder.
3. Using the spatula (for solids) add a small amount (just enough to cover the TIP of the spatula) of the item to be tested into both beakers. For liquid solutes add 2 drops.
4. Using a glass stirring rod, mix the solutes into the solvents. Stir for up to 2 minutes.
5. Check to see if the substance dissolves into the solvent to make a solution. Check for signs of solubility such as the disappearance of the solute. If you are unsure, repeat step 4, and watch to see if the substance dissolves.
6. Record your observations if solubility in the data table.
7. In the last column of the data table, write whether the substance is polar or non-polar based on your observations.
8. Carefully pour the entire contents of the beaker into the waste beakers provided by the teacher.
9. Rinse both of your beakers.
10. Repeat steps 1-9 until you have tested all substances.

CLEAN-UP:
1. Wash out beakers and graduated cylinders, with soap and water, then dry with a clean paper towel.
2. Return all cleaned items to lab bench for next class or place on back tables for putting away.

 Name__________________________Group_____

DATA TABLE – Polar or Non-Polar? ***"Like Dissolves Like" LAB***

SOLUTE	DISSOLVES in H_2O?	DISSOLVES in OIL?	POLAR or NON_POLAR?
NaCl			
KI			
CH_3OH			
$NaHCO_3$			
$C_{12}H_{22}O_{11}$			
NH_2CONH_2			
OIL			

CONCLUSION QUESTIONS:

1. For centuries, sailors used tree sap (pitch) to seal the spaces between the planks on wooden boats. **EXPLAIN** why pitch worked well as a sealant in this situation.

2. In order to reduce the expose to organic solvents like turpentine, some art instructors recommend the students clean brushes and hands with vegetable oil or mineral oil. Would such oils be more effective removing water-based paints or oil-based paints? **EXPLAIN**.

3. Coffee, tea, and soft-drink stains are generally removed in the wash, while stains from candle wax, salad dressing, and peanut butter require special treatment. **EXPLAIN** why.

4. **EXPLAIN** why oil can't blend/mix with water using the analogy of people holding hands to illustrate.

5. Based upon your lab, **EXPLAIN** the phrase *"like dissolves like."*

Hydrogel Design Question-From what you have learned in this lab activity can you say why your manager selected sodium alginate as the starting polymer for the hydrogel?

 Name___________________________**Group**_____

TOOTH and NOTCH: Ionic Bonding

PROCEDURE:

1. In this activity, you will be using paper representations of ***Ions*** (charged atoms) to model the formation of compounds when ions bond. Follow the guidelines listed below.
2. Each person will find the elements to which he is assigned.
   a. **Person 1**: Li and Mg **Person 2**: Na and Ba **Person 3**: K and Ca **Person 4**: Be and Al
   b. **Person 1**: F and Cl **Person 2**: Br and I **Person 3**: O and S **Person 4**: P and PO_4
3. Place each notched piece together with each of the toothed 'elements' until all notches are filled and all teeth are covered. More than 1 piece may be needed to do this. At this point, you should have created a rectangle.
4. The 1st step to creating the formula for the compound is to write the symbols for the elements in the boxes below. The symbol for the ion in the LEFT most columns should be written followed by the symbol that appears at the top of each column.
5. The ***Subscript*** for each of the symbols is determined by the number of paper pieces that were needed to form the rectangle.
6. Exchange your formulas with others in your group to complete the table.
7. Complete the questions on the reverse side of this sheet.

DATA TABLE:

IONS	F^{-1}	Cl^{-1}	Br^{-1}	I^{-1}	O^{-2}	S^{-2}	P^{-3}	PO_4^{-3}
Li^{+1}								
Na^{+1}								
K^{+1}								
Be^{+2}								
Mg^{+2}								
Ba^{+2}								
Ca^{+2}								
Al^{+3}								

INTURPRETATION OF DATA/CONCLUSIONS

Answer the following questions after completing the ***Tooth and Notch*** activity & the **DATA TABLE** on the reverse of this page. Remember: A ***cation*** is an ion that has acquired a charge by *losing* electrons. An ***anion*** is an ion that has acquired a charge by *gaining* electrons.

1. Which of the model atoms, toothed or notched, looks as if it lost electrons?
2. Electrons have a _______________ charge. Losing one or more electrons will cause the remaining particle to have a ______ _______________ charge.
3. What would be the charge (sign and magnitude) for an ion formed from an atom that has lost 1 electron? _______________ 2 electrons? ___________
4. Which of the model atoms, toothed or notched, looks as if it gained electrons?
5. Gaining one or more electrons will cause the resulting particle to have a _____________ charge.
6. What would be the charge (sign and magnitude) for an ion formed from an atom that gained 1 electron?_________ 2 electrons? ___________
7. What would be the charge on an ion with 2 teeth? ________________ 3 notches? ____________
8. When writing a formula, which comes first: the cation ______ or the anion? __________ (Chose one)
9. What is the charge on a [Na] ion? _________ [Mg] ion? ______[O] Ion?________
10. Based on the information in this chart and the ***Periodic Table***, what do F, Cl, Br and I have in common?
11. Based on the information in this charge and the ***Periodic Table***, what do Li, Na and K have in common?
12. EXPLAIN why each of the following formulas is written incorrectly.

    CaP

    Al_3O_2

    P_2Mg_3

Hydrogel Design Question-Positive ions are attracted to negative ions. How could you use this idea to help make your hydrogel?

EXPLORING METAL REACTIVITIES

PART A: Wet Lab – In this lab activity you will explore the reactivity of metals by combining small sample of metals with solutions of metal salts and observing the results.

EQUIPMENT:
Microplate, 24 well or 9 test tubes
Test tube rack
White paper, paper towels
Disposable pipettes/dropper bottles
Goggles and Aprons

CHEMICALS: small pieces of the metals: Cu, Mg, and Zn
0.1M solutions of these solutions:
Copper nitrate, Cu $(NO_3)_2$
Magnesium nitrate, Mg $(NO_3)_2$
Zinc nitrate, Zn $(NO_3)_2$
Silver nitrate, Ag $(NO_3)_2$

PROCEDURE:

1. Obtain 3 pieces of each metal: Cu, Mg, and Zn. All pieces of each metal should be of similar size.
2. Place one piece of each metal in the individual wells of Microplate or in the individual test tubes (in the rack) in an arrangement that matches the data table below.
3. Place the Microplate or test tube rack over a piece of white paper to better see the reactions.
4. Following the pattern on the data table, add enough of each of the solutions to just cover (~3-5 drops, at most) the metals.
5. Wait about 5 minutes and then record your observations. If there is **NO** visible evidence of a chemical reaction, write **"NR"** in the appropriate space.
6. Dispose of the metals and solutions as directed by your teacher.

OBSERVATIONS - DATA TABLE #1:

METAL		**SOLUTIONS**		
	Copper Nitrate	**Magnesium Nitrate**	**Zinc Nitrate**	**Silver Nitrate**
Mg		-----[2]		
Cu				
Zn				
Ag[1]				

[1] Silver is too expensive to purchase in the pure form. The observations for silver will be obtained from the virtual (on-line) version of the lab.

[2] Metals will not be placed in the salt solution containing the ion of that metal. As you answer the questions, consider the reasons why.

PART B: Online Lab – Continue your exploration of the relative reactivities of metals using the online simulation of the investigation you completed in the lab for the 3 metals. Complete this part at home.

PROCEDURE:

1. Go to the website: http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/redox/home.html
2. Click on "Start" and then on "Activity 1." Notice that this is the activity is the one you completed in the lab except for the silver. Select the metal silver and follow the directions on the site.
3. Record the results for the silver in DATA TABLE #1.
4. Complete Activities 2 & 3 on the site, recording your observations in DATA TABLE #2, and #3. Only the skeletons of the tables have been provided. You will need to fill in the metals and solutions in addition to recording your observations.
5. When you are finished, answer the questions that follow.

OBSERVATIONS - DATA TABLE #2: **Activity #2**

METAL		SOLUTIONS		

OBSERVATIONS - DATA TABLE #3: **Activity #3**

METAL		SOLUTIONS		

ANALYSIS and CONCLUSIONS: Use your observations of the metal reactivities online lab and your knowledge of chemistry to answer the following questions:

1. In the table below, record which metal reacted with the greatest number of solutions and which reacted with the fewest solution in each situation.

	Wet Lab	Activity 2 – Virtual Lab	Activity 3 – Virtual Lab
Metal that reacted with the greatest number of solutions			
Metals that reacted with the fewest number of solution			

2. Elements are often listed according to their reactivity, from MOST to LEAST reactive. These lists are referred to as ACTIVITY SERIES and are based on experiments similar to the wet lab and virtual lab that you performed. Use YOUR observations to create an activity series for the wet lab and the 2 online, virtual labs in the 2 left-hand columns in the table below.

Wet Lab	Activity 2 – Virtual Lab	Activity 3 – Virtual Lab

3. Combine the 3 activity series to create a single activity series with each of the eight metals listed only once in the column below labeled "Combined Activity". The **MOST Reactive** should be listed **FIRST** & the **LEAST** Reactive should be listed **LAST**.

Combined Activity

4. List **TWO** observations of the metals that suggest a chemical reaction did actually take place.

5. Which of the eight metals in the lab would most likely to be found in a “free” or uncombined state in nature? EXPLAIN how you know.

6. The Statue of Liberty was constructed of copper metals. Based on your observations from this lab, answer the following questions.

    a. Why was copper chosen?

    b. Suggest a better choice of metal than copper.

    c. Why do you suppose this “better choice” wasn’t chosen (give a reason for you supposition)?

7. What do you predict would happen if a piece of calcium was added to the copper nitrate solution? EXPLAIN the reason for your prediction.

Hydrogel Design Question-Chemists can make predictions using their scientific knowledge about the behavior of substances such as metals and compounds under certain circumstances. Who might use the knowledge of metal reactivities in their jobs?

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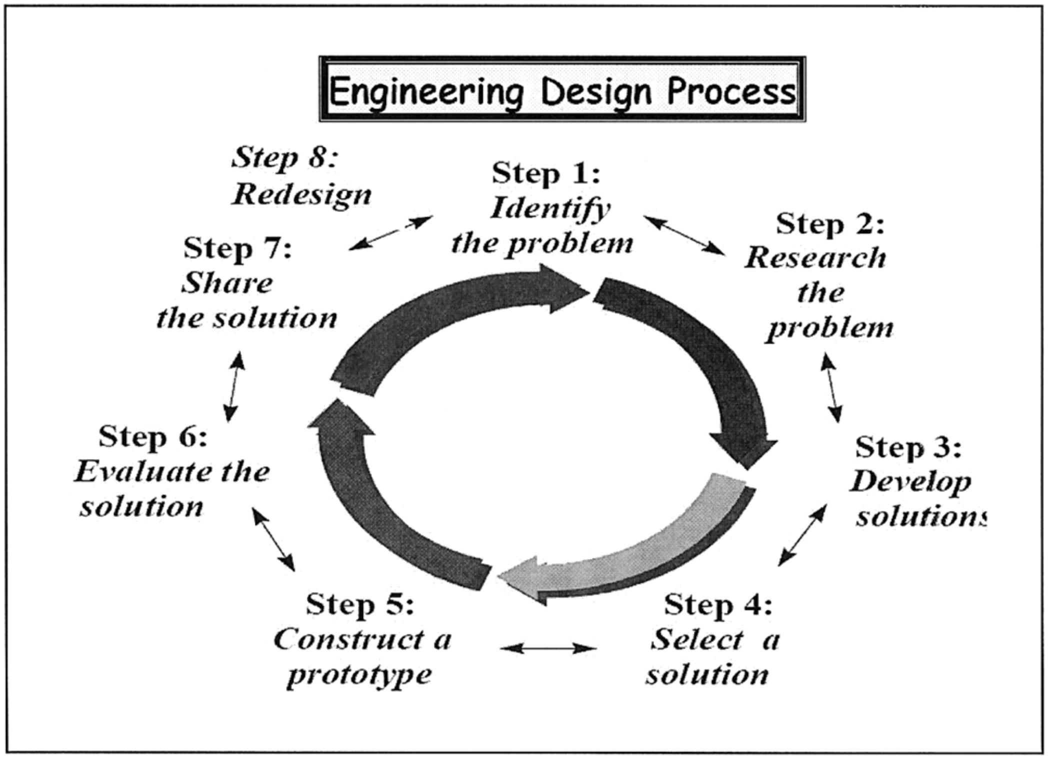
DEEP DIVE VIDEO VIEWING WORKSHEET

PREVIEWING: What do engineers do? What is their workplace like?

While watching the ***"Deep Dive"*** video (Nightline®), complete the table below with phrases and examples.

Activities the Team(s) are Engaged In	Characteristics of Effecting Collaboration & Communication

Other observations and characteristics of the teams:



From: Teach Engineering
www.teachengineering.com

After watching the video DEFINE the following terms and how they relate to the design process:

Iterative –

Prototyping –

Requirement –

Optimization –

Constraint –

Analyzing –

Trade-off –

Invention –

Modeling –

Innovation -

Predicting Outcomes: Part II

The metal activity series can be used to predict whether a reaction between a metal and an aqueous metal salt will occur, but how can we predict if a reaction between 2 dissolved ionic compounds will occur?

The procedure to make this prediction is shown here using 2 examples and the ***Solubility Rules*** on the reverse of this page.

Predicting whether a reaction will occur…

$NiCl_2$ (aq) + $(NH_4)_2S$ (aq) →

$NaCl$ (aq) + $(NH_4)_2S$ (aq) →

1. **Write down the cations and anions present in each of the reactants.** You will recall some of the ions, but you may need to look up the others.

   Ni^{+2} (aq) + Cl^{-1} (aq) + NH_4^{+1} (aq) + S^{-2} (aq) →

   Na^{+1} (aq) + Cl^{-1} (aq) + NH_4^{+1} (aq) + S^{-2} (aq) →
2. **Swap the ions to build the products.** In the first example, Ni^{+2} will pair up with the S^{-2} to produce NiS. The NH_4^{+1} and the Cl^{-1} will produce NH_4Cl. In the second example, Na^{+1} will pair up with the S^{-2} to produce Na_2S. Make sure that you combine the cations and anions so that he charges balance. So **IF** a reaction occurs, this is what we would have: $NiCl_2$ (aq) + $(NH_4)_2S$ (aq) → NiS + NH_4Cl

   $NaCl$ (aq) + $(NH_4)_2S$ (aq) → Na_2S + NH_4Cl

   BUT… a reaction will occur **ONLY** if one of the products is ***Insoluble*** in water, is a gas, or is pure water. In these examples, none of the products is water, but are any of them insoluble in water or a gas?
3. **Label the phases of the products as solid, liquid, or aqueous.** Check the ***Solubility Rules*** sheet and the list of gases on that sheet. In these examples, the sodium and ammonium compounds are soluble (Rule 1) and the NiS is insoluble (Rule 6). So, we have:

   $NiCl_2$ (aq) + $(NH_4)_2S$ (aq) → NiS (s) + NH_4Cl (aq)

   $NaCl$ (aq) + $(NH_4)_2S$ (aq) → Na_2S (aq) + NH_4Cl (aq)
4. **Does a reaction occur?** A reaction occurs only in the first example because NiS is a solid.
5. **Balance the equation.** To correctly write the chemical equation for this reaction, it should be balanced by changing the coefficients in front of each compound so that you have the same number of each type of atom on each side of the equation as follows.

   $NiCl_2$ (aq) + $(NH_4)_2S$ (aq) → NiS (s) + **2**NH_4Cl (aq)

Solubility of Ionic Compounds in Water

Either of the tables below can be used to predict the solubility of ionic compounds in water.

In Table 1, find the intersection of the row and column for the ions in the compound. The entry in the box indicates whether the compound will dissolve (aq) or will not dissolve (s) in water.

Table 1: Solubility of Ionic Compounds in Water
aq = aqueous (dissolves in water); s = solid (does not dissolve in water)

Ions	Acetate	Bromide	Carbonate	Chlorate	Chloride	Fluoride	Hydrogen Carbonate	Hydroxide	Iodide	Nitrate	Nitrite	Phosphate	Sulfate	Sulfide	Sulfite
Aluminum	s	aq		aq	aq	s		s	--	aq		s	aq	--	
Ammonium	aq	aq	aq	aq	aq	aq	aq	--	aq	aq	aq	aq	aq	aq	aq
Barium	aq	aq	s	aq	aq	s		aq	aq	aq	aq	s	s	--	s
Calcium	aq	aq	s	aq	aq	s		s	aq	aq	aq	s	s	--	s
Cobalt (II)	aq	aq	s	aq	aq	--		s	aq	aq		s	aq	s	s
Copper (II)	aq	aq	s	aq	aq	aq		s		aq		s	aq	s	
Iron (II)	aq	aq	s		aq	s		s	aq	aq		s	aq	s	s
Iron (III)	--	aq			aq	s		s	aq	aq		s	aq	--	
Lead (II)	aq	s	s	aq	s	s		s	s	aq	aq	s	s	s	s
Lithium	aq	aq	aq	aq	aq	aq	aq	aq	aq	aq	aq	s	aq	aq	aq
Magnesium	aq	aq	s	aq	aq	s		s	aq	aq	aq	s	aq	--	aq
Nickel	aq	aq	s	aq	aq	aq		s	aq	aq		s	aq	s	s
Potassium	aq	aq	aq	aq	aq	aq	aq	aq	aq	aq	aq	aq	aq	aq	aq
Silver	s	s	s	aq	s	aq		--	s	aq	s	s	s	s	s
Sodium	aq	aq	aq	aq	aq	aq	aq	aq	aq	aq	aq	aq	aq	aq	aq
Zinc	aq	aq	s	aq	aq	aq		s	aq	aq		s	aq	s	s

For Table 2, read the rules in order beginning with rule #1. The first rule that is encountered for a given compound will indicate whether the compound is soluble or insoluble.

Table 2: Solubility Rules

1. All common compounds of Group 1 and ammonium ions are SOLUBLE.
2. All nitrates, acetates, and chlorates are SOLUBLE.
3. All binary compounds of the halogens (other than F) with metals are SOLUBLE, EXCEPT those of Ag, Hg(I), and Pb. Pb halides are soluble in hot water.)
4. All sulfates are SOLUBLE, EXCEPT those of barium, strontium, calcium, lead, silver, and mercury (I). The later three are SLIGHTLY SOLUBLE.
5. Except for Rule #1, carbonates, hydroxides, oxides, silicates and phosphates are INSOLUBLE.
6. Sulfides are INSOLUBLE, EXCEPT for calcium, barium, strontium, magnesium, sodium, potassium and ammonium.

Days 11-12: Bonding Revisited: Covalent Bonds, Carbon and Hydrocarbons

Overview – In this lesson students will be introduced to covalent bonds and bonding in carbon compounds that allows for the large range of structures and variety of organic compounds.

Objectives – Students will be able to:

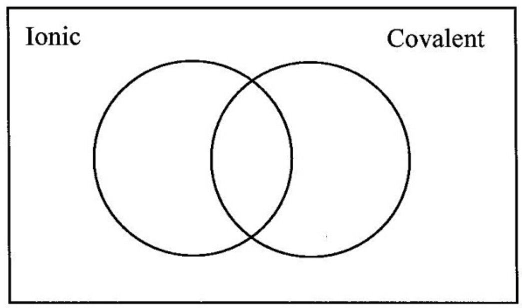
1. Compare and contrast Ionic and Covalent Bonding
2. Describe how carbon is unique in the formation of long chain & ring structures.

Materials and Resources –

1. Computer with internet access
2. Diaper, beaker, tap water

Activities – 1. Video Clip #1, http://allthingsscience.com/video/849/Ionic-and-covalent-bonding-animation

2. Using a Venn Diagram discuss the similarities & differences between ionic & covalent bonding.



Video Clip #2, http://videos.howstuffworks.com/hsw/22641-compounds-covalent-bonds-video.htm

or: Video Clip #3, http://howstuffworks.com/discovery/29398-assignment-discovery-chemicalbond-video.htm

or: Video Clip #4, http://www.youtube.com/watch?v=QqjcCvzWwww

3. Video Clip #5 (on Polymers), http://www.chemistryland.com/PolymerPlanet/Polymers/PolymerTutorial.htm

Polymer PowerPoint: RECORD 5 interesting facts about polymers based on the PowerPoint presentation.

Days 13-15: Solving the Problem: Synthesizing a Hydrogel for Drug Delivery

Overview: This is the final, multi-day lesson. Students will work in their groups to solve the design problem that was proposed at the beginning of the module.

Objectives: Students will be able to:

Apply chemistry concepts to the design problem that requires specific criteria to be met within certain constraints.

Work effectively in a group to share knowledge, address problems, propose possible solutions, and/or critique proposed solutions.

Materials and Resources:

Engineering Design Documentation: Project AB Delivery

Memorandum: Project AB Delivery - Supplies

Memorandum: Reassignment

Internet Access

Sodium alginate solution (2%) – prepared within 24-48 hrs of use.

Lab materials as specified in the original memorandum

Activities:

Use of chemistry knowledge and engineering design process to solve the problem that was presented in the beginning of the module.

Use sodium alginate as the basis of their hydrogel. Observe demo and formation of hydrogel beads in a Petri dish.

Students working in their groups will begin the final project using *Engineering Design Documentation: Project AB Delivery*.

Reinforcing Communication & Collaboration: (A 21st century "skill")

Students should work together to research all necessary aspects of the chemicals they wish to use to create their hydrogels and submit a WRITTEN proposal for teacher approval.

SAFETY NOTE:

When working with the 1M HCL solution, use a test tube and stirring rod. This step is to test the stability of your hydrogel in "stomach acid."

Memorandum

To: Engineering department

From: H. Rogel

Date: 7/26/2011

Re: Project AB delivery

Your prototype hydrogel must be synthesized from materials available here and that are approved by you department manager. The following materials are available through your department manager:

- ✓ Balance
- ✓ Glassware
  - o Beakers
  - o Test tubes
  - o Graduated Cylinders
  - o Stirring rods
- ✓ Spatula
- ✓ Disposable pipets
- ✓ Petri dishes – plastic
- ✓ Sodium alginate solution
- ✓ Salts
  - o Aluminum sulfate
  - o Barium chloride
  - o Calcium chloride
  - o Copper (II) sulfate
  - o Iron (III) chloride
  - o Lead (II) sulfate
  - o Magnesium chloride
  - o Mercury (II) chloride
  - o Potassium chloride
  - o Silver nitrate
  - o Sodium chloride
  - o Tin (II) chloride
  - o Zinc sulfate
- ✓ Distilled water
- ✓ Hydrochloric acid, 1M solution

ENGINEERING DESIGN DOCUMENTATION: Project AB Delivery

IDENTIFY THE PROBLEM – In the table below, list what you know about the design problem and the materials provided that are important for this design problem. Then LIST what you need to know about the problem or the materials for you to design a solution.

What YOU Know	What you NEED to Know

RESEARCH THE PROBLEM – Research the information that you need to know to solve this design problem. In the space below, **SUMMARIZE** what you learned from you research.

DEVELOP SOLUTIONS – In the boxes below, **DOCUMENT** several possible solutions.

SR/DR	SR/DR
DR	DR

SELECT A SOLUTION – Select **ONE** of your designs to be your group's prototype that you will test in the lab. **PLACE AN "X"** in the selected solution in the table above. In the space below, **EXPLAIN** the reasons for selecting this design.

MATERIALS and PRODEDURE: LIST the materials that will be used and the ENUMERATE the steps involved with your procedure.

Obtain approval before proceeding!
TEACHERS Signature:________________________

CONSTRUCT A PROTOTYPE: TEST your design in the lab. **RECORD** your observations.

EVALUATE THE SOLUTION – Based on the observations of your design test, consider & document the PROs and CONs of your design. In the table below **LIST** any problems that were noted during testing of your design and **LIST** improvements that might be made to correct each design problem.

Design Problems	Suggested Improvements
1.	
2.	
3.	
4.	

REDESIGN – Based on your evaluation, **PROPOSE** a new design and **OBTAIN** approval from your department manager (teacher) before proceeding with testing. **LIST** materials & **LIST** procedure in the space below.

Obtain approval before proceeding!

TEACHERS Signature:________________________

CONSTRUCT A PROTOTYPE: - TEST your new design in the lab. **RECORD** your observations.

JUSTIFICAITON OF COST AND SAFETY – How did you consider **cost** and **safety** in you final design?

Hydrogel Design Question-In the hydrogel that you will design where are the ***covalent bonds*** and where are the ***ionic bonds?***

Atoms attached to which of these bonds can be changed by introducing metals ions ***(cations)*** in the sodium alginate solution?