Educational Module

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Audience

Level: High School
Grade: 12
Teaching Strategies: Project Based Learning (PBL), Cooperative Work and Technology Integration

Time Frame

Activity 1: 50min
Activity 2: 100min
Activity 3: 50min

Objectives

1. Explain the concepts related to crystallization: solution, purity, crystalline structures, types of crystallization, melting point, melting crystallization, seeding method, diffraction and pharmaceutical industry.
2. Identify the type of sugar crystal using a microscope.
3. Use the sowing and fusion method to crystallize the sugar.
4. Determine the melting and cooling point of sugar experimentally and build tables / graphs using the Excel Program.

Puerto Rico National Standards

1. ***Estructuras y Niveles de la Organización de la Materia***
   ES.F.CF3.EM.1- Explica la energía en términos de escala, desde la escala atómica a macroscópica.

   ES.F.CF3.EM.2 - Clasifica la energía como cinética o potencial y contrasta los diferentes tipos: térmica, química, nuclear, electromagnéticas y mecánica. Calcula los cambios en energía cinética y potencial en un sistema.

2. ***Interacciones y Energía***
   ES.F.CF3.IE.2 - Diseña un modelo que ilustra que la energía a escala macroscópica se puede entender como una combinación de energía asociada al movimiento de las partículas (objetos) y energía asociada a la posición relativa de las partículas (objetos).

   ES.F.CF4.IE.6 - Planifica una investigación para demostrar cómo las ondas producen campos que usan o generan partículas.

Standards Addressed: Next Generation Science Standards

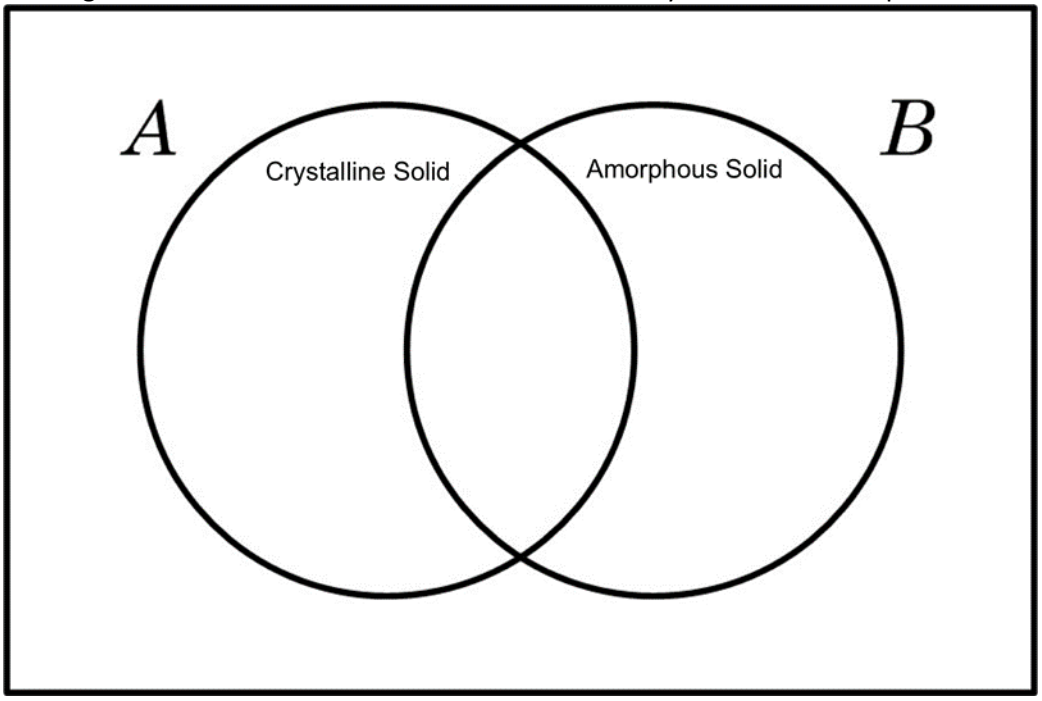
1. NGSS Performance Expectation: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. (Grades 9 - 12)
   A. Science & Engineering Practices
      i. Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

B. Disciplinary Core Ideas
    i. The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.
    ii. In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.
    iii. Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.
C. Crosscutting Concepts
    i. Much of science deals with constructing explanations of how things change and how they remain stable.

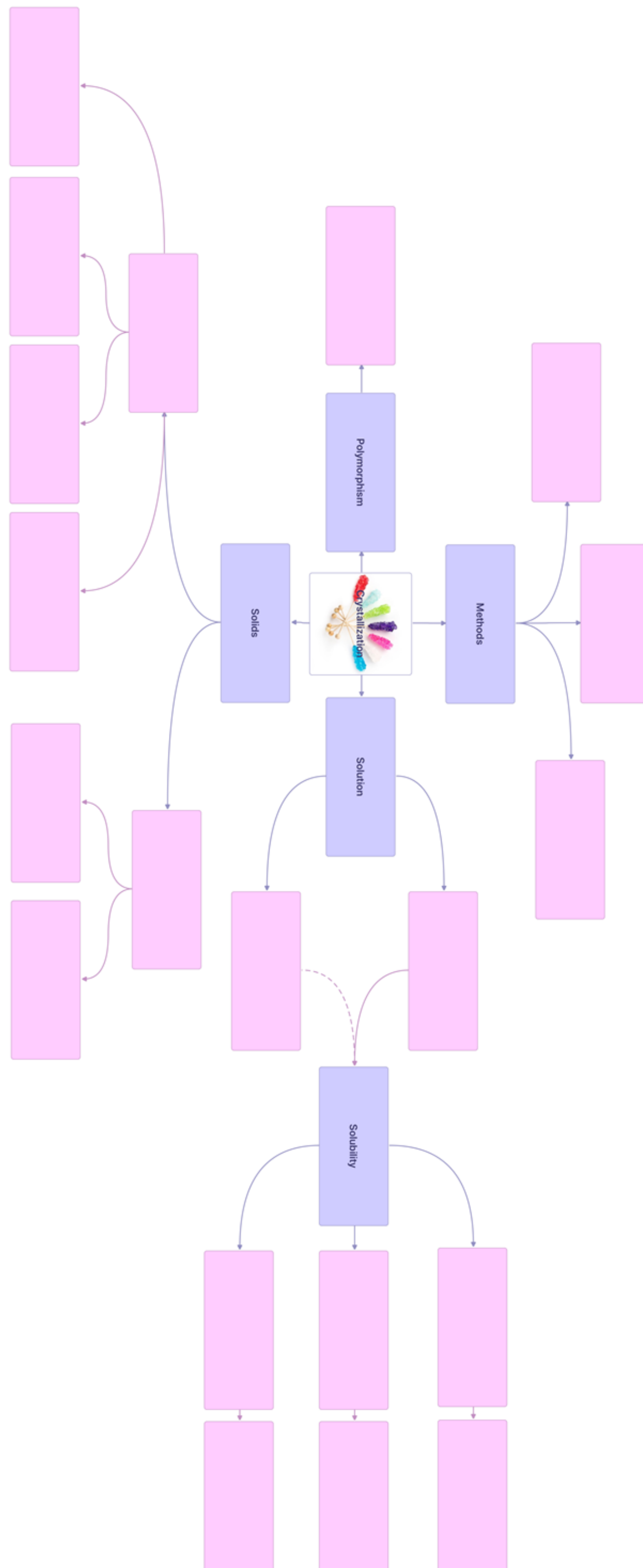
2. NGSS Performance Expectation: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. (Grades 9 - 12)
    A. Science & Engineering Practices
        i. Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.
    B. Disciplinary Core Ideas
        i. Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.

Activity 1: Background - Is used a presentation for explain all the concepts related to the crystallization and the pharmaceutical.

Part I: Venn Diagram. Write the similarities and differences of crystalline and amorphous solids.



Part II: Map Concept. Complete the following concept map using the words found in the table.



Amorphous Solids	Homogeneity
Dissolution Crystallization	Solute
Solvent	Crystalline Solids
Anisotropy	Melt Crystallization
Supersaturated	Nucleation and growth
No solid	Precipitate
Symmetry	Saturated
Disordered molecules	Isotropy
Sublimation Crystallization	Unsaturated
Periodicity	Crystallize in more of a structure crystalline.

Activity 2: Crystallization of Sugar: Method of Sowing (rock candy sugar)

Part I:

- Students will be evaluated by a rubric entitled "Laboratory Report". within the report will include a paragraph with the questions to guide the analysis and all the components of the report.
- The students will develop the problem and the hypothesis of the investigation with the given variables.

Dependent variables: unsaturated, saturated and supersaturated solution

Independent variables: morphology of sugar crystal

Problem: ?

Hypothesis: ?

Part II: Experimental Design

Materials

*Sugar	* Filter Paper	* Hotplate
* Water	* Funnel	
* Beaker	* Sticks of wood	

Procedure

1. Label the glasses as A, B and C.
2. Pour 1 cup of sugar and 1 cup of water in the glass A.
3. Pour 2 cup of sugar and 1 cup of water in the glass B.
4. Pour 3 cup of sugar and 1 cup of water in the glass C.
5. Stir the solution and heat until the sugar dissolves.

Note: The solution cannot boil.

6. Take the wooden stick, moisten it and pass it through sugar.
7. Introduce the wooden stick with sugar in the solution and wait 4 to 5 days.
8. Annotate the observations.

Part III: Data Collection

Observations of the sugar crystals grown in each glass.	
Sample	**Observations (Size, color, morphology and shape)**
Glass A	
Glass B	
Glass C	

Summary of weight of sugar crystallized and dissolved in each glass			
	Glass A	**Glass B**	**Glass C**
Mass of Sugar crystals in wooden pallet (g)			
Mass of sugar crystals at the bottom of the glass (g)			
Total mass of crystallized sugar (g)			
Amount of sugar dissolved in solution (g/mL)			

Part IV: Analysis Questions

- Which of the solutions had to be heated to dissolve the solute, which had not?
- In which of the solutions were there more crystals?
- In which of the three solutions could crystallization be better controlled?
- What is the size and morphology of the crystals that form in the different glasses?
- What prediction can you make if a single crystal of sugar had been dipped in the supersaturated solution?

Activity 3: Point of fusion and cooling of the sugar.

Part I:

- Students will be evaluated by a rubric entitled "Laboratory Report". Within the report will include a paragraph with the questions guides of analysis and all the components of the Report.
- The students will create the problem and the hypothesis of the investigation with the given variables.

Dependent variable: melt crystallization

Independent variable: morphology of sugar crystal

Problem: ?

Hypothesis: ?

Part II: Experimental Design

Materials:

* Sugar
* Hotplate
* Stopwatch
* Beaker
*Thermometer

Procedure:

1. Put 1/4 cup of sugar in the beaker.
2. Put the hotplate in high temperature.
3. Place the beaker with the sugar in the hotplate.
4. Place the thermometer in the sugar without touching the bottom.
5. Take the temperature every 30 seconds until the sugar melts.
6. When the sugar melts, turn off the hotplate and take cooling temperature every 30 seconds until it solidifies.
7. Use the Excel program to create temperature vs. time graph.

Part III: Data Collection

Melting point of sugar

Sample	**Time each 30 sec.**	Temp C	**observations**
Sugar			

Cooling point of sugar

Sample	**Time each 30 sec.**	Temp C Melt point	**observations**
Sugar			

Graph
Temperature vs Time

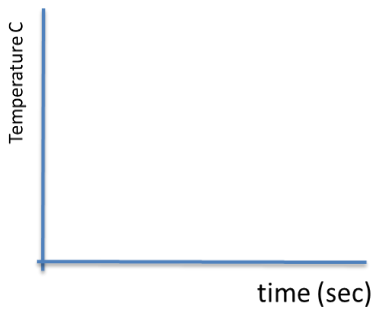


Table: Physical properties of sugar crystal

Sample	**Observations**
Sugar	

Part IV: Analysis Question

1. What is the impact of heat on a crystalline solid?
2. What is the importance of knowing the melting point of a solid?
3. Does any change in the morphology of the sugar crystal happen after reaching its melting and cooling point? If there is any change, describe it.
4. What is the importance of the construction of melting and cooling graphs of a solid?
5. What prediction can you make based on the graph obtained in this laboratory?
6. What is the relationship between polymorphism and crystallization by fusion in the pharmaceutical industry?

Laboratory Report:

_____

Value: 100pts

Teacher's name: Profa. H. De Jesus

Student's name:_____
_____
_____
Punctuation:____

CATEGORY	**10**	**8**	**6**	**4**
Question / Purpose	The purpose of the laboratory or the question to be answered during the laboratory is clearly identified and presented.	The purpose of the laboratory or the question to be answered during the laboratory is identified, but it is presented in a way that is not very clear.	The purpose of the laboratory or the question to be answered during the laboratory is partially identified and is presented in a way that is not very clear.	The purpose of the laboratory or the question to be answered during the laboratory is erroneous or irrelevant.
Experimental hypothesis	The postulated relationship between the variables and the anticipated results is clear and reasonable based on what has been studied.	The postulated relationship between the variables and the anticipated results is reasonably based on general knowledge and observations.	The postulated relation between the variables and the anticipated results has been exposed, but it seems to be based on a faulty logic.	A hypothesis was not proposed.
Experimental design	The experimental design is a well-constructed test of the presented hypothesis.	The experimental design is suitable for testing the hypothesis but leaves some questions unanswered.	The experimental design is related to the hypothesis, but it is not a complete test.	The experimental design is not related to the hypothesis.

Materials	All the materials used in the experiment are clearly and precisely described. The sketches of the devices and the preparation are ordered, easy to read and are completely labeled.	Almost all the materials used in the experiment are clearly and precisely described. A labeled sketch of a stop is included.	Most of the materials used in the experiment are described accurately. The preparation of the apparatus is described with precision.	Many materials are described without precision or are not fully described.
Procedures	The procedures are listed with clear steps. Each step is listed and is a complete sentence.	The procedures are listed in a logical order, but the steps are not listed and / or are not complete sentences.	The procedures are listed, but they are not in a logical order or are difficult to follow.	The procedures do not accurately list all the steps of the experiment.
Data	An accurate representation of the data in tables and / or graphs. The graphs and tables are labeled and titled.	An accurate representation of the data in tables and / or graphs. The graphs and tables are partially labeled and titled.	An accurate representation of the data in written form.	The data is not proven or is not accurate.
Analysis	The relationship between the variables is discussed and the trends / patterns analyzed logically. Predictions are made about what might happen if part of the laboratory was changed or how the experimental design could be changed.	The relationship between the variables is discussed and the trends / patterns analyzed logically.	The relationship between the variables is discussed, but neither the patterns, trends or pedicures are facts based on the data.	The relationship between the variables is not discussed.
Conclusion	The conclusion includes the findings that support the hypothesis, possible sources of error and what was learned from the experiment.	The conclusion includes the findings that support the hypothesis and what was learned from the experiment.	The conclusion includes what was learned from the experiment.	There is no conclusion included in the report.

Appearance / Organization	The lab report is typed and uses titles and subtitles to visually organize the material.	The laboratory report is handwritten with care and uses titles to visually organize the material.	The laboratory report is written or typed with care, but the format does not help to organize the material visually.	The laboratory report is handwritten and looks careless and with studs, multiple blots and / or tears and folds.
Spelling, Punctuation and Grammar	One or few errors of spelling, punctuation and grammar in the report.	Two or three errors of spelling, punctuation and grammar in the report.	Four errors of spelling, punctuation and grammar in the report.	More than 4 errors of spelling, punctuation and grammar in the report.

References

CSIC. (2019). Cristalografía. Estructura de los cristales. Recovered from http://www.xtal.iqfr.csic.es/Cristalografia/parte_01.html

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