

Introduction

Formative Assessment Exemplar - CHEM.3.5

Introduction:

The following formative assessment exemplar was created by a team of Utah educators to be used as a resource in the classroom. It was reviewed for appropriateness by a Bias and Sensitivity/Special Education team and by state science leaders. While no assessment is perfect, it is intended to be used as a formative tool that enables teachers to obtain evidence of student learning, identify gaps in that learning, and adjust instruction for all three dimensions (i.e., Science and Engineering Practices, Crosscutting Concepts, Disciplinary Core Ideas) included in a specific Science and Engineering Education (SEEd) Standard.

In order to fully assess students' understanding of all three dimensions of a SEEd standard, the assessment is written in a format called a cluster. Each cluster starts with a phenomenon, provides a task statement, necessary supporting information, and a sequenced list of questions using the gather, reason, and communicate model (Moulding et al., 2021) as a way to scaffold student sensemaking. The phenomenon used in an assessment exemplar is an analogous phenomenon (one that should not have been taught during instruction) to assess how well students can transfer and apply their learning in a novel situation. The cluster provides an example of the expected rigor of student learning for all three dimensions of a specific standard. In order to serve this purpose, this assessment is NOT INTENDED TO BE USED AS A LESSON FOR STUDENTS.

Because this assessment exemplar is a resource, teachers can choose to use it however they want for formative assessment purposes. It can be adjusted and formatted to fit a teacher's instructional needs. For example, teachers can choose to delete questions, add questions, edit questions, or break the tasks into smaller segments to be given to students over multiple days.

Of note: All formative assessment clusters were revised based on feedback from educators after being utilized in the classroom. During the revision process, each cluster was specifically checked to make sure the phenomena was authentic to the DCI, supporting information was provided for the phenomena, the SEPs, CCCs, and DCIs were appropriate for the learning progressions, the cluster supported student sensemaking through the Gather, Reason, and Communicate instructional model, and the final communication prompt aligned with the cluster phenomena. As inconsistencies were found, revisions were made to support student sensemaking. If other inconsistencies exist that need to be addressed, please email the current Utah State Science Education Specialists with feedback.

General Format:

Each formative assessment exemplar contains the following components:

1. Teacher Facing Information: This provides teachers with the full cluster as well as additional information including the question types, alignment to three dimensions, and answer key. Additionally, an example of a proficient student answer and a proficiency scale for all three dimensions are included to support the evaluation of the last item of the assessment.
2. Students Facing Assessment: This is what the student may see. It is in a form that can be printed or uploaded to a learning platform. (Exception: Questions including simulations will need technology to utilize during assessment.)

Accommodation Considerations:

Teachers should consider possible common ways to provide accommodations for students with disabilities, English language learners, students with diverse needs or students from different cultural backgrounds. For example, these accommodations may include: Providing academic language supports, presenting sentence stems, or reading aloud to students. All students should be allowed access to a dictionary.

References:

Moulding, B., Huff, K., & Van der Veen, W. (2021). *Engaging Students in Science Investigation Using GRC*. Ogden, UT: ELM Tree Publishing.

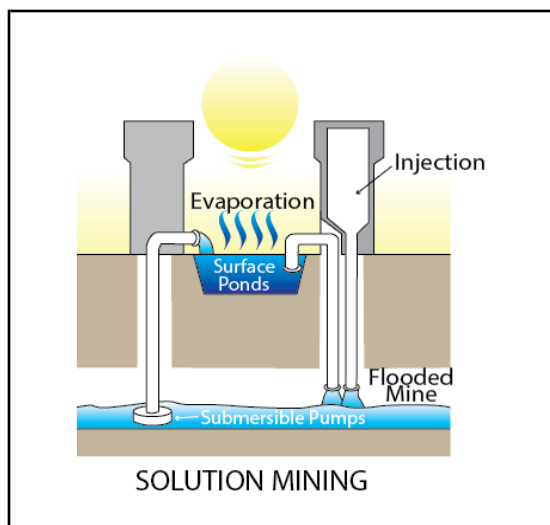
Teacher Facing

Teacher Facing Information

Standard: CHEM.3.5

Assessment Format: Printable or Online Format (Does not require students to have online access)

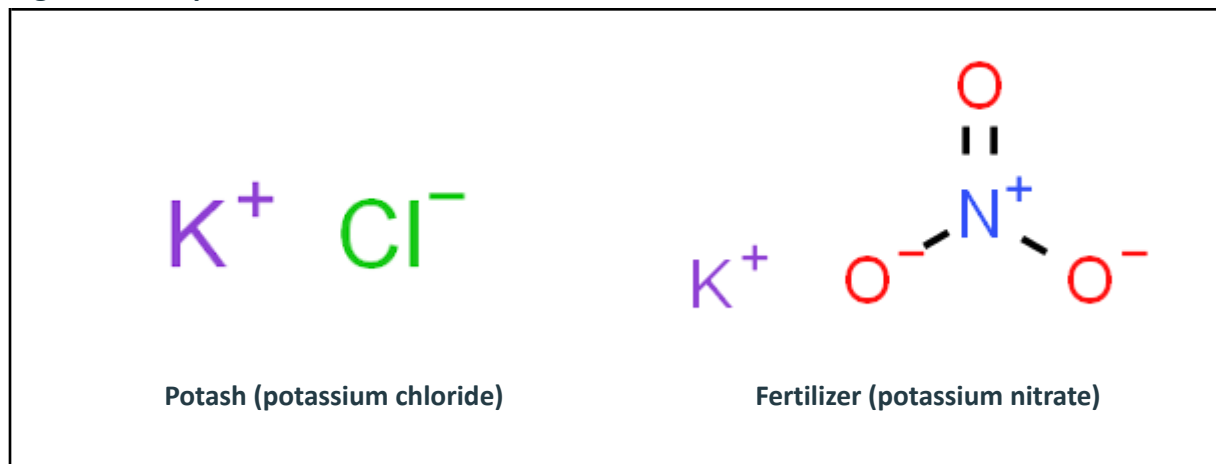
Phenomenon	
A student saw an image of the colorful ponds in southern Utah near Moab. The student found out that these colorful ponds are used in mining operations to extract potash from underground.  (Image by Doc Searls, CC BY; https://commons.wikimedia.org/wiki/File:Potash_evaporation_ponds_near_Moab,_Utah.jpg)	Proficient Student Explanation of Phenomenon: Potash is a limited resource that is important to create fertilizers to increase the production of crops. Potash is mined by pumping groundwater deep into the ground via solution mining. Potash's chemical compound is commonly potassium chloride. The potassium in potassium chloride is used to create potassium nitrate fertilizers. There are constraints that limit the production of potash that include time, temperature, and limited supply.
Cluster Task Statement	
You will use the information provided and diagrams about potash mining to recognize the potential constraints of solution mining and design solutions to increase the sustainable production of potash to create fertilizers.	
Supporting Information	
Potash is a valuable resource used to create fertilizers. This is due to the potassium compounds of potash. Potash was originally collected from the ashes of burned wood in a pot, hence the name potash. In the 1940s potash production increased due to the discovery of potash mining. Potash mining utilizes solution mining techniques to flood underground caverns to harvest potash compounds. Below is a diagram of potash mining. Figure 1: Solution Mining Process	



In Figure 1, a water solution is injected into the mine causing it to flood. A submersible pump pumps the brine solution into surface ponds. The surface pond is exposed to the sun to begin the process of evaporation. Once all of the water is evaporated, the remaining material is potash.

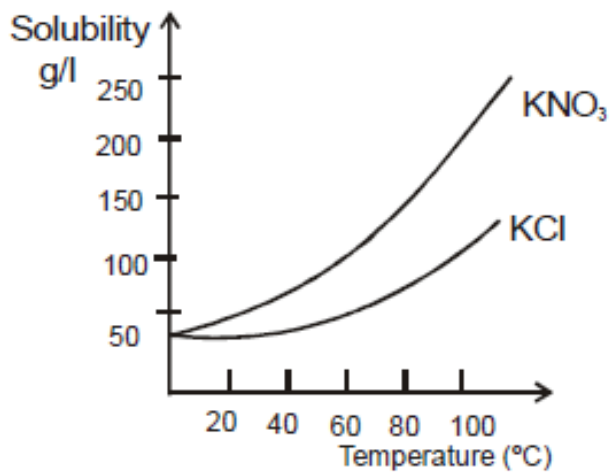
Potash is a valuable resource that is used to create fertilizers. This is due to the potassium that is found in the compounds. Potassium is one of the required nutrients for plant growth. Chemically, potash is commonly potassium chloride (KCl). Industry uses the potassium in potassium chloride to create potassium nitrate (KNO_3).

Figure 2: Compounds of Potassium Chloride and Potassium Nitrate



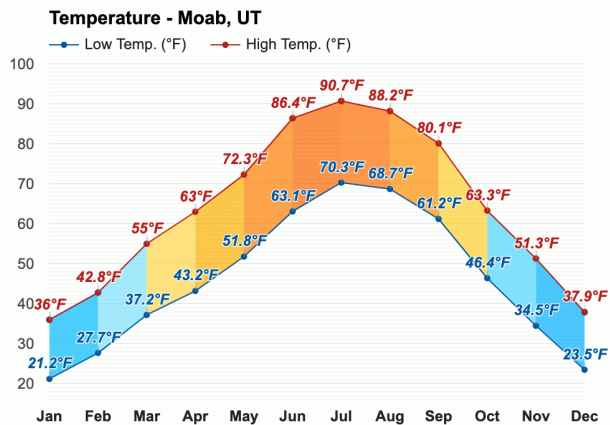
Ionic compounds are made of pairs of oppositely electrically charged ions. A property of ionic compounds is their ability to easily dissolve in water. Potassium chloride can be mined because it dissolves in the water pumped deep into the ground and is retrieved by evaporating the water using sunlight.

Figure 3: Solubility Graph for Potassium Chloride and Potassium Nitrate in Water



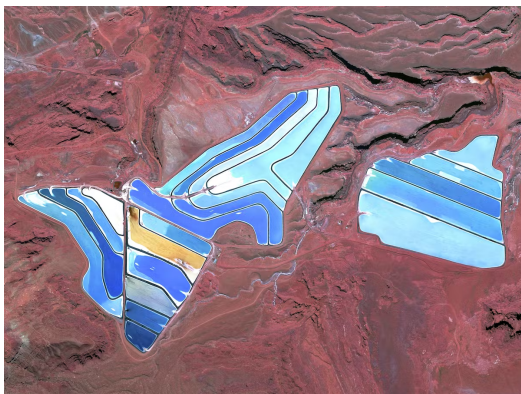
In Figure 3, the temperature of potassium chloride and potassium nitrate solutions increases their solubility.

Figure 4: Average Temperature of Moab



In Figure 4, the average high and low temperatures were recorded each month in Moab, UT. Temperature directly impacts two factors in solution mining. The amount of potash being dissolved in solution and the speed of evaporation.

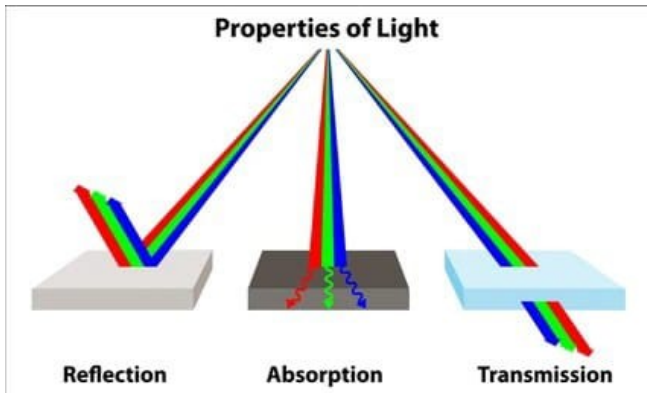
Figure 5: Blue Dyes and Absorption



In Figure 5, blue dyes are added to the evaporation ponds to increase the rate of evaporation. Darker

colors absorb more sunlight causing the water to evaporate more quickly.

Figure 6: Light can be reflected, absorbed, or transmitted through matter.



As light strikes the dark surface, as shown in Figure 6, the light energy is absorbed.

Cluster Questions

Cluster Question #1

Question Type: Table-Match

Practices Sequence: Gather

Addresses:

☒ DCI (PS1.B)

☒ SEP - design solutions

☒ CCC

Answer:

More Efficient

Higher temperature

Warm weather

Dark color dye

Less Efficient

low temperature

cold weather

light color dye

Question 1:

Potash is a limited resource that is important to create fertilizers to increase the production of crops.

Based on the figures above, drag-and-drop mining conditions that would either make the mining of potash more or less efficient.

More Efficient Mining of Potash	Less Efficient Mining of Potash

- Use a higher temperature for the mining solution
- lower temperature for the mining solution
- Warm weather for pond evaporation
- cool weather for pond evaporation
- light color dye
- dark color dye

Gather:

Cluster Question #2

Question 2:

Question Type: short answer Practices Sequence: Gather Addresses: ☒ DCI ☐ SEP ☒ CCC Answer: A	Two compounds are represented above in Figure 2. What is the name of the type of bond being formed between the potassium and the chlorine? - Ionic bond - Covalent bond - Metallic bond - None of these
Cluster Question #3 Question Type: Multiple choice Practices Sequence: Gather Addresses: ☒ DCI ☐ SEP ☒ CCC Answer: A	Question 3: Using figure 3, describe the relationship between potassium chloride and its ability to be dissolved in relation to the temperature of the solution. - As the temperature increases, the solubility increases - As the temperature increases the solubility decreases - As the temperature decreases the solubility increases. - Solubility does not change with temperature.
Cluster Question #4 Question Type: Multiple Choice Practices Sequence: Gather Addresses: ☒ DCI ☐ SEP ☒ CCC Answer: C	Question 4: A saturated solution of potassium chloride is cooled from 100°C to 80°C. About how much solid potassium chloride would be precipitated per liter of solution? 0g 10g 50g 100 g
Cluster Question #5 Question Type: Multiple choice Practices Sequence: Reason Addresses: ☒ DCI ☒ SEP ☒ CCC Answer: A	Question 5: What is the purpose of the blue dyes added to the ponds, as shown in figure 5? - Speed up the evaporation process by increasing the light absorbed - Slow down the evaporation process by increasing the light absorbed - Increase the visibility of the ponds - Decrease the visibility of the ponds
Cluster Question #6 Question Type: Short answer Practices Sequence: Communicate Addresses: ☒ DCI	Question 6: Using the information from all figures determine which months are least efficient in mass of potash collected. Determine the best solution to increase efficiency during these months considering constraints of cost, safety, reliability, and environmental impacts.

X SEP

 X CCC

Answer:

Answers could include:

- Summer when the temperature is warmer
- Using hot water to pump underground
- Maximizing the amount of blue dye used while still cost-effective
- Cost-effective additional ways to evaporate the solutions in ponds during cold months
- Possible Environmental impacts of proposed solutions

Proficiency Scale

Proficient Student Explanation:

Potash is a limited resource that is important to create fertilizers to increase the production of crops. Potash is mined by pumping groundwater deep into the ground via solution mining. Potash's chemical compound is commonly potassium chloride. The potassium in potassium chloride is used to create potassium nitrate fertilizers. There are constraints that limit the production of potash that include time, temperature, and limited supply.

Level 1 - Emerging	Level 2 - Partially Proficient	Level 3 - Proficient	Level 4 - Extending
SEP: Does not meet the minimum standard to receive a 2.	SEP: Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.	SEP: Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	SEP: Extends beyond proficient in any way.
CCC: Does not meet the minimum standard to receive a 2.	CCC: Phenomena may have more than one cause, and some cause and effect relationships in	CCC: Systems can be designed to cause a desired effect. Changes in systems may	CCC: Extends beyond proficient in any way.

	systems can only be described using probability.	have various causes that may not have equal effects	
DCI: Does not meet the minimum standard to receive a 2.	DCI: Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions)	DCI: Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) When evaluating solutions, it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts.	DCI: Extends beyond proficient in any way.

(Student Facing Format on following page)

Student Assessment

Name: _____ Date: _____

Stimulus

A student saw an image of the colorful ponds in southern Utah near Moab. The student found out that these colorful ponds are used in mining operations to extract potash from underground.

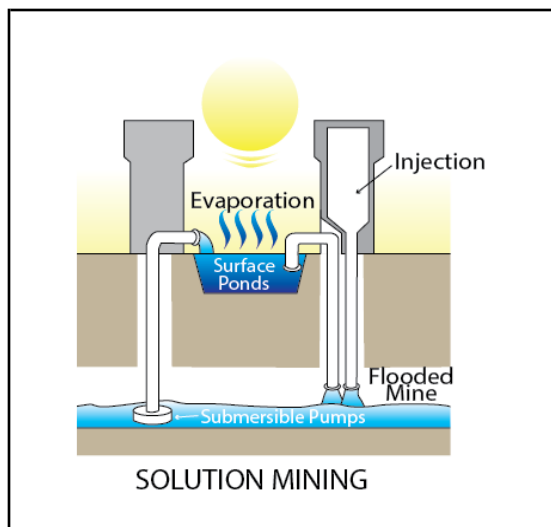


(Image by Doc Searls, CC BY;

https://commons.wikimedia.org/wiki/File:Potash_evaporation_ponds_near_Moab,_Utah.jpg)

Potash is a valuable resource used to create fertilizers. This is due to the potassium compounds of potash. Potash was originally collected from the ashes of burned wood in a pot, hence the name potash. In the 1940s potash production increased due to the discovery of potash mining. Potash mining utilizes solution mining techniques to flood underground caverns to harvest potash compounds. Below is a diagram of potash mining.

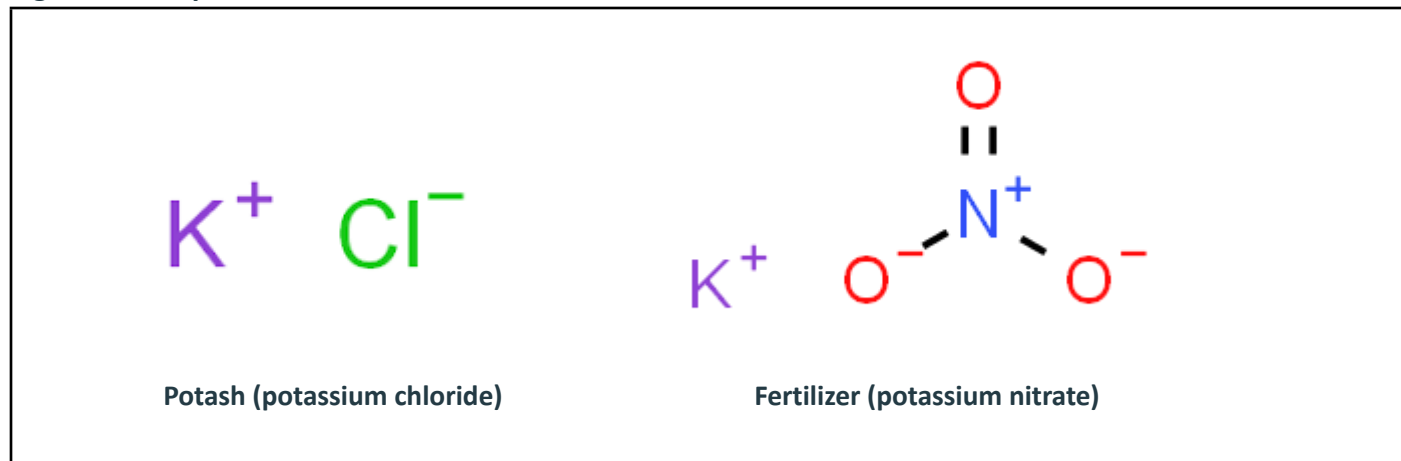
Figure 1: Solution Mining Process



In Figure 1, a water solution is injected into the mine causing it to flood. A submersible pump pumps the brine solution into surface ponds. The surface pond is exposed to the sun to begin the process of evaporation. Once all of the water is evaporated, the remaining material is potash.

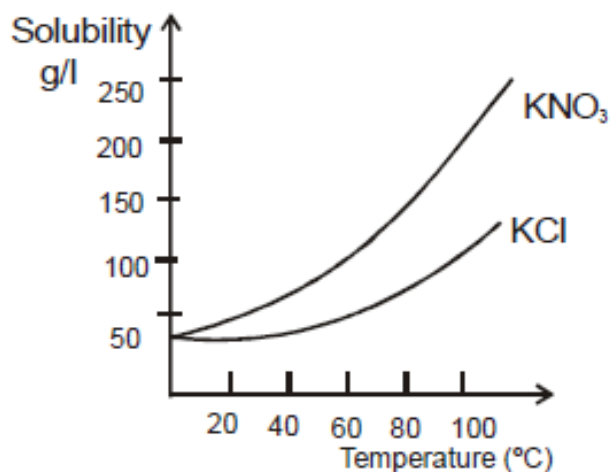
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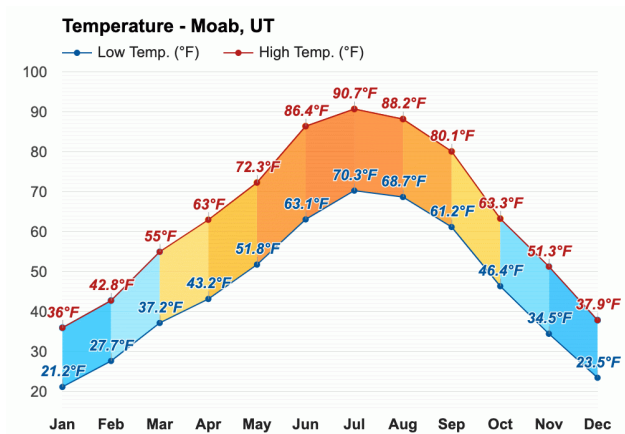
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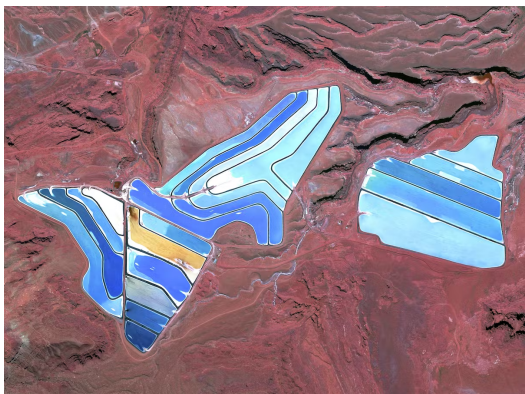
In Figure 3, the temperature of potassium chloride and potassium nitrate solutions increases their solubility.

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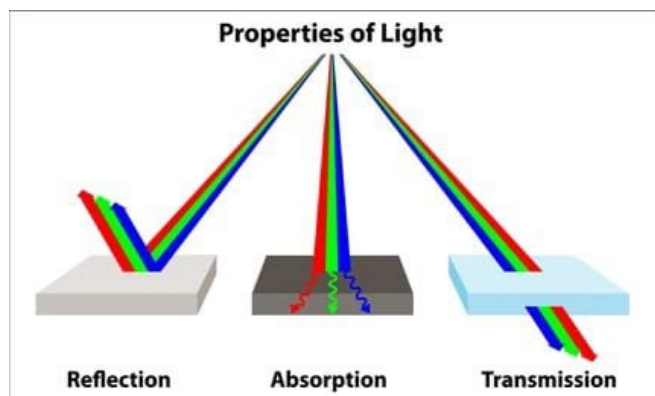
In Figure 4, the average high and low temperatures were recorded each month in Moab, UT. Temperature directly impacts two factors in solution mining. The amount of potash dissolved in solution and the speed of evaporation.

Figure 5: Blue Dyes and Absorption



In Figure 5, blue dyes are added to the evaporation ponds to prevent the growth of bacteria and increase the rate of evaporation. Darker colors absorb more sunlight causing the water to evaporate more quickly.

Figure 6: Light can be reflected, absorbed, or transmitted through matter.



As light strikes the dark surface, as shown in Figure 6, the light energy is absorbed.

Your Task

You will use the information provided and diagrams about potash mining to recognize the potential constraints of solution mining and design solutions to increase the sustainable production of potash to create fertilizers.

Question 1

Potash is a limited resource that is important to create fertilizers to increase the production of crops.

Based on the figures above, drag-and-drop mining conditions that would either make the mining of potash more or less efficient.

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- Use a higher temperature for the mining solution
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- Warm weather for pond evaporation
- cool weather for pond evaporation
- light color dye
- dark color dye

Question 2

Two compounds are represented above in **Figure 2**. What is the name of the type of bond being formed between the potassium and the chlorine?

- a) Ionic bond
- b) Covalent bond
- c) Metallic bond
- d) None of these

Question 3

Using **Figure 3**, describe the relationship between potassium chloride and its ability to be dissolved in relation to the temperature of the solution.

- a. As the temperature increases, the solubility increases
- b. As the temperature increases the solubility decreases
- c. As the temperature decreases the solubility increases.
- d. Solubility does not change with temperature.

Question 4

A saturated solution of potassium chloride is cooled from 100°C to 80°C, about how much solid potassium chloride would be obtained?

- a. 0g
- b. 10g
- c. 50g
- d. 100 g

Question 5

What is the purpose of the blue dyes added to the ponds, as shown in **Figure 5**?

- a. Speed up the evaporation process by increasing the light absorbed
- b. Slow down the evaporation process by increasing the light absorbed
- c. Increase the visibility of the ponds
- d. Decrease the visibility of the ponds

Question 6

Using the information from all figures determine which months are least efficient in mass of potash collected. Determine the best solution to increase efficiency during these months considering constraints of cost, safety, reliability, and environmental impacts.