

#### Overview

The students will simulate the work of a Chemical Engineer/Geochemist/Chemist /Chemical technician and general operations personnel by studying solubility curves to determine that the mineral precipitated out of solution was sylvite (KCl).

**Duration:** 1 class

#### Materials:

- [Solubility Curves of KCl and NaCl with Questions](#)

#### Prior Knowledge:

Before attempting these activities students should have some understanding of the following:

- Factors that affect solubility
- Saturated and unsaturated solutions
- The use of water as a solvent
- Solubility charts

#### Instructional Methods:

- Brainstorming
- Individual learning

#### Note to Teacher:

Although this lesson stands alone, it is a good cumulative lesson after Dissolving Potash and Reclaiming Potash.



Dredge on cooling pond. Mosaic Potash Belle Plaine

**MS7.1 Distinguish between pure substances and mixtures (mechanical mixtures and solutions) using the particle model of matter. [SI, CP]**

- Describe the characteristics of pure substances, mechanical mixtures, and solutions. (MS7.1b)

**MS7.2 Investigate methods of separating the components of mechanical mixtures and solutions, and analyze the impact of industrial and agricultural applications of those methods. [SI, TPS]**

- Describe methods used to separate the components of mechanical mixtures and solutions, including mechanical sorting, filtration, evaporation, distillation, magnetism, and chromatography. (MS7.2a)

**MS7.3 Investigate the properties and applications of solutions, including solubility and concentration. [SI, DM]**

- Research how various science disciplines and engineering fields study and apply scientific knowledge related to solutions. (MS7.3j)

Students will also:

- Carry out an activity to simulate the work of a Geochemist/Chemical Engineer/Chemist/Technician and general operations personnel, in determining how to separate the valuable potash from the rest of the ore.
- Demonstrate the ability to interpret examples of solubility charts.

Source: [Saskatchewan Evergreen Curriculum](#)

#### Big Picture Question

1. How is the potash mineral sylvite separated from the potash ore?

#### Learning Outcomes and Indicators

#### Background Information

Potash is a general term covering several types of potassium salts, of which the most important is potassium chloride, the mineral sylvite (KCl). In Saskatchewan, potash is extracted from deep underground deposits (generally 1000 m or 1 km) using either conventional (mining machines) or solution mining (brine is used to remove the mineral in solution) techniques.

The largest potash solution mine in the world is in Saskatchewan. With this technique the potash is dissolved deep underground and the solution is pumped to the surface where the potash is removed. The same process can be used above ground to extract the potash from the sylvinitic ore. After potash is mined, it is processed in a surface mill, where it is separated into product (KCl) and waste (tailings comprised of salt and clays).

In 2010 there were 10 potash mines in Saskatchewan; two are solution mines, and the remaining 8 are conventional underground mines that use machines to mine the ore.

Potash is a nutrient essential for plant growth, and is a main component of modern agricultural fertilizers. Roughly 95 per cent of world potash production goes into fertilizer, while the other five per cent is used in commercial and industrial products - everything from soap to television tubes.

Potash is a major export of Saskatchewan. It is transported by rail to the United States and to Canadian ports where it is shipped to other countries including China, Korea, Japan, Malaysia, India, Brazil and Australia. Canadian markets make up less than 5% of potash sales.

### Vocabulary

brine	concentration
dense	density
dissolve	halite
mixture	ore
potash	saturated
solute	solution
solvent	unsaturated
dense	sylvinitic
sylvite	

### THE ACTIVITY

#### How Do We Know That The Precipitate is KCl? (Brainstorming, Individual learning ) (45 minutes)

##### Key Questions:

- Which salt would precipitate first if the solution was cooled quickly?

*Students should look at the solubility curves and be able to see that as the temperature lowers KCl would precipitate out first.*

- Why would this be important to a potash mining company?

*This is important to the mining company because the mineral sylvite (KCl) is the valuable mineral they want to recover. If it precipitates out first they can collect it and not have to do a second precipitation. For the solution mining method the remaining NaCl brine can be reused and pumped back into the ground to help dissolve more of the potash ore.*

1. Hand out [Solubility Chart for NaCl and KCl and Question sheet](#). Have the students do the solubility curve activity.

### Assessment Method and Evidence

✓ Solubility chart and associated questions:

- By looking at the solubility charts, students will be able to determine that the valuable mineral sylvite (KCl) will precipitate before the salt halite (NaCl) as it cools. They will know that it is this property that is used when processing the potash ore to recover the valuable mineral sylvite.
- Students will be able to describe how lowering the temperature to precipitate KCl is the method used by potash mining companies to separate the valuable KCl from a saturated solution containing both KCl and NaCl.
- Students will experience how the chemical staff and general operations personnel study and apply scientific knowledge related to solutions when determining how to separate the valuable potash from the rest of the ore.
- Students will be able to interpret KCl and NaCl solubility charts.

### Summary

Through brainstorming and individual study of KCl and NaCl solubility curves students investigated how the staff

at a Potash mill (processing plant) confirm that mineral precipitated during processing is the desirable sylvite (KCl) and not halite (NaCl).

### Extension Activities

1. Students could investigate a career as a Chemical Engineer, Chemical Technologist, Chemical Technician, Chemist, and Geochemist by going to Future Paths  
<http://www.futurepaths.ca/storage/CareerTree-Mining.pdf>
2. Have students investigate the uses of potash through a web search of Saskatchewan's potash companies:

### Resources

Mining and milling processes used at the PotashCorp mines.  
[http://www.potashcorp.com/media/POT\\_Mini\\_Mine\\_Tour\\_brochure.pdf](http://www.potashcorp.com/media/POT_Mini_Mine_Tour_brochure.pdf)

Saskatchewan Potash Interpretive Centre:  
<http://www.potashinterpretivecentre.com/index2.htm>

Saskatchewan Mining Association Website:  
<http://www.saskmining.ca>

Potash Corporation of Saskatchewan Website:  
<http://www.potashcorp.com/>

International Fertilizer Association Website:  
<http://www.fertilizer.org/ifa/default.asp>

Agrium Website: <http://www.agrium.com>

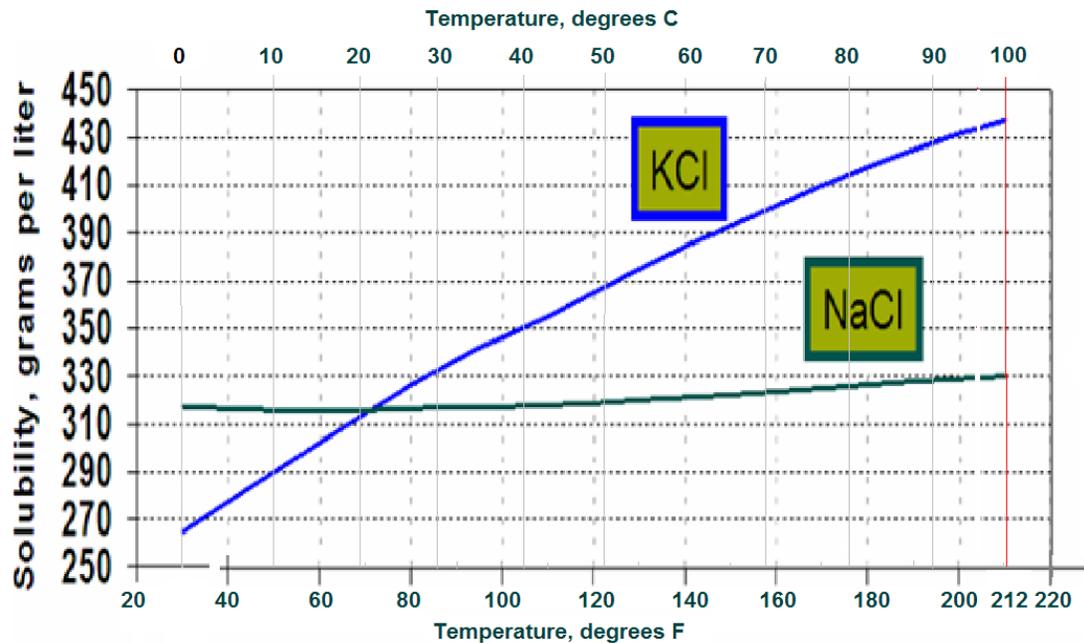
The Mosaic Company Website:  
<http://www.mosaicco.com>

Fuzesy, A. (1981): Potash in Saskatchewan;  
Saskatchewan Energy and Mines Report No.181, 44p.

Holter, M.E. (1969): The Middle Devonian Prairie Evaporite of Saskatchewan; Department of Mineral Resources-Geological Sciences Branch-Industrial Minerals Division-Province of Saskatchewan; Report No.123, 134p.

## How do we know what we are precipitating is the KCl?

Solubility Curves of KCl (sylvite) and NaCl (halite)



Modified from: Mosaic Potash PowerPoint –Showcase Belle Plaine

1. Find the point on the line (the green one) where there are 330 grams of NaCl at 100°C (212°F) and mark with a green star. This is at the boiling temperature. At this point you cannot add any more NaCl because the solution is saturated.
2. How many grams of KCl can be dissolved in one litre of water at 100°C (212°F)? (435 grams).
3. As the temperature cools crystals will precipitate out. At 22°C how many grams of NaCl can be dissolved in one litre of solution? (315 grams). How many grams of KCl? (415 grams). Which would precipitate more as it cooled the NaCl or the KCl? (There would be more KCl precipitating as crystals than NaCl as the solution cooled)
4. If we took a 1 litre solution with a mixture of NaCl and KCl in it and cooled it very quickly what do you think would happen? What would precipitate as crystals? What would be left in the solution?  
(KCl would precipitate out as crystals and the solution would be salty with NaCl).

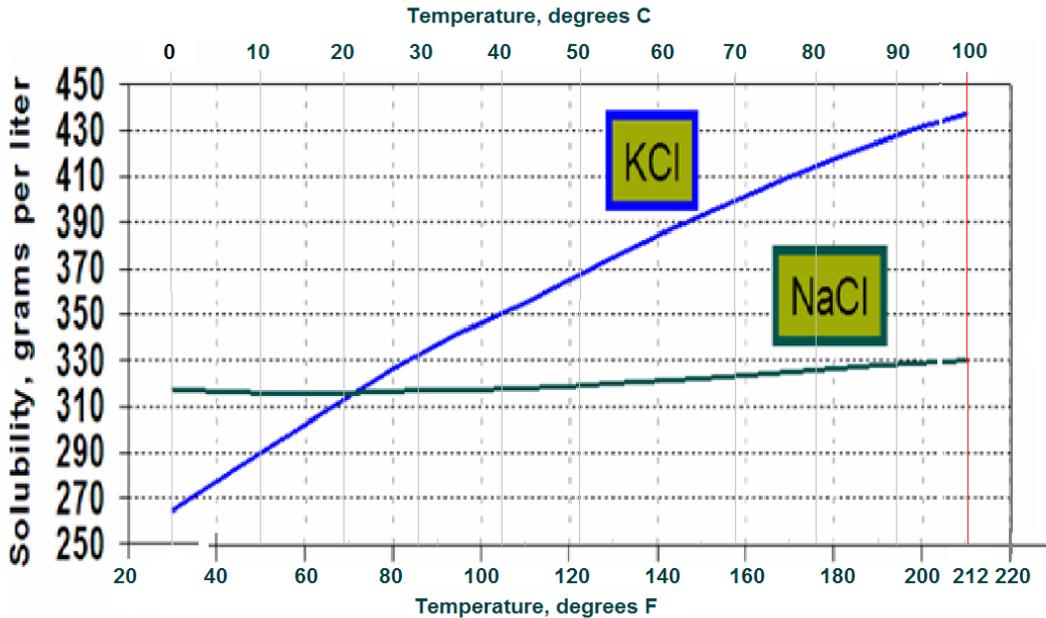
### Extension

5. In the teacher demonstration (Method A) the solution is boiled until it is about half of the amount (500 ml solution). Explain why the crystals start to precipitate?  
With a reduction of the amount of solvent the amount of dissolved KCl and NaCl is too much and the minerals sylvite and halite should precipitate out.

How do we know what we are precipitating is the KCl?

Name: \_\_\_\_\_

Solubility Curves of KCl (sylvite) and NaCl (halite)



Modified from: Mosaic Potash PowerPoint –Showcase Belle Plaine

1. Find the point on the line (the green one) where there are 330 grams of NaCl at 100°C (212°F) and mark with a green star. This is at the boiling temperature. At this point you cannot add any more NaCl because the solution is saturated.

2. How many grams of KCL can be dissolved in one litre of water at 100°C (212°F)?  
 \_\_\_\_\_ grams

3. As the temperature cools crystals will precipitate out. At 22°C how many grams of NaCl can be dissolved in one litre of solution? \_\_\_\_\_ grams. How many grams of KCl? \_\_\_\_\_ grams. Which would precipitate the most as it cooled the NaCl or the KCl?

\_\_\_\_\_

\_\_\_\_\_

4. If we took a 1 litre solution with a mixture of NaCl and KCl in it and cooled it very quickly what do you think would happen? What would precipitate as crystals? What would be left in the solution?

\_\_\_\_\_

\_\_\_\_\_

**Extension**

5. In the teacher demonstration the solution is boiled until it is about half of the amount (500 ml solution). Explain why the crystals start to precipitate?

## Vocabulary

**Brine:** Water saturated with or containing large amounts of a salt, especially sodium chloride. The water of a sea or an ocean is a brine.

**Dense:** Closely packed. Having relatively high density.

**Density:** The measure of the compactness of a substance, expressed as its mass per unit volume.

**Dissolve:** To break into component parts to become incorporated into a liquid so as to form a solution.

**Halite:** Sodium chloride (NaCl) as a mineral, typically occurring as colourless cubic crystals; what we know as salt.

**Mixture:** is a material system made up by two or more different substances which are mixed together but are not combined chemically

**Ore:** Is rock that contains important minerals including metals. The ore is extracted through mining and processed to extract the valuable element(s). Ore contains minerals that can be mined at a profit.

**Potash:** Is Saskatchewan's provincial mineral. Potash is the common name for the potassium rich ore mined in Saskatchewan. It is made up of the minerals sylvite, halite, sometimes carnallite, clay and iron oxides.

**Saturated:** If saturated, it has absorbed the maximum amount of something that it can.

**Solute:** A substance dissolved in solvent, forming a solution.

**Solution:** A liquid with something dissolved in it. It is a homogeneous mixture composed of two or more substances. In such a mixture, a **solute** is dissolved in another substance, known as a **solvent**.

**Solvent:** is a liquid, solid, or gas that dissolves another solid, liquid, or gaseous solute,

**Sylvinite:** is the most important ore for the production of potash in North America. It is a mechanical mixture of sylvite (KCl, or potassium chloride) and halite (NaCl, or sodium chloride).<sup>1</sup>

**Sylvite:** is potassium chloride (KCl) in natural mineral form. It forms very similar to normal rock salt, halite (NaCl). Sylvite is colorless to white with shades of yellow and red due to inclusions. It has a Mohs hardness of 2.5. Sylvite has a salty taste with a distinct bitterness. Sylvite is one of the last evaporite minerals to precipitate out of solution. As such, it is only found in very dry saline areas. Its principal use is as a potassium fertilizer.

**Waste rock:** Barren or sub-marginal rock or ore that has been mined, but is not of sufficient value to warrant treatment and is therefore removed ahead of the milling processes.

### Source:

Wikipedia. Available at: <http://en.wikipedia.org/wiki/>

## Grade 7 Mixtures and Solutions: Potash Solution Mining: How Do we Know Its KCl? continued

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Dictionary of Mining, Minerals and Related Terms. Available at:

<http://xmlwords.infomine.com/xmlwords.htm>

Oxford English Dictionary on-line: Available at: <http://oxforddictionaries.com>

Yahoo Kids: Available at: <http://kids.yahoo.com/reference/dictionary/english/>