

# The solubility curve of potassium nitrate experiment report essay sample



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The chemical compound potassium nitrate is a naturally occurring mineral source of nitrogen. It is a nitrate with chemical formula  $\text{KNO}_3$ .

Its common names include saltpetre (from Medieval Latin *sal petrae*: “stone salt” or possibly “Salt of Petra”), American English salt peter, Nitrate of potash and nitre. The name salt peter is also applied to sodium nitrate.

#### Description:

Potassium nitrate is the oxidizing (oxygen-supplying) component of black powder. Prior to the large-scale industrial fixation of nitrogen through the Haber process, a major source of Potassium nitrate was the deposits crystallising from cave walls or the drainings of decomposing organic material. Dung-heaps were a particularly common source: ammonia from the decomposition of urea and other nitrogenous materials would undergo bacterial oxidation to produce nitrate. It was and is also used as a component in some fertilizers. When used by itself as a fertilizer, it has an NPK rating of 13-0-44 (indicating 13%, 0%, and 44% of nitrogen, phosphorus, and potassium, by mass, respectively).

#### Manufacture:

Historically, nitre-beds were prepared by mixing manure with either mortar or wood ashes, common earth and organic materials such as straw to give porosity to a compost pile typically 1.5 metres high by 2 metres wide by 5 metres long. The heap was usually under a cover from the rain, kept moist with urine, turned often to accelerate the decomposition and leached with water after approximately one year. The liquid containing various nitrates

was then converted with wood ashes to potassium nitrates, crystallized and refined for use in gunpowder. Today, most potassium nitrate comes from the vast deposits of sodium nitrate ( $\text{NaNO}_3$ , nitratine) in the Chilean deserts. The sodium nitrate is purified and then reacted in solution with potassium chloride ( $\text{KCl}$ , sylvite), from which the less-soluble potassium nitrate is precipitated out.

In England, the privilege of manufacturing explosives had been in the hands of the family of John Evelyn, the celebrated diarist, as a crown monopoly since before 1588.

Applications:

One of the most useful applications of potassium nitrate is in the production of nitric acid, by adding concentrated sulfuric acid to an aqueous solution of potassium nitrate, yielding nitric acid and potassium sulfate which are separated through fractional distillation.

Potassium nitrate is also used as a fertilizer, in model rocket propellant, and in several fireworks such as smoke bombs, in which a mixture with sugar produces a smoke cloud of 600 times their own volume. The ratio for smoke bombs using sucrose (powdered sugar) and potassium nitrate is 40( $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ ): 60( $\text{KNO}_3$ ). It can be used as is, or carefully melted together using a hot plate.

In the process of food preservation, potassium nitrate is a common ingredient of salted meat, but heart patients need to take care with it. As a preservative it can be known as E249.

Potassium Nitrate is also a main component in stump remover; it accelerates the natural decomposition of the stump. Stump remover is usually about 98% pure  $\text{KNO}_3$ , and is a common source of  $\text{KNO}_3$ .

It has also been used in the manufacture of ice cream and can be found in some toothpastes for sensitive teeth. Recently, the use of potassium nitrate in toothpastes for sensitive teeth has increased dramatically, despite the fact that it has not been conclusively shown to help dental hypersensitivity.

A popular misconception is that potassium nitrate is an anaphrodisiac and was added to food in all-male institutions. In fact, potassium nitrate has no such effect in humans.

Although potassium nitrate is used in gunpowder, by itself, potassium nitrate is not combustible or flammable.

Solubility is the amount of a solute that will dissolve in a specific solvent under given conditions. The dissolved substance is called the solute and the dissolving fluid (usually present in excess) is called the solvent, which together form a solution. The process of dissolving is called solvation, or hydration if the solvent is water.

A solution at equilibrium that cannot hold any more solute is said to be saturated. The equilibrium of a solution is mainly dependent on temperature. The maximum equilibrium amount of solute which can normally dissolve per amount of solvent is the solubility of that solute in that solvent. It is often expressed as a maximum concentration of a saturated solution. These

maximum concentrations are often expressed as grams of solute per 100 milliliters of solvent. The solubility of one substance dissolving in another is determined by the intermolecular forces between the solvent and solute, temperature, the entropy change that accompanies the solvation, the presence and amount of other substances, and sometimes pressure or partial pressure of a solute gas.

Solubility constants are used to describe saturated solutions of ionic compounds of relatively low solubility (see solubility equilibrium). For salts, solubility in aqueous solutions or the maximum amount of salt that can be dissolved is the solubility constant. The solubility constant is a special case of an equilibrium constant. It describes the balance between dissolved salt and undissolved salt. The solubility constant is also “ applicable” (i. e. useful) to precipitation, the reverse of the dissolving reaction. As with other equilibrium constants, temperature can affect the numerical value of solubility constant.

While solutions are typically thought of as solids being mixed into liquids, any two states of matter can be mixed and be called a solution. Carbonated water is a solution of a gas in a liquid, hydrogen (a gas) can dissolve in palladium (a solid), and stainless steel is a solution of a solid in a solid (called an alloy). Phthalates dissolve in plastics and act as plasticizer.

Solutions may, under special conditions, hold more solute than the solvent can normally dissolve. This is called supersaturation.

When more of a substance can still be dissolved in water, we say the water is unsaturated.

Solvents are normally characterized as polar or nonpolar. The general rule of thumb is “ Like Dissolves Like.” This means that polar solvents will dissolve ionic compounds and covalent compounds which ionize, while nonpolar solvents will dissolve nonpolar covalent compounds. For example, ordinary table salt, an ionic compound, will dissolve in water, but not in ethanol.

Water and nonpolar solvents are immiscible; they do not form homogeneous mixtures but separate into two distinct phases or form milky emulsions.

Crystallization:

Crystallization is the (natural or artificial) process of formation of solid crystals from a homogeneous solution. Crystallization is also a chemical solid-liquid separation technique.

The crystallization process consists of two major events, nucleation and crystal growth.

Nucleation is the step where the solute molecules dispersed in the solvent start to gather to create clusters in the nanometer scale (elevating solute concentration in a small region) as to become stable under the current operating conditions. These stable clusters constitute the nuclei. However when the clusters are not stable, they redissolve. Therefore, the clusters need to reach a critical size in order to become stable nuclei. Such critical size is dictated by the operating conditions (temperature, supersaturation, irregularities, etc.). It is at the stage of nucleation that the atoms arrange in a defined and periodic manner that defines the crystal structure.

The crystal growth is the subsequent growth of the nuclei that succeed in achieving the critical cluster size. Subsequently, nucleation and growth continue to occur simultaneously while the supersaturation exists.

Supersaturation is the driving force of the crystallization, hence the rate of nucleation and growth is driven by the existing supersaturation in the solution. Depending upon the conditions, either nucleation or growth may be predominant over the other, and as a result, crystals with different sizes and shapes are obtained (Control of crystal size and shape constitutes one of the main challenges in industrial manufacturing, such as for pharmaceuticals). Once the supersaturation is exhausted, the solid-liquid system reaches the equilibrium and the crystallization is completed, unless the operating conditions are modified from equilibrium as to supersaturate the solution again.

Procedure:

1- Label four test tubes 1-4 with a marking pen. Place them in a test tube rack.

2- Fill a 400 mL beaker three-fourths full of tap water, place a thermometer in it, and heat the water on a hot plate until its temperature is about 90°C.

While you are waiting for the water to heat up, go on with steps 3 and 4.

3- Place the following masses of potassium nitrate, into test tubes:

2. 0 g in test tube 1

4. 0 g in test tube 2

6. 0 g in test tube 3

8. 0 g in test tube 4

4- Add 5. 0 mL distilled water to each test tube. Attach a utility clamp to a ring stand.

5- Place the test tube 1 in the clamp and lower it into the hot water bath. Stir the potassium nitrate solution with the stirring rod until the solid is completely dissolved. Remove the stirring rod and rinse it off. Loosen the utility clamp and, using a test tube holder, remove the test tube.

6- One lab partner should place the warm thermometer from the hot water bath into the test tube 1 while the other repeats step 5 for the test tube 2.

7- Watch test tube 1 for the first sign of crystallization and when it occurs record the temperature in the Data Table.

Remove test tube 2 from the hot water bath and repeat steps 6 and 7.

8- Repeat steps 5-7 for test tubes 3 and 4.

9- Place all the test tubes back in the hot water bath and redissolve the solid.

Flush the solutions down the drain with plenty of hot water.

Turn off the hot plate.

Description of the Experiment:



First, we filled the beaker with 150 mL of water and put it on the hot plate to heat it up.

Then, we placed 2.0, 4.0, 6.0, 8.0 grams of potassium nitrate into the test tubes which were marked 1-4 before.

One by one poured 5 mL of distilled water to each test tube and stirred for a couple of times before putting into the beaker.

We put test tube #1 into the beaker after a short while of stirring the test tube inside the beaker, to speed up its solubility, we put it out and placed under running cold water with a thermometer inside the test tube, waited for crystallization to start.

At the moment it did start, we recorded the temperature we read on the thermometer.

We have done the same steps for the rest of the test tubes.

And calculated the solubility, for each tube, of potassium nitrate in grams per 100 g water

Observations:

Data Table

Samples Temperature, C KNO<sub>3</sub>. (2 g) crystals begin to form. 21 C

KNO<sub>3</sub>. (4 g) crystals begin to form. 38 C

KNO<sub>3</sub>. (6 g) crystals begin to form. 45 C

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KNO<sub>3</sub>. (8 g) crystals begin to form. 65 C

The mixtures we stirred in the test tubes before putting into hot water bath did not dissolved, but in hot water bath they did quite well.

The test tube #1 which had 2. 0 grams of potassium nitrate in 5 mL of distilled water began to crystallize after a few minutes we put it under running cold water, but the others crystallizations started quicker as the amount of potassium nitrate they had in were more than the ones before. And had the crystallization temperatures higher.

Calculations:

Test tube #1:

2 grams of potassium nitrate in 5 mL of water

How many grams of potassium nitrate, KNO<sub>3</sub> in 100 mL of water -> 40 g

Test tube #2:

4 grams of potassium nitrate in 5 mL of water

How many grams of potassium nitrate, KNO<sub>3</sub> in 100 mL of water -> 80 g

Test tube #3:

6 grams of potassium nitrate in 5 mL of water

How many grams of potassium nitrate, KNO<sub>3</sub> in 100 mL of water -> 120 g

Test tube #4:

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8 grams of potassium nitrate in 5 mL of water

How many grams of potassium nitrate,  $\text{KNO}_3$  in 100 mL of water -> 160 g

Critical Thinking : Analysis and Conclusions

1-Using your graph, determine how many grams of  $\text{KNO}_3$  can be dissolved in 100 g of water at the following temperatures

35 C -> 70 g

60 C -> 150 g

70 C -> 175 g

2-Using your graph, predict whether the following solutions of  $\text{KNO}_3$  would be considered saturated, unsaturated, or supersaturated:

i. 75 g  $\text{KNO}_3$  / 100 g  $\text{H}_2\text{O}$  at 40 C ; Saturated

ii. 60 g  $\text{KNO}_3$  / 100 g  $\text{H}_2\text{O}$  at 50 C ; Saturated

3-A student stated that the solubility of  $\text{KCl}$  at 20 C was 36g of  $\text{KCl}$  per 100g of solution. What is wrong with this statement?

The statement only could be with grams per 100g of  $\text{H}_2\text{O}$ , not solution