

ScE7.3.2 : Solutions and Concentrations - ANSWERS

Outline and Study Guide



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8. Solubility of different substances. (p.12)
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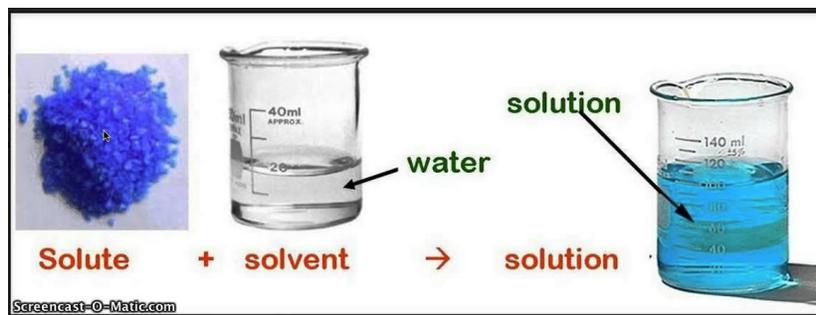
Concentration	Insoluble	Solubility	Solute
Concentrated	Unsaturated	Soluble	Solvent
Dilute	Saturated	Solution	

Definitions

1. **solution** : a homogeneous mixture composed of a solvent and one or more solute.
2. **solvent** : the substance that dissolves the solute; the substance that is in greater amount in the solution.
3. **solute** : the substance that is dissolved in the solvent
4. **soluble** substance : a substance that CAN dissolve in a particular solvent.
5. **insoluble** substance : a substance that CANNOT dissolve in a particular solvent.
6. **dilute** solution: a solution that contains less solute for the amount of solvent.
7. **concentrated** solution: a solution that contains more solute for the amount of solvent.
8. **concentration** : a measurement of the amount of solute for the amount of solvent in a solution
9. **solubility** : the maximum concentration of a solute that is capable of dissolving in that solvent
10. saturated solution: a solution that contains the MAXIMUM concentration possible of that solute.
11. **unsaturated** solution: a solution that contains LESS THAN THE MAXIMUM concentration possible of that solute.

Solution, Solvent, Solute

Use a labelled drawing to represent the relationship between the solvent, the solute, and a solution.



Define each term and give an example:

Solvent: **The substance that dissolves the solute; the substance that is in greater amount in the solution**

Solute: **the substance that is dissolved by the solvent**

Solution: a **homogeneous mixture; contains a solvent and one or more solute.**

For each example below, identify the name of the solution, the solvent, and the solute.

Example	Solution	Solvent	Solute
Vinegar contains 5% acetic acid and 95% water	<u>Vinegar</u>	<u>Water</u>	<u>Acetic acid</u>
Windshield wiper fluid contains propylene glycol dissolved in water	<u>Windshield wiper fluid</u>	<u>Water</u>	<u>Propylene glycol</u>
Dental amalgam is a metal alloy that can be used to fill cavities in people's teeth. It is made of tin dissolved in mercury.	<u>Dental amalgam</u>	<u>Mercury</u>	<u>Tin</u>
You can make Kool Aid from powder at home by mixing the powder with water.	<u>Kool-Aid drink</u>	<u>Water</u>	<u>Powder</u>
Seawater (use your own knowledge!)	<u>Seawater</u>	<u>Water</u>	<u>Salt</u>
A trumpet is made of brass, an alloy of zinc dissolved in copper.	<u>Brass</u>	<u>Copper</u>	<u>Zinc</u>
Air contains about 21% oxygen, 78% nitrogen, 0.04% carbon dioxide, 1% argon, and the rest is water vapor and traces of other gases.	<u>Air</u>	<u>Nitrogen</u>	<u>Oxygen</u> <u>Carbon dioxide</u> <u>Argon</u> <u>Water vapor</u> <u>Other gases</u>

Soluble / Insoluble

Listen to the SmartBoard activity and complete the examples of soluble and insoluble substances

Soluble in Water	Insoluble in Water
<p><u>Salt</u> <u>Sugar</u> <u>Soap</u> <u>Rubbing alcohol</u> <u>Baking Soda</u></p>	<p><u>Oil</u> <u>Gasoline</u> <u>Sand</u> <u>Iron</u> <u>Glass</u> <u>Plastics</u></p>

Define soluble and insoluble.

Soluble: Something that dissolves in a certain solvent

Insoluble: something that doesn't dissolve in that solvent.

Why do you have to specify the solvent when you say if a substance is soluble or insoluble?

Because a substance that doesn't dissolve in one solvent might dissolve in something else.

Examples :

- **grease is insoluble in water but will dissolve if you add dish detergent.**
- **Salt dissolves in water but not in oil**
- **Grass stains on clothes don't dissolve in water but do dissolve in rubbing alcohol**

What happens to the particles of a substance when it dissolves in water?

When a grain of substance like sugar dissolve in water, the molecules of sugar separate from each other and mix completely with the molecules of water.

How does particle theory explain why some substances are soluble in a certain solvent but others are not?

It's because of the way different particles are attracted to each other.

When a soluble substance like sugar dissolves in water, the particles of sugar are more attracted to the water particles than to each other. That's why each sugar particle separates from the others and goes with the water particles instead.

But with an insoluble substance like sand, the sand particles are more attracted to each other than to the water particles. So they stay together, and the sand does not dissolve.

Concentrated / Dilute

Listen to your teacher showing the activities on the SmartBoard, then explain the difference between a concentrated and a dilute solution.

Concentrated solution : **A solution that contains MORE solute for the amount of solvent.**

Dilute solution : **A solution that contains LESS solute for the amount of solvent.**

In each example below, indicate the most concentrated solution with **C**, and the most dilute with **D**.

The activity consists of several examples where you must identify the most concentrated (C) and most dilute (D) solution:

- Beakers:** Two beakers with different particle densities. The one with more particles is labeled 'C', and the one with fewer is labeled 'D'.
- Glasses:** A row of five glasses containing increasing amounts of red liquid, labeled 'A' through 'E'.
- Mugs:** Two mugs of tea. The one with more tea leaves is labeled 'C', and the one with fewer is labeled 'D'.
- Particles:** Two panels showing blue particles. The one with more particles is labeled 'C', and the one with fewer is labeled 'D'.
- Cups:** Two cups of coffee. The one with more coffee powder is labeled 'C', and the one with less is labeled 'D'.
- Buckets:** Two buckets of detergent. The one with more detergent is labeled 'C', and the one with less is labeled 'D'.
- Labels:** A separate box labeled 'D' is also present.

Measuring Concentration

Define *concentration*: a measurement of the amount of solute for the amount of solvent in a solution

Examples of concentration of different products:

Name of Product	Solute	Concentration
Vinegar	Acetic acid	5%
		ppm (parts per million)

How to Calculate Concentration in g/L

Formula :

$$\text{Concentration} = \text{grams solute} / \text{liters solvent}$$

Note: you are ALLOWED to use a calculator for this section! 😊

In science, the way to SHOW YOUR WORKINGS is to include the formula and the units as in the following examples!

Calculating Concentration - Examples

1. What is the concentration in g/L of a sugar solution made from 45 g of sugar in 1 litre of water ?

$$\text{Conc} = \text{grams} / \text{litre} = 45 \text{ g} / 1 \text{ L} = 45 \text{ g/L}$$

2. If I dissolve 150 g of salt in 0.5 L of water, what is the concentration ?

$$\text{Conc} = \text{grams} / \text{litre} = 150 \text{ g} / 0.5 \text{ L} = 300 \text{ g/L}$$

3. Calculate the Kool-Aid concentration of 600 g of crystals in a 3 L pitcher of water.

$$\text{Conc} = \text{grams} / \text{litre} = 600 \text{ g} / 3 \text{ L} = 200 \text{ g/L}$$

4. Hydrogen peroxyde is a chemical used to bleach hair before dyeing. If a 0.25 L bottle contains 10 g of hydrogen peroxyde, what is its concentration?

$$\text{Conc} = \text{grams} / \text{litre} = 10 \text{ g} / 0.25 \text{ L} = 40 \text{ g/L}$$

Individual Practice

1. If you dissolve 5 g of instant coffee crystals in a small cup (0.2 L) of boiling water, what is the concentration ?

$$\text{Conc} = \text{grams} / \text{litre} = 5 \text{ g} / 0.2 \text{ L} = 25 \text{ g/L}$$

2. A small swimming pool contains 1000 L of water. If 1.2 g of chlorine is added to disinfect the water, what is the concentration in g/L?

$$\text{Conc} = \text{grams} / \text{litre} = 1.2 \text{ g} / 1000 \text{ L} = 0.0012 \text{ g/L}$$



3. Honey contains mostly sugar and water. If 100 mL (0.1 L) of honey contains 60 g of sugar, what is its concentration in g/L?

$$\text{Conc} = \text{grams} / \text{litre} = 60 \text{ g} / 0.1 \text{ L} = 600 \text{ g/L}$$

4. Benadryl is a medication often used to help people having allergic reactions. According to the information on the label, liquid Benadryl contains 0.0125 g of medicine in each 5 mL dose (0.005 L). What is the concentration of Benadryl in g/mL ?

$$\text{Conc} = \text{grams} / \text{litre} = 0.0125 \text{ g} / 0.005 \text{ L} = 2.5 \text{ g/L}$$



5. An epipen is a special needle that can be used to give a medication called epinephrin to someone who is having a life-threatening anaphylactic reaction to something they are allergic to. According to the information on the label, each dose contains 0.0005 g of epinephrin in 10 mL (0.01 L) of liquid. What is the concentration in g/L?



$$\text{Conc} = \text{grams} / \text{litre} = 0.0005 \text{ g} / 0.01 \text{ L} = 0.05 \text{ g/L}$$

Solubility : Saturated and Unsaturated Solutions.

So, salt is soluble in water, but is there a limit?

Yes! You can only dissolve so much and then if you keep adding more salt it just sits in the bottom.

Explain the difference between a saturated and an unsaturated solution.

A saturated solution contains the maximum amount of solute that it is capable of dissolving.

An unsaturated solution contains less than the maximum amount of solute.

Define solubility : **The solubility of a substance is the maximum concentration that it is capable of being dissolved under specified conditions.**

Would you expect the solubility of salt to be affected by the temperature? In other words, do you think you can dissolve more salt in hot water or cold? Explain your answer.
(personal answer)

Conclusion of Lab Activity :

Effect of Temperature on the Solubility of Salt in Water.

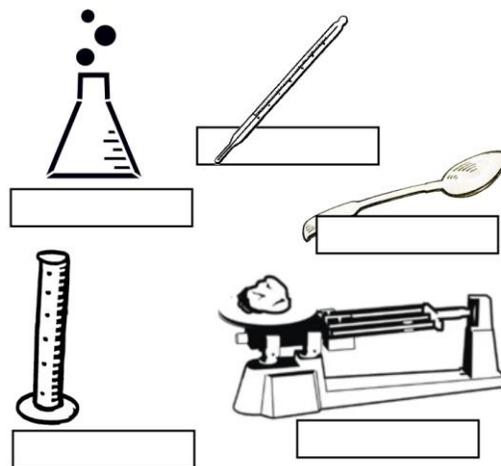
Considering the results of all the groups in the class, what can we conclude about the effect of temperature on the solubility of salt?

Usually, some groups find that hot water dissolves more salt and others find the opposite.

In reality, scientists have found that salt is SLIGHTLY more soluble in hot water than cold, but the difference is very small, and the method we use is not very precise. So it's not surprising if student results vary from group to group.

Label the following lab equipment :

Scale, graduate cylinder, thermometer, spoon, erlenmeyer.



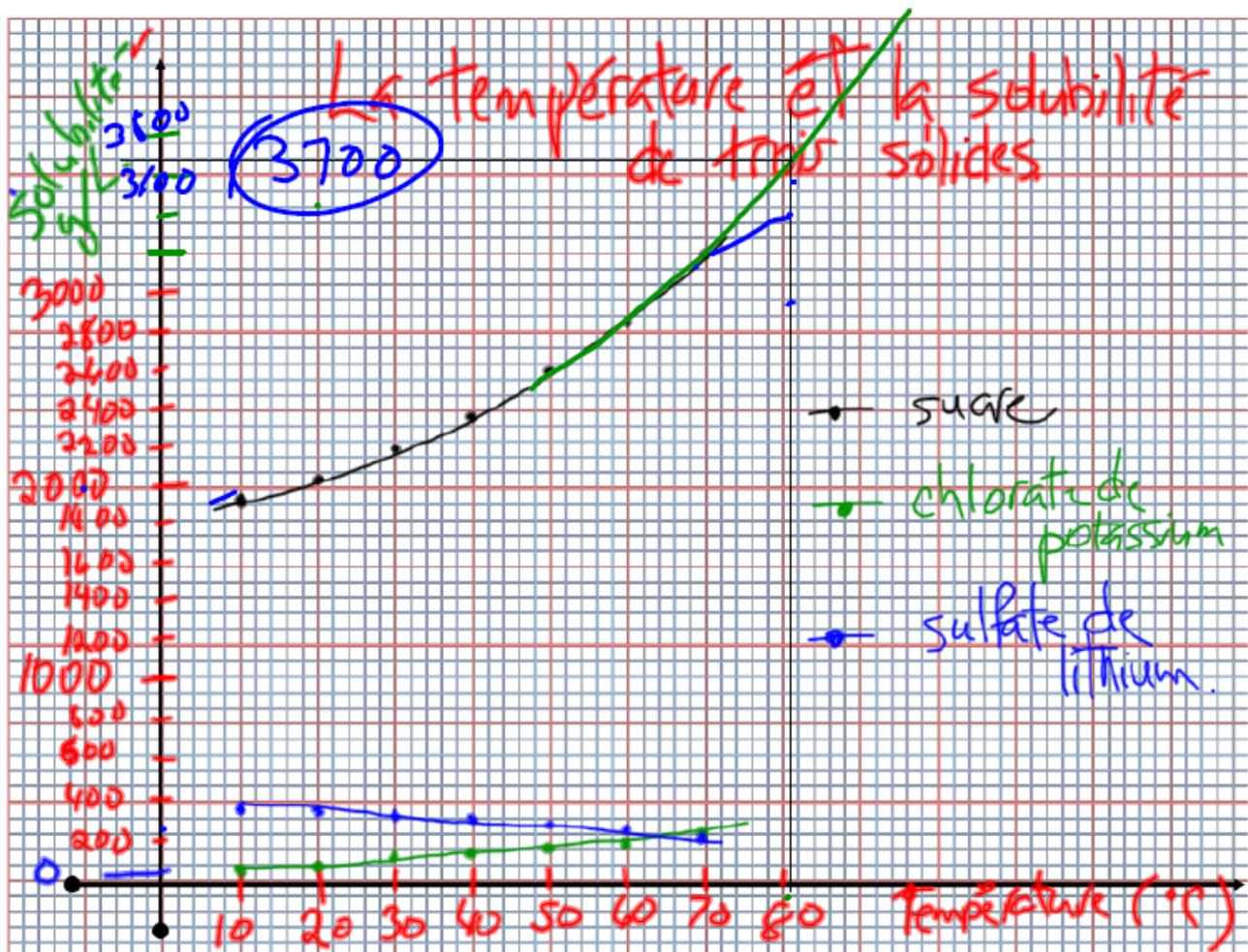
Graphing Practice : The Effect of Temperature on the Solubility of Three Solids

It turns out that salt is very slightly more soluble in hot water than cold. For different substances, the effect of temperature on solubility can be different. Consider the three solids in the table below.

Temperature (°C)	Solubility in water (g/L)		
	Solid A: Sugar	Solid B : Potassium Chlorate	Solid C : Lithium Sulfate
10	1910	50	370
20	2040	70	360
30	2200	110	350
40	2390	150	340
50	2610	210	330
60	2870	270	320
70	3200	340	310

- Based on these results
 - Which solid is most soluble overall? **sugar**
 - Which solid has a solubility that increases the most with temperature? **sugar**
 - Which solid has a solubility that decreases with temperature? **Lithium sulfate (solid C)**
- Graph these results using a THREE LINE graph on the following page. Use a legend to identify each line. Don't forget to label your axes and to give a title to your graph.
- In your graph, what is the independent variable? **The temperature (and/or the solid)**
What is the dependent variable? **The solubility**
- In this data, what is the unit for temperature ? **°C**
What is the unit for solubility? **g/L**
- Estimate the solubility of each substance at 55 °C and 80 °C:

	Estimated solubility at 55 °C	Estimated solubility at 80 °C
Sugar	2740	3530
Potassium Chlorate	240	410
Lithium Sulfate	325	300



The Solubility of Various Substances

Consider the following table of solubilities

Solute	Solubility in Water at 0 °C
Baking soda (solid)	69
Bluestone (solid)	316
Calcium hydroxide (solid)	1,9
Carbon dioxide (gas)	3,4
Epsom salts (solid)	700
Ethanol (liquid)	unlimited
Limestone (solid)	0,007
Nitrogen (gas)	0,03
Oxygen (gas)	0,07
Salt (solid)	357
Sugar (solid)	1792

- In what solvent were these solubilities measured? **Water**
- At what temperature? **0 °C**
- Why is it necessary for the chart to indicate the temperature?
Because the solubility changes when the temperature is different.
- What states of matter are the solutes in this chart?
Solid, liquid and gas – all three states of matter are capable of dissolving in water.
- List these substances in order from the least to the most soluble.
Limestone, nitrogen, oxygen, calcium hydroxide, carbon dioxide, baking soda, bluestone, salt, Epsom salts, sugar, ethanol.
- Use particle theory to explain why some substances like limestone have a very low solubility in water while others like sugar are much more soluble. (HINT : the difference is in the attraction between particles. See p.4 in this booklet.)

Limestone is less soluble because its particles are more attracted to each other to each other than to water particles, so they tend to stick together and they do not mix with the water.

Sugar is very soluble because sugar particles are much more attracted to water particles than to each other, so they separate from the crystals and mix with the water.

Dissolving Gases

Watch a [youtube video](#) on how soda fountains work, and the demonstration on the effect of temperature on soda water. Then complete the notes below.

1. Name two examples of gases that can dissolve in water.

Oxygen, nitrogen, carbon dioxide

2. What is the effect of pressure on the solubility of a gas in water?

The higher the gas pressure, the more gas molecules are pushed into the water and dissolve.

3. Why do you hear a “pssshhhht!” when you crack open a soft drink?

The can or bottle of soft drink holds the carbon dioxide pressure. When you crack it open the pressure is released and the gas bubbles quickly out of the liquid, which makes that sound.

4. How does the solubility of carbon dioxide in water change with temperature? Explain why, using particle theory.

Gases are less soluble in warmer liquids, because when the solution is warmer the molecules move faster which makes it more likely that the gas molecules will escape into the air.

5. Fish depend on oxygen dissolved in water to breathe, because they have no lungs and cannot use the oxygen from the air. Why could fish have trouble breathing in the summer if the water gets too warm?

The warmer the water, the less oxygen it contains, so the fish have less to breathe.

Fish can adapt by staying in shady, cooler spots or deeper water.