

SI Chemistry - Full Discipline Demo

Solubility and Solubility Curves

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Chemistry - Full Discipline Demo
Course	SI Chemistry - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Match each term with the best definition.

⌘ Miscible	Solution component present in the lesser amount	1
⌘ Saturated	Solution formed when a saturated solution cools	2
⌘ Solute	A homogeneous mixture	3
⌘ Solution	Solution containing the maximum amount of solute under the current conditions	4
⌘ Solvent	Solution component that dissolves the other components	5
⌘ Supersaturated	Two liquids that dissolve in each other	6
⌘ Unsaturated	Solution that can accept more solute	7

Correct answers:

- 1 Solute 2 Supersaturated 3 Solution 4 Saturated 5 Solvent
6 Miscible 7 Unsaturated

Identify the statements as true or false.

⚡ Ionic compounds dissolve in water as separate cations and anions. ⚡ Nonpolar compounds tend to dissolve in nonpolar solvents. ⚡ Nonpolar molecules contain all nonpolar bonds. ⚡ Polar compounds tend to dissolve in nonpolar solvents. ⚡ Polar molecules contain polar bonds. ⚡ Symmetrical molecules tend to be polar molecules.	
True	False
1	2

Correct answers:

1 Polar molecules contain polar bonds.

Nonpolar compounds tend to dissolve in nonpolar solvents.

Ionic compounds dissolve in water as separate cations and anions.

2 Nonpolar molecules contain all nonpolar bonds.

Symmetrical molecules tend to be polar molecules.

Polar compounds tend to dissolve in nonpolar solvents.

Complete the sentences with the terms provided.

⌵ Decreases

⌵ Increases

⌵ Remains unchanged

As temperature increases, solubility for solids:

1

As temperature increases, solubility for gases:

2

As partial pressure decreases, the solubility of solid solutes: 3

Correct answers:

1 Increases 2 Decreases 3 Remains unchanged

Exploration

A solution is formed when a ____ is dissolved in a ____.

- ☐ solvent; solute
- ☒ solute; solvent
- ☐ solvent; miscible
- ☐ solute; miscible

✓

Dissolution is a kinetic process defined by rate, and not specific to concentration.

- ☒ True
- ☐ False

✓

The polarity of a compound is dependent upon ____.

- ☐ the presence of polar bonds
- ☐ the shape of the molecule
- ☒ the presence of polar bonds and the shape of the molecule
- ☐ the surrounding molecules

✓

All ionic compounds are equally soluble in H₂O.

- ☐ True
- ☒ False

✓

The solubility of gaseous solutes ____ as temperature increases.

- ☐ increases
- ☒ decreases
- ☐ remains constant

✓

For most solid solutes, solubility ____ as the temperature goes up.

- ☒ increases
- ☐ decreases
- ☐ remains constant

✓

The solubility of gaseous solutes ____ as temperature increases.

- ☐ increases
- ☒ decreases
- ☐ remains constant

✓

Exercise 1

In the experiment, was NH_4Cl the solute or the solvent?

The NH_4Cl was the solute. The distilled water was the solvent.

Observe the solubility curves created for NH_4Cl and NaCl . How are they similar to one another and how are they different from each other?

The solubility for both chemicals increases with temperature. However, while the solubility of NH_4Cl continues to increase with temperature, the solubility of NaCl does not increase after 40g/100mL with or without a temperature increase.

How many grams of NH_4Cl can be dissolved in 100.0 mL of H_2O at 10°C ? At 100°C ? You will need to extrapolate from the experimental curve (that is, extend the lines below and above the experimental segment).

For 10°C , approximately 27 g. For 100°C , approximately 62 g.

Define the terms unsaturated, saturated, and supersaturated.

If a solution is unsaturated, it means that there is room for more solute to be added and dissolved in the solvent.

If a solution is saturated, it means that the maximum amount of solute is dissolved in the solvent.

If a solution is supersaturated, it means that the maximum solubility has been exceeded, typically

by dissolving solute at a higher temperature with a higher solubility and then cooling the solution to a lower solubility.

Using your graph, would 60.00 g NaCl in 100.0 mL H₂O at 100°C be an unsaturated, saturated, or supersaturated solution? How did you reach this conclusion?

It would be a supersaturated solution. The solubility chart shows that solubility does not increase after 40 g/100 mL of H₂O. Any amount over 40 g/100mL, at any temperature, would be a supersaturated solution.

Using your graph, would 30.00 g NH₄Cl in 100.0 mL H₂O at 80°C be an unsaturated, saturated, or supersaturated solution? How did you reach this conclusion?

It would be an unsaturated solution, as this point would be well under the curve. The solubility chart shows that at 80°C there would need to be approximately 53 g of NH₄Cl in the solution for it to be saturated.

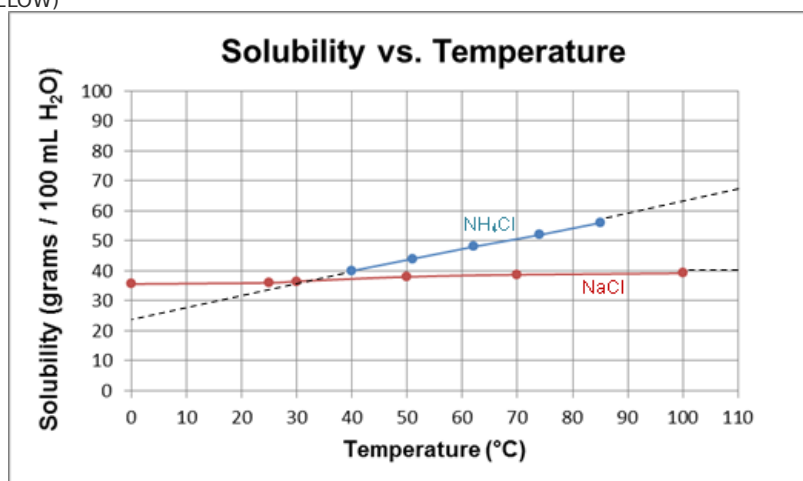
Data Table 1: Experiment Data
(SAMPLE ANSWER BELOW)

Experiment Stage	Total Mass of NH ₄ Cl (g)	Volume of Water (mL)	Crystallization Temperature (°C)	Convert to: g / 100.0 mL
1	2.00	5.0	40	40 / 100.0
2	2.20	5.0	51	44 / 100.0
3	2.40	5.0	62	48 / 100.0
4	2.60	5.0	74	52 / 100.0
5	2.80	5.0	85	56 / 100.0

Data Table 2: Solubility and Crystallization Temperature
(SAMPLE ANSWER BELOW)

Solubility of NH ₄ Cl (g/100.0 mL H ₂ O)	Crystallization Temperature (°C)
40 / 100.0	40
44 / 100.0	51
48 / 100.0	62
52 / 100.0	74

Graph 1: Solubility Curve
(SAMPLE ANSWER BELOW)



Exercise 2

From your experiment results, Figure 2, and Table 1, would you expect Na_2SO_4 to be polar or nonpolar? Explain your answer.

Na_2SO_4 would be polar because it was soluble in polar water, but not nonpolar oils. Additionally, the solubility guide states that sulfates are soluble in water - except for Ag^+ , Pb^{2+} , Ba^{2+} , Sr^{2+} , and Ca^{2+} compounds. Sodium (Na^+) is not on the exception list.

Using the solubility guide for ionic compounds shown in Table 1, would you expect Na_2SO_4 to be soluble or insoluble in water? Did the results of your experiment support the solubility guide? Explain your answer.

According to the solubility rules, all sulfates except for silver, lead, barium, calcium, and strontium are soluble in water. Therefore, sodium sulfate should be soluble in water. The results of my experiment supported these solubility rules because my experiment showed sodium sulfate to be soluble in water.

Use your experimental results to describe the polarity (or non-polarity) of corn oil and canola oil. Explain your reasoning.

Knowing that water is a polar substance, and that neither corn oil nor canola oil were miscible in water, the results suggest that both canola oil and corn oil are nonpolar substances. Additionally, sodium sulfate, a polar substance, was not soluble in canola oil or corn oil. As the simple solubility rule says that "like dissolves like," it suggests that both canola oil and corn oil are nonpolar.

Data Table 3: Solubility Results
(SAMPLE ANSWER BELOW)

Compound Mixture	Soluble or Insoluble?
Distilled H_2O + Na_2SO_4	No sample answer
Corn Oil + Na_2SO_4	No sample answer

Canola Oil + Na ₂ SO ₄	No sample answer
Compound Mixture	Miscible or Immiscible?
Distilled H ₂ O + Corn Oil	No sample answer
Distilled H ₂ O + Canola Oil	No sample answer
Canola Oil + Corn Oil	No sample answer

Competency Review

A solvent can be a solid, liquid, or gas, but is most commonly a liquid.

- ☒ True
- ☐ False
- ✓

Solubility is defined in terms of ____ and is independent of ____.

- ☒ concentration; rate
- ☐ rate; concentration
- ☐ rate; dissolution
- ☐ dissolution; concentration
- ✓

Water is a "polar molecule" which is another term for a dipole.

- ☒ True
- ☐ False
- ✓

Ionic compounds dissolve in water and are surrounded by water molecules in specific orientations through a process called ____.

- ☐ dissolution
- ☒ hydration
- ☐ miscibility
- ☐ supersaturation
- ✓

_____ is an ionic compound that is soluble in water.

- ☐ NaNO_3
- ☐ NaBr
- ☐ NaCl
- ☐ NaNO_3 and NaBr
- ☒ All of the above

✓

Solubility curves are used to determine if a solution is unsaturated, saturated, or supersaturated at a specific pressure.

- ☐ True
- ☒ False

✓

The solubility of _____ are typically affected by changes in pressure.

- ☐ solids
- ☐ liquids
- ☒ gases
- ☐ All of the above

✓

Consider an experiment to create a solubility curve of ammonium chloride (NH_4Cl). A known amount of water and NH_4Cl are added to a test tube. The test tube is placed in a hot water bath and then allowed to cool to room temperature. Why is the solution heated and then cooled?

- ☐ To allow crystallization
- ☐ To determine the solubility of ammonium chloride
- ☐ To generate temperature data points for the solubility curve
- ☒ All of the above

✓

A novice scientist would like to test the solubility of an unknown compound. She adds a known amount of the compound to a test tube that holds 10 mL of water. She swirls the solution, mixing the substances together and places the test tube in a rack. A cloudy film begins to form near the bottom of the test tube. One possible conclusion might be that ____.

- ☐ the compound is miscible in water
- ☒ the compound is insoluble in water
- ☐ the compound is polar
- ☐ the solution is unsaturated

Corn oil is immiscible with water. Therefore, it may be concluded that corn oil is a ____ molecule.

- ☐ polar
- ☒ nonpolar

Extension Questions

Many power plants and manufacturing facilities generate heat or use high temperatures in their processes. The temperature is often lowered by circulating water around the equipment and discharging this heated water into ponds or rivers. This can lead to raising the temperature of the pond, river or discharge water supply. Raising the temperature of these water sources is termed "thermal pollution." Thermal pollution can affect the ecosystem and cause fish and other aerobic organisms to die. Based on what you know about the temperature effects on gas solubility, explain why the elevated water temperature can kill fish.

(SAMPLE ANSWER BELOW)

Gas solubility decreases in the solvent at elevated temperatures. Fish and other aerobic organisms need oxygen to survive. As the temperature of the water is raised, the amount of dissolved oxygen in the water decreases. If the oxygen levels decrease sufficiently, the fish would essentially suffocate since they would not be able to get enough oxygen.