

Chapter 16 – Solutions

SOLUTIONS & SOLUBILITY VOCABULARY & CONCEPTS

1. SOLUTE is the substance that is dissolved.
2. SOLVENT is the substance that does the dissolving.
3. SOLUTION is a homogeneous solution.
4. A SATURATED solution has the maximum amount of solute dissolved in a given amount of solvent.
5. A UNSATURATED solution can dissolve more solute.
6. Opposite of soluble is INSOLUBLE.
7. SOLUBILITY is how many grams of solute dissolves in 100 mL of water.
8. For most solid solutes, as temperature goes up, solubility goes UP.
9. For most gas solutes, as temperature goes up solubility goes Down.
10. What are the three factors that increase the rate of dissolving of a solute? Explain how they aid a substance in dissolving on a molecular level. Temperature, Surface Area (particle size), stirring
11. Why must you keep a carbonated beverage cool to prevent it from going "flat"? As temp. goes up solubility of gas goes down.
12. Explain the difference among saturated, unsaturated, and supersaturated solutions.

SOLUBILITY CHARTS

13. What is the solubility of NaCl at 25 °C?

38 g NaCl

14. What is the solubility of KNO₃ at 70 °C?

130 g KNO₃

15. At what temperature is the solubility of NaNO₃ 90g/100mL H₂O?

23 °C

16. How many grams of KClO₃ dissolve in 200 mL H₂O at 30 °C?

$$\frac{12 \text{ g KClO}_3}{100 \text{ g H}_2\text{O}} \times \frac{200 \text{ g}}{100 \text{ g}} = \frac{24 \text{ g KClO}_3}{200 \text{ g}}$$

17. How many grams of KCl would dissolve in 40 mL H₂O at 80 °C?

$$\frac{50 \text{ g KCl}}{100 \text{ g H}_2\text{O}} = \frac{x}{40 \text{ g H}_2\text{O}} \quad \boxed{20 \text{ g KCl}}$$

18. How many grams of NH₃ would dissolve in 500 mL H₂O at 80 °C?

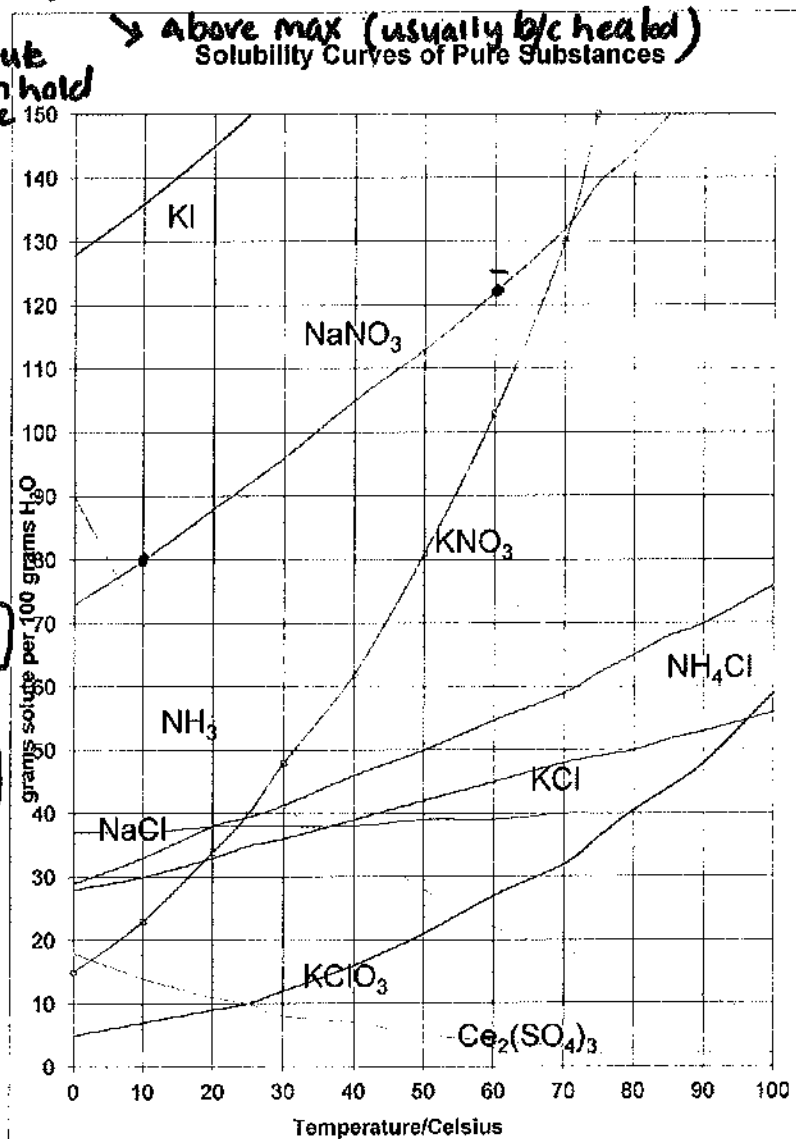
$$\frac{14 \text{ g NH}_3}{100 \text{ g H}_2\text{O}} = \frac{x}{500 \text{ g}} \quad \boxed{70 \text{ g NH}_3}$$

19. If 30 grams of KNO₃ are dissolved in 100 mL H₂O at 20 °C, will the solution be saturated or unsaturated?

Explain why. Solubility is 33 g KNO₃ per 100 g of H₂O @ 20 °C, so 30 g is less than maximum amount of solute

20. If a solution of NaNO₃ was cooled from 60 °C to 10 °C, how much solute would precipitate out of solution?

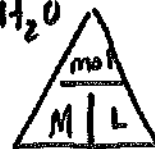
80g 123g - 80g = 43g 123g



MOLARITY

$$1000 \text{ mL} = 1 \text{ L}$$

$$1 \text{ g H}_2\text{O} = 1 \text{ mL H}_2\text{O}$$



$$M_1 V_1 = M_2 V_2$$

21. What is the molarity of a solution of Na_3PO_4 with 0.75 mol of solute in 950 mL of solution?

$$M = \frac{\text{mol Na}_3\text{PO}_4}{\text{L soln}} = \frac{0.75 \text{ mol}}{0.950 \text{ L}} = \boxed{0.789 \text{ M}}$$

22. What is the molarity of a solution containing 10.00 g of H_3PO_4 dissolved in 500.0 mL of solution?

$$\frac{10.00 \text{ g H}_3\text{PO}_4}{98 \text{ g}} \times \frac{1 \text{ mol}}{1 \text{ mol}} = 0.102 \text{ mol} \quad M = \frac{\text{mol H}_3\text{PO}_4}{\text{L soln}} = \frac{0.102 \text{ mol}}{0.500 \text{ L}} = \boxed{0.204 \text{ M}}$$

23. What mass of sodium chloride is needed to make 300 mL of a 0.50 M solution?

$$0.50 \text{ M} = \frac{\text{mol NaCl}}{0.300 \text{ L}} \quad \frac{0.15 \text{ mol NaCl}}{1 \text{ mol}} \times \frac{58.44 \text{ g NaCl}}{1 \text{ mol}} = \boxed{8.77 \text{ g NaCl}}$$

24. What is the molarity of a solution that contains 212.5 g of sodium nitrate (NaNO_3) in 3.0 L of solution?

$$\frac{212.5 \text{ g NaNO}_3}{85 \text{ g NaNO}_3} \times \frac{1 \text{ mol}}{1 \text{ mol}} = 2.5 \text{ mol} \quad M = \frac{\text{mol NaNO}_3}{\text{L soln}} = \frac{2.5 \text{ mol}}{3 \text{ L}} = \boxed{0.83 \text{ M}}$$

25. How many liters of solution are needed to dissolve 25.5 g sodium chloride if a concentration of 0.25 M is needed?

$$\frac{25.5 \text{ g NaCl}}{58.44 \text{ g}} \times \frac{1 \text{ mol}}{1 \text{ mol}} = 0.436 \text{ mol} \quad 0.25 \text{ M} = \frac{0.436 \text{ mol}}{\text{L soln}} = \boxed{1.74 \text{ L}}$$

MOLAR DILUTIONS

26. You add 500 mL to 100 mL of a stock solution of 12 M HCl. What is the final concentration?

must add 100 mL to get $V_2 = 600 \text{ mL}$

$$M_1 V_1 = M_2 V_2 \quad 12 \text{ M} \cdot 100 \text{ mL} = M_2 \cdot 600 \text{ mL} \quad \boxed{M_2 = 2 \text{ M}}$$

27. To make 1000 mL of a 1 M dilution of phosphoric acid solution (H_3PO_4), what volume of 6 M stock solution should you use?

$$M_1 V_1 = M_2 V_2 \quad 6 \text{ M} \cdot V_1 = 1 \text{ M} \cdot 1000 \text{ mL} \quad \boxed{V_1 = 166.7 \text{ mL}}$$

28. If a 1000 mL dilute solution of CaCl_2 is made from 550 mL of 6 M stock solution, what is the concentration of dilute CaCl_2 solution?

$$M_1 V_1 = M_2 V_2 \quad 6 \text{ M} \cdot 550 \text{ mL} = M_2 \cdot 1000 \text{ mL} \quad \boxed{M_2 = 3.3 \text{ M}}$$

29. How would you prepare 90 mL of 2.0 M sulfuric acid from 18 M stock solution?

$$M_1 V_1 = M_2 V_2 \quad 18 \text{ M} \cdot V_1 = 2 \text{ M} \cdot 90 \text{ mL} \quad \boxed{V_1 = 10 \text{ mL}}$$

VOCABULARY & CONCEPTS

1. An ionic compound that forms from an acid-base neutralization reaction is a(n) salt.
2. A(n) electrolyte is a substance that conducts electricity.
3. The reaction between an acid and a base is called a(n) neutralization reaction.
4. According to Arrhenius, a compound containing hydrogen that ionizes to yield hydrogen ions in an aqueous solution is called a(n) acid.
5. According to Arrhenius, a compound that ionizes to yield hydroxide ions (OH^-) in an aqueous solution is called a(n) base.

Write "A" if the statement is a property of an acidic solution. Write "B" if the statement is a property of a base, and "X" if it is a property of both a basic and acidic solution.

- | | |
|---|--|
| 6. Feels smooth and slippery <u>B</u> | 10. Has a sour taste <u>A</u> |
| 7. Reacts vigorously with metals <u>A</u> | 11. Turns litmus paper from blue to red <u>A</u> |
| 8. Has a bitter taste <u>B</u> | 12. Turns litmus paper from red to blue <u>B</u> |
| 9. Is an electrolyte <u>X</u> | 13. Usually does not react with metals <u>B</u> |

State "A" for acid, "B" for base and "S" for salt. In addition, write the name for the compound.

- | | |
|---|--|
| 14. HCl <u>A</u> <u>hydrochloric acid</u> | 18. NaOH <u>B</u> <u>sodium hydroxide</u> |
| 15. CaCl_2 <u>S</u> <u>calcium chloride</u> | 19. H_3PO_4 <u>A</u> <u>phosphoric acid</u> |
| 16. Na_2SO_4 <u>S</u> <u>sodium sulfate</u> | 20. $\text{Mg}(\text{OH})_2$ <u>B</u> <u>magnesium hydroxide</u> |
| 17. HNO_3 <u>A</u> <u>nitric acid</u> | 21. LiOH <u>B</u> <u>lithium hydroxide</u> |

ACID & BASE PROBLEMS

22. What is the hydrogen ion concentration in a wheat flour and water solution if $[\text{OH}^-] = 1.0 \times 10^{-8} \text{ M}$? Is the wheat flour and water acidic, basic or neutral?

$[\text{H}^+] = ?$ Find pOH : $\text{pOH} = -\log(1 \times 10^{-8}) = 8$ Find $[\text{H}^+]$: $[\text{H}^+] = 10^{-6}$

Find pH : $\text{pOH} + \text{pH} = 14$
 $8 + \text{pH} = 14$

$\text{pH} = 6$

$[\text{H}^+] = 1.0 \times 10^{-6} \text{ M}$

Acidic b/c $\text{pH} = 6$

23. What is the pH of peaches if the $[\text{OH}^-] = 3.16 \times 10^{-11} \text{ M}$? Are peaches acidic, basic or neutral?

Follow same steps as #22 (minus step to find $[\text{H}^+]$)

$\text{pOH} = -\log(3.16 \times 10^{-11}) = 10.5$

$\text{pH} = 14 - 10.5 = 3.5$

$\text{pH} = 3.5$, Acidic

24. What is the $[\text{H}^+]$ concentration in eggs if $[\text{OH}^-] = 6.0 \times 10^{-7} \text{ M}$? Are eggs acidic, basic or neutral?

Follow same steps as #22

$\text{pOH} = -\log(6.0 \times 10^{-7}) = 6.22$

$\text{pH} = 14 - 6.22 = 7.78$

Slightly basic

$[\text{H}^+] = 10^{-7.78}$

$[\text{H}^+] = 1.66 \times 10^{-8} \text{ M}$

25. An aqueous solution contains a 0.0361 M OH^- concentration. Calculate the pOH, pH and $[H^+]$. Determine if the solution is acidic or basic.

$$\text{pOH} = -\log(0.0361) = 1.44$$

$$\text{pH} = 14 - 1.44 = 12.56 \rightarrow \text{greater than } 7 \therefore \text{Basic}$$

$$[H^+] = 10^{-12.56} \quad [H^+] = 2.75 \times 10^{-13} \text{ M}$$

26. Lake Ontario has water with an $[H^+]$ of approximately $1.1 \times 10^{-6} \text{ M}$. Determine whether the water is slightly acidic or slightly basic.

must find pH to answer the question

$$\text{pH} = -\log[H^+] = -\log(1.1 \times 10^{-6}) = 5.96; \text{ less than } 7 \therefore \text{Acidic}$$

27. If the pH of a diet soda is 3.21 at 25°C , what are the hydrogen ion and hydroxide ion concentrations in the soda?

$$[H^+] = 10^{-3.21} \quad [H^+] = 6.17 \times 10^{-4} \text{ M} \quad [H^+] = ? \quad [OH^-] = ?$$

$$\text{pOH} = 14 - 3.21 = 10.79 \quad [OH^-] = 10^{-10.79} \quad [OH^-] = 1.62 \times 10^{-11} \text{ M}$$

28. Most fish species die in water with a $[H^+]$ of between $3.16 \times 10^{-5} \text{ M}$ and $1.0 \times 10^{-5} \text{ M}$. What is the pH range where most fish species die? What are the corresponding $[OH^-]$ values for fish death?

$$\text{pH} = -\log(3.16 \times 10^{-5}) = 4.5$$

$$\text{pH} = -\log(1 \times 10^{-5}) = 5$$

$$\text{Range } \text{pH} = 4.5 - 5$$

$$\text{pOH} = 9.5 \quad [OH^-] = 10^{-9.5} = 3.16 \times 10^{-10}$$

$$\text{pOH} = 9 \quad [OH^-] = 10^{-9} = 1 \times 10^{-9}$$

$$\text{Range } [OH^-] = 3.16 \times 10^{-10} - 1 \times 10^{-9}$$

TITRATION PROBLEMS

29. What is the molarity of carbonic acid if 25.0 mL of the solution is neutralized by 48.3 mL of 0.20 M NaOH?



$$\text{Find M Acid} \rightarrow 0.00483 \text{ mol}$$

$$? \text{ M}$$

$$25.0 \text{ mL}$$

$$0.20 \text{ M}$$

$$48.3 \text{ mL}$$

$$\text{Find moles base} \rightarrow 0.20 \text{ M} = \frac{\text{mol}}{0.0483 \text{ L}}$$

$$M = \frac{0.00483 \text{ mol}}{0.025 \text{ L}} = 0.19 \text{ M H}_2\text{CO}_3$$

$$\text{Find moles acid} \rightarrow 0.00966 \text{ mol NaOH} \left| \frac{1 \text{ mol H}_2\text{CO}_3}{2 \text{ mol NaOH}} \right| =$$

30. What is the molarity of sodium hydroxide if 30.0 mL of the solution is neutralized by 40.0 mL of 0.50 M H_3PO_4 ?



$$\text{Find mol acid} \rightarrow$$

$$0.5 \text{ M} = \frac{\text{mol}}{0.040 \text{ L}}$$

$$\left\{ \begin{array}{l} 0.5 \text{ M} \\ 40 \text{ mL} \end{array} \right.$$

$$\left\{ \begin{array}{l} ? \text{ M} \\ 30 \text{ mL} \end{array} \right.$$

$$\text{Find M base} \rightarrow M = \frac{0.06 \text{ mol}}{0.03 \text{ L}} = 2 \text{ M NaOH}$$

$$\text{Find moles base} \rightarrow 0.02 \text{ mol H}_3\text{PO}_4 \left| \frac{3 \text{ mol NaOH}}{1 \text{ mol H}_3\text{PO}_4} \right| = 0.06 \text{ mol NaOH}$$

31. How many milliliters of sulfuric acid are needed to neutralize 55 mL of a 0.75 M sodium hydroxide solution?



$$\text{Find M acid} \rightarrow$$

$$1.0 \text{ M} = \frac{0.020625 \text{ mol}}{\text{L}}$$

$$0.020625 \text{ L} = 20.625 \text{ mL}$$

$$\left\{ \begin{array}{l} ? \text{ M} \\ 1.0 \text{ M} \end{array} \right.$$

$$\left\{ \begin{array}{l} 55 \text{ mL} \\ 0.75 \text{ M} \end{array} \right.$$

$$\text{Find moles base} \rightarrow 0.75 \text{ M} = \frac{\text{mol}}{0.055}$$

$$\text{Find moles acid} \rightarrow 0.04125 \text{ mol NaOH} \left| \frac{1 \text{ mol H}_2\text{SO}_4}{2 \text{ mol NaOH}} \right| =$$