

## Knowledge/Understanding

### True/False

In your notebook, indicate whether each statement is true or false. Correct each false statement.

- The solubility of a gas increases with increased temperature.
- Molar concentration refers to the amount, in moles, of solute dissolved in one kilogram of solvent.
- The maximum amount of a solute that will dissolve in a solvent at a certain temperature is called its solubility.
- The term insoluble has a precise meaning.
- The component of a solution present in the smaller amount is called the solvent.
- The molar concentration of a solution containing 4 mol of solute dissolved in 2 L of solvent is 2 mol/L.
- The rate at which a solid solute dissolves in water can usually be increased by increasing the temperature of the solution.
- Each ten-fold increase in the concentration of hydronium ions in a solution increases the pH of the solution by one unit.
- Hydrobromic acid is a strong acid.

### Matching

10. Match each description in column B with the correct term in column A.

Column A	Column B
(a) Unsaturated solution	A solution with pH = 10
(b) Saturated solution	$\text{NH}_3$
(c) Dilute solution	$\text{SO}_3^{2-}$
(d) Concentrated solution	$\text{H}_2\text{SO}_3$
(e) Arrhenius acid	A solution that contains a relatively large amount of solute
(f) Brønsted–Lowry base	A solution with pH = 8
(g) An example of a weak acid	When solute is added to an aqueous solution, the solute does not dissolve

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|---|---|
| (h) The conjugate base of $\text{HSO}_3^-$      | When solute is added to an aqueous solution, the solute dissolves |
| (i) A solution more acidic than one with pH = 9 | A substance that produces $\text{H}^+$ when dissolved in water    |
| (j) A solution more basic than one with pH = 9  | A solution that contains a relatively small amount of solute      |

### Multiple Choice

In your notebook, write the letter of the best answer for each of the following questions.

- Which of the following would best indicate that a sample of water is pure?
  - Measure its boiling point.
  - Measure its pH.
  - Add it to a sample of pure water and see if it is miscible (dissolves infinitely).
  - Pass an electric current through it to see if it decomposes into hydrogen gas and oxygen gas.
  - See if sodium chloride dissolves in it.
- If 1.00 g of solid sodium chloride is dissolved in enough water to make 350 mL of solution, what is the molar concentration of the solution?
  - 5.98 mol/L
  - $1.67 \times 10^{-1}$  mol/L
  - $4.89 \times 10^{-2}$  mol/L
  - $5.98 \times 10^{-3}$  mol/L
  - $4.88 \times 10^{-5}$  mol/L
- What volume of  $5.00 \times 10^{-2}$  mol/L  $\text{Ca}(\text{NO}_3)_2$  solution will contain  $2.50 \times 10^{-2}$  mol of nitrate ions?
  - 200 mL
  - 250 mL
  - 500 mL
  - 750 mL
  - 1.00 L
- If 40.0 mL of 6.00 mol/L sulfuric acid is diluted to 120 mL by the addition of water, what is the molar concentration of the sulfuric acid after dilution?
  - $5.00 \times 10^{-2}$  mol/L
  - $7.50 \times 10^{-2}$  mol/L
  - 1.00 mol/L

- (d) 2.0 mol/L  
(e) 4.0 mol/L
15. When solutions of sodium chloride, NaCl, and silver nitrate, AgNO<sub>3</sub>, are mixed, what is the net ionic equation for the reaction that results?
- (a)  $\text{Na}^+_{(\text{aq})} + \text{NO}_3^-_{(\text{aq})} \rightarrow \text{NaNO}_3_{(\text{aq})}$   
 (b)  $\text{Ag}^+_{(\text{aq})} + \text{Cl}^-_{(\text{aq})} \rightarrow \text{AgCl}_{(\text{s})}$   
 (c)  $\text{Na}^+_{(\text{aq})} + \text{NO}_3^-_{(\text{aq})} + \text{Ag}^+_{(\text{aq})} + \text{Cl}^-_{(\text{aq})} \rightarrow \text{AgCl}_{(\text{s})} + \text{NaNO}_3_{(\text{aq})}$   
 (d)  $\text{Na}^+_{(\text{aq})} + \text{NO}_3^-_{(\text{aq})} + \text{Ag}^+_{(\text{aq})} + \text{Cl}^-_{(\text{aq})} \rightarrow \text{AgCl}_{(\text{s})} + \text{Na}^+_{(\text{aq})} + \text{NO}_3^-_{(\text{aq})}$   
 (e)  $\text{Na}^+_{(\text{aq})} + \text{NO}_3^-_{(\text{aq})} + \text{Ag}^+_{(\text{aq})} + \text{Cl}^-_{(\text{aq})} \rightarrow \text{NaNO}_3_{(\text{aq})} + \text{Ag}^+_{(\text{aq})} + \text{Na}^+_{(\text{aq})}$
16. The acidity in a sample of soil could be neutralized by adding:
- (a) sodium chloride  
 (b) ammonium nitrate  
 (c) potassium sulfate  
 (d) calcium oxide  
 (e) magnesium phosphate
- ### Short Answers
- In your notebook, write a sentence or a short paragraph to answer each of the following questions:
17. Is a saturated solution always a concentrated solution? Give an example to explain your answer.
18. How can a homogeneous mixture be distinguished from a heterogeneous mixture? Give one example of each.
19. List three different ways in which the concentration of a solution could be described.
20. What would you observe if a saturated solution of sodium carbonate (commonly called washing soda) at room temperature was cooled to 5°C?
21. Explain why calcium hydroxide (solubility 0.165 g per 100 g water at 20°C) is much more soluble than magnesium hydroxide (solubility 0.0009 g per 100 g water at 20°C).
22. Iron concentrations of 0.2 to 0.3 parts per million in water can cause fabric staining when washing clothes. A typical wash uses 12 L of water. What is the maximum mass of iron that can be present so that the clothes will not be stained?
23. High levels of phosphorus are not toxic, but can cause digestive problems. The allowable drinking water concentration is 0.05 ppm. What is the maximum mass of phosphorus that could be present in a 250 mL glass of tap water?
24. Is a 1% solution of table salt, NaCl<sub>(aq)</sub>, more concentrated, less concentrated, or at the same concentration as a 1% solution of sugar, C<sub>12</sub>H<sub>22</sub>O<sub>11(aq)</sub>? Explain.
25. Bones and teeth consist mostly of a compound called hydroxyapatite, Ca<sub>10</sub>(PO<sub>4</sub>)<sub>6</sub>(OH)<sub>2</sub>. This compound contains PO<sub>4</sub><sup>3-</sup> and OH<sup>-</sup> ions.
- (a) Do you expect hydroxyapatite will be an acid or a base?
- (b) Foods that contain sucrose form lactic acid in the mouth and the pH drops. As a result, eating candy promotes a reaction between hydroxyapatite and H<sup>+</sup><sub>(aq)</sub>. Balance the skeleton reaction:  
 $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2 + \text{H}^+_{(\text{aq})} \rightarrow \text{CaHPO}_4_{(\text{s})} + \text{H}_2\text{O}_{(\ell)} + \text{Ca}^{2+}_{(\text{aq})}$
- (c) At lower pH values, the CaHPO<sub>4(s)</sub> also reacts with H<sup>+</sup><sub>(aq)</sub>:  
 $\text{CaHPO}_4_{(\text{s})} + \text{H}^+_{(\text{aq})} \rightarrow \text{Ca}^{2+}_{(\text{aq})} + \text{H}_2\text{PO}_4^-_{(\text{aq})}$   
 Dentists and toothpaste manufacturers warn that eating candy promotes tooth decay. What chemical evidence have you seen to support this advice?
26. (a) Why does water from different regions vary in its hardness?  
 (b) Why is filtration not an effective method to remove the hardness from water?  
 (c) Why should hard water be treated before it is heated in a hot water boiler?
27. Vinegar is added to a kettle with a build-up of scale due to hard water. What would you expect to observe? Explain.
28. Chloroform and diethyl ether were among the first substances used as anaesthetics. Both are non-polar substances.
- (a) Would you expect either or both of these substances to be soluble in water? Explain.  
 (b) Write a sentence or two to describe how you think these substances are able to get from the lungs to the brain.

## Inquiry

29. A Chemist has a large beaker containing ice-cold water, and another containing boiling water. The laboratory is well-equipped with other apparatus.
- Explain how the chemist could maximize the solubility of the following solutes in water (following appropriate safety precautions):
    - magnesium chloride,  $\text{MgCl}_2$ , used to fire-proof wood
    - benzene, a non-polar liquid used by the industry and found in gasoline
    - carbon monoxide,  $\text{CO}$ , a poisonous gas formed by incomplete combustion of hydrocarbons
  - Explain how you could minimize the solubility of the same solutes in water.
30. Design an experiment to collect data on the pH of a stream, over a period of one year. Why might the pH vary at different times of the year?
31. The table below shows the colours of various indicators at different pH values.
- If a vinegar solution is at pH 5, what colour would you expect the following indicators to show if placed into separate samples of the vinegar?
    - Thymol blue

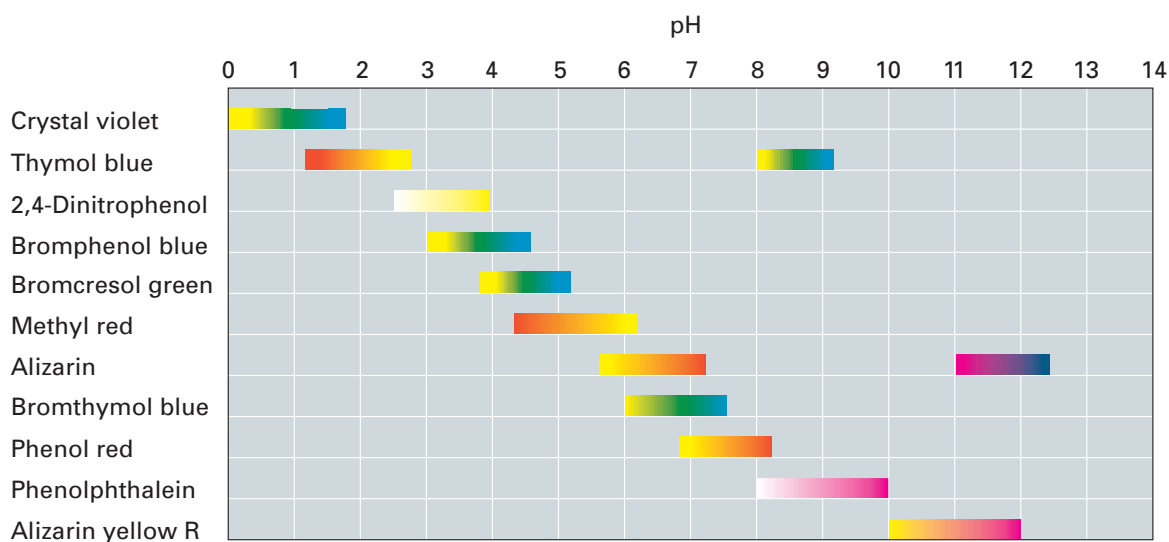
(ii) Bromophenol blue

(iii) Phenolphthalein

- An aqueous solution of sodium acetate used in photographic development makes phenol red indicator red, and phenolphthalein pink. What is the pH of this sodium acetate solution?

## Communicating

32. Lead is highly toxic when absorbed into the body, especially for young children. A level of 10 micrograms of lead per decilitre of blood is cause for concern. Do research, then write a report describing the health effects of lead. Include information on the sources of this heavy metal and on how lead might be absorbed by a child.
33. Sulfuric acid is the chemical produced in the largest quantity in the world. Research some of the uses of sulfuric acid. Design a poster for students in a younger grade, illustrating one way in which this acid is used. Your poster should be informative and visually interesting.
34. In the past, scurvy was a disease that killed many sailors. James Lind discovered that eating citrus fruits prevents scurvy. Citrus fruits contain ascorbic acid (vitamin C). Research the life of James Lind, and write a brief biography.



## Making Connections

35. The disposal of nuclear waste presents many difficulties. Some proposals suggest burying the waste in glass or ceramic containers deep in the earth.
- (a) Why would these containers be superior to containers made of metal or concrete?
  - (b) What are some of the concerns related to burying radioactive waste?
  - (c) Make a suggestion on a different way to dispose of radioactive waste. Include a list of the pros and cons of your suggestion.
36. The following is a short list of some weak bases and their uses. Which ones are Brønsted–Lowry bases, but not Arrhenius bases?
- (a) ammonia,  $\text{NH}_3$ , used in the manufacture of fertilizers, plastics, and explosives
  - (b) zinc oxide,  $\text{ZnO}$ , a white pigment used in paints and cosmetics
  - (c) copper(II) hydroxide,  $\text{Cu}(\text{OH})_2$ , used to kill fungi and bacteria
  - (d) hydrazine,  $\text{N}_2\text{H}_4$ , a colourless liquid that can be used as a rocket fuel
37. In 1963, a treaty was signed by the US, UK, and USSR to ban the atmospheric testing of atomic weapons. Previous testing of atomic weapons had added radioactive isotopes of strontium ( $\text{Sr-90}$ ) and cesium ( $\text{Cs-137}$ ) to the atmosphere. Eventually, these pollutants fell to the ground and may have entered the food chain.
- (a) Which would you expect to form more soluble compounds, strontium or cesium? Explain your answer.
  - (b) State two important factors that might help you to determine the health risks of these isotopes.

### COURSE CHALLENGE

Think about these questions as you plan for your Chemistry Course Challenge.

- How might you use your knowledge of solutions to analyze the purity of a sample of water?
- How could you precipitate out contaminants to purify a sample of water?
- What dissolved substances might end up in water as it passes through rock? How might you identify these substances? How could you extract them from the contaminated water?