1. As a solute is added to a solvent, what happens to the freezing point and the boiling point of the solution?

   A) The freezing point decreases and the boiling point increases.
   B) The freezing point increases and the boiling point increases.
   C) The freezing point increases and the boiling point decreases.
   D) The freezing point decreases and the boiling point decreases.

2. Compared to the freezing point of 1.0 M KCl(aq) at standard pressure, the freezing point of 1.0 M $CaCl_2$(aq) at standard pressure is

   More ions

   A) lower   B) higher
   C) the same

3. Which aqueous solution of KI freezes at the lowest temperature?

   A) 1 mol of KI in 500. g of water
   B) 2 mol of KI in 500. g of water *(more concentrated)*
   C) 1 mol of KI in 1000. g of water
   D) 2 mol of KI in 1000. g of water

4. A 1 kilogram sample of water will have the highest freezing point when it contains

   A) 1×10^{21} dissolved particles
   B) 1×10^{17} dissolved particles
   C) 1×10^{19} dissolved particles
   D) 1×10^{23} dissolved particles *lowest f.p.*

5. A solution consists of 0.50 mole of $CaCl_2$ dissolved in 100. grams of H_2O at 25°C. Compared to the boiling point and freezing point of 100. grams of H_2O at standard pressure, the solution at standard pressure has

   A) a higher boiling point and a lower freezing point
   B) a lower boiling point and a lower freezing point
   C) a higher boiling point and a higher freezing point
   D) a lower boiling point and a higher freezing point

6. Which solution will freeze at the *lowest* temperature?

   A) 1 mole of sugar in 500 g of water
   B) 1 mole of sugar in 1,000 g of water
   C) 2 moles of sugar in 1,000 g of water
   D) 2 moles of sugar in 500 g of water

7. Which solution has the highest boiling point at standard pressure?

   4 ions   3 K^+ 1 PO_4^{3-}

   A) 0.10 M K_3PO_4(aq)
   B) 0.10 M KCl(aq)
   C) 0.10 M KNO_3(aq)
   D) 0.10 M K_2SO_4(aq)

8. Which concentration of a solution of CH_3OH in water has the *lowest* freezing point?

   A) 0.001 M   B) 0.1 M
   C) 0.01 M   D) 0.0001 M

9. How do the boiling point and freezing point of a solution of water and calcium chloride at standard pressure compare to the boiling point and freezing point of water at standard pressure?

   A) Both the freezing point and boiling point of the solution are higher.
   B) The freezing point of the solution is higher and the boiling point of the solution is lower.
   C) The freezing point of the solution is lower and the boiling point of the solution is higher.
   D) Both the freezing point and boiling point of the solution are lower.

10. Compared to a 2.0 M aqueous solution of NaCl at 1 atmosphere, a 3.0 M aqueous solution of NaCl at 1 atmosphere has a

    A) lower boiling point and a higher freezing point
    B) higher boiling point and a higher freezing point
    C) lower boiling point and a lower freezing point
    D) higher boiling point and a lower freezing point

Concentration $10.0 = \frac{X}{2000.0g} \times 1,000,00$

15. Which solution is the most concentrated?

   A) 1 mole of solute dissolved in 1 liter of $\frac{1}{1} = 1M$ solution

   B) 2 moles of solute dissolved in 3 liters of $\frac{2}{3} = 0.67M$ solution

   C) 6 moles of solute dissolved in 4 liters of $\frac{6}{4} = 1.5M$ solution

   D) 4 moles of solute dissolved in 8 liters of solution $\frac{4}{8} = 0.5M$

16. A 2400.-gram sample of an aqueous solution contains 0.012 gram of NH_3. What is the concentration of NH_3 in the solution, expressed as parts per million?

   A) 5.0 ppm   B) 15 ppm $\frac{0.012}{2400.g} \times$

   C) 20. ppm   D) 50. ppm $1,000,000$

17. A 3.0 M HCl(aq) solution contains a total of

   A) 3.0 grams of HCl per mole of solution
   B) 3.0 moles of HCl per liter of solution
   C) 3.0 moles of HCl per mole of water
   D) 3.0 grams of HCl per liter of water

18. How many moles of solute are contained in 200 milliliters of a 1 M solution? $1M = \frac{X}{.2L}$

   A) 0.2   B) 0.8   C) 1   D) 200

19. What is the molarity of 1.5 liters of an aqueous solution that contains 52 grams of lithium fluoride, LiF, (gram-formula mass = 26 grams/mole)?

   A) 1.3 M   B) 2.0 M $M = \frac{2 moles}{1.5L}$
   C) 3.0 M   D) 0.75 M $\frac{52g}{26g} = 2 moles$

20. What is the molarity of a solution of NaOH if 2 liters of the solution contains 4 moles of NaOH?

   A) 0.5 M   B) 2 M $M = \frac{4M}{2L} = 2M$
   C) 8 M   D) 80 M

21. If 100. milliliters of a 1.0-molar NaCl solution is evaporated to 25 milliliters, what will be the concentration of the resulting NaCl solution?

   A) 0.25 M   B) 2.0 M
   C) 0.50 M   D) 4.0 M   same as #4 & 12

$.100 \times 1.0 = X \times .025$
$0.1 = X \times .025$
$\frac{0.1}{.025} = \frac{X \times .025}{.025}$
$X = 4M$

22. How many grams of KOH should be dissolved in water to make 2000.0 grams of a 10.0 ppm solution? $0.0001 = \frac{X}{2000.}$

   A) 2.0×10^{-1} g   B) 2.0×10^{-3} g $X = .02$
   C) 2.00 g   D) 2.0×10^{-2} g

23. How many grams of NaCl are needed to be dissolved in water to make 1.0 gram of a 100.0 ppm solution? $100.0 = \frac{X}{1.0} \times 1,000,000$

   A) 1.0×10^{-1} g   B) 1.0×10^{-2} g $0.0001 = \frac{X}{1.0}$
   C) 1.0×10^{-4} g   D) 1.0×10^{-3} g $X = 0.0001$

24. Which type of concentration is calculated when the grams of solute is divided by the grams of the solution, and the result is multiplied by 1,000,000?

   A) parts per million
   B) percent by mass
   C) percent by volume
   D) molarity

25. What is the concentration expressed in parts per million of a solution containing 5.0 grams of NH_4Cl in 95.0 grams of H_2O? $ppm = \frac{5.0g}{100g} \times 1,000,0$

   A) 2.0×10^7 ppm   B) 5.3×10^4 ppm $50,000$
   C) 1.9×10^7 ppm   D) 5.0×10^4 ppm

26. The concentration of a solution can be expressed in

   A) joules per kilogram
   B) kelvins
   C) milliliters
   D) moles per liter

27. What is the concentration of a solution which contains 1 mole of $CaCl_2$ dissolved in 2,000 milliliters of solution?

   A) 1 M   B) 2 M $M = \frac{1 mole}{2.0L}$
   C) 0.5 M   D) 0.25 M $M = 0.5$

28. What is the total number of grams of NaOH (formula mass = 40.) needed to make 1.0 liter of a 0.20 M solution?

   A) 20. g   B) 2.0 g   C) 80. g   D) 8.0 g

$0.20M = \frac{moles}{1.0L}$
$moles = 0.2$
$g = 0.2 \times 40g = 8.0g$

1. What is the total number of moles of NaCl(s) needed to make 3.0 liters of a 2.0 M NaCl solution?

   A) 1.0 mol   B) 8.0 mol $2.0 = \dfrac{x}{3.0L}$

   C) 6.0 mol   D) 0.70 mol

2. How many grams of KOH are needed to prepare 250. milliliters of a 2.00 M solution of KOH (formula mass = 56.0)?

   .250 L

   A) 1.00 g   B) 2.00 g $2.00 = \dfrac{moles}{.250 L}$

   C) 28.0 g   D) 112 g   moles = 0.5

   $0.5 \times 56 = 28.0$

3. What is the total number of grams of HI in 0.500 liter of 1.00 M HI? GFM =

   A) 1.00 g   B) 0.500 g $1.00 = \dfrac{moles}{0.500 L}$

   C) 64.0 g   D) 128 g   moles = 0.5

4. When 20. milliliters of 1.0 M HCl is diluted to a total volume of 60. milliliters, the concentration of the resulting solution is

   Not in this Unit

   A) 1.0 M   B) 0.50 M

   C) 0.33 M   D) 0.25 M

5. What is the concentration of $O_2(g)$, in parts per million, in a solution that contains 0.008 gram of $O_2(g)$ dissolved in 1000. grams of $H_2O(l)$?

   A) 8 ppm   B) 80 ppm $ppm = \dfrac{0.008}{1000.g} \times 1,000,000$

   C) 800 ppm   D) 0.8 ppm

6. The concentration of a solution can be expressed in

   A) joules per gram

   B) grams per kelvin

   C) parts per million

   D) milliliters per minute

7. The molarity of an aqueous solution of NaCl is defined as the

   A) grams of NaCl per liter of solution

   B) moles of NaCl per liter of water

   C) moles of NaCl per liter of solution

   D) grams of NaCl per liter of water

8. Based on your reference tables, which compound could form a concentrated solution?

   Omit

   A) Ag_2CO_3 B) AgCl

   C) $AgNO_3$ D) AgBr

9. Which preparation produces a 2.0 M solution of $C_6H_{12}O_6$? [molecular mass = 180.0]

   A) 90.0 g of $C_6H_{12}O_6$ dissolved in 1000. mL of solution

   B) 90.0 g of $C_6H_{12}O_6$ dissolved in 500.0 mL of solution

   C) 180.0 g of $C_6H_{12}O_6$ dissolved in 1000. mL of solution

   D) 180.0 g of $C_6H_{12}O_6$ dissolved in 500.0 mL of solution

   0.5 L $\dfrac{1\ mole}{.5 L}$

   $\dfrac{180}{180} = 1\ mole$

10. What is the concentration expressed in parts per million of a solution containing 30.0 grams of $NaNO_3$ in 70.0 grams of H_2O?

   A) 3.33×10^6 ppm   B) 3.00×10^5 ppm

   C) 2.33×10^6 ppm   D) 4.29×10^5 ppm

   $\dfrac{30.0 g}{100.0 g} \times 1,000,000$

11. Which solution is most concentrated?

   A) 0.1 mole of solute dissolved in 400 ml of solvent   0.25

   B) 0.2 mole of solute dissolved in 300 ml of solvent   0.67 M

   C) 0.3 mole of solute dissolved in 200 ml of solvent   1.5 M

   D) 0.4 mole of solute dissolved in 100 ml of solvent   4 M

12. If 0.50 liters of a 2.0M HCl is diluted with H_2O to a volume of 1.0 liters, the molarity of the new solution will be

   Same as #4

   A) 1.0 M   B) 2.0 M

   C) .25 M   D) .50 M

13. Which unit can be used to express solution concentration?

   A) mol/s   B) J/mol

   C) L/mol   D) mol/L

14. Which unit can be used to express the concentration of a solution?

   A) ppm   B) L/s   C) kPa   D) J/g

Review Questions

1) As the number of effective collisions between reacting particles increases what will happen to the rate of the reaction? Explain.

The rate of the reaction will increase because a reaction can only occur if particles collide

2) Which of the following pairs of reactants will react most quickly? Be sure to give an explanation for your answer.
   solid   liquid   *Also covalent compounds
   a) sodium chloride and silver nitrate   react slower than
   gas   gas   ionic compounds.
   b) ethane (C_2H_6) and oxygen (O_2)

Reason: a) Solids react quickly in aqueous solutions.
For (b), the gas molecules are far apart, so won't
3) Given the reaction: $2 Mg_{(s)} + O_{2(g)} \rightarrow 2 MgO_{(s)}$ react as quickly as a.
List four ways that you could speed up the rate of the reaction:

1. Increase temp.   3. Add a catalyst
2. Increase surface   4. Add more reactants
   area

4) Why does raising the temperature speed up the rate of reaction?

The molecules would have more energy to collide more often.

5) Factors that affect the rate of reaction are:

a) Nature of reactants, or the substances used

b) Temperature, or the average kinetic energy of the molecules

c) Concentration, or the amount of contact between reactants

d) Pressure, which determines how close particles are to one another.

e) Presence of a catalyst, which lowers the activation energy for a reaction.

3

6) Explain how rate determining step and reaction rate are related. (Not in reading)

The rate determining step is the slowest step of a reaction that would determine the speed of the reaction.

7) What is the area of chemistry concerned with the speed of reactions?

Kinetics

8) Do all chemical reactions take place at the same speed? Why or why not?

No, the rate would depend on the nature of reactants, concentration and temperature.

9) Which statement most correctly describes the collision theory?
   a) if molecules collide with either proper alignment or enough energy, then reaction will occur
   b) when molecules collide a reaction always occurs
   c) collisions between particles often result in a reaction
   d) if molecules collide with enough energy and proper alignment, then a reaction will occur

4

4. Given the reaction:

$$A + B \rightarrow AB$$
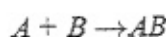
The table below shows student data obtained about the rate of reaction when the concentration of solution A is kept constant and the concentration of solution B is changed by adding H_2O. Based on the data, the student should conclude that the

Trial	Volume of Solution A	Volume of Solution B	Volume of H₂O Added	Reaction Time
1	10 mL	10 mL	0 mL	2.8 sec
2	10 mL	5 mL	5 mL	4.9 sec
3	10 mL	3 mL	7 mL	10.4 sec

A) concentration has no effect on the reaction rate
B) reaction rate increased when H_2O was added
C) reaction rate increased as solution B was diluted
D) reaction rate decreased as solution B was diluted

5. After being ignited in a Bunsen burner flame, a piece of magnesium ribbon burns brightly, giving off heat and light. In this situation, the Bunsen burner flame provides

A) ionization energy
B) activation energy
C) heat of reaction
D) heat of vaporization

6. An increase in the surface area of reactants in a heterogeneous reaction will result in

A) a decrease in the rate of the reaction
B) an increase in the rate of the reaction
C) a decrease in the heat of reaction
D) an increase in the heat of reaction

7. At 20.°C, a 1.2-gram sample of Mg ribbon reacts rapidly with 10.0 milliliters of 1.0 M HC1(aq). Which change in conditions would have caused the reaction to proceed more slowly?

A) increasing the initial temperature to 25°C
B) decreasing the concentration of HCl(aq) to 0.1 M
C) using 1.2 g of powdered Mg
D) using 2.4 g of Mg ribbon

8. Given the balanced equation representing a reaction:

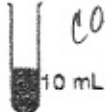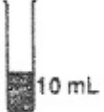$$Fe(s) + 2HCl(aq) \rightarrow FeCl_2 (aq) + H_2(g)$$
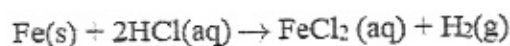
This reaction occurs more quickly when powdered iron is used instead of a single piece of iron of the same mass because the powdered iron

A) acts as a better catalyst than the single piece of iron
B) absorbs less energy than the single piece of iron
C) has a greater surface area than the single piece of iron
D) is more metallic than the single piece of iron

9. Each of four test tubes contains a different concentration of HCl(aq) at 25°C. A 1-gram cube of Zn is added to each test tube. In which test tube is the reaction occurring at the fastest rate?

A) 1 M HCl(aq)   *most concentrated*   B) 0.1 M HCl(aq)
   10 mL   10 mL

C) 0.01 M HCl(aq)   D) 0.001 M HCl(aq)
   10 mL   10 mL

10. As the concentration of reacting particles increases, the rate of reaction generally

A) decreases   B) increases
C) remains the same

11. Which change would most likely increase the rate of a chemical reaction?

A) decreasing a reactant's concentration
B) decreasing a reactant's surface area
C) cooling the reaction mixture
D) adding a catalyst to the reaction mixture

12. Which statement best describes how a catalyst increases the rate of a reaction?

A) The catalyst provides an alternate reaction pathway with a higher activation energy.
B) The catalyst provides an alternate reaction pathway with a lower activation energy.
C) The catalyst provides the same reaction pathway with a higher activation energy.
D) The catalyst provides the same reaction pathway with a lower activation energy.

13. If the pressure on gaseous reactants is increased, the rate of reaction is increased because there is an increase in the

A) activation energy   B) volume
C) concentration   D) heat of reaction

14. A 1.0-gram piece of zinc reacts with 5 milliliters of HCl(aq). Which of these conditions of concentration and temperature would produce the greatest rate of reaction?

A) 1.0 M HCl(aq) at 20.°C
B) 1.0 M HCl(aq) at 40.°C
C) 2.0 M HCl(aq) at 20.°C
D) 2.0 M HCl(aq) at 40.°C   → *highest concentration & temp.*

15. In a biochemical reaction, an enzyme acts as a catalyst, causing the

A) activation energy of the reaction to decrease
B) potential energy of the reactants to decrease
C) kinetic energy of the reactants to increase
D) heat of reaction to increase

16. Given the reaction:

$$A_2(g) + B_2(g) \leftrightarrow 2\,AB(g) + heat$$
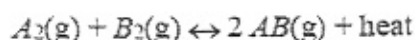
An increase in the concentration of $A_2(g)$ will

A) decrease the production of $AB(g)$
B) decrease the frequency of collisions between $A_2(g)$ and $B_2(g)$
C) increase the production of $B_2(g)$
D) increase the frequency of collisions between $A_2(g)$ and $B_2(g)$

17. A reaction is most likely to occur when reactant particles collide with

A) proper energy, only
B) proper orientation, only
C) both proper energy and proper orientation
D) neither proper energy nor proper orientation

18. Given the reaction:

$$A + B \rightarrow C + D$$

The reaction will most likely occur at the greatest rate if A and B represent

A) nonpolar molecular compounds in the solid phase
B) ionic compounds in the solid phase
C) solutions of nonpolar molecular compounds
D) solutions of ionic compounds