Name_________________________

Solutions and Acids/Bases/Salts

1. Which compound is insoluble in water?
   A) calcium bromide    B) potassium bromide
   C) silver bromide     D) sodium bromide

2. According to Reference Table F, which of these compounds is most soluble at 298 K and 1 atm?
   A) AgNO₃    B) AgCl
   C) PbCrO₄    D) PbCO₃

3. The attraction between water molecules and an Na⁺ ion or a Cl⁻ ion occurs because water molecules are
   A) linear    B) symmetrical
   C) polar     D) nonpolar

4. Which compound is least soluble in water at 60. °C?
   A) KClO₃    B) KNO₃    C) NaCl    D) NH₄Cl

5. An unsaturated aqueous solution of NH₃ is at 90°C in 100, grams of water. According to Reference Table G, how many grams of NH₃ could this unsaturated solution contain?
   A) 5 g    B) 10. g    C) 15 g    D) 20. g

6. The solubility of KClO₃(s) in water increases as the
   A) temperature of the solution increases
   B) temperature of the solution decreases
   C) pressure on the solution increases
   D) pressure on the solution decreases

7. At STP, which of these substances is most soluble in H₂ O?
   A) CCl₄    B) CO₂    C) HCl    D) N₂

8. Which compound decreases in solubility as the temperature of the solution is increased from 10°C to 50°C?
   A) NH₄Cl    B) NaCl
   C) NH₃
   D) NaNO₃

9. Under which conditions of temperature and pressure is a gas most soluble in water?
   A) high temperature and low pressure
   B) high temperature and high pressure
   C) low temperature and low pressure
   D) low temperature and high pressure

10. Base your answer to the following question on A student tested the solubility of a salt at different temperatures and then used Reference Table g to identify the salt. The student’s data table appears below.

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>g of salt per 10 g of water</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>1.2</td>
</tr>
<tr>
<td>50</td>
<td>2.2</td>
</tr>
<tr>
<td>62</td>
<td>3.0</td>
</tr>
<tr>
<td>76</td>
<td>4.0</td>
</tr>
</tbody>
</table>

What is the identity of the salt?
   A) potassium nitrate
   B) sodium chloride
   C) potassium chlorate
   D) ammonium chloride

11. A change in pressure would have the greatest effect on the solubility of a
   A) solid in a liquid
   B) gas in a liquid
   C) liquid in a liquid
   D) liquid in a solid

12. A student adds solid KCl to water in a flask. The flask is sealed with a stopper and thoroughly shaken until no more solid KCl dissolves. Some solid KCl is still visible in the flask. The solution in the flask is
   A) saturated and is at equilibrium with the solid KCl
   B) saturated and is not at equilibrium with the solid KCl
   C) unsaturated and is at equilibrium with the solid KCl
   D) unsaturated and is not at equilibrium with the solid KCl

13. As additional KNO₃(s) is added to a saturated solution of KNO₃ at constant temperature, the concentration of the solution
   A) decreases
   B) increases
   C) remains the same

14. The molarity of an aqueous solution of NaCl is defined as the
   A) grams of NaCl per liter of water
   B) grams of NaCl per liter of solution
   C) moles of NaCl per liter of water
   D) moles of NaCl per liter of solution
A student uses 200 grams of water at a temperature of 60°C to prepare a saturated solution of potassium chloride, KCl.

15. According to Reference Table G, how many grams of KCl must be used to create this saturated solution?

16. Identify the solute in this solution.

Base your answers to questions 17 and 18 on the data table below, which shows the solubility of a solid solute.

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Solute per 100 g of H₂O(g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>40</td>
<td>24</td>
</tr>
<tr>
<td>60</td>
<td>29</td>
</tr>
<tr>
<td>80</td>
<td>36</td>
</tr>
<tr>
<td>100</td>
<td>49</td>
</tr>
</tbody>
</table>

17. According to Reference Table G, how many grams of KClO₃ must be dissolved in 100 grams of H₂O at 10°C to produce a saturated solution?

18. Based on the data table, if 15 grams of solute is dissolved in 100 grams of water at 40°C, how many more grams of solute can be dissolved in this solution to make it saturated at 40°C?

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  C) 3.0 M  D) 0.75 M

20. The data collected from a laboratory titration are used to calculate the

A) rate of a chemical reaction
B) heat of a chemical reaction
C) concentration of a solution
D) boiling point of a solution
Scientists who study aquatic ecosystems are often interested in the concentration of dissolved oxygen in water. Oxygen, O₂, has a very low solubility in water, and therefore its solubility is usually expressed in units of milligrams per 1000. grams of water at 1.0 atmosphere. The graph below shows a solubility curve of oxygen in water.

![Solubility of Oxygen in Water Versus Temperature](image)

21. An aqueous solution has 0.0070 gram of oxygen dissolved in 1000. grams of water. Calculate the dissolved oxygen concentration of this solution in parts per million. Your response must include both a correct numerical setup and the calculated result.

22. Explain, in terms of molecular polarity, why oxygen gas has low solubility in water. Your response must include both oxygen and water.

23. A student determines that 8.2 milligrams of oxygen is dissolved in a 1000.-gram sample of water at 15°C and 1.0 atmosphere. In terms of saturation, what type of solution is this sample?

24. Which unit can be used to express solution concentration?
   A) J/mol  
   B) L/mol  
   C) mol/L  
   D) mol/s

25. What is the total number of moles of NaCl(s) needed to make 3.0 liters of a 2.0 M NaCl solution?
   A) 6.0 mol  
   B) 8.0 mol  
   C) 1.0 mol  
   D) 0.70 mol

26. What color is bromoresol green after it is added to a sample of NaOH(aq)?

27. What is the concentration of O₂(g), in parts per million, in a solution that contains 0.008 gram of O₂(g) dissolved in 1000. grams of H₂O(l)?
   A) 0.8 ppm  
   B) 8 ppm  
   C) 80 ppm  
   D) 800 ppm

28. Which two compounds are electrolytes?
   A) C₆H₁₂O₆ and CH₃CH₂OH  
   B) C₆H₁₂O₆ and HCl  
   C) NaOH and HCl  
   D) NaOH and CH₃CH₂OH
29. Base your answer to the following question on the information below.

Vitamin C, also known as ascorbic acid, is water soluble and cannot be produced by the human body. Each day, a person’s diet should include a source of vitamin C, such as orange juice. Ascorbic acid has a molecular formula of \( \text{C}_6\text{H}_8\text{O}_6 \) and a gram-formula mass of 176 grams per mole.

What is the color of the indicator thymol blue after it is added to an aqueous solution of vitamin C?

30. After the beverage bottle is left open for several hours, the hydronium ion concentration in the beverage solution decreases to \( \frac{1}{1000} \) of the original concentration. Determine the new pH of the beverage solution.

31. Using Table M, identify one indicator that is yellow in a solution that has the same pH value as this beverage.

32. State, in terms of the pH scale, why this beverage is classified as acidic.

33. Which laboratory test result can be used to determine if \( \text{KCl(s)} \) is an electrolyte?

   A) \( \text{pH of } \text{KCl(aq)} \)
   B) \( \text{pH of } \text{KCl(s)} \)
   C) \( \text{electrical conductivity of } \text{KCl(aq)} \)
   D) \( \text{electrical conductivity of } \text{KCl(s)} \)

34. When dissolved in water, an Arrhenius base yields

   A) hydrogen ions
   B) hydronium ions
   C) hydroxide ions
   D) oxide ions

35. Potassium hydroxide is classified as an Arrhenius base because \( \text{KOH} \) contains

   A) \( \text{OH}^- \) ions
   B) \( \text{O}^2^- \) ions
   C) \( \text{K}^+ \) ions
   D) \( \text{H}^+ \) ions

36. Which compound is an Arrhenius acid?

   A) \( \text{CaO} \)
   B) \( \text{HCl} \)
   C) \( \text{K}_2\text{O} \)
   D) \( \text{NH}_3 \)

37. According to the Arrhenius theory, a base reacts with an acid to produce

   A) ammonia and methane
   B) ammonia and a salt
   C) water and methane
   D) water and a salt

38. When one compound dissolves in water, the only positive ion produced in the solution is \( \text{H}_3\text{O}^+ \) (aq). This compound is classified as

   A) a salt
   B) a hydrocarbon
   C) an Arrhenius acid
   D) an Arrhenius base

39. An aqueous solution of lithium hydroxide contains hydroxide ions as the only negative ion in the solution. Lithium hydroxide is classified as an

   A) aldehyde
   B) alcohol
   C) Arrhenius acid
   D) Arrhenius base

40. Which substance is an Arrhenius base?

   A) \( \text{CH}_3\text{OH} \)
   B) \( \text{CH}_3\text{Cl} \)
   C) \( \text{LiOH} \)
   D) \( \text{LiCl} \)

41. When the pH value of a solution is changed from 2 to 1, the concentration of hydronium ions

   A) decreases by a factor of 2
   B) increases by a factor of 2
   C) decreases by a factor of 10
   D) increases by a factor of 10

42. As the pH of a solution is changed from 3 to 6, the concentration of hydronium ions

   A) increases by a factor of 3
   B) increases by a factor of 1000
   C) decreases by a factor of 3
   D) decreases by a factor of 1000

43. A hydrogen ion, \( \text{H}^+ \), in aqueous solution may also be written as

   A) \( \text{H}_2\text{O} \)
   B) \( \text{H}_2\text{O}_2 \)
   C) \( \text{H}_3\text{O}^+ \)
   D) \( \text{OH}^- \)
Base your answers to questions 44 and 45 on the information below.

In one trial of an investigation, 50.0 milliliters of HCl(aq) of an unknown concentration is titrated with 0.10 M NaOH(aq). During the titration, the total volume of NaOH(aq) added and the corresponding pH value of the reaction mixture are measured and recorded in the table below.

<table>
<thead>
<tr>
<th>Total Volume of NaOH(aq) Added (mL)</th>
<th>pH Value of Reaction Mixture</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0</td>
<td>1.6</td>
</tr>
<tr>
<td>20.0</td>
<td>2.2</td>
</tr>
<tr>
<td>24.0</td>
<td>2.9</td>
</tr>
<tr>
<td>24.9</td>
<td>3.9</td>
</tr>
<tr>
<td>25.1</td>
<td>10.1</td>
</tr>
<tr>
<td>26.0</td>
<td>11.1</td>
</tr>
<tr>
<td>30.0</td>
<td>11.8</td>
</tr>
</tbody>
</table>

44. In another trial, 40.0 milliliters of HCl(aq) is completely neutralized by 20.0 milliliters of this 0.10 M NaOH(aq). Calculate the molarity of the titrated acid in this trial. Your response must include both a numerical setup and the calculated result.

45. Write a balanced equation that represents this neutralization reaction.

Base your answers to questions 46 and 47 on the information below.

In a laboratory activity, 0.500 mole of NaOH(s) is completely dissolved in distilled water to form 400. milliliters of NaOH(aq). This solution is then used to titrate a solution of HNO₃(aq).

If 300ml of acid is used in this titration, what is the molarity of the acid? Show all work.

46. Calculate the molarity of the NaOH(aq). Your response must include both a correct numerical setup and the calculated result.

47. Identify the negative ion produced when the NaOH(s) is dissolved in distilled water.

A) CH₃OH(aq)  B) Ca(OH)₂(aq)  C) CH₃COOH(aq)  D) HNO₃(aq)

48. In which 0.01 M solution is phenolphthalein pink?

A) H⁺ donor  B) H⁺ acceptor  C) OH⁻ donor  D) OH⁻ acceptor

50. Which statement describes an alternate theory of acids and bases?

A) Acids and bases are both H⁺ acceptors.  B) Acids and bases are both H⁺ donors.
C) Acids are H⁺ acceptors, and bases are H⁺ donors.  D) Acids are H⁺ donors, and bases are H⁺ acceptors.
A laboratory worker filled a bottle with a hydrochloric acid solution. Another bottle was filled with methanol, while a third bottle was filled with a sodium hydroxide solution. However, the worker neglected to label each bottle. After a few days, the worker could not remember which liquid was in each bottle.

The worker needed to identify the liquid in each bottle. The bottles were labeled A, B, and C. Using materials found in the lab (indicators, conductivity apparatus, and pieces of Mg metal), the worker tested samples of liquid from each bottle. The test results are shown in the table below.

<table>
<thead>
<tr>
<th>Test</th>
<th>Test Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bottle A</td>
</tr>
<tr>
<td>methyl orange indicator</td>
<td>yellow</td>
</tr>
<tr>
<td>bromthymol blue indicator</td>
<td>blue</td>
</tr>
<tr>
<td>electrical conductivity</td>
<td>conductor</td>
</tr>
<tr>
<td>reactivity with Mg metal</td>
<td>no reaction</td>
</tr>
</tbody>
</table>

51. Explain, in terms of pH, why the methyl orange indicator test results were the same for each of the three liquids.

52. The worker concluded that bottle C contained hydrochloric acid. Identify one test and state the corresponding test result that supports this conclusion.

53. Using the test results, state how the worker differentiated the bottle that contained methanol from the other two bottles.

54. Which statement correctly describes a solution with a pH of 9?

A) It has a higher concentration of H₃O⁺ than OH⁻ and causes litmus to turn blue.
B) It has a higher concentration of OH⁻ than H₃O⁺ and causes litmus to turn blue.
C) It has a higher concentration of H₃O⁺ than OH⁻ and causes methyl orange to turn yellow.
D) It has a higher concentration of OH⁻ than H₃O⁺ and causes methyl orange to turn red.

55. The table below shows the color of the indicators methyl orange and litmus in two samples of the same solution.

<table>
<thead>
<tr>
<th>Results of Acid-Base Indicator Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>methyl orange</td>
</tr>
<tr>
<td>litmus</td>
</tr>
</tbody>
</table>

Which pH value is consistent with the indicator results?

A) 1  B) 5  C) 3  D) 10
56. Given the balanced equation representing a reaction:

\[ \text{NH}_3(g) + \text{H}_2\text{O}(l) \rightarrow \text{NH}_4^+(aq) + \text{OH}^-(aq) \]

According to one acid-base theory, the NH\(_3\)(g) molecules act as

A) an acid because they accept H\(^+\) ions
B) an acid because they donate H\(^+\) ions
C) a base because they accept H\(^+\) ions
D) a base because they donate H\(^+\) ions
Answer Key

Solutions and Acids and Bases

1. C
2. A
3. C
4. A
5. A
6. A
7. C
8. C
9. D
10. C
11. B
12. A
13. C
14. D
15. Allow credit for 90 (±2).
16. Allow credit for KCl or potassium chloride.
17. 7; ± 1
18. 9
19. A
20. C
21. 
22. Oxygen molecules are nonpolar and water molecules are polar.
23. The sample is an unsaturated solution.
24. C
25. A
26. blue
27. B
28. C
29. yellow
30. – 6
31. – bromthymol blue – bromcresol green – thymol blue
32. – The beverage is acidic because its pH value is below 7. – A pH of 3 is in the acid range on the pH scale.
33. C
34. C
35. A
36. B
37. D
38. C
39. D
40. C
41. D
42. D
43. C
44. A correct numerical set up is shown. A result of 0.050 M or a response consistent with the student's numerical setup is shown.
45. • NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H₂O(ℓ)
   • HCl + NaOH \rightarrow NaCl + H₂O
   • H⁺(aq) + OH⁻(aq) \rightarrow H₂O(ℓ)
   • H₃O⁺ + OH⁻ \rightarrow 2H₂O
46. Examples: -Methanol does not conduct an electric current. -Bromthymol blue tests blue in a base and yellow in an acid, so bottle B must be methanol. -Bromthymol blue would be green in methanol because methanol is not an acid or a base.
47. OH⁻ or hydroxide ion
48. B
49. A
50. D
51. Examples: -All three solutions have a pH greater than 4.4. -Methyl orange changes to yellow at a pH of 4.4, which is still in the acid range. -A solution with a pH greater than 4.4 could be acidic, basic, or neutral.
52. Examples: -Test: bromthymol blue Test result - yellow ; Test: reactivity with Mg Test result - reaction