

**Instructions (shown before students start the test)**

Welcome to the Chem Lab event for the MI Region 7 January Workshop. Remember this is a non-competitive workshop and no places will be recognized.

This is the workshop practice test to provide students a general feel for the topics and test question types, as well as familiarity with the Scilympiad test platform.

**Introduction (shown after students start the test)**

The test questions should be pretty straightforward. Please do your best and hopefully you will gain some insight into how future tournaments may work.

The questions for this test have been taken from other invitational tests, most notable the Centerville 2020 and UGA 2020 tournaments.

For questions 1-3, which one is the best Lewis Acid in each pair?

1. (1.00 pts) A)  $\text{Al}^{3+}$   
or  
B)  $\text{Na}^+$

- A) A  
 B) B

2. (1.00 pts) A)  $\text{CO}_2$   
or  
B)  $\text{CN}^-$

- A) A  
 B) B

3. (1.00 pts) A)  $\text{BH}_3$   
or  
B)  $\text{NH}_3$

- A) A  
 B) B

The next two questions utilize this information about 3 acids. 0.10 M NaOH is used to titrate 25 mL samples of three weak acids. The acids are of equal concentration. The  $K_a$  values of the acids are shown below:

|        |                      |
|--------|----------------------|
| Acid 1 | $1.0 \times 10^{-4}$ |
| Acid 2 | $1.0 \times 10^{-5}$ |
| Acid 3 | $1.0 \times 10^{-6}$ |

4. (1.00 pts) Which acid will require the most NaOH to reach the equivalence point?

- A) Acid 1  
 B) Acid 2

- C) Acid 3  
 D) The volumes are equal

5. (1.00 pts) Which acid will have the largest pH at the equivalence point?

- A) Acid 1  
 B) Acid 2  
 C) Acid 3  
 D) The pH values are equal

6. (1.00 pts)

$$\text{HCN (aq)} + \text{H}_2\text{O (l)} \rightleftharpoons \text{H}_3\text{O}^+ \text{ (aq)} + \text{CN}^- \text{ (aq)}$$
  
In the equilibrium represented above, the species that act as acids include which of the following?

I.  $\text{CN}^-$

II.  $\text{H}_2\text{O}$

III.  $\text{HCN}$

- A) II only  
 B) III only  
 C) I and II  
 D) I and III  
 E) II and III

For the next two questions, based on structure, predict which acid in each pair would have the greatest  $K_a$  value.

7. (1.00 pts) A)  $\text{HCl}$   
vs.  
B)  $\text{HBr}$

- A) A  
 B) B

8. (1.00 pts) A)  $\text{HClO}_3$   
vs.  
B)  $\text{HClO}_2$

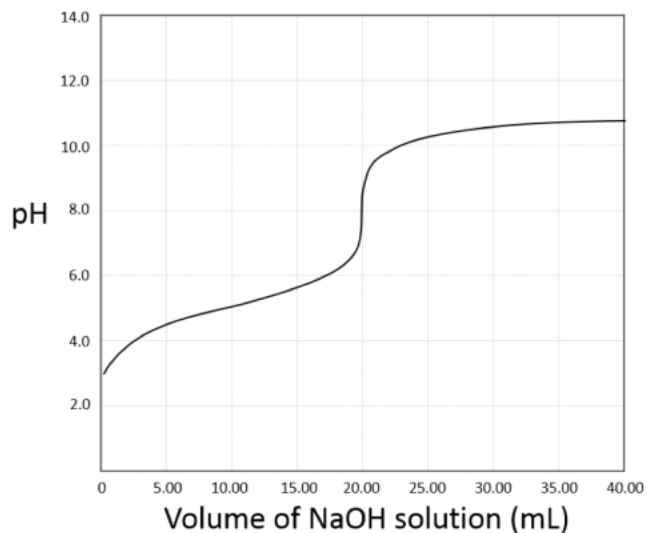
- A) A  
 B) B

9. (1.00 pts) A)  $\text{HClO}_3$   
vs.  
B)  $\text{HBrO}_3$

- A) A  
 B) B

The next TWO questions relate to this titration curve.

The titration curve below represents the titration of a weak acid, HA, with a strong base.



10. (1.00 pts) The best indicator for the acid-base titration above would be \_\_\_\_ . The pH interval for which the indicator changes colors is indicated in parenthesis.

- A) Thymol blue (1.2 - 2.8)
- B) Methyl Red (4.2 - 6.3)
- C) Phenolphthalein (8.3 - 9.8)
- D) Alizarin yellow 66 (10.0 - 12.0)

11. (1.00 pts) The equilibrium constant for the weak acid is....

- A)  $1.3 \times 10^{-3}$
- B)  $1.0 \times 10^{-5}$
- C)  $1.0 \times 10^{-8}$
- D)  $1.0 \times 10^{-9}$

12. (1.00 pts) Consider the data table below of the titration of a weak diprotic acid. Calculate this acid's molar mass.

|  |         |
|--|---------|
| Mass of solid acid                               | 0.561 g |
| Molarity of NaOH                                 | 0.209 M |
| Volume of NaOH needed to reach equivalence point | 55.8 mL |

- A) 48.1 g/mol
- B) 64.0 g/mol
- C) 96.2 g/mol
- D) 192.4 g/mol

13. (1.00 pts) In the titration above, the experimenter got a molar mass that was 5.4% HIGHER than the theoretical value.

Which choice below could account for this error?

- A) After massing the solid acid, the experimenter spilled some of the powder on the table.
- B) There were some droplets of distilled water left in the Erlenmeyer that the experimenter used to titrate with.
- C) The inside of the burette was wet with distilled water when it was filled with the NaOH used to titrate.

D) The experimenter went a few mL's pass the equivalence point.

**14. (1.00 pts)** Which of the following is probably true for a solid solute with a highly endothermic heat of solution when dissolved in water?

- A) The solid has a low lattice energy
- B) As the solute dissolves, the temperature of the solution increases.
- C) The resulting solution is ideal.
- D) The solid would be more soluble at higher temperatures
- E) The solid has a high energy of hydration.

**15. (1.00 pts)** Given that a solution is 5 percent sucrose by mass, what additional information is necessary to calculate the molarity of the solution?

**I. The density of water      II. The density of the solution      III. The molar mass of sucrose**

- A) I only
- B) II only
- C) III only
- D) I and III
- E) II and III

The next four questions concern Colligative Properties. Choose the solution which would depress a freezing point THE MOST.

**16. (1.00 pts)** a. 1.0 M NaBr  
b. 1.0 M Glucose (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>)  
c. the same

- A) A
- B) B
- C) C

**17. (1.00 pts)** a. 1.0 M NaBr  
b. 2.0 M NaBr  
c. the same

- A) A
- B) B
- C) C

**18. (1.00 pts)** a. 1.0 M NaC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>  
b. 1.0 M MgCl<sub>2</sub>  
c. the same

- A) A
- B) B
- C) C

- 19. (1.00 pts)** a. 1.0 M NaBr  
b. 1.0 M NaCl  
c. the same

- A) A  
 B) B  
 C) C

**20. (1.00 pts)** Which situation is an illustration of Henry's Law?

- A) As you increase temperature, sugar becomes more soluble in water.  
 B) After drinking lots of carbonated soda, you might feel a need to belch.  
 C) If a deep sea diver comes up too fast, she runs the risk of getting the bends.  
 D) Increasing the external pressure over a liquid increases its boiling point.  
 E) Adding antifreeze to water lowers the vapor pressure of the solution.

**21. (1.00 pts)** A solution contains equal masses of glucose (molar mass 180 g/mol) and toluene (molar mass 90 g/mol). What is the mole fraction of glucose in the solution?

- A) 1/4  
 B) 1/3  
 C) 1/2  
 D) 2/3  
 E) 3/4

**22. (1.00 pts)** What is the total mass of solute in 1000. grams of a solution having a concentration of 5 parts per million?

- A) 0.005 g  
 B) 0.05 g  
 C) 0.5 g  
 D) 5.0 g  
 E) 50 g

All Done! Hopefully you enjoyed the test and good luck on your other events today. Remember that you can join the virtual meeting to interact with some of the supervisors for today.