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### Multiple-Choice Questions

Circle the letter for the choice that best completes the statement or answers the question.

- Which of the following equations represents the formation of one type of acid rain?
  - $\text{N}_2\text{O}(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow 2\text{HNO}(\text{aq})$
  - $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{SO}_3(\text{g})$
  - $\text{SO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{SO}_3(\text{aq})$
  - $\text{NO}_x + \text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{NO}_x(\text{aq})$
- Acid rain with the same pH fell on two lakes surrounded by different rock types. One lake was damaged and the other was not. Which combination of lake-water pH and type of rock at the unharmed lake is the most probable after the acid rainfall?
  - pH 6.2, limestone
  - pH 8.2, limestone
  - pH 6.2, granite
  - pH 8.2, granite
- Consider the following sources of emissions to the atmosphere.

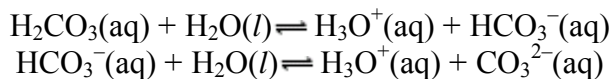
- I** combustion of natural gas
- II** heating certain metal ores
- III** burning coal

Which of these emissions contributes to acid deposition?

- I only
  - I and II only
  - III only
  - I, II, and III
- The hydrogen phosphate ion,  $\text{HPO}_4^{2-}(\text{aq})$  can act as either an acid or a base in terms of the Brønsted-Lowry definitions. In which one of the following reactions is  $\text{HPO}_4^{2-}(\text{aq})$  acting as a base?
    - $\text{HPO}_4^{2-}(\text{aq}) + \text{H}_3\text{O}^+(\text{aq}) \leftrightarrow \text{H}_2\text{PO}_4^-(\text{aq}) + \text{H}_2\text{O}(\text{l})$
    - $\text{HPO}_4^{2-}(\text{aq}) + \text{OH}^-(\text{aq}) \leftrightarrow \text{PO}_4^{3-}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
    - $\text{HPO}_4^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \leftrightarrow \text{PO}_4^{3-}(\text{aq}) + \text{H}_3\text{O}^+(\text{aq})$
    - $\text{HPO}_4^{2-}(\text{aq}) + \text{NH}_3(\text{aq}) \leftrightarrow \text{PO}_4^{3-}(\text{aq}) + \text{NH}_4^+(\text{aq})$
  - All of the following are acid-base conjugate pairs **except**
    - $\text{O}^{2-}, \text{OH}^-$
    - $\text{H}_3\text{PO}_4, \text{H}_2\text{PO}_4^-$
    - $\text{H}_2\text{CO}_3, \text{HCO}_3^-$
    - $\text{HNO}_2, \text{NO}_2^+$

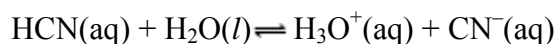
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6. In the following reactions, which are the Brønsted-Lowry acids?



- a)  $\text{HCO}_3^-(\text{aq})$ ,  $\text{H}_2\text{O}(\text{l})$ ,  $\text{CO}_3^{2-}(\text{aq})$
- b)  $\text{H}_2\text{CO}_3(\text{aq})$ ,  $\text{H}_2\text{O}(\text{l})$ ,  $\text{HCO}_3^-(\text{aq})$
- c)  $\text{H}_3\text{O}^+(\text{aq})$ ,  $\text{H}_2\text{O}(\text{l})$ ,  $\text{CO}_3^{2-}(\text{aq})$
- d)  $\text{H}_2\text{CO}_3(\text{aq})$ ,  $\text{H}_3\text{O}^+(\text{aq})$ ,  $\text{HCO}_3^-(\text{aq})$

7. Hydrocyanic acid is a weak acid.



What is the expression for the acid ionization constant?

- a)  $K_a = \frac{[\text{H}_3\text{O}^+][\text{CN}^-]}{[\text{HCN}][\text{H}_2\text{O}]}$
- b)  $K_a = \frac{[\text{H}_3\text{O}^+][\text{CN}^-]}{[\text{HCN}]}$
- c)  $K_a = \frac{[\text{HCN}]}{[\text{H}_3\text{O}^+][\text{CN}^-]}$
- d)  $K_a = \frac{[\text{HCN}][\text{H}_2\text{O}]}{[\text{H}_3\text{O}^+][\text{CN}^-]}$

8. What is the hydroxide ion concentration in a solution that has a pH = 4.80?

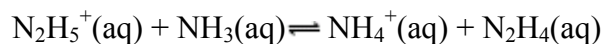
- a) 0.96 mol/L
- b) 0.68 mol/L
- c)  $1.6 \times 10^{-5}$  mol/L
- d)  $6.3 \times 10^{-10}$  mol/L

9. An aqueous solution of hydroxylamine,  $\text{HONH}_2(\text{aq})$ , is a weak base with  $K_b = 1.1 \times 10^{-8}$ . What is the pH of a 0.10 mol/L solution of hydroxylamine?

- a) 4.48
- b) 8.96
- c) 9.52
- d) 7.96

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10. The position of equilibrium lies to the right in the reaction

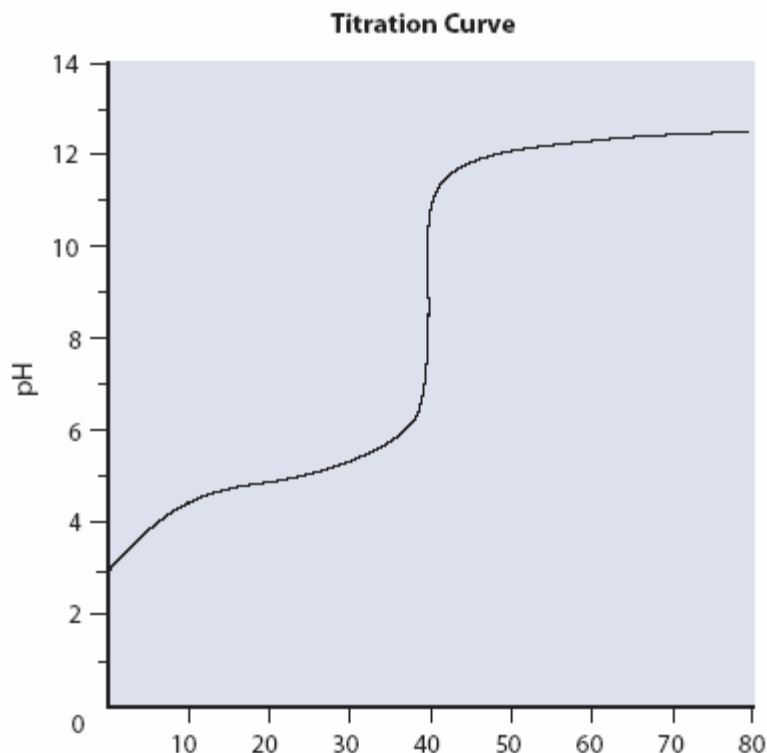


Which is the stronger acid?

- a)  $\text{N}_2\text{H}_5^+(\text{aq})$
  - b)  $\text{NH}_3(\text{aq})$
  - c)  $\text{NH}_4^+(\text{aq})$
  - d)  $\text{N}_2\text{H}_4(\text{aq})$
11. A 0.200 mol/L solution of an acid having the general formula HA is 10.0 percent ionized in aqueous solution. What is the mathematical expression for the calculation of the  $K_a$  for this acid?
- a)  $\frac{0.04}{0.02}$
  - b)  $\frac{0.02 \times 0.02}{0.18}$
  - c)  $\frac{0.01 \times 0.01}{0.20}$
  - d)  $\frac{0.02 \times 0.02}{0.16}$
12. What concentration of an aqueous solution of benzoic acid ( $K_a = 6.3 \times 10^{-5}$ ) produces a hydronium ion concentration of  $2.0 \times 10^{-3}$  mol/L?
- a) 0.032 mol/L
  - b) 0.063 mol/L
  - c) 16 mol/L
  - d) 32 mol/L
13. Methyl red is a commonly used acid-base indicator. The colour change for methyl red occurs between pH 4.6 (red) and pH 6.0 (yellow). If this indicator is added to a solution and the colour is yellow, which of the following statements about the solution is true?
- a) The solution is acidic.
  - b) The pH is between 4.6 and 6.0.
  - c) The pH is greater than 6.0.
  - d) The solution is basic.

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14. In an acid-base titration, 0.10 mol/L acid was placed in a flask and titrated against 0.10 mol/L base. Which pair of aqueous solutions would result in a titration curve like the one shown below?



- a)  $\text{H}_2\text{SO}_4(\text{aq})$  and  $\text{NaOH}(\text{aq})$   
b)  $\text{HNO}_3(\text{aq})$  and  $\text{NH}_3(\text{aq})$   
c)  $\text{HF}(\text{aq})$  and  $\text{NH}_3(\text{aq})$   
d)  $\text{CH}_3\text{COOH}(\text{aq})$  and  $\text{KOH}(\text{aq})$
15. Which pair of aqueous 1.0 mol/L solutions could be chosen to prepare a buffer?
- I**  $\text{NH}_4\text{Cl}(\text{aq})$  and  $\text{HCl}(\text{aq})$   
**II**  $\text{HF}(\text{aq})$  and  $\text{NaF}(\text{aq})$   
**III**  $\text{NH}_4\text{Cl}(\text{aq})$  and  $\text{NH}_3(\text{aq})$
- a) I only  
b) II only  
c) II and III only  
d) None of the solutions will be a buffer

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**Numerical Response Questions**

For each numerical response question, record the answer in the following response box.

16.	19.
17.	20.
18.	21.

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16. Calculate the pH of the following solutions.

a) a solution that contains  $4.8 \times 10^{-2}$  mol/L hydrochloric acid

b) an aqueous solution that is  $5.82 \times 10^{-3}$  mol/L sodium hydroxide

17. A solution has a pH of 3.89. What is the concentration of hydronium ion and hydroxide ion in the solution?

18. The active ingredient in Aspirin™ is acetylsalicylic acid,  $\text{HC}_9\text{H}_7\text{O}_4$  ( $K_a = 2.75 \times 10^{-5}$ ). To treat your headache after writing exams, you take two tablets dissolved in 250 mL of water. If each tablet contains 0.32 g acetylsalicylic acid, find the pH of the solution.

19. Hydrazine,  $\text{N}_2\text{H}_4$ , is a base in aqueous solution. A 0.20 mol/L solution of hydrazine in water has  $\text{pH} = 10.77$ . What is  $K_b$  for hydrazine?

20. The two acid ionization constants for oxalic acid,  $\text{HOCCOOH}$ , are  $K_{a1} = 5.6 \times 10^{-2}$  and  $K_{a2} = 1.5 \times 10^{-4}$ . What is the base dissociation constant,  $K_b$ , for  $\text{OCCOO}^{2-}(\text{aq})$ ?

21. Sodium azide,  $\text{NaN}_3(\text{s})$  has many uses. It is the chemical used to make automobile air bags inflate with  $\text{N}_2(\text{g})$ , and it is sometimes added to water to kill bacteria. What is the pH of a 0.010 mol/L aqueous solution of  $\text{NaN}_3(\text{aq})$ ? Only the azide ion,  $\text{N}_3^-(\text{aq})$ , affects the pH of water. For hydrazoic acid,  $\text{HN}_3(\text{aq})$ ,  $K_a = 1.9 \times 10^{-5}$ .

**Written Response Questions**

Answer each question in the space provided. Use complete sentences and diagrams when necessary.

22. a) Imagine that you have collected a sample of rainwater in your community. The pH of your sample is 4.5. At a community meeting where none of the residents has a background in chemistry, you must explain your findings. In a short paragraph, write what you would say at this meeting.

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- b) Suggest a possible factor that could be responsible for the pH you measured. What observations would you want to collect to help you gain confidence that this factor is responsible?

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23. Explain how the composition of soil can modify the effects of acid deposition. List three effects of acid deposition on the environment.

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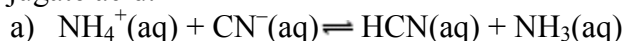
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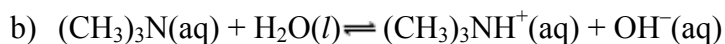
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24. For each of the following reactions, identify the acid, the base, the conjugate base, and the conjugate acid.



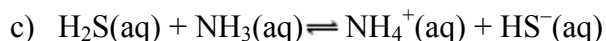
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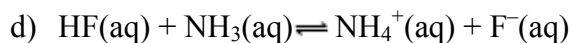
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25. The hydrogen ascorbate ion,  $\text{HC}_6\text{H}_6\text{O}_6^-(\text{aq})$  is amphiprotic. Illustrate this property by writing Brønsted-Lowry equations for acid-base reactions with water.

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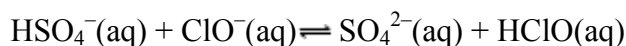
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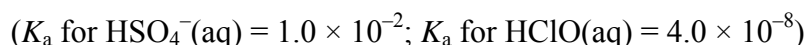
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26. In aqueous solution, the hydrogen sulfate ion,  $\text{HSO}_4^-(\text{aq})$ , reacts with the hypochlorite ion,  $\text{ClO}^-(\text{aq})$ .



At equilibrium, are products or reactants favoured? Explain your reasoning.



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27. Do you agree or disagree with the following statement: "The amount of acid present, not its strength, determines the equivalence point of the titration. The pH at equivalence depends on the strength of the acid used." Explain.

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28. Sketch two pH curves, one for the titration of a strong acid with a weak base and one for a weak acid with a strong base. How are the curves different? How are they the same?

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29. Explain why an aqueous mixture of  $\text{Na}_2\text{SO}_4$  and  $\text{H}_2\text{SO}_4$  does not act as a buffer, but an aqueous mixture of  $\text{NH}_3$  and  $(\text{NH}_4)_2\text{SO}_4$  does.

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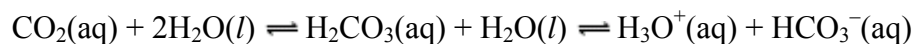
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30. The most important buffer system in the blood depends on the equilibrium between hydrogen carbonate ions and carbonate ions.



- a) How does hyperventilating (very rapid and deep breathing) affect blood pH?

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- b) Hyperventilating often causes dizziness. The usual treatment for hyperventilation is to have the patient breathe into a paper bag. Explain why this treatment is effective.

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