Adapted From-Acids and Bases-Concept Review Questions

(McMurry, **Fundementals of General, Organic, and Biological Chemistry**)

These are acid base questions that you should be able to answer by referring to the class notes or using what you know about chemistry and intermolecular reactions. There are a few ideas that we were going to go over in Discussion that were not addressed because of the Stoichiometry Retest.

1) These are rules for predicting Lowry-Brønsted acids and bases. Most of the time you can use the following concepts to make your decision

> **1) In order for a molecule to serve as a Lowry- Brønsted base it needs to form a covalent bond with a proton (H+). Since a proton has no electrons, and a covalent bond needs two electrons the Lowry-Bronsted base needs to have a loan pair of electrons.**
> **2) A Lowry- Brønsted acid must have a proton that it can give up.**
> **3) Something that has a negative charge is unlikely to be a strong Lowry-Brønsted acid.**
> **4) All of the acids composed of a halogen (F,Cl, Br, I) and a hydrogen, are strong acids.**

2) When an acid and a base react the acid loses a proton. Often this means that the acid takes on a negative charge when it loses a proton. The negative ion produced from the acid can then join with positive ions in the solution to form a salt.

For example the reaction between acetic acid and the base NaOH forms the salt sodium acetate. In terms of Lowry- Brønsted acid/base definitions, the salt, sodium acetate is the conjugate base of acetic acid.

$$NaOH + CH_3COOH \text{ --> } NaCH_3COO + H2O$$

The reaction between sodium hydroxide and sulfuric acid forms the salt sodium sulfate. In this case sulfuric acid and sodium sulfate are the conjugate acid base pair.

$$2NaOH + H_2SO_4 \text{--> } Na_2SO_4 + H_2O$$

When a buffer is made it is usually prepared with a nearly equal combination of an acid and its conjugate base. For example a buffer, with a pH of 4.8, can be prepared using acetic acid and its conjugate base sodium acetate.

(How to name the salts of the acids was described when ionic compounds were discussed and polyatomic ions were introduced. At this point it probably makes sense to go back and review the names of the polyatomic ions that you were given to memorize.)

3. In an acidic solution $[H^+] > [OH^-]$ and the $[H^+]$ is greater than $1x10^{-7}$ M. In a basic solution and $[H^+] < [OH^-]$ and $[H^+]$ is less than $1x10^{-7}$ M.

In all of the questions concentrations are given in molar units.

An answer key is available for these multiple choice questions.

1) Which statement concerning Arrhenius acid-base theory are correct?
   A) An Arrhenius acid produces hydrogen ions in water solution.
   B) An Arrhenius base produces hydroxide ions in water solution
   C) A neutralization reaction produces water
   D) Acid-base reactions must take place in aqueous solution.
   E) all of the above

2) A Bronsted-Lowry acid is a substance which
   A) produces hydrogen ions in aqueous solution.
   B) produces hydroxide ions in aqueous solution.
   C) donates protons to other substances.
   D) accepts protons from other substances.
   E) accepts hydronium ions from other substances.

3) A Bronsted-Lowry base is a substance which
   A) produces hydrogen ions in aqueous solution.
   B) produces hydroxide ions in aqueous solution.
   C) donates protons to other substances.
   D) accepts protons from other substances.

4) A necessary requirement for a Bronsted-Lowry base is
   A) the presence of water as a reaction medium.
   B) the presence of hydroxide in its formula.

C) a lone pair of electrons in its Lewis dot structure.
D) the production of hydronium ion upon reaction with water.
E) the presence of a metal ion in its formula.

5) The base forms a new _____ bond in a Bronsted-Lowry acid-base reaction.
A) covalent
B) aquo
C) hydrogen
D) ionic

6) According to Bronsted-Lowry theory, acid-base reactions can be described as ____reactions.
A) electrolytic
B) electron transfer
C) gas phase
D) nuclear transfer
E) proton transfer

7) $C_5H_5N + H_2CO_3 \rightleftharpoons C_5H_6N^+ + HCO_3^-$
In the reaction shown, the conjugate acid of C_5H_5N is _____.
A) C_5H_5N
B) H_2CO_3
C) $C_5H_6N^+$
D) HCO_3^-
E) H_3O^+

8) Which of the following **cannot** act as a Bronsted base?
A) HCO_3^-
B) CO_3^{2-}
C) NH_3
D) NH_2^-
E) NH_4^+

9) Ammonia reacts with acids because
A) it contains the hydroxide group.
B) it is neutral.
C) it is itself an acid.
D) it is a salt.
E) it contains a lone pair of electrons.

10) What is the conjugate acid of HSO_4^-?

A) SO_4^{2-}

B) H_2SO_4

C) H_3O^+

D) OH^-

E) H_2SO_3

11) Which statement is correct for pure water?

A) Pure water contains equal amounts of hydroxide, [OH^-], and hydronium, [H_3O^+], ions.

B) Pure water contains larger amounts of hydroxide, [OH^-], ions than hydronium, [H_3O^+], ions.

C) Pure water contains larger amounts of hydronium, [H_3O^+], ions than hydroxide, [OH^-], ions.

E) Pure water contains no ions.
(In this context [H_3O^+] is the same as [H^+])

12) Which **net ionic equation** correctly represents the neutralization of a solution of barium hydroxide by a solution of nitric acid? (HNO_3 is a strong acid.)

A) $Ba^{2+} + 2\ NO_3^- \rightarrow Ba(NO_3)_2$

B) $H^+ + NO_3^- \rightarrow HNO_3$

C) $Ba^{2+} + 2\ OH^- \rightarrow Ba(OH)_2$

D) $H^+ + OH^- \rightarrow H_2O$

E) $Ba(NO_3)_2 + H_2O \rightarrow Ba^{2+} + 2\ NO_3^-$

13) Which substance produces carbon dioxide and water upon reaction with an acid? (Refer to your lab work, or the discussion of this type of reaction using acetic acid in the thermodynamics presentation.)

A) $NaCH_3CO_2$

B) NH_4NO_3

C) $MgCO_3$

D) $H_2C_2O_4$

E) C_8H_{18}

14) Which equation correctly represents the neutralization of aluminum hydroxide by sulfuric acid? (Sulfuric Acid is H2SO4. Aluminum hydroxide is $Al(OH)_3$)

A) $2\ Al(OH)_3 + 3\ H_2SO_4 \Rightarrow Al_2(SO_4)_3 + 3\ H_2O$

B) $Al(OH)_3 + H_3SO_4 \Rightarrow AlSO_4 + 3\ H_2O$

C) $Al(OH)_2 + H_2SO_4 \Rightarrow AlSO_4 + 2\ H_2O$

D) $2\ Al(OH)_3 + 3\ H_2SO_4 \Rightarrow Al_2(SO_4)_3 + 6\ H_2O$

E) $3\ Al(OH)_3 + 2\ H_3SO_4 \Rightarrow Al_3(SO_4)_2 + 6\ H_2O$

15) The **net ionic equation** for the reaction of formic acid (HCO_2H), a weak acid,with potassium hydroxide, a strong base, is

A) $HCO_2H\ (aq) + KOH\ (aq) \rightleftharpoons KHCO_2\ (aq) + H_2O\ (l)$

B) $HCO_2H\ (aq) + K^+\ (aq) + OH^-\ (aq) \rightleftharpoons K^+\ (aq) + HCO_2^-\ (aq) + H_2O\ (l)$

C) $HCO_2H\ (aq) + OH^-\ (aq) \rightleftharpoons HCO_2^-\ (aq) + H_2O\ (l)$

D) $HCO_2^-\ (aq) + KOH\ (aq) \rightleftharpoons KHCO_2\ (aq) + OH^-\ (aq)$

E) $H^+\ (aq) + HCO_2^-\ (aq) + K^+\ (aq) + OH^-\ (aq) \rightleftharpoons K^+\ (aq) + HCO_2^-\ (aq) + H_2O\ (l)$

16) Acetic acid is a weak acid in water because it is
A) dilute.
B) only slightly soluble.
C) unable to hold onto its hydrogen ion.
D) only slightly dissociated into ions.
E) completely dissociated into hydronium ions and acetate ions.

17) Hydrogen cyanide, HCN, is a weak acid. Which equation **best** represents its aqueous chemistry?
A) $HCN\ (aq) + H_2\ (l) \rightleftharpoons CN^-\ (aq) + H_3O_+\ (aq)$
B) $HCN\ (aq) + H_2\ (l) \rightleftharpoons H_2CN^+\ (aq) + OH^-\ (aq)$
C) $HCN\ (aq) \rightleftharpoons H^+\ (aq) + CN^-\ (aq)$
D) $HCN\ (aq) \rightleftharpoons H^-\ (aq) + CN^+\ (aq)$
E) $H_2O\ (l) \rightleftharpoons H^+\ (aq) + OH^-\ (aq)$

18) Which of the following is a strong acid? (Eliminate the ones that you are not strong acids, for reasons given at the beginning of this exercise.)
A) HNO_3
B) NH_3
C) NaCl
D) HCO_3^-
E) H_2O

19) Which of the following is a weak acid?
A) CH_3COOH
B) $CaCl_2$
C) NH_3
D) HCl
E) OH^-

20) Which reaction **best** illustrates the behaviour of the **weak base** $H_2PO_4^-$ in aqueous solution?
A) $H_2PO_4^-\ (aq) + H_2O\ (l) \rightleftharpoons HPO_4^{2-}\ (aq) + H_3O^+\ (aq)$
B) $H_2PO_4^-\ (aq) + H_2O\ (l) \rightleftharpoons H_3PO_4\ (aq) + OH^-\ (aq)$
C) $H_2PO_4^-\ (aq) \rightleftharpoons 2\ H+\ (aq) + PO_4^{3-}\ (aq)$
D) $H_2PO_4^-\ (aq) \rightleftharpoons H+\ (aq) + HPO_4^{2-}\ (aq)$
E) $H_2PO_4^-\ (aq) + H^+\ (aq) \rightleftharpoons H_3PO_4\ (aq)$

21) Which solution is basic? (Look at the power points slides that introduce the relationship beteen pH and the proton concentration, and the one that discussed the composition of a neutral solution.)
A) $[H_3O_+] = 1.0 \times 10^{-4}$
B) $[H_3O_+] = 1.0 \times 10^{-7}$
C) $[H_3O_+] = 1.0 \times 10^{-10}$
D) $[OH^-] = 1.0 \times 10^{-7}$
E) $[OH^-] = 1.0 \times 10^{-10}$

22) In water solution that is **basic**, $[H_3O_+]$ is _____ than 1.0×10^{-7}, and _____ than $[OH^-]$.

A) greater; less
B) less; greater
C) greater; greater
D) less; less
E) none of the above

23) Which example is **not** acidic?
A) orange juice
B) soil for azaleas with pH of 4.8
C) a solution of NH_4NO_3 with pH < 7.00
D) lake water that turns blue litmus to red (Refer to your labwork)
E) a solution in which $[H_3O^+] = 1.00 \times 10^{-7}$

24) Which of the following statements is correct?
A) In an acidic solution, $[H_3O^+] < 10^{-7}$; $[OH^-] > [H_3O^+]$
B) In an acidic solution, $[H_3O^+] > 10^{-7}$; $[OH^-] > [H_3O^+]$
C) In an acidic solution, $[H_3O^+] > 10^{-7}$; $[OH^-] = [H_3O^+]$
D) In an acidic solution, $[H_3O^+] < 10^{-7}$; $[OH^-] > [H_3O^+]$
E) In an acidic solution, $[H_3O^+] > 10^{-7}$; ; $[OH^-] < [H_3O^+]$.

25) What is the conjugate base of water?
A) H_2O (l)
B) H_3O^+ (aq)
C) OH^- (aq)
D) H^+ (aq)
E) O_2^- (aq)

26) What is the conjugate acid of water?
A) H_2O (l)
B) H_3O^+ (aq)
C) OH^- (aq)
D) H^+ (aq)
E) O_2^- (aq)

27) Which of the following statements is correct?
A) In a basic solution, $[H_3O^+] < 10^{-7}$; $[OH^-] < 10^{-7}$.
B) In a basic solution, $[H_3O^+] > 10^{-7}$; $[OH^-] > 10^{-7}$.
C) In a basic solution, $[H_3O^+] > 10^{-7}$; $[OH^-] < 10^{-7}$.
D) In a basic solution, $[H_3O^+] < 10^{-7}$; $[OH^-] > 10^{-7}$.
E) In a basic solution, $[H_3O^+] > 10^{-7}$; $[OH^-] = 10^{-7}$.

28) If the $[H^+]$ of a water sample is 1×10^{-4} M, the pH of the sample is _____, and the sample is _____.
A) -4; acidic
B) 4; acidic
C) 4; basic
D) 10; basic
E) -10; basic

29) Which of the following pH's corresponds to a strongly basic solution?
A) 11.5
B) 2.7
C) 6.9
D) 7.4

E) 4.3

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30) Which of the following pH's corresponds to a neutral solution?

A) 7.0
B) 1.8
C) 6.2
D) 8.5
E) 14.0

31) Which of the following pH's corresponds to a weakly acidic solution?
A) 5.3
B) 1.4
C) 7.8
D) 9.2
E) 11.5

32) A buffer solution
A) is a salt solution.
B) maintains pH at 7.00.
C) is a strong base.
D) neutralizes only acids.
E) closely maintains its original pH.

33) The pH of a 250. mL sample of a buffer solution is 9.85. If 1.0 mL of 6 M HCl is added, the pH of the resulting mixture is closest to
A) 0.00
B) 1.65
C) 7.00
D) 9.70
E) 10.00

34) Which of the following solutions is a buffer?
A) a solution of acetic acid and sodium acetate
B) a solution of acetic acid and sodium sulfate
C) a solution of hydrochloric acid and sodium sulfate
D) a solution of hydrochloric acid and sodium acetate
E) a solution of sulfuric acid and sodium sulfate