KEY: Acids, Bases, and Salts
Review for Sections 4.1 – 4.15

1. Consider the following:

I $H_2CO_3 + F^- \leftrightarrows HCO_3^- + HF$
II $HCO_3^- + HC_2O_4^- \leftrightarrows H_2CO_3 + C_2O_4^{2-}$
III $HCO_3^- + H_2C_6H_6O_7^- \leftrightarrows H_2CO_3 + HC_6H_5O_7^{2-}$

The HCO_3^- is a base in

A. I only
B. I and II only
C. II and III only
D. I, II, and III

2. The volume of 0.200 M $Sr(OH)_2$ needed to neutralize 50.0 mL of 0.200 M HI is

A. 10.0 mL
B. 25.0 mL
C. 50.0 mL
D. 100.0 mL

3. The pOH of 0.050 M HCl is

A. 0.050
B. 1.30
C. 12.70
D. 13.70

4. The volume of 0.450 M HCl needed to neutralize 40.0 mL of 0.450 M $Sr(OH)_2$ is

A. 18.0 mL
B. 20.0 mL
C. 40.0 mL
D. 80.0 mL

5. Consider the following

I H_3PO_4 II $H_2PO_4^-$ III HPO_4^{2-} IV PO_4^{3-}

Which of the following solutions will have the largest $[H_30^+]$?

A. I and II only
B. II and III only
C. I, II, and III only
D. II, III, and IV only

6. Which of the following solutions will have the largest $[H_3O^+]$?

A. 1.0 M HNO_2
B. 1.0 M HBO_3
C. 1.0 M $H_2C_2O_4$
D. 1.0 M HCOOH

7. Consider the following: $H_2O + 57\ kJ \leftrightarrows H_3O^+ + OH^-$

When the temperature of the system is increased, the equilibrium shifts

A. left and the Kw increases
B. left and the Kw decreases
C. right and the Kw increases
D. right and the Kw decreases

8. A 1.0 M solution of sodium dihydrogen phosphate is

A. acidic and the pH < 7.00
B. acidic and the pH > 7.00
C. basic and the pH < 7.00
D. basic and the pH > 7.00

9. A Bronsted-Lowry base is defined as a chemical species that

A. accepts protons
B. neutralizes acids
C. donated electrons
D. produces hydroxides ions in solution

10. Which of the following solutions will have the greatest electrical conductivity?

A. 1.0 M HCN
B. 1.0 M H_2SO_4
C. 1.0 M H_3PO_4
D. 1.0 M CH_3COOH

11. Consider the following equilibrium: $HC_6H_5O_7^{2-} + HIO_3 \leftrightarrows H_2C_6H_5O_7^{-} + IO_3^{-}$

The order of Bronsted-Lowry acids and bases is

A. acid, base, acid, base
B. acid, base, base, acid
C. base, acid, acid, base
D. base, acid, base acid

12. Consider the following: $H_2O_{(l)} \leftrightarrows H^+ + OH^-$

When a small amount of 1.0 M KOH is added to the above system, the equilibrium

A. shifts left and $[H^+]$ decreases
B. shifts left and $[H^+]$ increases
C. shifts right and $[H^+]$ decreases
D. shifts right and $[H^+]$ increases

13. Which of the following has the highest pH?

A. 1.0 M $NaIO_3$
B. 1.0 M Na_2CO_3
C. 1.0 M Na_3PO_4
D. 1.0 M Na_2SO_4

14. In a 100.0 mL sample of 0.0800 M NaOH the $[H_3O^+]$ is

A. 1.25×10^{-13} M
B. 1.25×10^{-12} M
C. 8.00×10^{-3} M
D. 8.00×10^{-2} M

15. Consider the following:

I ammonium nitrate II calcium nitrate III iron III nitrate

When dissolved in water, which of these salts would form a neutral solution?

A. II only
B. III only
C. I and III only
D. I, II, and III

16. Consider the following: $SO_4^{2-} + HNO_2 \leftrightarrows HSO_4^- + NO_2^-$

Equilibrium would favour the

A. the products since HSO_4^- is a weaker acid than HNO_2
B. the reactants since HSO_4^- is a weaker acid than HNO_2
C. the products since HSO_4^- is a stronger acid than HNO_2
D. the reactants since HSO_4^- is a stronger acid than HNO_2

17. The net ionic equation for the hydrolysis of Na_2CO_3 is

A. $H_2O + Na^+ \leftrightarrows NaOH + H^+$
B. $H_2O + 2Na^+ \leftrightarrows Na_2O + 2H^+$
C. $H_2O + CO_3^{2-} \leftrightarrows H_2CO_3 + O^{2-}$
D. $H_2O + CO_3^{2-} \leftrightarrows HCO_3^- + OH^-$

18. Consider the following equilibrium: $2H_2O_{(l)} \leftrightarrows H_3O^+ + OH^-$

A few drops of 1.0 M HCl are added to the above system. When equilibrium is re-established, the

A. $[H_3O^+]$ has increased and the $[OH^-]$ has decreased
B. $[H_3O^+]$ has increased and the $[OH^-]$ has increased
C. $[H_3O^+]$ has decreased and the $[OH^-]$ has increased
D. $[H_3O^+]$ has decreased and the $[OH^-]$ has decreased

19. A basic solution

A. tastes sour
B. feels slippery
C. does not conduct electricity
D. reacts with metals to release oxygen gas

20. The balanced formula equation for the neutralization of H_2SO_4 by KOH is

A. $H_2SO_4 + KOH \rightarrow KSO_4 + H_2O$
B. $H_2SO_4 + KOH \rightarrow K_2SO_4 + H_2O$
C. $H_2SO_4 + 2KOH \rightarrow K_2SO_4 + H_2O$
D. $H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$

21. An Arrhenius base is defined as a substance which

A. donates protons
B. donates electrons
C. produces H^+ in solution
D. produces OH^- in solution

22. Consider the following equilibrium: $HS^- + H_3PO_4 \leftrightarrows H_2S + H_2PO_4^-$
The order of Bronsted-Lowry acids and bases is

A. acid, base, acid, base.
B. acid, base, base, acid
C. base, acid, acid, base
D. base, acid, base, acid

23. The equation representing the reaction of ethanoic acid with water is

A. $CH_3COO^- + H_2O \leftrightarrows CH_3COOH + OH^-$
B. $CH_3COO^- + H_2O \leftrightarrows CH_3COO^{2-} + H_3O^+$
C. $CH_3COOH + H_2O \leftrightarrows CH_3COO^- + H_3O^+$
D. $CH_3COOH + H_2O \leftrightarrows CH_3COOH_2^+ + OH^-$

24. Consider the following equilibrium: $2H_2O + 57kJ \leftrightarrows H_3O^+ + OH^-$

When the temperature is decreased, the water

A. stays neutral and the $[H_3O^+]$ increases
B. stays neutral and the $[H_3O^+]$ decreases
C. becomes basic and $[H_3O^+]$ decreases
D. becomes acidic and $[H_3O^+]$ increases

25. The conjugate acid of $C_6H_50^-$ is

A. $C_6H_4O^-$
B. C_6H_5OH
C. $C_6H_4O^{2-}$
D. $C_6H_5OH^+$

26. Which of the following solutions will have the greatest electrical conductivity?

A. 1.0 M HCl
B. 1.0 M HNO_2
C. 1.0 M H_3BO_3
D. 1.0 M HCOOH

27. A solution of 1.0 M HF has

A. a lower pH than a solution of 1.0 M HCl
B. a higher pOH than a solution of 1.0 M HCl
C. a higher $[OH^-]$ than a solution of 1.0 M HCl
D. a higher $[H_3O^+]$ than a solution of 1.0 M HCl

28. Which of the following is the weakest acid

A. HIO_3
B. HCN
C. HNO_3
D. C_6H_5COOH

29. Considering the following data

H_3AsO_4 Ka = 5.0×10^{-5}
$H_2AsO_4^-$ Ka = 8.0×10^{-8}
$HAsO_4^{2-}$ Ka = 6.0×10^{-10}

The Kb value for $H_2AsO_4^-$ is

A. 2.0×10^{-10}
B. 8.0×10^{-8}
C. 1.2×10^{-7}
D. 1.7×10^{-5}

30. In a solution at 25°C, the $[H_3O^+]$ is 3.5×10^{-6} M. The $[OH^-]$ is

A. 3.5×10^{-20} M
B. 2.9×10^{-9} M
C. 1.0×10^{-7} M
D. 3.5×10^{-6} M

31. In a solution with a pOH of 4.22, the [OH-] is

A. 1.7×10^{-10} M
B. 6.0×10^{-5} M
C. 6.3×10^{-1} M
D. 1.7×10^{4} M

32. An aqueous solution of NH_4CN is

A. basic because Ka < Kb
B. basic because Ka > Kb
C. acidic because Ka < Kb
D. acidic because Ka > Kb

33. The net ionic equation for the predominant hydrolysis reaction of $KHSO_4$ is

A. $HSO_4^- + H_2O \leftrightarrows SO_4^{2-} + H_3O^+$
B. $HSO_4^- + H_2O \leftrightarrows H_2SO_4 + OH^-$
C. $KHSO_4 + H_2O \leftrightarrows K^+ + SO_4^{2-} + H_3O^+$
D. $KHSO_4 + H_2O \leftrightarrows K^+ + H_2SO_4 + OH^-$

34. The $[OH^-]$ in an aqueous solution always equals

A. Kw x $[H_3O^+]$
B. Kw - $[H_3O^+]$
C. Kw/$[H_3O^+]$
D. $[H_3O^+]$/Kw

35. The $[H_3O^+]$ in a solution with pOH of 0.253 is

A. 5.58×10^{-15} M
B. 1.79×10^{-14} M
C. 5.58×10^{-1} M
D. 5.97×10^{-1} M

36. The equilibrium expression for the hydrolysis reaction of 1.0 M K_2HPO_4 is

A. $\frac{[H_2PO^{42-}][OH^-]}{[HPO_4^-]}$ B. $\frac{[H_3PO_4][OH^-]}{[H_2PO_4^-]}$

C. $\frac{[K^+]\,[KHPO_4^-]}{[K_2HPO_4]}$ D. $\frac{[K^+]^2\,[HPO_4^{2-}]}{[K_2HPO_4]}$

37. The solution with the highest pH is

A. 1.0 M NaCl
B. 1.0 M NaCN
C. 1.0 M $NaIO_3$
D. 1.0 M Na_2SO_4

38. The pH of 100.0 mL of 0.0050 M NaOH is

A. 2.30
B. 3.30
C. 10.70
D. 11.70

Written Response Practice

1. a) Write the net ionic equation for the reaction between $NaHSO_3$ and $NaHC_2O_4$.

$HSO_3^- + HC_2O_4^- \leftrightarrows H_2SO_3 + C_2O_4^{2-}$

b) Explain why the reactants are favoured in the above reaction.

H_2SO_3 is a stronger acid than $HC_2O_4^-$

2. What is the $[H_3O^+]$ in a solution formed by adding 60.0 mL of water to 40.0 mL of 0.400 M KOH?

KOH → K^+ + OH^-

$\frac{40}{100}$ x 0.400 M **0.160 M** **0.160 M**

$[H^+][OH^-] = 1.0 \times 10^{-14}$ **$[H^+] = 6.3 \times 10^{-14}$ M**

3. Calculate the pH of the solution formed by mixing 20.0 mL of 0.500 M HCl with 30.0 mL of 0.300 M NaOH.

HCl + NaOH → NaCl + H_2O

0.200 L x 0.500 $\frac{\text{mole}}{\text{L}}$ = 0.01000 mole HCl **0.300 L x 0.300 $\frac{\text{mole}}{\text{L}}$ = 0.00900 mole NaOH**

Total new volume = 20.0 mL + 30.0 mL = 50.0 mL = 0.0500 L

$$[H^+] = \frac{0.0010 \text{ moles}}{0.0500 \text{ L}} = 0.020 \text{ M}$$

pH = 1.70

4. a) Write the balanced equation representing the reaction of HF with H_2O.

$HF + H_2O \leftrightarrows H_3O^+ + F^-$

b) Identify the Bronsted-Lowry bases in the above equation.

H_2O and F^-

5. Consider the following data:

Barbituric acid	$HC_4H_3N_2O_3$	Ka = 9.8×10^{-5}
Sodium propanoate	$NaC_3H_5O_2$	Kb = 7.5×10^{-10}
Propanoic acid	$HC_3H_5O_2$	Ka = ?

Which is the stronger acid, propanoic acid or babituric acid? Explain using calculations.

$Ka\ (HC_4H_3N_2O_3) = \frac{Kw}{Kb(C_3H_5O_2^-)} = \frac{1.0 \times 10^{-14}}{7.5 \times 10^{-10}} = 1.3 \times 10^{-5}$

Barbituric acid is a stronger acid because it has a larger Ka.

6. a) Write equations showing the amphiprotic nature of water as it reacts with HCO_3^-.

$HCO_3^- + H_2O \leftrightarrows H_3O^+ + CO_3^{2-}$

$HCO_3^- + H_2O \leftrightarrows H_2CO_3 + OH^-$

b) Calculate the Kb for HCO_3^-.

$Kb\ (HCO_3^-) = \frac{Kw}{Ka(H_2CO_3)} = \frac{1.0 \times 10^{-14}}{4.3 \times 10^{-7}} = 2.3 \times 10^{-8}$