KEY

Acids Bases and Salts Review

1. Complete the Bronsted-Lowry equilibria which occur when the following pairs of substances are mixed in solution.

a. $HSO_3^- + HC_6H_5O_7^{2-} \rightleftharpoons H_2SO_3 + C_6H_5O_7^{3-}$ (H+ stronger A)

b. $HCO_3^- + HC_2O_4^- \rightleftharpoons H_2CO_3 + C_2O_4^{2-}$ (H+ stronger A)

2. List the following ACIDS in decreasing order of strength: CH_3COOH, HNO_2, $HClO_4$ and HCO_3^-.

$HClO_4 \rightarrow HNO_2 \rightarrow CH_3COOH \rightarrow HCO_3^-$

3. Complete the Bronsted-Lowry equilibrium and then determine whether reactants or products are favoured. Explain your answer.

$CH_3COOH + CO_3^{2-} \rightleftharpoons CH_3COO^- + HCO_3^-$

Products are favoured

b/c CH_3COOH is stronger acid than HCO_3^-

$K_a = 1.8\times10^{-5} > K_a = 5.6\times10^{-11}$

CO_3^{2-} is stronger base than CH_3COO^-

4. Calculate the K_b for $Fe(H_2O)_5(OH)^{2+}$.

$$K_b = \frac{K_w}{K_a(\text{conj acid})} = \frac{1.0\times10^{-14}}{6.0\times10^{-3}} = 1.67\times10^{-12}$$

5. Fill in the missing values. Show ONE sample calculation for each column.

Solution	$[H_3O^+]$	$[OH^-]$	pH	pOH
water	1.0×10^{-7}	1.0×10^{-7}	7.00	7.00
2sf 0.10 M HCl	0.10	$\frac{1\times10^{-14}}{0.10} = 1.0\times10^{-13}$	1.00*	13.00
2sf 0.010 M NaOH	antilog(-pH) 1.0×10^{-12}	0.010	12.00	pOH = 14 − pH 2.00
1sf 0.10 M Na_2O	$\frac{1\times10^{-14}}{0.10} = 1\times10^{-13}$	0.10	pH = 14 − pOH 13.0	pOH = −log(0.10) 1.0

(*2sf based on 1.00 pH)

6. Calculate the pH of a 1.0 M $AlCl_3$ solution.

$AlCl_3 \rightarrow Al^{3+}_{(aq)} + 3Cl^-_{(aq)}$ ← spectator

Acid hydrolysis:

$Al(H_2O)_6^{3+} + H_2O \rightleftharpoons H_3O^+ + Al(H_2O)_5OH^{2+}$

I	1.0 M	0	0
C	$-x$	$+x$	$+x$
E	$1.0-x$	x	x

$K_a = 1.4\times10^{-5} = \frac{x^2}{1.0-x}$

Assume $1.0-x = x$

$1.4\times10^{-5} = \frac{x^2}{1.0}$

$x = \sqrt{1.4\times10^{-5}}$

$x = 3.7\times10^{-3} = [H_3O^+]$

$pH = -\log[H_3O^+]$

$= -\log(3.7\times10^{-3})$

$pH = 2.43$

% dissociation $= \frac{3.7\times10^{-3}}{1.0} = 0.37\%$ ✓

7. Write dissociation equations for NH_4HSO_4, state whether cation hydrolyzes, anion hydrolyzes and whether the salt is acidic, basic or neutral.

$NH_4HSO_4 \rightarrow NH_4^+ + HSO_4^-$

ACID "BASE" ← amphiprotic but does not act as base (conj base of strong acid)

Acid hydrolysis:

$NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$

$HSO_4^- + H_2O \rightleftharpoons SO_4^{2-} + H_3O^+$

∴ salt will produce acidic solution

8. Select the best answer from the following multiple choice questions. Show your work and explain your answer.

At 30°C, $K_w = 3.0 \times 10^{-14}$. Therefore, a solution at 30°C in which the $[OH^-] = 1.732 \times 10^{-7}$ M is best described as

A. acidic B. basic C. neutral D. ~~amphoteric~~ E. ~~amphiprotic~~

$K_w = [OH^-][H_3O^+]$

$[OH^-] = [H_3O^+]$

$[H_3O^+] = \frac{K_w}{[OH^-]} = \frac{3.0\times10^{-14}}{1.732\times10^{-7}} = 1.732\times10^{-7}$

9. A student tests a 1.0 M solution with different pH indicators and finds that:

yellow 10.1 – 12.0 (11.05)

- alizarin yellow remains yellow in the solution

blue 8.0 – 9.6 (8.8)

- thymol blue remains blue in the solution

∴ pH 8.8 – 11.05

As a result of these observations it is correct to say that the solution is a

(A. weak base) B. weak acid C. strong base D. strong acid

10. The indicator Hin has a yellow acid form and a red base form. The equation for its ionization is

yellow red

$$Hin + H_2O \rightleftharpoons H_3O^+ + In^-$$

When KOH is added to the above system, the equilibrium

A. shifts left and the solution turns red

B. shifts left and the solution turns yellow

(C.) shifts right and the solution turns red

D. shifts right and the solution turns yellow.

11. An indicator undergoes transition form colourless to blue at pH 10.0. What is the K_a of the indicator?

A. 10^{-14} (B. 10^{-10}) C. 10^{-4} D. 10^{10}

@TP pH = pKa

Ka = antilog(-10)

12. An indicator HInd is yellow in 0.1M NaOH and blue in 0.1M HCl. The pH range in which the colour change occurs in this indicator is 3.6 - 5.2.

a) Write the equilibrium equation describing this indicator.

$$HIn + H_2O \rightleftharpoons H_3O^+ + In^-$$

CA CB

b) What is the colour of HInd? blue What is the colour of Ind^-? yellow

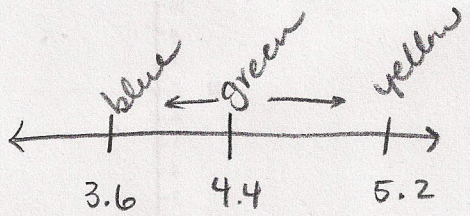
c) What is the pH at the transition point of this indicator?

$\frac{3.6 + 5.2}{2} = 4.4$

d) What is the value of pK_a for this indicator?

pH @TP = pKa

pKa = 4.4



e) What is the K_a of this indicator?

Ka = antilog (-pKa)

= antilog (-4.4) = 4.0×10^{-5}

f) At pH = 2.2, this indicator is the colour blue and [HInd] (>,<,=) > [Ind^-].

g) At pH = 7.0, this indicator is the colour yellow and [HInd] (>,<,=) < [Ind^-].

h) At pH = 11.3, this indicator is the colour yellow and [HInd] (>,<,=) < [Ind^-].