Recitation Worksheet 8 (Acids and Bases 2)

Name: UGA ID:

Instructions:

- Please enter your first and last name as it appears on the eLC roster (do not use a nickname).
- Your UGA myID is a combination of letters and numbers (example: mine is wpe28548). **Do not use your 81x number.**
- If you do not have a printer, type your answers in the then upload the worksheet template to Gradescope by Tuesday, March 30 at 11:59 pm. Write your work on separate sheets of paper, convert to a PDF and upload to eLC.
- If you have a printer download the worksheet, convert it to a PDF and upload to Gradescope by Tuesday, March 30 at 11:59 pm. You do not need to upload anything to eLC.

1. The base ionization constant K_b describes which of the following reactions for a weak base, B, in aqueous solution? (Note: often the base will be anionic rather than neutral, but "B" here is meant to represent anionic or neutral bases, which will gain one H and become one charge unit more positive whether starting neutral or anionic.)

A. $B + H^+ \leftrightharpoons BH^+$

B. $B + OH^- \leftrightharpoons BH^- + O^{2-}$

C. $B + H_3O^+ \leftrightharpoons BH^+ + H_2O$

D. $BH^+ + OH^- \leftrightharpoons B + H_2O$

D. $B + H_2O \leftrightharpoons BH^+ + OH^-$

2. Which **one** of the following **is** basic?

A. Cl^-

B. HSO_4^-

C. NO_3^-

D. SO_4^{2-}

E. ClO_4^-

3. When $[H^+] = 4.0 \times 10^{-9}$ M in water at 25 °C, then _____

A. pH = 9.40.

B. pH = 8.40.

C. pH = 7.00.

D. pH = –9.40

E. pH = –8.40.

$-\log 4.0 \times 10^{-9} = 8.40$

4. Solutions of each of the hypothetical acids in the following table are prepared with an initial concentration of 0.100 M. Which of the four solutions will have the lowest pH and be most acidic? Acid pK_a

HA 4.00

HB 7.00

HC 10.00

HD 11.00

Lowest pK_a is the strongest acid

A. HA

B. HD

C. HB

D. HC

E. All will have the same pH because the concentrations are the same.

5. When values of K_a are small (e.g., 1×10^{-5}) and concentrations of weak acids [HA] are relatively large (e.g., 0.10 M), and assuming there is no other source of anion A^-, the hydronium ion concentration of the solution can be calculated using which expression?

A. $[H^+] = K_a$

B. $[H^+] = K_aK_b[HA]$

C. $[H^+] = K_a[HA]$

D. $[H^+] = K_a[HA]^2 / [A^-]$

E. $[H^+] = (K_a[HA])^{1/2}$

$K_a = \frac{[H^+][A^-]}{[HA]}$

From the ICE TABLE you would have

$K_a = \frac{[x][x]}{[HA - x]}$ — x can be ignored

$K_a = \frac{[x]^2}{[HA]}$

6. Use the following acid ionization constants to identify the correct decreasing order of base strength

HF	$K_a = 7.2 \times 10^{-4}$
HNO_2	$K_a = 4.5 \times 10^{-4}$
HCN	$K_a = 6.2 \times 10–10$

A. $CN^- > NO_2^- > F^-$

B. $F^- > NO_2^- > CN^-$

C. $NO_2^- > F^- > CN^-$

D. $NO_2^- > CN^- > F^-$

E. $F^- > CN^- > NO_2^-$

$HA \rightarrow H^+ + A^-$ (conjugate base)

The smallest K_a will have the strongest conjugate base

7. Phosphoric acid is a triprotic acid, ionizing in the following sequential steps:

$$H_3PO_4 + H_2O \leftrightharpoons H_2PO_4^- + H_3O^+$$

$$H_2PO_4^- + H_2O \leftrightharpoons HPO_4^{2-} + H_3O^+$$

$$HPO_4^{2-} + H_2O \leftrightharpoons PO_4^{3-} + H_3O^+$$

Which equilibrium is most important in determining the pH of a solution of sodium phosphate?

A. $HPO_4^{2-} + H_2O \leftrightharpoons PO_4^{3-} + H_3O^+$

B. $H_2PO_4^- + H_2O \leftrightharpoons H_3PO_4 + OH^-$

C. $H_3PO_4 + H_2O \leftrightharpoons H_2PO_4^- + H_3O^+$

D. $2\ H_2O \leftrightharpoons H_3O^+ + OH^-$

D. $PO_4^{3-} + H_2O \leftrightharpoons HPO_4^{2-} + OH^-$

Na_3PO_4

8. Aqueous solutions of _____ are basic.

A. NaF

B. NaI

C. NaCl

D. KI

E. NaBr

Other are all salts of strong acids

9. Which one of the following salts forms aqueous solutions with pH = 7?

A. Na_2S

B. $NaNO_2$

C. NaBr

D. Na_2CO_3

E. $NaClO_2$

All the other are salts of weak acids which generate basic solutions

10. Which one of the following, A–D, is correct? If all are correct, respond E.

A. K_2SO_3 is a stronger base than $KHSO_3$.

B. Na_2HPO_4 is a weaker base than NaH_2PO_4.

C. K_2CO_3 is a weaker base than $KHCO_3$.

D. $NaHSO_3$ is a stronger acid than $NaHSO_4$.

E. All of these statements are correct.

11. Which of the following groups, A–D, consist of salts that all form basic solutions in water? (Ac = acetate) If none or all satisfy this criterion, respond E.

A. $NaNO_3$, NH_4CN, NaAc, NH_4Cl

B. $NaHCO_3$, NaF, NH_4Cl, Na_2SO_3

C. Na_2CO_3, KCl, $NaOOCH_3$, NH_4Cl

D. Na_2CO_3, NaF, $NaOOCH_3$, NaCN → all salts of weak acids

E. None or all of the above.

12. For the reaction shown, which of the following statements would be true, given the listed value for K_{eq}?

$$HNO_2(aq) + CH_3COO^-(aq) \leftrightharpoons CH_3COOH(aq) + NO_2^-(aq) \quad K_{eq} = 25$$

ACID BASE conj. ACID conj base

A. CH_3COO^- is the weakest acid

B. HNO_2 is the weakest acid

C. CH_3COOH is the weakest acid

D. NO_2^- is the strongest base

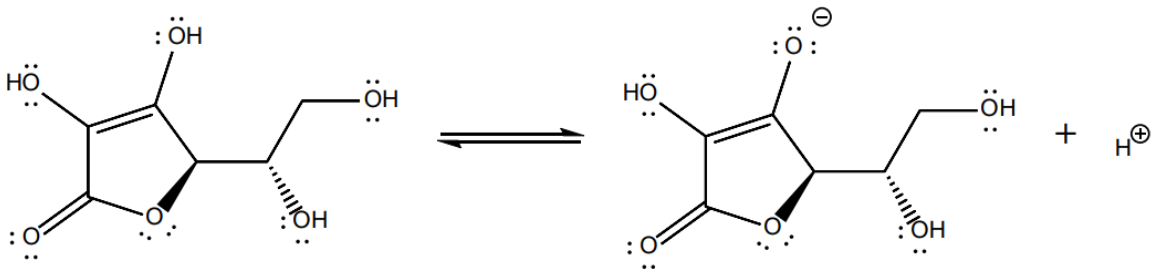
E. The solution will contain more HNO_2 than CH_3COOH at equilibrium

$K_{eq} > 1$ products favored

The conjugate pair are always on the product side if the forward reaction is favored

The conjugate acid is always weaker than the acid

13. What is the pH of a solution that is made up to be 0.25 M in ascorbic acid ($pK_a = 4.17$)?



4.1×10^{-3}

	HA	H^+	A^-
I	0.25	0	0
C	$-x$	$+x$	$+x$
E	$0.25-x$	$+x$	$+x$

$-x$ can be ignored

$pK_a = 4.17$

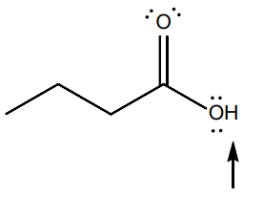
$K_a = 6.76 \times 10^{-5}$

$K_a = \frac{[H^+][A^-]}{[HA]}$

$6.76 \times 10^{-5} = \frac{x^2}{0.25}$

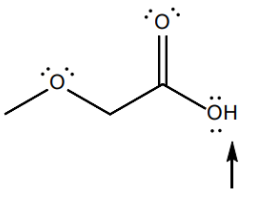
$x = 4.1 \times 10^{-3}\ M$

14. The structures and pK_a values for butanoic acid and methoxyethanoic acid are shown below:



$pK_a = 4.9$

butanoic acid



$pK_a = 3.7$

methoxyethanoic acid

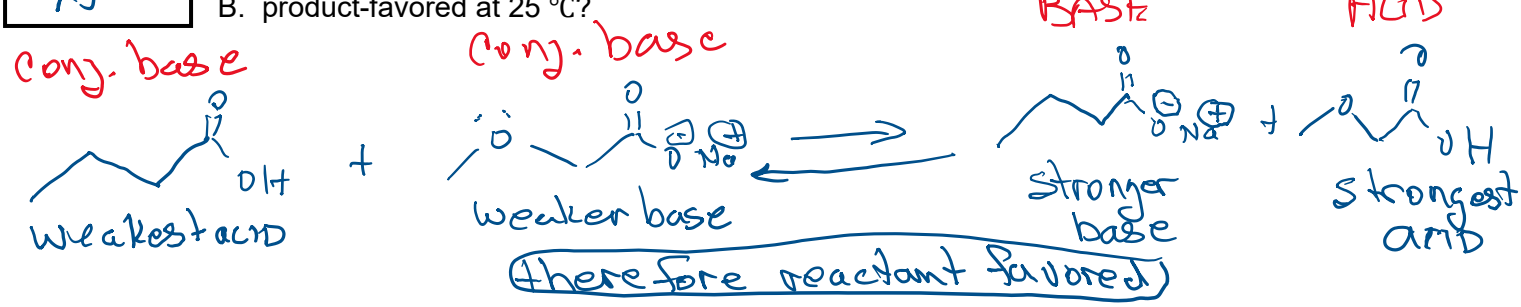
pK_a is smaller ∴ strongest acid

Is the reaction between butanoic acid and the methoxyethanoate anion ($CH_3CH_2CO_2^-$):

A

A. reactant favored

B. product-favored at 25 °C?



15. Calculate the pH of a 0.800 M CH_3NH_3Cl solution. K_b for methylamine, CH_3NH_2, is 3.7×10^{-4}.

5.33

$CH_3NH_3Cl \rightarrow CH_3NH_3^+ + Cl^-$

$CH_3NH_3^+ \rightleftharpoons CH_3NH_2 + H^+$

$K_w = K_a \cdot K_b \qquad 1\times10^{-14} = [x][3.7\times10^{-4}]$

$K_a = 2.7\times10^{-11}$

$K_a = \dfrac{[CH_3NH_2][H^+]}{[CH_3NH_3^+]}$

	$CH_3NH_3^+$	CH_3NH_2	H^+
I	0.800	0	0
C	$-x$	x	x
E	$0.800-x$	x	x

$-x$ can be ignored

$2.7\times10^{-11} = \dfrac{[x][x]}{0.800} \qquad x^2 = 2.16\times10^{-11} \qquad x = 4.65\times10^{-6}$

$pH = 5.33$

16. Calculate the pH of a 0.80 M H_2SO_3, solution that has the stepwise dissociation constants $K_{a1} = 1.5 \times 10^{-2}$ and $K_{a2} = 6.3 \times 10^{-8}$.

~~0.99~~

$H_2SO_4 \rightleftharpoons H^+ + HSO_3^-$

$HSO_3^- \rightleftharpoons H^+ + SO_3^{2-}$ does not contribute

$K_a = \dfrac{[H^+][HSO_3^-]}{[H_2SO_3]}$

	H_2SO_4	HSO_3^-	H^+
I	0.80	0	0
C	$-x$	x	x
E	$0.80-x$	x	x

↑ CANNOT IGNORE $-x$

$1.5\times10^{-2} = \dfrac{[x][x]}{[0.8-x]}$

$x^2 + 1.5\times10^{-2}x - 1.2\times10^{-2} = 0 \qquad x = 0.1023 \qquad pH = 0.99$

17. Calculate the pH of a 0.800 M KBrO solution. K_a for hypobromous acid, HBrO, is 2.0×10^{-9}.

11.30

$BrO^- + H_2O \rightleftharpoons HBrO + OH^-$

$K_a = 2.0 \times 10^{-9}$ use $K_w = K_a \cdot K_b$

$K_b = 5.0 \times 10^{-6}$

Since OH^- is formed you need to use K_b

$K_b = \frac{[HBrO][OH^-]}{[BrO^-]}$

$K_b = \frac{[X][X]}{.800} = 5 \times 10^{-6}$

$X = .002\ M$

	BrO^-	$HBrO$	OH^-
I	.800	0	0
C	$-x$	$+x$	$+x$
E	$.800-x$	x	x

$pOH = 2.7$ $pH = 11.3$ $-x$ can be ignored

18. From the following chemical reactions determine the relative Brønsted-Lowry acid strengths (strongest to weakest).

$HClO_4(aq) + H_2O(l) \rightarrow H_3O^+(aq) + ClO_4^-(aq)$

$HNO_2(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + NO_2^-(aq)$

reaction written with a single arrow ∴ $HClO_4$ is a strong acid

$HClO_4 > H_3O^+$

reaction written with a double arrow ∴ HNO_2 is a weak acid and

$HNO_2 < H_3O^+$

A. $HClO_4 > H_3O^+ > HNO_2$

B. $HClO_4 > HNO_2 > H_3O^+$

C. $H_3O^+ > HClO_4 > HNO_2$

D. $H_3O^+ > HNO_2 > HClO_4$

19. What is the pH of a 0.020 M $HClO_4$ solution?

1.70

strong acid

$pH = -\log[H^+] = -\log 0.020 = 1.70$

20. What is the pH of a solution prepared by diluting 25.00 mL of 0.020 M $Mg(OH)_2$ with enough water to produce a total volume of 250.00 mL?

11.60

$Mg(OH)_2 \rightleftharpoons Mg^{2+} + 2OH^-$

$0.020\ M \qquad 0.020\ M \qquad 0.040\ M$

$(.025\ L)(0.040\ M) = (0.25\ L)(X\ M)$

$X = .004\ M\ OH^-$

$pOH = 2.40$

$pH = 11.60$