Name **ANSWER KEY** Slayter Box **007**

Hour Examination 4 March 20, 2003

General Chemistry (CHEM 122-01)

Acids & Bases

Dr. Bennett

Please do not open until instructed

Acids & Bases

Notes:

* This exam consists of **5 questions on 5 pages** (including this cover page). Please check to make sure that you have a complete copy of the exam.
** Please do not simply give me answers. Give me well-supported answers. Numerical answers that are not backed by supporting calculations will receive minimal credit.*
* Please write clearly; if I can't read your answer, I can't give you credit for your answer.
* Please note that different questions are worth different numbers of points. Plan your time accordingly.
* Remember to include units and significant figures where appropriate.
* No books or notes are to be used on this exam.
* Please do NOT share calculators; if you need a calculator but do not have one, please let me know!

** If you feel that you would be better able to answer **any** question if you had additional information, please do not hesitate to ask for it.* I will happily provide any information that I feel will help you answer the question without compromising the efficacy and fairness of the test.

Question	Possible	Score
1	18	
2	14	
3	18	
4	10	
5	10	
TOTAL	70	
percent:		

The Quadratic Equation

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

1. SHORT ANSWER

4 (a). Identify the conjugate acid-base pairs in the following chemical equations.

$CH_3NH_{2(aq)}$ + $HCl_{(aq)}$ ↔ $CH_3NH_3^{+}{}_{(aq)}$ + $Cl^-{}_{(aq)}$

base acid acid base

$HPO_4^{2-}{}_{(aq)}$ + $HIO_{4(aq)}$ ↔ $H_2PO_4^-{}_{(aq)}$ + $IO_4^-{}_{(aq)}$

base acid acid base

8 (b). Classify the solutions of the following salts as acidic, basic or neutral.

Na_2CO_3 basic

$Cu(NO_3)_2$ acidic

Na_2S basic

$KClO_4$ neutral

3 (c) Rank the following substances in order of increasing acidity and explain your reasoning:

HOF > HOCl > HOBr > HOI

H—O—X more electronegative X further polarizes the H—O bond.

(d) Rank the following substances in order of increasing acidity and explain your reasoning:

3

SiH_4 < PH_3 < H_2S < HCl

→

the bonds in this direction are more polarized:

A — H A = Si, P, S, Cl

δ- δ+

2. (Potassium fluoride dissolves in water to give a solution that is basic.

(a) Write the chemical equation that illustrates why the solution is basic.

$$F^-_{(aq)} + H_2O_{(l)} \rightleftharpoons HF_{(aq)} + OH^-_{(aq)}$$

(b) For an 0.25 M solution of potassium fluoride, calculate the pH at equilibrium. Note $K_a(HF) = 6.8 \times 10^{-4}$.

Weak base ionization

$F^- + H_2O \overset{K_b}{\rightleftharpoons} HF + OH^-$

I	0.25	0	0
C	−x	+x	+x
E	(0.25−x)	x	x

$K_b = (K_w/K_a)$

$$K_b = \frac{[HF][OH^-]}{[F^-]} = \frac{x^2}{(0.25-x)} = \frac{10^{-14}}{6.8\times10^{-4}}$$

this is K_b ;

$K_b = 1.47\times10^{-11}$

$x^2 = 3.68\times10^{-12}$

$x = [OH^-] = 1.92\times10^{-6}\ M$

$pOH = 5.71$

$pH = 8.29$

(c) Calculate the pOH at equilibrium.

3. Ascorbic acid, $C_5H_7O_4COOH$, also known as Vitamin C, is an essential nutrient for all mammals. In lab it can also be used to make buffers. The K_a of ascorbic acid is 7.9×10^{-5}.

(a) Calculate the pH of a buffer solution which is made by mixing 0.250 moles of ascorbic acid and 0.200 moles of the conjugate base sodium ascorbate in a total volume of 0.750 liters.

$$[HA] = \frac{0.250 \text{ mol HA}}{0.750 \text{ L soln}} = 0.33 \text{ M}$$

$$[A^-] = \frac{0.200 \text{ mol } A^-}{0.750 \text{ L soln}} = 0.27 \text{ M}$$

	$HA \rightleftharpoons$	$H^+ +$	A^-
I	0.33	0	0.27
C	$-x$	$+x$	$+x$
E	$0.33-x$	x	$0.27+x$

$$K_a = 7.9 \times 10^{-5} = \frac{(x)(0.27+x)}{(0.33-x)}$$

$$x = [H^+] = 9.88 \times 10^{-5}$$

$$pH = 4.0$$

(b) Calculate the hydroxide ion concentration ($[OH^-]$) of this solution.

$$pOH = 10.0$$

$$[OH^-] = 1 \times 10^{-10} \text{ M}$$

(c) Calculate the pH of the ascorbic acid/ascorbate buffer solution after 0.100 moles of nitric acid (HNO_3) is added (assume no volume change).

moles of HA becomes 0.350 moles HA
moles of A^- becomes 0.100 moles A^-

because $A^- + H^+ \xrightarrow{100\%} HA$

molarities: $[HA] = 0.47 \text{ M}$

$[A^-] = 0.13 \text{ M}$

$$K_a = \frac{(x)(0.13+x)}{(0.47-x)} = 7.9 \times 10^{-5}$$

	$HA \rightleftharpoons$	$H^+ +$	A^-
I	0.47	0	0.13
C	$-x$	$+x$	$+x$
E	$(0.47-x)$	x	$(0.13+x)$

$$x = [H^+] = 2.86 \times 10^{-4} \text{ M}$$

$$pH = 3.5$$

4. What is the pH of the solution that results from mixing 350.0 mL of 0.600 M HBr with 225.0 mL of 0.500 M KOH? (The volume of the new solution is 575.0 mL.)

strong acid and base: how many moles of each are present?

$\text{moles } H^+ = 0.350\text{L} \times 0.600\text{M} = 0.21 \text{ moles}$

$\text{moles } OH^- = 0.225\text{L} \times 0.500\text{M} = 0.11 \text{ moles}$

An excess of H^+ means OH^- will be totally consumed, leaving 0.10 mol of H^+ in a volume of 0.575L. $[H^+] = \frac{0.10 \text{ mol } H^+}{0.575\text{L}} = 0.174\text{M}$

$\boxed{\text{pH} = 0.76}$

5. In many medical applications, the value of K_w at 37 °C (body temperature) may be more appropriate than the 25 °C value of 1.0×10^{-14}. At 37 °C, the pH of pure water is 6.80. Calculate K_w, pOH and $[OH^-]$ at 37 °C.

pure H_2O: $[H^+] = [OH^-]$ b/c they both only come from $H_2O \rightleftharpoons H^+ + OH^-$

So, $[OH^-] = [H^+] = 10^{-6.80}$

$\boxed{[OH^-] = 1.58 \times 10^{-7}\text{M}}$

$\boxed{\text{pOH} = 6.8}$

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

$= (1.58 \times 10^{-7})(1.58 \times 10^{-7})$

$\boxed{K_w = 2.5 \times 10^{-14}}$