

University of Bahrain, Department of Chemistry
Chemistry 102, Second Semester 2012-2013

3rd hour examination

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Time :90 min

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Name : *Key* ID# : Sec

Q1

(1pt)

What is the conjugate base of $C_2H_5NH_3^+$?

- A) $C_2H_5NH_2$
D) H_3O^+ B) $C_2H_5NH_2$
E) OH^- C) $C_2H_5N_2^-$

Q2

(1pt)

Solution X has a pH of 4.35. Solution Y has $[OH^-]$ ten times as large as solution X. Solution Z has a pH 4.0 units higher than that of solution X. What is the pH of solution Y and Z ?

- A) 3.35 & 8.35 respectively B) 5.35 & 4.35 respectively
 C) 5.35 & 8.35 respectively D) 14.35 & 8.35 respectively
E) 6.35 & 8.35 respectively

Q3

(1pt)

What is the pH of a 0.023 M HNO_3 solution ?

- A) 12.36 B) 3.68 C) 1.64
D) 2.30 E) 2.49

Q4

(1pt)

A 0.10 M HF solution is 8.4% ionized. Calculate the H^+ ion concentration.

- A) 0.84 M B) 0.12 M C) 0.10 M D) 0.084 M E) 8.4×10^{-3} M

86

Q5

(1pt)

Consider the acids :

Acid	A	B	C	D
pK _a	3.7	9.2	7.4	1.6

Arrange the acids in order of decreasing acid strength (from strongest to weakest).

- A) B>C>A>D B) A>C>B>D C) D>C>A>B
 D) B>D>A>C E) D>A>C>B

Q6

(1pt)

What is the pH of a 0.20 M solution of NH₄Cl? [K_b(NH₃) = 1.8x10⁻⁵]

- A) 3.74 B) 4.98 C) 6.53 D) 9.02 E) 10.25

Q7

(1pt)

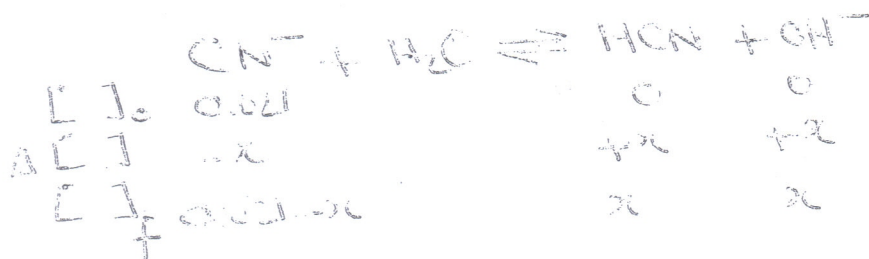
Which of the following will form an acidic solution in water?

- A) NH₄Cl B) NaF C) LiI D) KNO₃ E) None will be acidic

Q8 (Show your work)

(5pts)

Calculate the pH of a 0.021 M NaCN solution. [K_a(HCN) = 4.9x10⁻¹⁰]



$$K_b = \frac{x^2}{0.021 - x}$$

$$K_b = \frac{K_w}{K_a} = 2.041 \times 10^{-5}$$

Apply approximation:

$$\frac{x^2}{0.021} = 2.041 \times 10^{-5}$$

$$x^2 = 4.2861 \times 10^{-7}$$

$$x = 6.55 \times 10^{-4} = [\text{OH}^-]$$

$$[\text{H}^+] = \frac{K_w}{[\text{OH}^-]} = 1.527 \times 10^{-11} \text{ M}$$

$$\text{pH} = 10.82$$

$$\% \text{ Ionization} = \frac{6.55 \times 10^{-4}}{0.021} \times 100 = 3.11\% < 5\%$$

valid

Q9 (Show your work)

(4pts)

A solution of ascorbic acid, $\text{HC}_6\text{H}_7\text{O}_6$, is prepared by dissolving 2.00 g in water to make 100.0 mL of solution which has a pH of 2.54. What is K_a for ascorbic acid? (Molar mass of $\text{HC}_6\text{H}_7\text{O}_6 = 176.1 \text{ g/mol}$).

$$n_{\text{HC}_6\text{H}_7\text{O}_6} = \frac{2.00 \text{ g}}{176.1 \text{ g/mol}} = 0.01136 \text{ mol}$$

$$[\text{HC}_6\text{H}_7\text{O}_6] = \frac{0.01136 \text{ mol}}{0.100 \text{ L}} = 0.1136 \text{ mol/L}$$

$$[\text{H}^+] = 10^{-\text{pH}} = 10^{-2.54} = 2.88 \times 10^{-3}$$

$$\text{HC}_6\text{H}_7\text{O}_6 \rightleftharpoons \text{H}^+ + \text{C}_6\text{H}_6\text{O}_6^-$$

$$K_a = \frac{[\text{H}^+]^2}{[\text{HC}_6\text{H}_7\text{O}_6]} = \frac{(2.88 \times 10^{-3})^2}{0.1136} = 7.3 \times 10^{-5}$$

(if $\frac{1}{2}$ not reflected)
7.5 $\times 10^{-5}$

Q10 (Show your work)

(6pts)

(A) A buffer is prepared by dissolving 0.0250 mol of sodium nitrite, NaNO_2 , in 250.0 mL of 0.0410 M nitrous acid, HNO_2 . Assume no volume change, calculate the pH of this buffer. ($K_a \text{ HNO}_2 = 4.5 \times 10^{-4}$)

$$n_{\text{NaNO}_2} = \frac{0.0250 \text{ mol}}{0.250 \text{ L}} = 0.1000 \text{ mol/L}$$

$$[\text{HNO}_2] = K_a \left(\frac{n_{\text{NaNO}_2}}{n_{\text{HNO}_2}} \right)$$

$$= (4.5 \times 10^{-4}) \left(\frac{0.1000}{0.0250} \right) = 1.85 \times 10^{-4}$$

$$\text{pH} = 3.73$$

(B) What is the pH of the buffer after the addition of 0.0010 mole HCl?

	H^+	+	NO_2^-	\rightarrow	HNO_2	
no	0.0010		0.025		0.025	
at	-0.001		-0.001		+0.001	
∴	0		0.024		0.026	

$$[\text{H}^+] = (4.5 \times 10^{-4}) \left(\frac{0.026}{0.024} \right) = 2.11 \times 10^{-4}$$

$$\text{pH} = 3.68$$

(C) What is the pH of the buffer after the addition of 0.0010 mole NaOH?

	OH^-	+	HNO_2	\rightarrow	NO_2^-	+	H_2O
no	0.0010		0.025		0.025		
at	-0.001		-0.001		+0.001		
∴	0		0.024		0.026		

$$[\text{H}^+] = (4.5 \times 10^{-4}) \left(\frac{0.026}{0.024} \right) = 1.60 \times 10^{-4}$$

$$\text{pH} = 3.80$$

Q11

(10pts)

In an experiment, 50.0 mL of 0.0350 M butyric acid (HBut), a weak acid, is titrated with 0.225 M NaOH. (K_a HBut = 1.5×10^{-5}).

(A) Species present at the equivalence point is/are But⁻ (1pt)

(B) pH of the solution before any NaOH is added is (Show your work) (3pts)

$$\text{HBut} + \text{H}_2\text{O} \rightleftharpoons \text{But}^- + \text{H}_3\text{O}^+$$

E] 0.0350	0	0
ΔL] -x	+x	+x
E] 0.035-x	x	x

$$K_a = \frac{x^2}{0.035-x} = \frac{x^2}{0.035} = 1.5 \times 10^{-5}$$

$x = 7.25 \times 10^{-4} \text{ M}$
 $\% \text{ ionization} = 0.21\% < 5\%$
 Valid
 $\text{pH} = 3.14$

(C) pH of the solution at half the equivalence point is pH = pKa = 4.82 (1pt)

(D) pH at the equivalence point (Show your work) (5pts)

At equiv. pt., $\text{HBut} = \text{OH}^-$

$n_{\text{HBut}} = 0.0350 \text{ M} \times 0.05 \text{ L} = 0.00175 \text{ mol} = n_{\text{OH}^-}$
 $\text{Vol}(\text{OH}^-) = \frac{0.00175 \text{ mol}}{0.225 \text{ M}} = 0.00778 \text{ L} = 7.78 \text{ mL}$

$\text{mol But}^- = \text{mol HBut} = 0.00175$
 $[\text{But}^-] = \frac{0.00175}{\text{Total Vol.}} = \frac{0.00175 \text{ mol}}{(50 + 7.78) \times 10^{-3} \text{ L}} = 0.0303 \text{ M}$

At equiv. pt.: $\text{But}^- + \text{H}_2\text{O} \rightleftharpoons \text{HBut} + \text{OH}^-$

E] 0.0303	0	0
ΔL] -x	+x	+x
E] 0.0303-x	x	x

$K_b = \frac{x^2}{0.0303} = 6.67 \times 10^{-10} \Rightarrow x = [\text{OH}^-] = 4.99 \times 10^{-6}$
 $\% \text{ ionization} = 0.015\% \quad ([\text{H}^+] = 2.02 \times 10^{-9})$
 $\text{pH} = 8.65$

Q12 (Show your work)

(3pts)

The solubility of copper(II) hydroxide, $\text{Cu}(\text{OH})_2$, is $1.8 \times 10^{-7} \text{ mol/L}$. Calculate the value of K_{sp} for copper(II) hydroxide.

$$\text{Cu}(\text{OH})_2(s) \rightleftharpoons \text{Cu}^{2+}(aq) + 2\text{OH}^-(aq)$$

$$K_{sp} = [\text{Cu}^{2+}][\text{OH}^-]^2$$

$$[\text{Cu}^{2+}] = [\text{Cu}(\text{OH})_2] = 1.8 \times 10^{-7} \text{ mol/L}$$

$$[\text{OH}^-] = 2[\text{Cu}(\text{OH})_2] = 2 \times 1.8 \times 10^{-7} \text{ mol/L} = 3.6 \times 10^{-7}$$

$$K_{sp} = (1.8 \times 10^{-7}) (3.6 \times 10^{-7})^2 = 2.33 \times 10^{-17}$$