Chemistry 12

Spring 2008

20/20 Excellent go girl!

Quiz 3

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Section: Monday 2pm Ampah-Bonner

Welcome to the third short quiz in Chem 12! Answer all questions in the space provided. Show the details of your work. Good luck.

Henderson-Hasselbalch Equation: $pH = pK_a + \log\frac{[Base]}{[Acid]}$

$K_w = 1.0 \times 10^{-14}$

Question 1 (6 points)

Indicate which of the following statement(s) is (are) true and correct the one(s) that is (are) false

a. For a given chemical reaction at equilibrium, the free energy of the system has reached its minimum and the concentration of reactants is equal to that of products.

2 False

The first part "the free energy of the system has reached its minimum" is correct but the concentration of reactants is not necessarily equal to that of products. The second half could read, "and Q = K where $Q = \frac{[C]^c[D]^d}{[A]^a[B]^b}$ etc where $aA + bB \rightarrow cC + dD$".

b. A large value of K (the equilibrium constant) means that, at equilibrium, the reaction consists mainly of products.

mix

2 True

when K>1 the reaction favors products. If K is large, this would signify that products are favored very much over reactants.

c. For a given reaction, a negative and large value of $\Delta G°$ means that the reaction will go nearly to completion.

If $\Delta G°$ is negative, and large this means that $K > 1$ and large and signifies that the reaction will favor products. Whether this is "nearly to completion" depends on how large $\Delta G°$ is.

True

$\Delta G° = -RT \ln K$

2 ✓

Question 2 (6 points)

a. Calculate the pH of an aqueous solution containing 0.10 M NaOH (sodium hydroxide)

$pOH = -\log([OH^-])$

$pOH = -\log(.1) = 1$

$pOH + pH = 14$

$\boxed{pH = 13}$

NaOH dissociates (almost) completely so

$[OH^-] = .1M$

$[OH^-] >> 10^{-7}M$

so we can neglect the concentration of water

$20(10^{-7}) >> .1$

assumption good

3 ✓

b. Calculate the pH of an aqueous solution containing 0.10 M HNO_3 (nitric acid) and 0.10 M HOCl (hypochlorous acid; $K_a = 3.5 \times 10^{-8}$)

HNO_3 will dissociate completely so from it $[H^+] = .1$

$$K_a = \frac{[OCl^-][H^+]}{[HOCl]}$$

Let $x = [OCl^-]$

Assume $[H^+] >> 10^{-7}$ good based on presence of .1M HNO_3

$$3.5 \times 10^{-8} = \frac{x(.1 + x)}{(.1 - x)}$$

Assume $x << .1$

$$3.5 \times 10^{-8} = \frac{x(.1)}{(.1)}$$

Assumptions good

$20(x) < .1$

$3.5 \times 10^{-8} = x$

not even really necessary

$pH = -\log[H^+] = -\log[.1 + 3.5 \times 10^{-8}] = .99999998 \approx \boxed{1} = pH$

hypochlorous contribution is negligible

hypochlorous doesn't really affect the pH

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Question 3 (8 points)

25.00 ml of an unknown weak acid HX was titrated with 0.125 M NaOH. During the titration, the following observations were made:

1- 16.00 ml of the base were required to reach the equivalence point.
2- After adding 2.00 ml of NaOH, the pH of the solution was 6.912.

Calculate the initial concentration of the weak acid.
Calculate the dissociation constant (K_a) of the weak acid.

(1) Concentration at the equivalence point, moles of acid = moles of base

$M_1V_1 = M_2V_2$

$\left(\frac{25.00\,mL}{1000\,mL/L}\right)(M_1) = (.125\,M)\left(\frac{16.00\,mL}{1000\,mL/L}\right)$

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$M_1(acid) = 0.08\,M$ initial acid concentration

(2) Moles:

NaOH dissociates completely

	HX (acid)	+ OH^- (OH^-)	→ X^- (conjugate base)	+ H_2O
Initial	.002	0		
After addition of base before RXN:	.002	2.5×10^{-4}		
After RXN	.00175	—	2.5×10^{-4}	

$pH = pKa + \log\frac{[base]}{[acid]}$ ← Since volumes are equal we can use mol # for [ ] (volumes would cancel)

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$6.912 = pKa + \log\frac{2.5 \times 10^{-4}}{.00175}$

$pKa = 7.75709804 = -\log Ka$

$10^{-7.75709804} = 10^{\log Ka}$

$Ka = 1.749451713 \times 10^{-8} \approx 1.75 \times 10^{-8}$