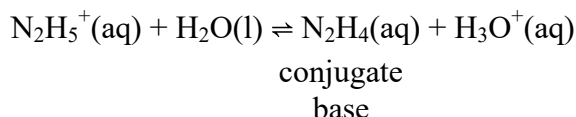


Chemistry 225 Semester 04 -2016

Homework for Submission #4 – Answer Key

1) The hydrazinium ion ($N_2H_5^+$) is a weak Brønsted-Lowry acid in water.

- a) Write the equation for the acid dissociation of this ion in water. Label the conjugate base of this acid in the equation. (2)



b) The pK_a of this ion is 8.23 at 25°C.

- i) Calculate the K_a value of the acid. (2)

$$pK_a = -\text{Log}_{10}(K_a)$$

$$\therefore K_a = 10^{-pK_a} = 10^{-8.23} = 5.8884 \times 10^{-9} \approx \underline{\underline{5.89 \times 10^{-9}}}$$
 to 3 s.f.

- ii) Calculate the pH of a solution which is made up by dissolving 0.015 mol of hydrazinium nitrate, $N_2H_5^+NO_3^-$, (sometimes used as a rocket fuel) in water to make 2.50 dm³ of solution. (NB. The nitrate ion has no appreciable acidic nor basic properties and need not be considered.) (8)

$$\text{Initial concentration of } N_2H_5^+ = [N_2H_5^+NO_3^-] = \frac{0.015 \text{ mol}}{2.5 \text{ dm}^3} = 6.00 \times 10^{-3}$$

	$N_2H_5^+(aq)$	+	$H_2O(l)$	\rightleftharpoons	$N_2H_4(aq)$	+	$H_3O^+(aq)$
Initial /M	6.00×10^{-3}		---		0		~ 0
Change /M	-x				+x		+x
Equilibrium /M	$6 \times 10^{-3} - x$				x		x

$$\therefore K_a = \frac{[N_2H_4]}{[N_2H_5^+][H_3O^+]} = \frac{x^2}{6 \times 10^{-3} - x}$$

Assume $x < 5\%$ of 6×10^{-3} .

$$\therefore 6 \times 10^{-3} - x \approx 6 \times 10^{-3}$$

$$\therefore \frac{x^2}{6 \times 10^{-3} - x} \approx \frac{x^2}{6 \times 10^{-3}} = K_a = 5.8884 \dots \times 10^{-9}$$

$$\therefore x^2 = 5.8884 \dots \times 10^{-9} \times 6 \times 10^{-3} = 3.5330 \times 10^{-11}$$

$$\therefore x = \sqrt{3.5330 \times 10^{-11}} = 5.9439 \times 10^{-6}$$

$$\therefore pH = -\text{Log}_{10}([H_3O^+]) = -\text{Log}_{10}(5.9439 \times 10^{-6}) = 5.2259 \approx \underline{\underline{5.23}}$$
 to 2 d.p.

Check assumption:

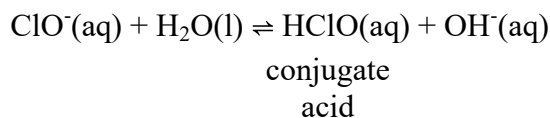
5% of $6 \times 10^{-3} = 3 \times 10^{-4}$ and since $x \approx 5.9 \times 10^{-6}$,

$x \ll 5\%$ of 6×10^{-3}

and the assumption is justified.

2) The hypochlorite ion (ClO^-) is a weak base in water. The base dissociation constant for this ion in water is 3.58×10^{-7} at 25°C .

a) Write the equation for the base dissociation of this ion in water. Label the conjugate acid of this base in the equation. (2)



b) Household bleach is a solution of sodium hypochlorite in water, typically 2.5%. This means that 100 cm^3 of solution contains 2.5 g of sodium hypochlorite, Na^+ClO^- .

i) Calculate the molarity of 2.50% sodium hypochlorite solution. (RAM of Na=22.99, Cl=35.45, O=16.00.) (3)

$$\text{Molar mass of NaClO} = 22.99 + 35.45 + 16.00 = 74.44 \text{ g mol}^{-1}$$

$$\therefore 2.50 \text{ g} = \frac{2.50 \text{ g}}{74.44 \text{ g mol}^{-1}} = 0.033584 \dots \text{ mol}$$

but 2.50 g is present in 100 cm^3 of solution.

$$\therefore \text{Molarity of 2.50\% sodium hypochlorite} = \frac{0.033584 \dots \text{ mol}}{0.1 \text{ dm}^3} = 0.33584 \dots \text{ mol dm}^{-3}$$

$\approx 0.336 \text{ M to 3 s.f.}$

ii) Calculate the pH of 2.50% sodium hypochlorite solution (bleach) at 25°C . (NB. The sodium ion has no appreciable acidic or basic properties and need not be considered.) (8)

	$\text{ClO}^-(\text{aq})$	+	$\text{H}_2\text{O}(\text{l})$	\rightleftharpoons	$\text{HClO}(\text{aq})$	+	$\text{OH}^-(\text{aq})$
Initial /M	0.33584		---		0		~ 0
Change /M	-x				+x		+x
Equilibrium /M	$0.33584 - x$				x		x

The base dissociation constant of the hypochlorite ion, ClO^- is $K_b = 3.58 \times 10^{-7}$

$$\therefore K_b = \frac{[HClO]}{[ClO^-][H_3O^+]} = \frac{x^2}{0.33584 - x}$$

and assuming $x < 5\%$ of 0.33584

$$x = \sqrt{0.33584K_b} = \sqrt{0.33584 \times 3.58 \times 10^{-7}} = 3.46743... \times 10^{-4}$$

$$\therefore pOH = -\text{Log}_{10}[OH^-] = \text{Log}_{10}(x) = \text{Log}_{10}(3.46743... \times 10^{-4}) = 3.4599...$$

But $pH + pOH = 14.00 @ 25^\circ C$

$$\therefore pH = 14 - 3.45992276... = 10.5400 \approx \underline{\underline{10.54}} \text{ to 2 d.p.}$$

Check assumption:

$$5\% \text{ of } 0.33584 \approx 1.68 \times 10^{-2} \text{ and since } x \approx 3.5 \times 10^{-4},$$

$x \ll 5\%$ of 0.33584

and the assumption is justified.