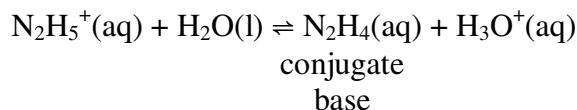


Chemistry 225 Semester 01-2013

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)

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

$$\therefore K_a = 10^{-\text{pK}_a} = 10^{-8.23} = 5.8884 \times 10^{-9} \approx \underline{\underline{5.89 \times 10^{-9}}} \text{ to 2 d.p.}$$

- ii) Calculate the pH of a solution which is made up by dissolving 0.015 mol of hydrazinium nitrate, $\text{N}_2\text{H}_5^+\text{NO}_3^-$, (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)

	$\text{N}_2\text{H}_5^+(\text{aq})$	+	$\text{H}_2\text{O}(\text{l})$	\rightleftharpoons	$\text{N}_2\text{H}_4(\text{aq})$	+	$\text{H}_3\text{O}^+(\text{aq})$
Initial /M	$0.015/2.50 = 6.00 \times 10^{-3}$		---		0		~0
Change /M	-x				+x		+x
Equilibrium /M	$6 \times 10^{-3} - x$				x		x

$$\therefore K_a = \frac{[\text{N}_2\text{H}_4]}{[\text{N}_2\text{H}_5^+][\text{H}_3\text{O}^+]} = \frac{x^2}{6 \times 10^{-3} - x}$$

Assume $x < 5\%$ of 6×10^{-3} .

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

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

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

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

$$\therefore \text{pH} = -\text{Log}_{10}([\text{H}_3\text{O}^+]) = -\text{Log}_{10}(5.9439 \times 10^{-6}) = 5.2259 \approx \underline{\underline{5.23}} \text{ to 2 d.p.}$$

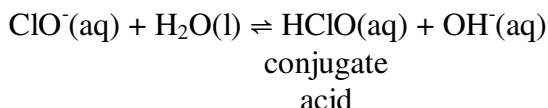
Check assumption:

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

$x \ll 5\%$ 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.

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

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

- 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

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

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

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

$$\therefore pH = 14 - 3.459992276... = 10.5400 \approx \underline{\underline{10.54}} \text{ to 2 d.p.}$$

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.