Chemistry 192
Quiz Number 4
Spring 2018
Solution

R =8.3144 J mol^{-1} K^{-1}

R=0.0821 L atm mol^{-1} K^{-1}

R=0.08314 L bar mol^{-1} K^{-1}

$N_A = 6.022 \times 10^{23}$ molecules mol^{-1}

$T = t + 273.15$

$[H_3O^+][OH^-] = 1.0 \times 10^{-14}$

Name:

The base dissociation constant of ethylamine ($CH_3CH_2NH_2$) is $K_b = 4.3 \times 10^{-4}$. A buffer is prepared by mixing ethylamine and the ethylammonium ion such that the initial concentrations of each are $[CH_3CH_2NH_2]$=0.250 M and $[CH_3CH_2NH_3^+]$=0.150 M. After the buffer is prepared, 0.100 L of the buffer are mixed with 0.0500 L of 0.100 M hydrochloric acid. Calculate 1) the pH of the initial buffer solution and 2) the pH of the solution after the buffer is mixed with the HCl. Approximations work for this problem.

Answer:

$$n_{CH_3CH_2NH_2} = (0.250 \text{ mol L}^{-1})(0.100 \text{ L}) = 0.0250 \text{ mol}$$

$$n_{CH_3CH_2NH_3^+} = (0.150 \text{ mol L}^{-1})(0.100 \text{ L}) = 0.0150 \text{ mol}$$

$$n_{H_3O^+} = (0.100 \text{ mol L}^{-1})(0.0500 \text{ L}) = 5.00 \times 10^{-3} \text{ mol}$$

Method 1, Henderson-Hasselbalch

$$CH_3CH_2NH_{3(aq)}^+ + H_2O_{(\ell)} \rightleftharpoons CH_3CH_2NH_{2(aq)} + H_3O_{(aq)}^+$$

$$K_a = \frac{K_w}{K_b} = \frac{1.0 \times 10^{-14}}{4.3 \times 10^{-4}} = 2.3 \times 10^{-11} \qquad \text{p}K_a = -\log_{10}(2.3 \times 10^{-11}) = 10.63$$

Before mixing

$$\text{pH} = \text{p}K_a + \log_{10}\frac{[CH_3CH_2NH_2]}{[CH_3CH_2NH_3^+]} = 10.63 + \log_{10}\frac{0.250}{0.150} = 10.85$$

After mixing

$$\text{pH} = 10.63 + \frac{(0.0250 - 5.00 \times 10^{-3})/0.150}{(0.0150 + 5.00 \times 10^{-3})/0.150} = 10.63$$

Method 2, ICE Table

Before mixing

$$CH_3CH_2NH_{2(aq)} + H_2O_{(\ell)} \rightleftharpoons CH_3CH_2NH_{3(aq)}^+ + OH_{(aq)}^-$$

	$[CH_3CH_2NH_2]$	$[CH_3CH_2NH_3^+]$	$[OH^-]$
initial	0.250 M	0.150 M	0 M
change	$-y$ M	y M	y M
equilibrium	$0.250 - y$ M	$0.150 + y$ M	y M

$$4.3 \times 10^{-4} = \frac{y(0.150 + y)}{0.250 - y} \approx \frac{0.150y}{0.250} \qquad y = [OH^-] = 7.2 \times 10^{-4} \text{ M}$$

$$\text{pOH} = 3.14 \qquad \text{pH} = 10.85$$

After mixing

Name:

	$n_{CH_3CH_2NH_2}$	$n_{CH_3CH_2NH_3^+}$	n_{OH^-}
initial	0.0250	0.0150	0
change	-5.00×10^{-3}	5.00×10^{-3}	y
equilibrium	0.0200	0.0200	y M

$$4.3 \times 10^{-4} = y \qquad [\text{OH}^-] = 4.3 \times 10^{-4} \text{ M}$$

$$\text{pOH} = 3.36 \qquad \text{pH} = 10.63$$

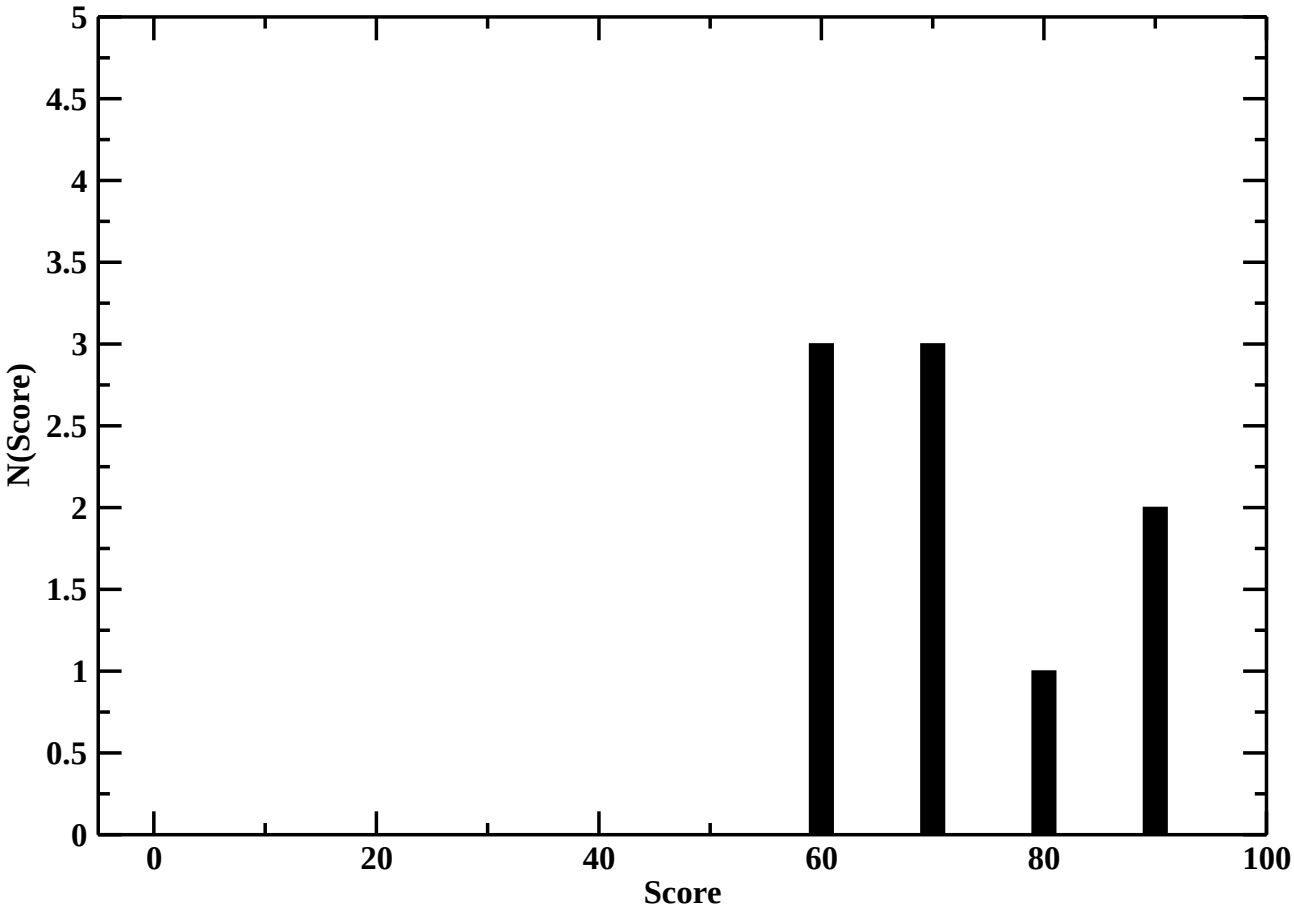

Figure 1: **High = 100, Median = 70, Mean = 76**