



AP Chemistry 1999 Sample Student Responses

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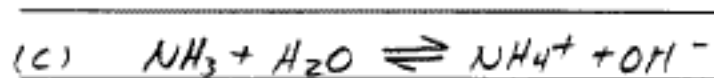
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$$(a) K_b = \frac{[NH_4^+][OH^-]}{[NH_3]}$$

$$(b) [OH^-] = 5.60 \times 10^{-4} M \quad pH = 10.7$$



$$.0180 M \quad - \quad \emptyset \quad \emptyset$$

$$- 5.60 \times 10^{-4} \quad - \quad + 5.60 \times 10^{-4} + 5.60 \times 10^{-4}$$

$$.0180 M \quad \quad 5.60 \times 10^{-4} \quad 5.60 \times 10^{-4}$$

$$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]}$$

$$K_b = \frac{(5.60 \times 10^{-4})^2}{.0180}$$

$$K_b = 1.74 \times 10^{-5}$$

$$(d) \frac{[OH^-]}{[NH_3]} \times 100 = \% \text{ ionization}$$

$$\frac{5.60 \times 10^{-4}}{.0180} \times 100 = 3.11 \% \text{ ionization } NH_3 \text{ at } .0180 M$$

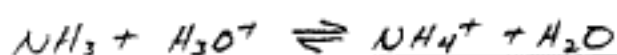
(e) i. At eq. pt mol H_3O^+ added = mol OH^- added

$$V_A M_A = V_B M_B$$

$$(x)(.0120 M) = (20.0)(.0180 M)$$

$$x = 30.0 \text{ mL HCl added}$$

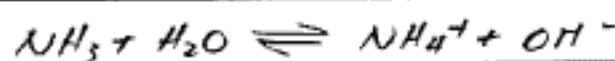
$$ii. .015 L \times \frac{.0120 \text{ mol HCl}}{1 L} = 1.80 \times 10^{-4} \text{ mol HCl} \quad .020 L \times \frac{.0180 \text{ mol } NH_3}{1 L} = 3.60 \times 10^{-4} \text{ mol } NH_3$$



$$3.60 \times 10^{-4} \text{ mol} \quad 1.80 \times 10^{-4} \text{ mol} \quad \emptyset \quad -$$

$$-1.80 \times 10^{-4} \quad -1.80 \times 10^{-4} \quad +1.80 \times 10^{-4} \quad -$$

$$1.80 \times 10^{-4} \quad \emptyset \quad 1.80 \times 10^{-4} \quad -$$



$$1.80 \times 10^{-4} \text{ mol} \quad - \quad 1.80 \times 10^{-4} \text{ mol} \quad x$$

$$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]}$$

$$1.74 \times 10^{-5} = \frac{(1.80 \times 10^{-4})x}{(1.80 \times 10^{-4})}$$

$$[OH^-] = 1.74 \times 10^{-5} M \quad pH = 9.24$$

$$iii. .040 L \times \frac{.0120 \text{ mol HCl}}{1 L} = 4.80 \times 10^{-4} \text{ mol HCl}$$



$$3.60 \times 10^{-4} \text{ mol} \quad 4.80 \times 10^{-4} \text{ mol} \quad \emptyset \quad -$$

$$-3.60 \times 10^{-4} \quad -3.60 \times 10^{-4} \quad +3.60 \times 10^{-4} \quad -$$

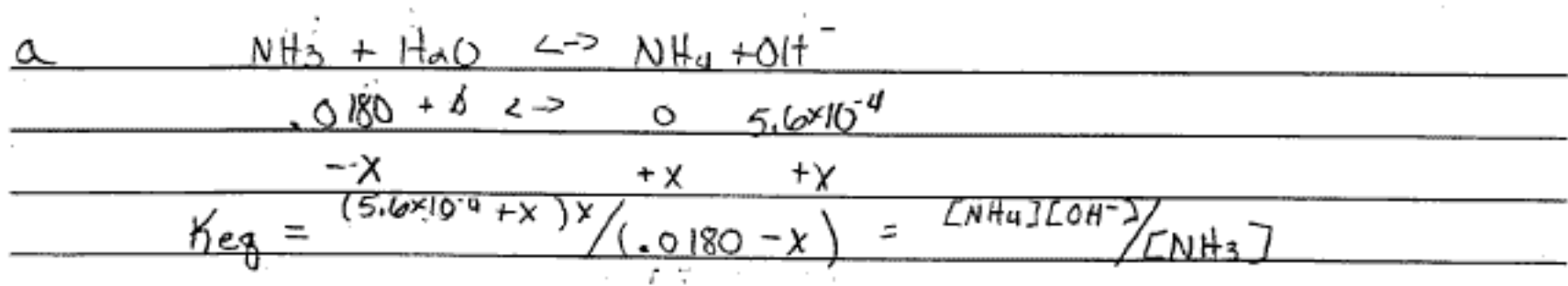
$$\emptyset \quad 1.20 \times 10^{-4} \text{ mol} \quad 3.60 \times 10^{-4} \text{ mol} \quad -$$



$$3.60 \times 10^{-4} \text{ mol} \quad - \quad x \quad 1.20 \times 10^{-4} \text{ mol}$$

$$1.20 \times 10^{-4} \text{ mol} / .0600 L = .002 M H_3O^+$$

$$pH = 2.70$$



$$b) \text{pH} = 14 - \text{pOH}$$

$$\text{pOH} = -\log(5.6 \times 10^{-4})$$

$$\text{pOH} = 3.25$$

$$\text{pH} = 10.75$$

$$c) K_b = \frac{[\text{OH}^-]^2}{C_b}$$

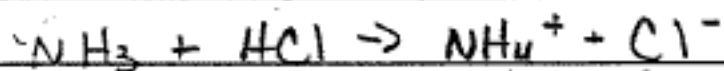
$$K_b = \frac{(5.6 \times 10^{-4})^2}{0.0180}$$

$$K_b = 1.74 \times 10^{-5}$$

$$d) \frac{0.0180 - 5.6 \times 10^{-4}}{0.0180} \times 100$$

$$96.9\%$$

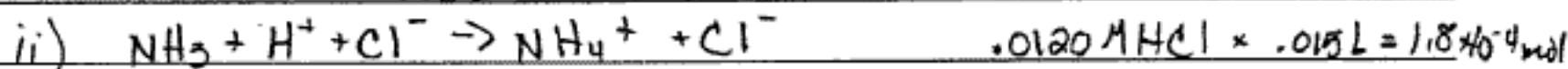
$$e) i) 0.0180 \text{ M NH}_3 \times 0.02 \text{ L} = 3.6 \times 10^{-4} \text{ mol NH}_3$$



$$3.6 \times 10^{-4} \text{ mol NH}_3 \times \frac{1 \text{ mol HCl}}{1 \text{ mol NH}_3}$$

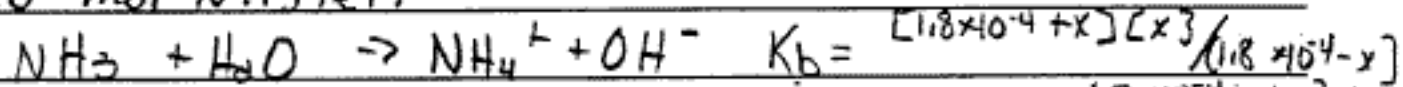
$$3.6 \times 10^{-4} \text{ mol HCl} \div 0.0120 \text{ M HCl}$$

$$0.03 \text{ L or } 30 \text{ mL}$$



$$3.6 \times 10^{-4} \text{ mol NH}_3, 1.8 \times 10^{-4} \text{ mol H}^+ \text{ \& Cl}^-$$

$$1.8 \times 10^{-4} \text{ mol NH}_3 \text{ left}$$



$$1.8 \times 10^{-4}$$

$$1.8 \times 10^{-4} \quad 0$$

$$1.74 \times 10^{-5} = \frac{1.8 \times 10^{-4} \cdot x}{1.8 \times 10^{-4}}$$

$$-x$$

$$+x \quad +x$$

$$x = 1.74 \times 10^{-5}$$

$$[\text{OH}^-] = 1.74 \times 10^{-5}$$

$$\text{pOH} = 4.76$$

$$\text{pH} = 14 - \text{pOH} = 9.24$$

$$iii) 0.0120 \text{ M HCl} \times 0.04 \text{ L} = 4.8 \times 10^{-4} \text{ mol HCl}$$

$$- 3.6 \times 10^{-4} + 4.8 \times 10^{-4} = 1.2 \times 10^{-4} \text{ mol H}^+$$

$$\text{pH} = -\log[\text{H}^+]$$

$$\text{pH} = 3.92$$

$$a. K_{eq} = \frac{[OH^-][NH_4^+]}{[NH_3]}$$

$$b. pOH = -\log 5.6 \times 10^{-4} = 3.25$$

$$pH = 14 - 3.25 = \boxed{10.75}$$

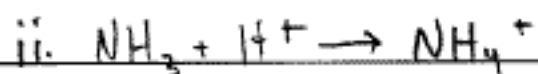
$$c. K_b = \frac{(5.6 \times 10^{-4})(5.6 \times 10^{-4})}{.018} = \boxed{1.74 \times 10^{-5}}$$

$$d. (5.6 \times 10^{-4}) / .018 = \boxed{3.11\%}$$

i. mols acid = mols base

$$.002 \text{ L} \times \frac{.018 \text{ mol}}{\text{L}} = 3.6 \times 10^{-5} \text{ mol NH}_3$$

$$3.6 \times 10^{-5} \text{ mol HCl} \times \frac{\text{L}}{.012 \text{ mol}} = \boxed{.003 \text{ L HCl}}$$



$$.015 \text{ L} \times \frac{.012 \text{ mol}}{\text{L}} = 1.8 \times 10^{-4} \text{ mol HCl}$$

$$3.6 \times 10^{-5} - 1.8 \times 10^{-4} = 1.44 \times 10^{-4} \text{ mol H}^+ \quad \frac{1.44 \times 10^{-4} \text{ mol}}{.035 \text{ L}} = .0041 \text{ M}$$

$$-\log (.0041) = \boxed{2.39 = \text{pH}}$$

iii. $4.44 \times 10^{-4} \text{ mol H}^+ = .0074 \text{ M}$ $-\log .0074 = \boxed{2.13 = \text{pH}}$
.06 L