

AP[®] CHEMISTRY
2005 SCORING GUIDELINES (Form B)

Question 1

$$K_a = \frac{[\text{H}_3\text{O}^+][\text{OCl}^-]}{[\text{HOCl}]} = 3.2 \times 10^{-8}$$

Hypochlorous acid, HOCl, is a weak acid in water. The K_a expression for HOCl is shown above.

(a) Write a chemical equation showing how HOCl behaves as an acid in water.

$\text{HOCl}(aq) + \text{H}_2\text{O}(l) \rightarrow \text{OCl}^-(aq) + \text{H}_3\text{O}^+(aq)$	One point is earned for the correct chemical equation.
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(b) Calculate the pH of a 0.175 M solution of HOCl.

$\text{HOCl}(aq) + \text{H}_2\text{O}(l) \rightleftharpoons \text{OCl}^-(aq) + \text{H}_3\text{O}^+(aq)$ <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 10%; padding-right: 10px;">I</td> <td style="width: 20%;">0.175</td> <td style="width: 10%; text-align: center;">–</td> <td style="width: 20%;">0</td> <td style="width: 10%; text-align: center;">~</td> <td style="width: 10%;">0</td> </tr> <tr> <td>C</td> <td>–x</td> <td>–</td> <td>+x</td> <td></td> <td>+x</td> </tr> <tr> <td>E</td> <td>0.175 – x</td> <td>–</td> <td>+x</td> <td></td> <td>+x</td> </tr> </table> $K_a = \frac{[\text{H}_3\text{O}^+][\text{OCl}^-]}{[\text{HOCl}]} = \frac{(x)(x)}{(0.175 - x)}$ <p>Assume that $0.175 - x \approx 0.175$</p> $3.2 \times 10^{-8} = \frac{x^2}{0.175}$ $x^2 = (3.2 \times 10^{-8})(0.175) = 5.6 \times 10^{-9}$ $x = [\text{H}_3\text{O}^+] = 7.5 \times 10^{-5} M$ $\text{pH} = -\log [\text{H}_3\text{O}^+] = -\log (7.5 \times 10^{-5}) = 4.13$	I	0.175	–	0	~	0	C	–x	–	+x		+x	E	0.175 – x	–	+x		+x	One point is earned for calculating the value of $[\text{H}_3\text{O}^+]$. One point is earned for calculating the pH.
I	0.175	–	0	~	0														
C	–x	–	+x		+x														
E	0.175 – x	–	+x		+x														

(c) Write the net ionic equation for the reaction between the weak acid HOCl(aq) and the strong base NaOH(aq).

$\text{HOCl}(aq) + \text{OH}^-(aq) \rightarrow \text{OCl}^-(aq) + \text{H}_2\text{O}(l)$	One point is earned for both of the correct reactants. One point is earned for both of the correct products.
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(d) In an experiment, 20.00 mL of 0.175 M HOCl(aq) is placed in a flask and titrated with 6.55 mL of 0.435 M NaOH(aq).

(i) Calculate the number of moles of NaOH(aq) added.

$\text{mol}_{\text{NaOH}} = 6.55 \text{ mL} \times \frac{1 \text{ L}}{1,000 \text{ mL}} \times \frac{0.435 \text{ mol NaOH}}{1 \text{ L}}$ $\text{mol}_{\text{NaOH}} = 2.85 \times 10^{-3} \text{ mol NaOH}$	One point is earned for the correct number of moles of NaOH.
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