pH of Weak Acids

1) The acid dissociation constant (K_a) for benzoic acid is 6.3×10^{-5}. Find the pH of a 0.35 M solution of benzoic acid.

2) Find the pH of a 0.275 M hypochlorous acid solution. $K_a = 3.0 \times 10^{-8}$.

3) Find the pH of a solution that contains 0.0925 M nitrous acid ($K_a = 4.5 \times 10^{-4}$) and 0.139 M acetic acid ($K_a = 1.8 \times 10^{-5}$).

1) $HC_7H_3O_{2(aq)} \leftrightarrows H^+_{(aq)} + C_7H_3O_2^-{}_{(aq)}$

initial	0.35 M	0 M	0 M
change	- x M	+ x M	+x M
equilibrium	(0.35 – x) M	x M	x M

Note that: (0.35 – x) M ≈ 0.35 M so

$$K_a = \frac{[H^+][C_7H_3O_2^-]}{[HC_7H_3O_2]} = \frac{(x)(x)}{(0.35 - x)} = \frac{(x)(x)}{(0.35)} = \frac{x^2}{(0.35)} = 6.3 \times 10^{-5}$$

$x^2 = (6.3 \times 10^{-5})(0.35) = 2.205 \times 10^{-5}$
$x = 4.7 \times 10^{-3}$ M   x = moles/L formed

pH = - log (4.7×10^{-3}) = 2.33

2) $HClO_{(aq)} \leftrightarrows H^+_{(aq)} + ClO^-_{(aq)}$

initial	0.275 M	0 M	0 M
change	- x M	+ x M	+x M
equilibrium	(0.275 – x) M	x M	x M

Note that: (0.275 – x) M ≈ 0.275 M so

$$K_a = \frac{[H^+][ClO^-]}{[HClO]} = \frac{(x)(x)}{(0.275 - x)} = \frac{(x)(x)}{(0.275)} = \frac{x^2}{(0.275)} = 3.0 \times 10^{-8}$$

$x^2 = (3.0 \times 10^{-8})(0.275) = 8.25 \times 10^{-9}$
$x = 9.08 \times 10^{-5}$ M

pH = - log (9.08×10^{-5}) = 4.042

3) First the amount of H^+ from each acid must be calculated.

$HNO_{2(aq)} \leftrightarrows H^+_{(aq)} + NO_2^-{}_{(aq)}$

initial	0.0925 M	0 M	0 M
change	- x M	+ x M	+x M
equilibrium	(0.0925 – x) M	x M	x M

Note that: (0.0925 – x) M ≈ 0.0925 M so

$$K_a = \frac{[H^+][NO_2^-]}{[HNO_2]} = \frac{(x)(x)}{(0.0925 - x)} = \frac{(x)(x)}{(0.0925)} = \frac{x^2}{(0.0925)} = 4.5 \times 10^{-4}$$

$x^2 = (4.5 \times 10^{-4})(0.0925) = 4.1625 \times 10^{-5}$
$x = 6.45 \times 10^{-3}$ M   x = moles/L formed

$HC_2H_3O_{2(aq)} \leftrightarrows H^+_{(aq)} + C_2H_3O_2^-{}_{(aq)}$

initial	0.139 M	0 M	0 M
change	- x M	+ x M	+x M
equilibrium	(0.139 – x) M	x M	x M

Note that: (0.139 – x) M ≈ 0.139 M so

$$K_a = \frac{[H^+][C_2H_3O_2^-]}{[H\,C_2H_3O_2]} = \frac{(x)(x)}{(0.139 - x)} = \frac{(x)(x)}{(0.139)} = \frac{x^2}{(0.139)} = 1.8 \times 10^{-5}$$

$x^2 = (1.8 \times 10^{-5})(0.139) = 2.502 \times 10^{-6}$
$x = 1.58 \times 10^{-3}$ M

Then add the results together and use that value to find the pH.

6.45×10^{-3} M + 1.58×10^{-3} M = 8.03×10^{-3} M

pH = - log (8.03×10^{-3}) = 2.095