

1. The dissociation constant for butanoic acid is $1.5 \times 10^{-5} \text{ mol l}^{-1}$.
Calculate the pH of a 0.010 mol l^{-1} butanoic acid solution.

2. The pH of a $0.0010 \text{ mol l}^{-1}$ solution of the base, BOH, is 10.

(a) Calculate the dissociation constant, K_b , for the base.

(b) State the relationship between K_b and pK_b .

(c) Calculate pK_b for the base.

3.

Acid	Dissociation in water	Dissociation constant
hydrogen sulphide	$H_2S \rightleftharpoons H^+ + HS^-$	8.9×10^{-8}
ethanoic	$CH_3COOH \rightleftharpoons H^+ + CH_3COO^-$	1.7×10^{-5}
chloroethanoic	$CH_2ClCOOH \rightleftharpoons H^+ + CH_2ClCOO^-$	1.3×10^{-3}
hypochlorous	$HClO \rightleftharpoons H^+ + ClO^-$	3.7×10^{-8}
chromic	$H_2CrO_4 \rightleftharpoons H^+ + HCrO_4^-$	1.0×10^1
propanoic	$CH_3CH_2COOH \rightleftharpoons H^+ + CH_3CH_2COO^-$	1.3×10^{-5}

(a) Which of the above acids is

(i) the weakest

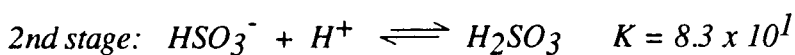
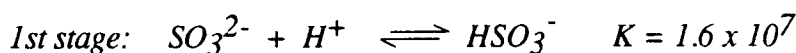
(ii) the strongest?

(b) Calculate the pK_a value for hypochlorous acid.

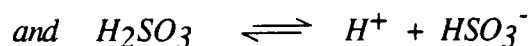
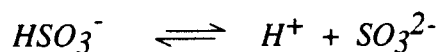
(c) Name the two acids from the above table which can undergo a second stage of dissociation.

For each of these acids, write the equation for the second stage of dissociation.

4. The reaction between sodium sulphite and hydrochloric acid takes place in two stages:



(a) Calculate the dissociation constant, K_a , and the corresponding pK_a value for each of the two acids, HSO_3^- and H_2SO_3 , given that they dissociate in the following way:



(b) Which is the weaker acid, HSO_3^- or H_2SO_3 ?

(c) Which of the species, SO_3^{2-} or HSO_3^- or H_2SO_3 , would predominate in a solution of

(i) $pH = 0$

(ii) $pH = 14$?

5. 0.12 mol l^{-1} methanoic acid solution has a pH of 2.3.

(a) Calculate the dissociation constant of methanoic acid.

(b) If solid sodium methanoate is added to this solution of methanoic acid, explain what will happen to

(i) the dissociation constant of methanoic acid

(ii) the pH of the solution.

$$1. \quad \begin{aligned} pK_a &= -\log K_a = -\log 1.5 \times 10^{-5} \\ (\text{butanoic acid}) &= 4.82 \end{aligned}$$

$$\begin{aligned} \text{pH} &= \frac{1}{2} pK_a - \frac{1}{2} \log C \\ &= \frac{1}{2} \times (4.82) - \frac{1}{2} \log(0.01) \\ &= 2.41 - \left(-\frac{2}{2}\right) \\ &= \underline{3.41} \end{aligned}$$

2.

$$[H^+] = \text{antilog}(-pH)$$

$$= \text{antilog}(-10)$$

$$= 1 \times 10^{-10}$$

$$[OH^-] = \frac{1 \times 10^{-14}}{1 \times 10^{-10}} = 1 \times 10^{-4} \text{ mol/l}$$

$$K_b = \frac{[OH^-]^2}{c} = \frac{(1 \times 10^{-4})^2}{0.001}$$

$$= \frac{1 \times 10^{-8}}{0.001}$$

$$= \underline{1 \times 10^{-5}}$$

3. (a) (i) hypochlorous (lowest K_a)
 (ii) chromic (Highest K_a)

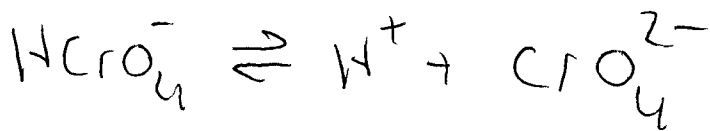
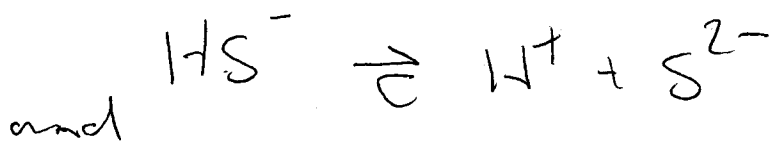
(b)

$$pK_a = -\log K_a = -\log (3.7 \times 10^{-8})$$

(hypochlorous)

$$= \underline{7.43}$$

(c) chromic and ~~H₂S~~ Hydrogen Sulphide



4. K_a (1st stage) = $\frac{[SO_3^{2-}][H^+]}{[HSO_3^-]} = \frac{1}{\frac{[HSO_3^-]}{[SO_3^{2-}][H^+]}} = \frac{1}{1.6 \times 10^{-7}} = \underline{6.25 \times 10^6}$

K_a (2nd stage) = $\frac{[HSO_3^-][H^+]}{[H_2SO_3]} = \frac{1}{\frac{[H_2SO_3]}{[HSO_3^-][H^+]}} = \frac{1}{8.3 \times 10^{-1}} = \underline{0.012}$

pK_a (1st stage) = $-\log K_a = -\log (6.25 \times 10^6) = \underline{7.2}$

pK_a 2nd stage = $-\log K_a = -\log (0.012) = \underline{1.92}$

5. (a) $[H^+] = \text{antilog}(-\text{pH})$
 $= \text{antilog}(-2.3) = 5.01 \times 10^{-3} \text{ mol/l}$

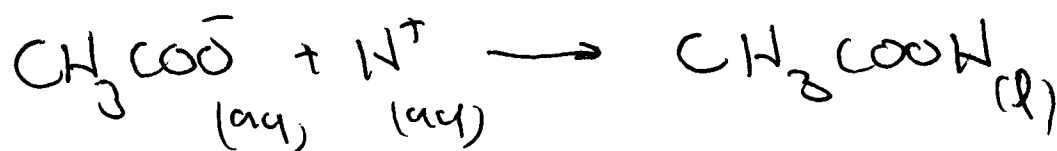
$$K_a = \frac{[H^+]^2}{C} = \frac{(5.01 \times 10^{-3})^2}{0.12} = \frac{2.51 \times 10^{-5}}{0.12}$$

$$= \underline{2.09 \times 10^{-4}}$$

(b) (i) no effect, K_a is independent of changes in concentration

(ii) pH would increase, $[H^+]$ would decrease due to the weak acid equilibrium shifting to reduce the concentration of methanoate ions

(c)



H^+ removed by joining to methanoate ions which form methanoic acid molecules.