

1. Calculate the hydrogen ion concentration and pH of the following solutions:

- 0.1 mol l<sup>-1</sup> ethanoic acid
- 0.01 mol l<sup>-1</sup> ethanoic acid
- 1.0 mol l<sup>-1</sup> phenol
- 0.5 mol l<sup>-1</sup> HCN solution

2. The table below gives information on some acids.

Name of acid	Dissociation in water	K <sub>a</sub> ( at 298 K)
hydrogen sulphide	$\text{H}_2\text{S} \rightleftharpoons \text{H}^+ + \text{HS}^-$	$8.9 \times 10^{-8}$
ethanoic	$\text{CH}_3\text{COOH} \rightleftharpoons \text{H}^+ + \text{CH}_3\text{COO}^-$	$1.7 \times 10^{-5}$
chloroethanoic	$\text{CH}_2\text{ClCOOH} \rightleftharpoons \text{H}^+ + \text{CH}_2\text{ClCOO}^-$	$1.3 \times 10^{-3}$
hypochlorous	$\text{HClO} \rightleftharpoons \text{H}^+ + \text{ClO}^-$	$3.7 \times 10^{-8}$
chromic	$\text{H}_2\text{CrO}_4 \rightleftharpoons \text{H}^+ + \text{HCrO}_4^-$	$1.0 \times 10^{-1}$
propanoic	$\text{C}_2\text{H}_5\text{COOH} \rightleftharpoons \text{H}^+ + \text{C}_2\text{H}_5\text{COO}^-$	$1.3 \times 10^{-5}$

- Which of the above is the weakest acid?
  - If the acids were listed in order of strength, strongest first, where on the list would water be placed?
  - Name an acid from the above table which can undergo a second stage of dissociation. Give the equation for this change.
3. A 0.01 mol l<sup>-1</sup> aqueous solution of benzoic acid (C<sub>6</sub>H<sub>5</sub>COOH); a weak monobasic acid has a pH value of 3.1.  
Calculate:
- the hydrogen ion concentration of the solution
  - the dissociation constant K<sub>a</sub> of the acid
4. Limewater is a saturated solution of calcium hydroxide. At 20°C, 100 cm<sup>3</sup> of lime water contained 0.126g of calcium hydroxide.
- Calculate the concentration of hydroxide ions in this solution.
  - Use your answer to part (a) to calculate the pH of the limewater.

1. (a) 
$$K_a = \frac{[H^+]^2}{C}$$

$$[H^+] = \sqrt{K_a \times C}$$

$$= \sqrt{1.7 \times 10^{-5} \times 0.1} = \sqrt{1.7 \times 10^{-6}}$$

$$= 1.30 \times 10^{-3} \text{ mol/l}$$

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

$$= -\log [1.30 \times 10^{-3}]$$

$$= \underline{2.89}$$

(b)

$$[H^+] = \sqrt{K_a \times C}$$

$$= \sqrt{1.7 \times 10^{-5} \times 0.01}$$

$$= \sqrt{1.7 \times 10^{-7}}$$

$$= 4.123 \times 10^{-4} \text{ mol/l}$$

$$pH = -\log [4.123 \times 10^{-4}]$$

$$= \underline{3.38}$$

(c)

$$[H^+] = \sqrt{K_a \times C}$$

$$= \sqrt{1.28 \times 10^{-10} \times 1}$$

$$= 1.13 \times 10^{-5} \text{ mol/l}$$

$$\text{pH} = -\log [1.13 \times 10^{-5}]$$

$$= \underline{\underline{4.95}}$$

(d)

$$[H^+] = \sqrt{K_a \times C}$$

$$= \sqrt{4.9 \times 10^{-10} \times 0.5}$$

$$= \sqrt{2.45 \times 10^{-10}}$$

$$= 1.56 \times 10^{-5} \text{ mol/l}$$

$$\text{pH} = -\log 1.56 \times 10^{-5}$$

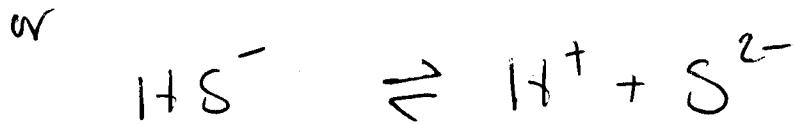
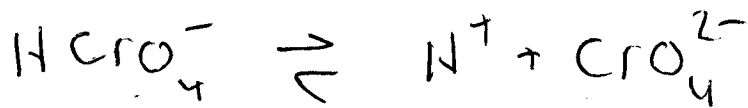
$$= \underline{\underline{4.8}}$$

2. (a) Hypochlorous, because it has the smallest  $K_a$

$$(b) K_{a(H_2O)} = \frac{[H^+][OH^-]}{[H_2O]} = \frac{1 \times 10^{-14}}{1} = 1 \times 10^{-14}$$

water therefore would be last as it is the weakest acid

(c)  $H_2CrO_4$  or  $H_2S$



$$3. \quad \text{pH} = -\log [\text{H}^+]$$

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

$$= \underline{7.94 \times 10^{-4}}$$

(b)

$$K_a = \frac{[\text{H}^+]^2}{c}$$

$$= \frac{(7.94 \times 10^{-4})^2}{0.01}$$

$$= \frac{\cancel{0.0282} 6.30 \times 10^{-7}}{0.01}$$

$$= \underline{6.3 \times 10^{-5}}$$

$$4 \quad (a) \quad \text{moles } \text{Ca(OH)}_2 = \frac{0.126}{74} = \frac{0.126}{74} = \underline{1.70 \times 10^{-3}}$$

$$\begin{aligned} \text{moles } \text{OH}^- &= 2 \times 1.70 \times 10^{-3} \\ &= 3.4 \times 10^{-3} \end{aligned}$$

$$\begin{aligned} \text{Conc} &= \frac{\text{moles}}{\text{Vol}} = \frac{3.4 \times 10^{-3}}{100/1000} \\ &= \underline{3.4 \times 10^{-2} \text{ mol/l}} \end{aligned}$$

$$\begin{aligned} \text{pOH} &= -\log[\text{OH}^-] \\ &= -\log[3.4 \times 10^{-2}] \\ &= \underline{1.47} \end{aligned}$$

$$\begin{aligned} \text{pH} &= 14 - \text{pOH} \\ &= 14 - 1.47 \\ &= \underline{12.53} \end{aligned}$$