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

   (a) 0·1 mol l^{-1} ethanoic acid
   (b) 0·01 mol l^{-1} ethanoic acid
   (c) 1·0 mol l-1 phenol
   (d) 0·5 mol l-1 HCN solution

2. The table below gives information on some acids.

Name of acid	**Dissociation in water**	**Ka (at 298 K)**
hydrogen sulphide	$H_2S \rightleftharpoons H^+ + HS^-$	$8{\cdot}9 \times 10^{-8}$
ethanoic	$CH_3COOH \rightleftharpoons H^+ + CH_3COO^-$	$1{\cdot}7 \times 10^{-5}$
chloroethanoic	$CH_2ClCOOH \rightleftharpoons H^+ + CH_2ClCOO^-$	$1{\cdot}3 \times 10^{-3}$
hypochlorous	$HClO \rightleftharpoons H^+ + ClO^-$	$3{\cdot}7 \times 10^{-8}$
chromic	$H_2CrO_4 \rightleftharpoons H^+ + HCrO_4^-$	$1{\cdot}0 \times 10^{-1}$
propanoic	$C_2H_5COOH \rightleftharpoons H^+ + C_2H_5COO^-$	$1{\cdot}3 \times 10^{-5}$

   (a) Which of the above is the weakest acid?
   (b) If the acids were listed in order of strength, strongest first, where on the list would water be placed?
   (c) 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^{-1} aqueous solution of benzoic acid (C_6H_5COOH); a weak monobasic acid has a pH value of 3·1.
   Calculate:
   (a) the hydrogen ion concentration of the solution
   (b) the dissociation constant Ka of the acid

4. Limewater is a saturated solution of calcium hydroxide. At 20°C, 100 cm^3 of lime water contained 0·126g of calcium hydroxide.
   (a) Calculate the concentration of hydroxide ions in this solution.
   (b) Use your answer to part (a) to calculate the pH of the limewater.

1.

(a)

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

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

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

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

$$pH = -\log[H^+]$$

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

$$= \underline{2.89}$$

(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)

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

$$= \sqrt{1{\cdot}28 \times 10^{-10} \times 1}$$

$$= 1{\cdot}13 \times 10^{-5} \text{ mol/l}$$

$$pH = -\log [1{\cdot}13 \times 10^{-5}]$$

$$= \underline{\underline{4{\cdot}95}}$$

(d)

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

$$= \sqrt{4{\cdot}9 \times 10^{-10} \times 0{\cdot}5}$$

$$= \sqrt{2{\cdot}45 \times 10^{-10}}$$

$$= 1{\cdot}56 \times 10^{-5} \text{ mol/l}$$

$$pH = -\log 1{\cdot}56 \times 10^{-5}$$

$$= \underline{\underline{4{\cdot}8}}$$

2\. (a) Hypochlorous, because it has the smallest Ka

(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

$HCrO_4^- \rightleftharpoons H^+ + CrO_4^{2-}$

or

$HS^- \rightleftharpoons H^+ + S^{2-}$

3. $pH = -\log[H^+]$

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

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

(b)

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

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

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

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

4 (a)

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

$$\text{moles } OH^- = 2 \times 1.70 \times 10^{-3}$$

$$= \underline{3.4 \times 10^{-3}}$$

$$\text{Conc} = \frac{\text{moles}}{\text{Vol}} = \frac{3.4 \times 10^{-3}}{100/1000}$$

$$= \underline{3.4 \times 10^{-2}} \text{ mol/l}$$

$$pOH = -\log[OH^-]$$

$$= -\log[3.4 \times 10^{-2}]$$

$$= \underline{1.47}$$

$$pH = 14 - pOH$$

$$= 14 - 1.47$$

$$= \underline{12.53}$$