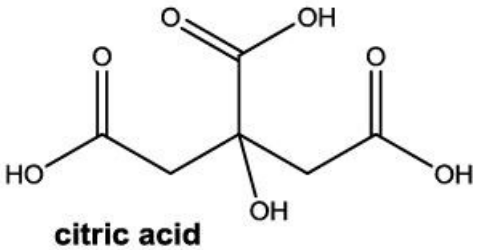
Problem 6: Acid erosion

Pre-Lab answers

1 & 2

Lemonade contains predominantly citric acid from the lemons



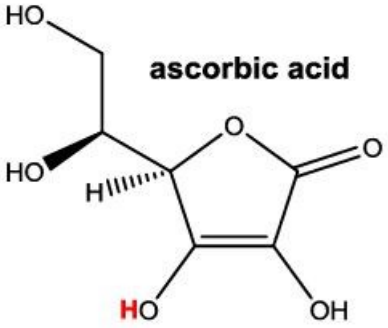
citric acid

pK_{a1} 3.06

pK_{a2} 4.74

pK_{a3} 5.40

Orange juice contains both citric acid and ascorbic acid (Vitamin C)

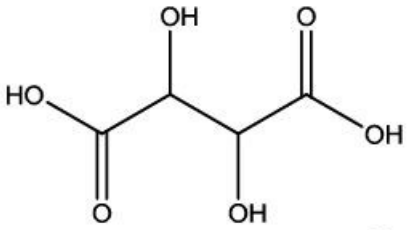


ascorbic acid

pK_{a1} 4.1

pK_{a2} 11.79

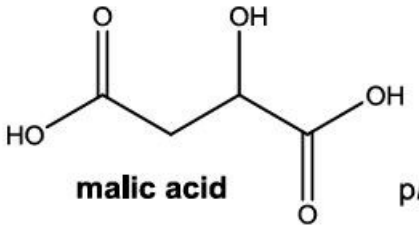
White wine contains principally tartaric acid and malic acid (although the students may find others)



tartaric acid

pK_{a1} 3.05

pK_{a2} 4.39



malic acid

pK_{a1} 3.48

pK_{a2} 5.10

All the acids are weak acids (NOTE In ascorbic acid the proton indicated in red is the acidic proton with a pKa of 4.1. The anion generated is stabilised through the conjugated carbonyl system.)

3. A strong acid is an acid which is fully dissociated in solution. An example is HCl which is fully dissociated to H^+ and Cl^- ions in solution;

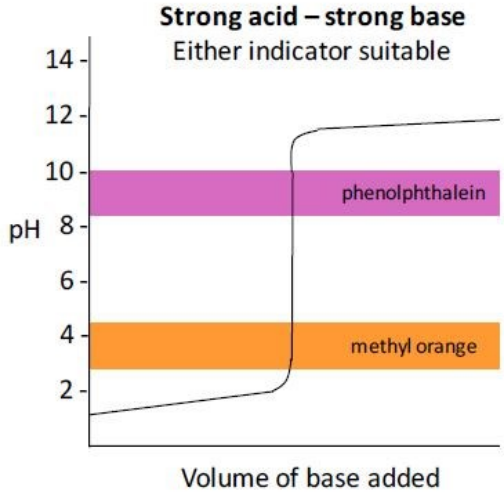
$$HCl \rightarrow H^+ (aq) + Cl^- (aq)$$

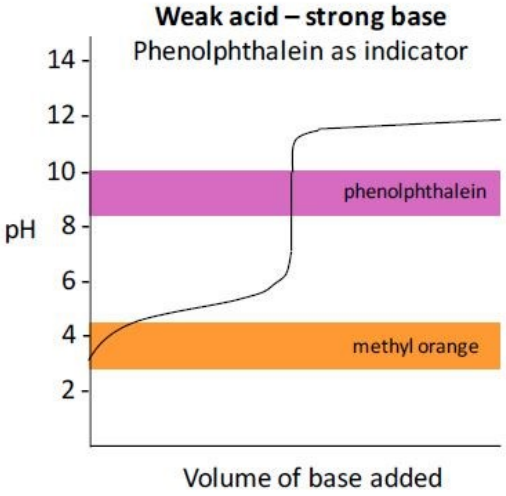
A weak acid is an acid which is only partially dissociated in solution. An equilibrium is established;

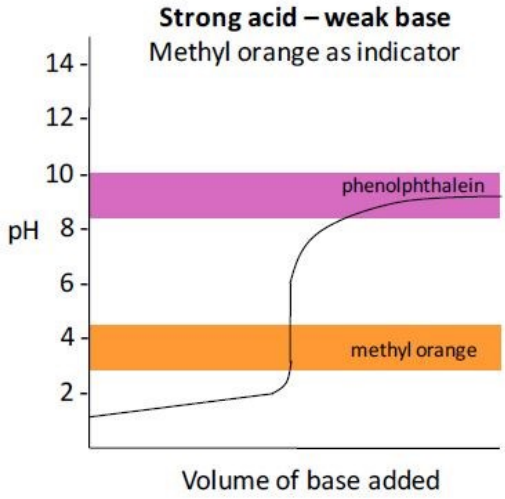
e.g. ethanoic acid, CH3COOH $\rightleftharpoons$ H^+ (aq) + CH_3COO^- (aq)

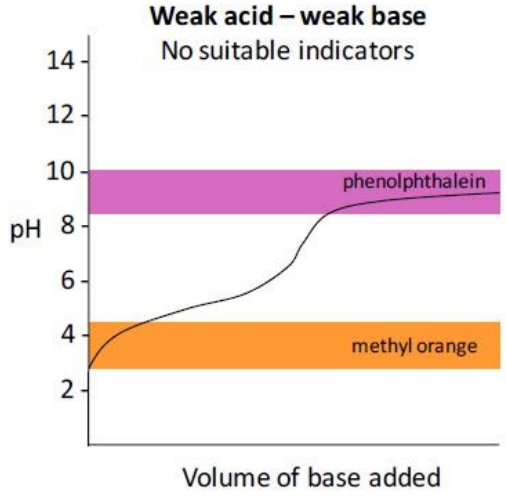
The concentration of an acid tells us how many moles of acid there are in the solution. The acid can be either a strong or a weak acid. So, for example, you can have a dilute solution of a strong acid e.g. 0.1 M HCl or a concentrated solution of a weak acid e.g. 10 M CH_3COOH.

4 & 5









At concentrations of 1 mol dm^{-3} or above, sodium hydroxide is corrosive and will cause severe eye damage. **Goggles** must be worn when it is in use.

Teacher and Technician Pack

Proposed method

NaOH soln (0.1 M **[Irritant]**; 1 M or 2 M **[Corrosive]**)

10 cm^3 aliquot of drink + phenolpthalein indicator **[Highly flammable; Harmful]**

Using the pre-lab questions, students realise that a titration with a strong base using phenolphthalein as indicator is required.
In order to decide on a suitable concentration for the base, students roughly determine the approximate volumes of the three bases needed to neutralise the acids in the drinks

From the results, the students conclude that the most appropriate base for the titration is;

= 0.1 M NaOH

0.1 M NaOH **[Irritant]** of known concentration

Students accurately determine the amount of acid in each of the drinks by titrating a 25 cm^3 aliquot of each drink against a 0.1 M solution of NaOH **[Irritant]** of known concentration, using phenolphthalein **[Highly flammable; Harmful]** as indicator.

25 cm^3 aliquot of drink + phenolphthalein indicator **[Highly flammable; Harmful]**

Using the results of the titration together the pK_a values of the acids in each of the drinks found in the pre-lab questions, students make a recommendation to the dentist.

Drink	White wine	Orange juice	Lemonade
Average titre / cm^3	22.95	33.75	17.20

Equipment list

Each group will need;

Initial investigations;

- Access to NaOH of varying concentrations (0.1 M [Irritant]; 1 M [Corrosive]; 2 M [Corrosive]). Approximate concentrations are adequate‡
- 3 × 10 cm^3 measuring cylinder
- Phenolphthalein indicator [Highly flammable; Harmful]
- Samples of orange juice, lemonade and white wine (30 cm^3 samples of each)
- 3 × 100 cm^3 conical flask
- Disposable pipettes

‡ Each group should only need approx 50 cm3 of 0.1 M NaOH, 10 cm^3 of 1 M NaOH and 5 cm^3 of 2 M NaOH in total if they try and neutralise the acid in 10 cm^3 samples of each of the drinks

Accurate titration;

- M NaOH of known, accurate concentration [Irritant]†
- 125 cm^3 White wine
- 125 cm^3 Lemonade (opened several days previously to allow all the CO_2 to come out of solution)
- 125 cm^3 Orange juice
- Phenolphthalein indicator [Highly flammable; Harmful]

If the group is to split up the work load and analyse the acid content in one drink each, each group will need 3 of each of the following;

- 50 cm^3 burette*
- Funnel
- Burette stand and clamp
- 25 cm^3 volumetric pipette with pipette filler*
- 250 cm^3 conical flask
- White tile
- Distilled water
- 250 cm^3 beaker (for the NaOH)

* The equipment must either be labelled with its accuracy or the information provided separately.

† If the titration is carried out on 25 cm^3 samples of drink, the approximate titres are; white wine 23 cm^3; orange juice 34 cm^3; lemonade 17 cm^3 (although this will vary with exact origin of drink)

For the titration, each student group will therefore need access to 150 cm^3 of each drink and 600 cm^3 of 0.1 M NaOH of known concentration (allowing for washing etc).