Dr. Z on pH

Dr. Z Chemistry Class

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Since the cosmetic chemist is first and foremost a chemist, I am pleased to present the following short review of pH. HAPPY FORMULATING!

Dr. Z's Chemistry Class

The pH scale

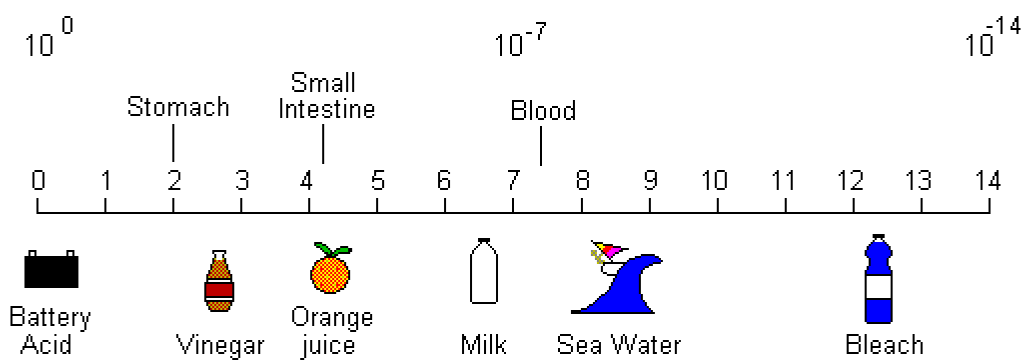
Arrhenius 1887 was the first person to give a definition of an acid and a base, namely that an Acid gives rise to excess of H+ in aqueous solution whereas a Base gives rise to excess of OH- in solution.

The theory was refined by Bronsted-Lowry in 1923 such that a proton donor was defined as an acid and a proton acceptor as a base. They also introduced the familiar concept of the conjugate acid - case pair. The final refinement to acid base theory was completed by Lewis in 1923 who extended the concept to be an acid is an e -pair acceptor and a base an e -pair donor.

The pH scale derives from the characteristics of the auto-dissociation of Water. Pure water has a low conductivity and is only slightly ionized however does water dissociate slightly into hydronium ions and hydroxide ions:

$2H_2O = H_3O^+ + OH^-$ or $H_2O = H^+ + OH^-$

pH scale



Relationship between pH and pKa

We all remember pKa from chemistry class. For some it is a blur of classes past, but it is a powerful concept. The famous Henderson-Hasselbach equation defines the relationship between pH, and pKa. It allows us to calculate the relative concentrations of an acid and its salt.

$$pH = pKa + \log \frac{[A^-]}{[HA]}$$

where $[A^-]$ is the molar concentration of the salt (dissociated species) and [HA] is the concentration of the undissociated acid. When the concentrations of the salt and acid are equal, the pH of the system equals the pKa of the acid.

Example

What is the concentration of sodium acetate and acetic acid at pH 5.75 and 6.75 (25^oC) given the following:

$$pH = pKa + \log \frac{[A^-]}{[HA]}$$

Acids	T(°C)	pKa
Acetic	25	4.75

Answer 1

5.75 = 4.75 + log [Acetate]/[Acid]

1 = log [Acetate]/[Acid]

There is 10 acetate molecules to each1 acid molecule at pH 5.75

Answer 2

6.75 = 4.75 + log [Acetate]/[Acid]

2 = log [Acetate]/[Acid]

There is 100 acetate molecules to each1 acid molecule at pH 6.75

pKa of Common acids and Common Bases

When using buffer solutions, the effective buffering range of any weak acid or base is ± 1 pH unit.

Acids	T(°C)	pKa
Acetic	25	4.75
Benzoic	25	4.20
Citrate (1)	25	3.13
(2)	25	4.76
(3)	25	6.40
o-Phosphoric (1)	25	2.12
(2)	25	7.21
(3)	25	12.67
Succinic (1)	-	4.19
(2)	-	5.57

Bases	T(°C)	pKa
Ammonia	25	9.25
Diethylamine	20	11.09
Dimethylamine	25	10.73
Ethylamine	20	10.81
Ethylenediamine (1)	20	10.08
(2)	20	6.99
Methylamine	25	10.66

Happy Formulating !

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