THEORY OF INDICATORS

(FOR B.Sc.Part-II (Hons & Subs)

Dr. Sanjay Kumar Srivastava

Deptt of Chemistry

S.G.G.S College, Patna city

INDICATORS

INDICATORS are those substance employed to determine the end point of a volumetric titration.

'Indicators are either organic weak acid or weak bases having different colours in different medium' .

Phenolphthalein, methyl orange, litmus solution, methyl red and etc are acid - base indicators.

An Indicator is also defined as a substance which indicates completion of acid-base titration or end point by changing its colour within limits with variation in P_H of the solution to which it is added.

THEORY OF INDICATORS

There are two theory of indicators as given below :-

(1) Ostwald's theory (2) Quinonoid's theory

OSTWALD'S THEORY

Ostwald's theory is as follows :-

(1) The indicators are weak electrolytes whose ionized form has different colour than the unionized form. The colour change is due to ionization of the indicator.

(2) Since indicators are weak acids or bases so the ionization of the indicator is largely affected in acids and bases. IF the indicator is weak acid, its ionization is very much low in acids due to common H^+ ions while it is fairly ionized in alkalies . Similarly if the indicator is a weak base, its ionization is large in acids and low in alkalies due to common OH^- ions .

The above theory can be understood by considering two important indicators methyl orange and phenolphthalein as given below :

PHENOLPHTHALEIN

Phenolphthalein is weak acid whose unionized molecule is colourless but its ionized form has pink colour and it ionises as given below

$$\underset{\text{Colourless}}{HPh} \leftrightarrow H^+ + \underset{\text{pink}}{Ph^-}$$

When phenolphthalein is added to acid the above equilibrium shifts towards left due to increase in concentration of H^+ and hence the ionization of indicator is suppressed consequently solution becomes colourless. On the other hand when phenolphthalein is added to an alkaline solution eg NaOH ,KOH, the OH^- produced by alkali reacts with H^+ and forms feebly dissociated molecule of H_2O due to this above equilibrium shifts towards right and hence concentration of Ph- ions increases in solution and solution becomes pink .

$$HPh + OH^- \leftrightarrow H_2O + Ph^-$$

But when phenolphthalein is added to solution of salt of weak base and strong acid eg NH_4OH then only few OH^- ions with which H^+ ions of phenolphthalein may combine and thus equilibrium is not shift sufficiently right and pink colour is not appeared boldly.

METHYL ORANGE

Methyl orange is a weak base and can be represented by MeOH .Its unionized form is yellow which gives red coloured Me^+ ions on ionization.

$$\underset{\text{Yellow}}{MEOH} \leftrightarrow \underset{\text{red}}{Me^+} + \underset{\text{colourless}}{OH^-}$$

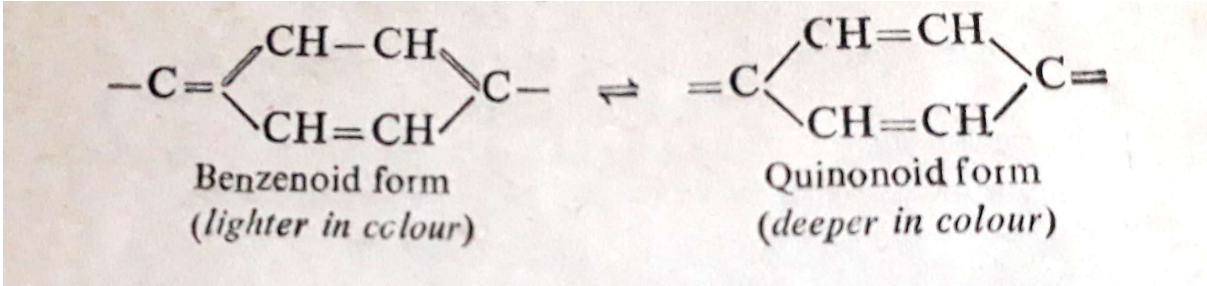
When solution of methyl orange is added to an alkali solution ,due to excess common ion OH^- the ionization of MeOH is suppressed, and the solution remains yellow . when acid is added then H^+ ions of acid combine with OH^- ions and form feebly ionized water and due to this above equilibrium shifts towards right and solution becomes red.

QUINONOID THEORY

QUINONOID THEORY is also known as modern theory.
According to this theory :
(1) The acid -base indicators used in volumetric titration are organic aromatic compounds which exist in two tautomeric forms having

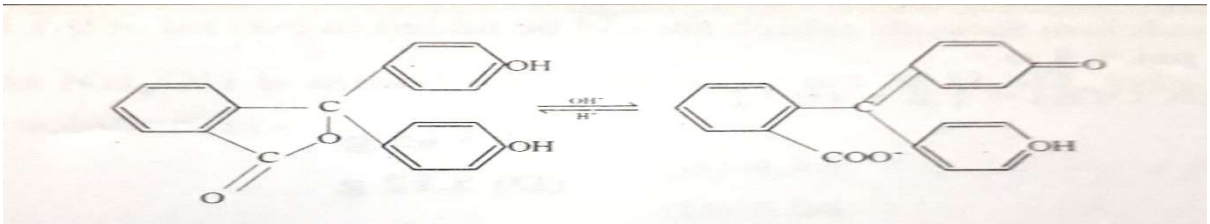
different structures . One form is termed benzenoid form and the other quinonoid form .

(2)TWO forms having different colour remain in equilibrium . One form exists in acidic medium while other form exists in alkaline medium. The quinonoid form is usually deeper in colour then the benzenoid form. The colour change is due to the interconversion of one tautomeric form into other.

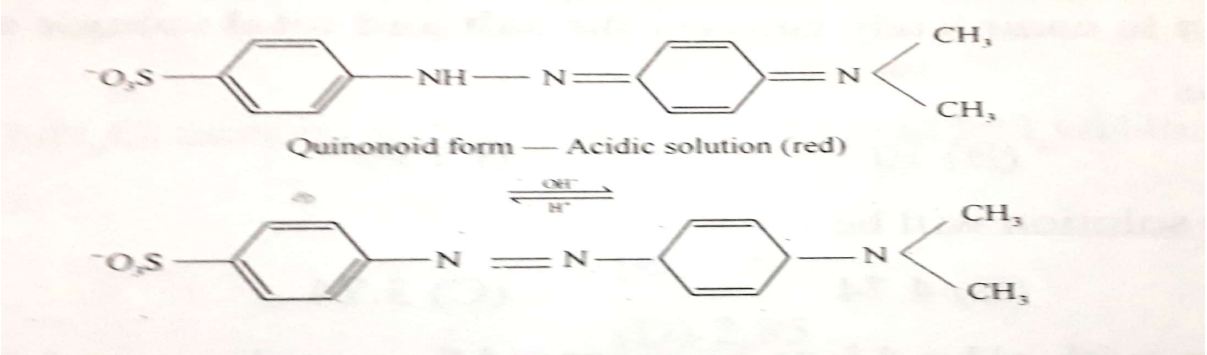


(3) During titration the medium changes from acidic to alkaline or vice-versa via neutral medium .The change in P_H converts one tautomeric form into other and thus, the colour change occurs.

Eg Phenolphthalein in acidic medium exists in benzenoid form so it is colourless but when medium of solution changes into alkaline medium it get converted into quinonoid form and colour of solution changes to pink.



eg methyl orange exists in two tautomeric forms. The quinonoid form has red colour in acidic medium while benzenoid form has yellow colour. when alkali solution is added to converts solution having methyl orange from acidic to alkaline medium then colour changes from red to yellow.


$^{-}O_3S$
NH
N
N
CH_3
CH_3
Quinonoid form — Acidic solution (red)
OH^-
H^+
$^{-}O_3S$
N
N
N
CH_3
CH_3

######################Thanks ##############