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Passing the litmus test

Litmus, the third umpire

In chemistry *indicators* are the referees who blow the whistle when a medium crosses the boundary between acid or base, says S.Ananthanarayanan.

In chemistry, a *base* is like the opposite of an acid – mix and acid and a base and you end up with salt and water, which means the acid and base *neutralize*.

Acids and bases

The important chemical quality of an acid is that it *donates* hydrogen ions. When acids react with metals, the metal takes the place of hydrogen in the acid and the hydrogen comes off as gas. It is the same with acid and an oxide, but in this case the hydrogen joins the oxygen to give water. Examples of acids are hydrochloric acid, which has hydrogen and chlorine (HCl) or nitric acid (HNO_3), which has hydrogen, nitrogen and oxygen. In both cases, the H^+ portion gets free to react, once in solution. Acids could even be thought of as the H^+ of water (water is H_2O which splits as: H^+ + OH^-) with the OH^- part replaced by Cl^- or NO_3^- .

Bases, in contrast, are metals combined with a part that readily reacts with the H^+ that acids are keen to donate. In solution, bases are very often like the OH^- part of water, with the H^+ portion replaced by a metal, like sodium (Na^+) or potassium (K^+). Examples are sodium hydroxide, NaOH, caustic soda or potassium hydroxide, KOH, caustic potash. The metal ions in these bases have strong tendency to replace hydrogen of other chemicals and the OH^- is always ready to combine with hydrogen to form water.

Is it acid or base?

We can see that when an acid is added to a base, the acid will neutralise a bit of the base leaving less of the base than before. This will continue till there is very little base and then, none at all, and after that, the mixture starts getting more and more acid. Situations arise where it is important to know when the mixture has just become neutral, or just changed character.

The time-honoured way to do this is to use an *indicator*. ***Litmus paper*** and a substance called ***phenolphthalein*** are the common examples. Litmus paper is blue in a basic solution and red in an acidic one. Phenolphthalein is colourless in an acidic medium but gets pink as the medium grows basic. The good part is that the medium needs to get just a *wee* bit basic or acidic for the indicators to change colour, which makes them sensitive indeed.

How do they work?

Things have one colour or another depending on which frequencies of light they absorb and the colours they transmit or reflect. The disposition of the atoms that make up the phenolphthalein molecule absorb light at ultraviolet frequencies. Hence, visible light comes through intact and the liquid is colourless.

But this is so only so long as the medium is acid or neutral. The least presence of a base and hydrogen atoms that are present in the structure of the phenolphthalein molecule get pulled off, to combine with the OH^- in the base. Taking away H^+ like this leaves the phenolphthalein molecule with a (—) charge and the molecule starts absorbing light at a lower frequency, in the blue region. With the blue part of white light getting absorbed, what is left is on the red side, and, to start with, it is pink.

Litmus is similar. When the molecule is intact, in an acid medium, litmus absorbs in the blue region and its appearance is red. But in a basic medium, the H^+ is pulled off and the molecule stars absorbing in the red region. This lets blue light come through, as soon as the medium gets even just a bit basic.