Chemguide – answers

INDICATORS

1. a) The alkaline solution reacts with the hydrogen ions on the right-hand side of the equilibrium. According to Le Chatelier, that will shift the position of the equilibrium to the right as it moves to replace the lost hydrogen ions. That produces more of the yellow form of the indicator, and uses up the red form. The indicator therefore turns yellow.

   b) According to Le Chatelier, that will shift the position of the equilibrium to the left as it moves to remove the extra hydrogen ions. That produces more of the red form of the indicator, and uses up the yellow form. The indicator therefore turns red.

   c) At pH 3.7, the methyl orange is half-way through its colour change, and there are equal concentrations of the red and yellow form present. The indicator will therefore look orange. The pH range of 3.1 - 4.4 tells you that at a pH of 3.1 or lower, the indicator will be red - there will be so little yellow form present that the eye can't detect it. At a pH of 4.4 or higher, the indicator will be yellow - there will be so little red form present that the eye can't detect it. As you go from pH 3.1 to 4.4, the indicator will start red, gradually move through various shades of orange, and end up yellow.

   d) Yellow. Any pH above 4.4 will give you a yellow colour.

   e) Yellow. Any pH above 4.4 will give you a yellow colour.

   f) A slightly reddish orange. The pH is slightly below the mid-point of the change at 3.7, and so there will be slightly more red form than yellow form present,

2.

pH	**bromophenol blue**	**methyl red**	**phenolphthalein**
2.0	yellow	red	colourless
3.0	yellow	red	colourless
4.0	green (a mixture of yellow and blue)	red	colourless
5.0	blue	orange (a mixture of red and yellow)	colourless
6.0	blue	a slightly orangey yellow	colourless
7.0	blue	yellow	colourless
8.0	blue	yellow	colourless
9.0	blue	yellow	pink

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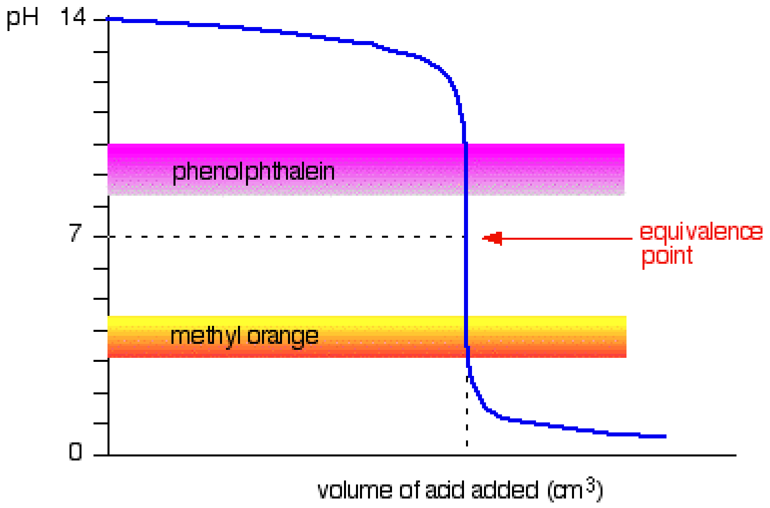
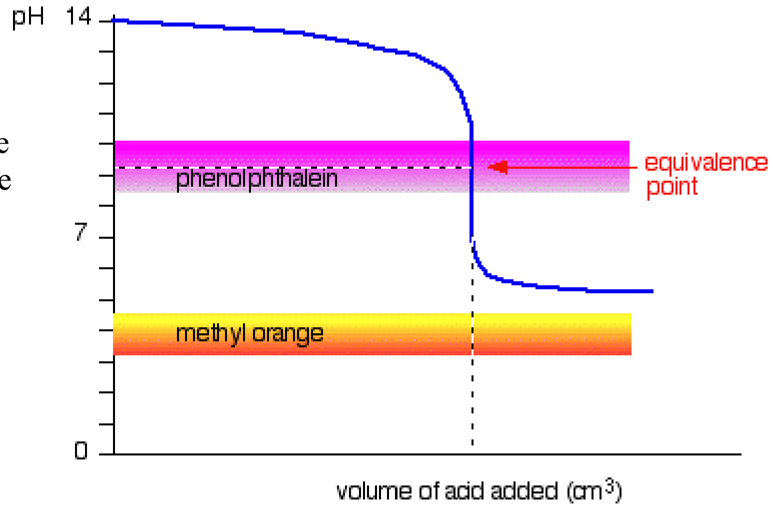
3. a) Titrating a strong base with a strong acid:

You could use either indicator, because both change colour on the very steep bit of the graph. Therefore the difference between the two titration values would be very small.



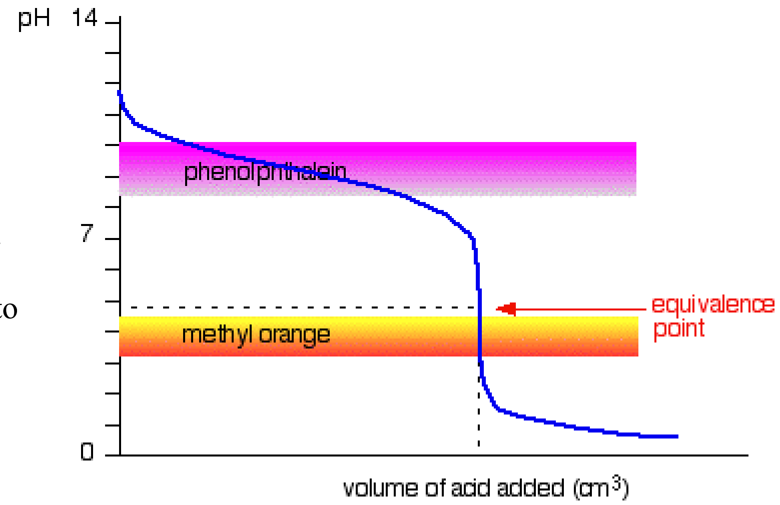
b) Titrating a strong base with a weak acid:

Phenolphthalein would give an accurate result, if you titrated until it just became colourless, or better still, almost colourless. Methyl orange would obviously not change colour at all, because its range doesn't fall anywhere on the curve.



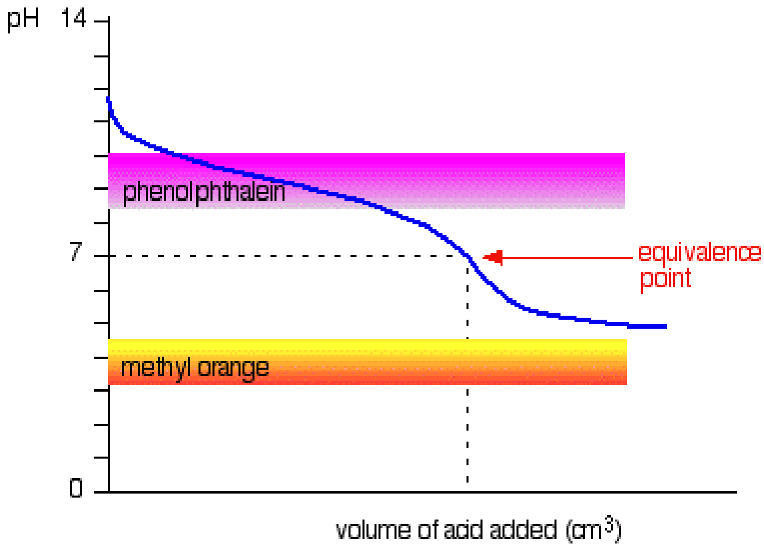
c) Titrating a weak base with a strong acid:

Phenolphthalein would be useless, slowly getter paler over the course of most of the titration, and becoming colourless before the last important bit. Methyl orange would be fine. For maximum accuracy, you would titrate to the first trace of orange in the solution in order to get as close to the equivalence point as possible



d) Titrating a weak base with a weak acid:

Neither indicator will change colour at the equivalence point.



e) The indicator would be half-way through its colour change at pH 7.0, but would have started changing colour at pH 7.6. If you look at the graph, that might be several cm^3 before the equivalence point. It won't finish changing until pH 6.0 which could be a few cm^3 after the equivalence point. You can't possibly guess when it was half-way through the change under those circumstances.

4. a) $$Na_2CO_{3(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + NaHCO_{3(aq)}$$

b) The equivalence point happens to be at the exact bottom end of phenolphthalein's pH range, and phenolphthalein fades from red to colourless at this point. It is relatively easy to see when a solution has become colourless rather than some particular colour.

c) Bromophenol blue could be used because its pK_{ind} of 4.0 falls on the steep part of the curve. It would probably be better to continue adding the acid until the colour was a yellowish green so that you are getting towards the bottom end of its range to match the equivalence point pH as closely as possible.

Methyl red would start changing colour at pH 6.3 and finish at 4.2. Although the finish is just about on the steep bit of the curve, there is no way of being certain when you had a final red rather than an orangey-red if the colour is changing very slowly. An accurate result would be impossible.