Second Year blog on the signposts for calculating the changing pH values in a titration that involves either a weak acid or a weak base: 29th March 2019

(This is a **revision** blog. It is merely a _summary_ of some of the things that you need to know. Everything in this blog can be found in the relevant Chapters of the two books.)

1) The p of X $= -\log_{10}(X)$, therefore the **pH of a solution $= -\log_{10}([H^+])$** , but
2) for a base please remember you will need to use   **pH $= 14.0 - $ pOH** .
3) Concentration = Number of moles ÷ Volume of the solution, or **C = N ÷ V in dm³**
4) If you are dealing with a Weak Acid or a Weak Base, then you **MUST** use an ICE table.
5) For reversible reactions that are at dynamic equilibrium at a given temperature, K_a and K_b are all about concentrations (raised to the power of their stoichiometric ratios). You must therefore construct an ICE table for **concentrations** (or for moles which you must then divide by volumes). **Your answer will therefore be wrong if you forget to put your Water in the reversible reaction equation** (because you must divide moles by the same number of volumes on each side of the reversible reaction equation).
6) Please remember that in an ICE table you ignore the **change** in $[H_2O]$. $[H_2O]$ is very small ($K_w = 1 \times 10^{-14}$) and you can ignore $\Delta[H_2O]$. **However, we are not ignoring the "$[H_2O] = 1.0$".** We **cannot** ignore the "1.0" because then we would have two lots of the volume as the DIVISOR on one side of an equation and only one lot of volume on the other side – and then ALL our calculations would be wrong thereafter. K_a and K_b are about **concentrations**, and $C = N \div V$.
7) Therefore keep track of the number of moles of the Titrant that you are adding to the Analyte, **and** keep track of your volumes (because K_a and K_b are all about **concentrations**).
8) If the unknown variable in an ICE table is designated as "z", then you _can_ resolve the value of "z" by using a _quadratic equation_ – but that will involve you in a fair amount of number crunching and (usually) it will **not** make any difference to the value of the pH that eventually emerges. In the **vast** majority of cases, when solving for the value of **"z^2"** you can ignore any numbers that involve "–z" or "+z", but you **cannot** ignore any numbers that involve "times z" and "÷ z". That makes the arithmetic much easier and doing so makes no difference to the final value of the pH (which is normally given to just ONE decimal place anyway).
9) **$K_a . K_b = K_w = 1 \times 10^{-14}$** , and taking the log of both sides of that equation then **pKa + pKb = 14.0**
10) A titration curve is 'S-shaped' and it has three parts to it
- a bottom bit where either the acid or the base is being neutralised (i.e. if it is an acid/base titration)
- a central point where the two reacting substances (the titrant and the analyte) have exactly reacted with each other, and this point is called the Equivalence Point**,** and
- a top bit where the concentration of the second substance, the Titrant (either the acid or the base) is getting larger and larger.
11) When dealing with either a Weak Acid or a Weak Base, then by the very definition of "weakness" you are involved in reactions that reach a position of dynamic equilibrium when only a small proportion of their "acidity" or their "basicity" has been released and, to calculate your pH values, you must then use the Henderson-Hasselbalch equation which for a Weak Acid
" HA $\rightleftharpoons$ H^+ + A^- " says
$$pH = pK_a + \log_{10} \left\{ \frac{[A^- (aq)]}{[HA (aq)]} \right\} \frac{\text{Concentration of the SALT}}{\text{Concentration of the ACID}}$$
12) Whenever you add a Weak Acid to Water you get **H^+ ions**, and when you add a Weak Base to Water you get **OH^- ions**.
13) At half the volume of the volume at the equivalence point, the pH of a Weak Acid is equal to its pK_a. This stems from something called the Henderson-Hasselbalch equation (Chapter 9 of the Year 2 book)

and this is what Q12/Edexcel/2016 was all about – and what all acid/base titrations are about.