From page 33, 36 and 37 of lecture notes

Question with answers: Calculate the pH of the following three solutions:

i) 0.001 M HNO_3 $[H^+]$ = 0.001 M $\therefore$ pH = –log(0.001) = **3.0**

ii) 0.001 M NaOH $[OH^-]$ = 0.001 M $\therefore$ pOH =–log(0.001) = 3.0

and pH = 14.00 – pOH = 14.00 – 3.0 = **11.0**

iii) The solution resulting from mixing 400 mL of 0.05 M HCl with 600 mL of 0.05 M NaOH.

There are a number of ways to solve this question; here is one way. The concentrations of acid and base are the same but the volumes are different. We can see there is an excess of 200 mL of NaOH solution after neutralisation of the acid.

Amount of NaOH in excess: moles = conc x volume = (0.05 mol L^{-1}) (0.200 L) = 0.01 mol.

Total volume is now 1000 mL or 1 L.

$[OH^-]$ = moles / volume = (0.01 mol) / (1 L) = 0.01 M

pOH = –log$[OH^-]$ = –log(0.01) = 2.0 and pH = 14.00 – 2.0 = **12.0**

iv) What is the $[H^+]$ of a solution with a pH of 4.5 ?

pH = –log$[H^+]$

$\therefore$ –pH = log$[H^+]$

$\therefore$ $10^{-pH} = [H^+]$

$[H^+] = 10^{-4.5} = 3.2 \times 10^{-5}$ M = **3×10^{-5} M** to 1 significant figure

v) What is the $[OH^-]$ of a solution with a pH of 12.2 ?

pOH = 14.00 – 12.2 = 1.8

$\therefore$ $[OH^-] = 10^{-1.8}$ = 0.016 M = **0.02 M** to 1 significant figure

From page 33, 36 and 37 of lecture notes

Question: Indicate with a √ or X which of the following acid – base reactions will occur.

Answer:

In all these acid – base reactions we can identify two conjugate pairs (**Acid(1), Base(1)** and **Acid(2), Base(2)**). In a reaction we have **Acid(1)** reacting with **Base(2)** to give the conjugate pair of each:

Acid(1) + Base(2) ⇌ Base(1) + Acid(2)

This is an equilibrium and the side that is favoured depends on the relative strengths of the acids involved.

So let's say the carboxylic acid is CH_3COOH and hence its conjugate base is CH_3COO^-. We are reacting the carboxylic acid with the base NH_2^- which has its conjugate acid as NH_3.

$$CH_3COOH + NH_2^- \rightleftharpoons CH_3COO^- + NH_3$$

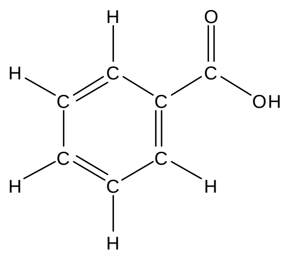
Compare the pK_a values of the two acids (here, he carboxylic acid ~5 and NH_3 ~ 25), the smaller value indicates the stronger acid and hence the one that will be dissociated – that is the carboxylic acid. Hence we can say this equilibrium is to the right and reaction will occur.

$$CH_3COOH + NH_2^- \rightarrow CH_3COO^- + NH_3$$

		Base		
Acid		NH_2^- (pK_a = 25)	OH^- (pK_a = 15.7)	HCO_3^- (pK_a = 6.35)
	Carboxylic acid (pK_a ~ 5)	√	√	√
	Phenol (pK_a ~ 10)	√	√	**X**
	Alcohol (pK_a ~ 17)	√	**X**	**X**

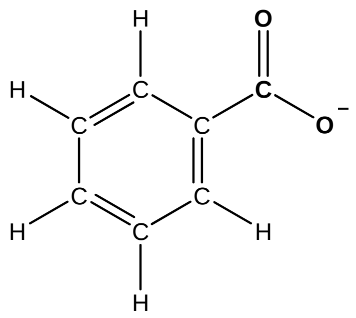
From page 33, 36 and 37 of lecture notes

Question: Benzoic acid (structure below, pK_a = 4.19) is found in mouth wash preparations. What will its structure be at pH = 7 and at pH = 2?



Answer: Compare the value of pH with that of pK_a. If pH < pK_a (ie 'on the acid side') the conjugate acid will dominate and visa versa.

at pH = 7



at pH = 2