1. a) The equivalence point is where you have mixed the sodium hydroxide and the hydrochloric acid in exactly equal proportions.

\[ \text{NaOH}_{(aq)} + \text{HCl}_{(aq)} \rightarrow \text{NaCl}_{(aq)} + \text{H}_2\text{O}_{(l)} \]

So they would be there in a molar ratio of exactly 1:1

b) 

![pH Curve](image)

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c) 

![pH Curve](image)
2. a) Rapid fall of pH to start with, but the rate of fall slows down.

b)  

c)
3. a) \[ \text{Na}_2\text{CO}_3(\text{aq}) + \text{HCl}(\text{aq}) \rightarrow \text{NaCl}(\text{aq}) + \text{NaHCO}_3(\text{aq}) \]

b) \[ \text{NaHCO}_3(\text{aq}) + \text{HCl}(\text{aq}) \rightarrow \text{NaCl}(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \]

Or you could give the overall equation for the reaction for part (b):

\[ \text{Na}_2\text{CO}_3(\text{aq}) + 2\text{HCl}(\text{aq}) \rightarrow 2\text{NaCl}(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \]

c) (i) A diprotic has two protons (or hydrogen ions) which it can donate to a base.

(ii) \[ \text{COOH} \quad \text{COOH} \quad + \quad \text{NaCH}_2(\text{aq}) \rightarrow \text{COONa} \quad \text{COOH}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \]

(iii) \[ \text{COONa} \quad \text{COOH} \quad + \quad \text{NaCH}_2(\text{aq}) \rightarrow \text{COCNa} \quad \text{COONa}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \]

(You don't need to colour-code the hydrogens.)