A2 Physical Chemistry

Indicators and Titration Curves

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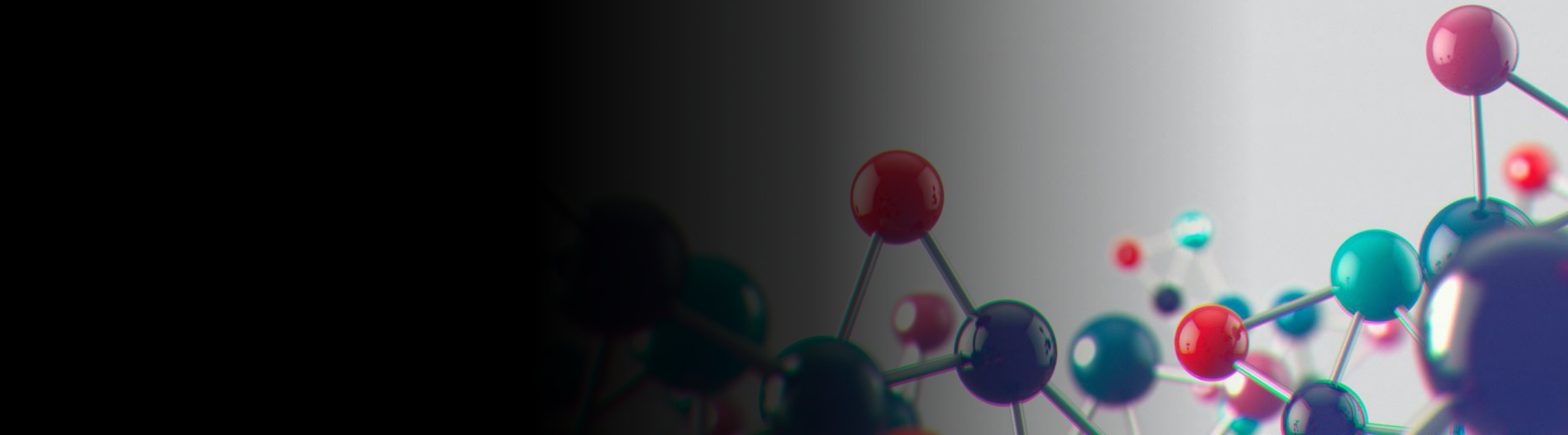

Indicators

Indicators change colour over a pH range. They are weak acids that have different colours as HIn and In^-.

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Colour in acidic conditions

Colour in alkaline conditions

The pH at which the indicator changes colour depends of its pK_a

When [HIn] = [In^-], the colour would be a 1:1 mixture of HIn:In^-

$$HIn \rightleftharpoons H^+ + In^-$$

$$K_{In} = \frac{[H^+][In^-]}{[HIn]}$$

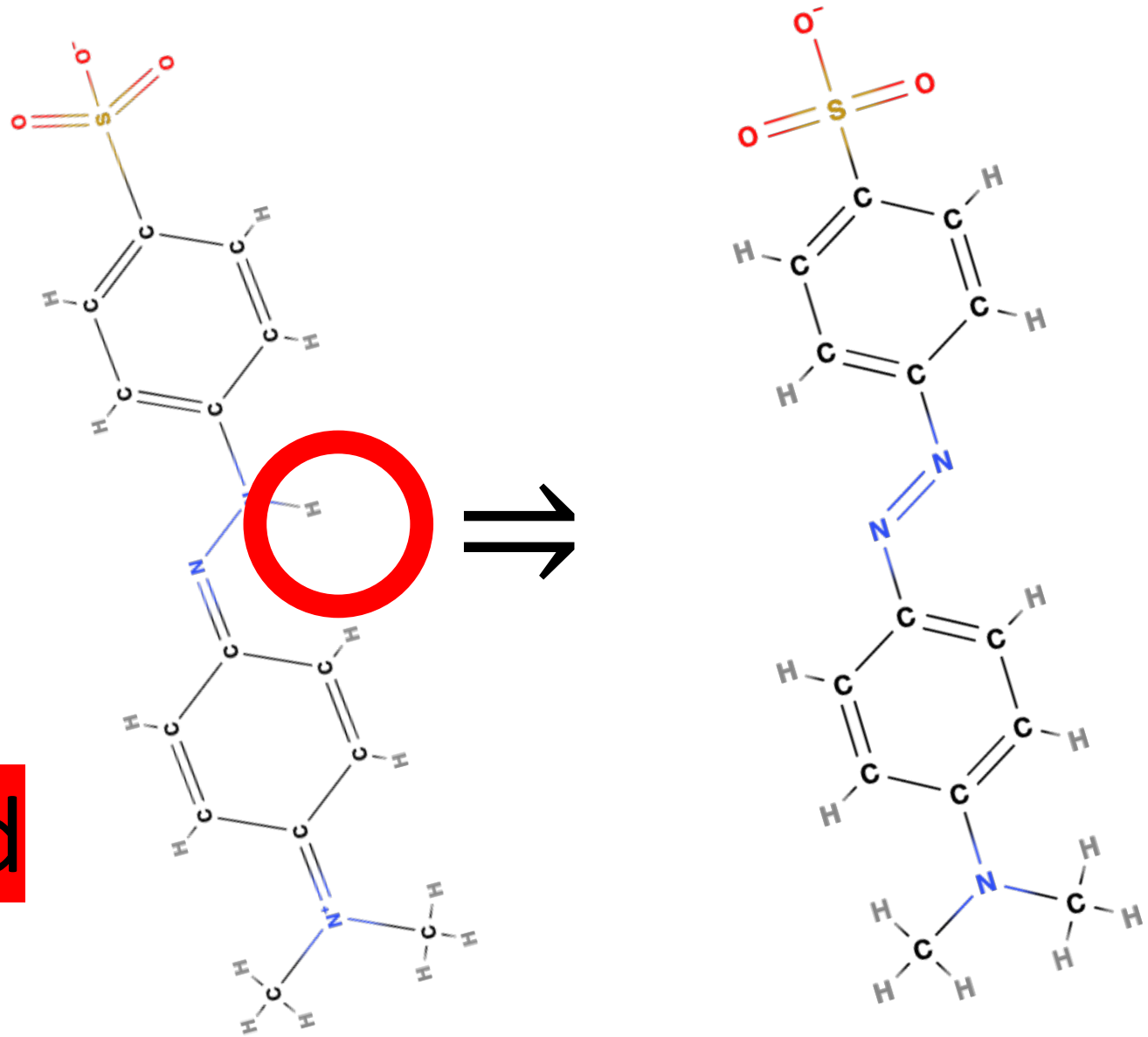
At halfway through the colour change $[HIn]=[In^-]$

$$K_{In} = [H^+] \qquad pK_{In} = pH$$

Indicators don't change colour sharply at one particular pH.
Instead, they change over a narrow range of pH.

Indicator	pK_{In}	pH range
Methyl orange	3.7	3.1 - 4.4
Phenolphthalein	9.3	8.2 - 10.0

Methyl Orange



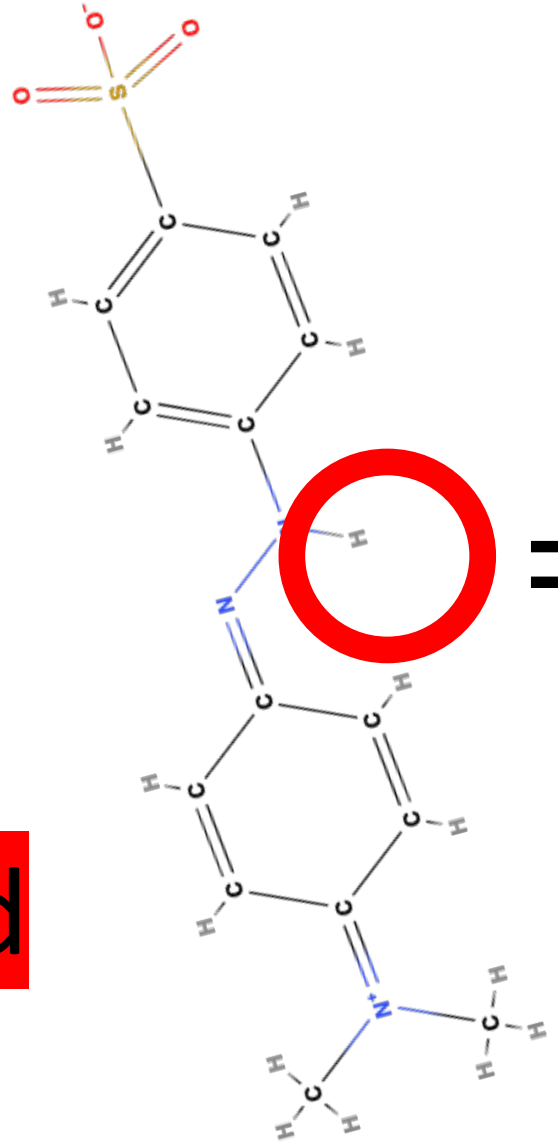
Red

+ H^+

Yellow

Methyl Orange

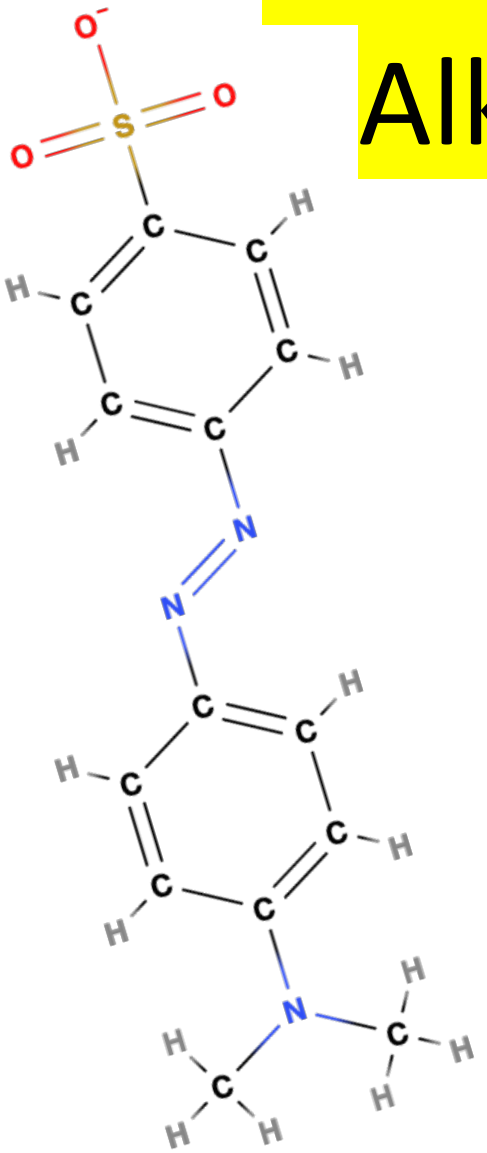
Colour in acid



Red

⇌

Colour in Alkali

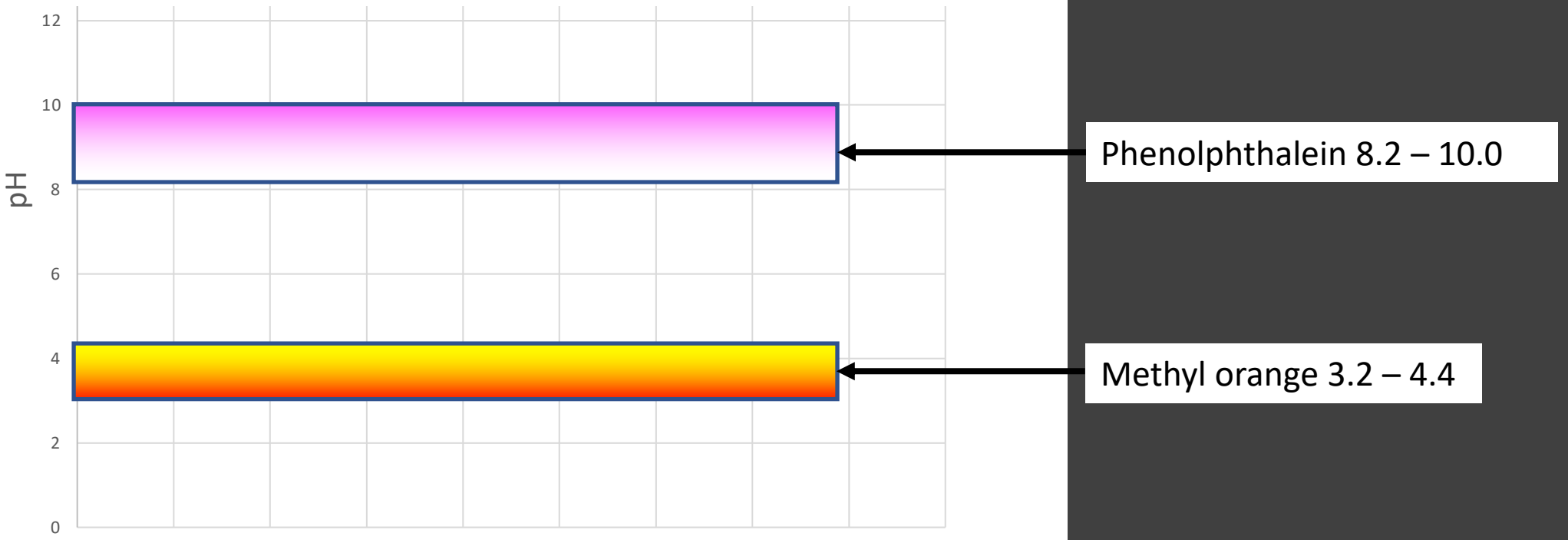


+ H^+

Yellow

Choosing An Indicator

- The equivalence point of a titration is where the two substances have been mixed in exactly equal proportions.
- An indicator must be used which changes colour as close as possible to that equivalence point.
- That varies from titration to titration.

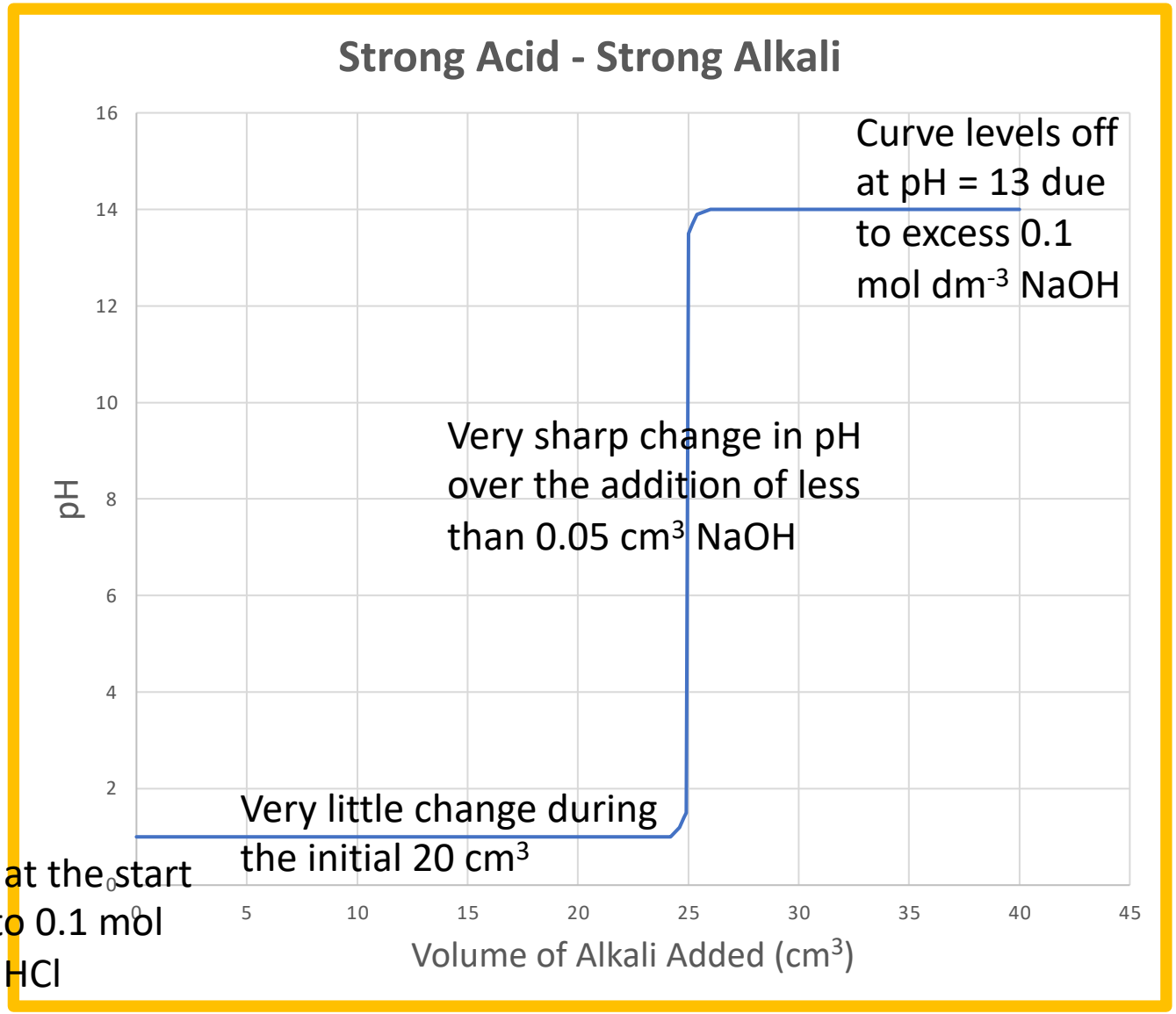


Neutralisation

- Titration curves show how pH changes during a titration.
- An indicator can give a sharp end-point if there is a sudden pH change covering the pH at which the indicator changes colour.
- The following titration curves assume that the alkali (in burette) is being added to the acid (in conical flask).
- You merely need to reverse them if the question specifies the acid is being added to alkali.

Strong Acid – Strong Alkali

0.1 mol dm^{-3} $NaOH_{(aq)}$ added to 0.1 mol dm^{-3} $HCl_{(aq)}$



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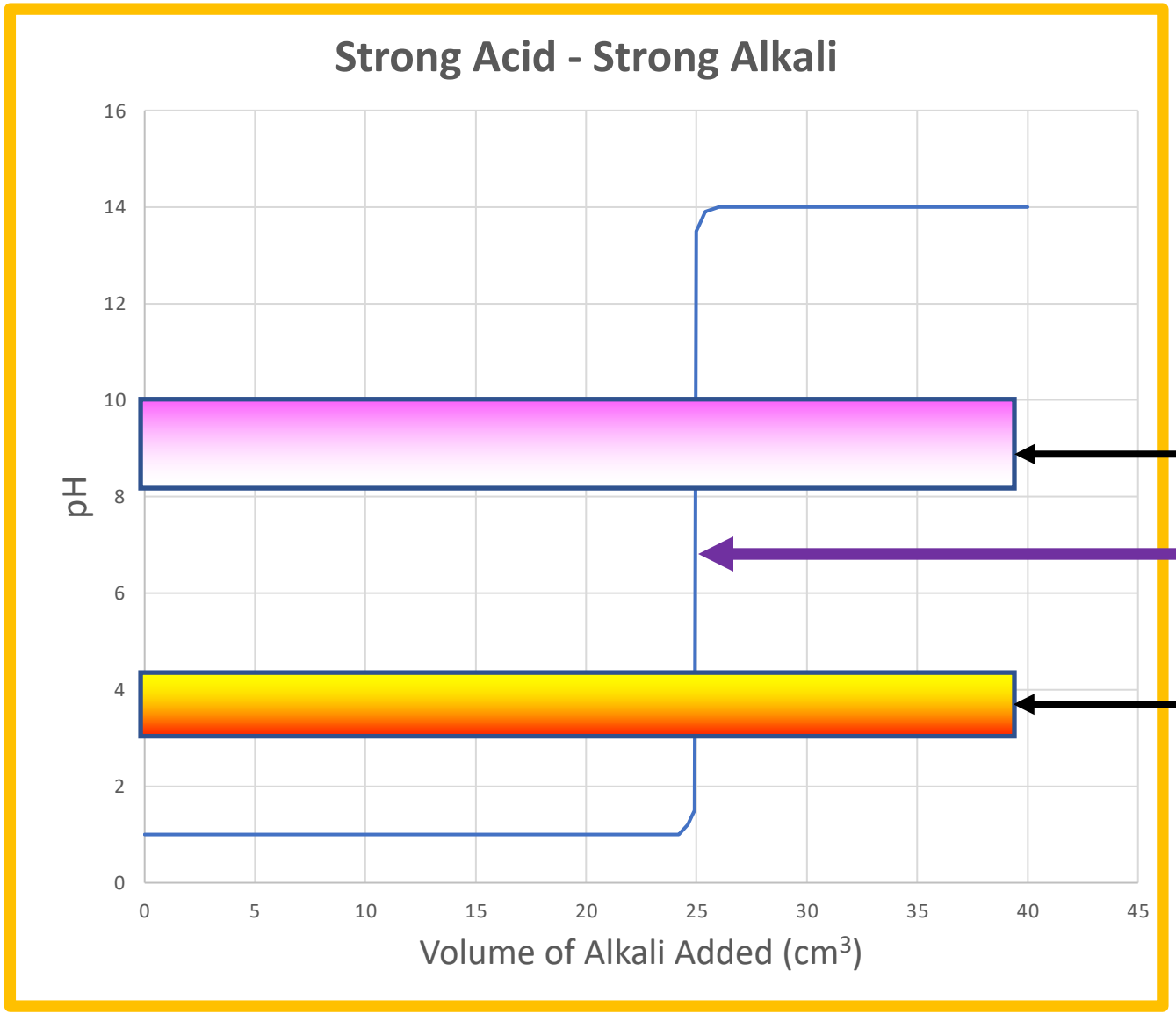


Phenolphthalein - titrate until it just becomes pink.

Phenolphthalein 8.2 – 10.0

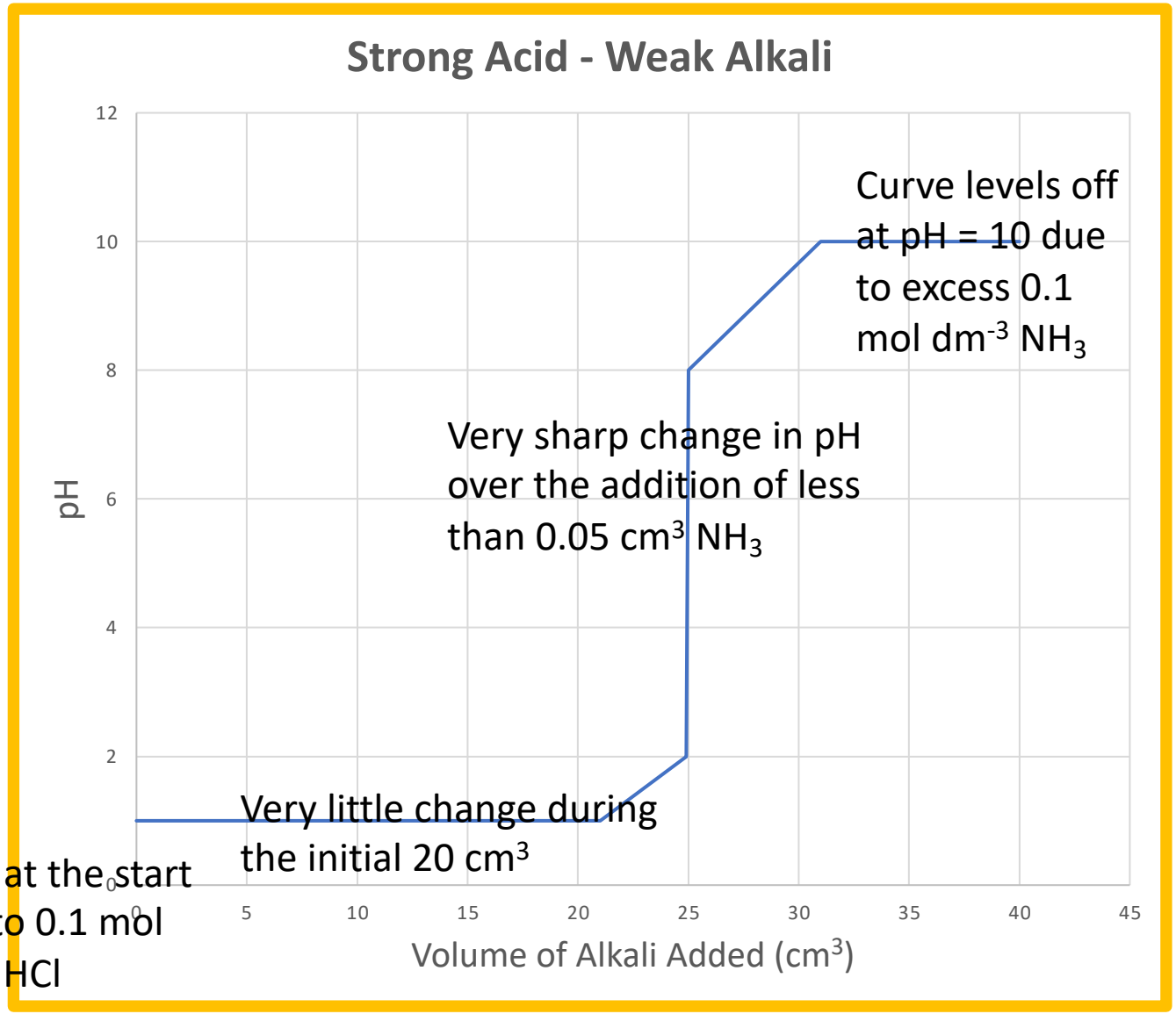
Equivalence Point

Methyl orange 3.2 – 4.4

Methyl orange - titrate until it is orange

Strong Acid – Weak Alkali

0.1 mol dm^{-3} $NH_{3(aq)}$ added to 0.1 mol dm^{-3} $HCl_{(aq)}$



pH 1 at the start due to 0.1 mol dm^{-3} HCl

Strong Acid – Weak Alkali

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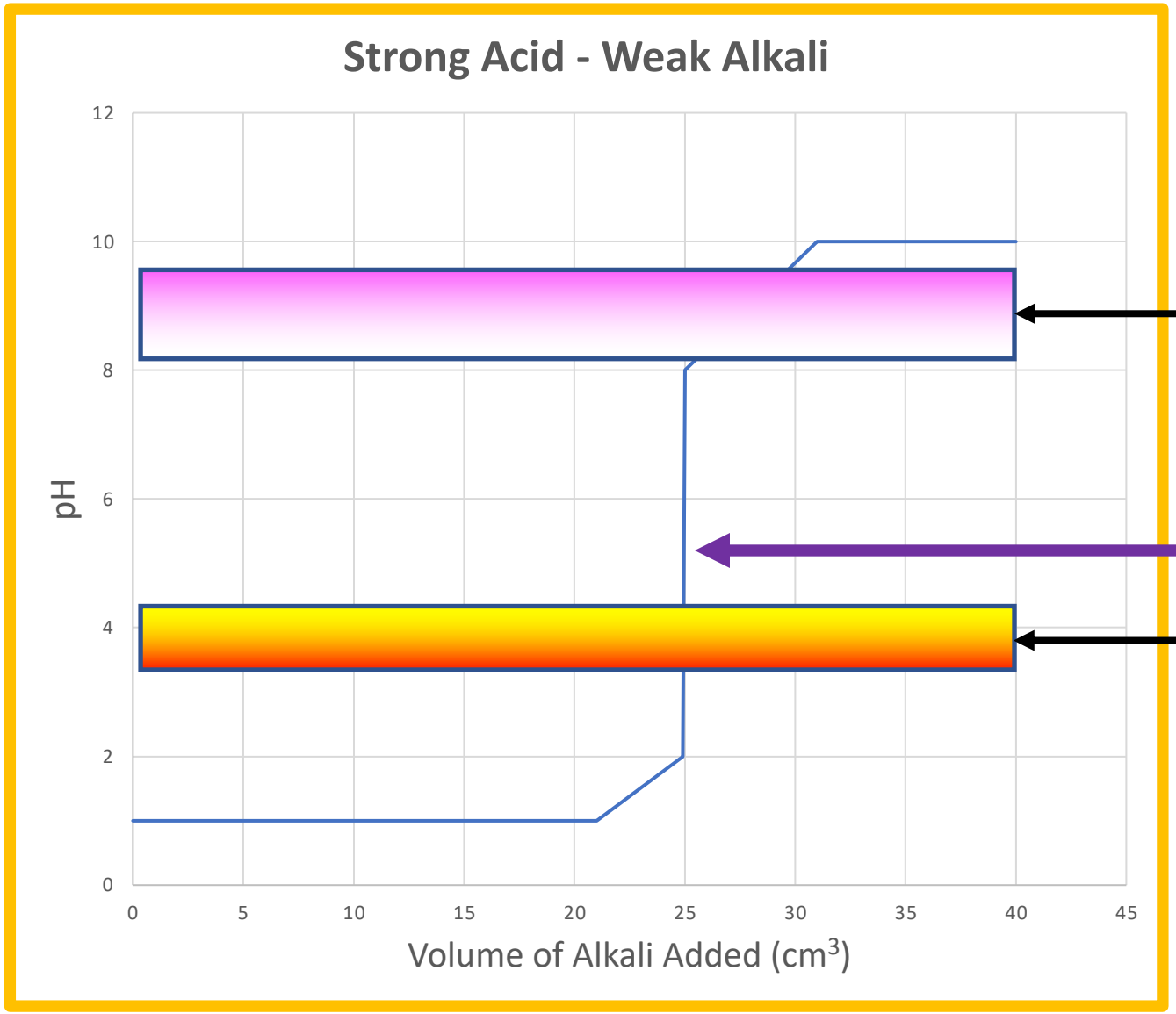


Phenolphthalein – cannot be used

Phenolphthalein 8.2 – 10.0

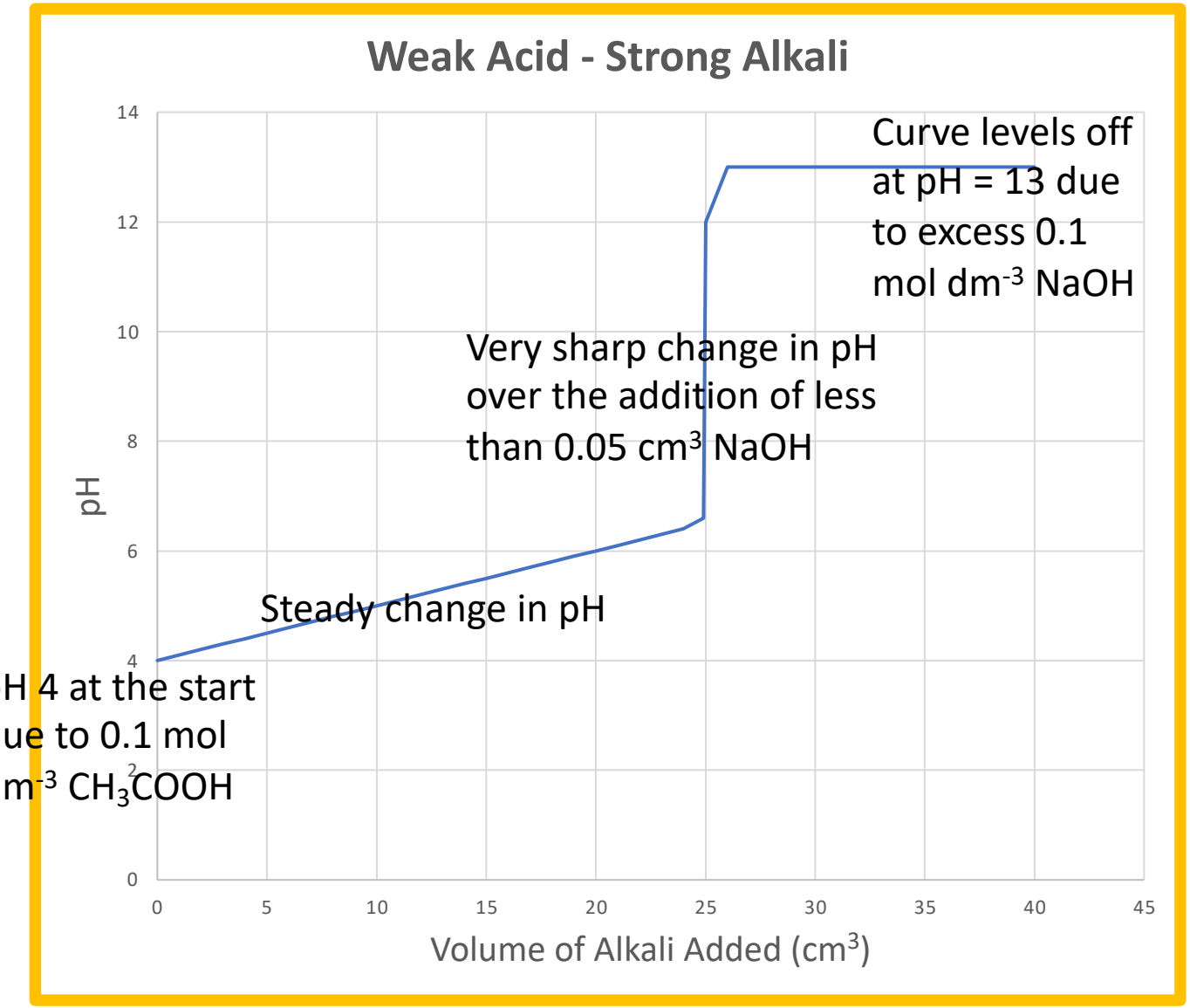
Equivalence Point

Methyl orange 3.2 – 4.4

Methyl orange - titrate until it is orange

Weak Acid – Strong Alkali

0.1 mol dm^{-3} $NaOH_{(aq)}$ added to 0.1 mol dm^{-3} $CH_3COOH_{(aq)}$



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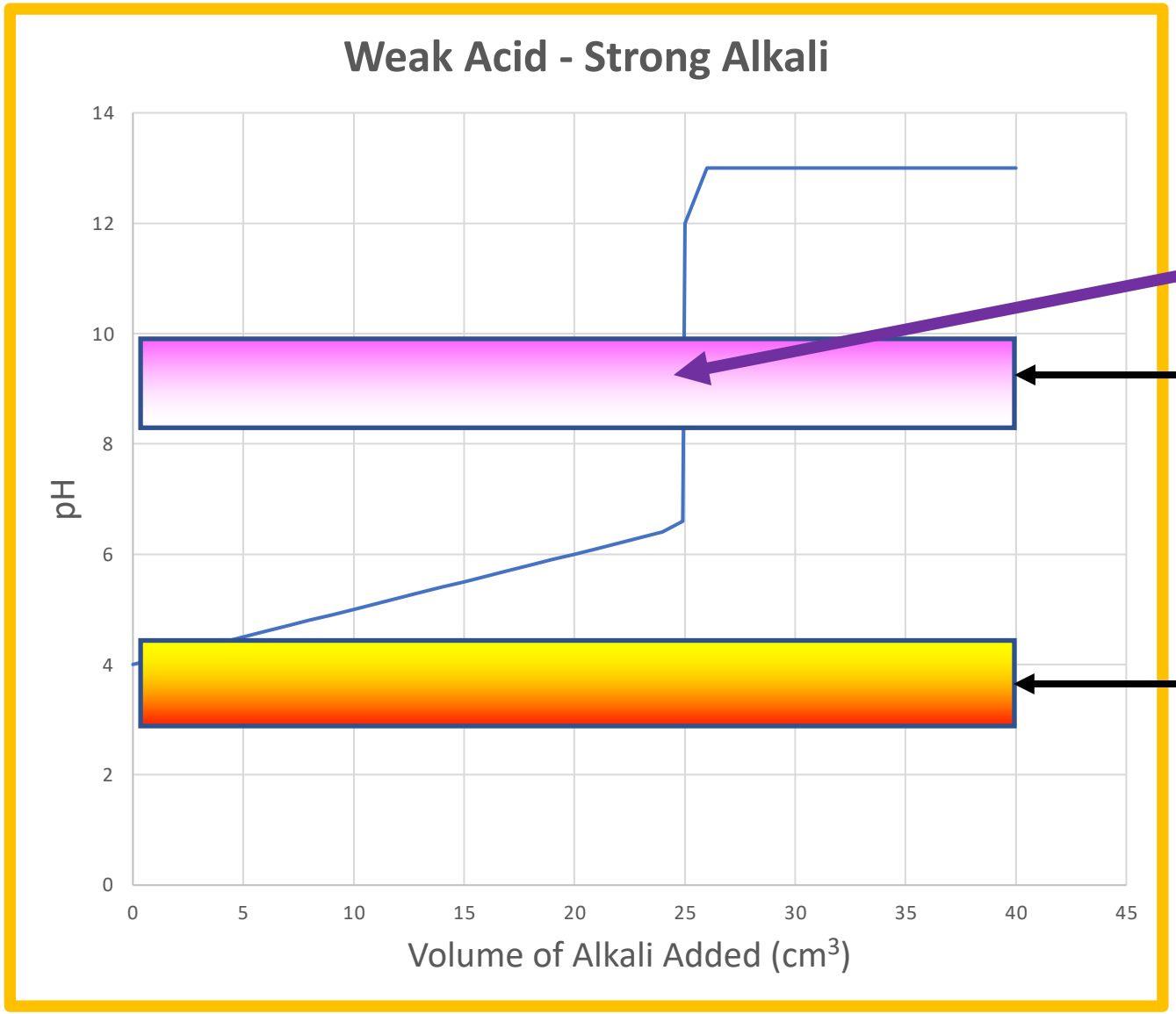

Equivalence Point

Phenolphthalein 8.2 – 10.0

Phenolphthalein – titrate until first sign of pink

Methyl orange 3.2 – 4.4

Methyl orange – cannot be used

Weak Acid – Weak Alkali

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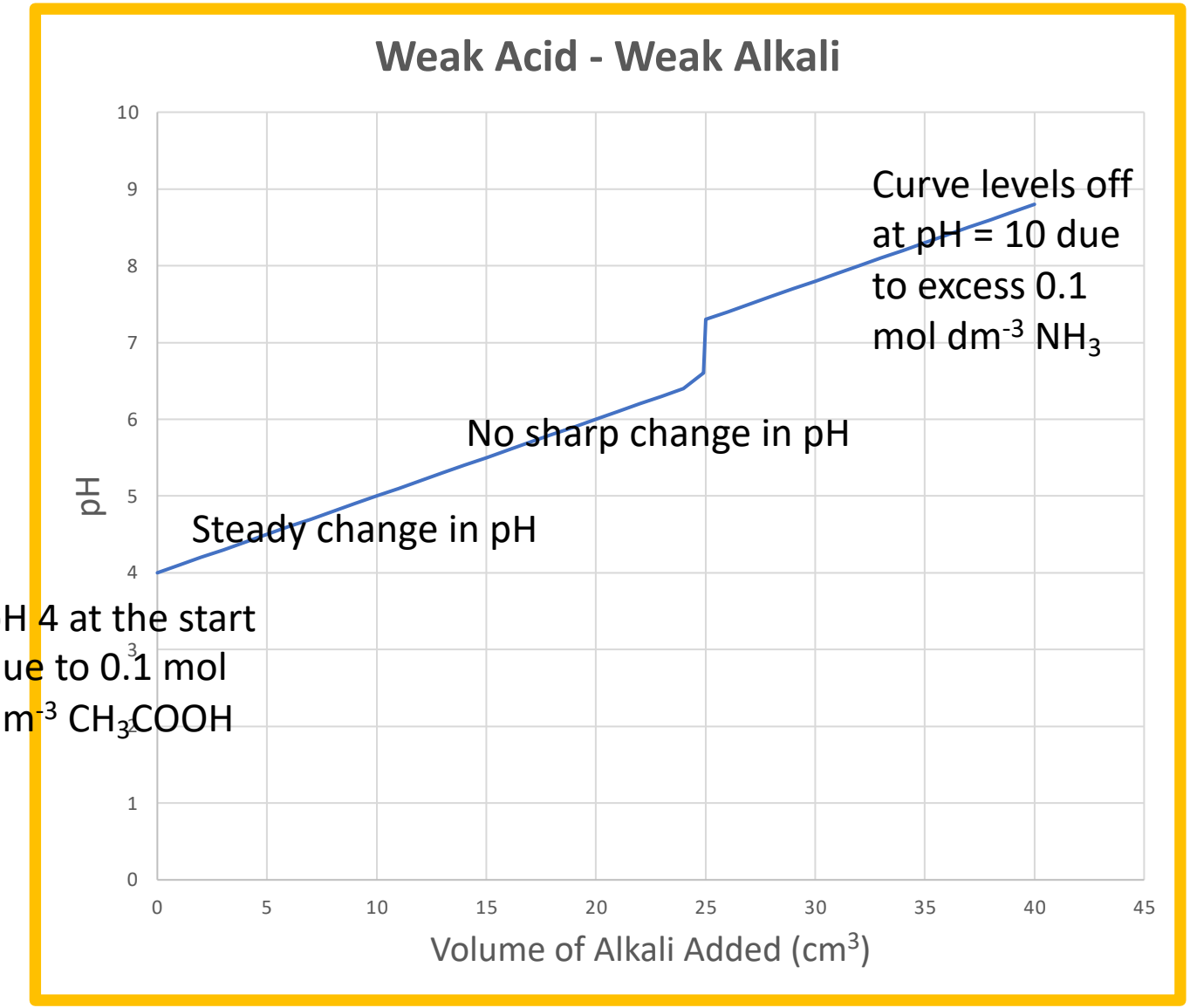

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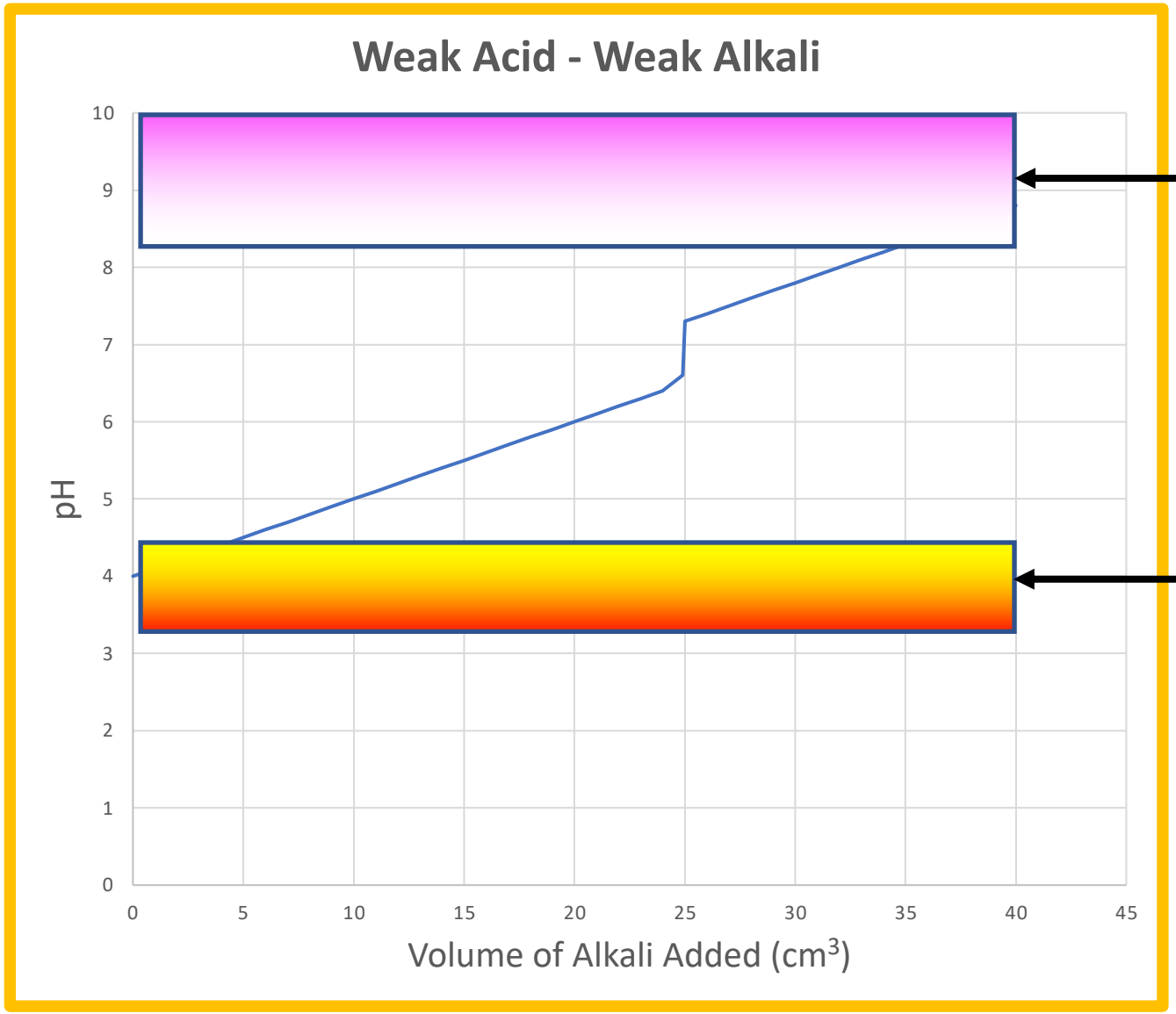

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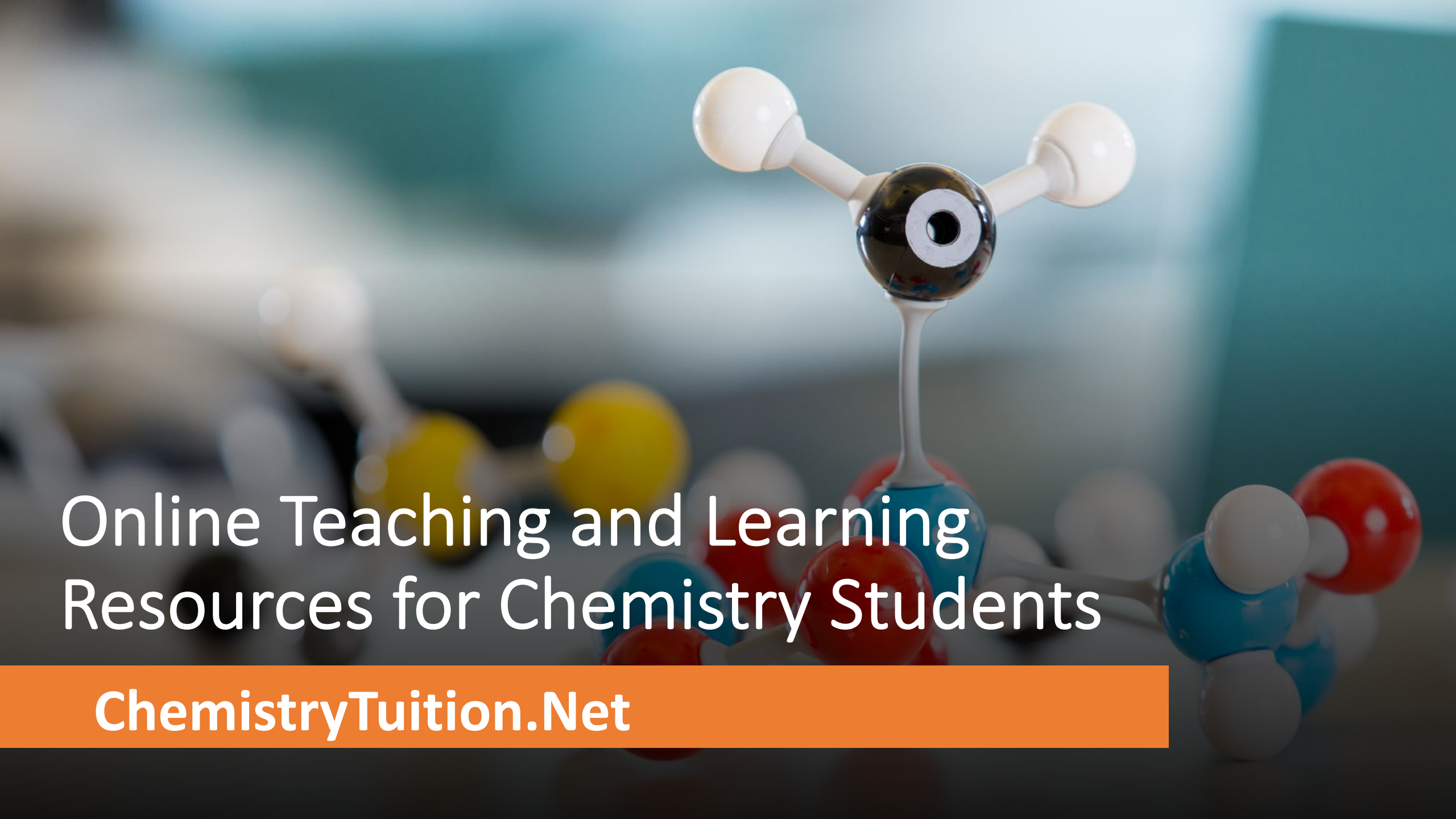

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