Edexcel Chemistry A-level

Topic 12 - Acid-Base Equilibria

Flashcards

Define a Bronsted-Lowry acid

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Proton donor

Define a Bronsted-Lowry base

Define a Bronsted-Lowry base

Proton acceptor

Complete the sentence:
Acid-base reaction involve the transfer of ...

Complete the sentence

PROTONS

Identify Brønsted–Lowry conjugate acid-base pairs:

$$HNO_3 + HNO_2 \rightleftharpoons NO_3^- + H_2NO_2^+$$

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Acid 1 Base 2 Base 1 Acid 2

Identify Brønsted–Lowry conjugate acid-base pairs:

$$HCOOH + CH_3(CH_2)_2COOH \rightleftharpoons HCOO^- + CH_3(CH_2)_2COOH_2^+$$

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What ion causes a solution to be acidic? (2 answers) Name and formula

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H^+ (hydrogen ion) or, more accurately, H_3O^+ (oxonium ion), as protons react with H_2O to form it

What ion causes a solution to be alkaline?

What ion causes a solution to be alkaline?

^{-}OH (hydroxide ion)

Write an equation for the ionisation of water (2)

Write an equation for the ionisation of water (2)

$2H_2O\ (l) \rightleftharpoons H_3O^+\ (aq) + {}^-OH\ (aq)$

OR $H_2O\ (l) \rightleftharpoons H^+\ (aq) + {}^-OH\ (aq)$

Derive Kw using the equation for ionisation of water

Derive Kw using the equation for the ionisation of water

$$K_{eq} = \frac{[H^+][OH^-]}{[H_2O]}$$

$$[H_2O]K_{eq} = [H^+][OH^-]$$

$[H_2O]$ is so large compared to $[H^+]$ and $[OH^-]$ that $[H_2O]K_{eq}$ can be considered to be constant. $[H_2O]K_{eq} = K_w$

$$\therefore K_w = [H^+][OH^-]$$

What is the value of K_w at 298K?

What is the value of K_w at 298K?

1.0×10^{-14}

What physical factors affect the value of K_w? How do they affect it?

What physical factors affect the value of K_w? How do they affect it?

Temperature only - if temperature is increased, the equilibrium moves to the right so K_w increases and the pH of pure water decreases

What is pKw?

What is pKw?

Sometimes pKw is used instead of Kw to make numbers more manageable

$pK_w = -\log K_w$

$K_w = 10^{-pK_w}$

Why is pure water still neutral, even if pH does not equal 7?

Why is pure water still neutral, even if pH does not equal 7?

$[H^+] = [^-OH]$

Give an expression for pH in terms of H^+

Give an expression for pH in terms of H^+

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

What is the relationship between pH and concentration of H^+?

What is the relationship between pH and concentration of H^+?

Lower pH = higher concentration of H^+

If two solutions have a pH difference of 1, what is the difference in $[H^+]$?

If two solutions have a pH difference of 1, what is the difference in $[H^+]$?

A factor of 10

How do you find $[H^+]$ from pH?

How do you find $[H^+]$ from pH?

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

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How do you find $[OH^-]$ from pH? (at 298K)

How do you find $[OH^-]$ from pH? (at 298K)

Find $[H^+]$, use $K_w = [H^+][OH^-]$ (equal to 1×10^{-14} at 298K) to calculate $[^-OH]$

What is different when finding $[H^+]$ from the concentration of diprotic and triprotic acids?

What is different when finding $[H^+]$ from the concentration of diprotic and triprotic acids?

Need to multiply the concentration of the acid by the number of protons to find $[H^+]$

How do you calculate the pH of a strong alkaline solution?

How do you calculate the pH of a strong alkaline solution?

Use Kw to calculate $[H^+]$ from $[OH^-]$

Use $pH=-log[H^+]$

Define the term strong acid

Define the term strong acid

One which fully dissociates in water ($HX \rightarrow H^+ + X^-$)

How do you calculate the pH of a strong acid?

How do you calculate the pH of a strong acid?

$$pH = -log[H^+]$$

Define the term strong base.

Define the term strong base.

One which fully dissociates in water ($XOH \rightarrow X^+ + {}^-OH$)

What is the difference between concentrated and strong?

What is the difference between concentrated and strong?

Concentrated means many mol per dm^3, strong refers to amount of dissociation

What is a weak acid and a weak base?

What is a weak acid and a weak base?

Weak acids and bases do not fully dissociate in water. They only partially dissociate into their ions.

Give some examples of strong acids

Give some examples of strong acids

HCl, H_2SO_4, H_3PO_4

Give some examples of strong bases

Give some examples of strong bases

$NaOH$, $CaCO_3$, Na_2CO_3

Give some examples of weak acids

Give some examples of weak acids

CH_3COOH (ethanoic), any organic acid

Give some examples of weak bases

Give some examples of weak bases

NH_3

What is K_a? (expression)

What is K_a?(expression)

For acid HA, $HA \rightleftharpoons H^+ + A^-$

$$K_a = \frac{[H^+][A^-]}{[HA]}$$

How would you work out the pH of a weak acid?

How would you work out the pH of a weak acid?

Use the equation for K_a, subbing in values for $[A^-]$ and $[HA]$.

Use $pH=-\log[H^+]$ equation to find pH

What is pKa?

What is pKa?

pKa is sometimes used to make Ka values more manageable

pKa = -log Ka

Ka = 10-pKa

What is a titration?

What is a titration?

The addition of an acid/base of know titration to a base/acid of unknown titration to determine the concentration. An indicator is used to show that neutralization has occurred, as is a pH meter.

Draw a diagram of the equipment that could be used for a titration.

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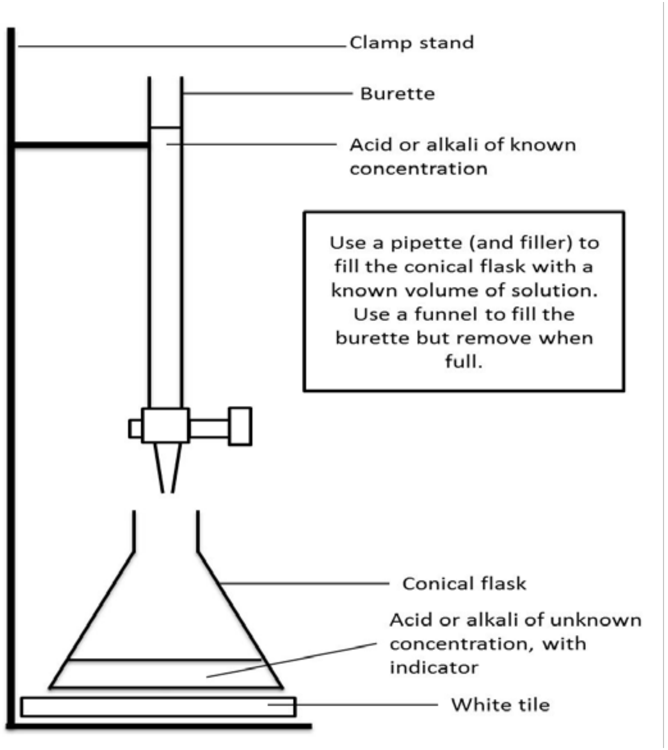

Draw the titration curve for a strong acid with a strong base added

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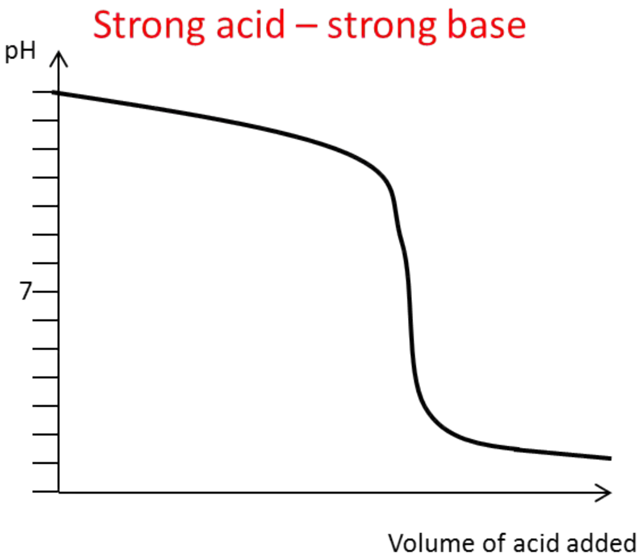
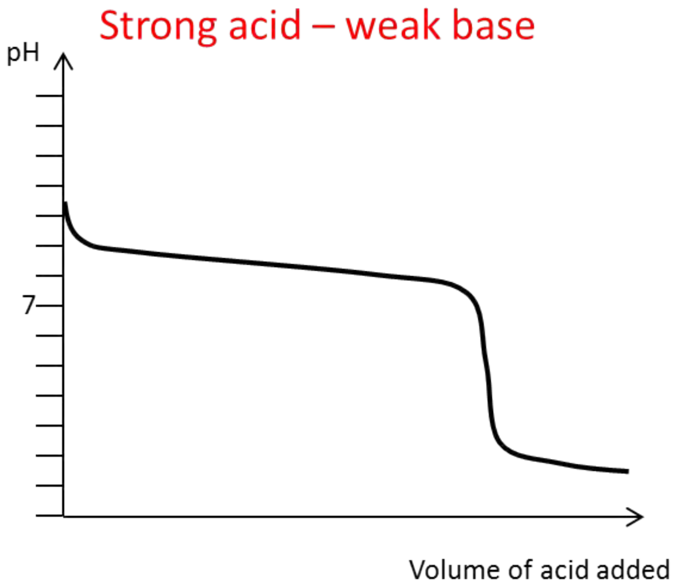


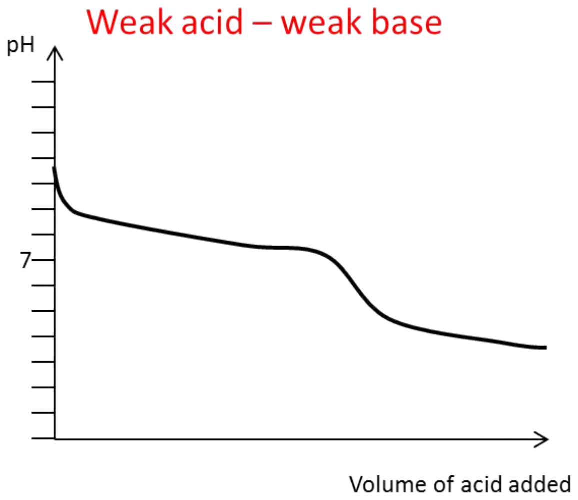
Draw the titration curve for a strong acid with a weak base added

Draw the titration curve for a strong acid with a weak base added



Draw the titration curve for a weak acid with a weak base added

Draw the titration curve for a weak acid with a weak base added



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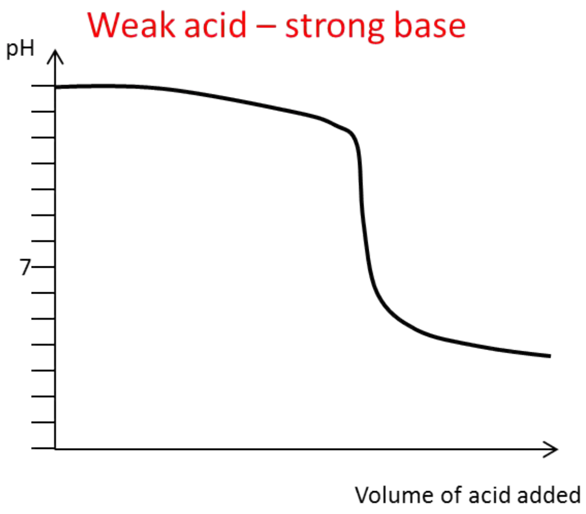

Define the term equivalence point.

Define the term equivalence point.

The point at which the exact volume of base has been added to just neutralise the acid, or vice-versa.

What generally happens to the pH of the solution around the equivalence point?

What generally happens to the pH of the solution around the equivalence point?

There is a large and rapid change in pH, except in the weak-weak titration.

How would you calculate the concentration of a reactant if you know the volume and conc of the other reactant and the volume of that reactant added

How would you calculate the concentration of a reactant if you know the volume and conc of the other reactant and the volume of that reactant added

Calculate mols of one reactant

use balanced equation to work out mols of the other

Use conc = mol/vol to calculate concentration

What is the end point?

What is the end point?

The volume of acid or alkali added when the indicator just changes colour. If the right indicator is chosen, equivalence point = end point.

What are the properties of a good indicator for a reaction? (3)

What are the properties of a good indicator for a reaction? (3)

Sharp colour change (not gradual) - no more than one drop of acid/alkali needed for colour change

End point must be the same as the equivalence point, or titration gives wrong answer.

Distinct colour change so it is obvious when the end point has been reached.

What indicator would you use for a strong acid-strong base titration?

What indicator would you use for a strong acid-strong base titration?

Phenolphthalein or methyl orange, but phenolphthalein is usually used as clearer colour change.

What indicator would you use for a strong acid-weak base titration?

What indicator would you use for a strong acid-weak base titration?

Methyl orange

What indicator would you use for a strong base-weak acid titration?

What indicator would you use for a strong base-weak acid titration?

Phenolphthalein

What indicator would you use from a weak acid-weak base titration?

What indicator would you use from a weak acid-weak base titration?

Neither methyl orange or phenolphthalein is suitable, as neither give a sharp change at the end point.

What colour is methyl orange in acid? In alkali? At what pH does it change?

What colour is methyl orange in acid? In alkali? At what pH does it change?

Red in acid; yellow in alkali. Changes at about pH = 4-5. Approx same as pK_a value

What colour is phenolphthalein in acid? In alkali? At what pH does it change?

What colour is phenolphthalein in acid? In alkali? At what pH does it change?

Colourless in acid; red in alkali. Changes at about pH = 9-10. Approx same as pK_a value

What is the half-neutralisation point?

What is the half-neutralisation point?

When volume = half the volume that has been added at the equivalence point

Define a buffer solution

Define a buffer solution

A solution that resist changes in pH when small amount of acid/alkali are added.

What do acidic buffer solutions contain in general terms?

What do acidic buffer solutions contain in general terms?

A weak acid and a soluble salt of that acid that fully dissociates.

Write a reaction for an acidic buffer with added acid

Write a reaction for an acidic buffer with added acid

$A^- + H^+ \rightarrow HA$, opposes addition of H^+

Write a reaction for an acidic buffer with added alkali.

Write a reaction for an acidic buffer with added alkali.

$$HA + OH^- \rightarrow H_2O + A^-$$

How else can you achieve an acidic buffer solution other than just mixing the constituents?

How else can you achieve an acidic buffer solution other than just mixing the constituents?

Neutralise half of a weak acid (meaning the acid must be in excess) with an alkali - this forms a weak acid / soluble salt mixture.

What do basic buffer solutions contain in general terms?

What do basic buffer solutions contain in general terms?

Weak base and soluble salt of that weak base

How can you calculate the pH of buffer solutions?

How can you calculate the pH of buffer solutions?

Use the K_a of the weak acid, sub in $[A^-$ and $[HA]$, calculate $[H^+] \rightarrow$ pH

How can you calculate the new pH of a buffer solution when acid or base is added?

How can you calculate the new pH of a buffer solution when acid or base is added?

Calculate number of moles of H^+ and A^- and HA before acid or base is added. Use equations to work out new moles of A^- and HA → find $[H^+]$ → pH

Complete this question:

The student plans to prepare a buffer solution that has a pH of 4.50. The buffer solution will contain ethanoic acid, CH_3COOH, and sodium ethanoate, CH_3COONa.

The student plans to add 9.08 g CH_3COONa to 250 cm^3 of 0.800 mol dm^{-3} CH_3COOH. The student assumes that the volume of the solution does not change.

(i) Show by calculation whether, or not, the student's experimental method would produce the required pH.

Show **all** your working.

Question			Answer	Marks	Guidance
	(c)	(i)	**$[CH_3COO^-]$** $n(CH_3COONa) = \frac{9.08}{82.0}$ OR 0.111 ✓ (Calc: 0.1107317073) $[CH_3COO^-] = \frac{9.08}{82.0} \times \frac{1000}{250} = 0.443$ (mol dm^{-3}) OR $n(CH_3COOH) = 0.800 \times \frac{250}{1000} = 0.200$ (mol) ✓ **$[H^+]$** $[H^+] = K_a \times \frac{[CH_3COOH]}{[CH_3COO^-]}$ **OR** $K_a \times \frac{n(CH_3COOH)}{n(CH_3COO^-)}$ $= 1.75 \times 10^{-5} \times \frac{0.800}{0.443}$ **OR** $1.75 \times 10^{-5} \times \frac{0.200}{0.111}$ ✓ $= 3.16 \times 10^{-5}$ (mol dm^{-3}) ✓ **pH** **(must come from *calculated* $[H^+]$)** $pH = -\log(3.16 \times 10^{-5}) = 4.50$ ✓ ----------------------------------- **LAST 3 marks** are **NOT** available using • K_a square root approach (weak acid pH) • $K_w / 10^{-14}$ approach (strong base pH) ----------------------------------- **Henderson–Hasselbalch (HH) alternative** $pK_a = -\log 1.75 \times 10^{-5} = 4.757$ (or 4.756961951..) $pH = pK_a + \log \frac{[CH_3COO^-]}{[CH_3COOH]}$ **OR** $= pK_a - \log \frac{[CH_3COOH]}{[CH_3COO^-]}$ **OR** $pK_a + \log \frac{0.443}{0.800}$ **OR** $= pK_a - \log \frac{0.800}{0.443}$ ✓ $= pK_a - 0.257$ ✓ $= 4.757 - 0.257 = 4.50$ ✓	5	**ALLOW** 2 sig fig **ALLOW** use of **HA** and **A$^-$** Mark by **ECF** ----------------------------------- **Alternative method** (If both methods are attempted, mark the method which produces the higher mark) **$[H^+]$** $[H^+] = 10^{-pH} = 10^{-4.50}$ $= 3.16 \times 10^{-5}$ (mol dm^{-3}) ✓ **$[CH_3COO^-]$** $[CH_3COO^-] = K_a \times \frac{[CH_3COOH]}{[H^+]}$ **OR** $1.75 \times 10^{-5} \times \frac{0.800}{3.16 \times 10^{-5}}$ ✓ $= 0.443$ (mol dm^{-3}) ✓ **mass of CH_3COONa** mass $CH_3COONa = 0.443 \times \frac{250}{1000}$ **OR** 0.111 ✓ $0.111 \times 82.0 =$ **9.08** (g) ✓ ----------------------------------- **Common errors** **4.64** Use of $M(CH_3COONa) = 60$ 4 marks **2.40** Use of K_a of FCH_2COOH 4 marks

Which buffer system maintains blood pH at 7.4? What happens when acid/alkali is added?

Which buffer system maintains blood pH at 7.4? What happens when acid/alkali is added?

$H^+ + HCO_3^{--} \rightleftharpoons CO_2 + H_2O$

Add OH^- → reacts with H^+ to form H_2O, then shifts equilibrium left to restore H^+ lost

Add H^+ → equilibrium shifts to the right, removing excess H^+

What products are buffers found in?

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What products are buffers found in?

Shampoos, detergents → important to keep pH right to avoid damage to skin, hair, fabrics

Why is there a difference in enthalpy changes of neutralisation values for strong and weak acids?

Why is there a difference in enthalpy changes of neutralisation values for strong and weak acids?

Enthalpy changes of neutralisation are always exothermic. The value for this enthalpy change is similar for strong acids and alkalis because the same reaction is occurring $H^+ + OH^- \rightarrow H_2O$.

Weak acids have a less exothermic enthalpy change of neutralisation because energy is absorbed to ionise the acid and break the bond to the hydrogen in the un-dissociated acid.