Summary of solubility calculations – Q1

Question: Calculate K_s

Starting information:
Mass, Molar mass and Volume

Calculate c

n = m/M and then c = n/v

Question: Calculate mass

Starting information:
Ks and Molar Mass

Calculate s

1:1 $s = \sqrt{Ks}$ 2:1 $s = \sqrt[3]{Ks/4}$

Assume concentration (c) = s

Calculate Ks

1:1 salt Ks = [s][s] (or s^2)

2:1 salt Ks = $[2s]^2[s]$ (or $4s^3$)

Calculate Mass

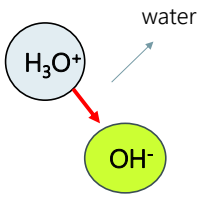
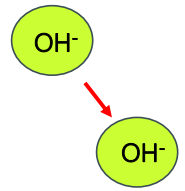
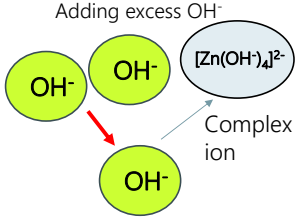
use n = c.v

then m = n x M

Mass (g) concentration ($molL^{-1}$) answers to 3 sgf

Summary of Equilibrium changes in Solubility – Q2

$Zn(OH)_{2(s)} \rightleftharpoons Zn^{2+}_{(aq)} + 2OH^-_{(aq)}$

pH is below 4	pH is above 4 but below 10	pH is above 10
		
Hydronium ions in acid solution **neutralise** OH-, and removing as product.	Total OH- concentration increases, therefore more product.	Complex ion forms, and removes product., by removing Zn^{2+} ions.
Forward reaction increases	Reverse reaction increases	Forward reaction increases
Solubility increases	**Solubility decreases**	**Solubility increases**

Remove product – solubility increases. Add to product – solubility decreases

Summary of Common ion calculations – Q3

Q = ratio of the concentrations of products and reactants.

Ks is the maximum concentration of ions the solution can hold (at a given temperature)

1:1 salt	2:1 salt
$Q = (c) \times (c)$	$Q = (c) \times (c)^2$

Where can c come from?

- **s** (calculated from K_s)
- n = m/M and then c = n/v
- $c = \frac{\text{initial volume}}{\text{total volume}} \times \text{conc.}$
- c provided in the question
- $C(OH^-)$ from pH: pOH = 14 - pH $[OH^-] = 10^{-pOH}$

If I.P. < K_s NO precipitate If I.P. > K_s precipitate forms

pH Calculations – Q6

Convert pK_a to K_a

$K_a = 10^{-pKa}$

If given Weak Acid	If given Weak Base
HF, CH_3COOH, and NH_4^+	NH_3, CH_3NH_2, and CH_3COO^-
$[H_3O^+] = \sqrt{K_a \times c(HA)}$	$[H_3O^+] = \sqrt{(K_a \times K_w \div [B])}$

$pH = -\log [H_3O^+]$

strong acids HCl, HBr, HNO_3, H_2SO_4 strong bases KOH, NaOH

Summary of Species/conductivity in Solution – Acid –Q7

Strong Acids	Weak Acids	Acid salts
H_2O + HCl	H_2O + CH_3COOH	H_2O + NH_4Cl
1×10^{-14} molL^{-1}	1×10^{-14} molL^{-1}	1×10^{-14} molL^{-1}
$H_3O^+ = OH^-$	$H_3O^+ = OH^-$	H_3O^+ + OH^-
$H_3O^+ = Cl^-$	$H_3O^+ = CH_3COO^-$	$NH_4^+ = Cl^-$
		$H_3O^+ = NH_3$
Complete dissociation **No strong acid** remains High conductivity	Partial dissociation **Most weak acid** remains Low conductivity	Weak acid reacts further **No salt** remains High conductivity

Water concentration is assumed to remain constant so is left out

Summary of Species / conductivity in Solution – Base – Q7

Strong Bases	Weak Bases	Base salts
H_2O + $NaOH$	H_2O + NH_3	H_2O + CH_3COONa
1×10^{-14} molL^{-1}	1×10^{-14} molL^{-1}	1×10^{-14} molL^{-1}
$H_3O^+ = OH^-$	$H_3O^+ = OH^-$	$H_3O^+ = OH^-$
$OH^- = Na^+$	$OH^- = NH_4^+$	$CH_3COO^- = Na^+$
		$OH^- = CH_3COOH$
Complete dissociation **No strong base** remains High conductivity	Partial dissociation **Most weak base** remains Low conductivity	Weak base reacts further **No salt** remains High conductivity

water concentration is assumed to remain constant so is left out

Effectiveness of Buffer solutions – weak base buffer

The pH of a solution falls within a buffer zone when it is 1 pH either side of the pKa), and therefore it will function as a buffer.

When the pH < p*K*a, this means [weak acid] > [conjugate], so the buffer will be more effective against added strong base.

$COOH_{(aq)} + OH^-_{(aq)} \leftrightharpoons COO^-_{(aq)} + H_2O_{(l)}$

When the pH > p*K*a, this means [conjugate] > [weak acid], so the buffer will be more effective against added strong acid.

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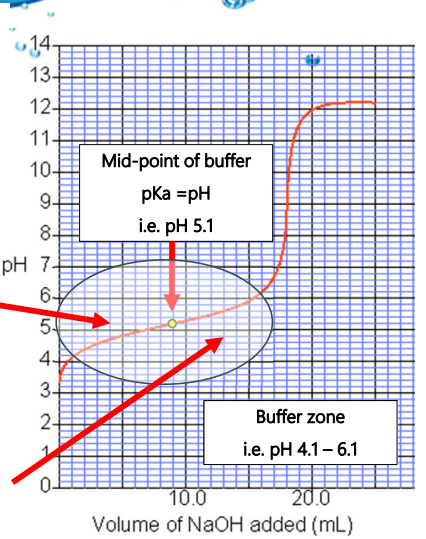

Both reactions still take place in the buffer zone, however.

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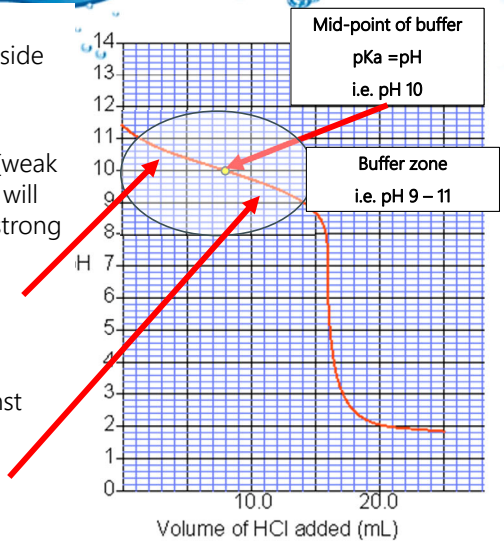
$CH_3NH_2 + H_3O^+ \rightarrow CH_3NH_3^+ + H_2O$

When the pH < p*K*a, this means [conjugate] > [weak base], so the buffer will be more effective against added strong base.

$CH_3NH_3^+ + OH^- \rightarrow CH_3NH_2 + H_2O$



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Buffer calculations for monoprotic acids

Calculate pH of buffer given: k_a or Pk_a + conc of [HA] and [A^-]

1. Write dissociation equation, and K expression of weak acid (weak acid conjugate)

$$HA + H_2O \rightleftharpoons H_3O^+ + A^-$$

$$K_a = \frac{[H_3O^+][A^-]}{[HA]} \quad \text{to} \quad [H_3O^+] = \frac{K_a \times [HA]}{[A^-]}$$

[A^-] and [HA] swapped as + log

2. Calculate pH – may need to calculate c =n/v (+ n= m/M) first

$$pH = pK_a - \log\left(\frac{[HA]}{[A^-]}\right) \quad \text{or} \quad pH = pK_a + \log\left(\frac{[A^-]}{[HA]}\right)$$

Note: in a buffer solution [H_3O^+] does not equal [A^-] since the A^- has not been produced by the dissociation of the acid HA alone

Reminder that **pH = -log[H_3O^+]** So applied to both sides

Summary of steps – After amount base/acid added – Q9

Concentration and volume given for both acid and base

Weak base vs Strong Acid

1. Calculate n weak base
   n(weak base (start)) = cv
2. Calculate n strong acid
   n(strong acid (start)) = cv

After acid added

3. n(weak base) = n(weak base(start)) – n(acid)
4. c(weak base) = n(weak base) / total volume

NOTE: n(conj. acid) = n(strong acid)

3. c(conj. acid) = n(conj. acid) / total volume

$$pH = pK_a + \log\left(\frac{[\text{weak base}]}{[\text{conj. acid}]}\right)$$

Weak acid vs Strong Base

1. Calculate n weak acid
   n(weak acid (start)) = cv
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   n(strong base (start)) = cv

After base added

3. n(weak acid) = n(weak acid (start)) – n(base)
4. c(weak acid) = n(weak acid) / total volume

NOTE: n(conj. base) = n(strong base)

3. c(conj. base) = n(conj. Base) / total volume

$$pH = pK_a + \log\left(\frac{[\text{conj. base}]}{[\text{weak acid}]}\right)$$

Summary of steps - Equivalence point pH – Q10

From neutralisation equation
n(acid) =n(weak base) = n(conjugate acid)

From neutralisation equation
n(base) =n(weak acid) = n(conjugate base)

Weak base vs Strong Acid

1. Calculate n weak base
   n(weak base) = cv (info from question)
2. Calculate v strong acid
   v(strong acid) =n/c
3. Calculate c conjugate acid
   c (conjugate acid)= n/total v
4. [H_3O^+] = √ K_a x c(conjugate acid)
5. pH = -log [H_3O^+]

Weak acid vs Strong Base

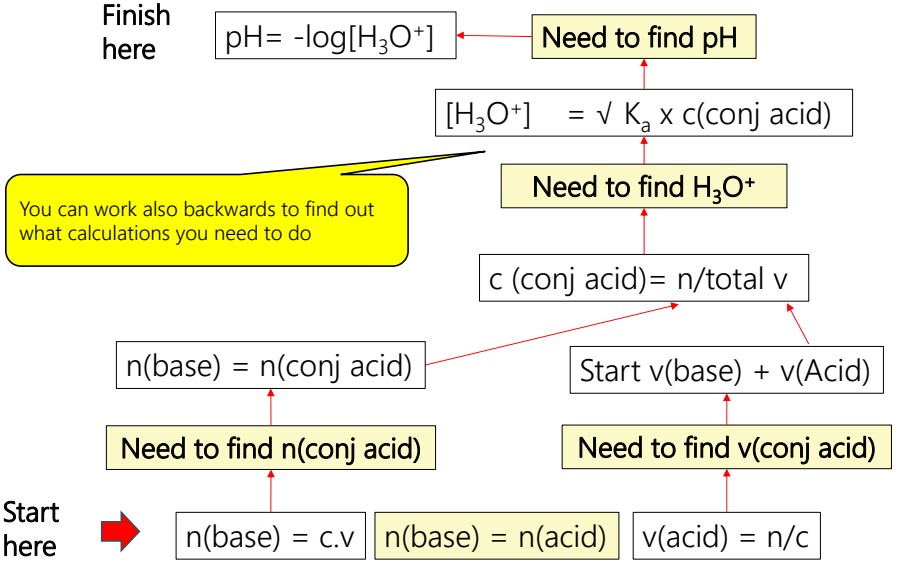
1. Calculate n weak acid
   n(weak acid) = cv (info from question)
2. Calculate v strong base
   v(strong base) =n/c
3. Calculate c conjugate base
   c (conjugate base)= n/total v
4. $[H_3O^+] = \sqrt{\frac{K_a \times K_w}{c(\text{conjugate base})}}$
5. pH = -log [H_3O^+]

Alternative

$$K_a = \frac{[H_3O^+]^2}{(c(\text{acid}) \times \text{original v/total v})}$$

If given v in the question (from graph)

Summary of steps - Equivalence point pH – Q10



Given conc of acid + base and volume start base