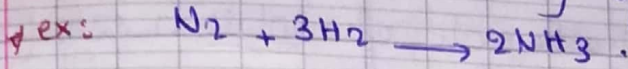


Vancy Mokh

Chemistry:
Rate of rxns:

Rate of rxn: Is the study of progress of rxn with time.



$$\frac{n N_2 \text{ reacted}}{1} = \frac{n H_2 \text{ reacted}}{3} = \frac{n NH_3 \text{ formed}}{2}$$

$$-\frac{\Delta n N_2 \text{ reacted}}{1} = -\frac{\Delta n H_2 \text{ reacted}}{3} = \frac{\Delta n NH_3}{2}$$

$$-\frac{\Delta t}{\Delta t} N_2 = -\frac{\Delta n H_2}{3 \Delta t} = \frac{\Delta n NH_3}{2 \Delta t}$$

Δt (happens at interval of time)

\bar{r} : Average rate of rxn reactant: $-\frac{\Delta n}{\Delta t}$ (reactant)

\bar{r} : Average rate of product: $\frac{\Delta n}{\Delta t}$ (product)

$$\frac{\bar{r} N_2}{1} = \frac{\bar{r} H_2}{3} = \frac{\bar{r} NH_3}{2}, \text{ (average rate is always } \oplus \text{ve).}$$

Average rate is always \oplus ve.

Average rate of disappearance: is equal to the \ominus ve value of slope of secant between 2 pts of abscissas t_1 & t_2 respectively.

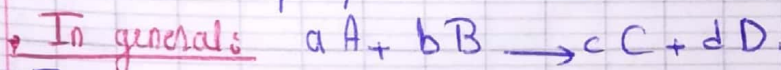
Average rate of appearance: is equal to the \oplus ve value of slope of secant between 2 pts of abscissas t_1 & t_2 respectively.

Instantaneous rate: $r(t)$ "reactant" = $-\frac{d}{dt}(R)_t$
 $r(t)$ product = $\frac{d}{dt}(P)_t$

Instantaneous rate is always \oplus ve

Instantaneous rate of reactant = \ominus ve slope value of slope of tangent to curve at pt of abscissa t_1 .

Instantaneous rate of product = \oplus ve value of slope of tang to curve at pt of abscissa t_1 .



Average $\frac{\bar{r}(A)}{a} = \frac{\bar{r}(B)}{b} = \frac{\bar{r}(C)}{c} = \frac{\bar{r}(D)}{d} = \bar{r}_{rxn}$

Instan. $\frac{r(A)}{a} = \frac{r(B)}{b} = \frac{r(C)}{c} = \frac{r(D)}{d} = r_{rxn}$ when rxn's over.

rate \searrow with time & becomes zero

→ Role of ice water: Blocks rate of rxn except titration.

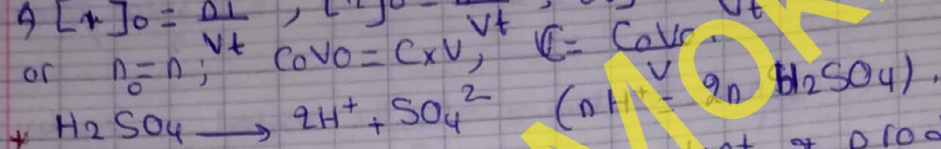
→ Each rxn has a selective catalyst.

→ Ques: Determine $[]$ of species in mixture at $t=0$. (given C & V of ^{spec} ~~rxn~~)

$n_1 = C_1 \times V_1 = n$, $n_2 = C_2 \times V_2 = n$,

The initial n_0 of ~~solu~~ mole of solute is conserved.

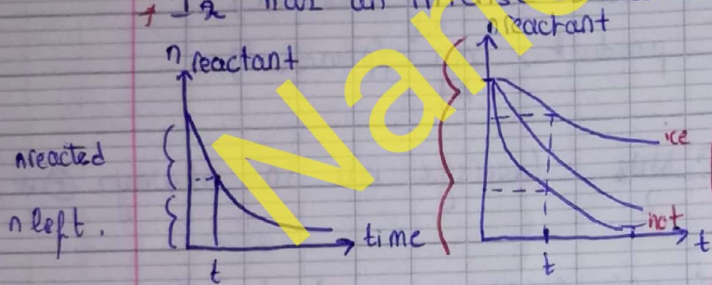
$[1]_0 = \frac{n_1}{V_t}$, $[2]_0 = \frac{n_2}{V_t}$; $[3]_0 = \frac{n_3}{V_t}$



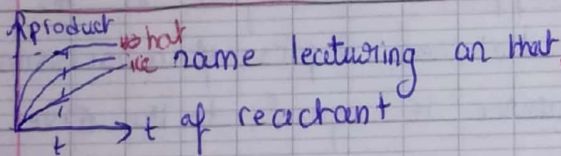
* To prove relation between reactant & products: we always start from n reactants = n remained reactant + n reacted reactant

As $[] \uparrow$, rate of rxn \uparrow & vice versa, so $[]$ is kinetic factor.

→ I_2 has an intense brown color that gives blue color with starch.



At same instant n reactant reacted in ice water is the lowest where that in hot water is the greatest, so rxn is faster in hot water, so rate of rxn is faster in " " , as a result, temp is a kinetic factor.



→ Catalyst: is a substance that \uparrow se rate of rxn without interfering in rxn.

→ same reactant but diff catalyst produces diff product, so each rxn has a selective catalyst.

→ lesser amount of catalyst should be used.

→ Half life:

1) of reactant: is the time needed for $[reactant]$ to \downarrow to $\frac{1}{2}$ of its initial value.

2) of limiting reactant: is the time needed for $[limiting reactant]$ to \downarrow to $\frac{1}{2}$ of its initial value.

3) of products: is the time needed to reach $\frac{1}{2}$ amount of max product formed.

When we're asked to bring $\frac{1}{2}$ life we've to:

- 1) Define half life.
- 2) $[]_{t_{1/2}} = [m]_{\frac{1}{2}} \max.$
- 3) from graph: $t_{1/2} = \frac{1}{k}$
- 4) draw the pt of $t_{1/2}$ on graph.

Adv of using Zn powder in solution instead of Zn plate: the contact surface between Zn powder & HCl is greater than that of Zn plate, so rate of rxn is faster with Zn powder than plate. so rxn needs less time in powder than in plate.

During titration: At equivs reactants are introduced in stoich. prop.

For $[]$: deduce kinetic factor. As time passes [limiting] \rightarrow , so rxn becomes slower then rate of rxn \rightarrow , as a result $[]$ is a kinetic factor.

Choose time for $\frac{1}{2}$ life: less than $\frac{T_{rxn}}{2}$, since the 1st $\frac{1}{2}$ of $[]$ needs time less than 2nd $\frac{1}{2}$, rate of 1st $\frac{1}{2}$ of $[]$ is faster than 2nd half.

As temp \uparrow , the decomposition of compound $\uparrow \rightarrow$ compound loses its efficiency.

Specify effect of adding cold water:

1) Cold temp, temp is low, rate of rxn \downarrow (blocks rate of rxn except in titration).

2) adding water, no solution \uparrow , but no of each solute is conserved, $n = \frac{C}{V}$, so $[] \downarrow$, rate of rxn \downarrow , $[]$ K.F.

Notes $n_s = \frac{m}{M}$; $n_g = \frac{V}{V_m}$.

1) How to prepare solution from powder (Materials & procedure):

2) Materials: Volumetric flask (size); Balance; spatula; watch glass; funnel.

3) Procedure: weigh m (g) of powder by using balance, spatula & watch glass.

Place the weighed amount of powder in volumetric flask (size) through funnel.

3

- Add distilled water till $\frac{1}{2}$,
- Shake (agitate) so well till solution becomes homogeneous.
- Continue adding distilled water till line mark.

2) Dilution The purpose of it is to \downarrow [] of solution.

i) Glassware used: volumetric pipet (initial volume) for graduated volumetric flask (final volume).

ii) Procedure:

- Pipette \sim ml of solution. So using volumetric pipet (\sim ml) + pipet filler.

- Place them in an empty volumetric flask (\sim ml), then add distilled water till line mark, cover it with stopper.

→ During dilution: n_{mole} of mole of solute is conserved.

→ Note: materials used: all.

glassware used: only ones made of glass.

Imp:

→ Que:

We have a graph of product (n or $[] = f(t)$) \rightarrow we're asked to draw on same graph $[\text{reactant}] = f(t)$; so we bring a relation between reactant + product, substitute each value of product in it \rightarrow draw graph.

→ Auto catalyst: One of products is catalyst of rxn.

→ It's not necessary for volume of cold water to be precise since n_{mole} of mole of solute is conserved.

Characteristics of titration: fast, complete, unique, must happen alone.



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Chemical Equilibrium:

At equilibrium: rate of forward rxn (\rightarrow) = rate of backward rxn (\leftarrow).

Rxn usually favors to be endothermic (absorb heat)

Le Chatelier's principle: (at equilibrium):

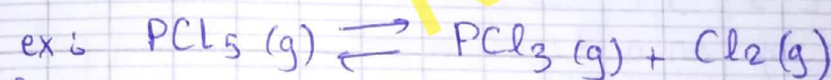
When system is subjected to increase in temperature, the system shifts its temperature (absorb heat) endo.

If $T \uparrow, K_c \uparrow$
 $T \downarrow, K_c \downarrow$ } \Rightarrow rxn's endothermic.

If $T \uparrow, K_c \downarrow$
 $T \downarrow, K_c \uparrow$ } \Rightarrow rxn's exothermic.

degree of conversion (dissociation) α :

$$\alpha = \frac{x \leftarrow \text{reacted}}{n^0} \quad \text{or} \quad \alpha = \frac{x \leftarrow \text{converted}}{C^0} \quad 0 < \alpha < 1$$



i	1	0	0	}	$\alpha = \frac{x}{n^0}$	
c	-x	x	x			
e	1-x	x	x			$\alpha = \frac{x}{1} = x$
	1-x	x	x			
	1-x	x	x			

molar composition: n_{b_i} of moles.

In general:

1) At equilibrium:

i) n_{b_i} of moles isn't altered.

ii) rate of rxn forward = rate of rxn backward.

2) The only case we can use K_c is at equilibrium.



at equilibrium: $K_c = \frac{[D]^d \times [C]^c}{[A]^a \times [B]^b} = Q$

$Q = K_c$ only at equilibrium

i) If $Q > K_c$, [product] > [reactants]

ii) If $Q < K_c$, " " < " "

Strong acid Strong base

pH-meter titrations

1) Strong acid: is a substance that ionizes completely in water ($\alpha=1$) to produce H_3O^+ , ex: HCl, HBr, HNO_3 .

→ In general: $HA + H_2O \rightarrow H_3O^+_{(aq)} + A^-_{(aq)}$, (water interferes in rxn).

→ Ideas related to strong acid:

1) $pH < 7$ (character of an acid).

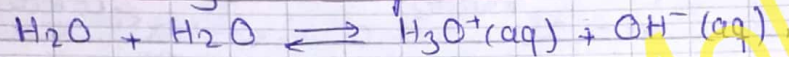
2) $C_a = [H_3O^+]$.

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

4) $[H_3O^+] = 10^{-pH}$ → in weaker or strong

pH is the strength of H^+ in solution, or it's the potential of an acid.

→ Auto ionization of water:



$$K_w = [H_3O^+] \times [OH^-] = 10^{-14} \text{ at } t=25^\circ C.$$

→ Dilution of an acid:

→ Upon dilution of a strong acid 10^n times, $pH \rightarrow n$ units.

- Upon extreme dilution of strong acid, pH tends to reach 7.

2) Strong base: is a substance that ionizes completely in water ($\alpha=1$) to produce OH^- ions ex NaOH, KOH.

In general: $BOH + H_2O \xrightarrow{\text{water}} B^+ + OH^-$ (water doesn't interfere).

→ Ideas related to strong base:

1) $pH > 7$ (character of base).

2) $[OH^-] = C_b$.

3) $pH = 14 + \log [OH^-]$.

4) $[OH^-] = 10^{pH-14}$ → in weaker or strong

→ Dilution of strong base:

- Upon diluting strong base 10^n times, $pH \rightarrow n$ units.

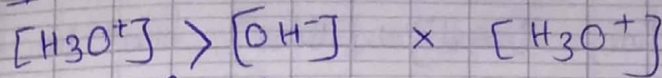
⑥

- Upon extreme dilution of strong base pH tends to 7.

* $pH = pK_w$:

* $pK_w = -\log K_w$.

1) In acid:



$$[H_3O^+]^2 > K_w$$

$$\log [H_3O^+]^2 > \log K_w$$

$$2 \log [H_3O^+] > \log K_w \quad \times -$$

$$-2 \log [H_3O^+] < -\log K_w$$

$$+2 pH < + pK_w$$

$$pH < \frac{pK_w}{2} \quad \left(pH < \frac{-\log 10^{-14}}{2}; pH < 7 \right)$$

2) In base:



$$[OH^-]^2 > K_w$$

$$\log [OH^-]^2 > \log K_w$$

$$2 \log [OH^-] > \log K_w \quad (+14)$$

$$\log [OH^-] > \frac{\log K_w}{2}$$

$$14 + \log [OH^-] > \frac{\log K_w}{2} + 14$$

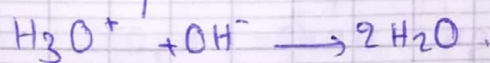
$$pH > \frac{pK_w}{2}$$

3) case of neutrality: $pH = \frac{pK_w}{2} = 7$.

Titration of strong acid with strong base:

Materials: buret, beaker, magnetic stirrer, pH meter or indicator

* Equation of titration between strong acid & strong base:



* nature of solution at equ:

species at equiv: Na^+ ; Cl^- ; H_2O .

Na^+ & Cl^- : spectator ions (\Rightarrow solution at equivalence is neutral)

H_2O : neutral medium $\Rightarrow pH = 7$.

→ At equivalence: reactants are introduced in stoich prop:
 $n[\text{OH}^-]_{\text{in beaker}} = n[\text{H}_3\text{O}^+]_{\text{added from buret}}$

→ Coordinates at equivalence: Apply method of th tangents (V_{BE}, pH).

→ During titration, $[\text{acid}] \approx [\text{base}]$ must be small & near to each other.

→ Graph of $\text{pH} = f(V_{\text{b}} \text{ or } V_{\text{a}})$ consists of 3 parts & 1 inflection pt:

1) If $\text{pH} = f(V_{\text{b}}) \Rightarrow$ curve is ascending.

2) If $\text{pH} = f(V_{\text{a}}) \Rightarrow$ curve is descending.

→ Imp Questions:

1) Why it is necessary to dilute solution in beaker bef titration?
- In order not to use the buret more than 1 time.

- pH meter can't read precisely when solution is concentrated.

2) Why do we add distilled water to beaker bef titration?
In order to immerse the electrode of pH meter.

3) Justify if pH changes upon addition of water in beaker before titration:

Yes, since n_{b} of mole of solute is conserved, but $[\text{H}_3\text{O}^+] \downarrow$, so $\text{pH} \uparrow$.

4) Does pH_E changes upon adding distilled water at equivalence?

No, since species at equivalence are $\text{Na}^+, \text{Cl}^- \text{ \& } \text{H}_2\text{O}$, whatever amount of distilled water added is, pH_E doesn't change.

5) Justify if V_{BE} changes upon adding water in beaker containing strong acid before titration:

No, since at equ. $n\text{OH}^- = n\text{H}_3\text{O}^+$.

~~Q~~ of: at equivalence:

$$n\text{H}_3\text{O}^+ = n\text{OH}^- \quad \left\{ \begin{array}{l} \text{but from dilution } n_0 = n \\ \text{so } C_a V_a = C_b V_{BE} \end{array} \right.$$

$$C_a V_a = C_b V_{BE} \quad \left\{ \begin{array}{l} \text{so } C_a' V_a' = C_b V_{BE} \\ \text{so } V_{BE} \text{ isn't altered.} \end{array} \right.$$

so $C_a' V_a' = C_b V_{BE}$, so V_{BE} isn't altered.

6) % by mass:

$$\% \text{ by mass} = \frac{m \text{ solute}}{m \text{ solution}} \times 100$$

$$= \frac{n \text{ solute} \times M \text{ solution}}{f \text{ solute} \times V \text{ solution}} \times 100$$

$$= \frac{C \times M}{f} \times 100$$

→ need to be proved in exam.

7) % of error = $\frac{m \text{ indicated} - m \text{ calculated}}{m \text{ indicated}} \times 100$

% of error shouldn't exceed 5% in good products.

8) % by mass powder = $\frac{m \text{ pure}}{m \text{ impure (sample)}} \times 100$, ⇒ given.

Note: $m \text{ pure}$ & $m \text{ impure}$ both must be found in ~~same~~ same volume, with $m \text{ pure} = n \times M = C \times \underbrace{V}_{\text{in initial volume}} \times M$

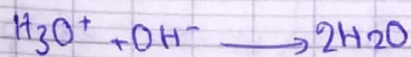
→ yellow - BTB - (green) - 7.6 - blue, is the suitable indicator of titration between strong acid & strong base: where color changes from yellow to green (with 1 drop error to blue).

→ ptr of graph (0, pH = given). pH → slightly
 (V_{BE} , $pE=7$). pH drops suddenly
 ($V_{BE} = \infty$, $pH = 14 + \log [OH^-]$). pH → slightly

→ $C_m = \frac{m \text{ solute}}{V \text{ solution}}$; $f = \frac{m \text{ solution}}{V \text{ solution}}$

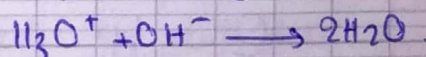
→ Relation among: pH, C_a, C_b, V_a, V_b . for $V_b < V_{BE}$ (base is limiting).

$V_b < V_{BE}$ (base is limiting)



n_a	n_b	0
$-n_b$	$-n_b$	n_b
$n_a - n_b$	0	n_b

$V_b > V_{BE}$ (acid is limiting)



n_a	n_b	0
$-n_a$	$-n_a$	n_a
0	$n_b - n_a$	n_a

$pH = -\log [H_3O^+] = -\log \frac{n_a - n_b}{V_a + V_b}$ $pH = 14 + \log [OH^-] = 14 + \log \frac{C_b V_b - C_a V_a}{V_a + V_b}$

$= -\log \frac{C_a V_a - C_b V_b}{V_a + V_b}$

⑨

We calculate pH on the amount of remaining acid or base.

Weak acid - Weak bases

Hint: water in front of base acts as acid.

" " " acid " " base.

Weak acid: In a substance that ionizes partially in water ($0 < \alpha < 1$) to produce H_3O^+ ions (HF, NH_4^+, \dots).

In general: $HA + H_2O \rightleftharpoons H_3O^+ + A^-$.

Indicators related to weak acid:

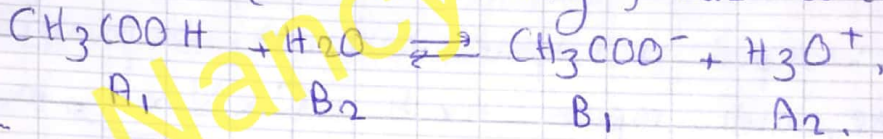
1) $pH < 7$ (character of an acid)

2) $[H_3O^+] < C_a$.

3) $pH > -\log C_a$.

4) $[H_3O^+] = 10^{-pH}$.

Each acid (weak or strong) has a conjugate base:



Conjugate pairs: A/B: CH_3COOH/CH_3COO^- .

Degree of dissociation of weak acid (α):

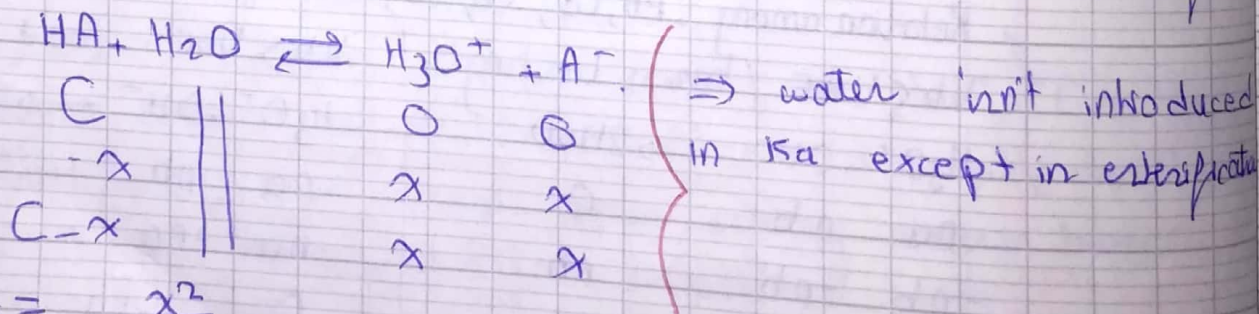
$$\alpha = \frac{n_{\text{reacted}}}{n^0} = \frac{C_{\text{reacted}}}{C^0} = \frac{[H_3O^+]}{C_0} = \frac{10^{-pH}}{C_0}$$

with: $[HA]_{\text{reacted}} = [H_3O^+]_{\text{formed}}$.

Dilution of weak acids:

Upon dilution of weak acid by 10^n times, $pH \nearrow$ by less than 1 unit, α increase.

Acidity constant (K_a): each weak acid has a specific K_a .



$$K_a = \frac{x^2}{C-x}$$

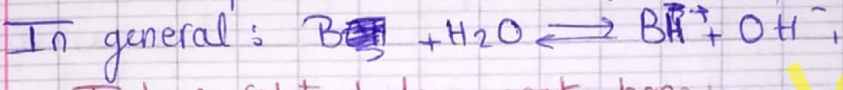
$$pK_a = -\log K_a$$

$$K_a = 10^{-pK_a}$$

$$K_w = K_a \times K_b$$

pKa axis: $\left\{ \begin{array}{l} \uparrow B \\ \uparrow A \end{array} \right\}$ strength of acid
 strength of base $\left\{ \begin{array}{l} \downarrow B' \\ \downarrow A' \\ \downarrow A'' \end{array} \right\}$
 as pKa \nearrow , acidity \downarrow , basicity \uparrow .

weak base: is a substance that ionizes partially in water to produce OH⁻ ions, (ex: NH₃).



1. Character related to weak base:

- 1) pH > 7 (character of base).
- 2) $[OH^-] = 10^{pH-14}$.
- 3) $[OH^-] < C_b$.
- 4) $pH < 14 + \log C_b$.

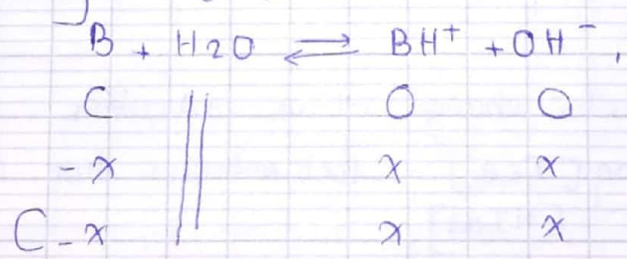
Degree of conversion of weak base α :

$$\alpha = \frac{n \text{ reacted}}{n^0} = \frac{C_{\text{reacted}}}{C^0} = \frac{[OH^-]}{C^0} = \frac{10^{pH-14}}{C^0}$$

Dilution of weak base:

Upon diluting weak base by 10ⁿ times, pH \rightarrow by less than n unit, $\alpha \nearrow$ s.

Acidity cst (K_b): each weak base acidity cst K' or K_b:



$$K_b = \frac{x^2}{C-x}$$

K_b \approx K_a aren't affected by dilution.

Relation between pH, pKa, weak acid & its conjugate base:

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

$$\frac{K_a}{[H_3O^+]} = \frac{[B]}{[A]} \quad \left\{ \begin{array}{l} \log K_a - \log [H_3O^+] = \log \frac{[B]}{[A]} \\ \text{pH} = \text{pKa} + \log \frac{[B]}{[A]} \end{array} \right.$$

1) $pH < pK_a$

$pH - pK_a < 0$

$\log \frac{[B]}{[A]} < \log 1$

$\frac{[B]}{[A]} < 1$

$[B] < [A]$

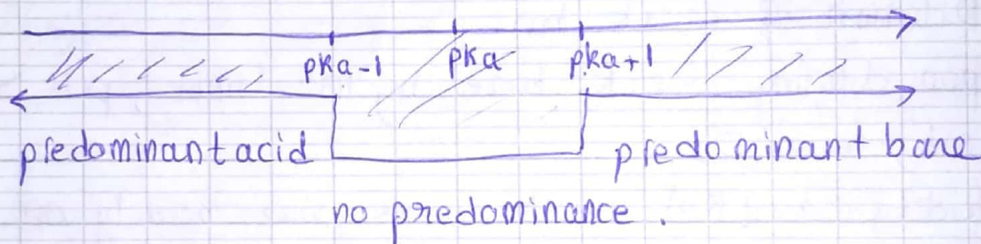
$[A] > [B]$

acid is predominant

$pH < pK_a - 1$

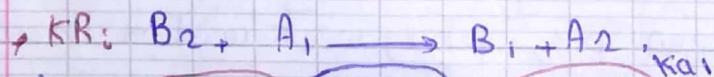
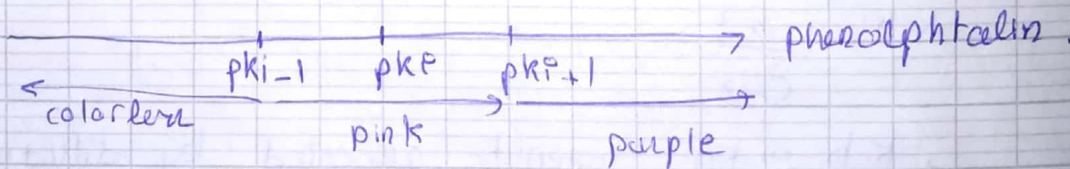
for $\frac{[A]}{[B]} > 10$

→ pH scale of predominance:



→ pH range of color change of an indicator:

$pH = pK_i + \log \frac{[Ind^-]}{[HInd]}$, each indicator has specific pK_i



$KR = \frac{[B_1] \times [A_2] \times [H_3O^+]}{[B_2] \times [A_1] \times [H_3O^+]}$ $\frac{K_{a1}}{K_{a2}}$

$KR = \frac{K_{a1}}{K_{a2}}$

$KR > 10^4 \Rightarrow$ rxn is fast & complete & total

$KR < 10^4 \Rightarrow$ rxn is reversible (limited)

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- rxn is always done between stronger acid & stronger base.

- There are 2 conditions for rxn to be complete:
1) $KR > 10^4$; or $\Delta pK_a > 4$, or ~~$pK_a > 4$~~
2) rxn must be with (δ) .

If 1 of condition 2 is lost, rxn is reversible.

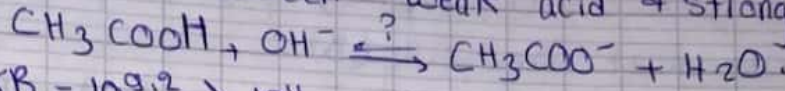
→ If rxn isn't with δ : we take $\Delta pK_a = pK_{a1} - pK_{a2}$, where $pK_{a1} < pK_{a2}$, $\Delta pK_a < 0$.

- If rxn is with δ we take $\Delta pK_a = pK_{a1} - pK_{a2}$, where $pK_{a1} > pK_{a2}$, $\Delta pK_a > 0$.

Weak acid - strong base titration

Weak base - strong acid titration

Reaction between weak acid + strong base:



$K_B = 10^{9.2} > 10^4 \Rightarrow$ rxn is complete \rightarrow 1 arrow.

In rxn of weak acid with strong base, we put formula of weak acid as it is, & instead of strong base we represent it by OH^- .

In general: $\text{HA} + \text{OH}^- \rightarrow \text{A}^- + \text{H}_2\text{O}$.

Curve: it has 2 inflection pts & its' consisted of 4 parts:

- 1st part: pH \nearrow slightly rapid. ($V_{AE} = 0$; pH = given)
- 2nd part: - pH varies slightly forming a plateau. (V_{AE} , pH = pKa)
- pH \nearrow rapidly (V_{AE} , pH = $\frac{pK_a}{2}$)
- pH varies slightly forming another plateau. ($V_{AE} = \frac{V}{2}$; pH = $\frac{14 + \log(C_a)}{2}$)

At equivalence: we apply method of tangents to determine coordinates, pH_E must be > 7 .

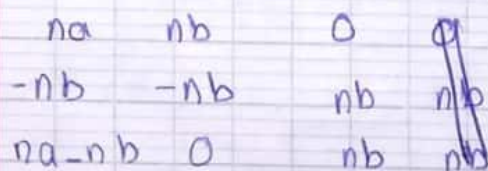
At equivalence: $n \text{CH}_3\text{COOH}_{\text{beaker}} = n \text{OH}^-_{\text{added from buret}}$

Convenient indicator is phenolphthalein.

to bring pH_E , we bring $[\text{CH}_3\text{COO}^-]$, then bring K_B with $K_B = \frac{x^2}{C-x}$, then we use pH.

Relation between $C_a, V_a, C_b, V_b, pH, pK_a$.

1) for $V_b < V_{BE}$

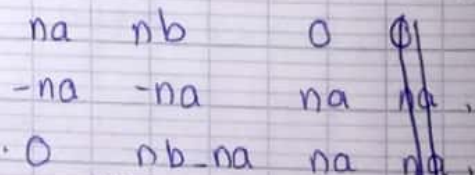


$$pH = pK_a + \log \frac{[B]}{[A]}$$

$$= pK_a + \log \frac{n_b}{n_a - n_b}$$

$$= pK_a + \log \frac{C_b V_b}{C_a V_a - C_b V_b} \quad (14)$$

2) for $V_b > V_{BE}$.



$$pH = 14 + \log \frac{[B]}{[A]} = 14 + \log \frac{[OH^-]}{[A]}$$

$$= pK_a + \log =$$

$$pH = 14 + \log [OH^-] = 14 + \log \frac{n_b - n_a}{V_b + V_a} = 14 + \log \frac{C_b V_b - C_a V_a}{V_b + V_a}$$

- Rxn (titration) between weak base + strong acid:
 $\text{NH}_3 + \text{H}_3\text{O}^+ \rightarrow \text{NH}_4^+ + \text{H}_2\text{O}$ (complete with $K_R > 10^4$).

- $\text{pH} < 7$.

- Half equivalence: is the pt corresponding to equal concentrations of weak base + its conjugate acid solution.
graphically: $V = \frac{V_{\text{AE}}}{2}$

$$\text{pH} = \text{pK}_a + \log \frac{[\text{B}]}{[\text{A}]}$$

$$\text{pH} = \text{pK}_a$$

→ Suitable indicator for titration between strong acid + weak base is Methyl red where color changes from yellow to orange.

→ Nature of solution at equiv:

Cl^- : spectator ion; H_2O : neutral medium:

NH_4^+ is a conjugate acid of weak base,

so NH_4^+ reacts with H_2O to give

$\text{NH}_3 + \text{H}_3\text{O}^+$, so solution is acidic: $\text{NH}_4^+ + \text{H}_2\text{O} \rightleftharpoons \text{NH}_3 + \text{H}_3\text{O}^+$

$\text{pH} < 7$.

we've to write it.

→ degree: % by mass of solution.

→ Buffer zone:

1) Buffer solution: is a mixture containing weak acid + its conjugate base, It's characterized by a pH that changes slightly with dilution or addition of strong acid or strong base.

- Any amount of strong acid or strong base added is considered as limiting reagent.

- $\text{pH} = \text{pK}_a$.

- for $V_b = \frac{V_{\text{DE}}}{2}$.

→ pH must be included in pH range of indicator.

Questions:

In titration of strong acid & strong base:

Ques: do pH change if we add water to solution in buret at $t=0$?

No, since pH depends on the strength of acid & that of base, and at equivalence both are strong so pH isn't altered.

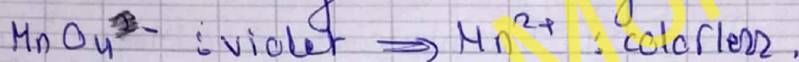
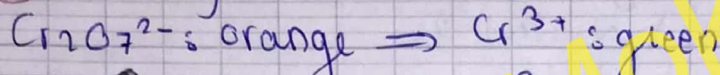
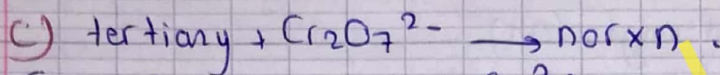
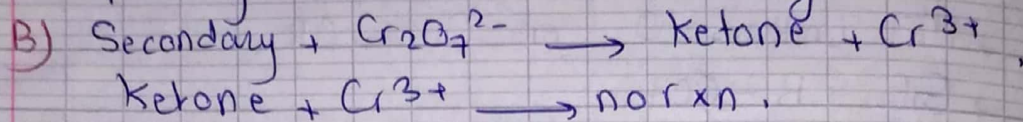
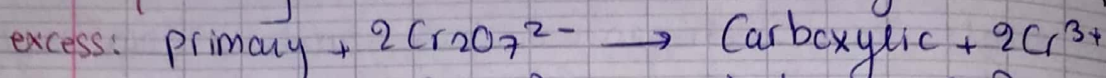
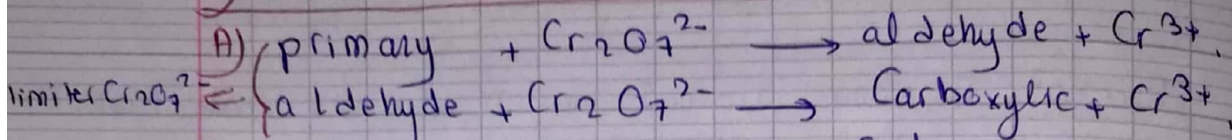
* Amphoteric substance:

Is a substance that plays the role of acid & base simultaneously.

The logo for TOLLABLEBEN features a stylized 'T' composed of two overlapping triangles, one red and one teal. To the right of this symbol, the word 'TOLLABLEBEN' is written in a bold, red, sans-serif font, with 'TOLLAB' on the top line and 'LEBEN' on the bottom line.

www.tollableben.com

3) Oxidation with oxidants ($\text{Cr}_2\text{O}_7^{2-}$ or MnO_4^-).



→ To identify alkene we make test by bromine (orange) it becomes colorless.

→ Law of definite proportion of mass: for $\text{C}_x\text{H}_y\text{O}_z$.

$$\frac{M}{100} = \frac{Cx}{\%C} = \frac{Hy}{\%H} = \frac{Oz}{\%O}$$

→ $C_m = \frac{m_{\text{solute}}}{V_{\text{solution}}}$ $\left\{ \begin{array}{l} \Rightarrow \text{but, solubility is the max} \\ \text{amount dissolved in } V_{\text{solution}} \\ \text{where solution is super saturated.} \end{array} \right.$

→ $\text{Solubility} = \frac{m_{\text{solute}}}{V_{\text{solution}}}$

→ $C_p = \frac{C_m}{M}$

→ To determine n actual:

- 1) from n_b of mole at equil using conversion table
- 2) from given: n_b of mole obtained, produced.
- 3) from graph: at any time
- 4) from a given table.

→ Note:

When we've to bring volume of liquid we can't use $n = \frac{V}{V_m}$ we bring n, then m, then we say $\rho = \frac{m}{V}$, then bring V.

Aldehyde & ketone have same M.F.
Aldehyde & ketone

Aldehyde:

- 1) MF: $C_nH_{2n}O$
- 2) G.F: $R-\overset{\overset{O}{\parallel}}{C}-H$
- 3) F.G: Carbonyl: $\overset{\overset{O}{\parallel}}{C}-$
- 4) for ~~al~~ (al)

- Ketone:

- 1) $C_nH_{2n}O$
- 2) $R-\overset{\overset{O}{\parallel}}{C}-R'$
- 3) F.G: Carbonyl, $-\overset{\overset{O}{\parallel}}{C}-$
- 4) for $n > 3$, (one).

→ physical properties: As nb of carbon atoms ↑ in the molecule, boiling pt ↑, solubility ↓.

→ Tests:

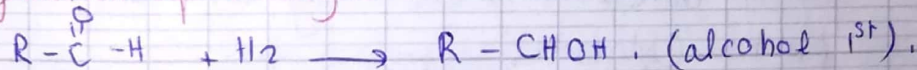
→ Common tests for aldehydes & ketones:

- 1) Sodium Bisulfite ($NaHSO_3$) + Carbonyl → white crystal precip.
- 2) DNPH + Alde Carbonyl → orange-yellow precipitate.

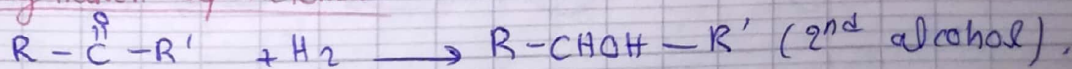
→ Distinguishing tests between aldehydes & ketone:

- 1) Fehling test + aldehyde → brick-red precipitate.
 Fehling test + ketone → no rxn (blue).
- 2) Tollen's reagent (ammonical silver nitrate) + alde $\xrightarrow{Ag(NH_3)_2^+}$ silver layer.
 Tollen's reagent ($Ag(NH_3)_2^+$) + ketone → no rxn (colorless).
- 3) Schiff's reagent + aldehyde → pink color,
 Schiff's + ketone → colorless.

→ Hydrogenation of aldehyde:



→ Hydrogenation of ketones



→ % by mole of atom = $\frac{\text{nb of moles of element} \times 100}{\text{total nb of moles}}$

Carboxylic acid and ester have same MF, but n ester > 2.

Carboxylic Acid

Its Derivatives:

MF: $C_n H_{2n} O_2$.

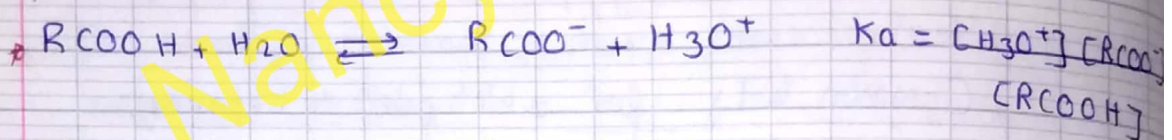
GF: $R - \overset{\overset{O}{\parallel}}{C} - OH$.

FG: $-\overset{\overset{O}{\parallel}}{C} - OH$: carboxyl.

ester & carboxylic are functional isomers.

All carboxylic acids are weak acids.

Chemical rxns:



Derivatives of carboxylic acid:

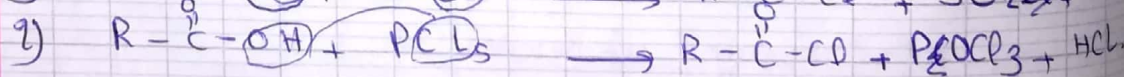
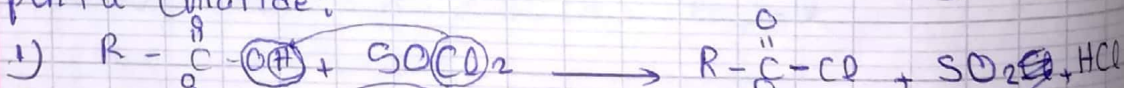
- 1) Acyl chloride.
- 2) Acid Anhydride
- 3) Ester
- 4) Amide.

1) Acyl chloride:

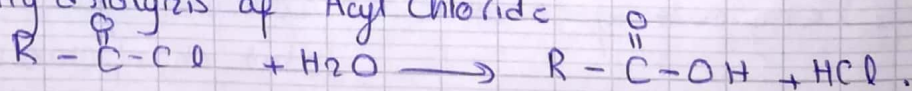
MF: $C_n H_{2n-1} OCl$.

GF: $(H)R - \overset{\overset{O}{\parallel}}{C} - Cl$.

Preparation of Acyl Chlorides by substitution of carboxylic acid with Thionyl Chloride $SOCl_2$ or by phosphorus penta Chloride:

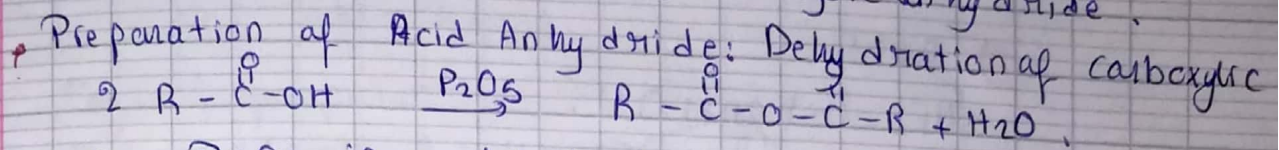
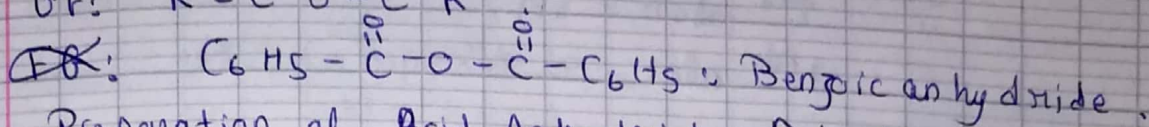
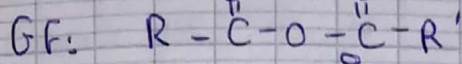
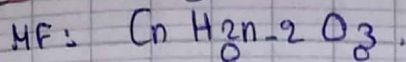


Hydrolysis of Acyl Chloride



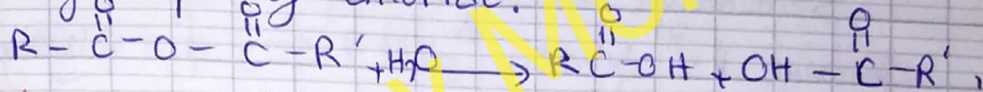
Charac of this rxn: fast, complete, exo, vigorous.

2) Acid Anhydride: (Alkanoic Anhydride)



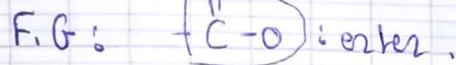
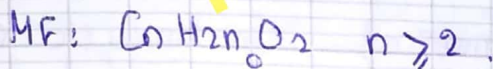
where P_2O_5 is a dehydrating agent that remove water from organic compound.

Hydrolysis of Acyl chloride:



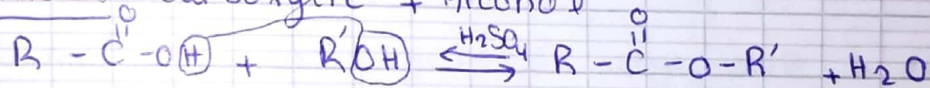
Characteristics of rxn: fast, complete, exo.

3) Esters



Preparation of ester: by 3 methods:

1st method: Carboxylic + Alcohol

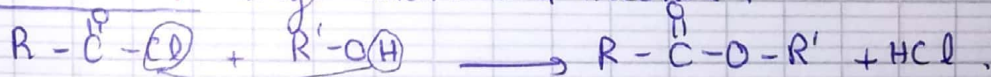


forward (\rightarrow): esterification.

backward (\leftarrow): hydrolysis.

Charact of rxn: slow, reversible, athermic.

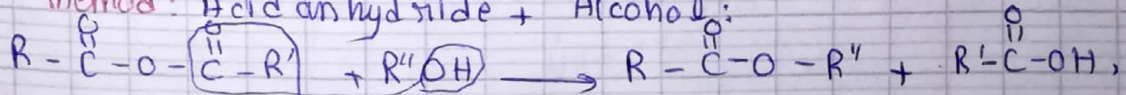
2nd method: Acyl chloride + Alcohol.



Characteristics: fast, complete, exo.

Condition: beaker should be dry to avoid hydrolysis of Acyl chloride. % yield = 100%.

3rd method: Acid anhydride + Alcohol:



Characteristics: complete, fast, exo.

Condition: dry beaker to avoid hydrolysis. % yield = 60%.

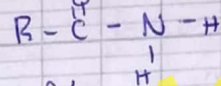
If reactants are equimolar, then:
 % yield 1st alc = 67%
 " 2nd alc = 60%
 " 3rd alc = 25%

4) Amide:

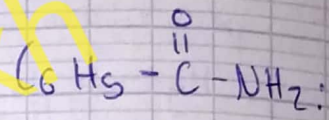
MF: $C_n H_{2n+1} O N$

GF: $R - \overset{\overset{O}{\parallel}}{C} - N$ its functional gp is amide.

Primary amide:



Secondary: $R - \overset{\overset{O}{\parallel}}{C} - N - R'$



Tertiary: $R - \overset{\overset{O}{\parallel}}{C} - N - R'$

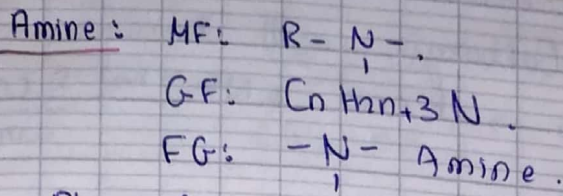


phenyl methanamide.

Hydrolysis of amide: $R - \overset{\overset{O}{\parallel}}{C} - N - H + H_2O \rightarrow R - \overset{\overset{O}{\parallel}}{C} - OH + \overset{\ominus}{N} - H$

Notes Only derivatives of Carboxylic make hydroly

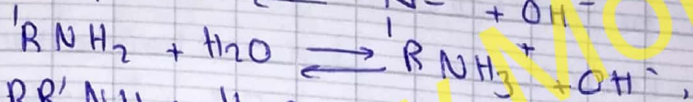
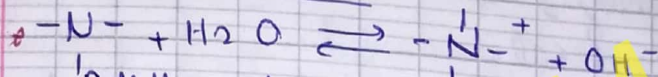
Amine \rightarrow α -Amino Acid :



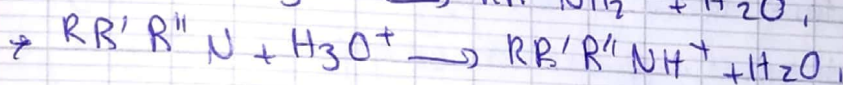
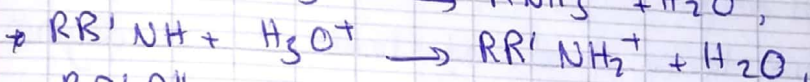
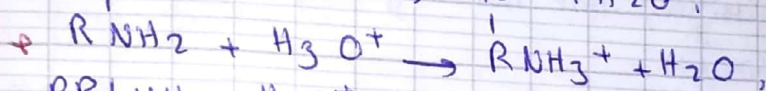
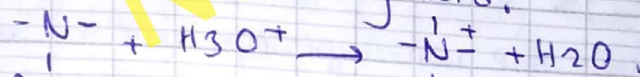
Physical properties:

As no. of carbon atoms \rightarrow

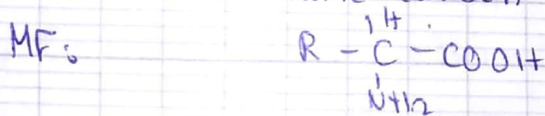
\rightarrow Chemical rxns:



\rightarrow Amine with strong acid:

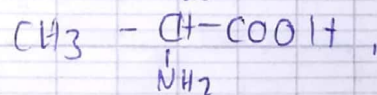


- α Amino acid is a carboxylic acid, where the molecule contains amino functional group on α position (carboxyl & amino must be on same carbon).

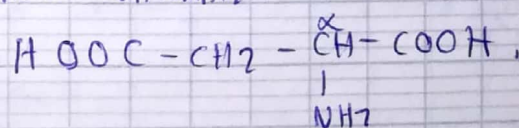


Types of α -amino acid:

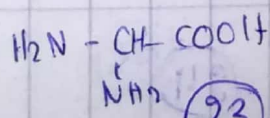
1) neutral amino acid: doesn't contain acidic or basic functional group:



2) acidic amino: contains acidic functional group:

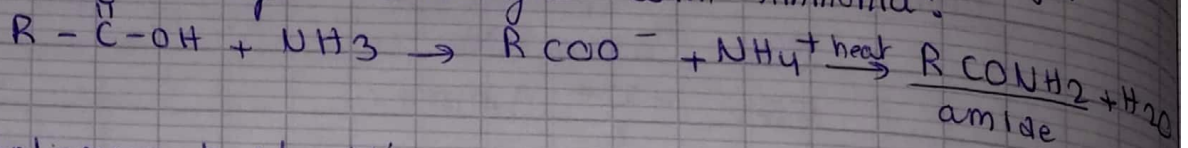


3) basic amino: contains basic functional group:



• We name α -amino acid: α amino alkanic acid
If R group doesn't contain other functional groups.

→ Reaction of Carboxylic with Ammonia:



→ Anantiomers: hard, it's a greek word.

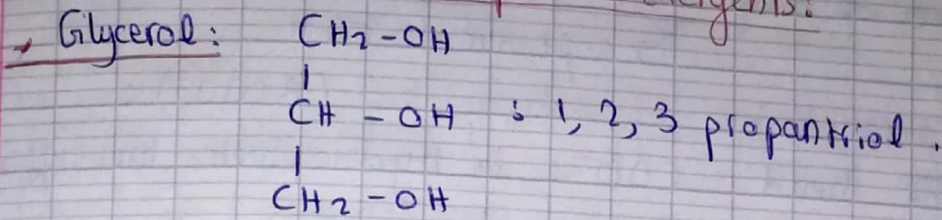
→ Chirality: A chiral molecule is non-superimposable on its mirror image, when molecule is superimposable it said to be achiral.

→ Asymmetric carbon: in a chiral carbon attached to 4 diff atoms or group of atoms. C^* ; $*$: asterix.

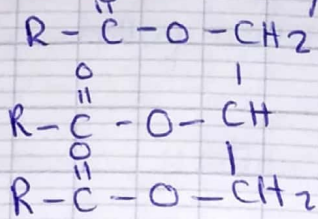
→ Enantiomers: non-superimposable, chiral. Enantiomerism: is a relation existing between 2 molecules which are non-superimposable & are mirror images.

→ For atom to be chiral: it should have asymm carbon attached on 4 diff atoms or group of atoms.

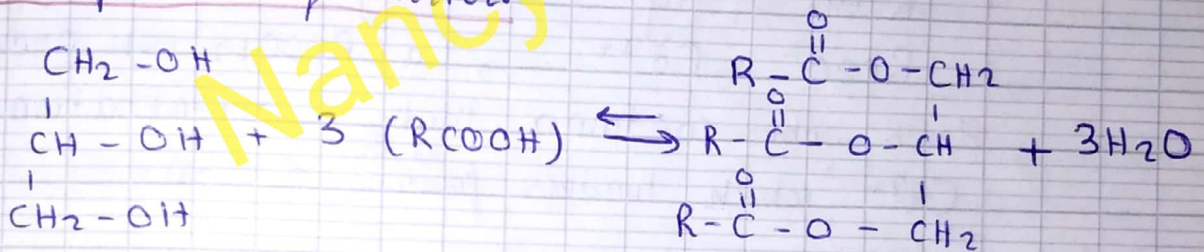
Soap & Detergents:



→ Triester: (oil, fat, triglyceride).



→ Preparation of triester:



→ There are two types of carboxylic acid:

1) saturated: there's no double bond between carbon & carbon. $\text{C}_n\text{H}_{2n}\text{O}_2$; $\text{C}_x\text{H}_{2x+1}$ ($x=n-1$).

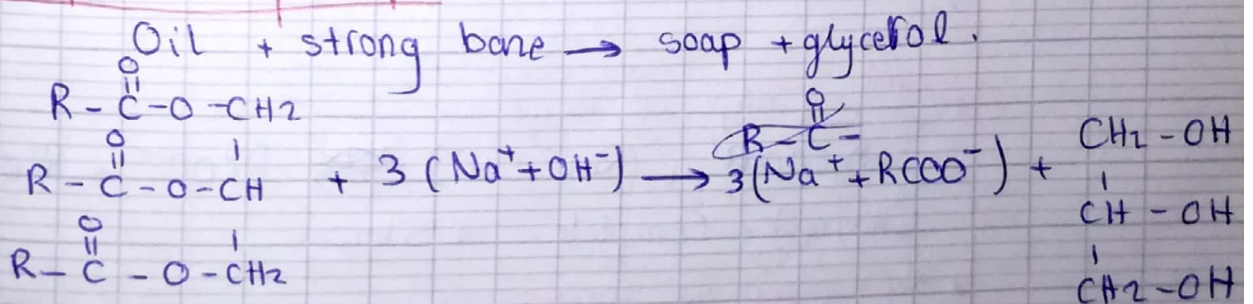
2) unsaturated:

→ $\text{C}_n\text{H}_{2n-2}\text{O}_2$; $\text{C}_x\text{H}_{2x-1}\text{COOH}$: 1 double bond between carbon & carbon.

→ $\text{C}_n\text{H}_{2n-4}\text{O}_2$; $\text{C}_x\text{H}_{2x-3}\text{COOH}$: 2 double bonds between carbon & carbon.

→ $\text{C}_n\text{H}_{2n-6}\text{O}_2$; $\text{C}_x\text{H}_{2x-5}\text{COOH}$: 3 double bonds between carbon.

→ Preparation of soap:



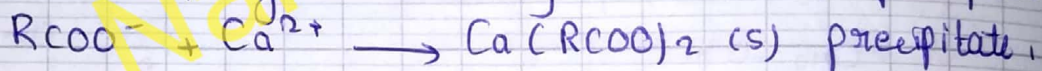
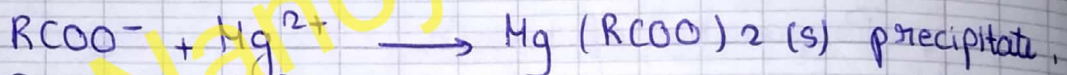
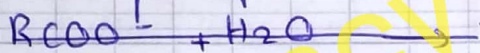
Types of soaps: → hard due to NaOH,
→ soft due to KOH.

Characteristics of carboxylate: (RCOO^-):

The head: COO^- is hydrophilic has affinity of water (loves water) it's polar.

The tail R: is lipophilic, has affinity of lipids, is hydrophobic & non polar.

Rxn of soap with hard water:



Hard water: contains high concentration of Mg^{2+} & Ca^{2+} which hinders foaming of soap.

Rxn of soap with strong acid:



When soap reacts with strong acid, a precipitate is formed since $nC < 10$.

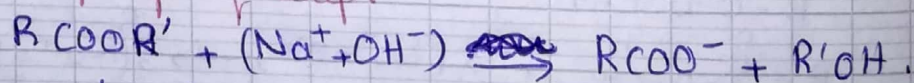
Salty water containing Cl^- & Na^+ .

H_3O^+ isn't suitable for washing soap.

Separating soap from glycerol:

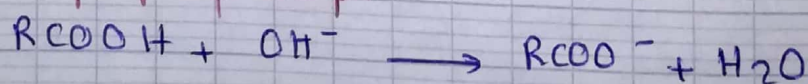
by adding ^{concentrated} sodium chloride (NaCl), soap will float as well as Na^+ makes soap harder.

2nd prep of soap:



Charact: Complete & Slow.

3rd prep of soap:



Principle of detergency

Carboxylate has 2 parts:

- 1) head: COO^- ,
- 2) tail: R.

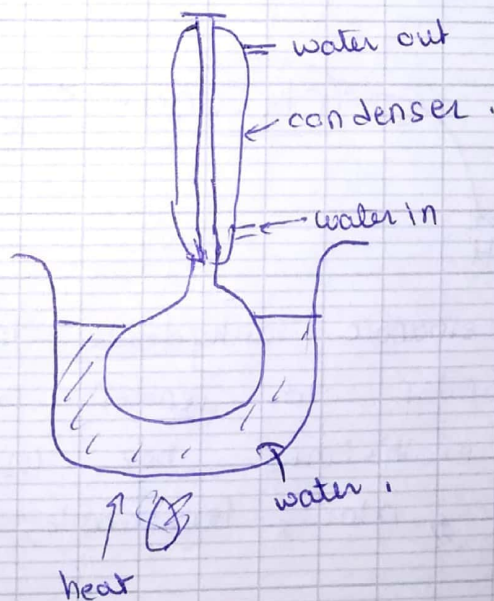
The tail (R) that's lipophilic hydrocarbon penetrates between the fat molecules which shows similar properties to the fat, so this process permits the stains to detach & to get dispersed in the solution surrounded by molecules of soap.

Steps to separate soap from glycerol:

- 1) Flocculation (adding salty water),
- 2) Filtration

Reflux heating:

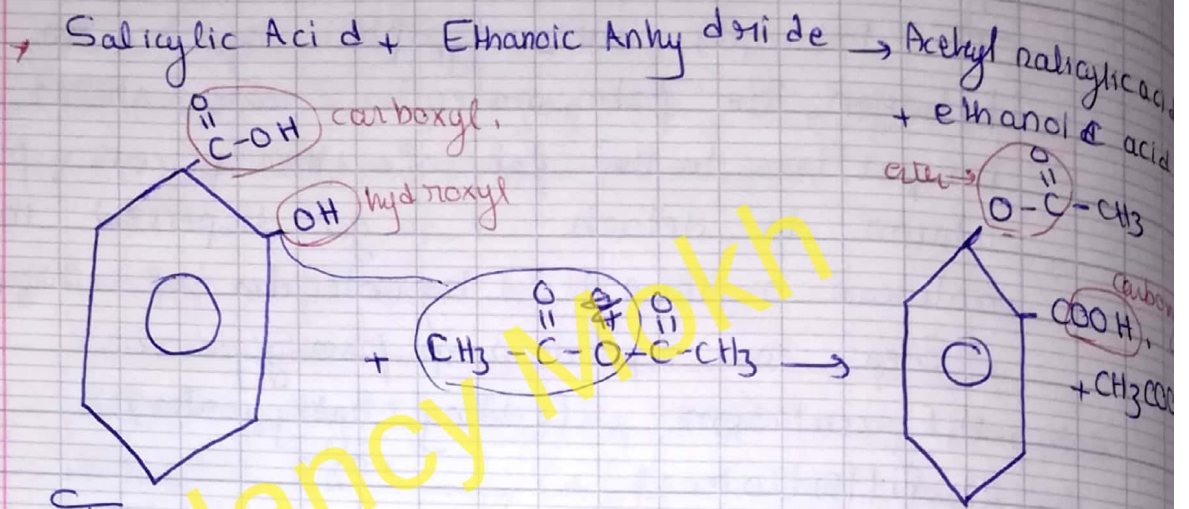
- 1) Role: condense vapor of reactional medium not to lose any of its components,
- 2) Role of heating: \uparrow rate of rxn.
- 3) Role of boiling stones: to absorb extra heat & regulate temperature to prevent explosion of flask,



Aspirin:

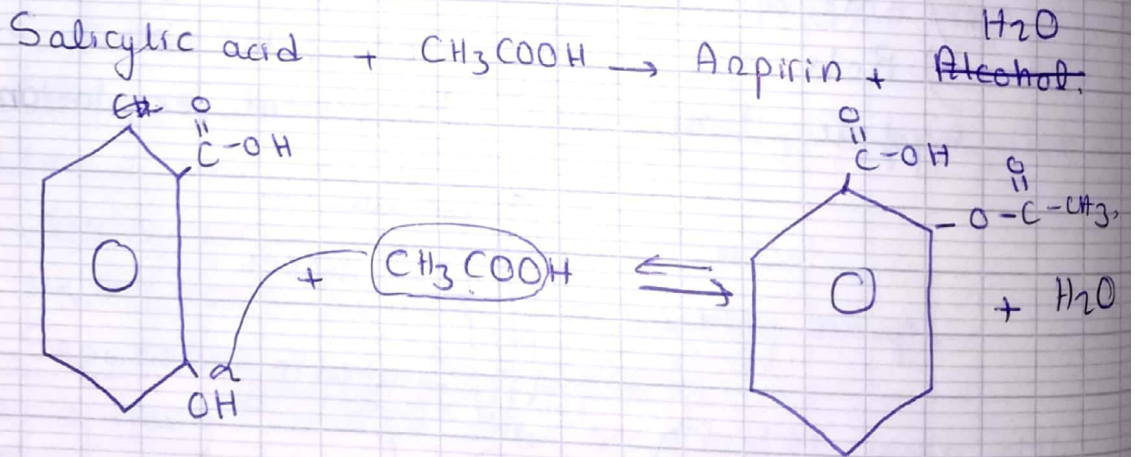
Preparation of Aspirin:

1st method:



- This rxn is called esterification.
- Characteristics of rxn: fast + complete.
- Condition: absence of water to avoid hydrolysis of ethanoic anhydride.

2nd method:



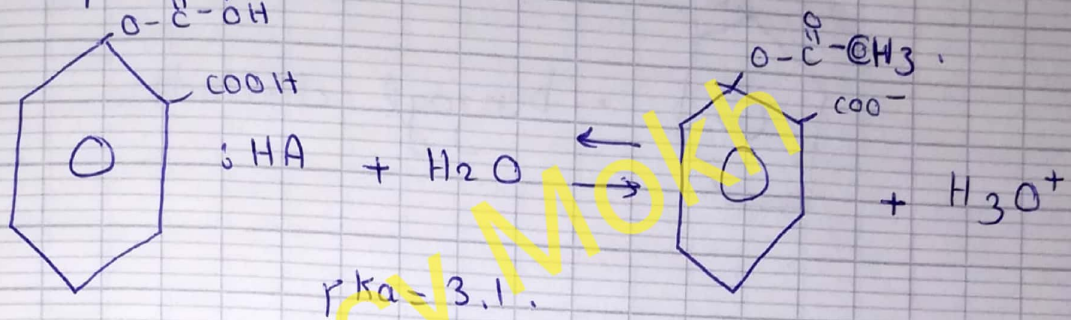
we use ethanoic anhydride instead of ethanoic acid in order to render rxn to be fast, complete \rightarrow exothermic, bec using ethanoic acid, makes rxn \rightarrow slow, reversible, endothermic.

- Role of sulfuric acid:
- Used in low amount as catalyst to \rightarrow rate
- Used in high amount as dehydrating agent, it increases rate of rxn.

Formulation 2 of Aspirin:

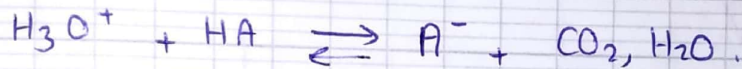
- 1) Simple Aspirin.
- 2) Effervescent Aspirin.
- 3) Buffer Aspirin.

1) Simple Aspirin:



2) Effervescent Aspirin:

Contains Acetylsalicylic acid, sodium bicarbonate, & citric acid.



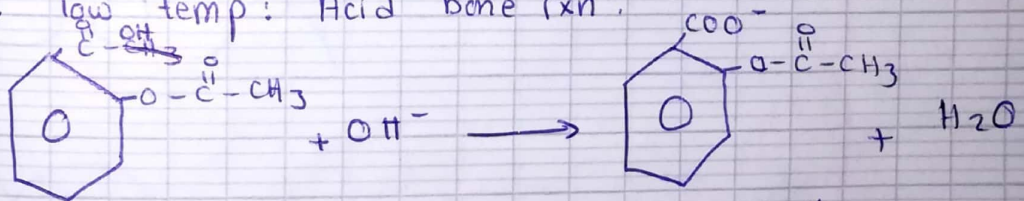
$\Delta pK_a = 2.9 \Rightarrow$ reversible rxn.

rxn of bicarbonate with H_3O^+ in the stomach \searrow
 $[H_3O^+]$ which permits Aspirin to be absorbed in the small intestine.

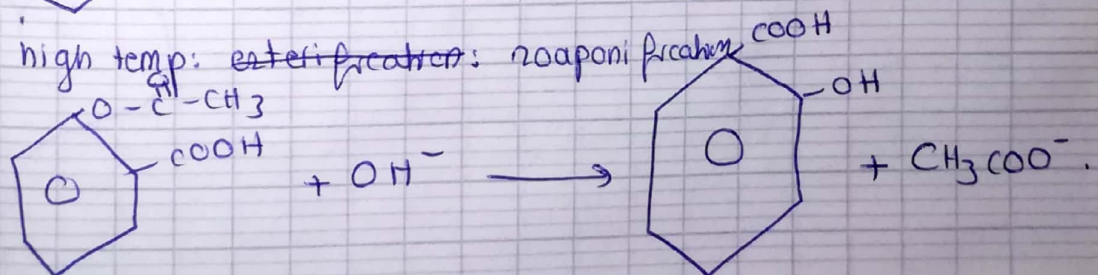
3) Buffer Aspirin:

It's made of weak acid (aspirin) & conjugate base (acetylsalicylate) (acetylsalicylate).

* At low temp: Acid base rxn.

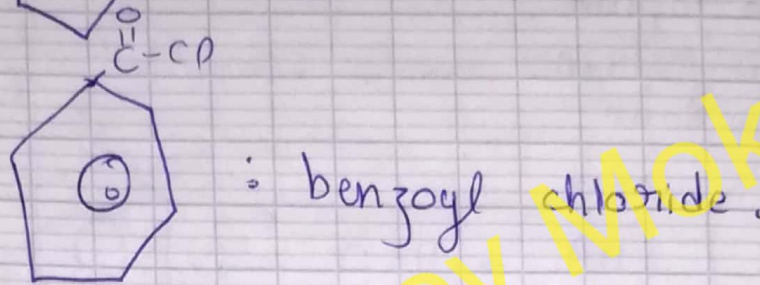
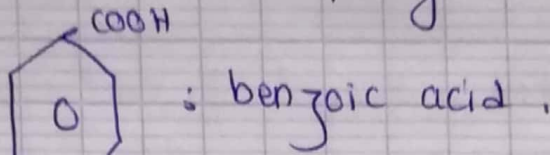


* At high temp: esterification: saponification



* Sometimes at high temp 2 rxns may be done, but priority is to saponification. (29)

Note: C_6H_5 : phenyl.



Nancy Mokh

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