

# 1. Techniques and Measurements

\* Beakers and Erlenmeyer flasks → roughly estimate

\* Graduated cylinders, Burets, and Pipets } → more precise

## Physical Properties

### Intensive

doesn't depend on the amount of substance.

e.g. temperature, density, ...

### Extensive

depend on the amount of substance

e.g. volume, heat, mass, ...

$$\left( \frac{\text{extensive}}{\text{extensive}} = \text{intensive} \Rightarrow \frac{\text{mass}}{\text{volume}} = \text{density} \right)$$

$$\boxed{\text{Density} = \frac{\text{Mass}}{\text{Volume}}}$$

units: g/mL → liquids }  
g/cm<sup>3</sup> → solids } "تلك"

- density of water at 4°C = 1.0 g/mL

- density of Osmium = 22.6 g/cm<sup>3</sup> (greatest density among elements)

\* Factors of density:

1) Temperature:

if it increase → the volume increase → the density decrease

2) Pressure:

if it increase → the volume decrease → the density increase.

\* Safety Rules (6-10)

\* Laboratory Techniques (12-19)

\* Significant Figures (149-152)

} Reading

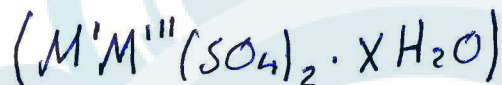
## [2] Formula of a Hydrate

\* Hydrate : is a compound that has crystallized from aqueous solution with weakly bound water molecules contained in the crystal.

→ Transition metal salts : as  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$

→ Non-transition metal salts : as  $\text{NaC}_2\text{H}_3\text{O}_2 \cdot 3\text{H}_2\text{O}$

\* Alums : a class of hydrates, with the general formula

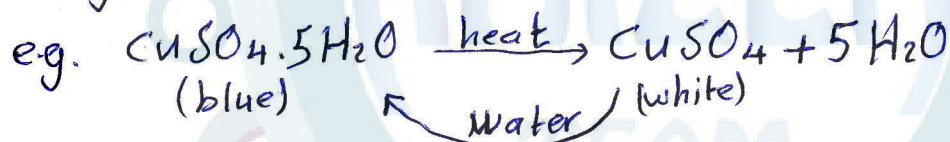


$\text{M}'$  : univalent cation

$\text{M}''$  : trivalent cation

example :  $\text{KAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$

\* Hydrate  $\xrightarrow{\text{heat}}$  anhydrous (without water)



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Hydrate  $\xrightarrow{\text{heat}}$  anhydrous +  $\text{H}_2\text{O}$

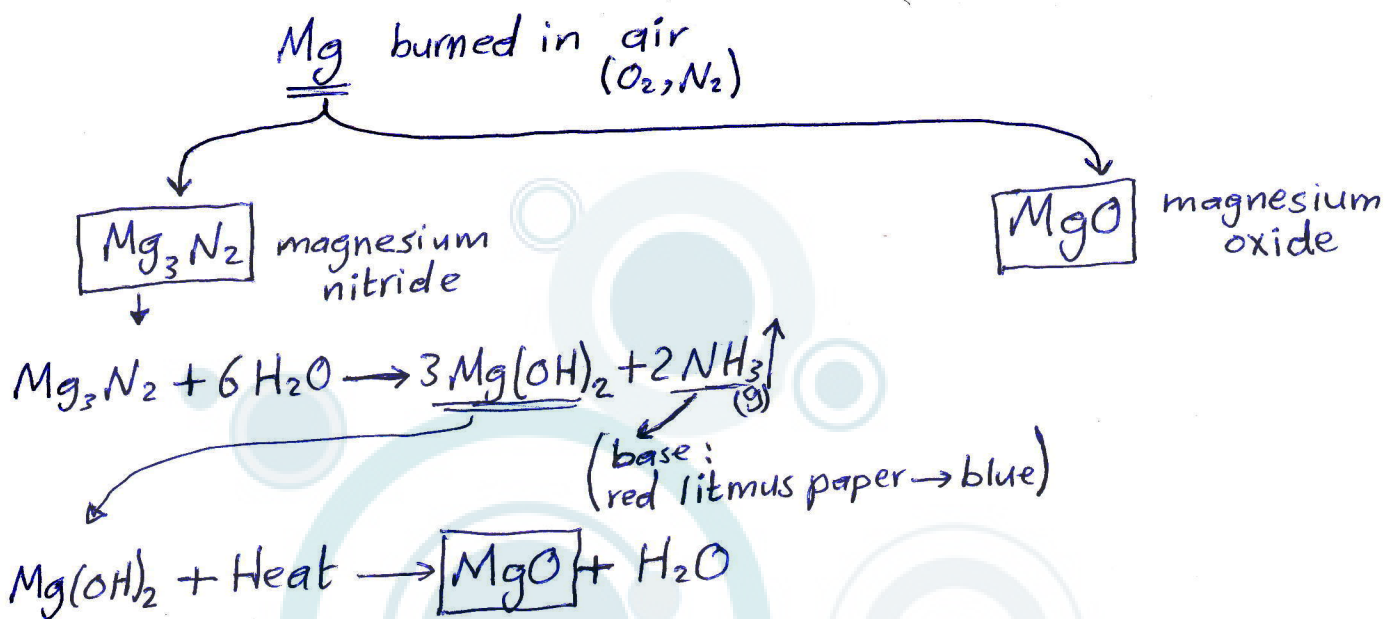
$$\text{mass}(\text{Hydrate}) = \text{mass}(\text{anhydrous}) + \text{mass}(\text{H}_2\text{O})$$

(Hydrate or Alum)  
the same

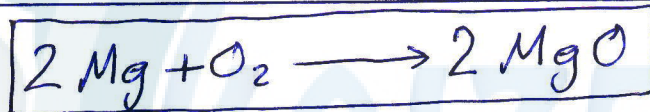
\* % of water of crystallization by mass =  $\frac{\text{mass}(\text{water})}{\text{mass}(\text{hydrate})} \times 100\%$

\* value of  $x = \frac{\text{moles}(\text{water})}{\text{moles}(\text{anhydrous})}$

### [3] The Empirical Formula of an Oxide



$\rightarrow$  although the amount of ( $N_2$ ) in the air is approximately 4 times that of ( $O_2$ ) more oxide than nitride is formed when an active metal is burned in air  $\rightarrow$  the reason is the superior reactivity of ( $O_2$ ).



mass of ( $MgO$ ) = mass of  $Mg$  + mass of  $O_2$

- to determine the empirical formula:

1- find masses of  $Mg, O_2$ .

2- then calculate number of moles of  $Mg, O_2$  (moles =  $\frac{\text{mass}}{M.m}$ )

3-  $\frac{m}{M} \rightarrow$  moles of  $Mg$        $\frac{n}{O} \rightarrow$  moles of  $O$        $\rightarrow$  اقسام (m.m) على الالهة

mass % of  $Mg$  in the oxide =  $\frac{\text{mass}(Mg)}{\text{mass}(MgO)} \times 100\% \Rightarrow$  experimentally (من التجربة)

mass % of  $Mg$  in the oxide =  $\frac{M_{\text{theoretical}}(Mg)}{M_{\text{theoretical}}(MgO)} \times 100\% \Rightarrow$  theoretically (من الجدول الدوري)

% error =  $\frac{|X_2 - X_1|}{X_2} \times 100\%$   
 $(X_2) \rightarrow$  true value

\* cover of the crucible is slightly open  $\rightarrow$  because opening the cover too far allow the metal to enflame.

## 4. Limiting Reactant

- reaction between two hydrates as the follow :



\* طريقة تحديد ال (limiting reactant)

$$\text{moles of } Na_3PO_4 = \frac{\text{mass of } Na_3PO_4}{M.m (Na_3PO_4 \cdot 12H_2O)} = n_{Na_3PO_4}$$

كامل

$$\text{moles of } BaCl_2 = \frac{\text{mass of } BaCl_2}{M.m (BaCl_2 \cdot 2H_2O)} = n_{BaCl_2}$$

كامل

ثم نقسم عدد مولات كل مادة على معاملها في المعادلة :

$$\frac{n_{Na_3PO_4}}{2}$$

$$\frac{n_{BaCl_2}}{3}$$

الناتج الاقل يكون (limiting)  
والناتج الاكبر يكون (excess)

ويمكن تحديد (limiting & excess) عملياً بإضافة إحدى المادتين إلى محلولي ( $BaCl_2$  &  $Na_3PO_4$ )

فإذا تكون الراسب في إحدىهما يكون : المادة المضافة ← limiting  
(precipitate)  
المادة الموجودة في المحلول ← excess

\* Purpose of heating the mixture → to get large particle size.

\* Purpose of washing the precipitate with hot water →  
to ionize NaCl and filter  $Ba_3(PO_4)_2$  only.

$$\Rightarrow \text{mass \% of } BaCl_2 \cdot 2H_2O = \frac{\text{mass of } BaCl_2}{\text{total mass (mixture)}} \times 100\%$$

$$\Rightarrow \text{mass \% of } Na_3PO_4 \cdot 12H_2O = \frac{\text{mass } Na_3PO_4}{\text{total mass (mixture)}} \times 100\%$$

} Mixture

## [5] Determination of Acetic Acid in Vinegar

- Vinegar is a dilute solution of acetic acid ( $\text{CH}_3\text{COOH}$ ) in water.

\* number of moles ( $n$ ):

→  $n = \text{Molarity} \times \text{Volume (Liters)}$

$n = M \times V$  → for a solution

→  $n = \frac{\text{mass}}{\text{molar mass}}$

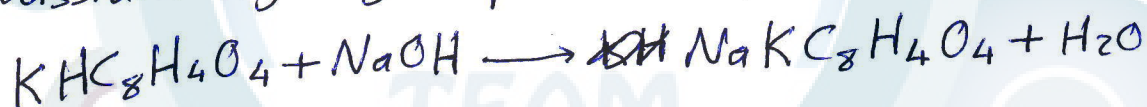
$n = \frac{m}{M.m}$  → for a pure substance.

\* Indicator: Phenolphthalein   
 (colorless) in acid   
 (pink) in base

### [A] Standardization of NaOH solution:

↳ because NaOH is secondary standard solution, and it absorbs moisture from atmosphere.

so we standardize it with primary standard (KHP) potassium hydrogen phthalate (has the formula  $\text{KHC}_8\text{H}_4\text{O}_4$ )



$$n_{\text{NaOH}} = n_{\text{KHP}}$$

$$M \times V = \frac{m}{M.m}$$

### [B] Mass percent of acetic acid in vinegar:



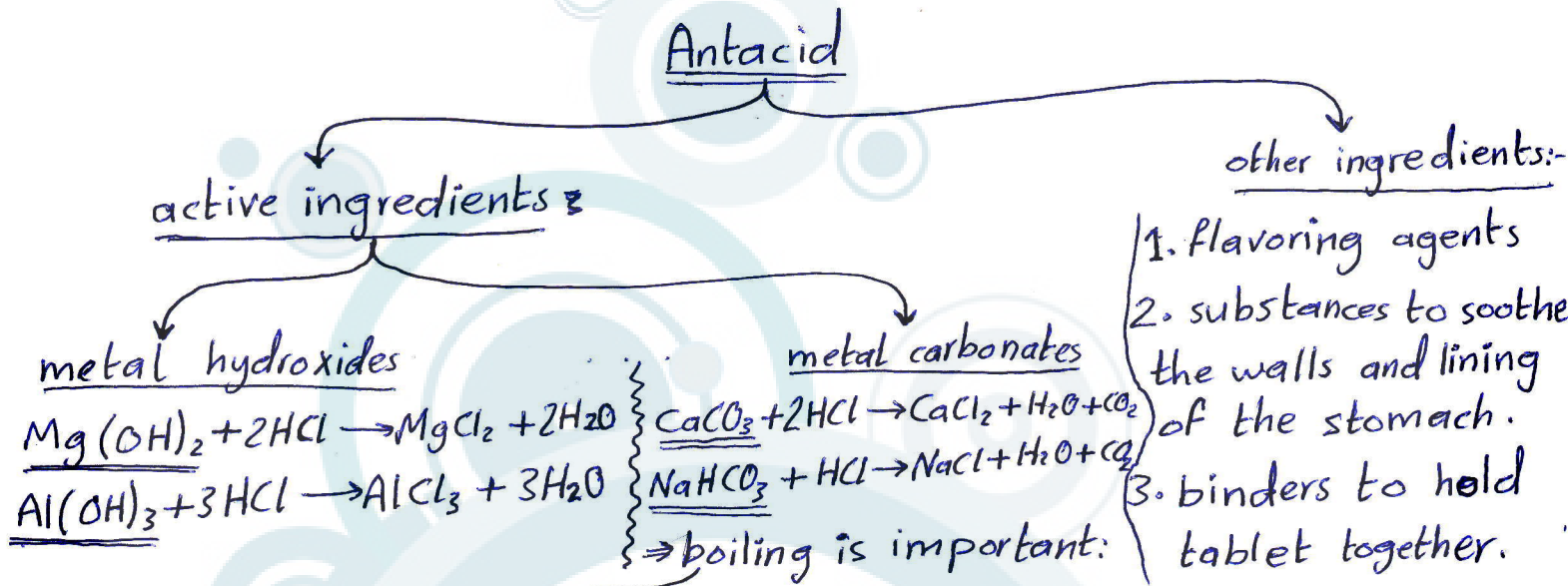
$$n_{\text{CH}_3\text{COOH}} = n_{\text{NaOH}}$$

$$(M \times V)_{\text{CH}_3\text{COOH}} = (M \times V)_{\text{NaOH}}$$

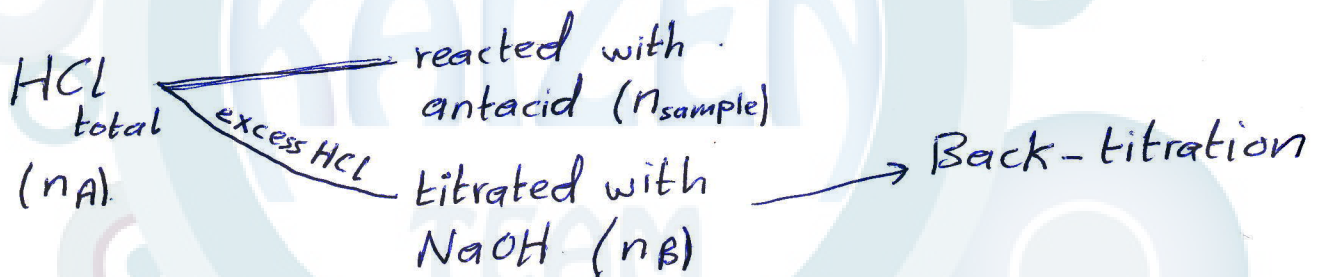
$$\text{mass \% of acetic acid in vinegar} = \frac{\text{mass of acetic acid in 1L} \times 100}{\text{mass of 1L vinegar}} = \frac{M \times M.m \times 100}{d \times V}$$

# 6. The Neutralizing Capacity of Antacid Tablets

- Antacids are weak bases - because strong bases will react with HCl in an exothermic reaction and strong bases are corrosive substances.



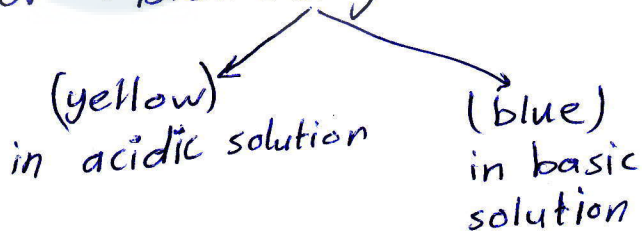
to remove  $\text{CO}_2$  which converted to the weak acid ( $\text{H}_2\text{CO}_3$ )  
 $[\text{H}_2\text{CO}_3 \rightleftharpoons \text{CO}_2 + \text{H}_2\text{O}]$  which reacts with NaOH.



$$n_{\text{sample}} = n_A - n_B$$

$$\text{neutralizing capacity of antacid} = \frac{\text{moles of HCl needed to neutralize antacid}}{\text{mass of antacid}} \quad (\text{mol/g})$$

\* Indicator → bromothymol blue

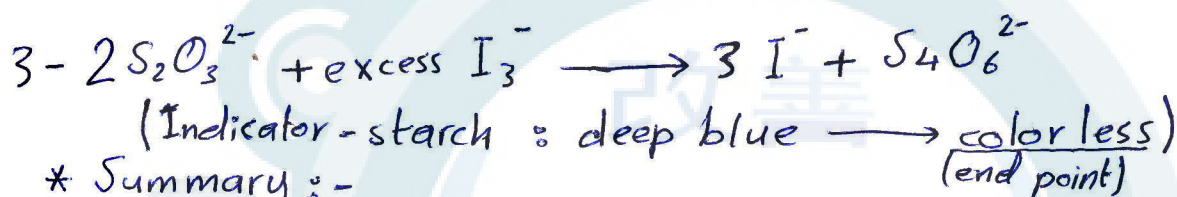
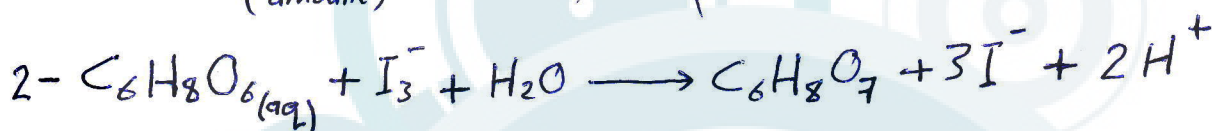
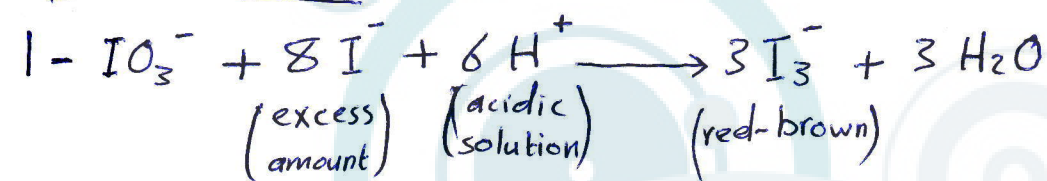


# 7 Vitamin C Analysis

- \* Vitamin C ( $C_6H_8O_6$ ):
- called (ascorbic acid)
  - water soluble.
  - Powerful reducing agent

⇒ reducing properties of vit. C used to analysis (even it is an acid)  
 ↳ because there are other acids present in foods that would interfere with the selective determination of vit. C.

## \* Equations :-

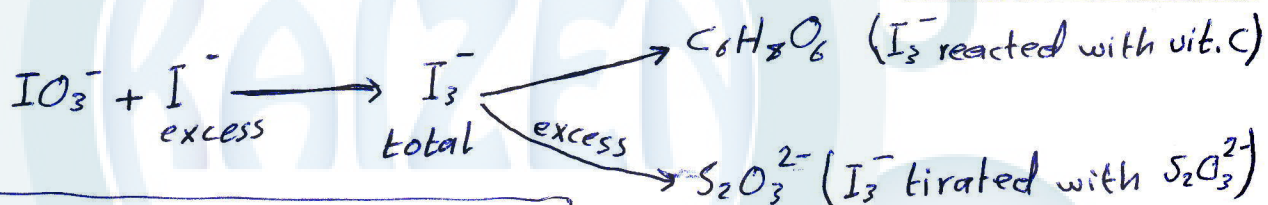


## \* Summary :-

in this experiment :-

oxidizing agents (get reduced):  
 $IO_3^-$  (strong)  
 $I_3^-$  (mild)

reducing agents (get oxidized):  
 $C_6H_8O_6$   
 $I^-$   
 $S_2O_3^{2-}$



$$I_3^- \text{ (reacted with vitamin C)} = I_3^- \text{ total} - I_3^- \text{ excess} \quad (\text{Back-titration})$$

$$\# I_3^- \text{ (total)} = 3 * \# \text{ moles of } IO_3^- \quad \dots \text{ from equation 1}$$

$$\# I_3^- \text{ (reacted with vitamin C)} = \# \text{ moles of } C_6H_8O_6 \quad \dots \text{ from equation 2}$$

$$\# I_3^- \text{ (excess)} = \frac{1}{2} * \# \text{ moles of } S_2O_3^{2-} \quad \dots \text{ from equation 3}$$

$$\% \text{ mass of vit. C in sample} = \frac{\text{mass vit. C}}{\text{mass sample}} * 100\%$$

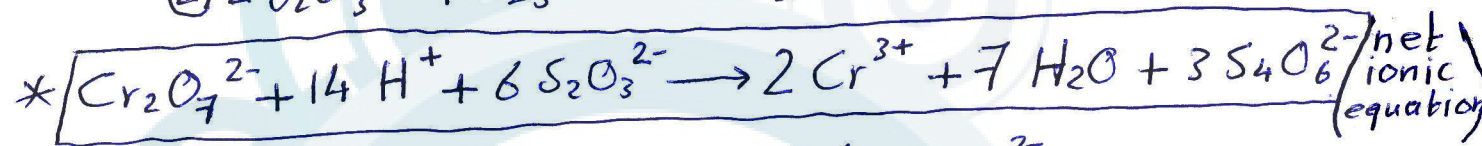
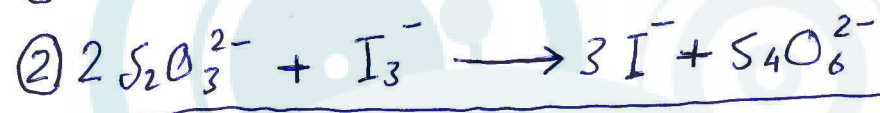
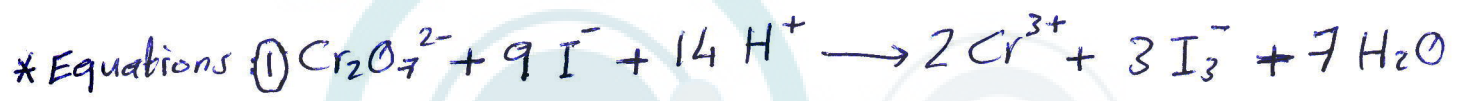
$$\text{mass vit. C} = \text{moles of vit. C} * M.m \text{ vit. C} (176 \text{ g/mol})$$

# 8. Bleach Analysis

-the active ingredient in most chlorine bleaches is sodium hypochlorite  $\text{NaOCl}$  (or  $\text{ClO}^-$ ).

## A Standardization of thiosulfate solution :

- because  $\text{S}_2\text{O}_3^{2-}$  may be oxidized by oxygen or by bacterial action.
- $\text{S}_2\text{O}_3^{2-}$  standardize with primary standard (e.g.  $\text{Cr}_2\text{O}_7^{2-}$  <sup>dichromate</sup>).



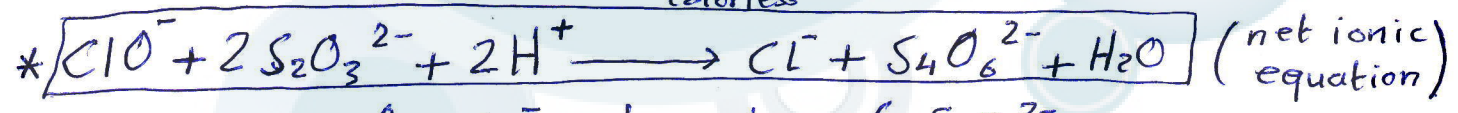
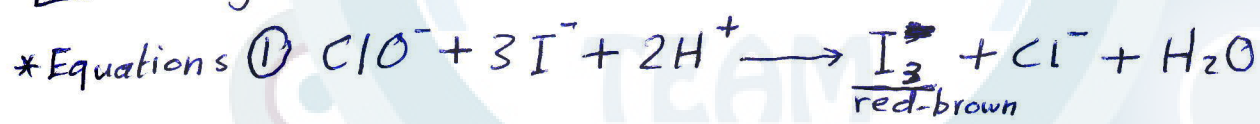
\*\* moles of  $\text{S}_2\text{O}_3^{2-} = 6 \times$  moles of  $\text{Cr}_2\text{O}_7^{2-}$

Colors red  $\xrightarrow[\text{(S}_2\text{O}_3^{2-})]{\text{titration}}$  yellow  $\xrightarrow[\text{(starch)}]{\text{indicator}}$  dark blue  $\xrightarrow[\text{(S}_2\text{O}_3^{2-})]{\text{titration}}$  yellow-green ( $\text{Cr}^{3+}$  color)

$M_{\text{S}_2\text{O}_3^{2-}} = \frac{\text{moles of S}_2\text{O}_3^{2-}}{\text{Volume (Liters)}}$

oxidizing agents $\text{ClO}^-$ , $\text{I}_3^-$ , $\text{Cr}_2\text{O}_7^{2-}$
reducing agents $\text{I}^-$ , $\text{S}_2\text{O}_3^{2-}$

## B Analysis of bleach solution :



\*\* moles of  $\text{ClO}^- = \frac{1}{2}$  moles of  $\text{S}_2\text{O}_3^{2-}$

Colors red  $\xrightarrow[\text{(S}_2\text{O}_3^{2-})]{\text{titration}}$  yellow  $\xrightarrow[\text{(starch)}]{\text{indicator}}$  dark blue  $\xrightarrow[\text{(S}_2\text{O}_3^{2-})]{\text{titration}}$  colorless

$M_{\text{ClO}^- \text{ diluted}} = \frac{\text{moles of ClO}^-}{\text{Volume (Liters)}}$

$M_{\text{ClO}^- \text{ original}} = M_{\text{ClO}^- \text{ diluted}} \times \text{dilution factor}$

$\text{Mass \% NaClO}^- = \frac{M_{\text{original}} \times M.m}{\text{density}(d) \times 1000} \times 100\%$

داخل آ کبر من واحد  
وقد يكون عدد صحيح  
أو عدد كسري



## [9] Molar Mass of a Volatile Liquid (Dumas method)

\* at STP (standard temperature - pressure) conditions:-

$$\begin{array}{l} T = 0^\circ\text{C} = 273\text{ K} \\ P = 1\text{ atm} \end{array} \Rightarrow \text{Volume of ideal gas} = 22.4\text{ L}$$

\* Gases behave ideally at:

- very low pressure .
- very high temperature .

$$\boxed{PV = nRT} \quad \text{ideal gas law}$$

P: Pressure in (atm)  $\Rightarrow 1\text{ atm} = 760\text{ mmHg} = 760\text{ torr}$

V: Volume in (Liters)

n: number of moles

R: gas constant =  $0.0821 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}}$

T: temperature in (K)  $\Rightarrow K = C + 273$

$$n = \frac{\text{mass (m)}}{\text{molar mass (M)}}$$

$$\Rightarrow \boxed{M = \frac{mRT}{PV}}$$

m: in grams  
M: (g/mol)

$$\text{density (d)} = \frac{\text{mass (m)}}{\text{volume (V)}}$$

$$\Rightarrow \boxed{d = \frac{PM}{RT}}$$

d: (g/L)

# 10. Thermochemistry and Hess's Law

- Heat flows are measured by Calorimeter.
- In the calorimeter, a small quantity of heat may be transferred to the calorimeter itself, ~~through~~ the metal wire used for stirring, or to the thermometer. Therefore the calorimeter will be calibrated.

$$q = m * s * \Delta t$$

heat (Joule)  $\left[ J = kg \ m^2 \ s^{-2} \right]$       mass      specific heat

quantity of heat required to raise the temperature of one gram of the substance by  $1^\circ C$   
 (unit  $\rightarrow J/g \cdot ^\circ C$ )

## A] Determination of the heat capacity of calorimeter [Calibration]:

Heat lost = Heat gained  $\rightarrow$  (conservation of energy)

$$q_{\text{warm water}} = q_{\text{cold water}} + q_{\text{calorimeter}}$$

$$(m * s * \Delta t)_{\text{warm}} = (m * s * \Delta t)_{\text{cold}} + (C * \Delta t)_{\text{calorimeter}}$$

the same  $\rightarrow$  calorimeter constant ( $J/^\circ C$ ) or heat capacity

remember  $m = \text{volume} \times \text{density}$

- Water has very high specific heat ( $4.184 \ J/g \cdot ^\circ C$ )

- Stirring water during heating  $\rightarrow$  to ensure that the temperature is uniform.

(C) depends on material  
 • the higher conductivity  
 the higher C value  
 e.g.  $C_{\text{metal}} > C_{\text{plastic}}$

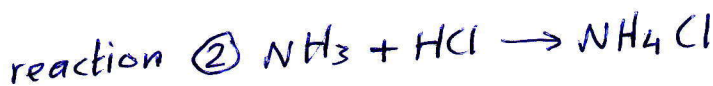
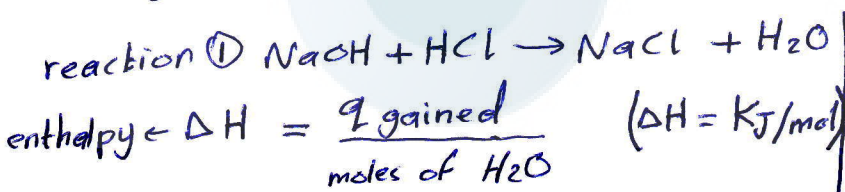
## B] Heat of Acid-Base Reaction:

$$q_{\text{gained}} = (m \ s \ \Delta t)_{\text{solution}} + C \ \Delta t$$

the same

$$\Delta t = t_f - t_i$$

mixture بعد التفاعل  
 معدل درجة حرارة اللادئين المتساويين قبل التفاعل



$$\Delta H = \frac{q_{\text{gained}}}{\text{moles of } NH_4Cl}$$

$\Delta H \rightarrow$  temperature increase (exothermic)  $\rightarrow \Delta H \ominus$   
 $\Delta H \rightarrow$  temperature decrease (endothermic)  $\rightarrow \Delta H \oplus$

Hess's Law:

١. عند ضرب المعادلة برقم  $\rightarrow$  تضرب  $\Delta H$  بنفس الرقم  
 ٢. عند عكس المعادلة  $\rightarrow$  عكس إشارة  $\Delta H$

# 11. Molar Mass from Freezing Point Depression

→ to determine the molar mass of a nonvolatile solute.

\* Solutions differ from pure solvents in these properties:-

- |                               |   |
|-------------------------------|---|
| 1- Vapor pressure.            | } <u>Colligative properties:</u><br>depends only on the number of particles of solute not on the type of particles. |
| 2- Osmotic pressure.          |   |
| 3- Freezing point depression. |   |
| 4. Boiling point elevation.   |   |

$$\Delta T_f = K_f m$$

→ used for dilute solutions of non-dissociating and non-associating solutes.

$$m = \frac{\Delta T_f}{K_f}$$

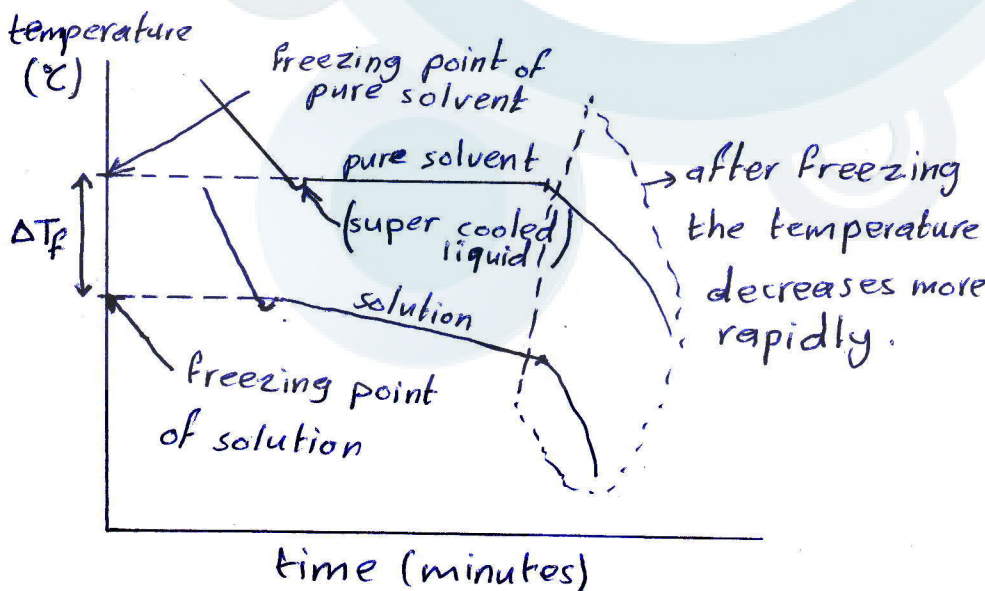
$$\frac{\text{moles of solute}}{\text{mass of solvent (Kg)}} = \frac{\Delta T_f}{K_f}$$

$$\frac{\left( \frac{\text{mass of solute}}{M.m} \right)}{\text{mass of solvent (Kg)}} = \frac{\Delta T_f}{K_f}$$

$$M.m = \frac{K_f \cdot \text{mass of solute (g)}}{\Delta T_f \cdot \text{mass of solvent (Kg)}}$$

where :-

- $\Delta T_f$  (Freezing point depression)  
 $\Delta T_f = \left( \begin{array}{l} \text{Freezing point} \\ \text{of solvent} \end{array} - \begin{array}{l} \text{Freezing point} \\ \text{of solution} \end{array} \right)$
- $K_f$ : molal freezing-point depression constant ( $^{\circ}\text{C}/m$ )
- $m$ : molal concentration  
 $m = \frac{\text{moles of solute}}{\text{mass of solvent (Kg)}}$



\* pure solvent: (constant temperature) that occurs while solvent is freezing.

\* solution: (initial freezing point) at which only a small fraction of solvent solidifies.