

**Equivalent weight (Eq.wt):-** also known as **gram equivalent** or **equivalent mass**, is the formula weight divided by the number of reacting units.

الوزن المكافئ (Eq.wt): المعروف أيضاً بالجرام المكافئ أو الكتلة المكافئة، هو صيغة الوزن مقسومة على عدد الوحدات المتفاعلة.

$$\text{Equivalent weight (Eq.wt)} = \frac{\text{formula weight}}{\text{no. of reacting units}}$$

#### Reacting units:

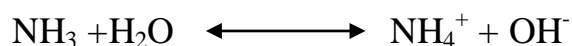
- (H<sup>+</sup> or OH<sup>-</sup>) for acid and base
- Number of electrons for oxidation-reduction reaction
- Number of cations or anions multiplied by charge of ion.

$(\text{Eq. wt})\left(\frac{\text{g}}{\text{Eq}}\right) \text{ for acid - base reaction} = \frac{\text{formula weight (F. wt)}}{(\text{No. of H}^+ \text{ or OH}^-)_{\text{react}}}$
$(\text{Eq. wt})\left(\frac{\text{g}}{\text{Eq}}\right) \text{ for redox reaction} = \frac{\text{formula weight (F. wt)}}{\text{No. of electron}}$
$(\text{Eq. wt})\left(\frac{\text{g}}{\text{Eq}}\right) \text{ for salt reaction} = \frac{\text{formula weight (F. wt)}}{\text{No. of (cation or anion)} * \text{charge of ion}}$

**Example (1):-** Calculate the equivalent weight of the following substances: (a) NH<sub>3</sub>, (b) H<sub>2</sub>SO<sub>4</sub>, (c) H<sub>2</sub>C<sub>2</sub>O<sub>4</sub> (in reaction with NaOH), (d) KMnO<sub>4</sub> [Mn<sup>7+</sup> is reduced to Mn<sup>2+</sup>], and (e) Al<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub>

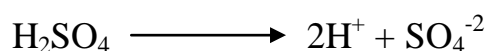
#### Solution:

(a) Base NH<sub>3</sub>



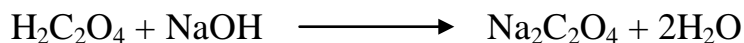
$$\text{Eq wt} = \frac{\text{Mwt}}{\text{No. of H}^+ \text{ or OH}^-} = \frac{17.03}{1} = 17.03 \frac{\text{g}}{\text{Eq.}}$$

(b) Strong acid H<sub>2</sub>SO<sub>4</sub>



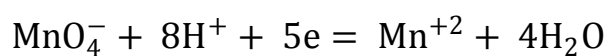
$$\text{Eq wt} = \frac{98}{2} = 49 \frac{\text{g}}{\text{Eq.}}$$

**(C) Weak acid  $\text{H}_2\text{C}_2\text{O}_4$  (in reaction with NaOH)**



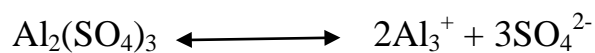
$$\text{Eq wt} = \frac{90.04}{2} = 45.02 \frac{\text{g}}{\text{Eq.}}$$

**(d)  $\text{KMnO}_4$  [ $\text{Mn}^{7+}$  is reduced to  $\text{Mn}^{2+}$ ]**



$$\text{Eq wt} = \frac{\text{M. wt}}{\text{No. of electron}} = \frac{158.04}{5} = 31.608 \frac{\text{g}}{\text{Eq.}}$$

**(e) Salt  $\text{Al}_2(\text{SO}_4)_3$**



$$\text{Eq wt} = \frac{\text{formula weight (F. wt)}}{\text{No. of (cation or anion) * charge of ion}} = \frac{342}{2 * 3} = 57 \frac{\text{g}}{\text{Eq.}}$$

**Homework : Example (2):-** Calculate the equivalent weight of the following substances: (a)  $\text{Na}_2\text{CO}_3$ , (b)  $\text{Ba}(\text{OH})_2$ .

**Normality (N):** Normal concentration: Number of equivalent solute in solution volume in litre.

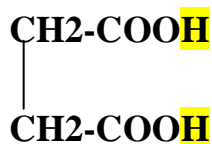
التركيز النورمالي (العيارية): وهي صيغة أخرى من صيغ التركيز: هو عدد الأوزان المكافئة للمذاب في واحد لتر من المحلول

عدد المكافئات	$\text{No. of Eq} = \frac{wt}{\text{Eq. wt}}$
الوزن المكافئ	$\text{Eq. wt} = \frac{Mwt}{n}$
وحدات حجم اللتر	$N = \frac{\text{No. of equivalent (Eq)}}{\text{Solution Volumn (L)}}$
	$\text{No. of Eq} = N \times V(L)$
	$N = \frac{wt}{\text{Eq. wt}} \times \frac{1}{V(L)}$
وحدات حجم مل	$N = \frac{\text{No. of equivalent (meq)}}{\text{Solution Volumn (ml)}}$
	$\text{No. of meq} = N \times V(\text{ml})$
	$N = \frac{wt}{\text{Eq. wt}} \times \frac{1000}{V(\text{mL})}$
	$N = \left( \frac{\text{Eq.}}{L} \right) = \left( \frac{\text{meq.}}{\text{mL}} \right)$
قانون تحويل نورمالية الى مولارية وبالعكس	$N = nM$

ملاحظات مفيدة بالحل :

1- الحوامض 3 انواع هي

- الحوامض المعدنية ( تكون  $H^+$  بالبداية ) مثل  $HCl$  و  $HClO_4$  و  $H_2SO_4$
- الحوامض العضوية ( تكون  $H^+$  بالآخر ) مثل  $CH_3COOH$
- الحوامض العضوية متعدد البروتون مثل حامض الاوكزاليك

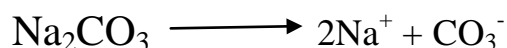
2- القواعد تنتهي دائما بـ  $OH^-$  مثل  $Bi(OH)_3$ ,  $Mg(OH)_2$ ,  $NaOH$ 3 – الأملاح: الأملاح تتكون من أيونات موجبة (كاتيونات) على اليسار وأيونات سالبة (أنيونات) على اليمين مثال  $NaCl$  ( الصوديوم على اليسار ايون موجب والكلور على اليمين ايون سالب )

4- في معادلات الأكسدة والاختزال يجب ان يتم موازنه المعادلة ثم ايجاد عدد الالكترونات المفقودة او المكتسبة

**Example(3):-** Calculate the normality of the solutions containing the following: (a) 5.300gm/L  $Na_2CO_3$  (when the  $CO_3^{2-}$  reacts with two protons), (b) 5.267 gm/L  $K_2Cr_2O_7$  (the  $Cr^{6+}$  is reduced to  $Cr^{3+}$ ).

**Solution :** (a)

$$M.wt \ Na_2CO_3 = (23 \times 2) + 12 + (16 \times 3) = 106 \frac{g}{mol}$$



$$Eq. wt = \frac{\text{formula weight (F. wt)}}{\text{No. of (cation or anion) * charge of ion}}$$

$$Eq. wt = \frac{106}{2 \times 1} = 53$$

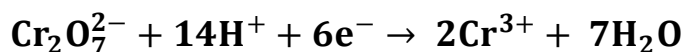
$$N = \frac{wt}{Eq. wt} \times \frac{1}{V (L)}$$

نقوم بترتيب القانون لان اعطى بالسؤال الوزن بوحدات 5.300 g/L

$$N = \frac{wt(g)}{V (L)} \times \frac{1}{Eq. wt}$$

$$N = 5.3 \frac{\text{g}}{\text{L}} \times \frac{1}{53} = 0.10 \text{ Eq/L}$$

$$(b) \text{ M.wt } K_2Cr_2O_7 = (39 \times 2) + (52 \times 2) + (16 \times 7) = 294 \frac{\text{g}}{\text{mol}}$$



$$(\text{Eq. wt}) \left( \frac{\text{g}}{\text{Eq}} \right) \text{ for redox reaction} = \frac{\text{formula weight (F. wt)}}{\text{No. of electron}}$$

$$\text{Eq. wt} = \frac{294}{6} = 49$$

$$N = \frac{\text{wt}}{\text{Eq. wt}} \times \frac{1}{V (\text{L})}$$

نقوم بترتيب القانون لان اعطى بالسؤال الوزن بوحدة 5.267 gm/L

$$N = \frac{\text{wt}}{V (\text{L})} \times \frac{1}{\text{Eq. wt}}$$

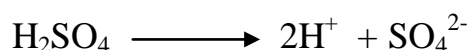
$$N = 5.267 \frac{\text{g}}{\text{L}} \times \frac{1}{49} = 0.1074 \text{ Eq/L}$$

**Example (4):-**How many millilitres of a 0.25M solution of  $H_2SO_4$  will react with 10mL of a 0.25N solution of NaOH.

**Solution:**

لدينا التراكيز مختلفة احدها نورمالي والاخر مولاري لذلك يجب ان يتم التوحيد

$$N = nM \quad (n = \text{No. of equivalent, } H^+, OH^-, \text{ or electron})$$



**n = عدد ذرات  $H^+$  هو 2**

$$N_{H_2SO_4} = 2 \times 0.25 = 0.5 \text{ N}$$



$$\begin{aligned}\text{Meq H}_2\text{SO}_4 &= \text{Meq NaOH} \\ (N \times V)_{\text{H}_2\text{SO}_4} &= (N \times V)_{\text{NaOH}}\end{aligned}$$

$$\begin{aligned}(0.5 \times V) \text{H}_2\text{SO}_4 &= (0.25 \times 10 \text{ mL}) \text{NaOH} \\ V_{\text{H}_2\text{SO}_4} &= 5.0 \text{ mL}\end{aligned}$$

**Example(5):-** A solution of sodium carbonate is prepared by dissolving 0.212 gm  $\text{Na}_2\text{CO}_3$  and diluting to 100mL. Calculate the normality of the solution (a) if it is used as a **monoacidic base**, and (b) if it is used as a **diacidic base**.

**Solution :** (a)

$$\text{M.wt Na}_2\text{CO}_3 = (23 \times 2) + 12 + (16 \times 3) = 106 \frac{\text{g}}{\text{mol}}$$

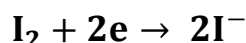
$$N = \frac{\text{wt}}{\text{Eq. wt}} \times \frac{1000}{V (\text{mL})} = \frac{0.212}{\frac{106.0}{1}} \times \frac{1000}{100} = 0.020 \text{ meq/mL}$$

(b)

$$N = \frac{0.212}{\frac{106.0}{2}} \times \frac{1000}{100} = 0.040 \text{ meq/mL}$$

**Example(6):-** Iodine ( $\text{I}_2$ ) is an oxidizing agent that in reactions with reducing agent is reduced to iodide ( $\text{I}^-$ ). How many grams  $\text{I}_2$  would you weigh out to prepare 100mL of a 0.10N  $\text{I}_2$  solution?

**Solution :** (M.Wt  $\text{I}_2 = 254 \text{ g/mol}$ )

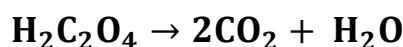


$$N = \frac{\text{wt}}{\text{Eq.wt}} \times \frac{1000}{V (\text{mL})} \longrightarrow 0.1 = \frac{\text{wt}}{\frac{254}{2}} \times \frac{1000}{100}$$

$$\text{wt} = 1.27\text{g}$$

**Example (7):-** Calculate the normality of a solution of 0.25 g/L  $\text{H}_2\text{C}_2\text{O}_4$ , both as an acid and as a reducing agent. (M.wt  $\text{H}_2\text{C}_2\text{O}_4 = 90 \text{ g/mol}$ )

**Solution:**



$$N = \frac{\text{wt}}{\text{Eq. wt}} \times \frac{1}{V \text{ (L)}}$$

نقوم بترتيب القانون لان اعطى بالسؤال الوزن بوحدات 0.25 g/L

$$N = \frac{\text{wt(g)}}{V \text{ (L)}} \times \frac{1}{\text{Eq. wt}}$$

$$N = 0.25 \frac{\text{g}}{\text{L}} \times \frac{1}{\frac{90}{2}} = 0.00555 \text{ meq./mL}$$

**Example(8):-** How many milliequivalents (meq) are involved in 43.50 mL of 0.1379N  $\text{K}_2\text{Cr}_2\text{O}_7$ ?

**Solution:**

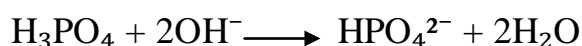
$$\text{no. of milliequivalents} = N \times V$$

$$\text{meq} = N \times V(\text{ml})$$

$$= 0.1379 \frac{\text{meq.}}{\text{mL}} \times 43.50 \text{ mL}$$

$$= 5.9987 \text{ meq}$$

**Example (9):** What is normality of 0.3 M  $\text{H}_3\text{PO}_4$  when it undergoes the following reaction?

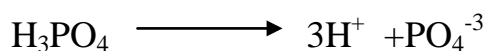


**Solution:**

$$\text{Normality} = \text{molarity} \times 2 = 0.3 \times 2 = 0.6 \text{ N}$$

**Homework:** What is normality of 0.3 M  $\text{H}_3\text{PO}_4$ ?

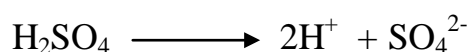
**Solution:**



$$\text{Normality} = \text{molarity} \times 2 = 0.3 \times 3 = 0.9 \text{ N}$$

**Example (10):** Calculate the number of **mg present in 1 ml** of 0.3 N  $\text{H}_2\text{SO}_4$  (Mwt = 98 g/mol) solution.

**Solution:**



$$\text{Eq wt} = \frac{98}{2} = 49 \frac{\text{g}}{\text{Eq.}}$$

$$N = \frac{\text{wt}}{\text{Eq. wt}} \times \frac{1000}{V (\text{mL})}$$

$$0.3 = \frac{\text{wt}}{49} \times \frac{1000}{1} = 0.0147 \text{ g}$$

$$\begin{aligned} & (\text{g}=1000 \text{ mg}) \\ & \text{wt} = 0.0147 \times 1000 = 14.7 \text{ mg} \end{aligned}$$

### Exercise

1. Calculate the normality of the solution obtained by dissolving 0.321 g of the salt sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) in 250 mL water. (Assuming the salt solution is being used in a complete neutralisation by a strong acid).
2. What is the normality of a- 0.138 M NaOH, b-0.052 M  $\text{H}_3\text{PO}_4$  and c- 0.34 M  $\text{Ca}_3(\text{PO}_4)_2$ ?
3. Determine the normality for each of the following solutions:
  - 0.44 mol of  $\text{CoCl}_2$  in 0.654 L of solution



- b. 0.87 g of phosphoric acid,  $\text{H}_3\text{PO}_4$ , in 1.00 L of solution (dibasic reaction)
  - c. 0.23 g of calcium hydroxide,  $\text{Ca}(\text{OH})_2$ , in 48.00 mL of solution
  - d. 9 kg of  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$  in 15.34 L of solution
4. In the following reaction, calculate and find the normality when it is 1.0 M  $\text{H}_3\text{PO}_4$ :  $\text{H}_3\text{AsO}_4 + 2\text{NaOH} \rightarrow \text{Na}_2\text{HASO}_4 + 2\text{H}_2\text{O}$
5. What is the molar concentration of aluminium in a 3.0 N solution of aluminium sulfate ( $\text{Al}_2(\text{SO}_4)_3$ )?
6. What volume of a 0.20 N of  $\text{K}_2\text{SO}_4$  solution contains 57 g of  $\text{K}_2\text{SO}_4$ ?
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