** Stoichiometry **

Calculation of the quantities of reactand and Products

قياس كميات المتفاعلات والنواتج

** The Coefficients ** المعاملات

The relative amounts in mole

Example

$$2\,C_8H_{18} + 25\,O_2 \rightarrow 16\,CO_2 + 18\,H_2O$$

2 mol C_8H_{18} + 25 mol O_2 → 16 mol CO_2 + 18 mol H_2O

⟹ what's the amount of CO_2 Produced when we burn 22 mol C_8H_{18}

هذه الخطوة نحسبها من المعادلة الأصلية

2 mol C_8H_{18} → 16 mol CO_2

22 mol C_8H_{18} → ??

$$CO_2 = \frac{22 \times 16}{2} = \boxed{176 \text{ moles } CO_2}$$

Mass To Mass Conversions التحويل من كتلة لكتلة

** Estimate The mass of CO_2 by Combustion of

3.5×10^{15} g gasolone.

$$2\,C_8H_{18} + 25\,O_2 \rightarrow 16\,CO_2 + 18\,H_2O$$

3.5×10^{15} g ⟵ $2\,C_8H_{18}$ ⟶ ?? $16\,CO_2$

① نحول الكتلة بالجرام المعطاة لمول

$$\frac{\text{الكتلة المعطاة}}{\text{الكتلة المولية}}$$

$$\frac{3.5 \times 10^{15}}{114\ g\ C_8H_{18}} = 3.070 \times 10^{13}\ mol$$

② نحسب mol C_8H_{18} ⟶ mol CO_2

$$2\ mol\ C_8H_{18} \rightarrow 16\ mol\ CO_2$$

$$10^{13} \times 3.070\ C_8H_{18} \rightarrow ?$$

$$\frac{16 \times 3.070 \times 10^{13}}{2} = 2.46 \times 10^{14}\ mol$$

③ نحول المول CO_2 ⟵ للجرام

$$\text{mol } CO_2 \times \text{الكتلة المولية بالكتلة } CO_2$$

$$2.46 \times 10^{14} \times (44) = 1.1 \times 10^{16}\ g\ CO_2$$

mass (g) ⟶ (÷ molar mass ← الكتلة المولية) ⟶ mole ⟶ mole ⟶ (× molar mass ← الكتلة المولية) ⟶ mass (g)

Example How many grams of glucose can be synthesized from 37.8 g of CO_2?

$$6CO_2 + 6H_2O \rightarrow 6O_2 + C_6H_{12}O_6$$

25.8 g

** Limiting reactant ** المادة المحددة

The reactant that completely consumed in chemical reaction and limits the amounts of product.

المادة التي تستهلك كلياً في التفاعل وتحدد كمية المادة الناتجة

** Excess Reactants ** المادة الفائضة

any reactant that occurs in quantity greater than is required

مادة توجد بكميات أكبر من المطلوبة

** Theoretical Yield ** المردود النظري

The calculated amount of product كمية المادة الناتجة حسابياً based on the amount of limiting reactant تعتمد على كمية المادة المحددة

** Actual Yield ** المردود الفعلي

The amount of product actually produced كمية المادة الناتجة فعلياً

.. less than theoretical yield أقل من المردود النظري

$$\text{The Percent Yield} = \frac{\text{Actual yield}}{\text{Theoretical yield}} \times 100$$

Example $H_2 + Cl_2 \rightarrow 2HCl$

if we started with $6\ H_2$ and $4\ Cl_2$

Find Limiting Reactant, Excess Reactant, Theoretical yield?

$1\ H_2 \rightarrow 2\ HCl$	$1\ Cl_2 \rightarrow 2\ HCl$
$6\ H_2 \rightarrow ?$	$4\ Cl_2 \rightarrow ?$
12 HCl	8 HCl

$\therefore Cl_2 \rightarrow$ limiting / $H_2 \rightarrow$ Excess / Theoretical = 8 HCl

---

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

If we have 5 CH_4 and 8 O_2 ?

what is the limiting, Excess, Theoretical ?

$N_2 + 3H_2 \rightarrow 2NH_3$

If we have 1 mol N_2 + 6 mole H_2 ?

** What is The Percent yield if 225.10 g of HI were isolated out of Possible yield of 255.824 g of HI?

الرقم الأقل

$$\text{The Percent yield} = \frac{\text{actual}}{\text{Theoretical}} \times 100$$

$$= \frac{225.10}{255.824} \times 100 = 87.989\%$$

Example $2Na + Cl_2 \rightarrow 2NaCl$

If we have : 53.2 g Na and 65.8 g Cl_2

Find : 1) Limiting reactant and Theoritical yield.

2) if The Actual yield = 86.4 g , Calculate % yield.

Na (23)

① نحول لمولات بالقسمة على الكتلة

$$\frac{53.2\ g}{23} = 2.31\ mol$$

② نحسب mol → mol

2 mol Na → 2 mol NaCl

2.31 mol → ??

= 2.31 mol × (molar mass of NaCl)

$2.31 \times (58.5) =$

135.13 NaCl

Cl_2 (2 × 35.5)

①

$$\frac{65.8\ g}{71} = 0.927$$

② 1 mol Cl_2 → 2 mol NaCl

0.927 Cl_2 → ??

= 1.85 Cl_2 × (molar mass of NaCl)

$1.85 \times (58.5) =$

108.4 NaCl

Theoritical yield.

$$\% = \frac{86.4}{108.4} \times 100 = 80\%$$

Example 2) $2NO + 5H_2 \rightarrow 2NH_3 + 2H_2O$

Starting with 86.3 g NO and 25.6 g H_2

Find Limiting / Theoretical.

Solution المحلول : homogenous mixture of Two or more substances خليط متجانس من مادتين أو أكثر

Solvent المذيب :- material Present in largest amount مادة توجد بكمية كبيرة مثل الماء

Solute المذاب : all of other materials.

****Concentration**** التركيز

The amount of solute Present in The solution كمية المذاب الموجود في المحلول

****Molarity**** M

$$\frac{\text{amount of solute (in mol)}}{\text{Volume of solution (in L)}}$$

$$M = \frac{n}{V}$$

وحدة القياس

Unit of molarity = mol / L { $mol.L^{-1}$ / molar

Example Find The molarity of a solution That has 25.5 g KBr dissolved in 1.75 L of solution?

$$M = \frac{\text{Solute (mol)}}{\text{solution (L)}}$$

① أول حاجة المذاب عندنا بالجرام 25.5 g KBr

لذلك لازم نحول الأول لـ mol

بالقسمة على الكتلة المولية

$$\frac{25.5}{(119.00)} = 0.214$$

$$M = \frac{0.214}{1.75} = 0.122\ M$$

** How many Litres of 0.125 M NaOH contain 0.255 mol NaOH?

** Stock Solutions ** Solution are stored as Concentrated.

$M_1 V_1 = M_2 V_2$

Concentration x Volume → Stock solution

Concentration x Voulume → diluted solution

(Example) $CaCl_2$ solution 3.00 L and 0.500 m

How should we Prepare This solution

10.0 m stock solution?

$M_1 V_1 = M_2 V_2$

$V_1 = \frac{M_2 V_2}{M_1}$

$V_1 = \frac{0.500 \times 3.00}{10.0} = \boxed{0.150\ L}$

How would you Prepare 200.0 mL of 0.25 m NaCl solution From a 2.0 m solution?

$\frac{200.0 \times 0.25}{2.0} = \boxed{25\ mL}$

Types of Aqueous Solutions and Solubility

Salt water

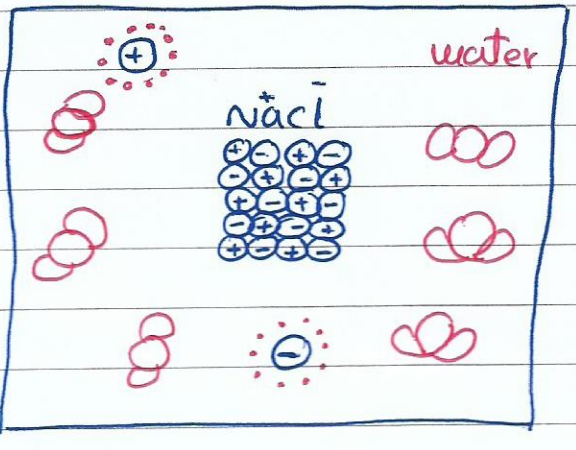
$NaCl + H_2O$

Sugar water

$C_{12}H_{22}O_{11} + H_2O$

What happens when asolute dissolve ? كيف تتم عملية الإذابة

- attractive forces between solute particles
  قوة تجاذب بين جزيئات المذاب
- attractive forces between solvent particles
  قوة تجاذب بين جزيئات المذيب
- when we mix solute + solvent → attractive forces between them.
  عندما نخلط المذاب المذيب تتولد قوة تجاذب بينهم
- If the attraction strong enough → the solute will dissolve
  لو التجاذب قوي كفاية المذاب يذوب



38 + 39

NaCl ⇒ ElectrolyTes

- dissociate into ions when dissolved in water
  الماء في إذابتها عند أيونات إلى يتفكك

- Solutions conduct electricity
  محاليلها توصل الكهرباء

Sucrose ($C_{12}O_{22}O_{11}$) non electrolyTes
يتفكك لا

- don't dissociate into ions when dissolved in water
- don't conduct electricity
  الكهرباء يوصل لا

but homogenously mixed with The water ولكنها تذوب في الماء

Electrolytes مواد Substances That الماء في تذوب dissolve in water

and form solutions conduct electricity
الكهرباء توصل محاليل تكون و

Acids الأحماض

- Substances That Produce H^+ (H. Proton)

$HCl \rightarrow H^+ + Cl^-$

$H^+ + H_2O \rightarrow H_3O^+$ Hydronium Ion

Examples :.

Strong Acids	weak Acids
H_2SO_4 / HNO_3	Acetic Acid (Vinegar CH_3COOH)
HCl / HBr / HI	HF

Base القاعدة (Alkali)

Substance That Produce OH^- (hydroxide ions)

$NaOH \rightarrow Na^+ + OH^-$

Examples

Strong bases	weak bases
NaOH / KOH / LiOH	NH_4OH
$Ba(OH)_2$, $Ca(OH)_2$	

Acid - Base Reactions (Neutralization Reactions)

تفاعلات التعادل — تفاعلات القاعدة مع الحمض

Acid + Base → Water + Salt

حمض — قاعدة — ماء — ملح

$\overset{+}{H}Cl + \overset{+}{N}aO\overset{-}{H} \rightarrow H_2O + NaCl$

Oxidation - Reduction Reactions (Redox)

تفاعلات الأكسدة والاختزال

تفاعلات — جزيئ — إلكترونات — تنتقل

are reactions in which electrons are Transferred

من — مادة — لآخر

From one reactant To The other

الأكسدة Oxidation :. فقد Loss إلكترون The electron

الاختزال Reduction :. اكتساب Gain إلكترون The electron

ملحوظة
- don't need To involve oxygen
- one Can't occur without The other

Examples on Redox Reactions

- $2Na + Cl_2 \rightarrow 2NaCl$

- $4Fe + 3O_2 \rightarrow 2Fe_2O_3$ (Rusting of iron) صدأ الحديد

- $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$

(Combustion of octane) احتراق الأوكتان

- $2H_2 + O_2 \rightarrow 2H_2O$ (Combustion of hydrogen)

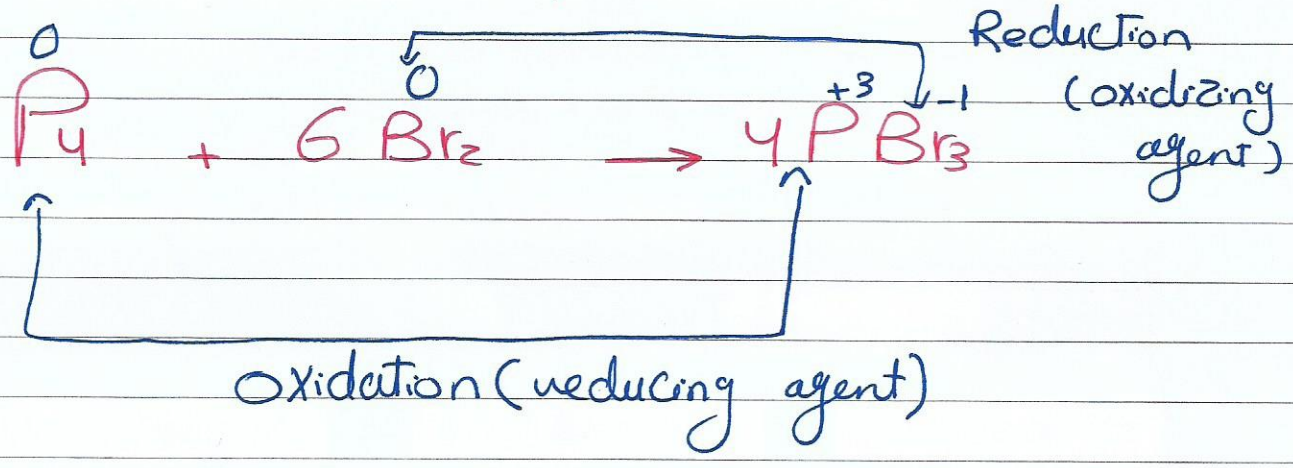
احتراق الهيدروجين

$$\overset{0}{C} + 2\overset{0}{S} \rightarrow \overset{+4\ -4}{CS_2}$$

Reduction decrease نقصان

oxidation increase زيادة

عامل مؤكسد Oxidizing agent	عامل مختزل Reducing agent
oxidizes something	reduces something
reduced itself	oxidized itself.



Practice

① $2Mg + O_2 \rightarrow 2MgO$

② $2HBr + Ca(OH)_2 \rightarrow 2H_2O + CaBr_2$

③ $Zn + Fe^{2+} \rightarrow Zn^{2+} + Fe$

Electrolyte and Nonelectrolyte Solutions

– **Strong Electrolyte:**

- Chemical substances that completely ionize into their ions.
  - ✓ Examples: Soluble ionic salts, strong acids or strong bases

$$HCl\,(aq) \rightarrow H^+ + Cl^- \quad \text{or} \quad CuCl_2 \rightarrow Cu^{2+} + 2\,Cl^-$$

  - ✓ Can conduct electrical current

– **Weak Electrolyte:**

- Chemical substances that partially ionize into their ions.
  - ✓ Examples: weak acids or weak bases

$$CH_3COOH(aq) \rightarrow CH_3COO^-(aq) + H^+(aq)$$

  - ✓ Can conduct electrical current

– **Nonelectrolytes:**

- Chemical substances that dissolve in water but do not ionize.
  - ✓ Example: polar molecular substances such as sugar or alcohol

$$C_6H_{12}O_6(s) \rightarrow C_6H_{12}O_6(aq)$$

  - ✓ They do not conduct electricity.

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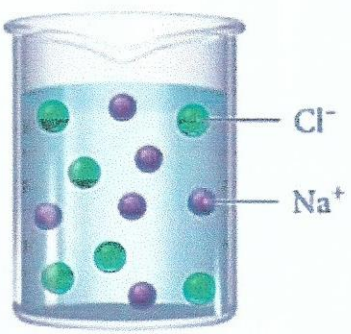
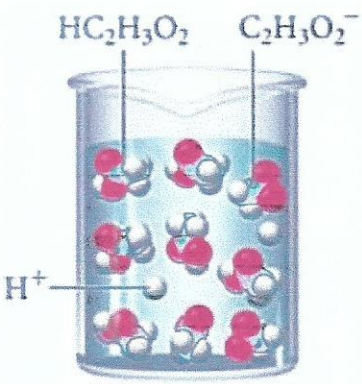
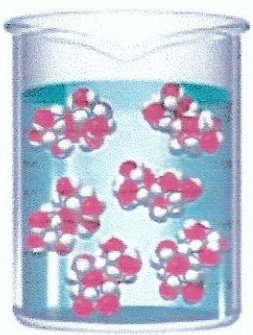
Electrolytes and Nonelectrolytes: A Summary

Strong Electrolyte	Weak Electrolyte	Nonelectrolyte
 $NaCl(aq)$	 $HC_2H_3O_2\,(aq)$	 $C_{12}H_{22}O_{11}(aq)$
Complete Ionizing in water (full dissociation) **Examples**: ionic salts, strong acids & strong bases	Partial Ionizing in water (partial dissociation) **Examples**: weak acids & weak bases	No Ionizing in water (no dissociation) **Examples**: many molecular (covalent) compounds as suga

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Assessment

Rules for Assigning Oxidation States

Do not confuse oxidation state with ionic charge. Unlike ionic charge—which is a real property of an ion—the oxidation state of an atom is merely a theoretical (but useful) construct.

Oxidation States of Nonmetals

Nonmetal	Oxidation State	Example
Fluorine	−1	MgF_2 −1 ox state
Hydrogen	+1	H_2O +1 ox state
Oxygen	−2	CO_2 −2 ox state
Group 7A	−1	CCl_4 −1 ox state
Group 6A	−2	H_2S −2 ox state
Group 5A	−3	NH_3 −3 ox state

Rules for Assigning Oxidation States	Examples

(These rules are hierarchical. If any two rules conflict, follow the rule that is higher on the list.)

1. The oxidation state of an atom in a free element is 0.

   Cu — 0 ox state; Cl_2 — 0 ox state

2. The oxidation state of a monoatomic ion is equal to its charge.

   Ca^{2+} — +2 ox state; Cl^- — −1 ox state

3. The sum of the oxidation states of all atoms in:
   - A neutral molecule or formula unit is 0.

     H_2O: 2(H ox state) + 1(O ox state) = 0
   - An ion is equal to the charge of the ion.

     NO_3^-: 1(N ox state) + 3(O ox state) = −1

4. In their compounds, metals have positive oxidation states.
   - Group 1A metals *always* have an oxidation state of +1.

     NaCl — +1 ox state
   - Group 2A metals *always* have an oxidation state of +2.

     CaF_2 — +2 ox state

5. In their compounds, nonmetals are assigned oxidation states according to the table, left. Entries at the top of the table take precedence over entries at the bottom of the table.