Taghoor Team

كيميـاء عامة (١)

تلخيص :سنابل سلمان
للدكتورة:لبنى الرواشده

(مادةالسكند)

لك شيءٌ في هذا العالم ، فقم

تطلب من مكتبة رغـد
الزرقاء : ٠٧٨٦٨١٠٩٩٤

اتحاد طلاب العلـوم الهاشمية

2) Acid - Base reaction (Neutralization reaction)

Acids	Bases
* have Sour taste (حامض)	* have Bitter taste مُر
* Cause colour change in dye litmus blue → red	* Bases feel Slippery
* react with metal to produce ($H_{2(g)}$)	* cause colour change of dye red litmus → Blue
Ex: $2HCl + Mg \rightarrow MgCl_2 + H_{2(g)}$	* Aqueous base conduct electricity
* react with compounds contain carbonat (CO_3) to produce ($CO_{2(g)}$)	
Ex: $HCl + CaCO_3 \rightarrow CaCl_2 + CO_{2(g)} + H_2O$	
* Aqueous acid conduct electricity	

---

* **Bronsted** Acid & base definition.

Bronsted Acid: is a proton donor مانح بروتون

Bronsted Base: is a proton acceptor مستقبل بروتون

⇓

Don't require to be in ~~Aqe~~ Aqueous solution

$HCl \xrightarrow{H_2O} H^+ + Cl^-$

⇓

$HCl + H_2O \rightarrow H_3O^+ + Cl^-$

Acid | base

H_3O^+ → أيون الهيدرونيوم

↳ hydronium ~~proton~~ Ion / proton (H^+)

Scanned by CamScanner

Arrhenius definition:

Acid :- Substance that produce H^+ in water → ينتج H^+

Base : " " " OH^- " " → ينتج OH^-

apply only to Aqueous Solution.

* (الماء H_2O ← يعطي بروتون → الحمض والقاعدة)

* Ex: (Bronsted)

$$\underset{\text{Base}}{NH_3} + \underset{\text{Acid}}{H_2O} \longrightarrow NH_4^+ + OH^-$$

* Acid can be:
  - → Monoprotic acid
  - → Diprotic acid
  - → Triprotic acid

1) Monoprotic → each unit of acid give $1H^+$ (upon ionization)

Ex: $HCl \xrightarrow{H_2O} H^+ + Cl^-$ → Strong electrolyte

Ex: $HNO_3 \xrightarrow{H_2O} H^+ + NO_3^-$ → "

Ex: $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$ weak electrolyte

2) Diprotic acid: each unit give $2H^+$ in two separate steps

Ex: $H_2SO_4 \xrightarrow{H_2O} H^+ + HSO_4^-$ → strong electrolyte

$HSO_4^- \rightleftharpoons H^+ + SO_4^{-2}$ → weak electrolyte

Scanned by CamScanner

③ Triprotic acid : each unit give $3H^+$ in separate steps.
خطوات منفصلة

Ex: $H_3PO_4 \xrightleftharpoons{H_2O} \cancel{H_2PO_4^-}\ H^+ + H_2PO_4^-$

$H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{-2}$

$HPO_4^{-2} \rightleftharpoons H^+ + PO_4^{-3}$

$\Rightarrow$ weak electrolyte

* Bases :

NaOH & $Ba(OH)_2$ $\rightarrow$ are strong electrolytes (Table 4.1)
حفظ

$NaOH_{(s)} \xrightarrow{H_2O} Na^+ + OH^-$

$Ba(OH)_2 \xrightarrow{H_2O} Ba^{+2} + 2OH^-$

$\Rightarrow$ Ammonia NH_3 is also base $\Rightarrow$ weak electrolyte

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

Ex: classify the following species as Bronsted Acid or base

① $HBr \rightsquigarrow H^+ + Br^-$ ((Acid))

② $NO_2^- \xrightarrow{H^+} HNO_2$ ((Base))

③ HCO_3^- $\rightleftharpoons H^+ + CO_3^{-2}$ ((Base)) Acid

$\rightleftharpoons H_2CO_3$ (Acid) Base

$\Rightarrow$ it's Amphotric
فذبذب
(أي يتفاعل كحمض أو قاعدة)

Scanned by CamScanner

2 * Acid - base neutralization reaction

(تفاعل التعادل
حمض وقاعدة)

⇒ it's a proton transfer reaction.

⇒ Neutralization reaction: reaction between acid & base in water

⇓

produce water and salt

Ex: $\underset{(aq)}{HCl}$ (strong ← يتفكك) + $\underset{(aq)}{NaOH}$ (strong → يتفكك) → $\underset{(aq)}{NaCl}$ (salt) + $\underset{(l)}{H_2O}$

* ionic equation ⇒ $H^+ + \cancel{Cl^-} + \cancel{Na^+} + OH^- \rightarrow \cancel{Na^+} + \cancel{Cl^-} + \underset{(l)}{H_2O}$ (لا تتفكك)

* Net equation ⇒ $H^+ + OH^- \rightarrow H_2O(l)$

* Spectator ions ⇒ Cl^- & Na^+

(* حمض قوي وقاعدة قوية يتفكك بالكامل .)

Ex2: $\underset{(aq)}{HCN}$ (weak ← لا يتفكك) + $\underset{(aq)}{NaOH}$ (Strong → يتفكك) → $\underset{(aq)}{NaCN}$ + $\underset{(l)}{H_2O}$

Ionic equation ⇒ $HCN + \cancel{Na^+} + OH^- \rightarrow \cancel{Na^+} + CN^- + H_2O(l)$

Net Ionic equation ⇒ $HCN + OH^- \rightarrow CN^- + H_2O_{(l)}$

* Spectator ions ⇒ Na^+

(* حمض أو قاعدة ضعيفة مع حمض أو قاعدة قوية الأقوى يتفكك والضعيف لا يتفكك)

Scanned by CamScanner

Ex: $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

$Na^{+1}X SO_4^{-2} \rightarrow Na_2SO_4$

تفاعل إتحاد وإختزال

3 Oxidation - reduction reaction ((redox reaction))

- electron transfer reaction

- contains (1) oxidation step (Half-reaction) ← نصف تفاعل تأكسد
  (2) Reduction step (Half-reaction) ← نصف تفاعل اختزال

$[A \rightarrow A^+ + e^-]$ ⇝ loss electron

$[B^+ + e^- \rightarrow B]$ ⇝ gain electron

⇓

Sum of these steps give overall reaction مجموعهم

Ex: $\overset{0}{Zn}_{(s)} + \overset{+2\ -2}{CuSO_4}_{(aq)} \rightarrow \overset{+2\ -2}{ZnSO_4}_{(aq)} + \overset{0}{Cu}_{(s)}$

$Zn^0_{(s)} \rightarrow Zn^{+2}_{(aq)} + 2e^-$ oxidation ← نصف تفاعل تأكسد

$+$

$Cu^{+2}_{(aq)} + 2e^- \rightarrow Cu^0_{(s)}$ reduction ← نصف تفاعل إختزال

$Zn^0_{(s)} + Cu^{+2}_{(aq)} \rightarrow Cu_{(s)} + Zn^{+2}_{(aq)}$

Scanned by CamScanner

* Rules of oxidation number :-

* Oxidation number : the charge the atom would has in a molecule if the electron are completing transfer.

⇒ reflect the # of electrons transfer

* Rules : 1) free element (uncombined state) has oxd # = zero

Ex : Na, F, Li, Be, O_2, H_2 ...

2) monoatomic ions, the oxd # is equal to charge of ion.

Ex : Li^{+} = +1 , I^{-} = -1 , Fe^{+3} = +3 , O^{-2} = -2

3) oxd # of Oxygen is usually -2 , but in H_2O_2 & O_2 is -1

4) oxd # of H usually is +1 , but H-metal has oxd # = -1

Ex : ($\overset{+1}{Li}\overset{-1}{H}$, $\overset{+1}{Na}\overset{-1}{H}$)

5) F is always -1

Cl, Br, I ⇒ negative oxd # when they are as halide in their compounds.

But when combine with O , they have +ve oxd #

Ex : $\overset{+4}{Cl}\overset{-2}{O_2}$ → Cl has +4 oxd # → 0 = 1(x) + 2(-2)

0 = x + -4

(x = 4)

Scanned by CamScanner

6) In neutral molecule, the sum of oxd-numbers of atoms must equal zero.

7) oxd #, do not have to be Integer (.كسور)

Ex: oxd # of O in O_2^- is $-1/2$ $\quad O_2^- \rightarrow 2(x) = -1$

{Superoxide} $\quad (x = \frac{-1}{2})$

Ex: ① $Li_2O \rightarrow 2x + -2 = 0 / 2x = 2 \rightarrow \boxed{x = +1}$

② $H(\overset{+1}{U}O_3)^{-1} \rightarrow x + 3(-2) = -1 \rightarrow \boxed{x = +5}$

③ $Cr_2O_7^{-2} \rightarrow 2x - 14 = -2 \rightarrow 2x = 12 \rightarrow \boxed{x = +6}$

* Types of Redox reaction :-

① Combination reaction ((A + B → C))

Ex: $2\overset{0}{Al}_{(s)} + 3\overset{0}{Br_2}_{(l)} \rightarrow \overset{+3}{Al}\overset{-1}{Br_3}$

② Decomposition reaction ((C → A + B))

Ex: $2\overset{+1}{Na}\overset{-1}{H}_{(s)} \rightarrow 2\overset{0}{Na}_{(s)} + \overset{0}{H_2}_{(g)}$

Scanned by CamScanner

3) Composition reaction ($A + O_2 \rightarrow C$) ⇒ O_2 يتفاعل

Ex: $\overset{0}{S} + \overset{0}{O_2} \rightarrow \overset{+4}{S}\overset{-4}{O_2}$

4) Displacement reaction

1- Hydrogen displacement ⇒ alkali metals (group 1) & some alkaline earth metals (group 2) (Ca, Sr, Ba) can displace (H from water).

Ex: $2\overset{0}{Na} + 2\overset{+1}{H_2}\overset{-2}{O} \rightarrow 2\overset{+1}{Na}\overset{-1}{OH} + \overset{0}{H_2}_{(g)}$

⇒ Many metals, Including those that do not react with water, can displace (H from acid.)

Ex: $\overset{0}{Zn} + 2\overset{+1}{H}\overset{-1}{Cl} \rightarrow \overset{+2}{Zn}\overset{-1}{Cl_2} + \overset{0}{H_2}_{(g)}$

2- metal displacement :-
Metal in a compound can be displaced by another metal in the element state.

Ex: $\overset{0}{Zn}_{(s)} + \overset{+2}{Cu}\overset{-2}{SO_4}_{(aq)} \rightarrow \overset{+2}{Zn}\overset{-2}{SO_4}_{(aq)} + \overset{0}{Cu}_{(s)}$

Scanned by CamScanner

⇒ For displacement reaction we have to go to reactivity series → (الاستدلال)

→ any metal above H will displace it from water or acid

→ any metal listed in the series will react with any metal below it.

Ex: $Zn_{(s)} + CuSO_4 \rightarrow ZnSO_4 + Cu_{(s)}$ (أنشط)

Ex: Zn (above H) $+ 2HCl \rightarrow ZnCl + H_{2(g)}$

Ex: Ni (أقل نشاطاً من Fe) $+ FeSO_4 \rightarrow$ (No. reaction) (Zn/Fe/Ni H/Cu)

3 Halogen displacement

$$\{F_2 > Cl_2 > Br_2 > I_2\}$$

Ex: $Cl_{2(g)} + 2KBr \rightarrow 2KCl + Br_2$

5 Disproportionation reaction (نفس العنصر حدث له تأكسد واختزال)

→ Same element in reaction is oxidized & reduced

Decomposition of Hydrogen peroxied H_2O_2 {will has 3 oxd-state}

Ex: $\overset{+1}{H}_2\overset{-1}{O}_{2(aq)} \rightarrow 2\overset{+1}{H}_2\overset{-2}{O}_{(g)} + \overset{0}{O_2}_{(g)}$

Scanned by CamScanner

Ex 3: Classify the following redox reaction & indicate change in oxd. state.

① $2\overset{+1}{N}_2\overset{-2}{O}_{(g)} \rightarrow \overset{0}{N}_2 + \overset{0}{O}_{2(g)}$ ⇝ Decomposition

② $6\overset{0}{Li}_{(s)} + \overset{0}{N}_{2(g)} \rightarrow 2\overset{+1}{Li}_3\overset{-3}{N}_{(s)}$ ⇝ Combination

③ $\overset{0}{Ni}_{(s)} + \overset{+2}{Pb}(\overset{-1}{NO_3})_2 \rightarrow \overset{0}{Pb}_{(s)} + \overset{+2}{Ni}(\overset{-1}{NO_3})_{2(aq)}$ ⇝ metal disp.

④ $2\overset{+4}{N}\overset{-2}{O}_{2(g)} + \overset{+1}{H}_2\overset{-2}{O}_{(L)} \rightarrow \overset{+1}{H}\overset{+3}{N}\overset{-2}{O}_2 + \overset{+1}{H}\overset{+5}{N}\overset{-2}{O}_3$ ⇝ Disproportionation

---

* Concentraction of Solution :- (تركيز المحلول)

⇝ is the amount of solute present in a given amount of solvent.

⇝ concentration of solute can be described by

$$\text{Molarity } (M) = \frac{\text{mole of solute}}{\text{Liter of solution}} = \left(\frac{n}{V_{(L)\,solution}}\right)$$

Ex 8: If we have $\underset{n}{0.730}$ mole of $C_6H_{12}O_6$ in $\underset{V}{500\ ml}$ solution find the molarity of this solution.

$$M = \frac{n}{V} \rightarrow \frac{0.73}{\left(\frac{500}{1000}\right)L} = 1.46 \text{ mol/Liter.}$$

Scanned by CamScanner

Ex: $KCl_{(s)} \xrightarrow{H_2O} K^+ + Cl^-$ → (Strong electrolyte)

1 M

concentration التركيز [K^+] = 1 M
[Cl^-] = 1 M → (النسبة 1 إلى 1)

Ex: $Ba(NO_3)_2 \xrightarrow{H_2O} Ba^{+2} + 2NO_3^-$

1 M

[Ba^{+2}] = 1 M
[NO_3^-] = 2 * 1 M = 2 M (النسبة 1 إلى 2)

Ex: how many grams (m ??) of $K_2Cr_2O_7$ are required to prepare 250 mL solution, with concentration of 2.16 M ?

$M = \frac{n}{V(L)}$ → mass = M . V . Mm
= 2.16 * 0.250 * 294.2
= 159 g

* Dilution of Solution : (تخفيف المحلول) (تخفيف)

↳ process to prepare less concentrated solution from a more more concentrated one.

In Dilution process
- → Volume change ↗ (يزيد الحجم)
- → Concentration change ↘ (يقل التركيز)
- → No change in moles of solute X (عدد المولات)

Scanned by CamScanner

∴ mole of solute before dilution = mole of solute after dilution

$$\boxed{M_i V_i = M_f V_f}$$

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

(($M_i > M_f$)) → التركيز يقل

($V_f > V_i$) → الحجم يزيد

Ex: describe How you would prepare $5 * 10^2$ mL (V_f) of M_f 1.75 M H_2SO_4 solution, starting with 8.16 M (M_i) stock concentrated solution of H_2SO_4. V_i ??

$M_i V_i = M_f V_f$

$8.16\, V_i = 1.75 * (500\ mL)$

$V_i = \frac{1.75 * 500}{8.16} = 102\ mL$

*(Gravimetric analysis):

↳ analytical technique based on measurment of mass (precipitation reaction)

Ex: $AgNO_{3(aq)} + NaCl_{(aq)} \rightarrow NaNO_{3(aq)} + AgCl_{(s)}$

Scanned by CamScanner

Ex: 0.566g ionic compound, containing Cl^- ion & unknown metal is dissolved in water & treated with $AgNO_3$ excess, if 1,08882g AgCl precipitate, what is the % Cl in original compound?

$$\%\,Cl_{\text{in original compound}} = \frac{\text{mass Cl in original compound}}{\text{total mass of original compound}} * 100\%$$

(1)

mass of Cl in original compound = mass Cl in AgCl

(لـ) اعتبار أن المادة (L.R) تفاعلت بأكملها

$$\%\,Cl_{AgCl} = \frac{M.m\ Cl}{\text{Total } M.m \text{ of } AgCl} = \frac{35.45}{143.3} * 100 = \boxed{24.7}$$

$$\%\,Cl_{AgCl} = \frac{\text{mass Cl in AgCl ??}}{\text{Total mass of AgCl } (1,08882)}$$

$$\text{mass Cl in AgCl} = \left(\frac{24.7}{100}\right) * 1.088$$

$= 0.269\ g$ = mass of Cl in original compound

(3) تعويض في القانون الأول → $\%\,Cl = \frac{0.27}{0.566} * 100 = \boxed{47.7\%}$

$$\%\,Cl_{\text{in original compound}} = \frac{0.269}{0.566} * 100 = \boxed{47.5}\%$$

(2) $$\text{mass Cl in original comp.}_{AgCl} = \frac{m_{AgCl}}{M_m AgCl} * N_{Cl\ in\ AgCl} * M_m Cl$$

قانون سابق لكتلة العنصر في مركب

$$= \frac{1,08882}{143.3} * 1 * 35.45 = \boxed{0.27} = m_{Cl} \text{ in original comp.}$$

m_{Cl}

Scanned by CamScanner

* Acid Base Titration :-

⇒ Titration process : is an process used to know the concentration of substance (unknown concentration) using another substance with know concentration

⇒ acid Base Titration is one kind from many.

⇒ one of the most important problem for NaOH, Absorbing water from air.

⇒ For any solution of NaOH, we should standerize it before using in any Analytical work

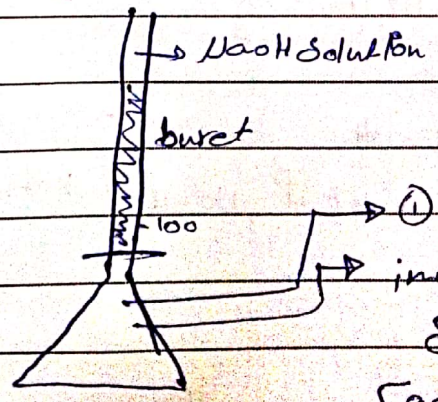
(using know concentration of acid) ← (Ex: $KHC_8H_4O_4$) pottassion hydrogen Phthalate.

⇒ $KHC_8H_4O_4 + NaOH \rightarrow KNaC_8H_4O_{4(aq)} + H_2O_{(l)}$

(salt)

acid (KHP) + base

⇒ (Method of titration)



→ ① Solution of KHP (known concentration)

→ indicator (phenolphthalein)

& color less → reddish - pink

[acidic & neutral medium] → [basic medium]

Scanned by CamScanner

* NaOH is added to KHp solution until get The
* equivalence point : point in which acid is completely react with base

↳ We know that we reach this point, by changing the color of the Indicator

↳ which has different color based on the medium (acid or base)

Ex: in titration experement, student found that 23.48 mL (V) NaOH solution are needed to neutralize 0.546 g (m) of KHp what is the concentration of NaOH solution? M_{NaOH} ??

$KHp + NaOH \rightarrow KNaC_8H_4O_4 + H_2O$

m = 0.546 g V = 23.48 mL

$M_{NaOH} = \frac{n(NaOH)}{V(L)}$

$n(NaOH) = n\,KHp = \frac{0.546}{204.2} = 2.67 \times 10^{-3}$ mol KHp

$M_{NaOH} = \frac{2.67 \times 10^{-3}}{0.0234\,L} = 0.114$ (mol/L)

{ 1 mol of KHp → 1 mol of NaOH
2.67×10^{-3} mol KHp → x mol of NaOH } ratio

Scanned by CamScanner

Ex: How many mL of 0.61 M NaOH solution are needed to neutralize 20 mL of 0.245 M H_2SO_4

(V??) (M) (V) (M)

$2\,NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

M = 0.61 20 mL

mL ?? 0.245 M

$M_{NaOH} = \frac{n_{NaOH}}{V} \rightarrow V = \frac{n}{M} \rightarrow V = \frac{9.8 \times 10^{-3}}{0.61}$

$= \boxed{0.016\ L}$

$\boxed{n_{H_2SO_4} = M \times V} = 0.245 \times 0.202\ L$

$= (4.9 \times 10^{-3}\ mol) \rightarrow (4.9 \times 10^{-3}) \times 2 = n_{NaOH}$

1 mol of $H_2SO_4 \rightarrow$ 2 mol of NaOH
4.9×10^{-3} mol of $H_2SO_4 \rightarrow$ x mol of NaOH } ratio

$n_{NaOH} = 2 \times 4.9 \times 10^{-3}$

Scanned by CamScanner

Chapter (5) Gases

→ Substance that exist as gases.

* elements that present as gases under normal atmospheric condition (1 atm, 25 °C)

* Monoatomic element : Nobel gases (He, Ar, ...)

* Diatomic element : (H_2, N_2, O_2 ...)

* ~~Monoatomic~~ Molecular compound : - Some are gases as (CO_2, NH_3, ...)
- The Majority are (Liquid & Solid) ⇝ by heating we convert them to gases.

⇝ Boiling point of ionic compounds > b.p of covalent compounds.
تساهمية

* Charachteristic of gases : (صفات الغازات)
- gases the most compressible of the state of matter.

- gases take volume & shape of their container.
- gases will mix completely when confined to same container.
- gases have much lower densities than liq & solid.

Scanned by CamScanner

* pressure of gas :- gases exert pressure on the surface.

→ ST unit of pressure

$\left[\text{pressure} = \frac{\text{force}}{\text{area}}\right] = \frac{N}{m^2} = \frac{1\ Kg \cdot m/s^2}{m^2}$

The ST unit is pascal (pa) $\left(1\ pa = 1\ N/m^2\right)$

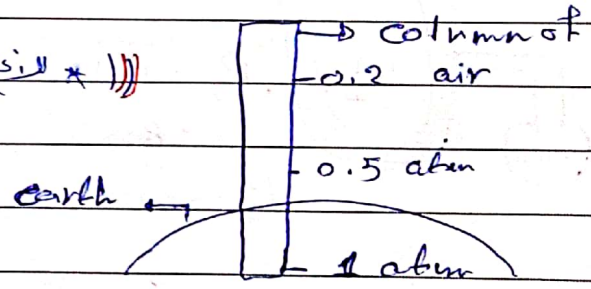
* atmospheric pressure :-

= The pressure exerted by earth atmosphere, results from equal to the weight of column of air above it.

وزن عمود الهواء

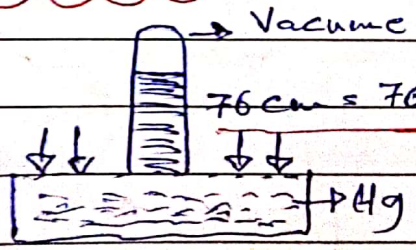
→ atm - pressure depend on the location.

((* لأنه يقل الضغط الجوي))



جهاز لقياس الضغط الجوي

* Barometer = Instrument for measuring atm - pressure



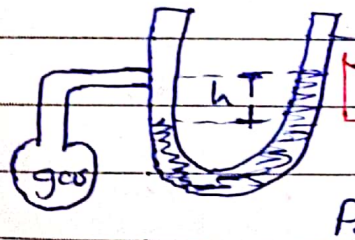
Scanned by CamScanner

→ The standered atm-pressure (1 atm) equal to pressure that support a column of Hg exactly 760 mm Hg at sea level.

∴ 1 atm = 760 mm Hg
1 atm = $1.01 * 10^5$ pa.
1 atm = 101.325 Kpa (1 kpa = 1000 pa)
1 mm Hg = 1 torr
⋮ ⇝ (حفظ)

* Manometer : device to measure the P of gases other than atm-pressure → (جهاز لقياس ضغط أي غاز)

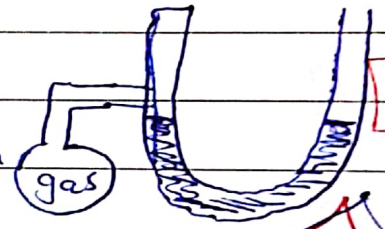
closed tube ① ↙ ↘ ② open tube



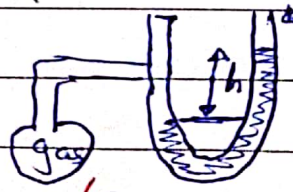
$P_g = P_h$

Ex : 800 mm Hg = h

P_g = 800 mm Hg



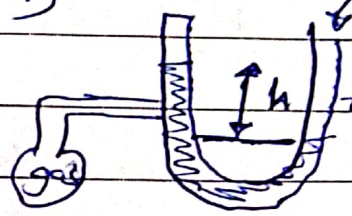
$P_g = P_h + P_{atm}$



atm P = 760 mm Hg

Ex : 60 mm Hg = h

($P_g > P_{atm}$) ← ضغط الغاز أكبر من الضغط الجوي



atm P = 760 mm Hg

Ex = 50 mm Hg = h

$P_g = P_{atm} + P_h$
$= 760 + 60$
820

($P_g < P_{atm}$)

(أكبر جمع) ← $P_g = P_{atm} + P_h$
$= 760 + 60$
$= 820$

(أصغر طرح) ← $P_g = P_h + P_{atm}$
$P_g = 760 - 50 = 710$

Scanned by CamScanner

* **Gas laws**: using P, T, V, n → n* of moles

① **Boyl's law** ⇒ (study the relation between V of gas & P of gas) → at constant T & n

→ $P \propto \frac{1}{V}$ → $\boxed{P_1V_1 = P_2V_2}$ * Boyl's Law

② **charles's & Gay - ~~Lussac~~ Lussea's law** (relation between V & T → at constant P & n
or T & P → at constant V & n

→ $V \propto T$ ⇒ $\boxed{\frac{V_1}{T_1} = \frac{V_2}{T_2}}$ *

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$

③ **Avogadro's Law** (relation between V & n at constant P & T).

→ $V \propto n$

$\boxed{\frac{V_1}{n_1} = \frac{V_2}{n_2}}$ *

④ Ideal gas law (combine all laws)

$V \propto \frac{nT}{P}$ ⇒ $V = \frac{RnT}{P}$ ⇒ $\boxed{PV = nRT}$ → Ideal gas law

P → Pressure in atm

V → Volume in L

R → gas constant $= 0.082 \frac{L.atm}{K.mol}$

T → Temp. in K

Scanned by CamScanner

* They found that R can be calculated under Standard Temp. & pressure (0°C, 1 atm)
↳ (STP) ↓ 273.15 K
(الظروف المعيارية)

→ at STP, for 1 mol of any gas → molar volume
{Volume of any gas at STP = n × 22.4 L} = 22.4 L

$\therefore R = \frac{PV}{nT} = \frac{1 \times 22.4}{1 \times 273.15} = 0.082 \left(\frac{L.atm}{K.mol}\right)$

1 n → 22.4 V (L)
1 atm → 273.15 T (K)

STP → n = 1 / P = 1
T = 273.15 / V = 22.4

Ex: For SF_6 gas, calculate the P in atm exerted by 1.82 moles of gas in vessel with V = 5.43 L at 69.5 °C?

$PV = nRT$

$P = \frac{nRT}{V} = \frac{(1.82)(0.0821)(69.5 + 273)}{5.43\ L}$

(P = 9.42 atm)

Ex: Calculate the volume in (L) occupied by 7.4 g of NH_3 at STP?

→ V_m at STP = n × 22.4 L = 22.4 L

→ V_m at STP = $\underset{(\frac{m}{Mm})}{n} \times 22.4\ L = \left(\frac{7.4\ g}{17}\right) \times 22.4 = 9.74\ L$

or → $PV = nRT$

Scanned by CamScanner

→ If we have ~~in~~ change in the conditions we will use the modified Ideal gas equations

before $\qquad$ after

$$R = \frac{P_1 V_1}{T_1 n_1} \quad , \quad R = \frac{P_2 V_2}{T_2 n_2}$$

$$\therefore \boxed{\frac{P_1 V_1}{T_1 n_1} = \frac{P_2 V_2}{T_2 n_2}} \rightarrow \text{if } n_1 = n_2 \quad \therefore \boxed{\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}}$$

Ex: He-ballon with $\overset{V_1}{V = 0.55\ L}$ at Sea level ($\overset{P_1}{P = 1\ atm}$), is allowed to rise to height 6.5 km ($\overset{P_2}{P = 0.4\ atm}$), assuming T remain constant, what is the Final Volume V_2 of ballon? (T, n) constant

$$\frac{P_1 V_1}{\cancel{n_1 T_1}} = \frac{P_2 V_2}{\cancel{n_2 T_2}} \rightarrow P_1 V_1 = P_2 V_2$$

$$\therefore V_2 = \frac{P_1 V_1}{P_2} = \frac{1 \times 0.55}{0.4} = 1.4\ L$$

Ex: Light-bulb containing Ar at 1.2 atm and 18 c° is heated to 85 c° at constant Volume, Calculate Final P?

$$\frac{P_1 \cancel{V_1}}{T_1 \cancel{n_1}} = \frac{P_2 \cancel{V_2}}{T_2 \cancel{n_2}}$$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \rightarrow P_2 = \frac{P_1 T_2}{T_1} = \frac{1.2 \times (85 + 273)}{(18 + 273)} = 1.4\ atm$$

Scanned by CamScanner

* Density calculation

$d = \frac{mass\ (g)}{volume\ (mL)}$

by using Ideal gas ~~law~~ equation $PV = nRT$ $\left(\frac{m}{Mm}\right)$

$$d_{(gas)} = \frac{P.Mm}{RT} = \frac{atm \cdot \frac{g}{mol}}{\frac{L.atm}{K.mol} * K} \rightsquigarrow d(g) = g/L$$

Ex: calculate the d of gas (CO_2) in g/L at 0.99 atm 855 °C?

$$d = \frac{0.99 * 44}{0.0821 * (855 + 273)} = 1.62\ g/L$$

⇒ From $d_{(g)} = \frac{P.Mm}{RT}$ ⇝ we can find Mm of gas of unknown Molecular Formula ∴ $\boxed{Mm = \frac{dRT}{P}}$ *

Ex: a greenish-yellow gaseous compound with d = 7.71 g/L at 36 °C & 2.88 atm, calculate the Mm of gas?

$$Mm = \frac{dRT}{P} = \frac{7.71 * 0.0821 * (36 + 273)}{2.88}$$

$= 67.9\ g/mol$

Scanned by CamScanner

* what is the M.F of this gas

35.4 ~ Cl O ~ 16 = Mm

بالتجريب { 1 1 = 51.45 *
1 2 = 67.9 ✓

* Gas stoichiometry

Ex: $2NaN_3 \rightarrow 2Na_{(s)} + 3N_{2(g)}$

calculate the volume of ~~He~~ N_2 generated at 80°C & 823 mm Hg. by decomposition of 60 g NaN_3 ?

$N_{2(g)} \rightarrow V??$, T = 80C / P = 823 ~~atm~~

$PV = nRT$

$V = \frac{nRT}{P}$

$= \frac{(1.38)(0.082)(80+273)}{\left(\frac{823}{760}\right)}$

$= \boxed{36.9\ L}$ *

$n_{NaN_3} = \frac{m}{Mm} = \frac{60}{65} = \boxed{0.91\ mol}$

2 mol $NaN_3 \rightarrow$ 3 mol N_2

0.91 $\rightarrow$??

$\frac{0.91 \times 3}{2} = 1.38$ mol N_2 (n_{N_2})

Ex: $2LiOH_{(aq)} + CO_{2(g)} \rightarrow Li_2CO_{3(s)} + H_2O_{(L)}$

P = 7.9×10^{-3} atm After introducing LiOH $\rightarrow P_{CO_2} = 1.2 \times 10^{-4}$ atm

V = 2.4×10^{5} L

at T = 312 K

How many g of Li_2CO_3 form ? $PV = nRT$

$\left(n = \frac{PV}{RT}\right)$

(g) $Li_2CO_3 \rightarrow n\ Li_2CO_3 \rightarrow n_{CO_2}$ (reacted)

Scanned by CamScanner

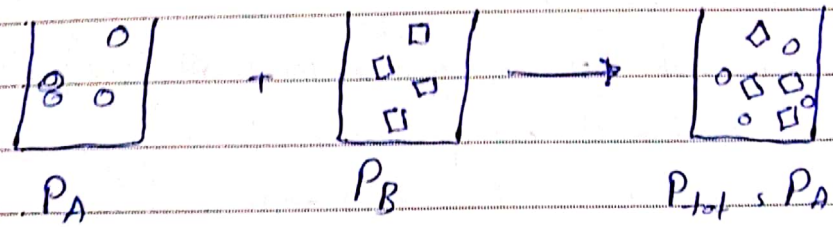
$$n_{CO_2}\ \text{reacted}\left(\frac{P_i V_i}{R_i T_i}\right) = n_{CO_2\,initial}\left(\frac{P_i V_i}{T_i R_i}\right) - n_{CO_2\,final}\left(\frac{P_f V_f}{T_f R_f}\right)$$

$$\Delta n = \Delta P\left(\frac{V}{RT}\right) = \left[(7.9\times10^{-3}) - (1.2\times10^{-4})\right]\left(\frac{2.4\times10^{3}}{6.082\times812}\right)$$

$\Delta n = 73\ mol \rightarrow$ mole of CO_2 reacted

$n_{Li_2CO_3} = 73\ mol \times 73.09 = (5.4\times10^{3}\ g)$

* Dalton Law of ~~partial pressure~~ Partial pressure.



$P_T = P_A + P_B \rightarrow$ Dalton law

$$= \frac{n_A RT}{V} + \frac{n_B RT}{V} = \frac{RT}{V}(n_A + n_B)$$

$$\boxed{P_{tot} = \frac{RT n_{tot}}{V}}$$

∴ Binary mixture of gases (A+B)

$P_T = P_A + P_B$

$$\frac{P_A}{P_{tot}} = \frac{n_A \cancel{RT/V}}{n_{tot}\cancel{RT/V}} = \frac{P_A}{P_{tot}} = \frac{n_A}{n_{tot}} = \cancel{XA}\ X_A$$

→ mole fraction of A

$$\boxed{X_i = \frac{n_i}{n_{tot}}}$$ → For Binary mixture $X_A + X_B = 1$

Scanned by CamScanner

$\frac{P_i}{P_{tot}} = X_i \longrightarrow \boxed{P_i = P_T X_i} \rightarrow \frac{n_i}{n_{tot}}$

Ex: mixture of gases contain 4.46 mol Ne / 0.74 mol Ar / 2.15 mol X, calculate the partial pressure of each gas in mixture.
الجزئي
if $P_{tot} = 2 atm$

① $P_{Ne} = P_{tot} \cdot X_{Ne} \rightarrow \frac{n_i}{n_{tot}} = \frac{n_{Ne}}{n_{Tot}} = \frac{4.46}{4.46 + 0.74 + 2.15} = 0.607$

$= (2)(0.607) = \underline{1.21 \text{ atm}}$

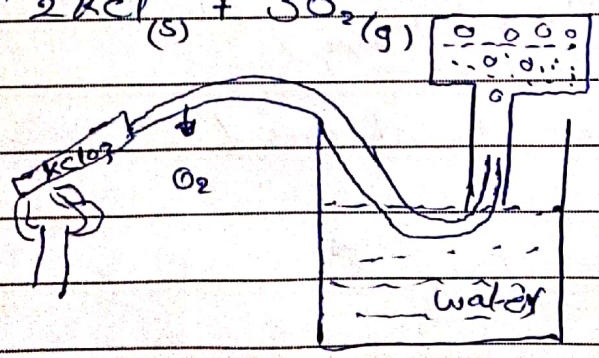
② $P_{Ar} = P_{tot} \cdot X_{Ar} = (2) \cdot \left(\frac{n_{Ar}}{n_{tot}}\right) = \underline{0.2 \text{ atm}}$

③ $P_{Xe} = P_{tot} \cdot X_{Xe} = 2 \cdot \left(\frac{n_{Xe}}{n_{tot}}\right) = \underline{0.586 \text{ atm}}$

2atm = ③ + ② + ① مجموع

⇝ Dalton Law is important to calculate volume of gas above water

Ex: $2KClO_3 \xrightarrow{heated} 2KCl_{(s)} + 3O_{2(g)}$



Scanned by CamScanner

* Oxygen gas generated by decomposition of $KClO_3$ if the volume of O_2 collected = 128 mL at 24 c° & atom-pressure = 762 mm Hg,

calculate the mass of O_2 gas? (vapor pressure of water at 24°C = 22 mm Hg)

$PV = nRT \rightarrow PV = \frac{m}{M_m} RT$

$P_{tot} = 762$

$P_{H_2O} = 22$

$P_{O_2} = P_{tot} - P_{H_2O} =$

$762 - 22 = 740$ mm Hg

$m = \frac{P.V.M_m}{RT} = \frac{(740/760)(0.128)(32)}{(0.082)(273+24)}$

$= \boxed{0.164 g}$

* Kinetic molecular ~~thorsy~~ theory

$\bar{KE} = \frac{1}{2} m \bar{u}^2 \rightarrow$ mean Sequare Speed $= CT$

$m \rightarrow$ mass of molecule

$\bar{KE} \rightarrow$ average kinetic energy.

$\therefore \bar{KE} \propto T$

We can calculate root mean Sequare Speed

$\sqrt{\bar{u}} = u_{rms} = \sqrt{\frac{3RT}{M_m}} \rightarrow$ unit = m/s

- $u_{rms} \nearrow$ as M_m of gas $\downarrow$

- $u_{rms} \nearrow$ as Temp. $\nearrow$

Scanned by CamScanner

Ex: Calculate the root-mean square speed ($\sqrt{\bar{u}}$) of He atom in (m/s) at 25°C

* To get unit of m/s ~~of~~ for $\sqrt{\bar{u}}$

① $R = 8.314 \frac{J}{K \cdot mol}$ $\left(1J = 1 \frac{kg \cdot m^2}{s^2} \right)$

② M_m should be in kg/mol

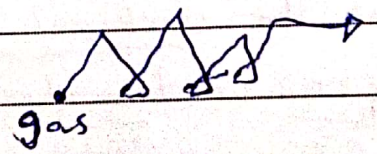
∴ M_m He = $4.003 \frac{g}{mol}$ = $4.003 * 10^{-3}$ kg/mol

∴ $u_{rms} = \sqrt{\frac{(8.314)(298)}{4.003 * 10^{-3}}} = \frac{J \cdot K^{-1} \cdot mol^{-1} \cdot K}{kg \cdot mol^{-1}} = J/kg$

$= \sqrt{1.86 * 10^6} = \sqrt{\frac{kg \cdot m^2 \cdot s^{-2}}{kg}}$ = ~~1.3 m²~~ $1.36 * 10^3$ m/s

* Gas diffusion : الانتشار

is the gradual mixing of molecules of one gas with molecules of another based on their kinetic properties



* Graham's Law of diffusion

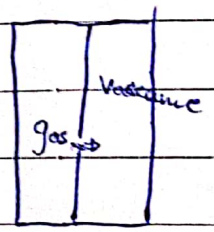
diffusion rate of gas ← $\frac{r_1}{r_2} = \sqrt{\frac{M_{m2}}{M_{m1}}}$ → M_m of gas 2, → M_m of gas 1

① diffusion rate of gas ②

Scanned by CamScanner

* Gas effusion: التدفق

→ process in which one gas under P escape from one compartment of ~~cat~~ container to another by passing through small opening



→ rate of effusion same as diffusion law

$$\frac{r_1}{r_2} = \sqrt{\frac{M_{m_2}}{M_{m_1}}}$$

Ch 7: Quantum theory & electronic structure of atom

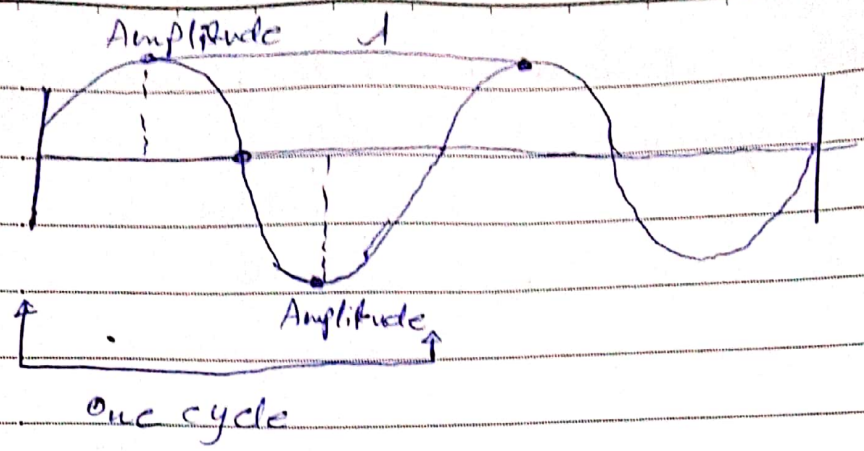
* properities of wave:

1- wave length (λ): is the distance between identical points.

2- wave height (Amplitude): is the vertical distance from midline of wave to the peak or trough
قمة التاج

3- Frequency (ν): # of waves that pass through a certain point in one second.

Scanned by CamScanner



* Speed of wave $= \boxed{u = \lambda \nu}$

λ can be in (m, nm, cm ...)
ν in Hertz (Hz) or 1 cycle / 1 second.

$$Hz = \frac{cycle}{second} = 1/s = s^{-1}$$

* Electro magnetic radiation : الإشعاع الكهرومغناطيسي

→ Maxwell proposed that visible light consist of electro magnetic radiation

electric field magnetic field

→ Elctromagnetic radiation : is the emission & transmission of energy in form of electromagnetic waves.
انبعاث
انتقال

* all electromagnetic radiation travell ≈ 3×10^8 m/s
speed of electromagnetic radiation
or speed of light (c)

Scanned by CamScanner

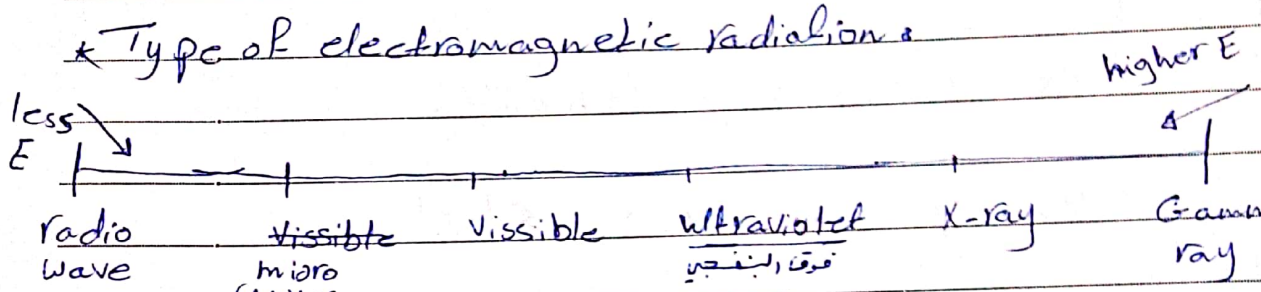
Ex: The wavelength of a green light is 522 nm (λ)
What is the frequency of this light?

ν = ?? λ = 522 nm $c = 3 \times 10^8$

$c = \lambda \cdot \nu$

$\nu = \frac{c}{\lambda} = \frac{3 \times 10^8 \ m/s}{522 \times 10^{-9} \ m} \rightarrow \nu = 5.74 \times 10^{14} \ \frac{1}{s} \rightarrow (Hz)$

* Type of electromagnetic radiation:

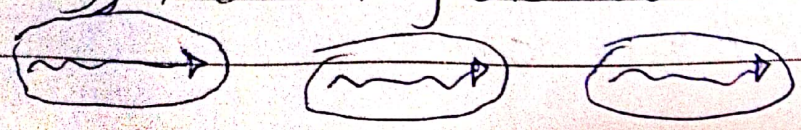


in this way → λ go down
ν go up
E go up

{ * all travell in 3×10^8 m/s
* but different in ν, λ & E }

* plank's Quantum theory
↳ He said that atom or molecule could emit or absorb energy only in discrete quantity called Quantum.
منفصلة

∴ the energy of electromagnetic radiation is Quantalized
كمية



Scanned by CamScanner

→ Energy of this Quantum ∝ ν of radiation.

$E \propto \nu \Rightarrow E = h\nu \rightarrow E = h\frac{c}{\lambda}$

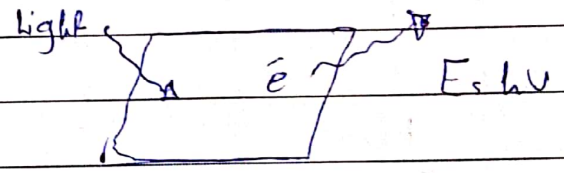
planck constant $= 6.63 * 10^{-34}$

⇝ Plank Says that light is behave as a wave

$E = h\frac{c}{\lambda}$

⇝ Einestein say that light can also behave as a particle (Photon).

To explain photoelectric effect



so he ~~E = hν~~ found ~~that~~

$E_{Photon} = h\nu = h\frac{c}{\lambda}$

↳ (plank's constant) $6.63 * 10^{-34}$

⇒ if $\nu < \nu_0$ → No electron is ejected

→ if $\nu > \nu_0$ → electron will be ejected from metal surface.

(ν_0 ≡ Threshold frequency ≡ minimum frequency needed to ~~el~~ eject ē)

Scanned by CamScanner

last result ⇒ light has particle-wave duality

Ex: Calculate E in J of photon with
$\lambda = 5 * 10^{4}$ nm.

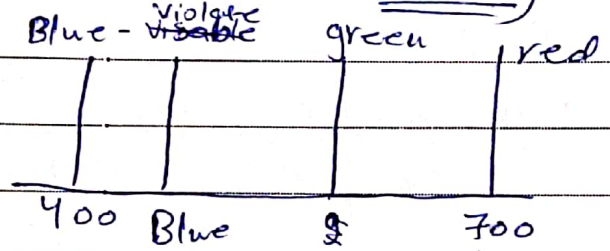
$E = h\nu = h\frac{c}{\lambda} \Rightarrow \frac{(6.63 * 10^{-34}\ J.s)(3 * 10^{8}\ m/s)}{(5 * 10^{4})(1 * 10^{-9}\ 1/m)}$

$= 3.9 * 10^{-21}\ J$

* Bohr's theory of H-atom

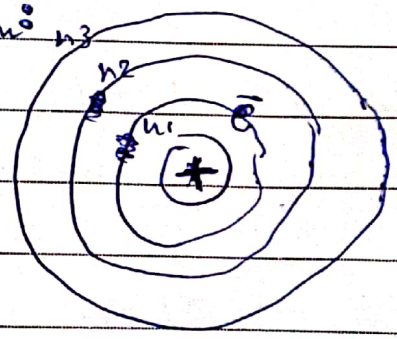
⇒ They found that sunlight is composed of various colour component (continous spectra) ⇝ (مش كويس)

⇒ while after heating H atom (gas-phase)



The atom produce bright lines in different part of of vis-spectrum.

⇒ Bohr explain this emission spectrum:



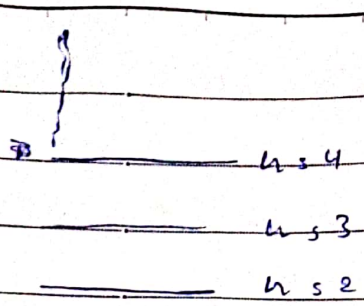
⇒ The lines produce as a result of dropping electron from high E-level To low E-level

$E_n = -Rh\left(\frac{1}{n^2}\right)$

energy of level

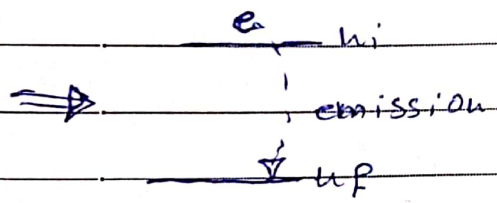
↳ Rydberg constant = $2.18 * 10^{-18}$ J

Scanned by CamScanner



n = 1 (ground-state) (n = 1) مستوى الاستقرار

if n > 1 ⇒ we call it excited state مستوى الإثارة
(higher in E than ground state)



$$\Delta E = E_f - E_i \Rightarrow \Delta E = Rh\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right)$$

$$\Delta E = h\nu = Rh\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right)$$

if $n_i > n_f \rightarrow \Delta E = \ominus \nu c$ (فقد طاقة) ⇒ emission (انبعاث) (energy released)

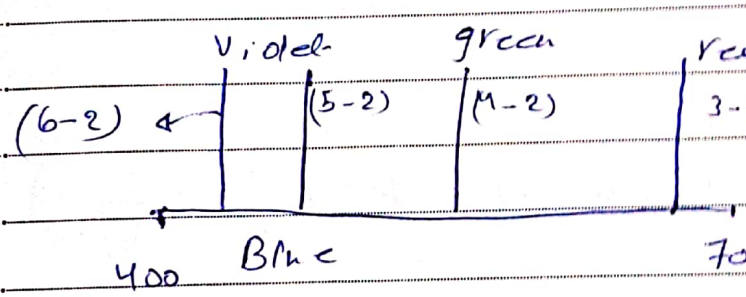
if $n_f > n_i \rightarrow \Delta E = \oplus \nu c$ (اكتساب طاقة) ⇒ energy absorbed (امتصاص)

⇒ The emission spectrum of H-atom include wide range of wavelength from IR — Vis — UV

Scanned by CamScanner

Table 7.1 List of H-atom series

Series	n_f	n_i	region
Lyman	1	2, 3, 4 ...	UV
Balmar	2	3, 4, 5 ...	Viss
Paschen	3	4, 5, 6 ...	IR
Brackett	4	5, 6, 7 ...	IR



$\Delta E = h\nu$

$= \frac{hc}{\lambda}$

Ex: what is the wavelength of a photon (nm) emitted during transition $n_i = 5$ to $n_f = 2$ in H-atom

$\lambda(nm) \rightarrow \Delta E = h\nu = \frac{hc}{\lambda}$

$\Delta E = R_h\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right) = (2.18 * 10^{-18})\left(\frac{1}{5^2} - \frac{1}{2^2}\right)$

$\Delta E = -4.58 * 10^{-4}\ J \longrightarrow \lambda = \frac{c.h}{\Delta E}$

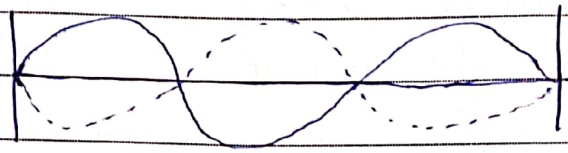
$= \frac{(3 * 10^8)(6.63 * 10^{-34})}{4.58 * 10^{-19}} = 434\ nm$

Scanned by CamScanner

* The Dual Nature of electron by De Broglie

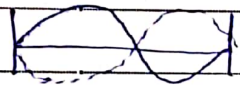
* Said that → electron can also behave as a particle & wave.

* electron behave like standing ~~wave~~ wave.

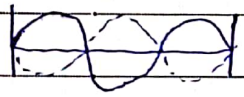


→ standing wave.

n=1



n=2 → So energy of $\bar{e}$ is Quantized



n=3 → as $\bar{e}$ behave as wave & partical

wave length $\lambda = \frac{h}{mu}$ → planck constant

mass ← mu → velocity

* Quantum mechanics by schrodinger → (ψ)

→ he found equation to tell the probability of finding $\bar{e}$ in a certain space (in term of ψ) → wave function of $\bar{e}$

⇒ ψ is a function of 4 Quantum numbers. (n, l, m_l, m_s)

→ every electron in atom has 4 different Quantum numbers.

Scanned by CamScanner