

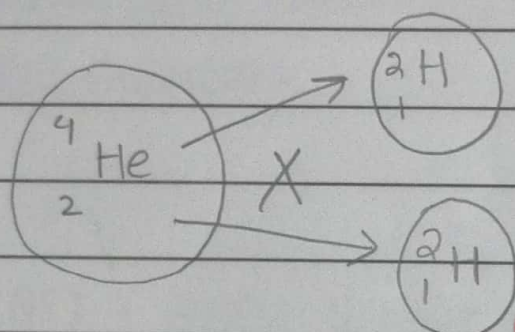
# ATOMIC STRUCTURE

Date: 1st Sept '2020

## \* Atom:

- Unit particle
- Can be divided into sub-atomic particles.
- No charge.

① Unit: Further simplification is not possible.



\* Simplification of element A into atom of element B is not possible.

- Consider Helium (He)

2 proton }  
2 electron }  
2 neutrons }

He

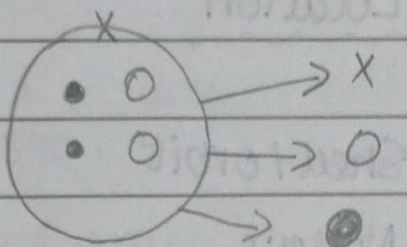
⇒ Simplify

1P }  
1e } H (Deuterium)  
1n }

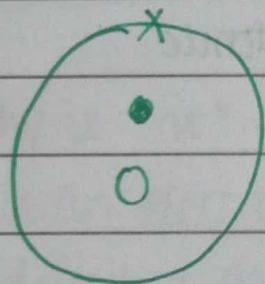
1P }  
1e } H (Deuterium)  
1n }

∴ not possible.

## ② Divisible :



↳ Atom can be divided into its 'sub-atomic particles' or 'Fundamental particles'.



— Divisible → X (electron)

→ ● (Proton)

→ ○ (neutron)

## ③ No Charge :

↳ Neutral: Atom has no charge, containing equal number of electrons (-ve) and protons (+ve)

$$+5 - 5 = 0$$

$$+7 - 7 = 0$$

⇒ Smallest part of any ~~atom~~ substance is Atom.

Date: 2nd Sept '2020

<u>Sub-atomic Particle</u>	<u>Charge</u>	<u>Mass</u>	<u>Location</u>
① Electron ( $e^-$ )	$1/-ve$	$1/1840 \text{ amu}$	Shell / orbit
② Proton ( $p^+$ )	$1/+ve$	$1 \text{ amu}$	Nucleus
③ Neutron ( $n^0$ )	$0/\text{neutral}$	$1 \text{ amu}$	Nucleus

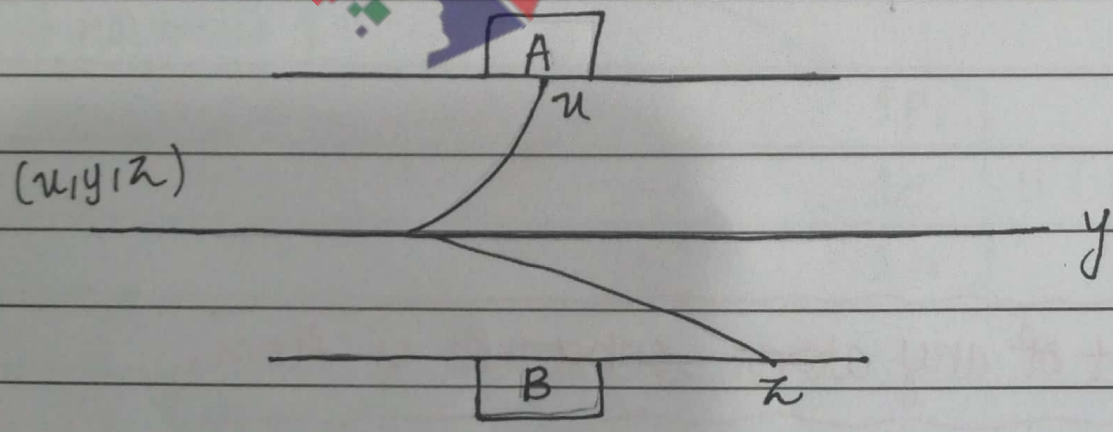
$\text{amu} \Rightarrow$  Atomic mass unit

(For the measurement of mass of sub-atomic particles)

$\Rightarrow$  "amu" is also known as "mu"

\* Movement of charged particles in external charged magnetic fields:

Q. Consider three particles  $x, y$  and  $z$  in an external magnetic field



① What is  $x, y, z$

② What is A and B?

③ What charge is on A and B?

Answer:

$$\bullet \alpha = e^-$$

$$\bullet 1e^- = \frac{1}{1840} \text{ amu}$$

$$1840e^- = 1 \text{ amu}$$

$$\bullet A = +ve$$

$$\bullet B = -ve$$

\* More lighter, the more quickly it will be attracted and deflected

○ Why is " $\alpha$ " collected earlier?

↳  $\alpha$  is an electron and due to its lighter mass,  $\alpha$  is attracted and deflected earlier.

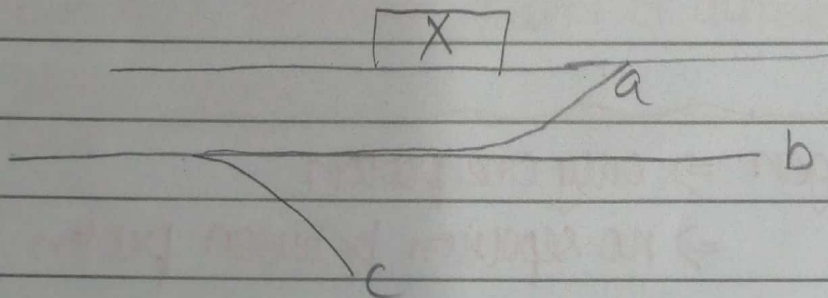
○ Why is " $\beta$ " collected later?

↳  $\beta$  is a proton that is attracted and deflected later due to its heavier mass.

○ Why is " $\gamma$ " not collected?

↳  $\gamma$  is a neutral particle and it is a neutron that is neither attracted nor deflected.

②



$$X = -ve$$

$$c = e^-$$

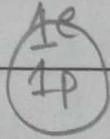
$$a = p^+$$

$$b = n^0$$

Q. Describe the essential sub-atomic particles.

⇒ Atom can exist without "Neutron" but existence without "proton" and "electron" is not possible.

e.g: Hydrogen can exist without neutron



Q. Why neutron is essential for the stability of any atom (except hydrogen)?

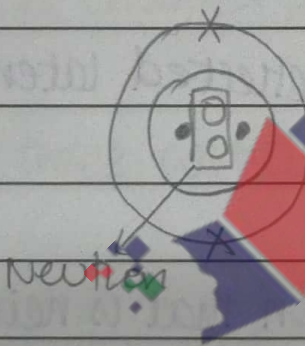
⇒ Neutron minimises the repulsion between protons and stabilises the nucleus.

e.g: Consider Helium

•  $\Rightarrow p^+$

•  $= n^0$

•  $= e^-$



• Nucleus without neutron

• Repulsion between particles.

• Destruction of nucleus.

[N] [wood] [N]

[N] ← → [N]

[N]

[N]

⊗ Remember in Hydrogen ⇒ only one proton

⇒ no repulsion between proton

⇒ nucleus becomes stable.

Q. Describe

⊙ Atomic Number

⊙ Atomic Mass

⊙ Relative Mass.

⊙ Atomic Number:

↳ It is also known as proton number

↳ Identification number of any atom. (unique number).

⇒ Chemical properties of any atom depends on its atomic number.

• In atoms  $\boxed{\text{Proton number} = \text{Electron number}}$

⊙ Atomic Mass :  $\rightarrow$  complete number (cannot be written in fraction).

↳ It is also known as "Mass number" or "Nucleon Number"

Sum of particles inside nucleus.

⇒ Atomic mass = Sum of protons and neutrons.

\* Remember two or more atoms of different elements can have same atomic mass.

## ⊙ Relative Mass:

↳ It is the compared mass of any substance with  $1/12$  Carbon isotope.

Q. Why not Hydrogen?

↳ Hydrogen is highly reactive and exist as  $H_2$  (molecule)

↳ Low abundance.

(availability)

Q. Why use carbon?

↳ Carbon is stable till further reaction.

↳ High abundance.

Q. Why using  $1/12$  carbon?

↳ Remember mass of 1 carbon is 12g.

1 carbon — 12g

$1/12$  carbon — 1g → unit mass.

⇒ Because we require unit mass.

↳ Types of Relative Mass:

① Atomic (R.A.M): → Can come in fraction.

↳ Mass of any atom compared with  $1/12$  Carbon isotope.

Na = 23g, S = 32g, Ca = 40g

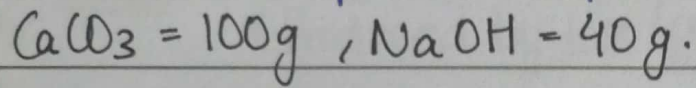
② Molecular (R.M.M): → Molecule = collection of atoms containing covalent bond.

↳ Mass of molecule compared with  $1/12$  Carbon isotope

$O_2 = 32g$ ,  $H_2O = 18g$ ,  $O_3 = 16 \times 3$

### ③ Formula (R.F.M) :

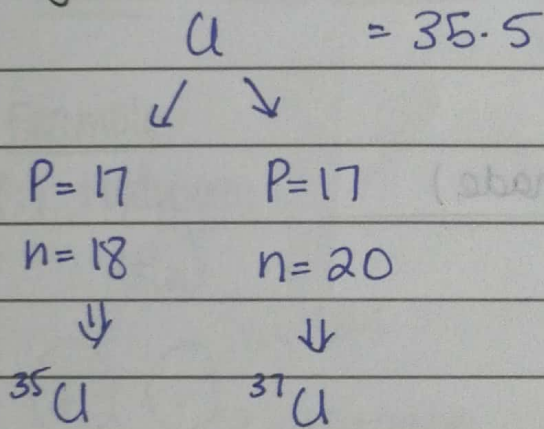
↳ Mass of compound compared with  $1/12$  Carbon isotope.



### ④ Relative isotopic Mass :

↳ Mass of isotopes compared with the mass of  $1/12$  carbon.

e.g.:



### \* Isotope :

↳ Atoms of same elements with same atomic number and different atomic mass. Same number of protons and different number of neutrons. → (2+3 marks definition)

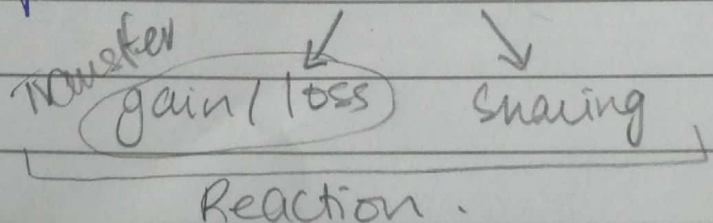
\* Physical properties ⇒ Different

• Reason ⇒ Different mass.

\* Chemical properties ⇒ Same

• Reason ⇒ Same number of protons and electrons.

Chemical property depends on





• Example: Isotopes of Hydrogen.

# mass			
$\rightarrow$	${}^1_1\text{H}$	${}^2_1\text{H}$	${}^3_1\text{H}$
	Protium	Deuterium	Tritium
	$P=1$	$P=1$	$P=1$
	$e=1$	$e=1$	$e=1$
	$n=0$	$n=1$	$n=2$

$\downarrow$	$\downarrow$	$\downarrow$
<ul style="list-style-type: none"> <li>98% of Hydrogen (lighter)</li> </ul>	<ul style="list-style-type: none"> <li>1.2% of Hydrogen (Heavier)</li> </ul>	<ul style="list-style-type: none"> <li>Synthetic (man made)</li> <li>Radioactive</li> <li>(Heaviest)</li> </ul>

\* In natural elements radiation started from 83 atomic number.

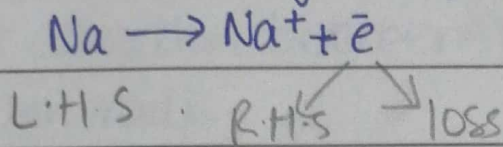
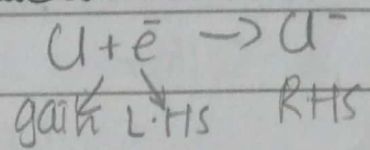
↳ Relative mass is measured by using  
⇒ Mass spectrometer

Date: 7<sup>th</sup> Sept '2020.

Q. Give difference between Atom, ions and Radicals.

↳ Ions ⇒ Charged particles

\* Produced by loss/gain of electrons.

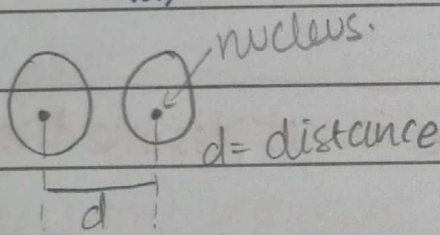


$Na^+ \Rightarrow$  Ion  
+ve  $\Rightarrow$  Cation.

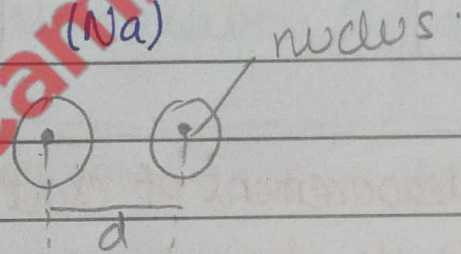
↳ Atom ⇒ Atomic size: Distance between the nuclei of two adjacent atoms from same element.

• Example:

(i) Hydrogen  
( $H_2$ )

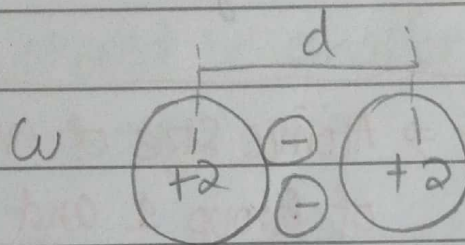
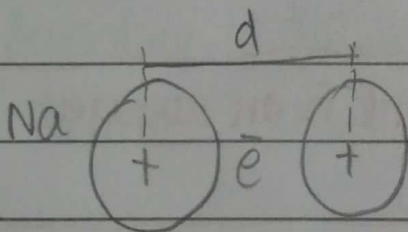


(ii) Sodium  
( $Na$ )



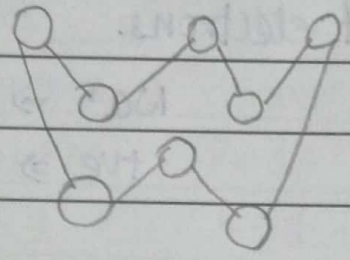
If  $r = \frac{d}{2} \Rightarrow$  Atomic Radii  $\Rightarrow$  Half of the distance between the nuclei of two adjacent atoms from same elements.

⊙ Metals  $\Rightarrow$  Metallic between metal bonds.



⊙ Non metals ⇒ Covalent bond between non metals bond .

Sulfur



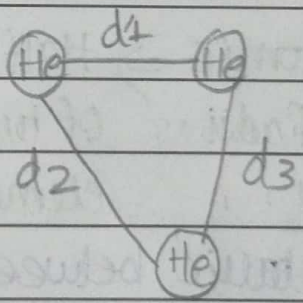
↳ Exceptional Case ⇒ Noble Gases (Grp 18)

1	2	3-10	11-18
		← 10 →	

\* Group 18 ⇒ Measurement of exact atomic size is not possible due to its monoatomic nature.

↳ Explanation : (Grp 18)

Helium gas



↳ NO Bonding

↳ NO fixed bond length.

\* Remember ⇒ Atomic size of group 18 element is an average of Group 1 and 17.  $\left[ \frac{17+1}{2} \right]$

1	2	-----	16	17	18	↗ monoatomic
						↳ $\frac{17+1}{2}$

Factors affecting Atomic size:

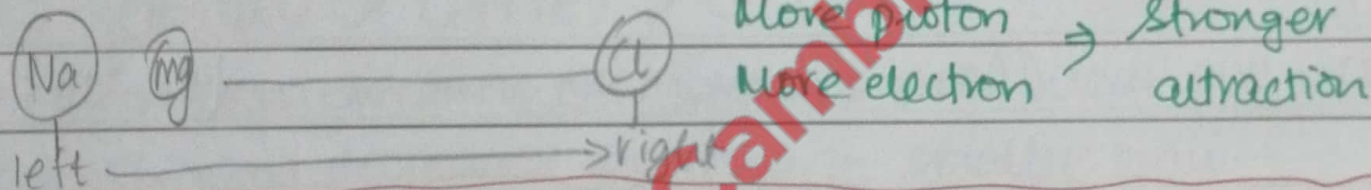
① Number of Protons: (Fixed no-of-shells)

↳ More protons → more electrons.

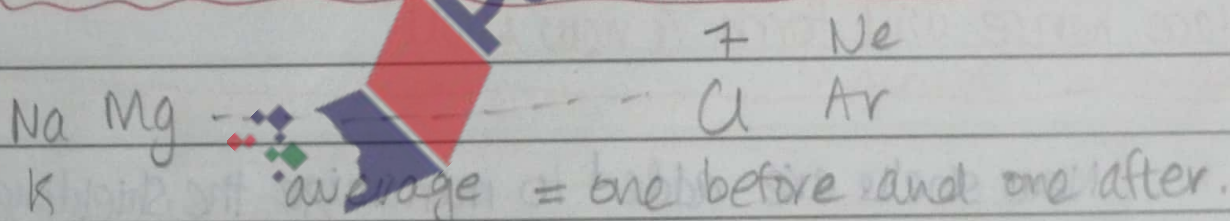
↳ Stronger attraction between nucleus and electron

\* smaller radii.

<sup>11</sup> Na	<sup>12</sup> Mg	<sup>13</sup> Al	<sup>14</sup> Si	<sup>15</sup> P	<sup>16</sup> S	<sup>17</sup> Cl	<sup>18</sup> Ar	Noble
11p	12p	13p	14p	15	16	17	18	Theory
11e	12e	13e	14e					



In periodic table left to right atomic size decreases as electrons increase within same period.



for Ar =  $\frac{Cl + Na}{2}$  for Ne =  $\frac{F + Na}{2}$

↳ According to the theory size should be smaller but as we are taking average it would be greater.

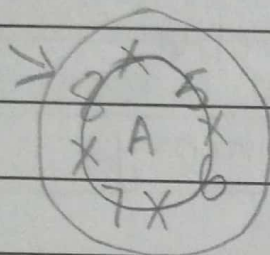
## (a) Shielding Effect : (Repulsion between electrons)

(i) \* Down the group shielding effect increases

⇒ increase in radii.

(ii) \* Addition of electrons (-ve ion formation)

⇒ increase in radii.



⇒ Already maximum repulsion so a new electron cannot be added. A new shell is to be added. (Greater repulsion ⇒ more shells added.)

(Same charge maximum repulsion)

\* Due to maximum repulsion / greater shielding effect, the new electron which will be added it will be added to a new place hence will form a new shell.

(i)  $\text{Li } 2$

$\text{Na } 8$

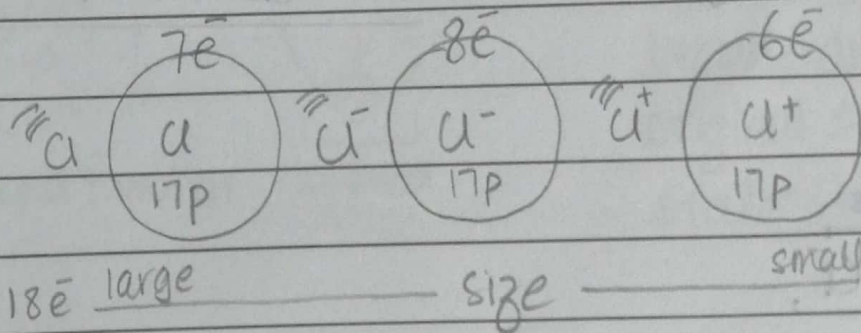
$\text{K } 18$

New shells are added to minimize the shielding effect as electrons increases down the group (repulsion increases for the last electron).

\* 3<sup>rd</sup> shell has capacity of 18 electrons but due to the repulsion between electron it only holds 8 electrons then new shell is added.

\* Proton pull not to be discussed down the group.

(ii) Compare the size of  $U/U^-/U^+$



$n = \text{shell}$	1	2	3
$2n^2 =$	2	8	18
$2 \times (1)^2 =$	2		
$2 \times (2)^2 =$		8	
$2 \times (3)^2 =$			18

$\Rightarrow$  More electrons, greater shielding (repulsion), more distance, larger radii.

$$U^- (18e^-) > U (17e^-) > U^+ (16e^-)$$

$\Rightarrow U^+ \rightarrow$  Less electrons than protons so nuclear pull increases and shielding decreases resulting in smaller radii.

(i) (within period)  $\xrightarrow{\text{Across period}}$   $R$

\* Nuclear pull (depends on no. of protons)

$\rightarrow$  greater  $\rightarrow$  smaller radii

(ii) Formation of Positive ion

(i) Down the group (same group)

\* Shielding effect

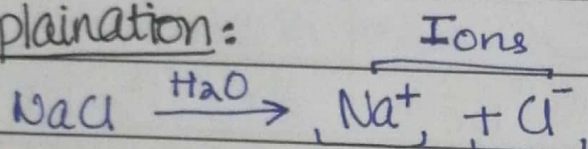
$\rightarrow$  greater  $\rightarrow$  large radii

(ii) Formation of negative ion

## \* Radical:

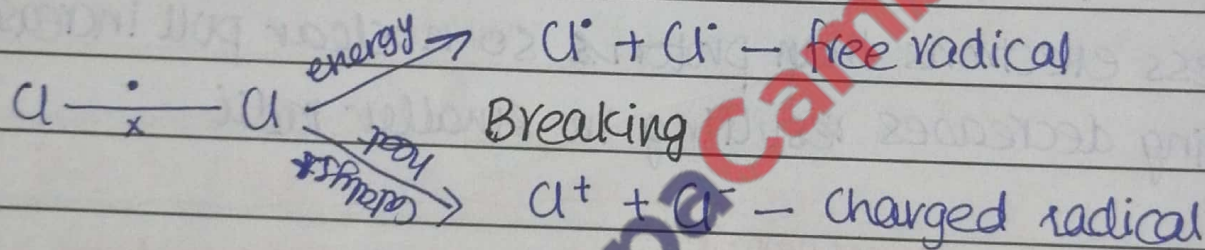
↳ Particles produced by breaking of bond or dissociation of compound.

### Explanation:



↳ Ions produced by the breaking of bond are called radical

### ↳ Method #01:

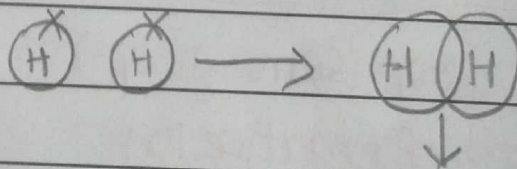


↳ Number of electron in free radical = Number of electron in neutral atom.

$$\text{CH}_3^{\cdot} \rightarrow 6 + 3 = 9e^-$$

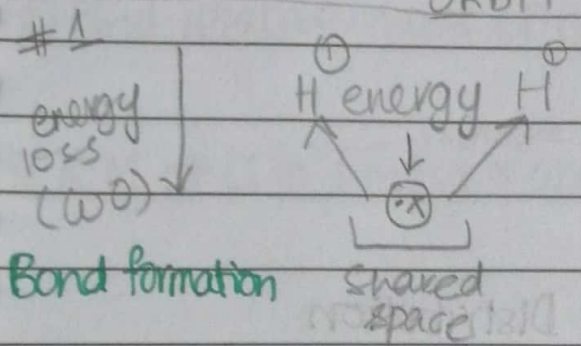
$$\text{CH}_3^+ \rightarrow (6 + 3) - 1 = 8e^-$$

$$\text{CH}_3^- \rightarrow (6 + 3) + 1 = 10e^-$$



energy lower than actual energy of shells in atom.

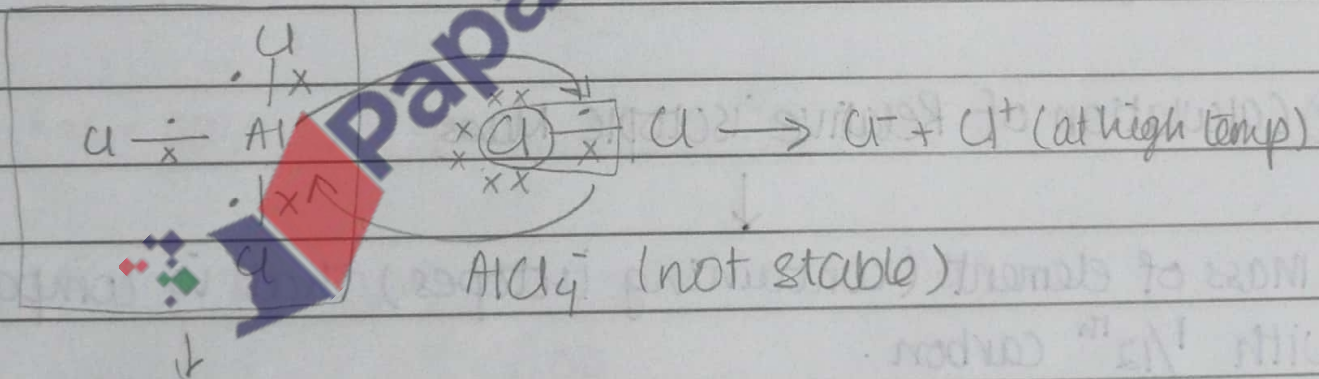
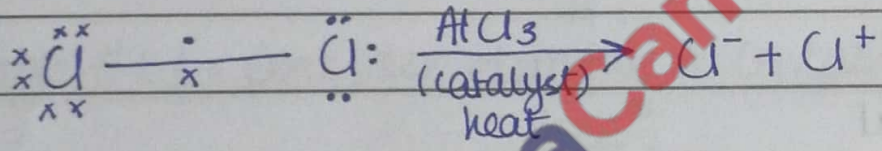
ORBIT CONCEPT



When we provide energy the bond breaks and atom goes into its original state that is neutral state.

↳ Where electron is shared, the energy of that place is less than the energy of the actual shell.

↳ Method #02:



↳ Al have 6e<sup>-</sup> in last shell so it needs 2 more e<sup>-</sup> so it will support 1Cl to gain 2e<sup>-</sup>, one of its own and one from another Cl.

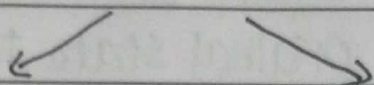
\* Al is a semi-metal or metalloid so it shows dual nature



### Bond Breaking

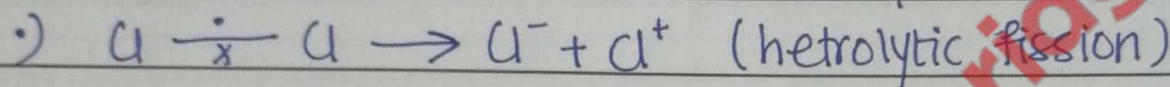
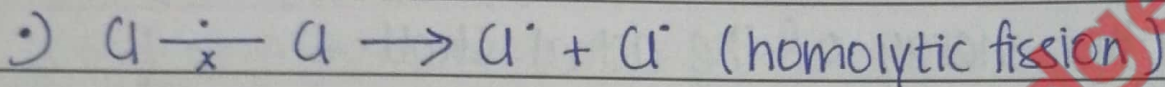


### Fission



Equal Distribution  
(Homolytic fission)

Unequal Distribution  
(Heterolytic fission)



$Cl^{\cdot}$  = Free radical

$Cl^{+}$  = Positive radical

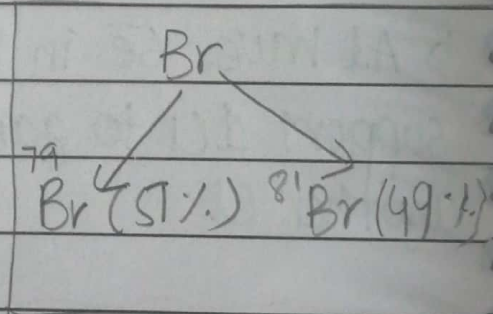
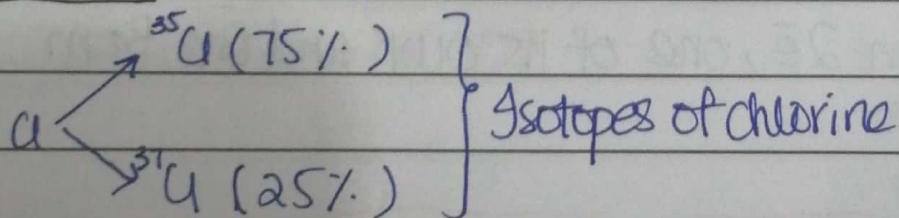
$Cl^{-}$  = negative radical

### \* Calculation of Relative isotopic Mass



↳ Mass of element (containing isotopes) that is compared with  $1/12^{th}$  carbon.

Explanation: Consider Chlorine



⊙ Find relative mass of chlorine:

$$\hookrightarrow \text{R.M of Cl} = \frac{\text{isotope 1 (mass x abundance)} + \text{isotope 2 (mass x abd)} + \text{isotope 3 (mass x abd)}}{\text{sum of abundance}}$$

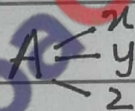
\* abundance = availability

$$\text{R.M of Cl} = \frac{(35 \times 75) + (37 \times 25)}{100}$$

$$= 3550/100 = \boxed{35.5}$$

F<sub>2</sub>O<sub>2</sub>N<sub>2</sub>Cl<sub>2</sub>Br<sub>2</sub>I<sub>2</sub>H<sub>2</sub><sup>35</sup>Cl <sup>35</sup>Cl<sup>35</sup>Cl <sup>37</sup>Cl<sup>37</sup>Cl <sup>37</sup>Cl

example #01: Consider element A containing three isotopes.



$${}^6\text{x} = 20\%, \quad {}^8\text{y} = 50\%, \quad {}^{10}\text{z} = 30\%$$

$$\hookrightarrow \text{R.M of A} = \frac{(6 \times 20) + (8 \times 50) + (10 \times 30)}{100}$$

$$= 820/100 = \boxed{8.2}$$

Date : 10<sup>th</sup> Sept 2020

\* Relative mass is measured by using mass spectrometer.

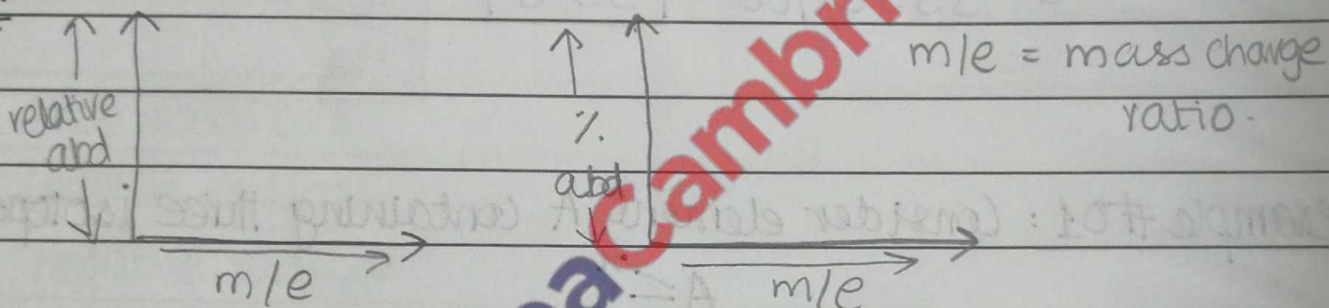


After analysis of sample a graph is produced by mass spectrometer known as "Mass Spectrum" (Graph)



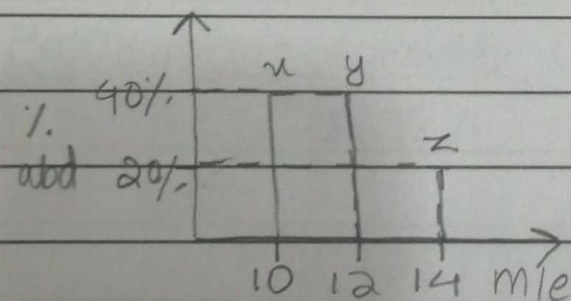
Represent relation between 'Mass' ( $m/e$ ) and abundance.

↳ Graph



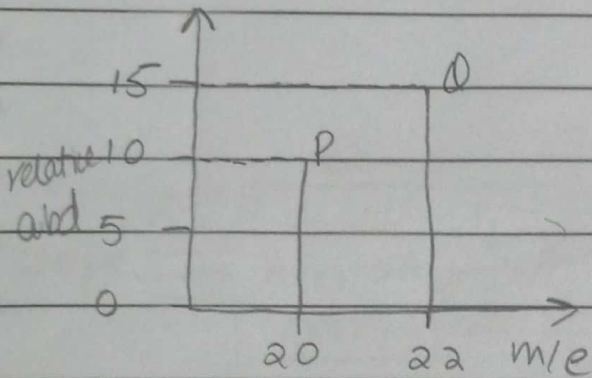
Example

i) Element 'A' is analysed



$$R.M \text{ of } A = \frac{(10 \times 40) + (12 \times 40) + (14 \times 20)}{(40 + 40 + 20)} \Rightarrow \frac{1160}{100} = \underline{\underline{11.6}}$$

(ii) Element 'X' is analysed



$$\text{R.M of X} = \frac{(20 \times 10) + (22 \times 15)}{(10 + 15)}$$

$$= \frac{530}{25} = \boxed{21.2}$$

\* Find % Abundance of isotopes

Q. Consider element A with R.M value 30.3 containing two isotopes  $^{30}\text{X}$  and  $^{32}\text{Y}$ . Find % abundance of 'X' and 'Y'.

$$\rightarrow A = X + Y \rightarrow 100\% = x\% + (100 - x\%)$$

$$\text{R.M} = \frac{(\text{mass} \times \text{abd}) + \dots}{\text{sum of abd}} \Rightarrow 30.3 = \frac{(30 \times x) + (32 \times (100 - x))}{100}$$

$$30.3 \times 100 = 30x + 3200 - 32x$$

$$3030 - 3200 = -2x$$

$$+170 = +2x$$

$$\frac{170}{2} = x$$

$$\boxed{x = 85\%}$$

$$y = 100 - 85$$

$$\boxed{y = 15\%}$$

$$\Rightarrow \boxed{\begin{matrix} ^{30}\text{X} = 85\% \\ ^{32}\text{Y} = 15\% \end{matrix}}$$

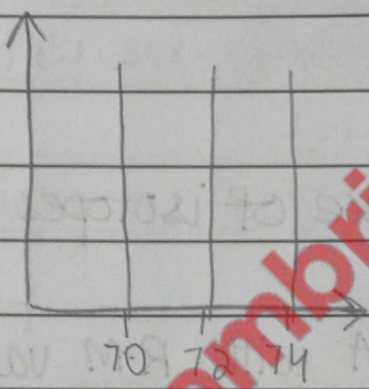
Answer.

\* Find total number of peaks produced by any element during analysis in Mass Spectrometer.

Example #01

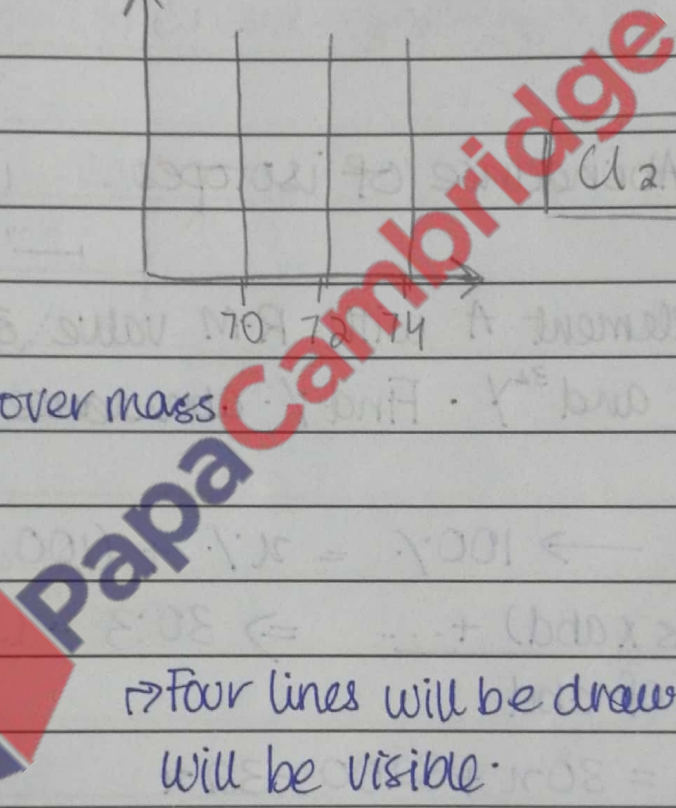
↳ Consider chlorine ( $Cl_2$ ) gas.

Cl	Cl	Cl
35	35	70
35	37	72
37	37	74



$Cl_2 = 3$  peaks

⊙ Line is generated over mass.



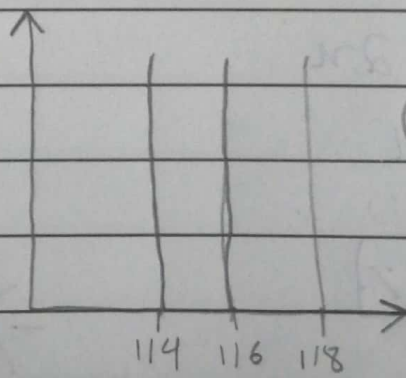
Example #02

↳ ClBr

↓  
Analysis

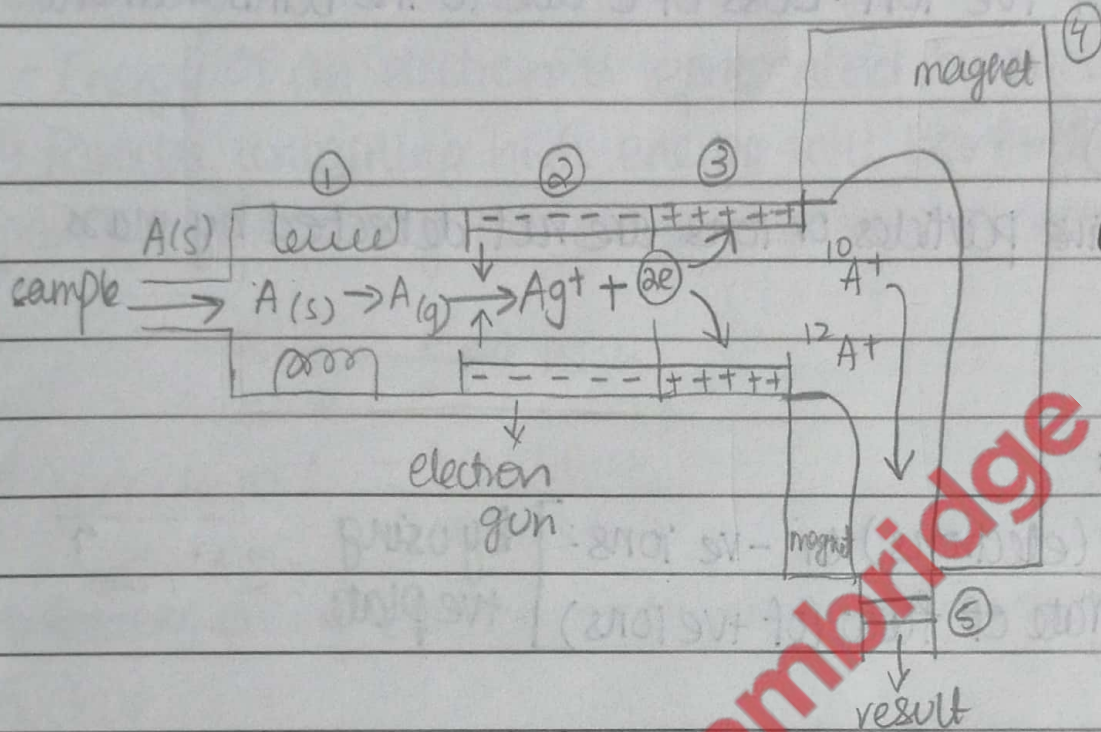
↳ Four lines will be drawn but three will be visible.

Cl	Br	ClBr
35	79	114
35	81	116
37	79	116
37	81	118



$ClBr = 3$  peaks

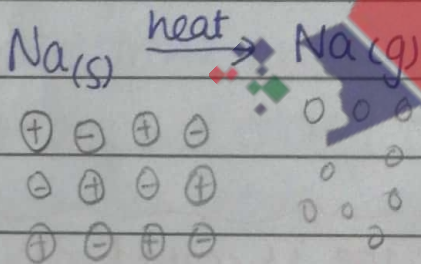
\* Working of Mass Spectrometer



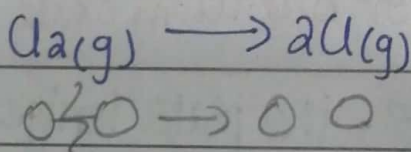
Formation of Ion  
 $A_s \downarrow$   $A_2 \rightarrow$   
 +ve (ionisation) -ve (electron affinity)  
 loss of  $e^-$  gain of  $e^-$

① Vapourisation

↳ Given sample is converted into gaseous atom by strong heating (Process is also known as Atomisation).



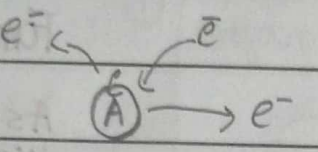
↳ Delocalised electron are  $e^-$  in outermost shell which can move freely and act as a binding agent or give between two atoms. (+ve)



\* Atom of any element exist in gaseous state

② Ionisation :

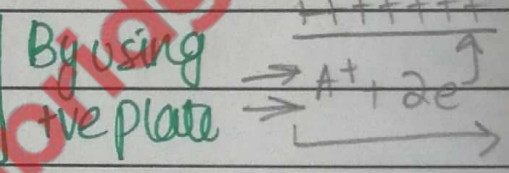
↳ Formation of +ve ion. Loss of  $e^-$  due to the bombardment of  $e^-$ .



- Example: Negative particles or ions are not detected by mass spectrometer.

③ Acceleration :

↳ Removal of  $e^-$  (electrons) or -ve ions.  
 ↳ Speed up the rate of flow (of +ve ions)



④ Deflection :

↳ Separation of heavier from lighter.  
 ↳ lighter particles deflected earlier.

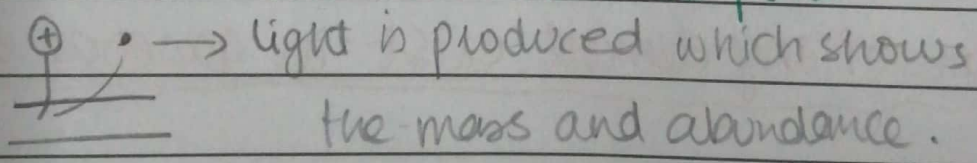
⑤ Detection :

↳  $m/e$  and abundance is measured.  
 ↳ +ve ions are detected.

↳ mass is called  $m/e$ .

\* Plate is coated with zinc or barium oxide

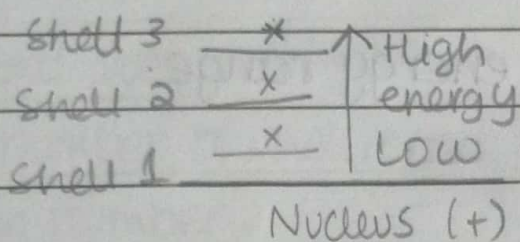
↳ When positive ion collide with the plate, the plate ionizes but when atom collide, it does not affect the plate.



Date: 15<sup>th</sup> Sept '2020

### \* Energy Level:

- ↳ Shell or orbit is called energy level.
- Energy of an electron is represented by shell/orbit:
- ↳ Particles containing high energy will be further apart while particles containing less energy are closer together.



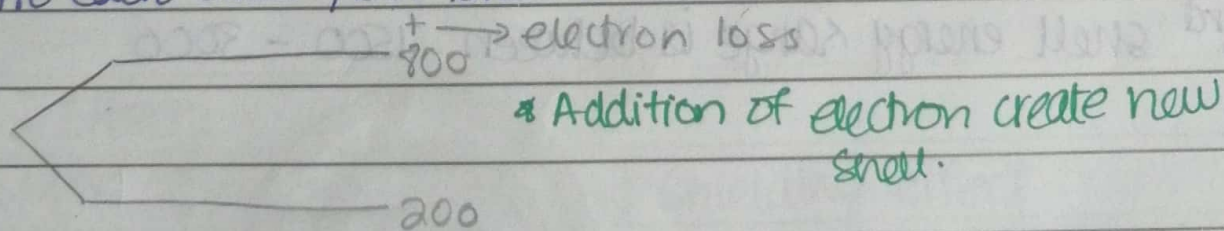
↳ Greater energy electron or shell are further away from the nucleus.

↳ Lower energy electron or shell are closer to the nucleus.

↳ We can not place electrons on same energy level because they will repel each other.

- electrons on different level to minimise repulsion.

↳ Range of energy of shell remains same, but energy of electrons differ from each other, but shell is same.



↳  $H^+$  does not exist independently but combine with some another for e.g  $H^+ + H_2O \rightarrow H^+(aq)$



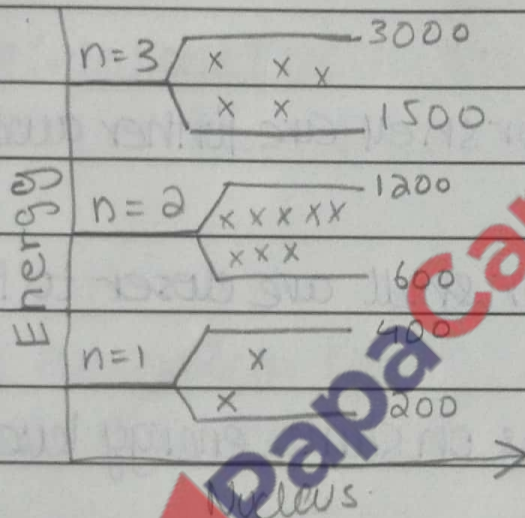
Date: 16th Sept '2020

### \* Energy Level:

- ↳ Area around the nucleus is called shell/orbit.
- Each shell/orbit represent specific energy range.

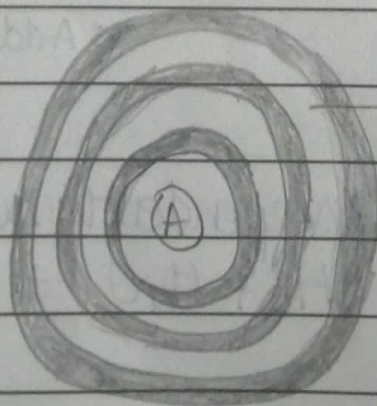
### ⊙ Consider atom A

- containing three orbit/shell.
- each shell represent specific energy range.



For:

- 1<sup>st</sup> shell energy range is between 200 - 400
- 2<sup>nd</sup> shell energy range is between 600 - 1200
- 3<sup>rd</sup> shell energy range is between 1500 - 3000



transit region (unstable) e<sup>-</sup>

- ↳ energy level is represented by 'n'
- ↳ It is also known as 'Principal Quantum Number'.
- Unstable electron will either gain energy and move to above shell or will release energy and will come back to lower (original) shell.

### \* Principal Quantum Number:

- ↳ Total number of shell/orbit in any atom is called Principal Quantum number.
- ↳ It represents energy level (energy range of an electron)
- ↳ It represents total number of electrons.
- ↳ Its symbol is n.

$$n = 1, 2, 3 \dots 7$$

- Total number of electrons in any energy level is calculated by following formula:

$$2n^2$$

maximum  
no. of  
capacity of  
total shell  
electron

$$n=1 \Rightarrow 2$$

$$n=2 \Rightarrow 8$$

$$n=3 \Rightarrow 18$$

modern periodic table configuration:

$$2, 8, 8, 18, 18, 32$$

### \* Shielding Effect:

- ↳ Repulsion between electrons is called shielding effect.
- Due to greater shielding effect.
- ↳ Electrons are added in new energy level.
- ↳ Electrons having different energy.

## \* Orbit (shell) $\rightarrow$ Floor:

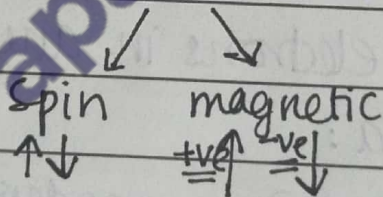
- $\hookrightarrow$  Area or space around nucleus is called orbit/shell.
- $\hookrightarrow$  It represents energy level or energy range of an electron.
- $\hookrightarrow$  In shell/orbit electrons are placed by increasing energy.
- $\hookrightarrow$  Shell or orbit is known as principal quantum number where principal quantum number is represented by 'n'.

## o Orbital (sub-shell) $\rightarrow$ room:

- where electrons are present
- exact energy or location.

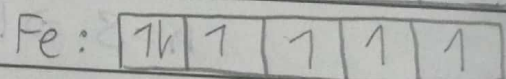
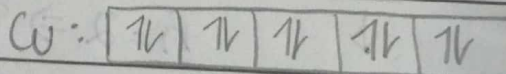
## \* Quantum Number:

- $\hookrightarrow$  It represents energy and orientation of an electron.



## o Types of Quantum Number:

- 1 Principal Quantum Number
- 2 Azimuthal Quantum number.
- 3 Spin Quantum Number
- 4 Magnetic Quantum Number.



double spin : no magnetic field

single spin : magnetic field

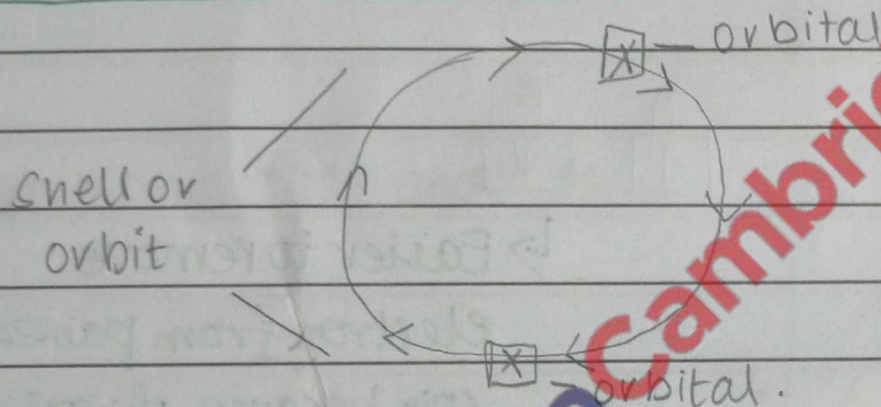
- 1 Principal Quantum Number: It represents total number of shell or valence shell in any atom.

⊙ Orbital / sub-shell:

↳ It represents exact energy and exact location of an electron.

### \* Heisenberg Uncertainty

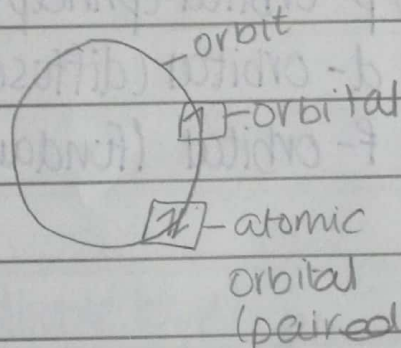
↳ It is difficult to measure both exact energy and exact position of electron (as it is revolving so changing its position every time; angular momentum).



↳ Orbitals are very small in size as compared to the size of shell / orbit.

↳ Relationship between orbit and orbitals.

Shell / orbit	orbitals / sub shell
$n = 1$	one orbital (s)
$n = 2$	two orbitals (s, p)
$n = 3$	three orbitals (s, p, d)
$n = 4$	four orbitals (s, p, d, f)



⊙ Area or space around nucleus

⊙ Exact location or energy

⊙ Atomic orbital:

↳ Represents the spin of an electron.

**\* Pauli's Rule:**

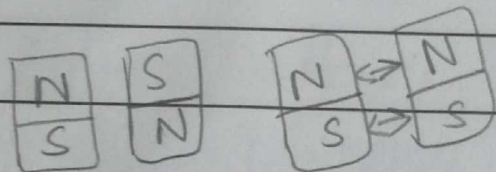
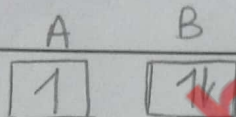
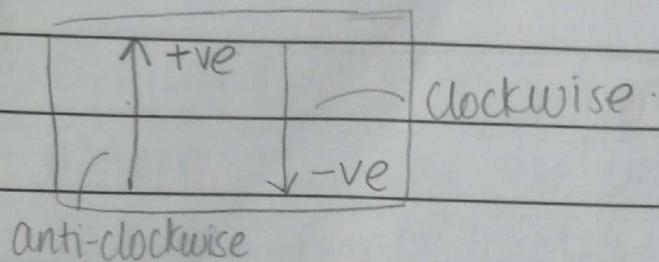
↳ An atomic orbital can hold one or two electrons but not more than two.

unpaired/individual spin

paired spin.

Atomic orbital

Atomic Orbital



↳ Easier to remove electron from paired spin because of repulsion.

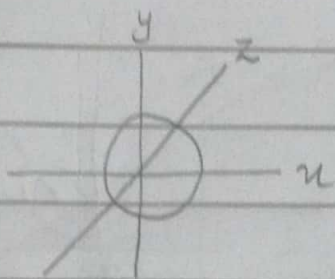
**\* Types of orbitals:**

- ① s-orbital (spin)
- ② p-orbital (principle)
- ③ d-orbital (diffuse)
- ④ f-orbital (fundamental)

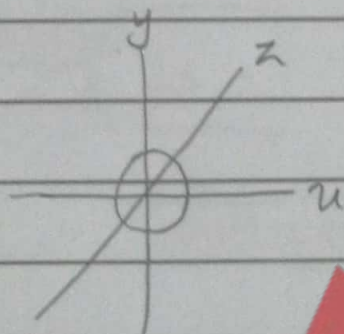
Date: 22<sup>nd</sup> Sept 2020

### ① s-orbital:

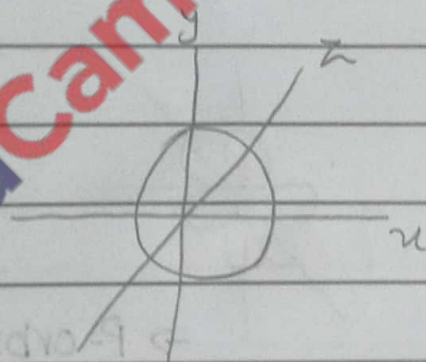
- ↳ It can hold maximum two electrons.
- ↳ containing one atomic orbital.
- ↳ Shape is called "spherical". (3-D circle).



Exam  $\Rightarrow$  Draw "2s" and "3s".



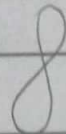
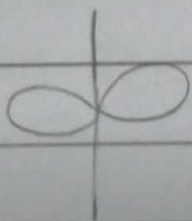
2s



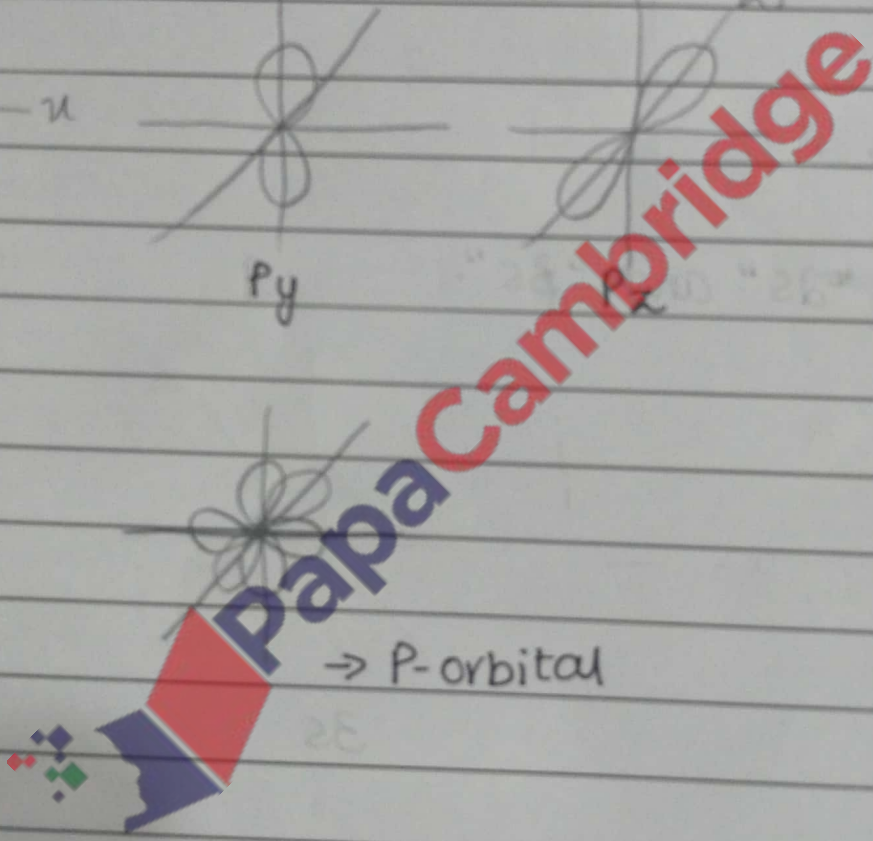
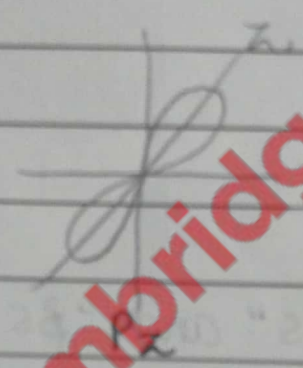
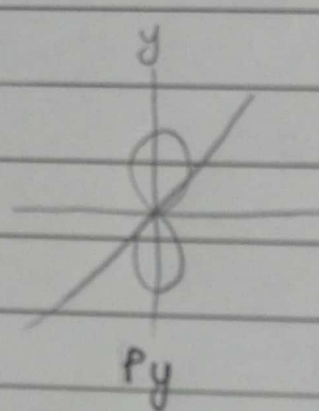
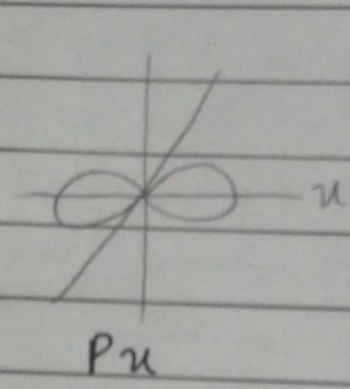
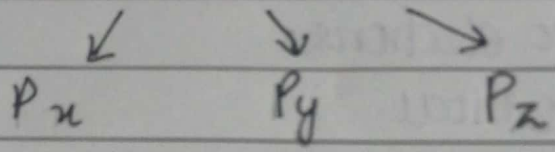
3s

### ② p-orbital:

- ↳ It can hold maximum six electrons.
- ↳ containing three atomic orbitals.
- ↳ Shape is called "Dumb-bell". (Hour Glass or double loop)



↳ P-orbital is a collection of three.



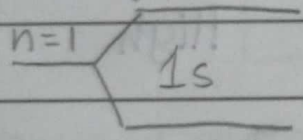
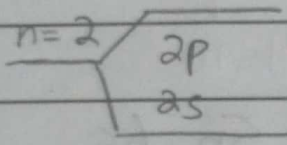
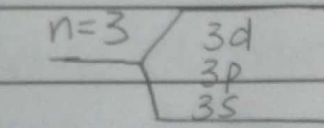
→ P-orbital

③ d-orbital :

- ↳ It can hold maximum 10 electrons.
- ↳ containing five atomic orbitals.
- ↳ Shape is dumb-bell.

(4) p-orbital:

- ↳ It can hold maximum 4 electrons.
- ↳ containing seven atomic orbitals.
- ↳ shape is dumbbell.

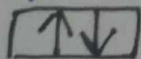


Nucleus

PapaCambridge

(\*) Hunds rule:

- ↳ Electrons prefer to have individual spin rather than paired spin.
- Reason: Spin pair repulsion



• According to the Hunds rule

A.  $\boxed{\uparrow}$   $\boxed{\uparrow\uparrow\uparrow}$  2s is not filled first

B.  $\boxed{\uparrow\downarrow}$   $\boxed{\uparrow\uparrow\uparrow}$

C.  $\boxed{\uparrow\downarrow}$   $\boxed{\uparrow\downarrow\uparrow}$  rule is not followed



\* School school public school public school district public school  
 district public school  
 s s p s p s d p s d p s

Date : .....

\* Electronic Configuration:

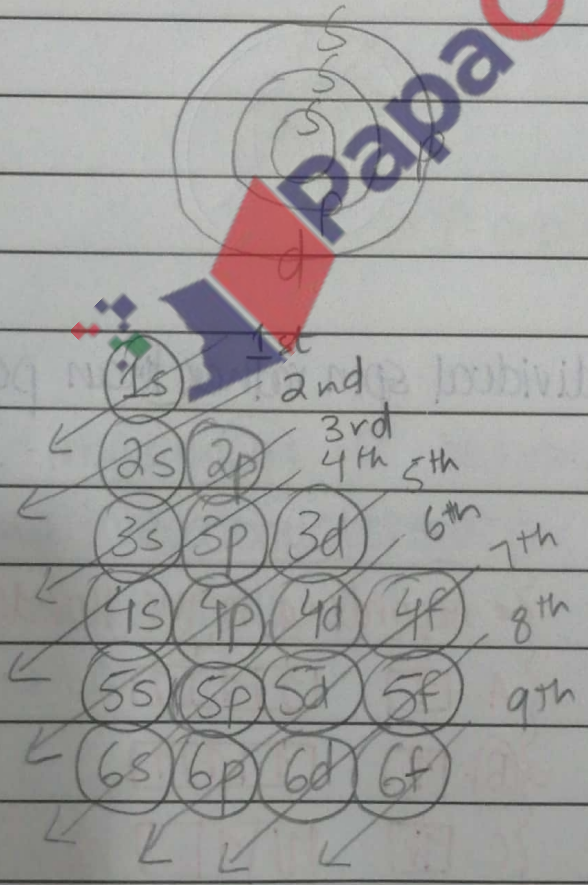
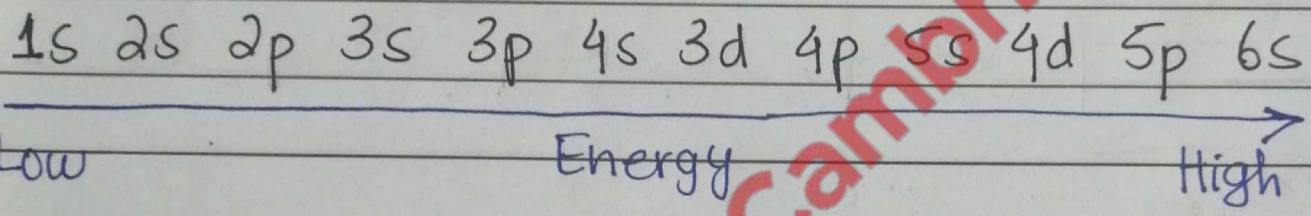
↳ Filling of electrons in orbit (shell) and orbitals (sub-shell) by increasing energy.

\* Aufbau Rule:

↳ To build up or construct.

"Filling of orbitals by increasing energy".

$s = 2$   
 $p = 6$   
 $d = 10$

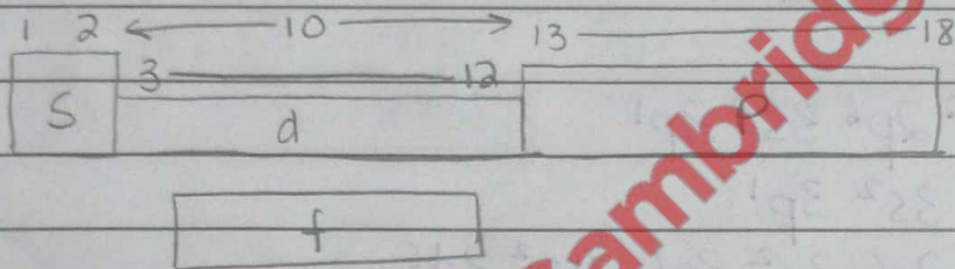


⊙ Prediction of Group, period and Block by using electronic configuration

- Period = Highest number of shell.
- Group = sum of electrons in highest shell / outermost shell.

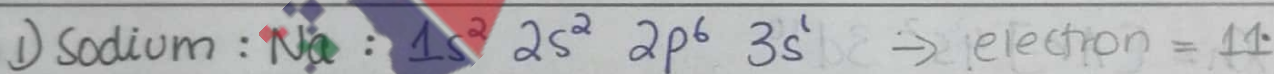
↳ If 's' and 'p' are valence orbitals ; group no is 10 + valence electron.

- Block = It represents valence orbitals.

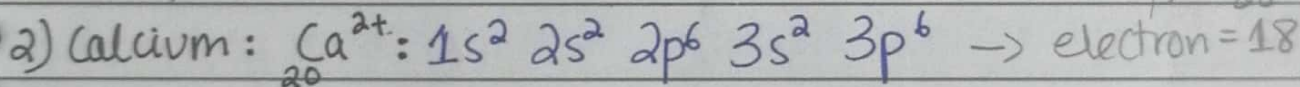


\* Transition metals are blocked elements (group = s+d).

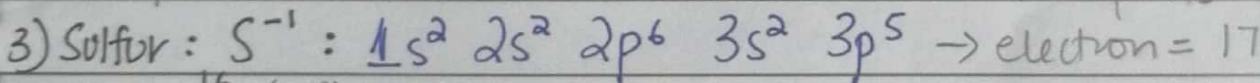
\* Filling of orbitals:



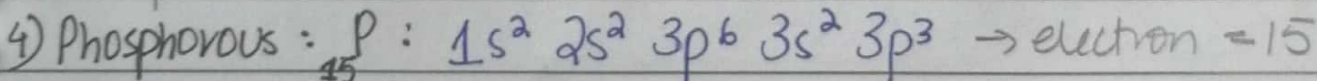
Group = 1    Period = 3    Block = S



Group = 2    Period = 4    Block = S



Group = 16 <sup>(6+10)</sup>    Period = 3    Block = P



Group = 15 <sup>(5+10)</sup>    Period = 3    Block = P

\* Short Hand Rule:

⇒ Instead of using complete configuration; we use noble gas configuration.

• 10 - 17 : [Ne]

• 18 - 35 : [Ar]

↳  $10e^- \rightarrow [Ne] = 1s^2 2s^2 2p^6$

↳  $18e^- \rightarrow [Ar] = 1s^2 2s^2 2p^6 3s^2 3p^6$   
 $[Ar] 4s^2 3d^6$

①  $_{13}Al = 1s^2 2s^2 2p^6 3s^2 3p^1$

$Al = [Ne] 3s^2 3p^1$

②  $_{26}Fe = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$

$Fe = [Ar] 4s^2 3d^6$

Block = d Group = (transition) s+d = 8 Period = 4

③ Zinc :  $_{30}Zn : 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10}$

$Zn = [Ar] 4s^2 3d^{10}$

Block = d Period = 4 Group = 12

- \* Copper is non-magnetic
- \* Chromium is magnetic

→ Different / Abnormal

Date: 24<sup>th</sup> Sept 2020.

(\*) Describe Anomalous configuration of Copper (Cu) and Chromium (Cr).

Ans:

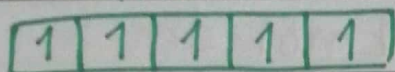
\* Transition elements are d-block elements.

⇒ To get stable d-orbital, transfer electron from "4s" to "3d" OR due to low energy difference.

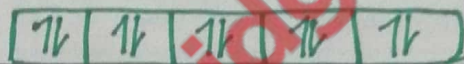
\* d-orbital gets stable when it is half-filled or completely filled.

• Half-filled

• Completely filled



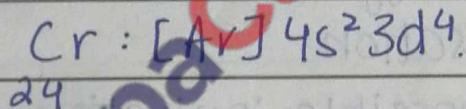
OR



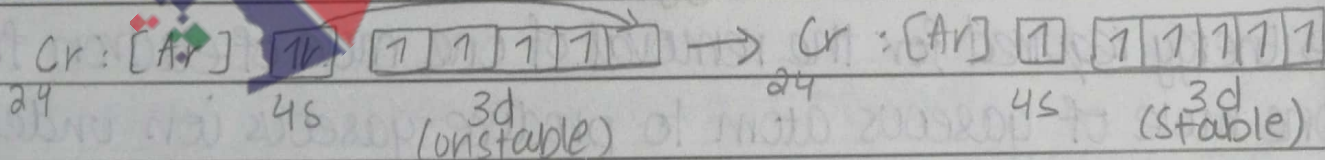
d<sup>5</sup>

d<sup>10</sup>

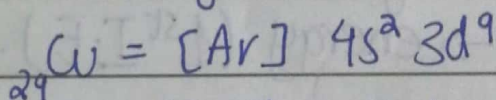
↳ According to Aufbau Rule electronic configuration of Chromium is :



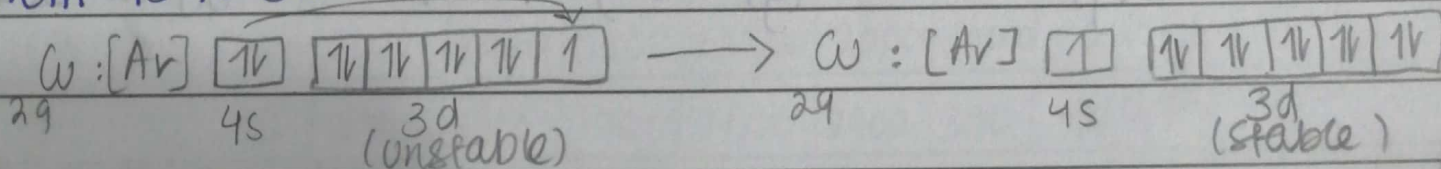
→ But to get a stable d-orbital in chromium one electron is shifted from 4s to 3d. Transfer



↳ According to Aufbau Rule electronic configuration of Copper is :

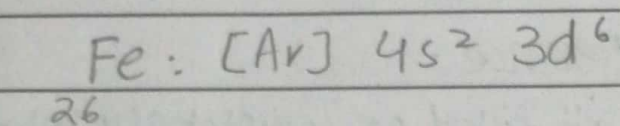


→ But to get a stable d-orbital in copper one electron is shifted from 4s to 3d. Transfer

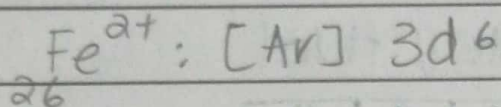


(\*) Describe why further oxidation of  $\text{Fe}^{3+}$  is not possible?

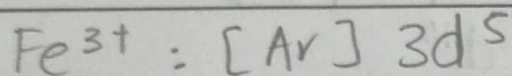
↳ Due to the presence of half filled or stable d-orbital.



26



26



26

\* Standard Conditions

① Temp:  $25^\circ\text{C}$  or  $298\text{K}$

② Pressure:  $1\text{atm}$  or  $100\text{KPa}$

③ Conc:  $1\text{mol}\cdot\text{dm}^{-3}$

(\*) Ionization Energy: Energy for the removal of electron.

\* Equation for the ionisation

\* Predict the group / possible ionisation.

⇒ Standard Ionisation Energy:

↳ Energy required for the removal of one mole of electron from one mole of gaseous atom to produce gaseous ion under standard conditions. (fixed conditions; not vary)

Example:-  $\text{Na}_{(g)} \longrightarrow \text{Na}^+_{(g)} + e^-$ ;  $494 \rightarrow$  energy ( $1^{\text{st}}$  I.E.)

$\text{Na}^+_{(g)} \longrightarrow \text{Na}^{2+}_{(g)} + e^-$ ;  $4560 \rightarrow$  energy ( $2^{\text{nd}}$  I.E.)

⊛ We have to take out difference of 2.

Date: .....

\* If there is a large difference between two ionisation energies; then further ionization is not possible; if difference is small or similar to initial value, then proceed

$X \rightarrow$	$X^{+1}$	$X^{+2}$	$\rightarrow X^{+1}$ is possible only
	494	4560	$\rightarrow$ Group 1

Consider element 'B'

1st	2nd	3rd	4th	Group 2
900	1760	4800*	21000	$B^{2+}$

\* Ions are only produced in gaseous state.

Consider element 'Y'

1st	2nd	3rd	4th	Group 3
577	1820	2740	11600	

\* Ionisation is endo-thermic (we provide energy to remove electron).

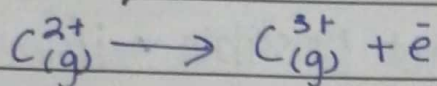
\* Atom  $\rightarrow$  gas

↳ largest energy difference represent shift of shell.

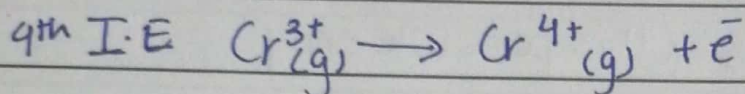
↳ shell is closed to nuclei means greater pull and high I.E.

	1st	2nd	3rd	4th	5th	6th	7th	8th	
A	200	350	600	1100	3400	4500	5700	8000	$\rightarrow$ GP4: $A^{4+}$
B	1100	7000	8000	8900	11000	13000	20000	30000	$\rightarrow$ GP1: $B^{1+}$
C	70	110	270	1300	1700	2000	2900	3100	$\rightarrow$ GP3: $C^{3+}$

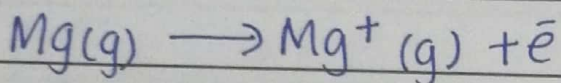
⊙ Write equation for the ionization of "C".



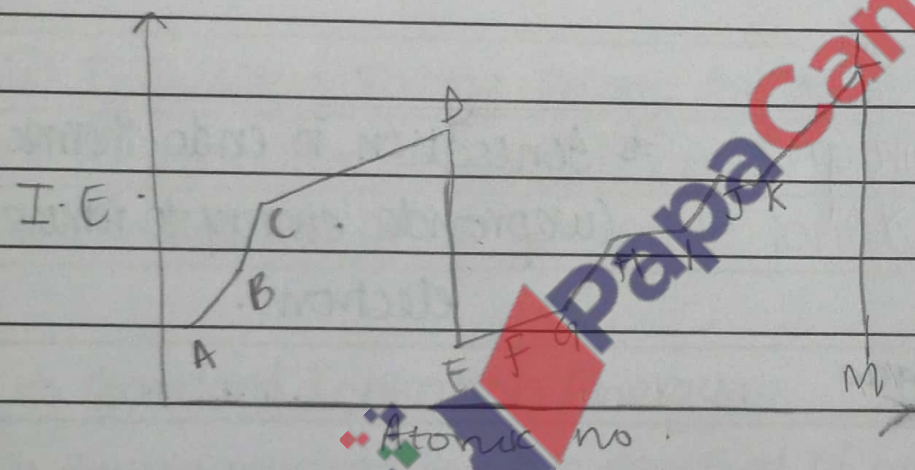
⊙ Consider element "Cr"  $\Rightarrow$   $Cr^{6+}$



Magnesium  $\Rightarrow$   $1^{st}$  I.E equation



\* In graph, peak represents Group 18.



Q<sup>1</sup> Identify elements with two unpaired p-orbital.

B, H, J

Q<sup>2</sup> Completely filled p-orbital.

D, L

Q<sup>3</sup> p-orbital not present?

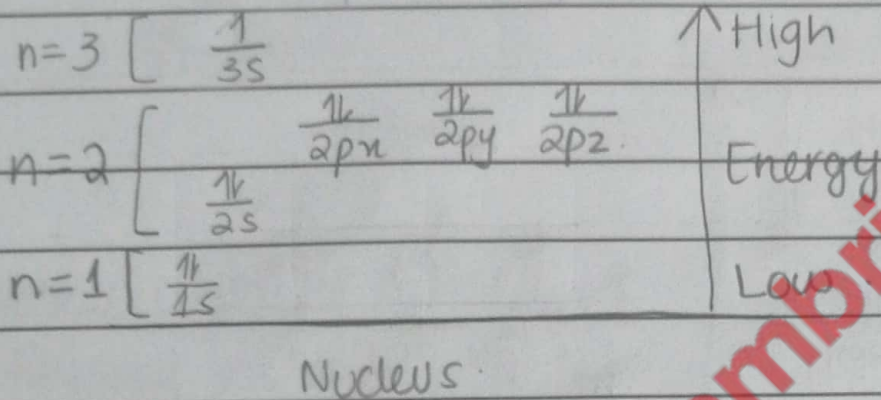
E, F, M.

Q. Draw energy profile diagram.

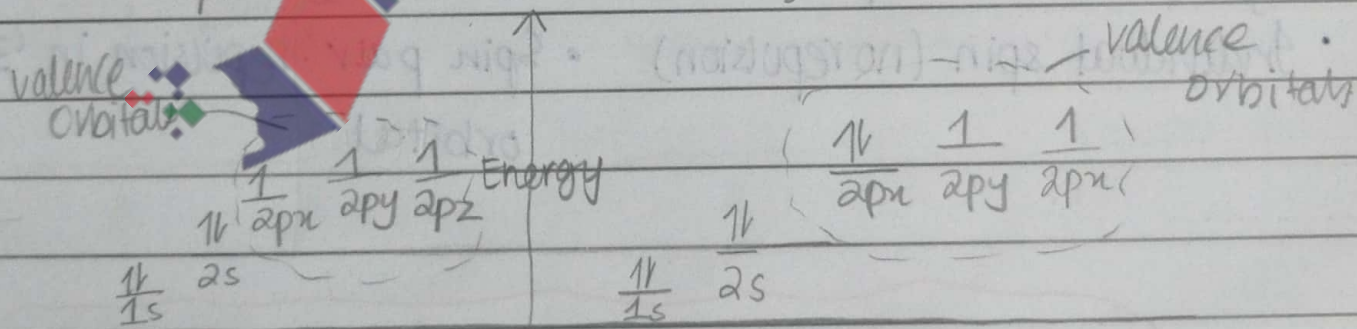
↳ Arrangement of orbitals by increasing energy.

- Explanation:

Consider Sodium (Na)



Example #01: Draw energy profile diagram for Nitrogen ( ${}_7\text{N}$ ) and Oxygen ( ${}_8\text{O}$ ).



$1^{\text{st}}$  I.E. of oxygen <  $1^{\text{st}}$  I.E. of Nitrogen

↓ Low: paired spin (repulsion between electron)

approx = 1400

approx = 1600



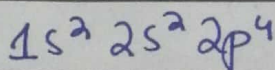
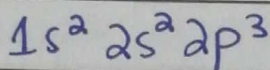
Example #02: Compare 1<sup>st</sup> I.E of Phosphorus with sulfur.

GP15

GP16

7N

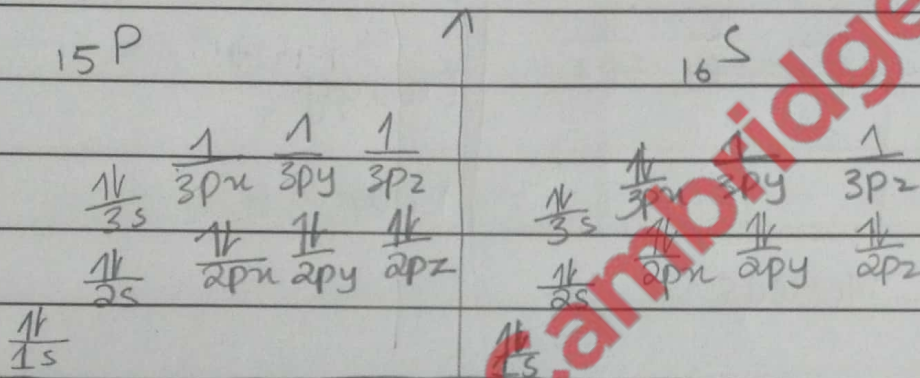
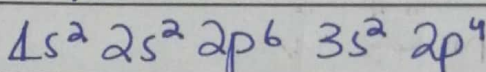
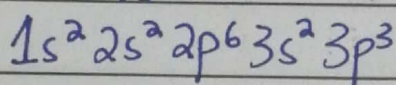
8O



Identical valence orbital configuration.

15P

16S



Nucleus

Nucleus



- High 1<sup>st</sup> I.E (Phosphorus)
- Individual spin (no repulsion)

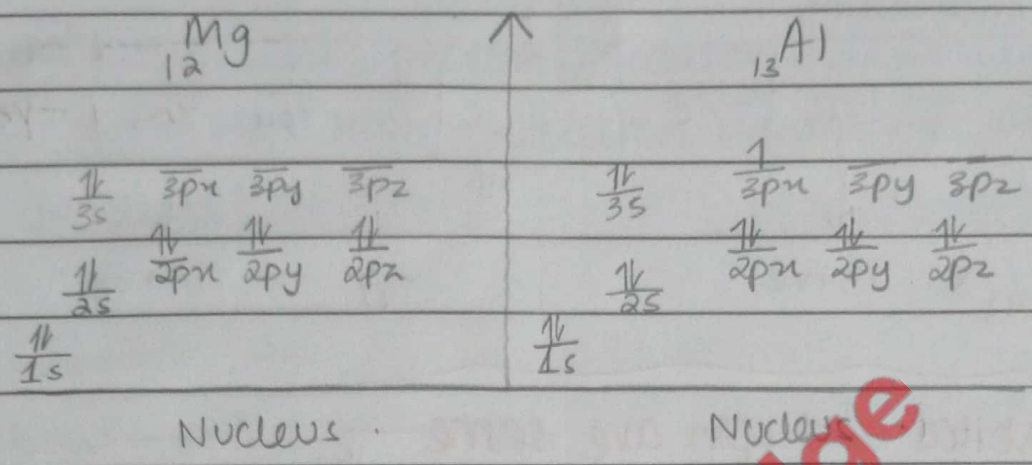
- Low 1<sup>st</sup> I.E (sulfur)
- Spin pair repulsion in '3p<sub>x</sub>' orbital.

If orbitals are same  
 ⇒ Check spin of orbitals

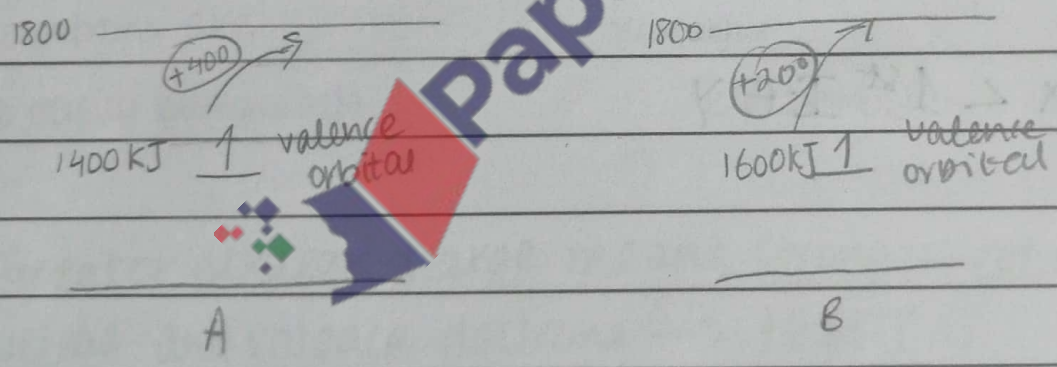
↗ Paired spin (low energy)

↘ Unpaired spin (high energy)

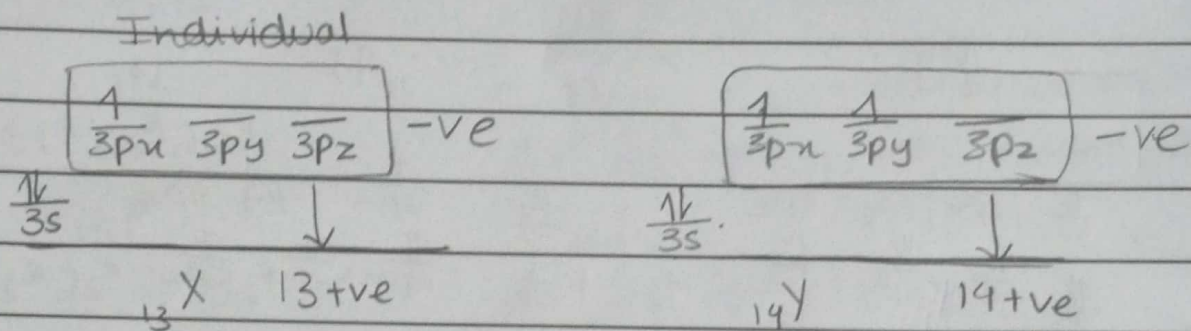
Q. Compare 1<sup>st</sup> I.E of Magnesium ( $_{12}\text{Mg}$ ) with Aluminium ( $_{13}\text{Al}$ ).



- ↳ Valence orbital of Aluminium is high energy orbital (3p).
- Required less energy for the removal of electron.
- Low 1<sup>st</sup> I.E of electron in 'Al'.



① Consider two elements "X" and "Y".



\* If orbital and spin are same  
→ Nuclear pull

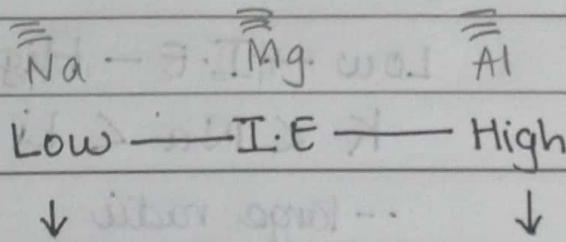
Greater Weak

• High I.E • Low I.E

①  $1^{st} I.E X < 1^{st} I.E Y$

\* Factors Affecting Ionization :

① Nuclear Charge : More proton, greater nuclear charge, stronger attraction, high ionization energy. (If no. of orbit or shell are same).



- |   |   |
|---|---|
| <ul style="list-style-type: none"> <li>• less protons</li> <li>• weaker nuclear pull</li> <li>• Low ionization (electrons are easily eliminated)</li> </ul> | <ul style="list-style-type: none"> <li>• more protons</li> <li>• stronger nuclear pull.</li> <li>• High ionization (difficult to remove electrons)</li> </ul> |
|---|---|

• Greater nuclear charge means stronger attraction: between nucleus and valence electrons → High I.E.

## ② Atomic Size or Atomic Radii:

- ↳ Small atomic size or small atomic radii means less distance between valence electrons and nucleus.
- ↳ Stronger attraction between nucleus and electrons.
- ↳ High ionisation energy.

### Explanation:

Li	Small	Low — I.E. — High
Na	Atomic Radii	$K < Na < Li$
K	↓ large	↓ -- large radii ↓

- weak attraction
- electron easily eliminated.

## ③ Shielding Effect:

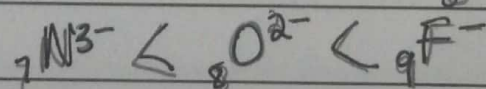
- ↳ Repulsion between electrons.
- ↳ Greater shielding means low I.E.

### Explanation:

Consider  $\Rightarrow$   $F^- / O^{2-} / N^{3-}$ ,  
same no of electrons.

	P	$\bar{e}$
${}_{9}F^-$	9	10
${}_{8}O^{2-}$	8	10
${}_{7}N^{3-}$	7	10

Low — I.E. — High



- — greater repulsion
- — more shielding.

- ⊙ It is easier to remove electron from atom ; it is difficult to remove electron from ion, because electrons are reduced so shielding effect decreases and nuclear charge increases.
- ⊙ Gain of electron is exothermic ; to release extra energy.

