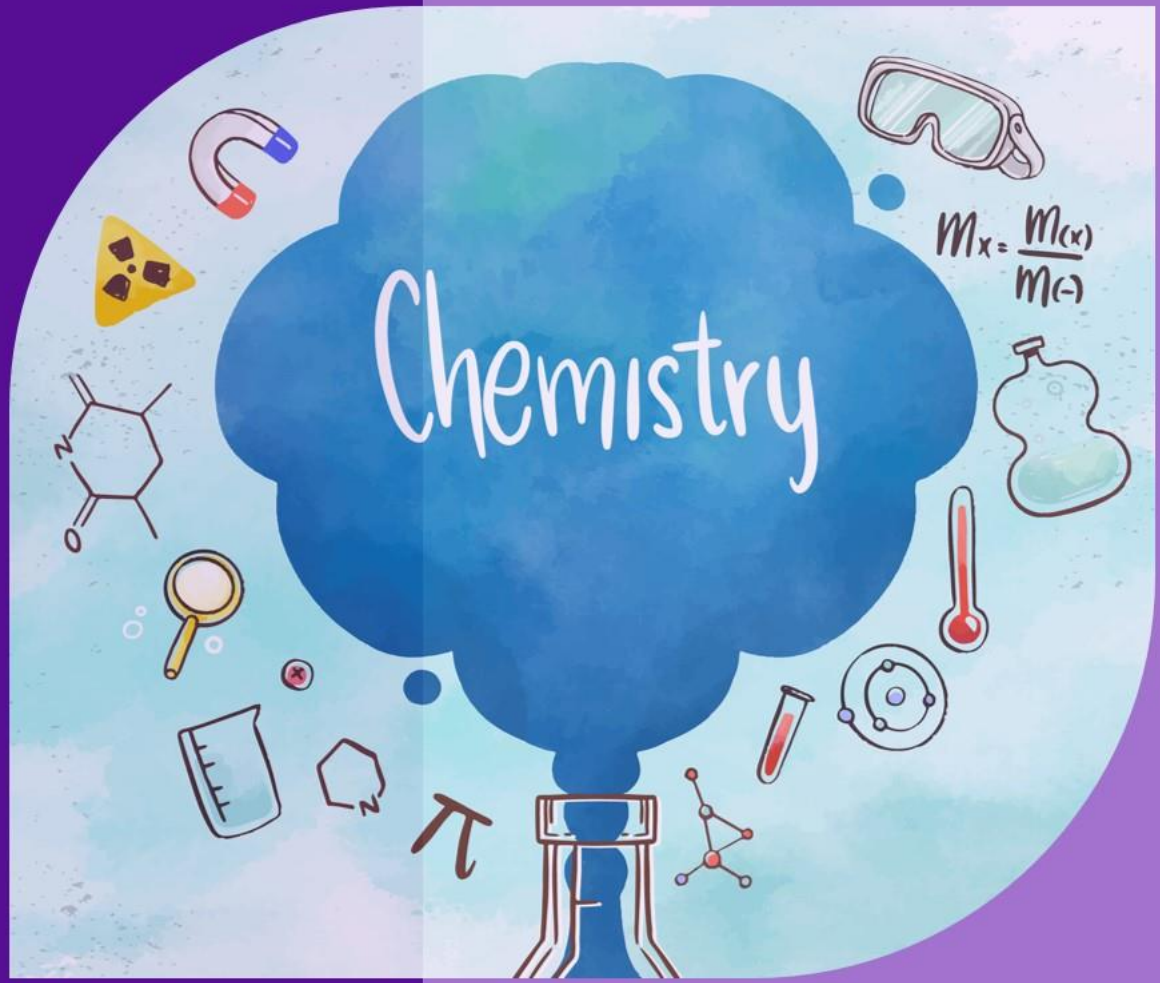
ENGINEERING ADMISSION PROGRAM 2020

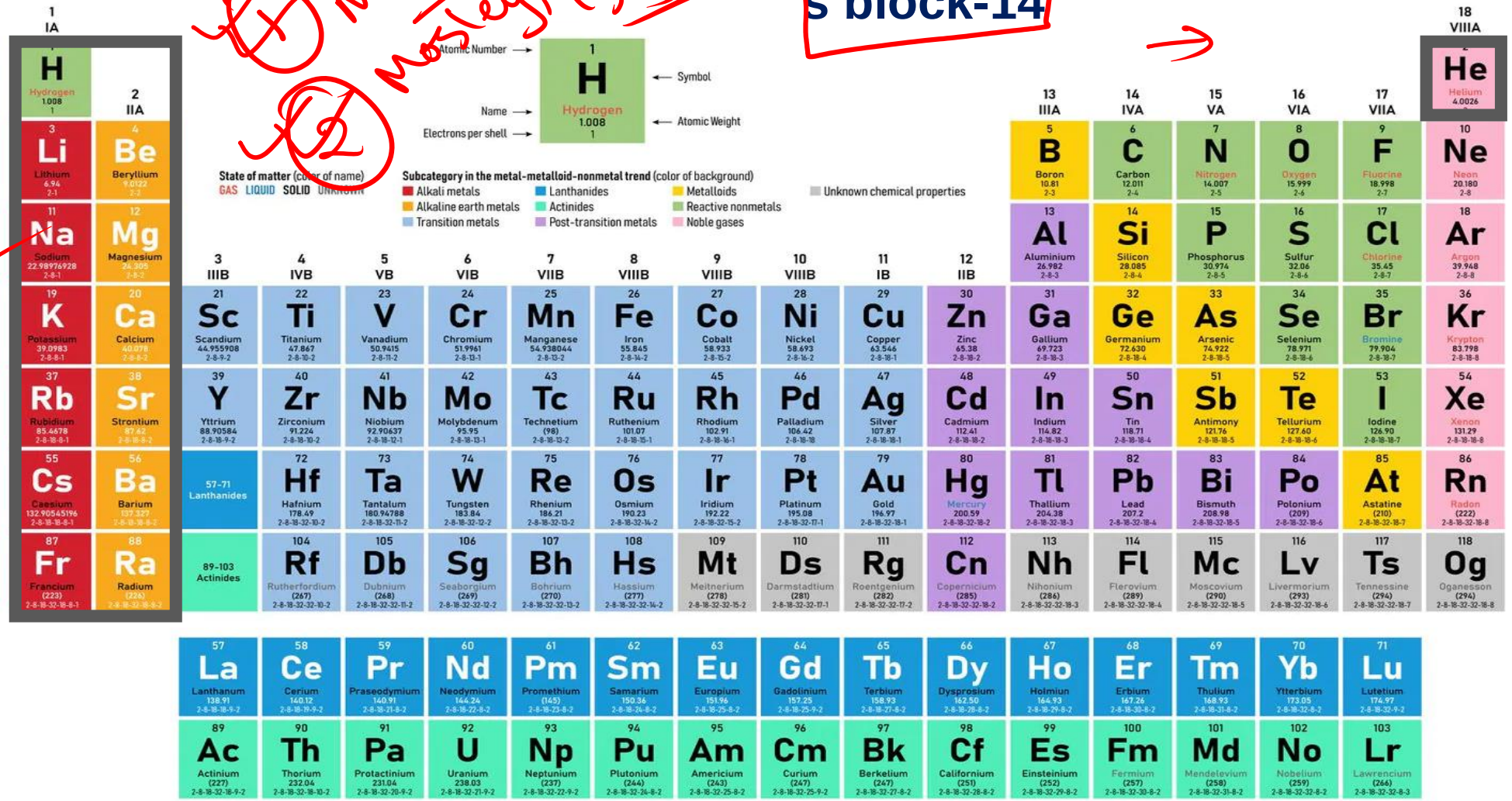
CHEMISTRY

LECTURE : C-01

CHAPTER 3 : PERIODIC PROPERTIES OF ELEMENTS



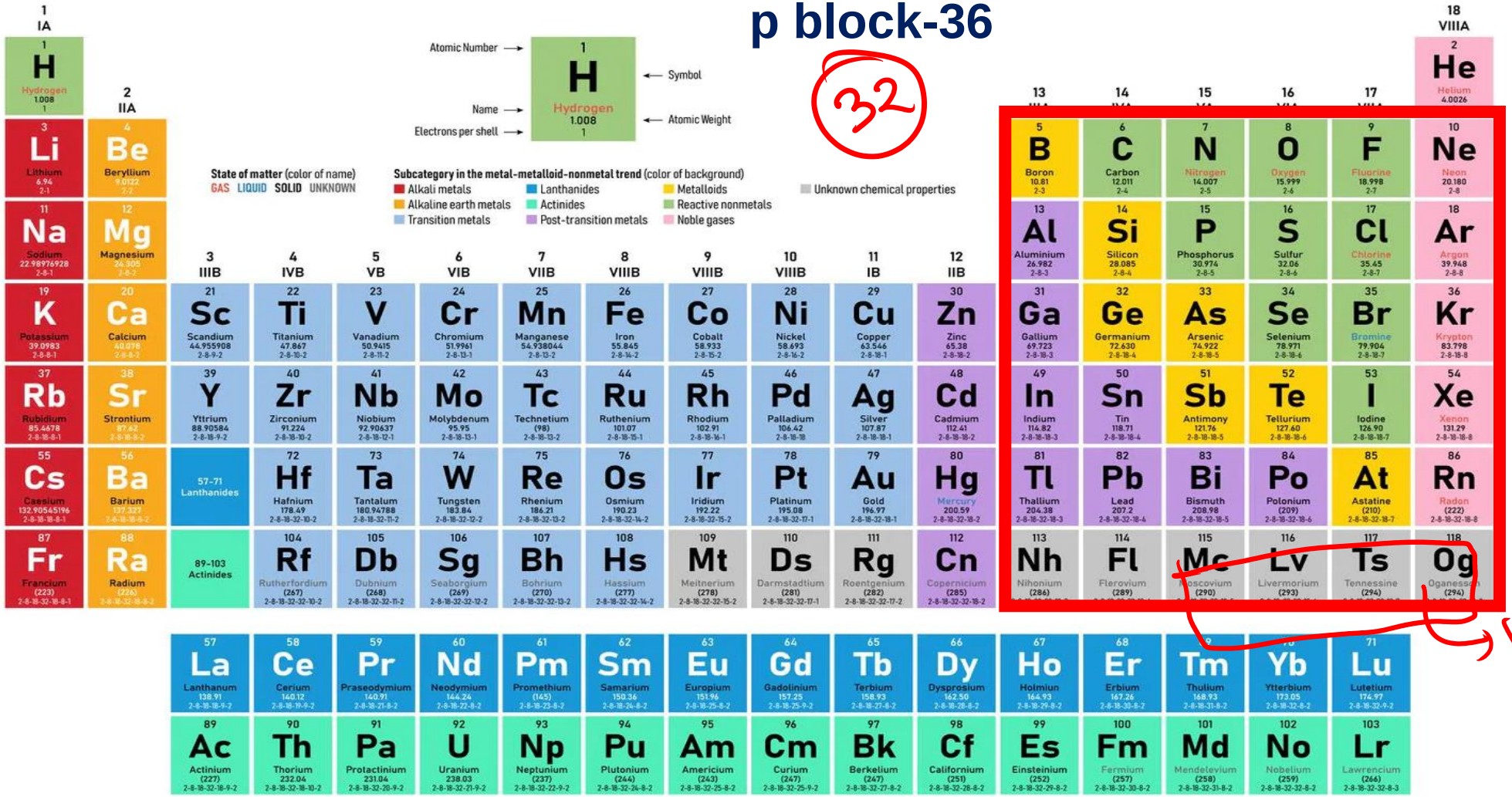
Periodic Table of the Elements



Mendeleev, 1869
Moseley, 1913
s, p, d, f
s block-14

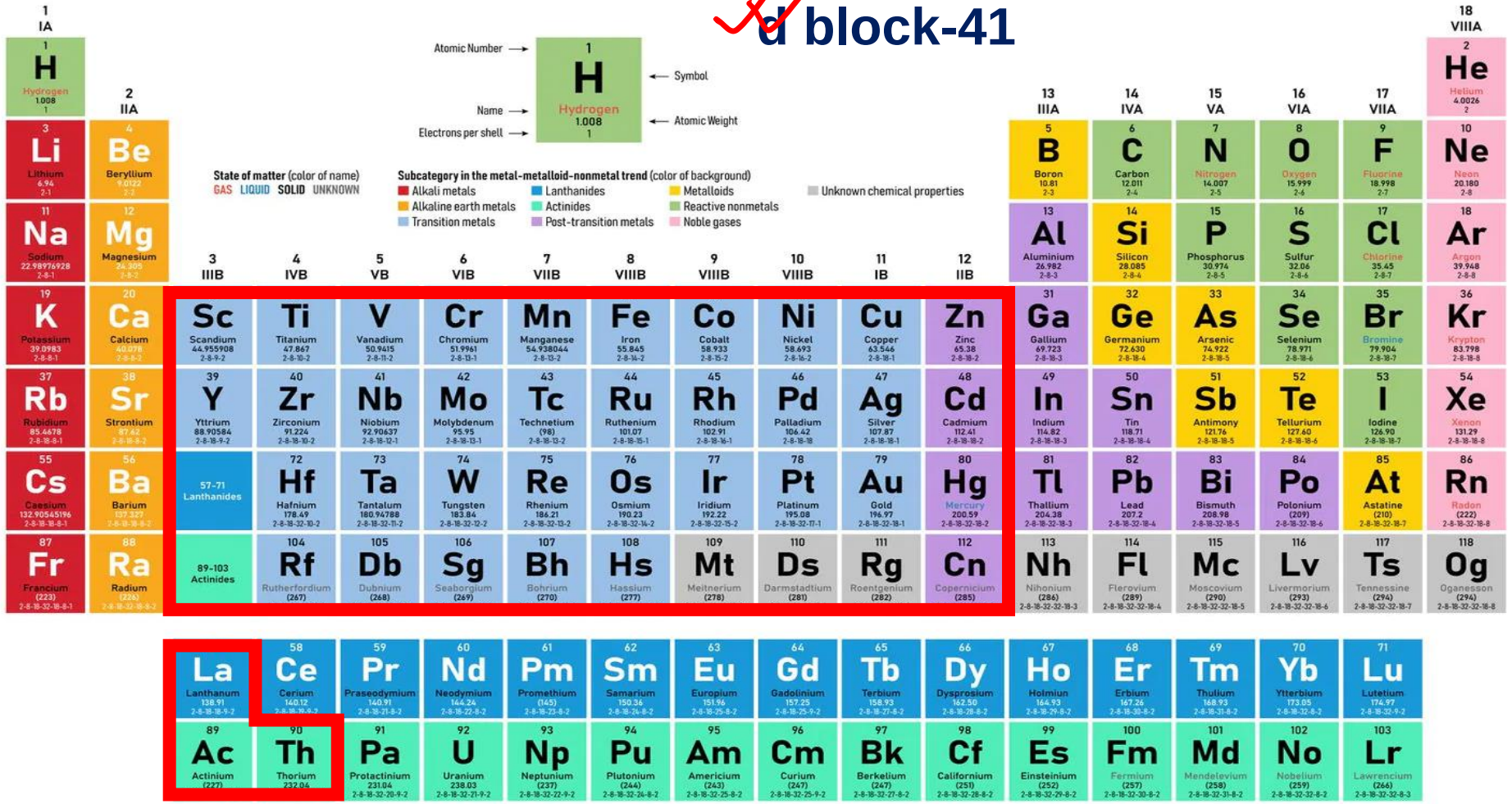
Periodic Table of the Elements

p block-36



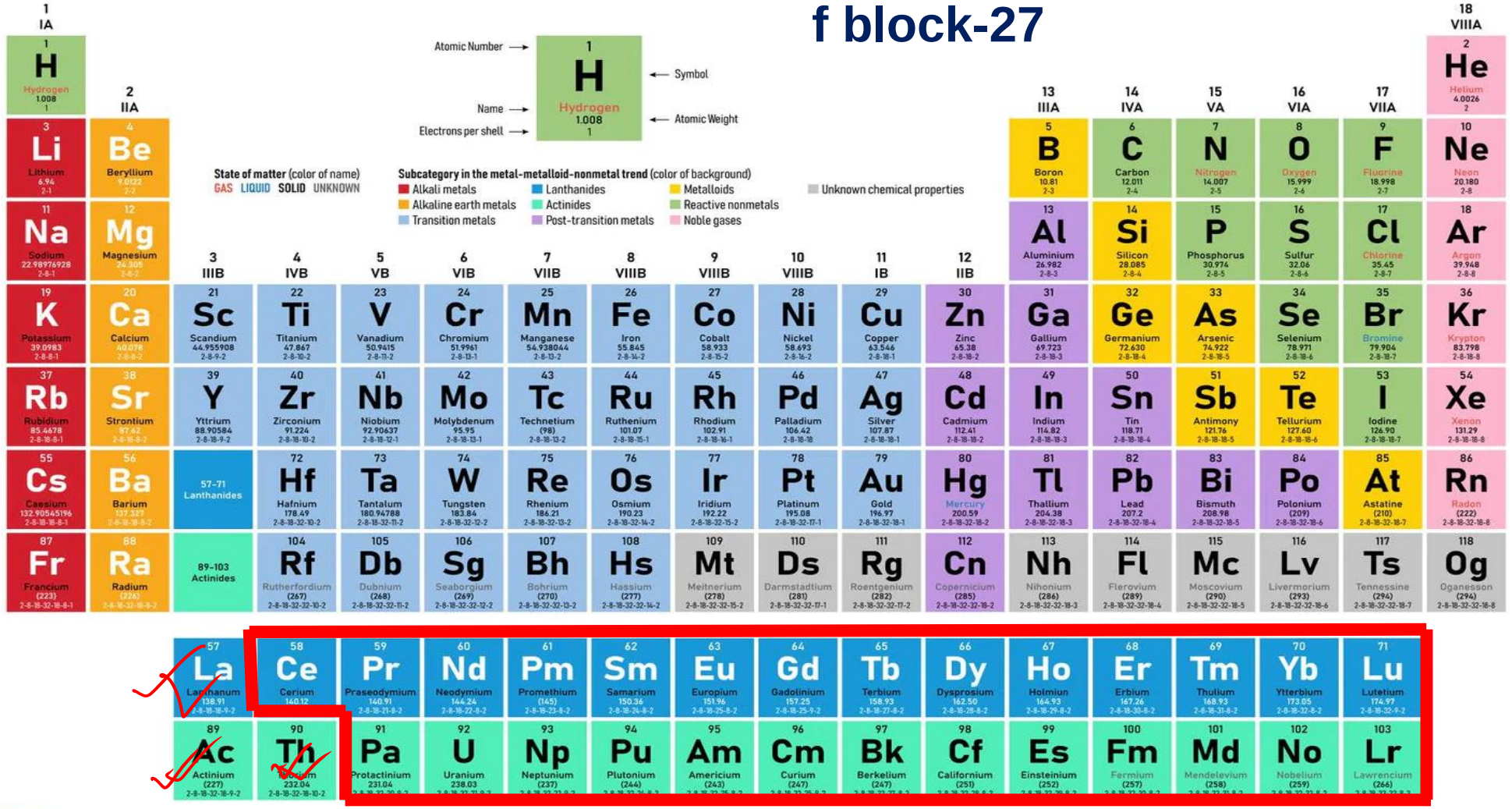
Periodic Table of the Elements

d block-41



Periodic Table of the Elements

f block-27

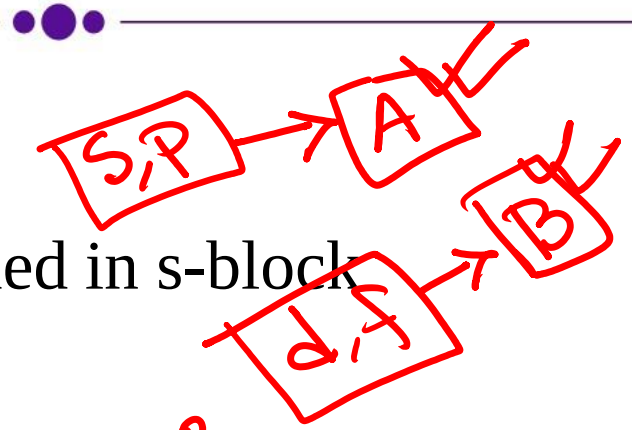


❑ s-block elements:

1(IA) & 2(IIA) and He are included in s-block

Number of elements is 14

general electronic configuration → ns^{1-2}



❑ p-block elements:

13(IIIA) to 18(Zero group)(except He) are included in p-block

Number of elements is 36

s and p block elements are representative elements → inert gas ও convert হয়ে যায়।

general electronic configuration ns^2 np^{1-6}

- **d- block elements:** transitional → d^{1-9}

  3(IIIB) to 12(IIB) are included in d-block

  Number of elements is 41

  general electronic configuration $ns^{1-2}(n-1)d^{1-10}$

- **f- block elements:** inner transitional f^{1-13}

  All elements of this block are included in (IIIB)

  Number of elements is 27

  general electronic configuration $(n-2)f^{1-14}$

Poll Question 01

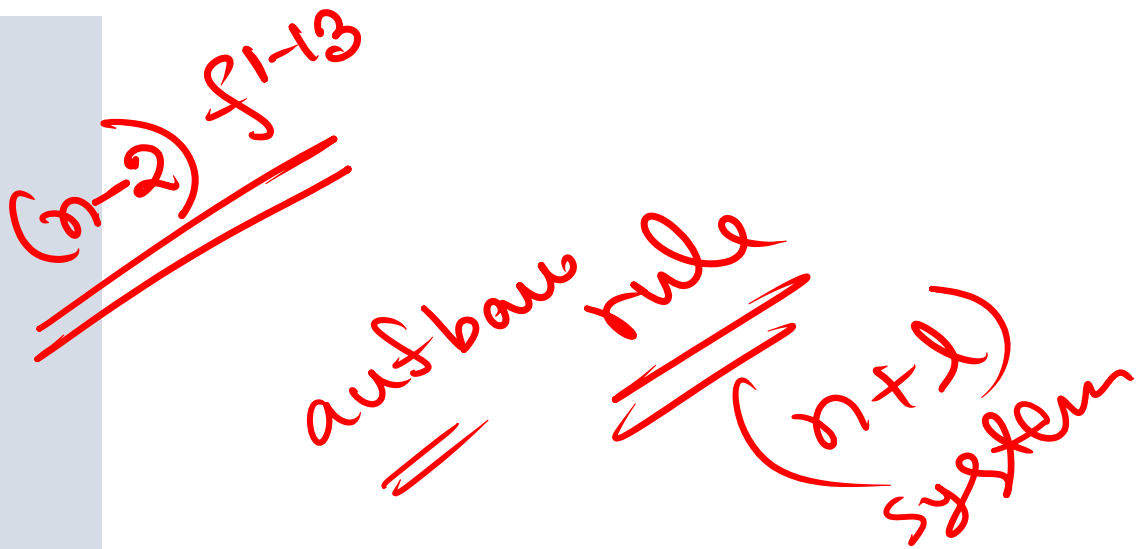
Electron Configuration of inner transition elements-

(a) (n-2)f 1-14

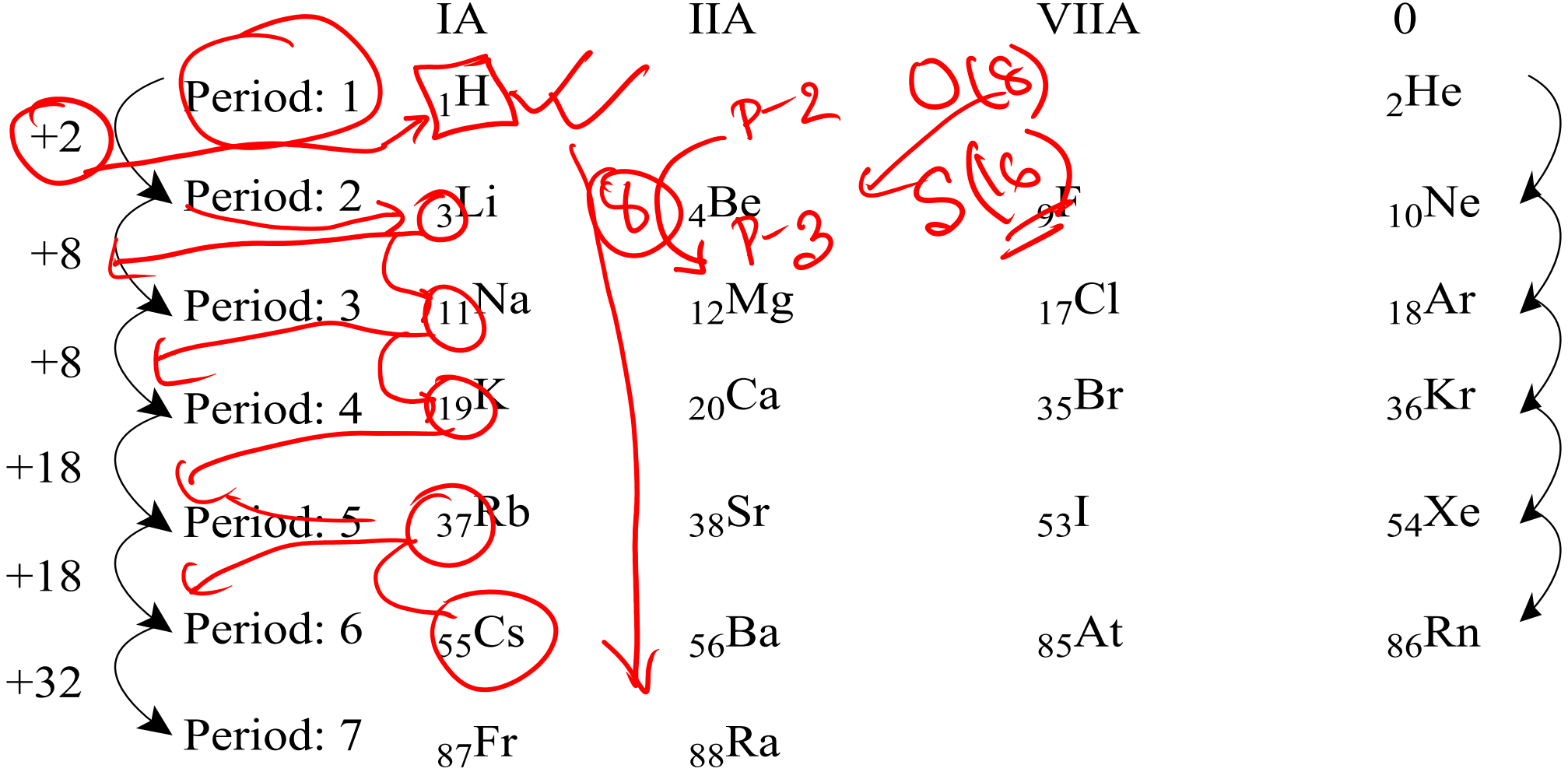
(b) (n-1)d 1-9

(c) (n-2)f 1-13

(d) (n-1)f 1-13



Magic Number → 2, 8, 8, 18, 18, 32, 32



Determination of position of elements in periodic table

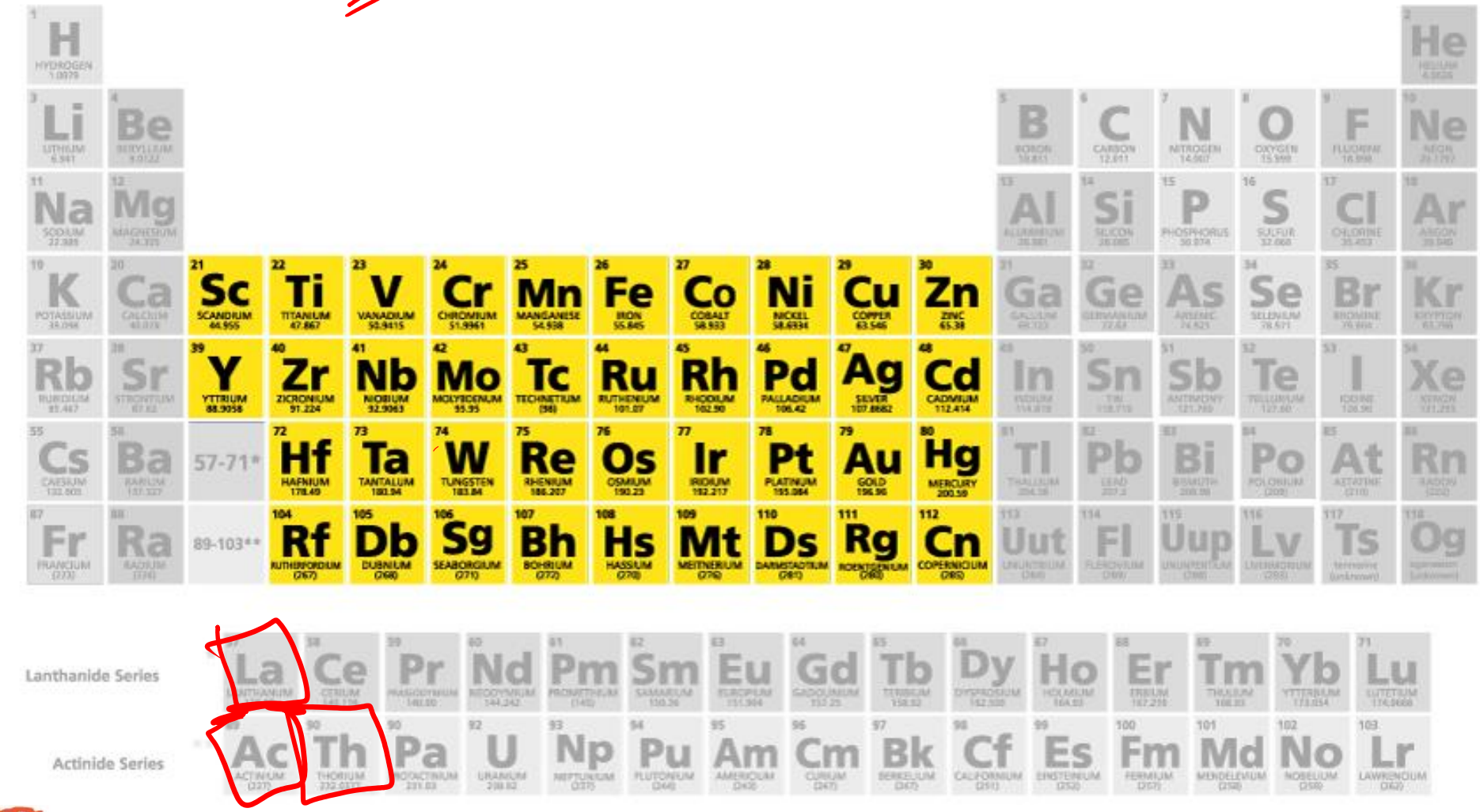
❑ Determination of group of elements

- ➢ s- block Number of electrons in outer most shell [Subgroup A]
- ➢ p- block = Total number of electrons in outer most shell (sum of e^- in ns & np) +10
- ➢ d- block Total number of electrons in (n-1) d+ns orbital [If the summation is 8, 9, 10 then the element is of Group VIII and if it is 11, 12 then of Group IB & Group IIB] [Subgroup B]
- ➢ f- block = IIIB

Determination of period of elements

The value of principal quantum number (n) is the period of that element.

d – block elements



d – block elements

general electronic configuration $(n-1)d^{1-10}ns^{1-2}$

Sc Ti V Cr Mn Fe Co Ni Cu Zn

Electron Configuration

Sc (21) – [Ar] $3d^1\ 4s^2$

Ti (22) – [Ar] $3d^2\ 4s^2$

V (23) – [Ar] $3d^3\ 4s^2$

Cr (24) – [Ar] $3d^5\ 4s^1$

Mn (25) – [Ar] $3d^5\ 4s^2$

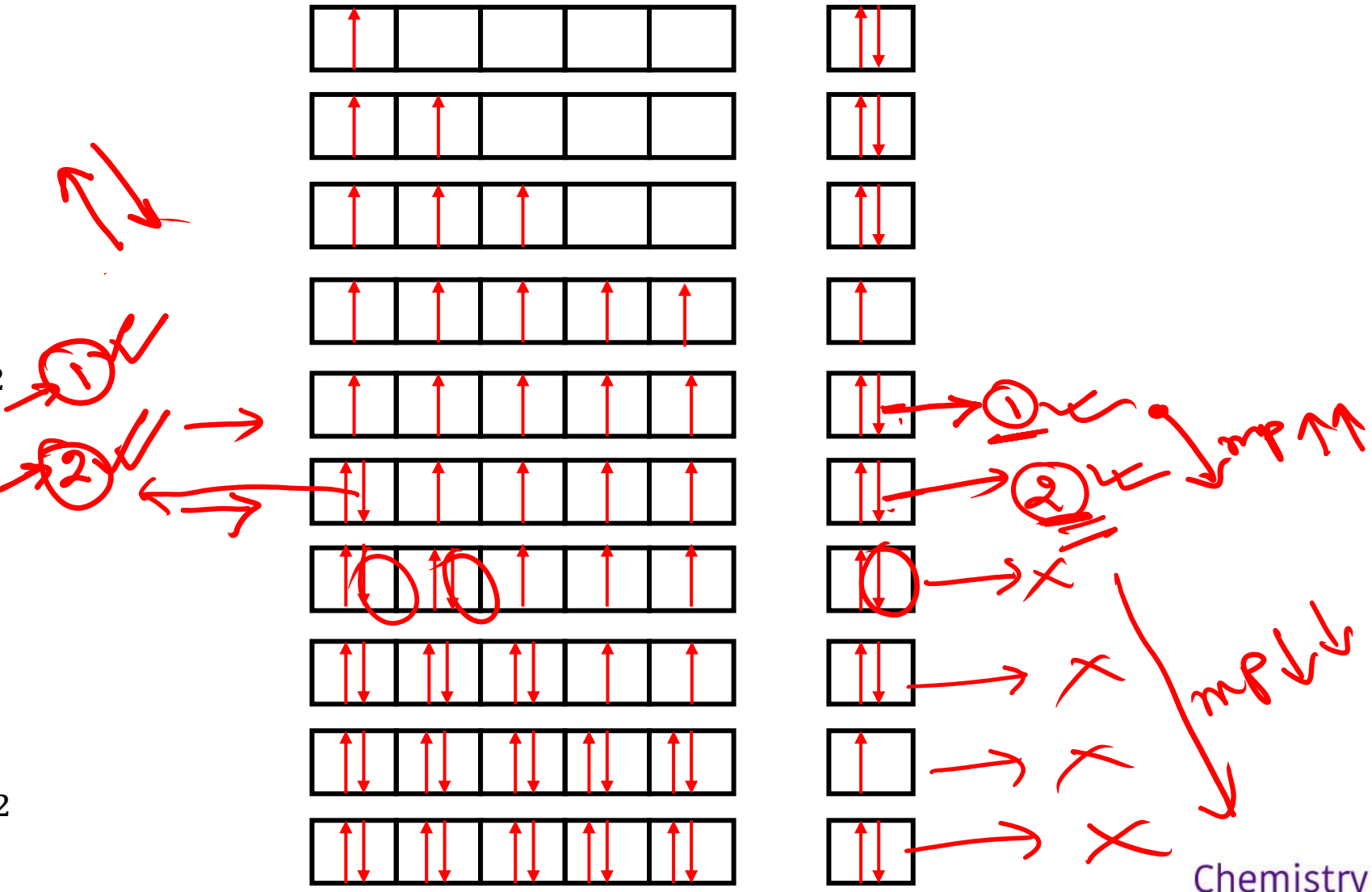
Fe (26) – [Ar] $3d^6\ 4s^2$

Co (27) – [Ar] $3d^7\ 4s^2$

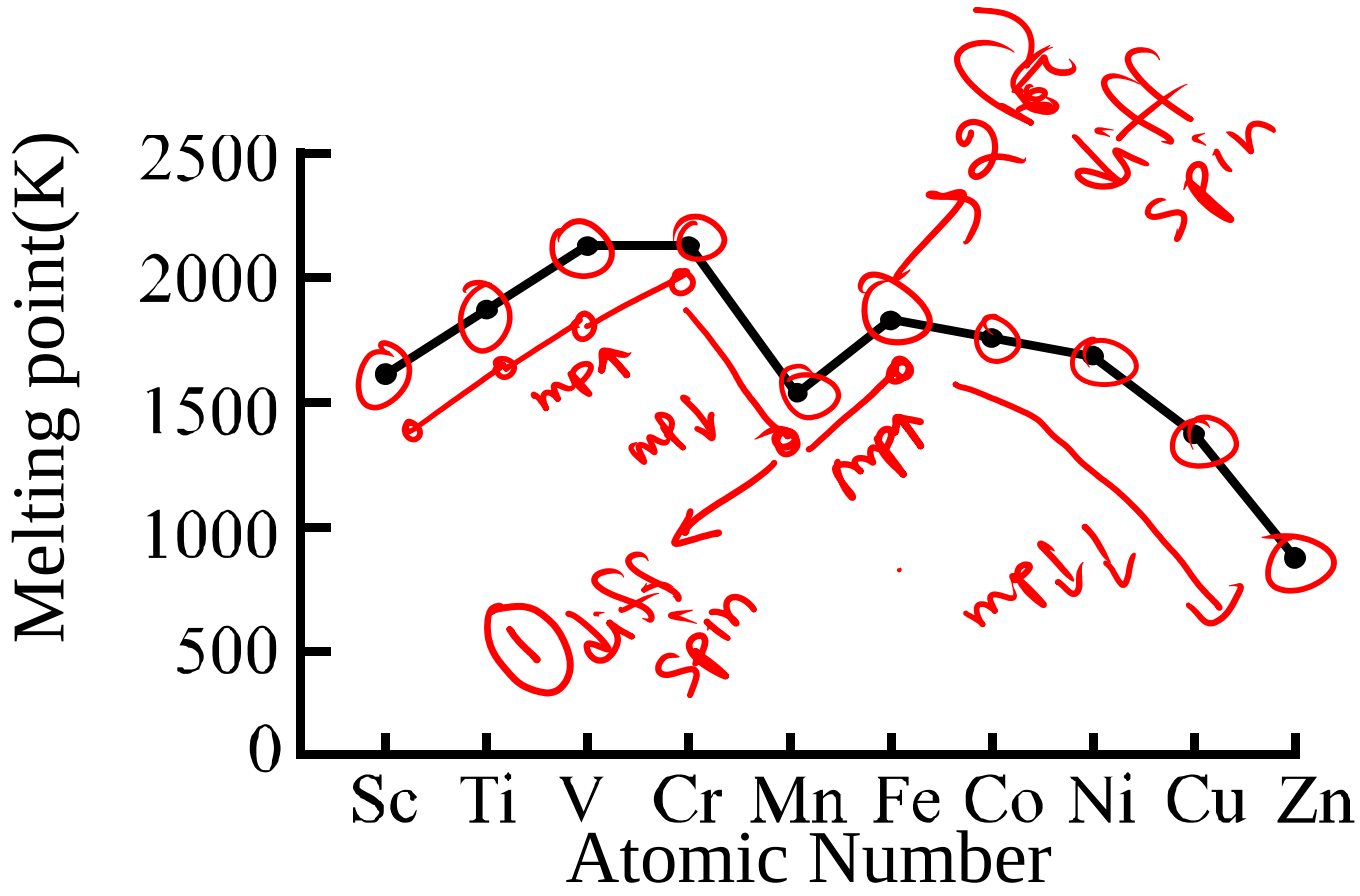
Ni (28) – [Ar] $3d^8\ 4s^2$

Cu (29) – [Ar] $3d^9\ 4s^1$

Zn (30) – [Ar] $3d^{10}\ 4s^2$

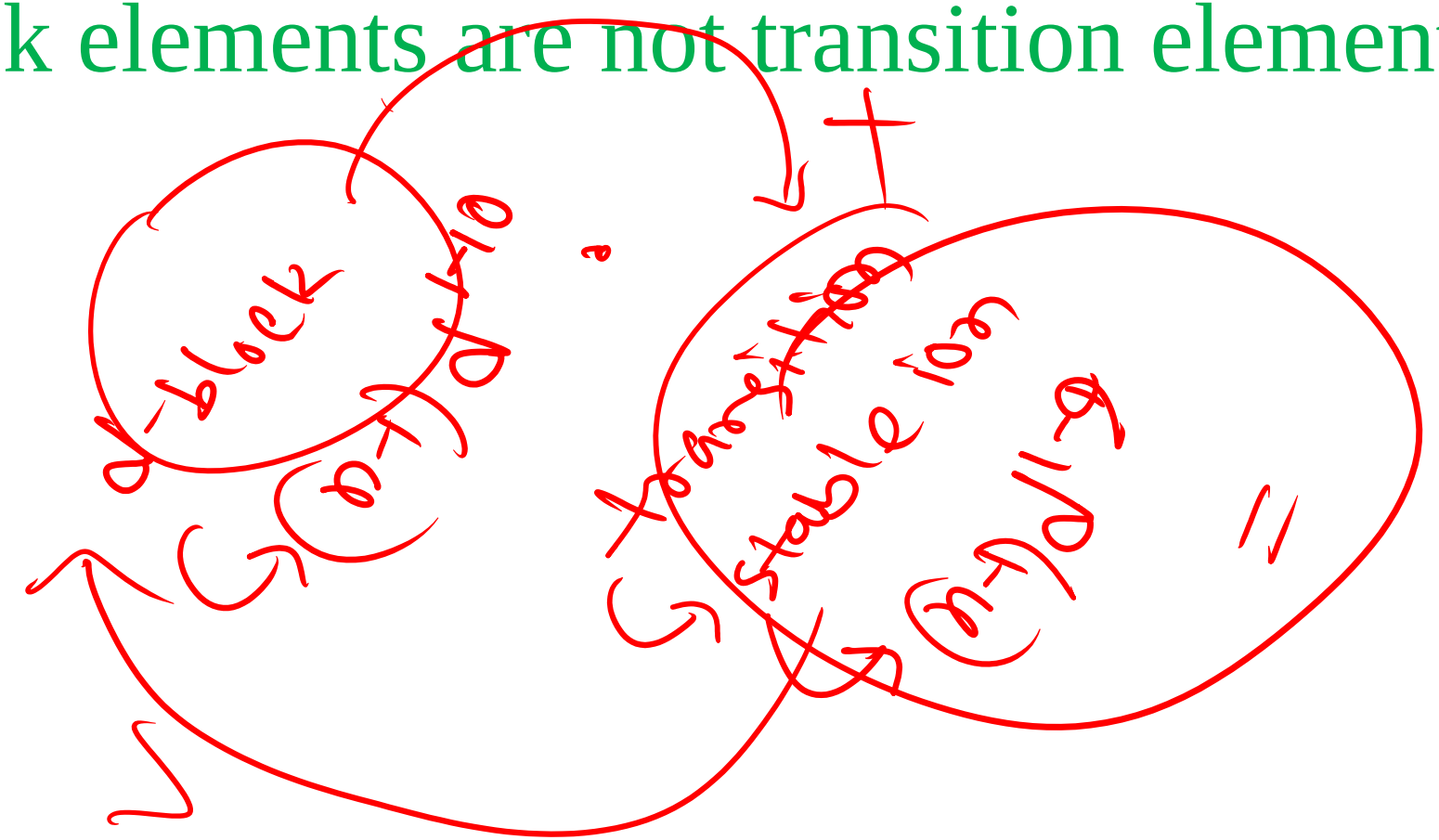


Melting point & Boiling Point



Change of melting point with gradual change of atomic number

All transition elements are d- block, but all d- block elements are not transition elements



Transition elements

- d- block element
- d- orbital of ions are partially filled with electron

Fe (26) →

Fe^{2+}

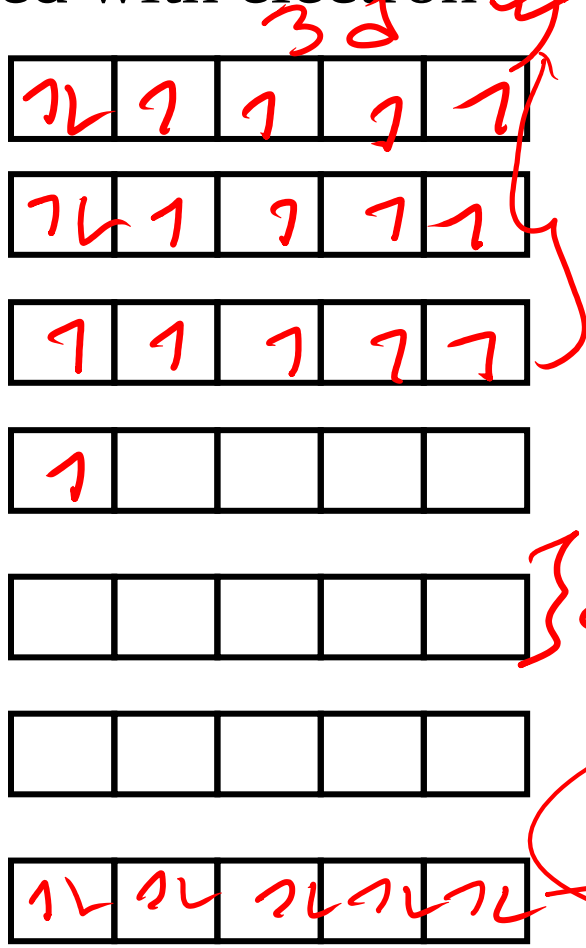
Fe^{3+}

Sc (21)

Sc^{3+}

Zn (30)

Zn^{2+} →



Poll Question 02

Electron Configuration of Fe^{2+} ion-

(a) $[Ar]4s^0\ 3d^6$

(b) $[Ar]4s^2\ 3d^4$

General Characteristics of Transition Elements

- ❑ Variable oxidation state
- ❑ Act as catalyst
- ❑ Form complex ions
- ❑ Form colored compounds
- ❑ Exhibit paramagnetism

Variable oxidation state

Elements	Electronic Config. Of Outer most shell	Oxidation State
Sc	$3d^1 4s^2$	+3
Ti	$3d^2 4s^2$	+3, +4
V	$3d^3 4s^2$	+3, +5
Cr	$3d^5 4s^1$	+2, +3, +6
Mn	$3d^5 4s^2$	+2, +3, +4, +6, +7
Fe	$3d^6 4s^2$	+ 2, +3
Co	$3d^7 4s^2$	+2, +3,
Ni	$3d^8 4s^2$	+2, +4
Cu	$3d^{10} 4s^1$	+1, +2
Zn	$3d^{10} 4s^2$	+2

Variable oxidation state

Electron Configuration

Sc (21) – [Ar] $3d^1\ 4s^2$

Ti (22) – [Ar] $3d^2\ 4s^2$

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Mn (25) – [Ar] $3d^5\ 4s^2$

Fe (26) – [Ar] $3d^6\ 4s^2$

Co (27) – [Ar] $3d^7\ 4s^2$

Ni (28) – [Ar] $3d^8\ 4s^2$

Cu (29) – [Ar] $3d^{10}\ 4s^1$

Zn (30) – [Ar] $3d^{10}\ 4s^2$

Act as catalyst

Fe is used as catalyst in the manufacture of NH_3 by Haber Bosch process.

$$N_2(g) + 3H_2(g) \xrightarrow[550°C]{Fe} 2NH_3(g)$$

Ni is used as catalyst for transforming unsaturated hydrocarbons into a saturated one.

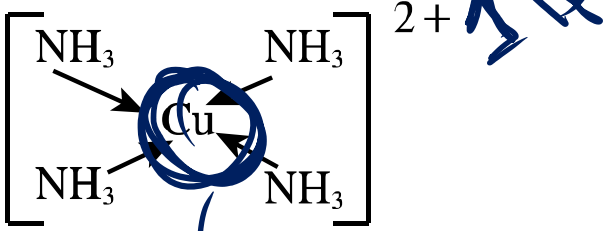
$$CH_2 = CH_2 + H_2 \xrightarrow[200°C]{Ni} CH_3 - CH_3$$

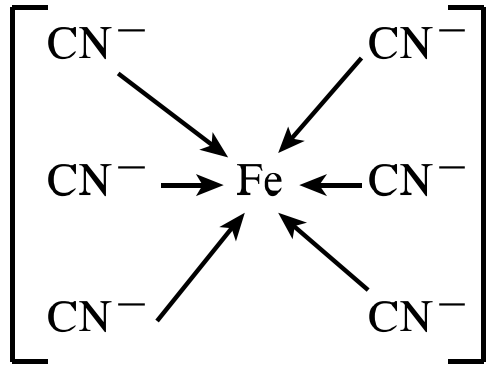
In the dehydrogenation reaction for preparing ethanal from ethanol, Cu is used as catalyst.

$$CH_3CH_2OH \xrightarrow[300°C]{Cu} CH_3CHO + H_2$$

Formation & hybridization of complex compounds

$[Cu(NH_3)_4]SO_4$





$K_3[Fe(CN)_6]$

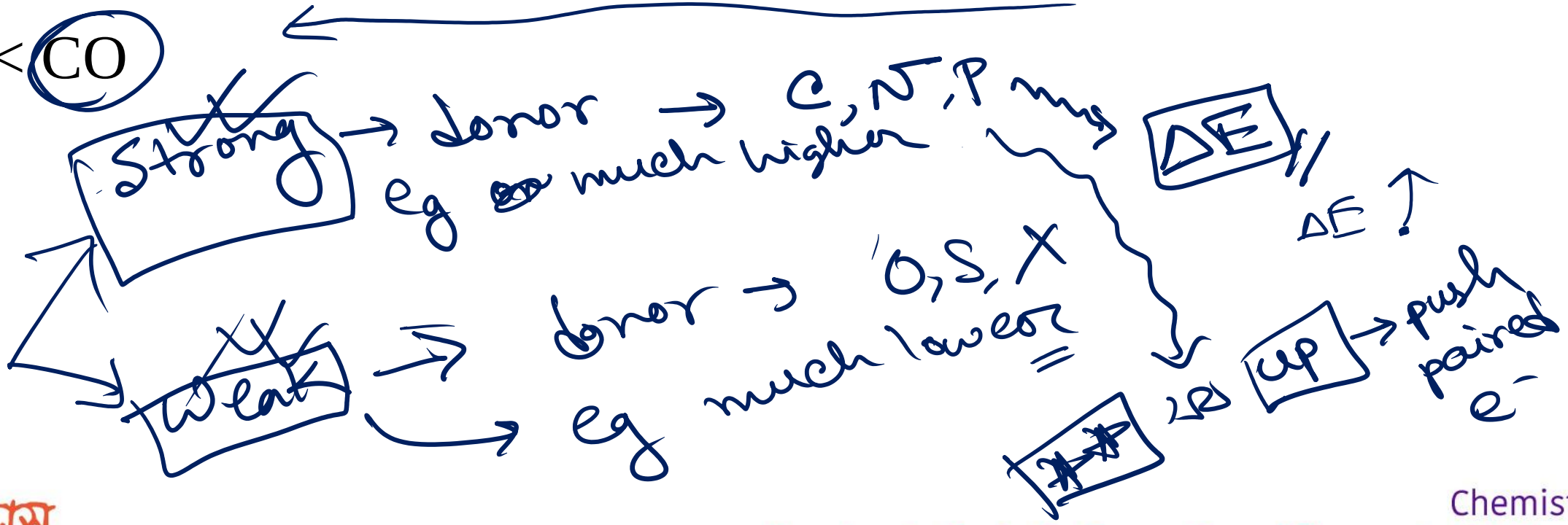
Spectrochemical Series

ligand type
↳ lp donor

$I^- < Br^- < S^{2-} <$ SCN$^-$ (S–bonded) $< Cl^- < N_3^- < F^- < OH^- <$

$O^{2-} < H_2O < <$ NCS$^-$ (N–bonded) $< CH_3CN < NH_3 < NO_2^- <$

$CN^- <$ CO



Nomenclature of Complex Compounds

Ligand name & number + Name of central transition element + O. N. of central transition metal

Positive Complex Ion:

Ligand name & number + central transition element(O.N.) + Anion

$[Cu(NH_3)_4]SO_4$ tetra ammin cupric / copper (II) sulphate

Negative Complex Ion:

Cation + Ligand name & number + central transition element (ate)

$K_3[Fe(CN)_6]$ potassium hexacyano ferrate (III)

Nomenclature of Complex Compounds

Ligand name & number

A prefix indicating the number must be added behind every ligand

Ligand	Name	Number of Ligands	Prefix
OH^-	hydroxo	1	–
NH_3	**Ammine	2	di
H_2O	Aqua	3	tri
Cl^-	Chloro	4	tetra
CN^-	*Cyano		
CNS^-	thiocyanato		
NO/NO^+	*Nitroso		
O^{2-}	oxo		
CO	*Carbonyl		

Poll Question 03

Which one is Penta aqua Nitroso Ferrous Sulphate?

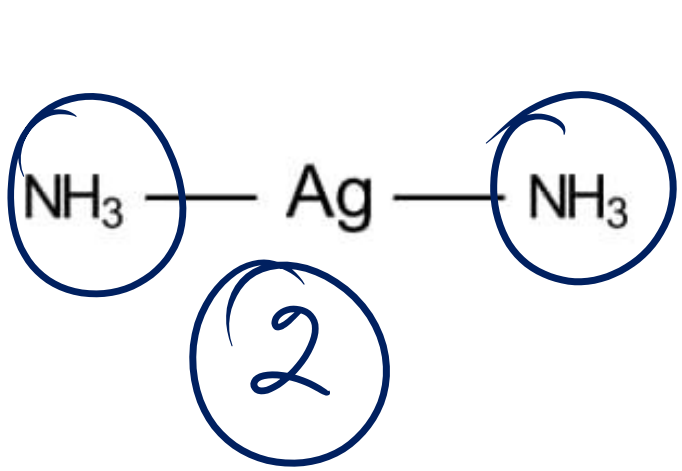
(a) $[Fe(NO)(OH)_5]SO_4$

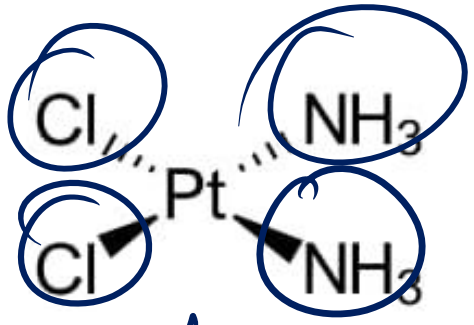
(b) $[Fe(NO_2)(H_2O)_5]SO_4$

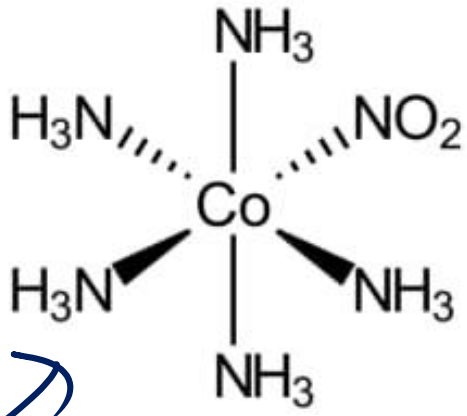
(c) $[Fe(NO)(H_2O)_5]SO_4$

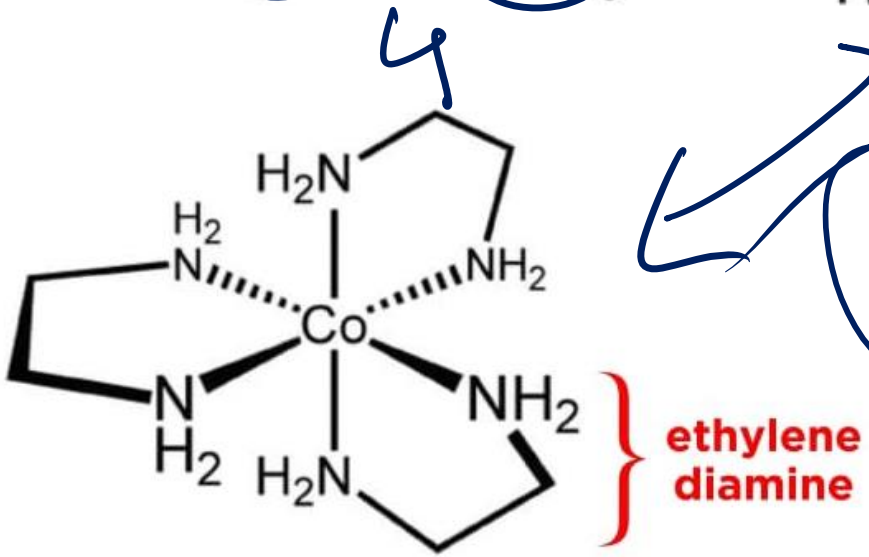
(d) $[Fe(NO)_2(H_2O)_5]SO_4$

Co-ordinate number

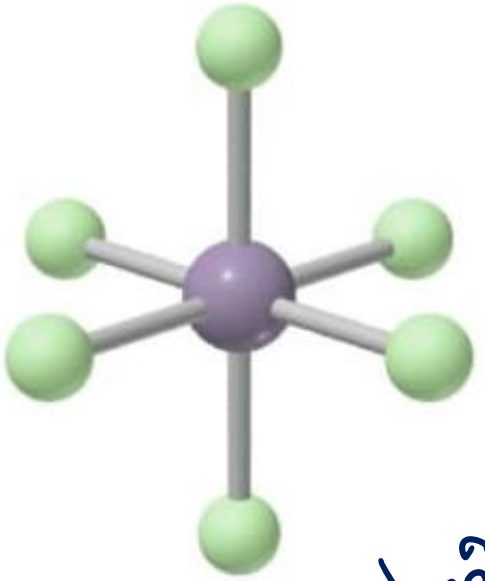




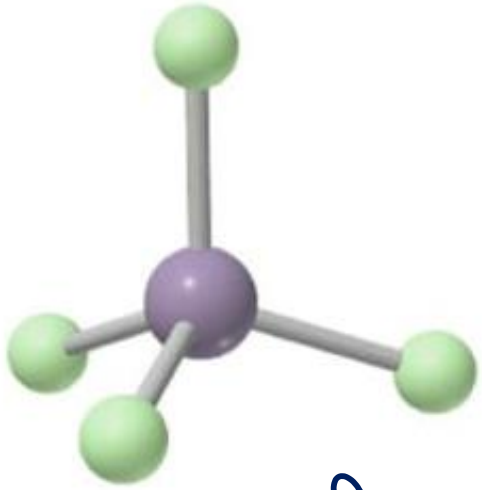




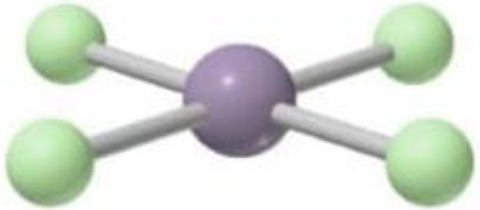
Shape of Complex Compounds



d^2sp^3 / sp^3d^2
octahedral



sp^3
tetrahedral

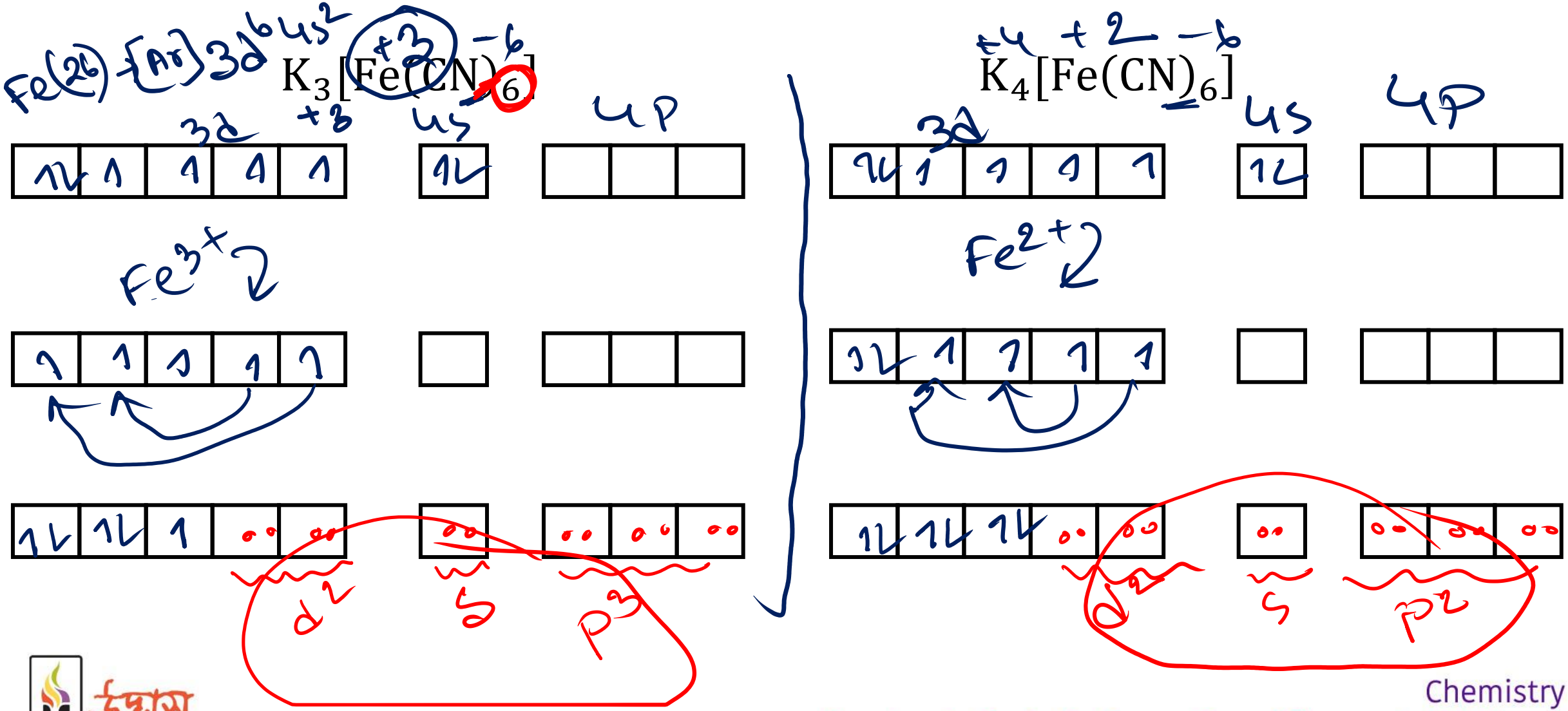


dsp^2 / sp^2d
square planar

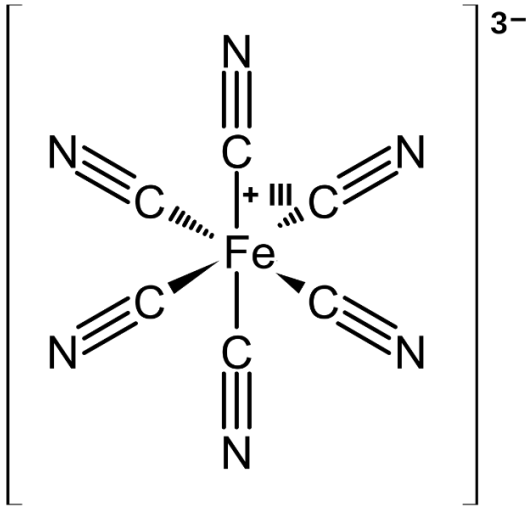
Formation & hybridization of complex compounds (V.B.T)

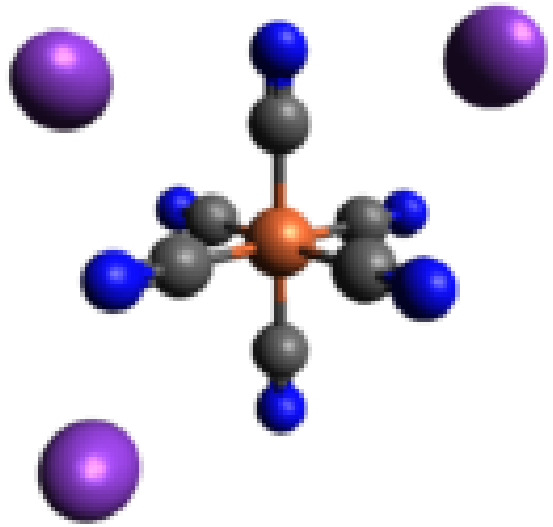
$K_3[Fe(CN)_6]$

$K_4[Fe(CN)_6]$

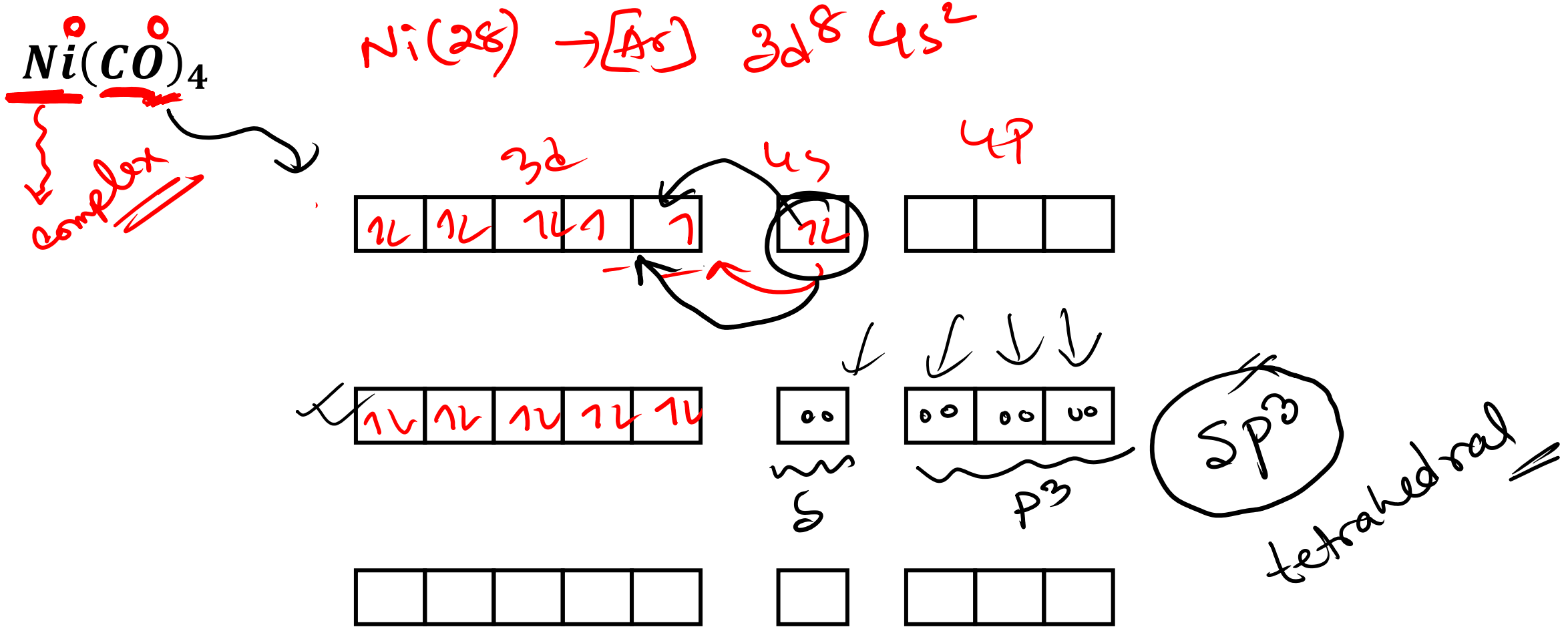


Formation & hybridization of complex compounds (V.B.T)





Formation & hybridization of complex compounds (V.B.T)

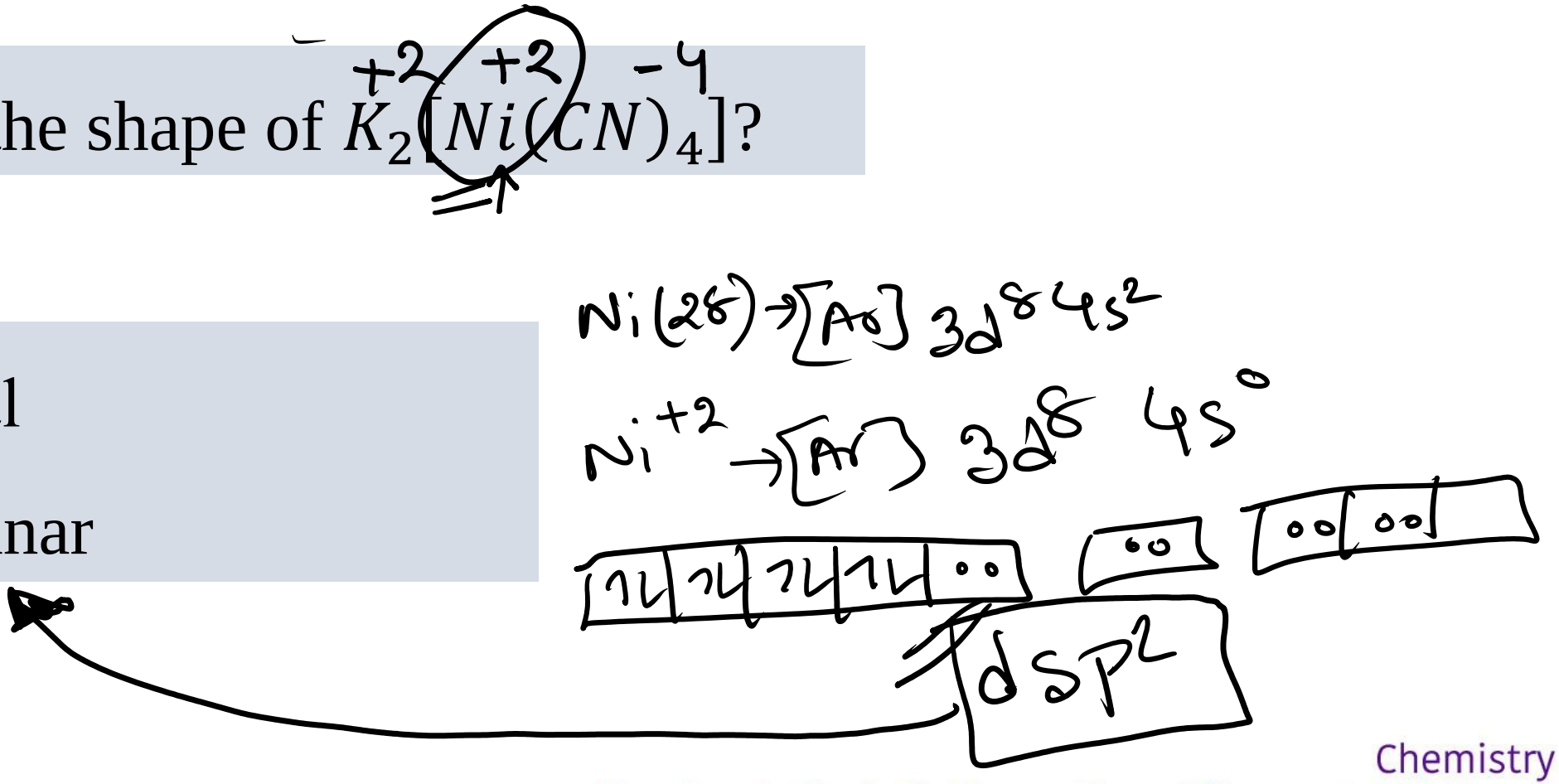


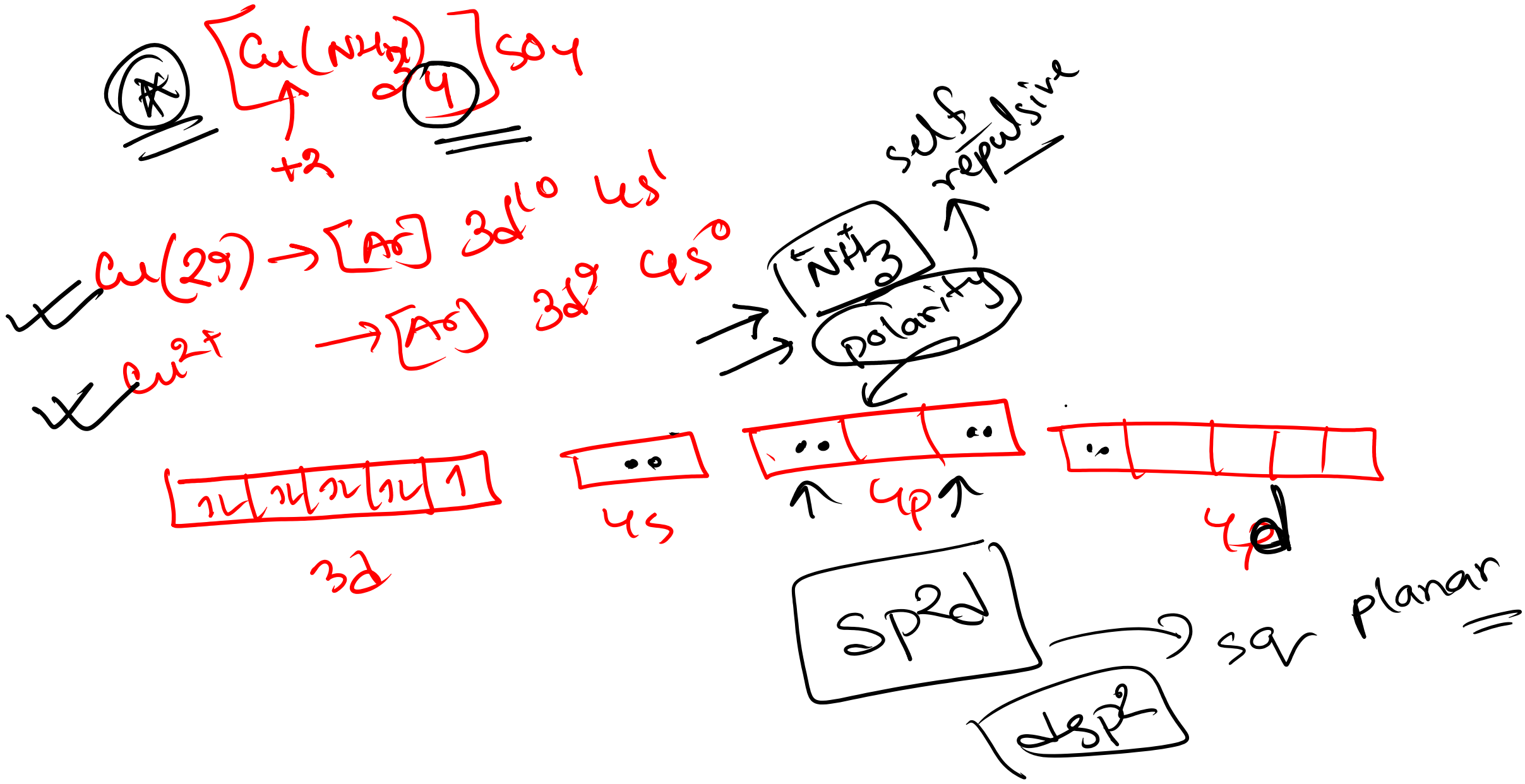
Poll Question 04

What will be the shape of $K_2[Ni(CN)_4]$?

(a) Tetrahedral

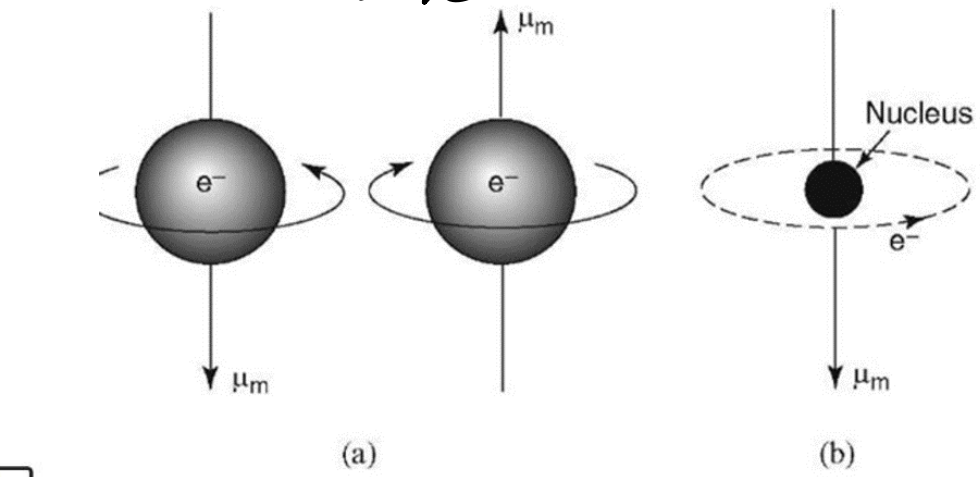
(b) Square Planar

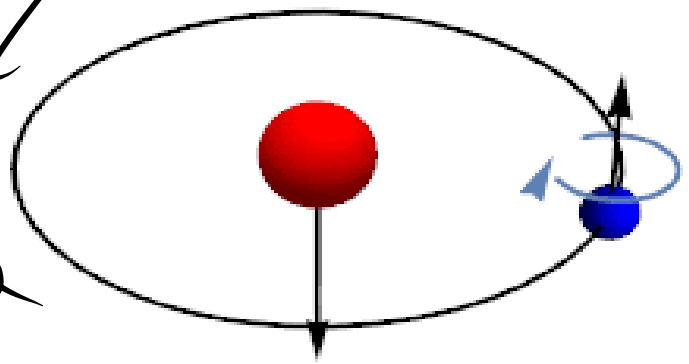



[Cu(NH3)4]SO4
+2
Cu(29) → [Ar] 3d10 4s1
Cu2+ → [Ar] 3d9 4s0
NH3
polarity
self repulsive
3d
4s
4p
4d
sp3d
dsp2
sq planar

Magnetic properties (V.B.T)

- Ferromagnetic substance → crystal structure
- Paramagnetic substance → d → partially fixed more
- Dia magnetic substance → d → filled

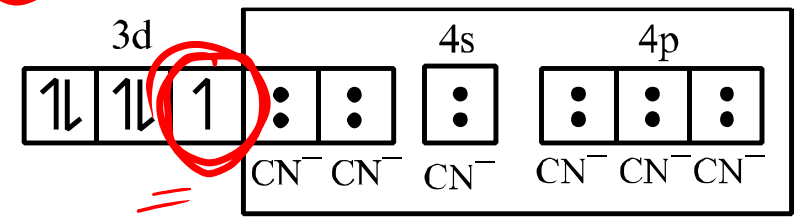




Magnetic properties (V.B.T)

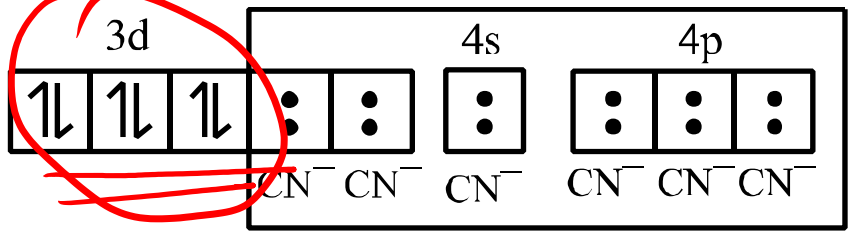
$K_3[Fe(CN)_6]$ → (P)

d^2sp^3

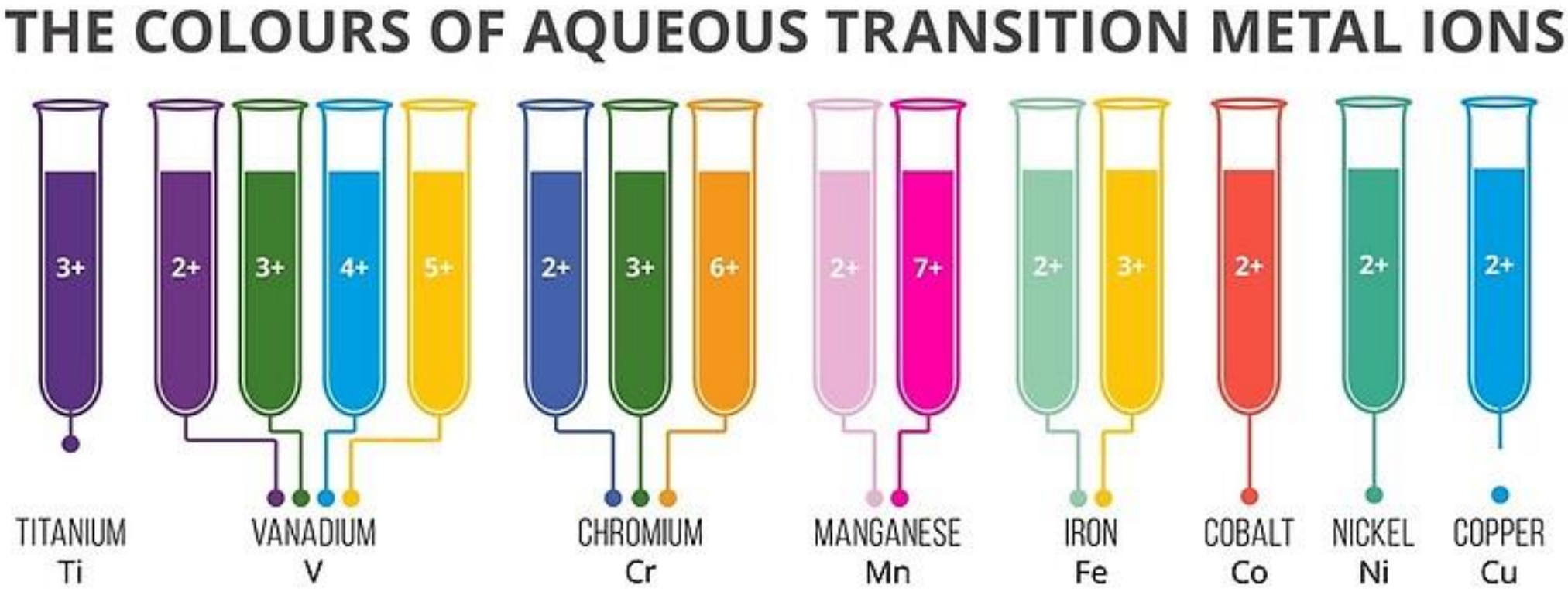


$K_4[Fe(CN)_6]$ → (D)

d^2sp^3

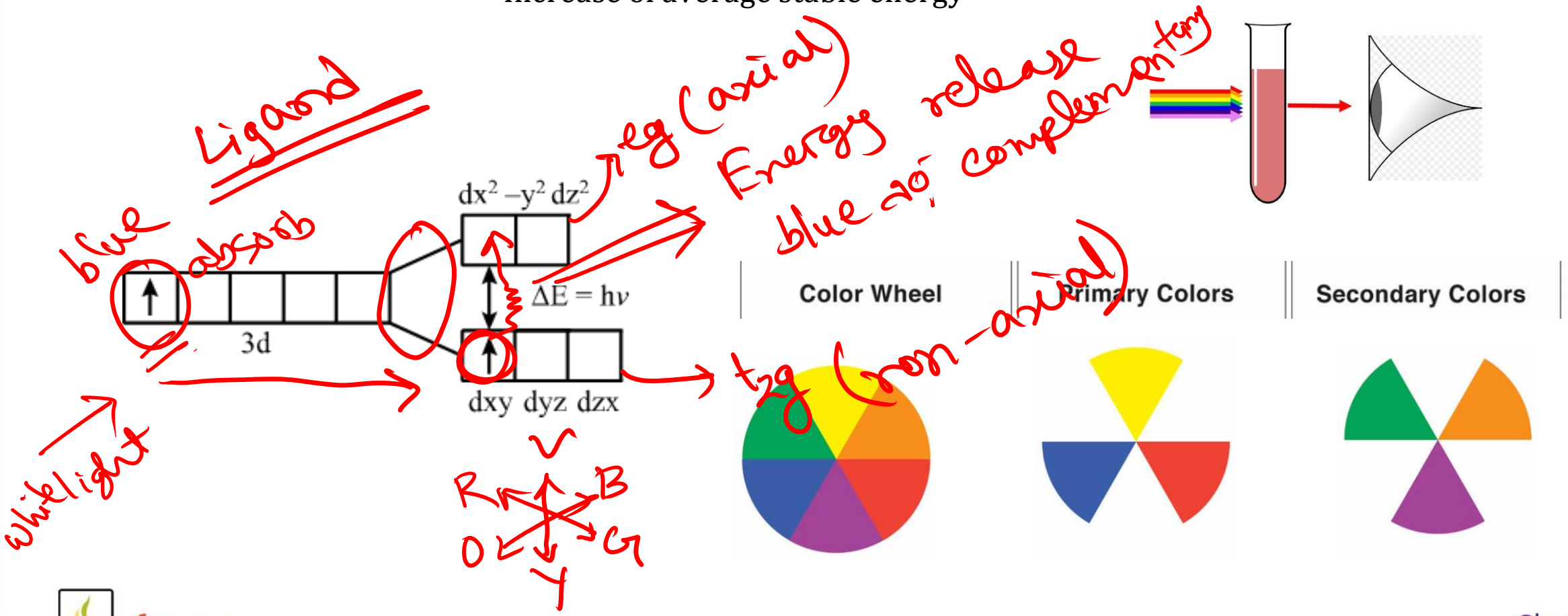


Formation of colorful compound (C.F.T)



Formation of colorful compound (C.F.T)

Degenerate condition $\xrightarrow[\text{Increase of average stable energy}]{\text{Effect of ligand}}$ Non-degenerate condition



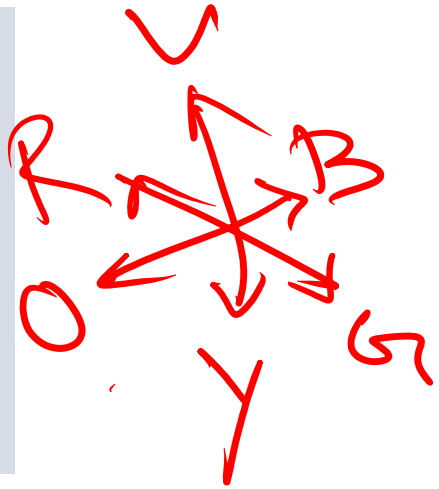
Poll Question 05

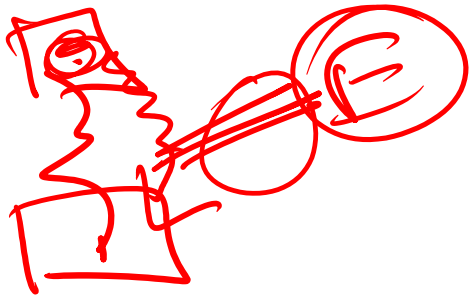
If a compound absorbs Blue light it's color will be-

(a) Green

(b) Orange

(c) Purple

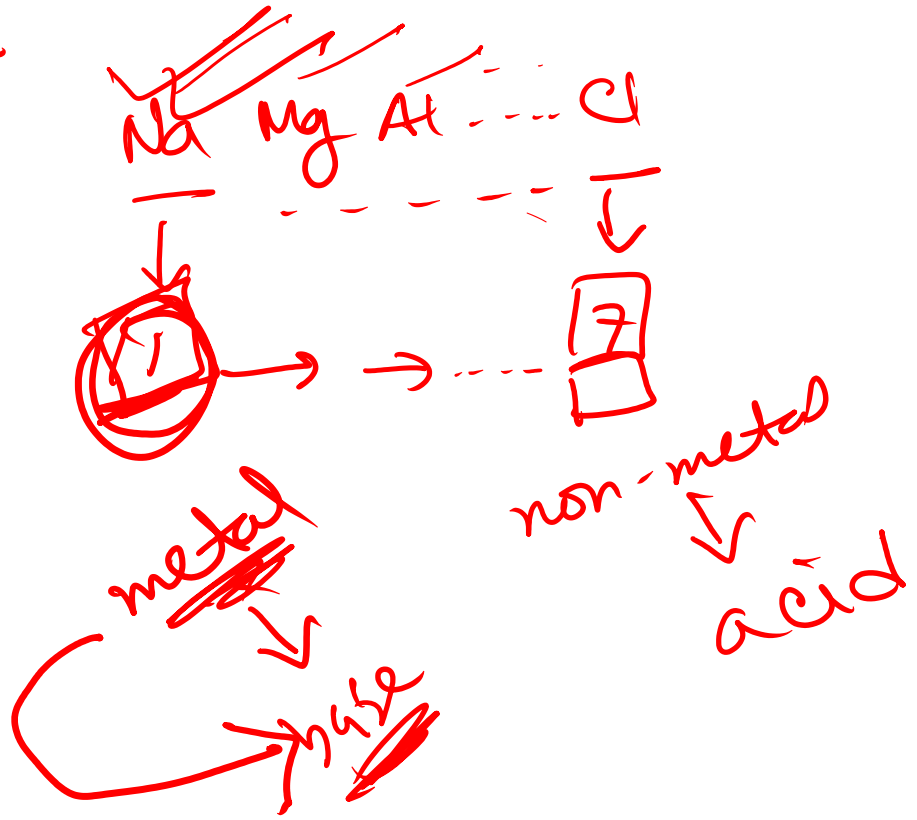




Periodic properties

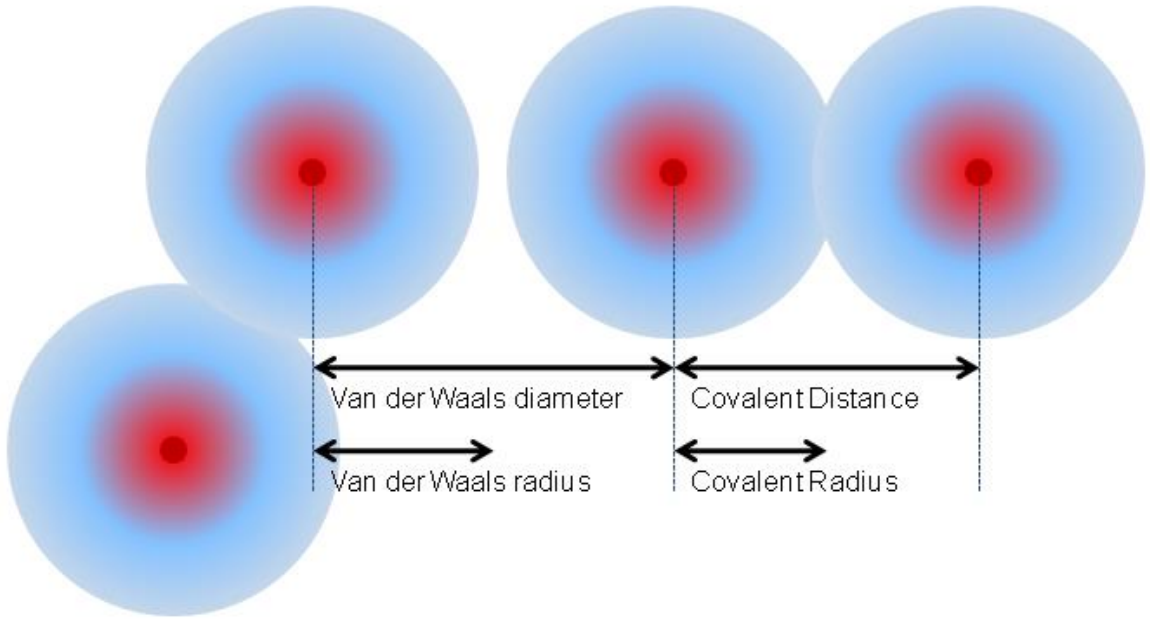
left to right

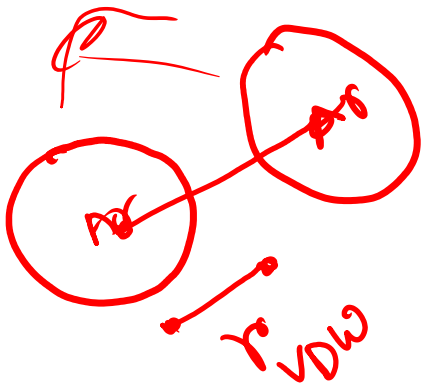
- Atomic & ionic radius → decreased
- Ionization energy → increase
- Electron affinity → increased
- Electronegativity → increase
- Metallic Properties → decrease
- Acidity → increase

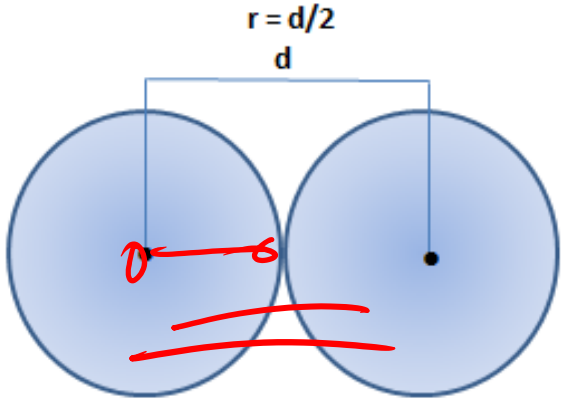


Atomic Radius

- Covalent radius
- Van Der Waals radius
- Metallic radius





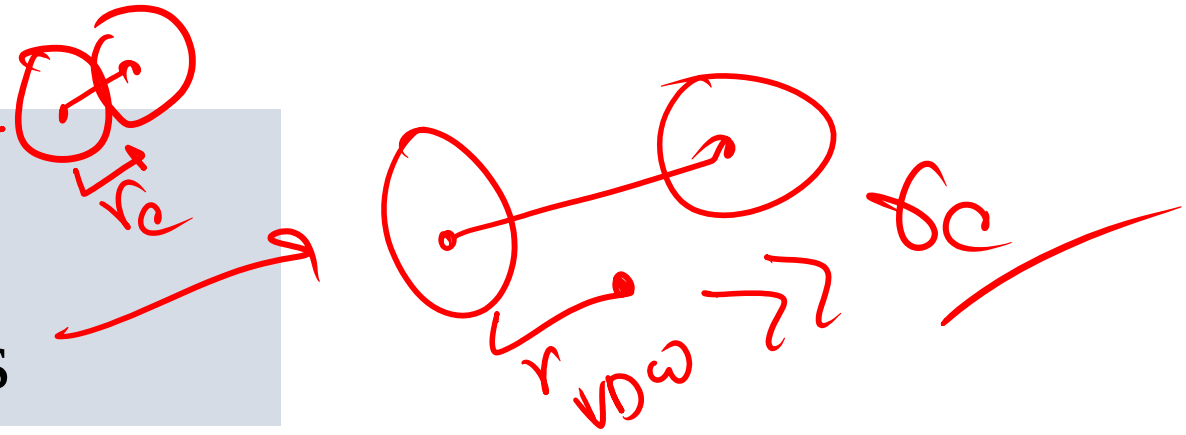


Poll Question 06

Which one is greater than the other?

(a) Covalent radius

(b) Van Der Waals radius



Ionic Radius

In any ion the distance up to which their nuclear attraction force is felt is called ionic radius.

Ions of third period	Na^+	Mg^{2+}	Al^{3+}
electron number	10	10	10
ionic radius(nm)	0.095	0.065	0.050
size			

Group	ion	ionic radius (nm)	size of ion	Group	ion	ionic radius (nm)	size of ion
IA	Li^+	0.060		VIIA	F^-	0.136	
	Na^+	0.095			C^-	0.181	
	K^+	0.133			Br^-	0.195	
	Rb^+	0.148			I^-	0.216	
	Cs^+	0.162					

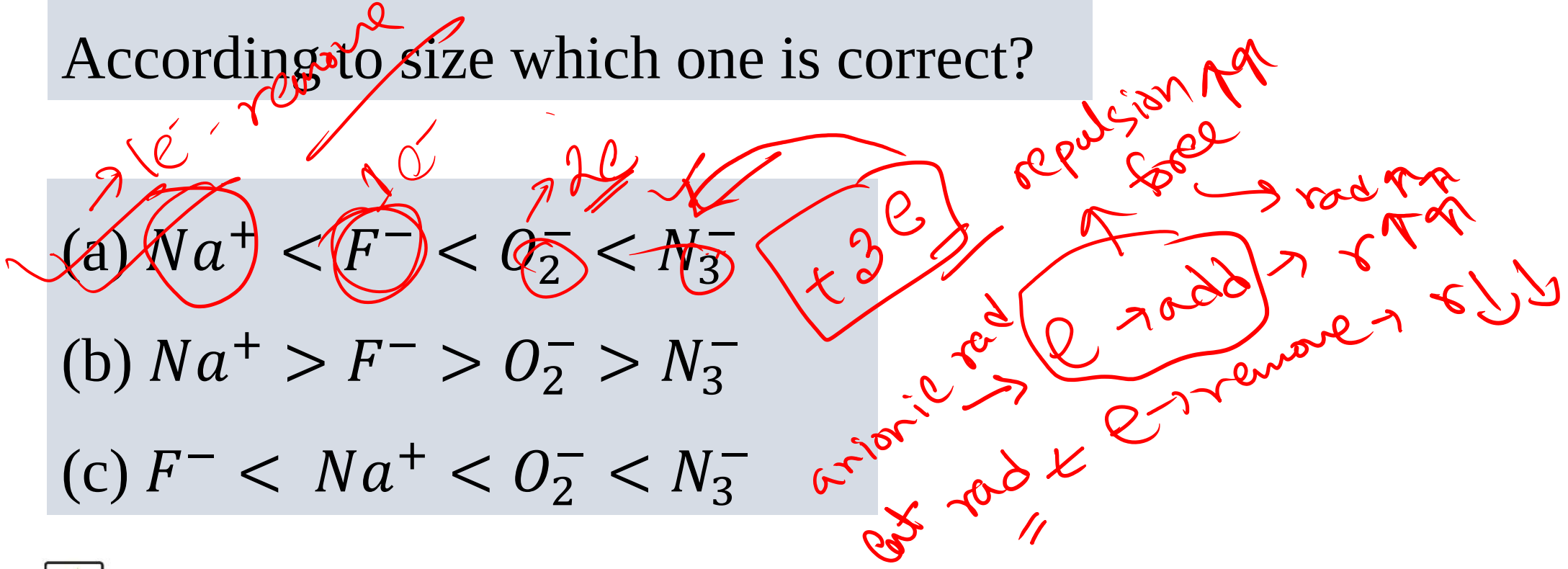
Poll Question 07

According to size which one is correct?

(a) $Na^+ < F^- < O_2^- < N_3^-$

(b) $Na^+ > F^- > O_2^- > N_3^-$

(c) $F^- < Na^+ < O_2^- < N_3^-$



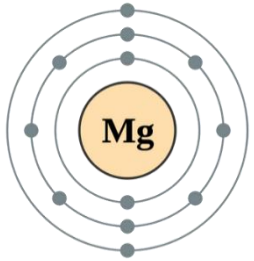
Ionization energy

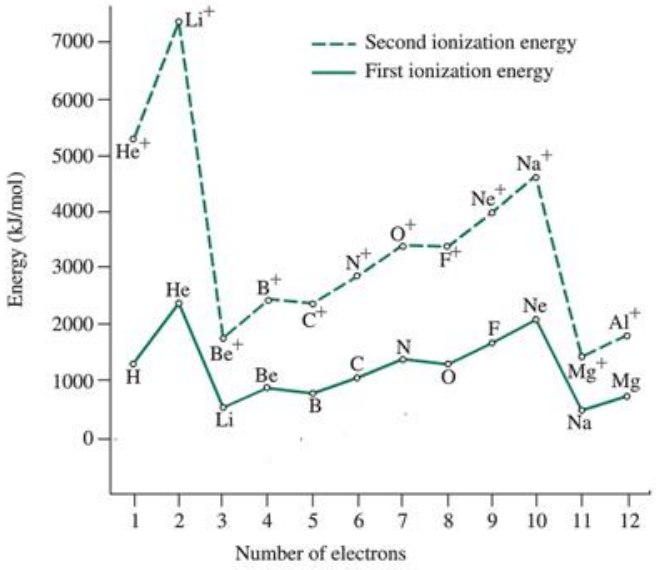
The ionization energy or ionization potential of an element means the amount of energy needed to turn 1 mole of gaseous atoms to 1 mole of positive ion by removing 1 mole electron from each atom.

$$Mg(g) \longrightarrow Mg^{+}(g) + e^{-} \quad ; \Delta IP_1 = 738 \text{ kJ mol}^{-1}$$

$$Mg^{+}(g) \longrightarrow Mg^{++}(g) + e^{-} \quad ; \Delta IP_2 = 1450 \text{ kJ mol}^{-1}$$

Why the value of ΔIP_2 is always greater than the value of ΔIP_1 ?



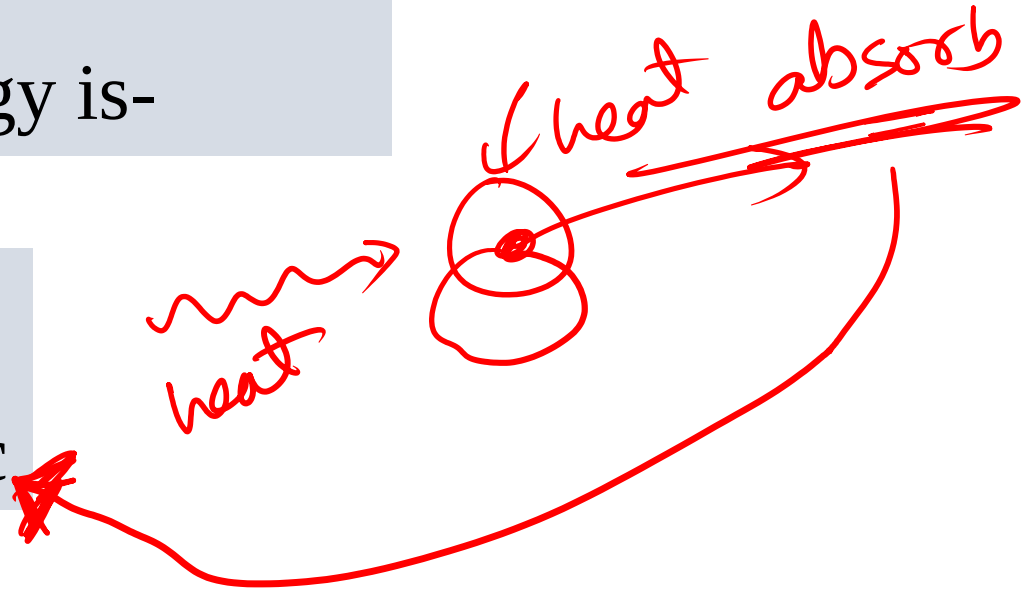


Poll Question 08

Ionization Energy is-

(a) Exothermic

(b) Endothermic



Ionization energy

The ionization potential depends on the following matters-

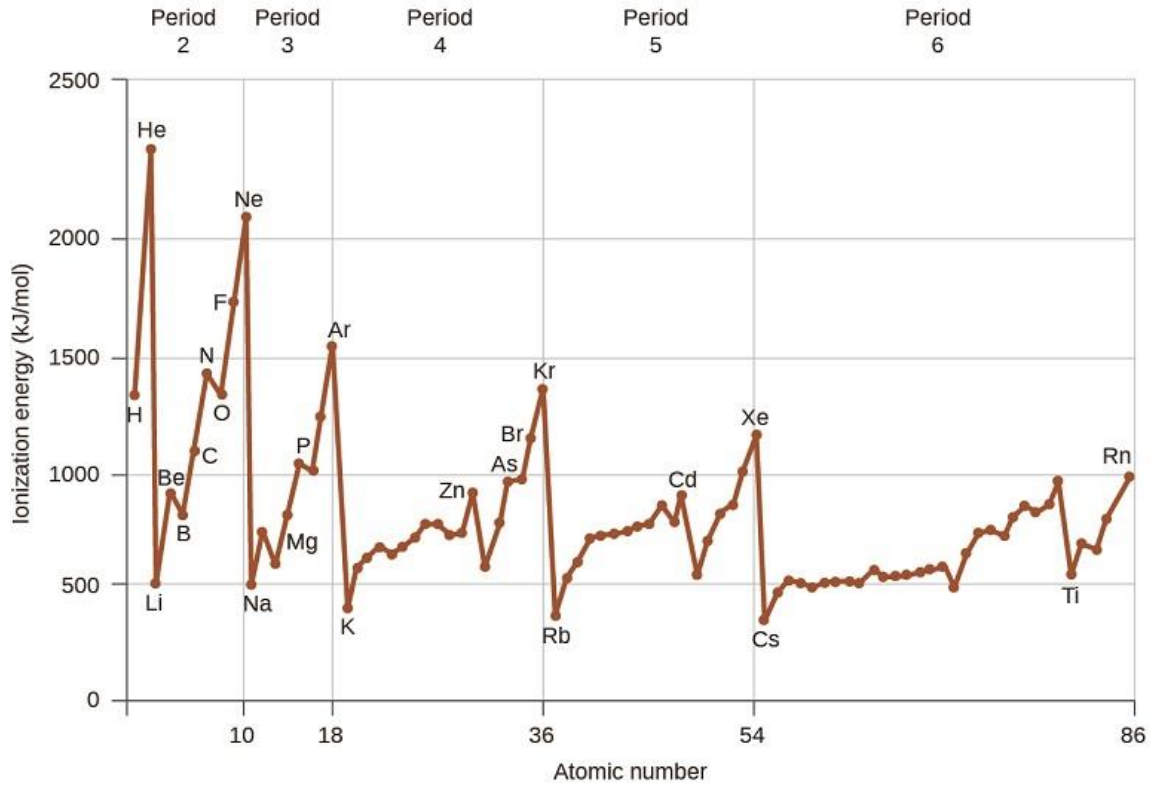
(i) Ionization potential reduces with the increase of size of atom- it's a group wise relation.

(ii) Ionization potential increases with the increase of charge- it's a periodic relation.

(iii) For full and half filled orbital in an atom this relation is varied.

(iv) Principle Quantum Number

(v) Shielding Effect



Ionization energy

Exception

$Be(4) = 1s^2 2s^2$

$B(5) = 1s^2 2s^2 2p^1$

$N(7) = 1s^2 2s^2 2p^3$

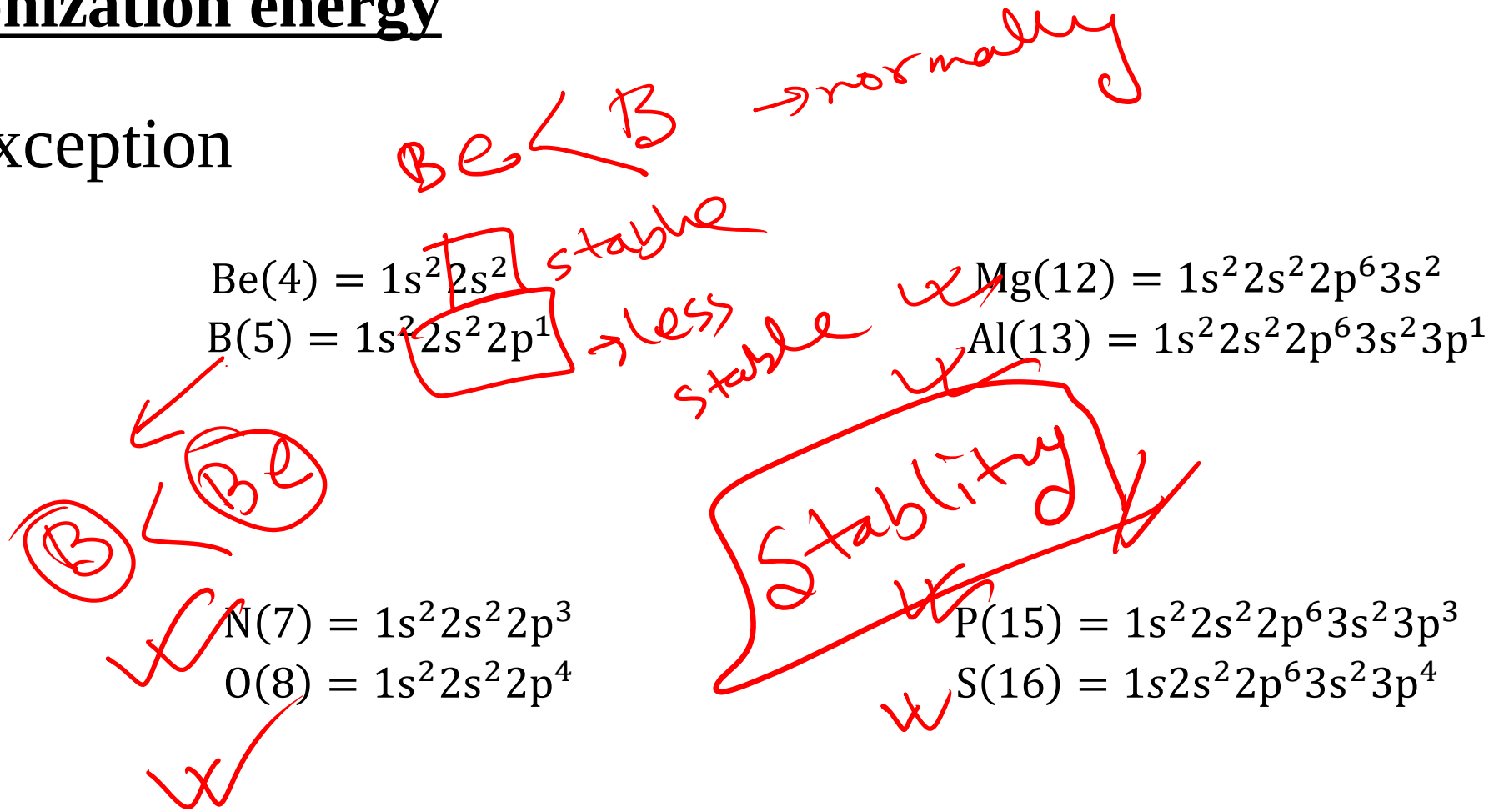
$O(8) = 1s^2 2s^2 2p^4$

$Mg(12) = 1s^2 2s^2 2p^6 3s^2$

$Al(13) = 1s^2 2s^2 2p^6 3s^2 3p^1$

$P(15) = 1s^2 2s^2 2p^6 3s^2 3p^3$

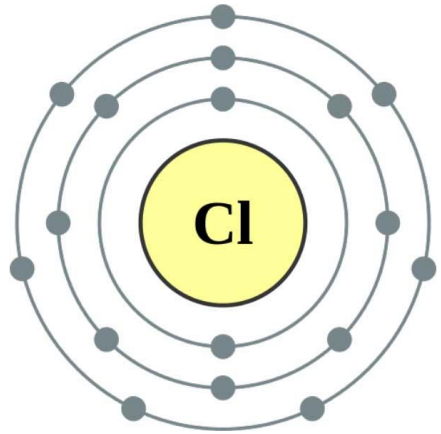
$S(16) = 1s 2s^2 2p^6 3s^2 3p^4$



Electron Affinity

The amount of energy changed to turn 1 mole neutral gaseous atoms to 1 mole negatively charged atoms by accepting 1 mole electrons is called electron affinity.

$$Cl(g) + e^- \longrightarrow Cl^-(g) \; ; \; \Delta EA = -348 kJ\ mol^{-1}$$



$$O(g) + e^- \longrightarrow O^-(g) \; ; \Delta EA_1 = -141\ kJ\ mol^{-1}$$
$$O^-(g) + e^- \longrightarrow O^{2-}(g) \; ; \Delta EA_2 = +798\ KJ\ mol^{-1}$$
$$O(g) + 2e^- \longrightarrow O^{2-}(g) \; ; \Delta EA = +657\ KJ\ mol^{-1}$$

Electron Affinity

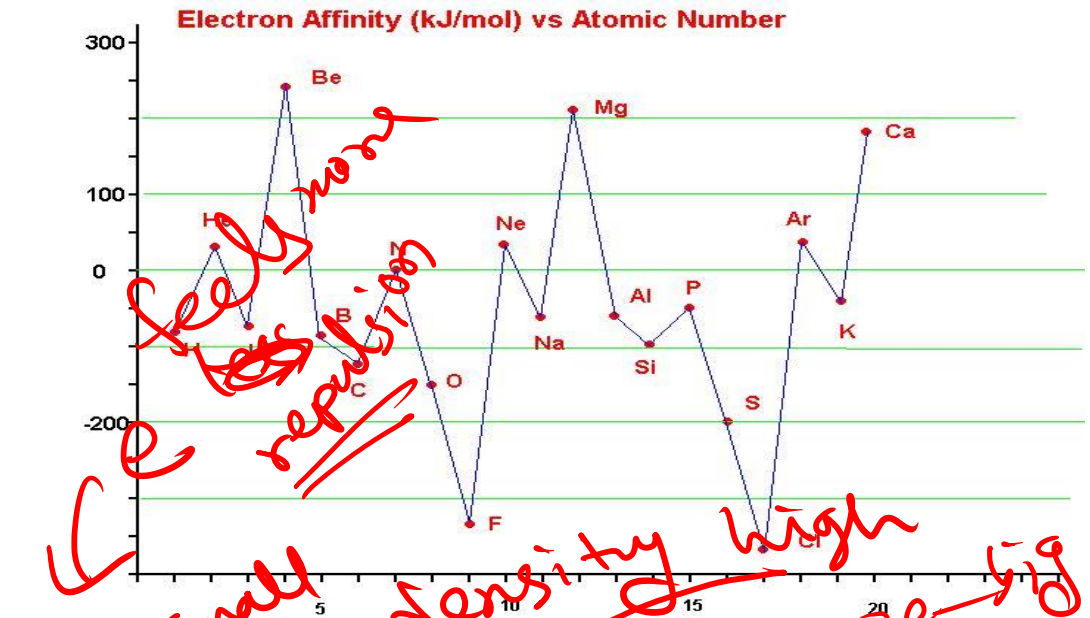
The electron affinity of any element mainly depends on the followings:

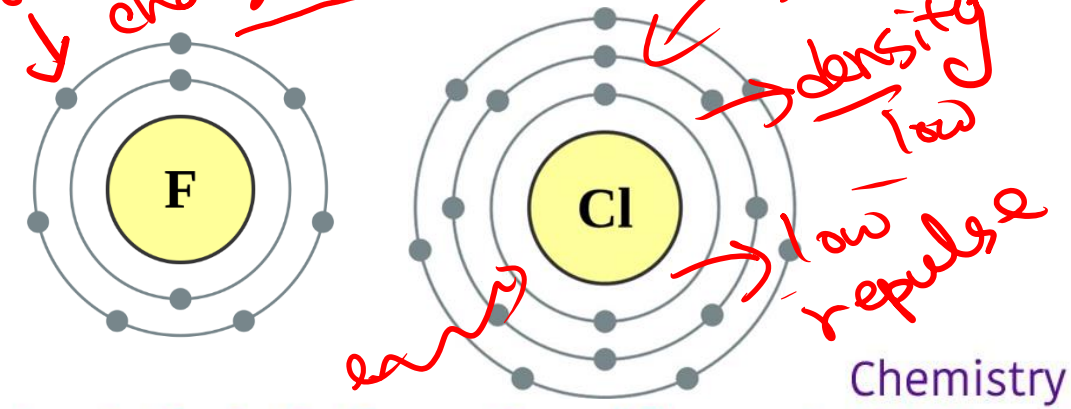
(i) Electron affinity increases with the increase of neuclear charge – tis is a periodic relation.

(ii) Electron affinityreduces with the increase of electron density- its also a periodic relation, seen in group -17.

(iii) Electron affinity decreases with the increase of size of atom - this is a group wise relation.

$$Cl > F > Br > I$$





Poll Question 09

The value of Electron Affinity is largest for-

(a) N

(b) O

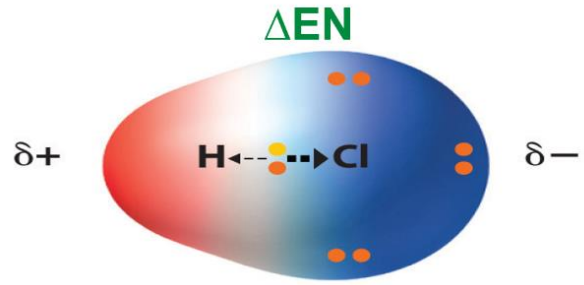
(c) C

(d) F

Electronegativity

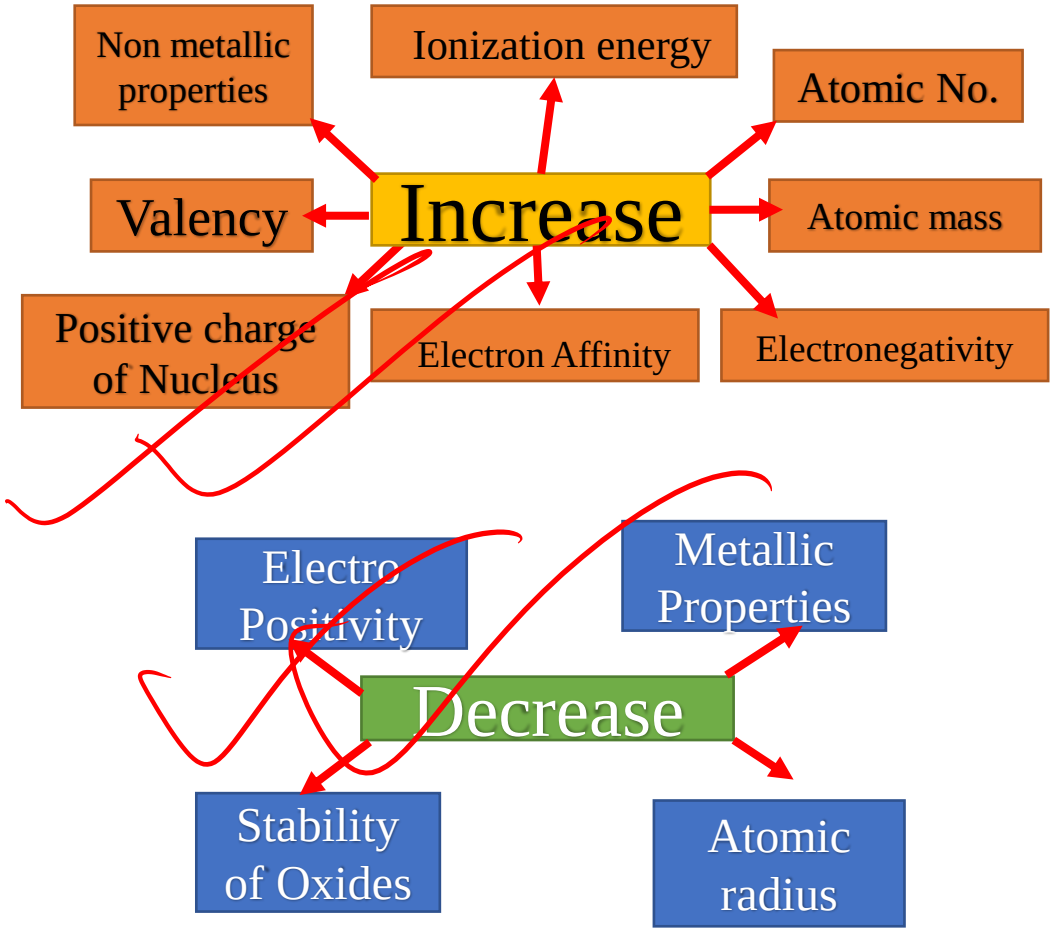
In a covalent compound molecule formed by different elements, the tendancy of an atom to attract the bond pair electron towards itself is called electronegativity.

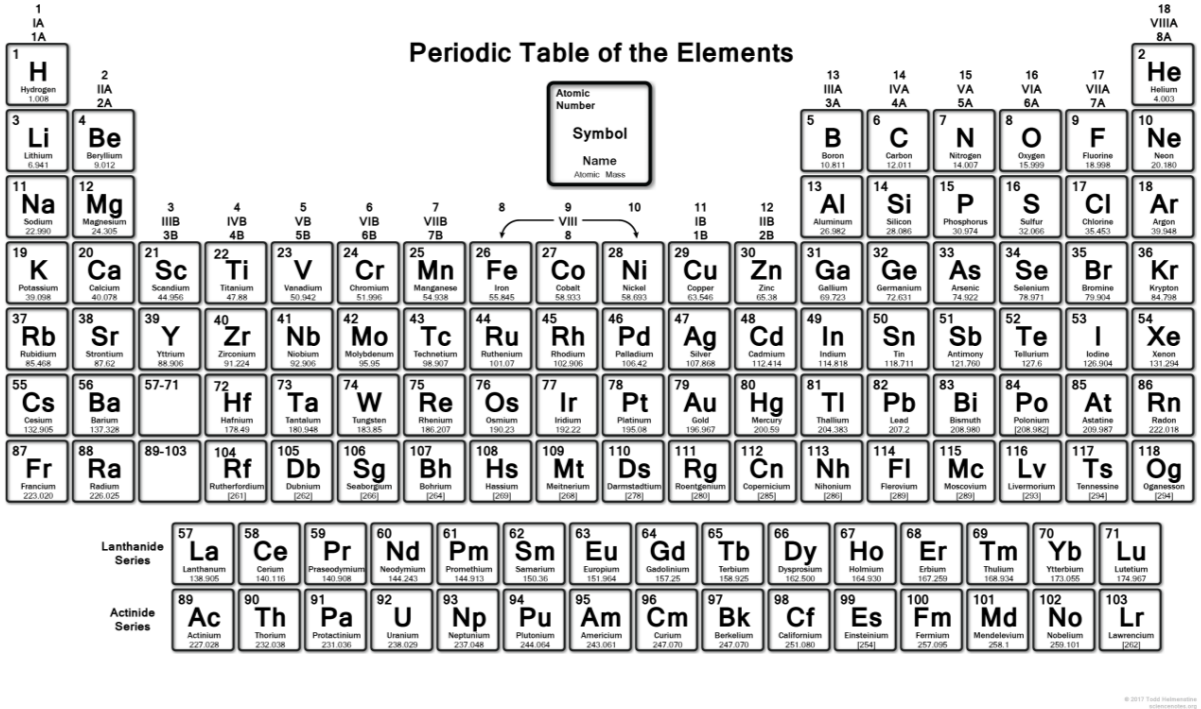
$H : Cl$ $\quad$ $H \div Cl$ $\quad$ $\overset{\delta+}{H} - \overset{\delta-}{Cl}$



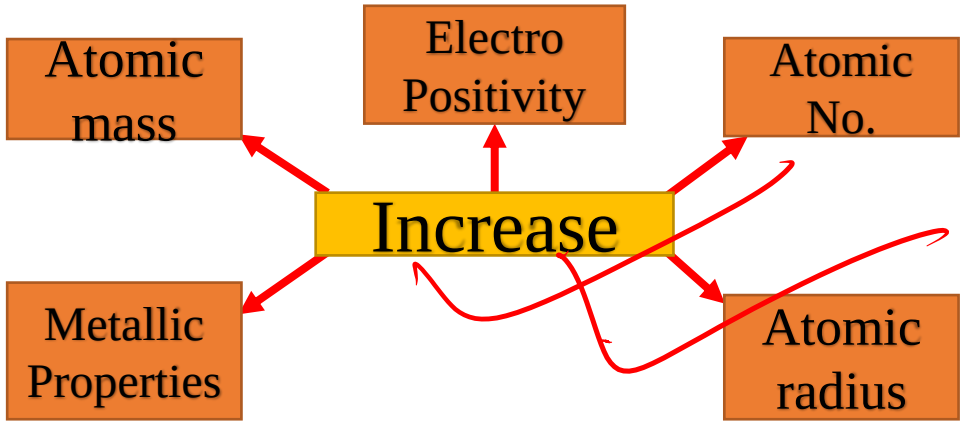
Period	Group						
	I	II	III	IV	V	VI	VII
2	Li	Be	B	C	N	O	F
	1.0	1.5	2.0	2.5	3.0	3.5	4.0
3	Na	Mg	Al	Si	P	S	Cl
	0.9	1.2	1.5	1.8	2.1	2.5	3.0
4	K	Ca	Ga	Ge	As	Se	Br
	0.8	1.0	1.3	1.75	2.0	2.4	2.8

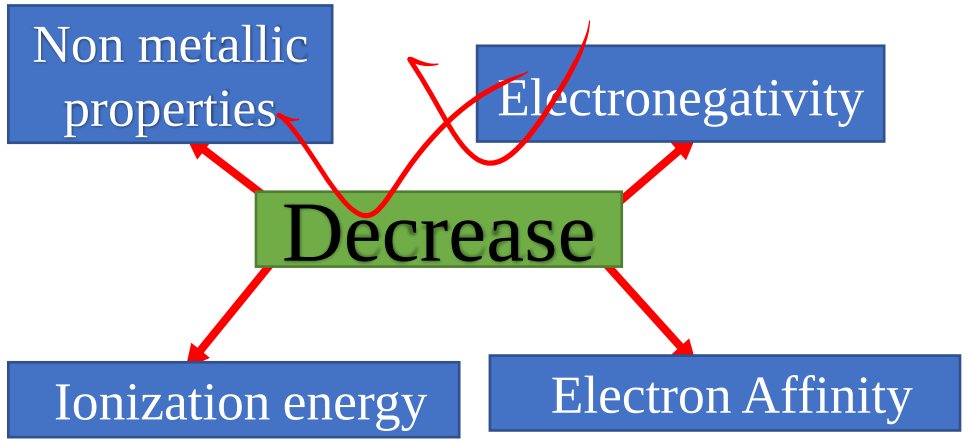
Variation of properties in a period from left to right

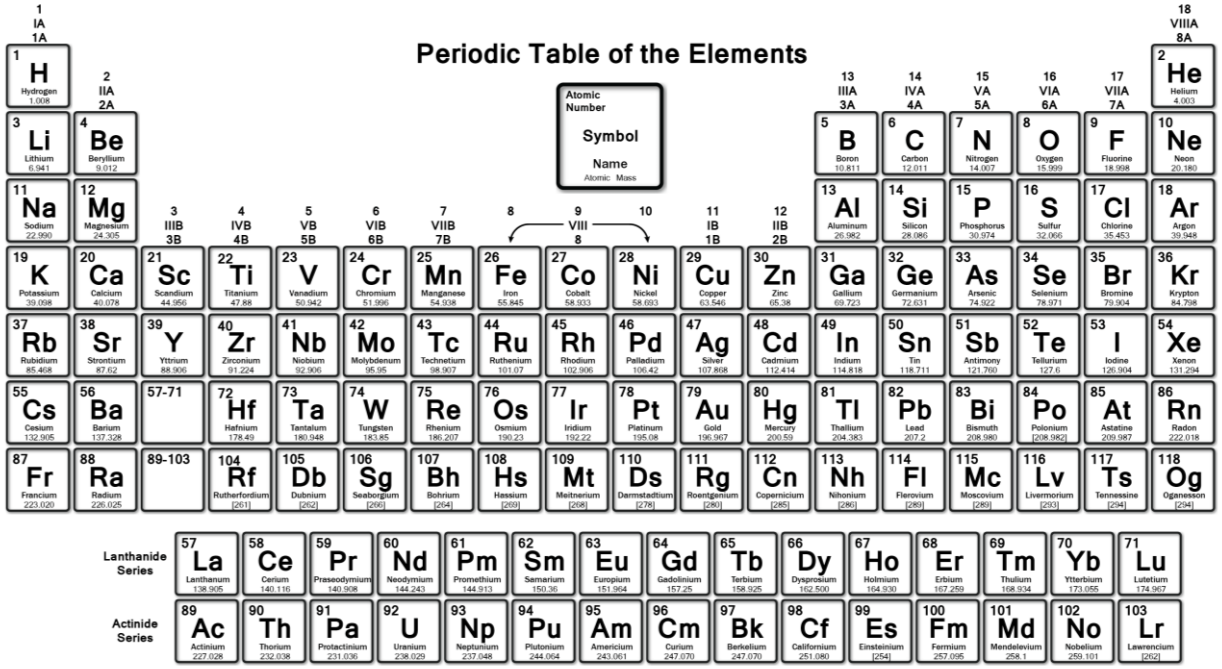




Variation of properties in a group from top to bottom

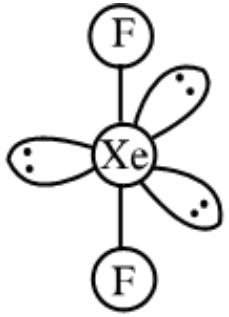




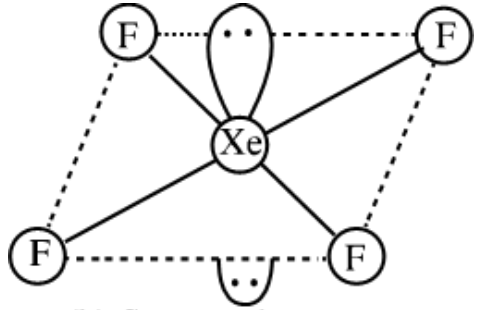


Various Compounds of Xe & their hybridization

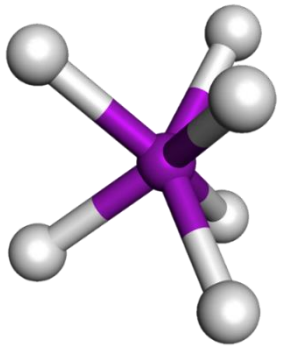
Compound	Hybrid.	Shape
XeF_2	sp^3d	Linear
XeF_4	sp^3d^2	Square planar
XeF_6	sp^3d^3	Trigonal Anti Prismatic
$XeOF_4$	sp^3d^2	Square pyramidal
XeO_3	sp^3	Pyramidal

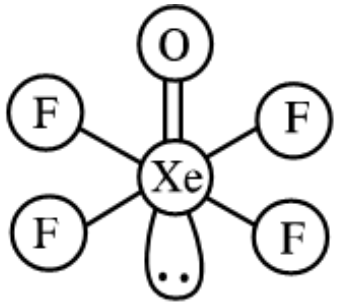


(a) Linear

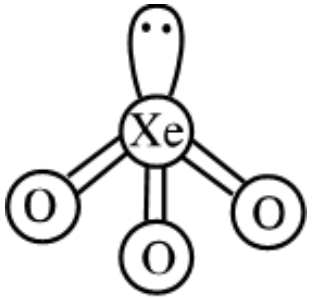


(b) Square planar


(c) Trigonal Anti Prismatic



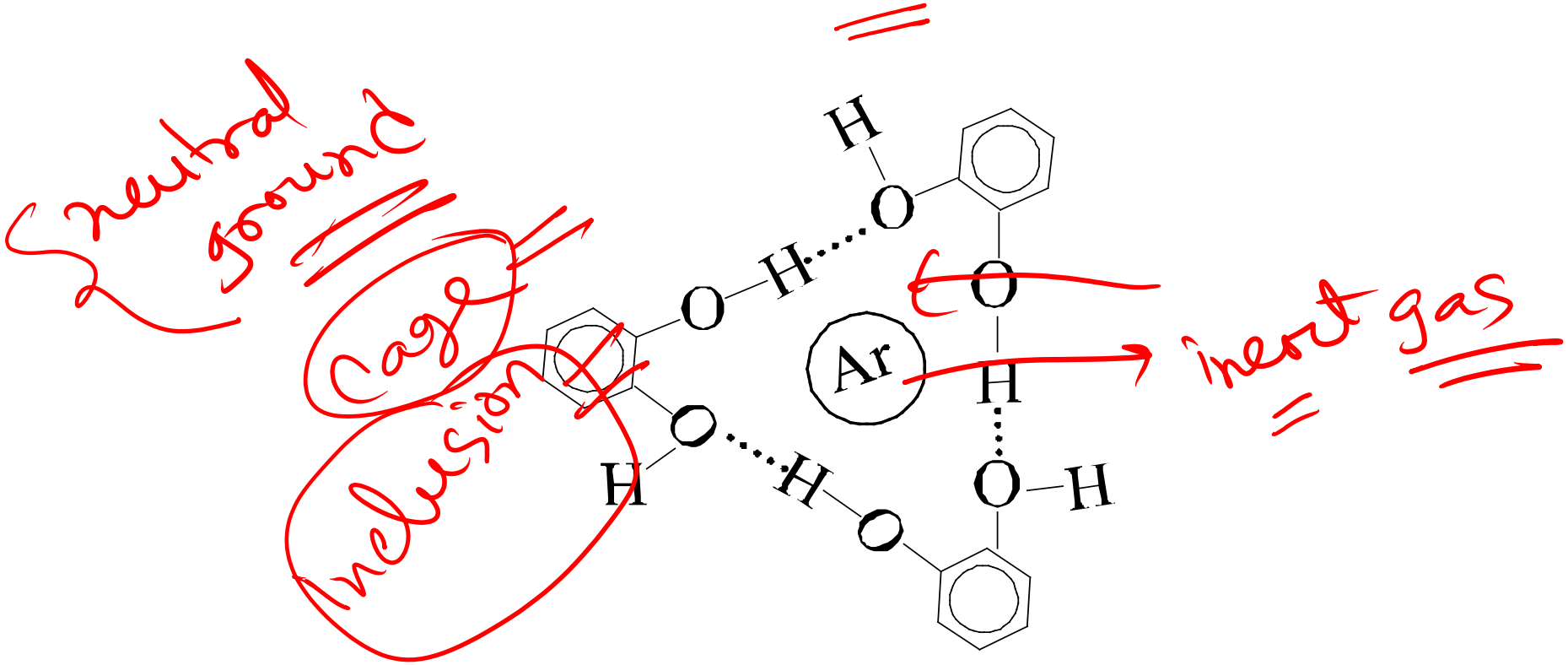
(d) Square pyramidal



(e) Pyramidal

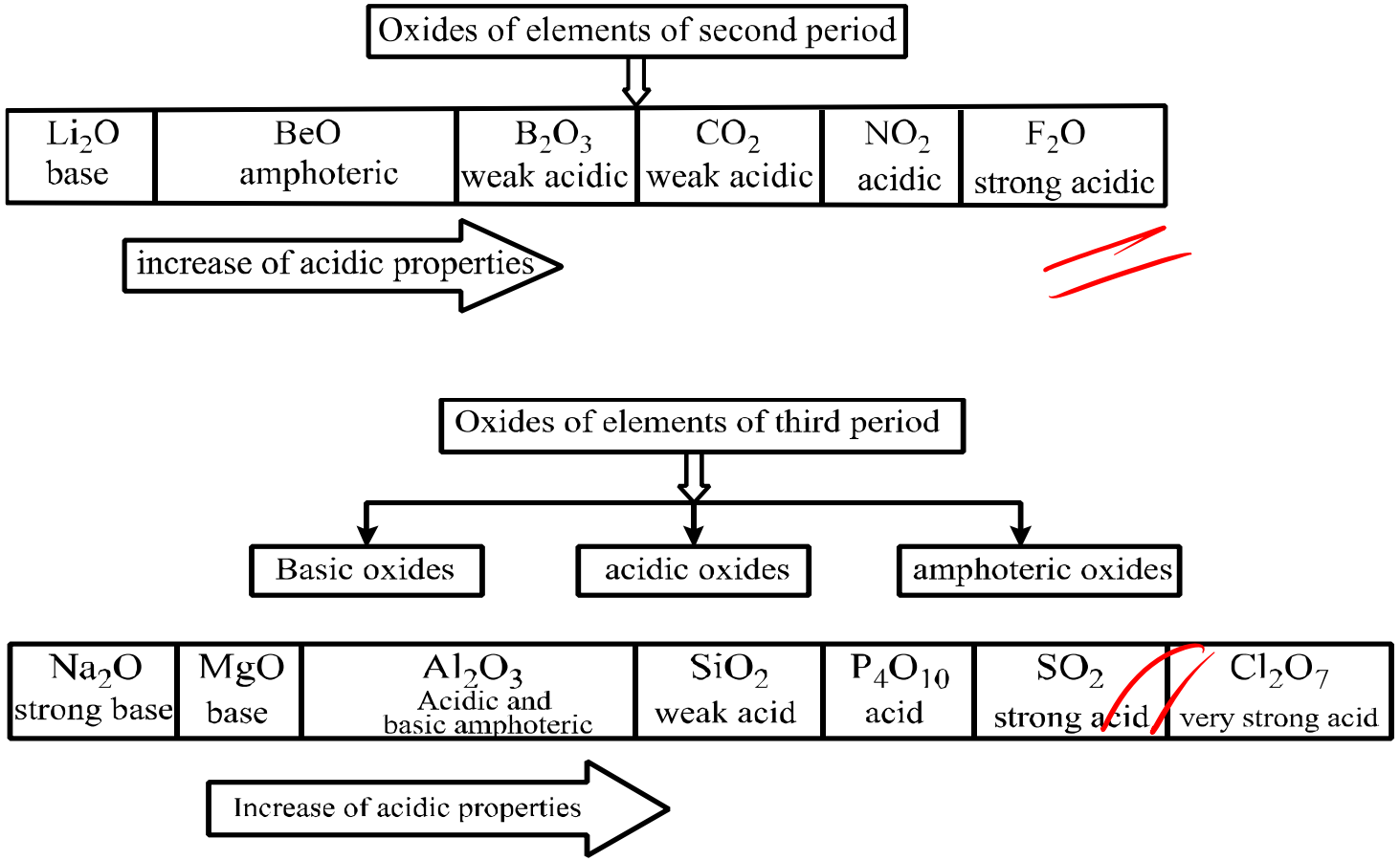
Clathrate compound:

There are certain inorganic compounds having a lattice structure with gaps, in which inert gases get trapped. These are called clathrate compounds.



$Ar[C_6H_4(OH)_2]_3$

Oxide properties of elements (acid-base properties)



লেগে থাকো সৎ ভাবে,
স্বপ্ন জয় তোমারই হবে।