d - BLOCK ELEMENTS

XII CHEMISTRY CHAPTER 5

SIDRA JAVED

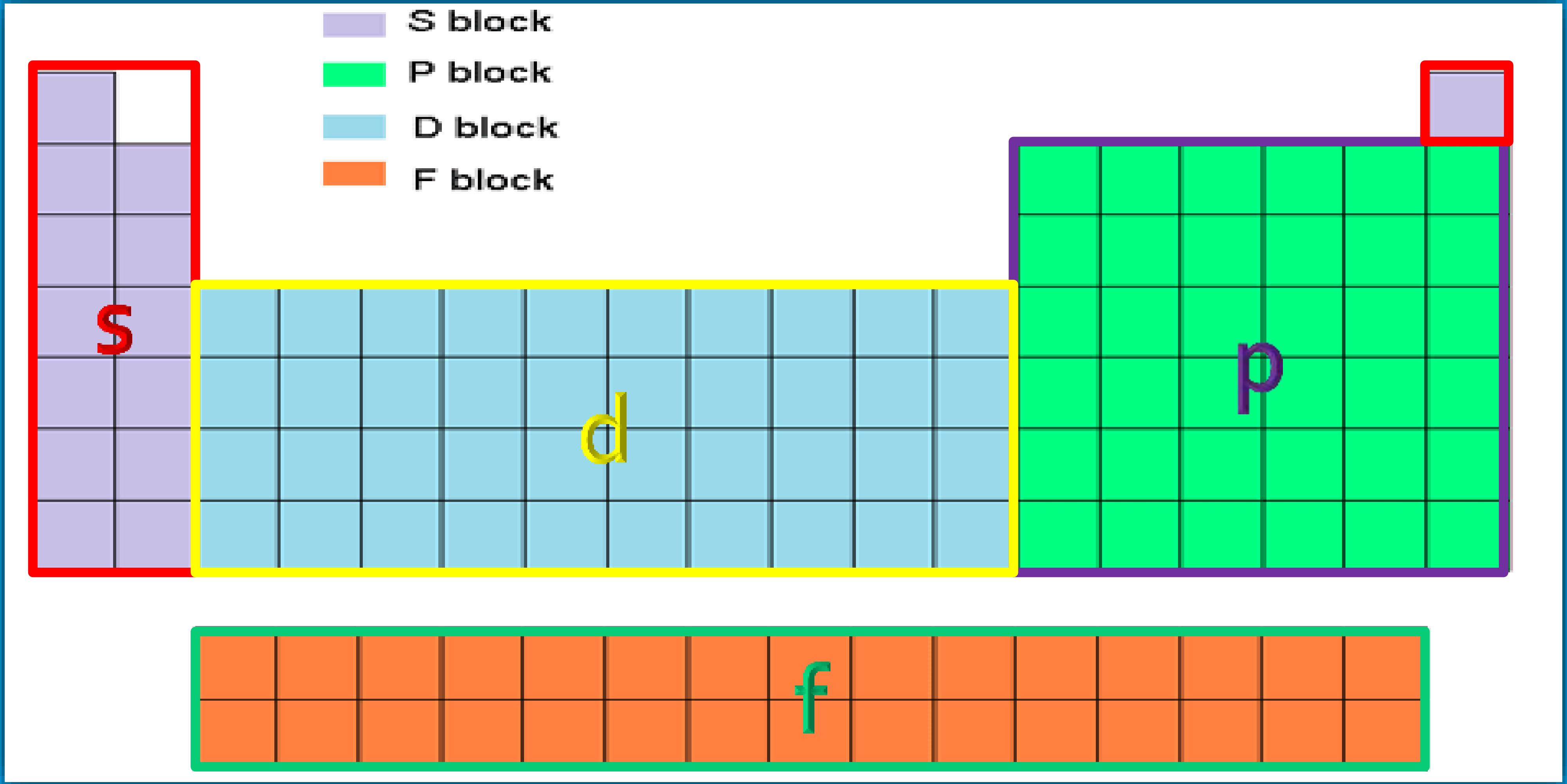
d – BLOCK ELEMENTS

Those elements with atoms in which there is a progressive filling of d sub shell are called d – block elements.

OR

Those elements with atoms in which last two shells are incomplete (i.e. n & n-1) are called d block elements.

PERIODIC TABLE BLOCKS



TRANSITION ELEMENTS

The elements which show properties which are transitional between electropositive s – block elements and electronegative p – block elements.

The transition elements include elements of d – block and f – block of periodic table.

TRANSITION SERIES OF d – BLOCK ELEMENTS

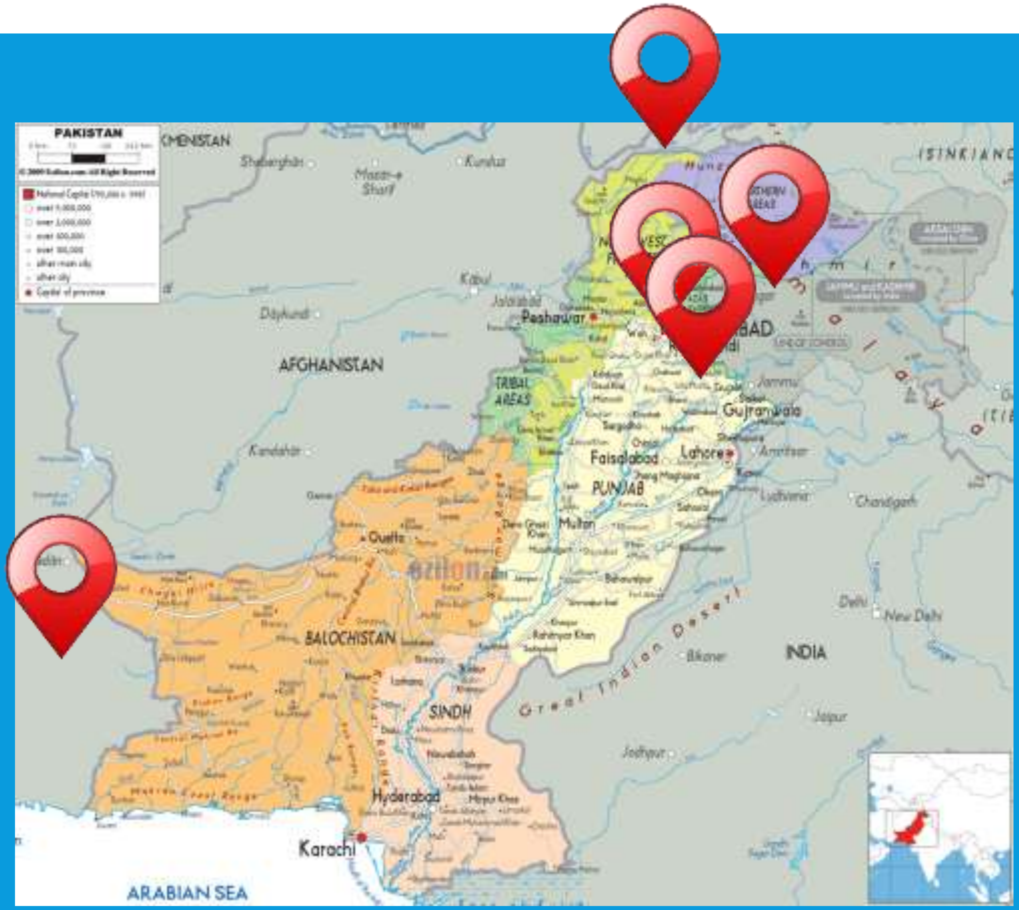
i. **First transition series: Scandium (Z= 21) to Zinc (Z=30)**

ii. **Second transition series: Yttrium (Z= 39) to Cadmium (Z=48)**

iii. **Third transition series: Lanthanum (Z= 57) to Mercury (Z=80) except Lanthanide series**

3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII	9 VIII	10 VIII	11 IB	12 IIB
1.36 **Sc** scandium	1.54 **Ti** titanium	1.63 **V** vanadium	1.66 **Cr** chromium	1.55 **Mn** manganese	1.83 **Fe** iron	1.88 **Co** cobalt	1.91 **Ni** nickel	1.90 **Cu** copper	1.65 **Zn** zinc
1.22 **Y** yttrium	1.33 **Zr** zirconium	1.6 41**Nb** niobium	2.16 **Mo** molybdenum	1.9 **Tc** technecium	2.2 **Ru** ruthenium	2.28 **Rh** rhodium	2.20 **Pd** palladium	1.93 **Ag** silver	1.69 **Cd** cadmium
1.1 **La** lanthanum	1.3 **Hf** hafnium	1.5 **Ta** tantalum	2.36 **W** tungsten	1.9 **Re** rhenium	2.2 **Os** osmium	2.20 **Ir** iridium	2.28 **Pt** palladium	2.54 **Au** gold	2.00 **Hg** mercury

OCCURRENCE OF d – BLOCK ELEMENTS



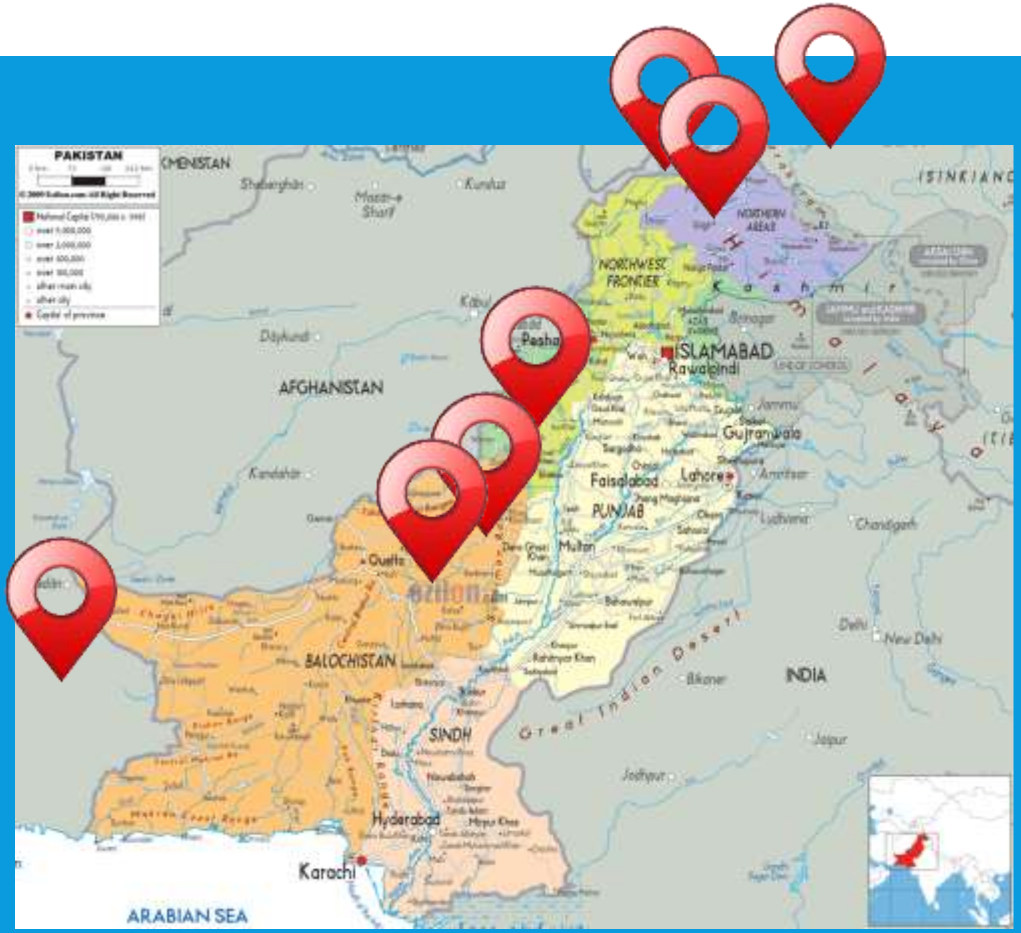
IRON:

- Kohat
- Hazara
- Chagai
- Chitral
- Kalabagh

OCCURRENCE OF d – BLOCK ELEMENTS

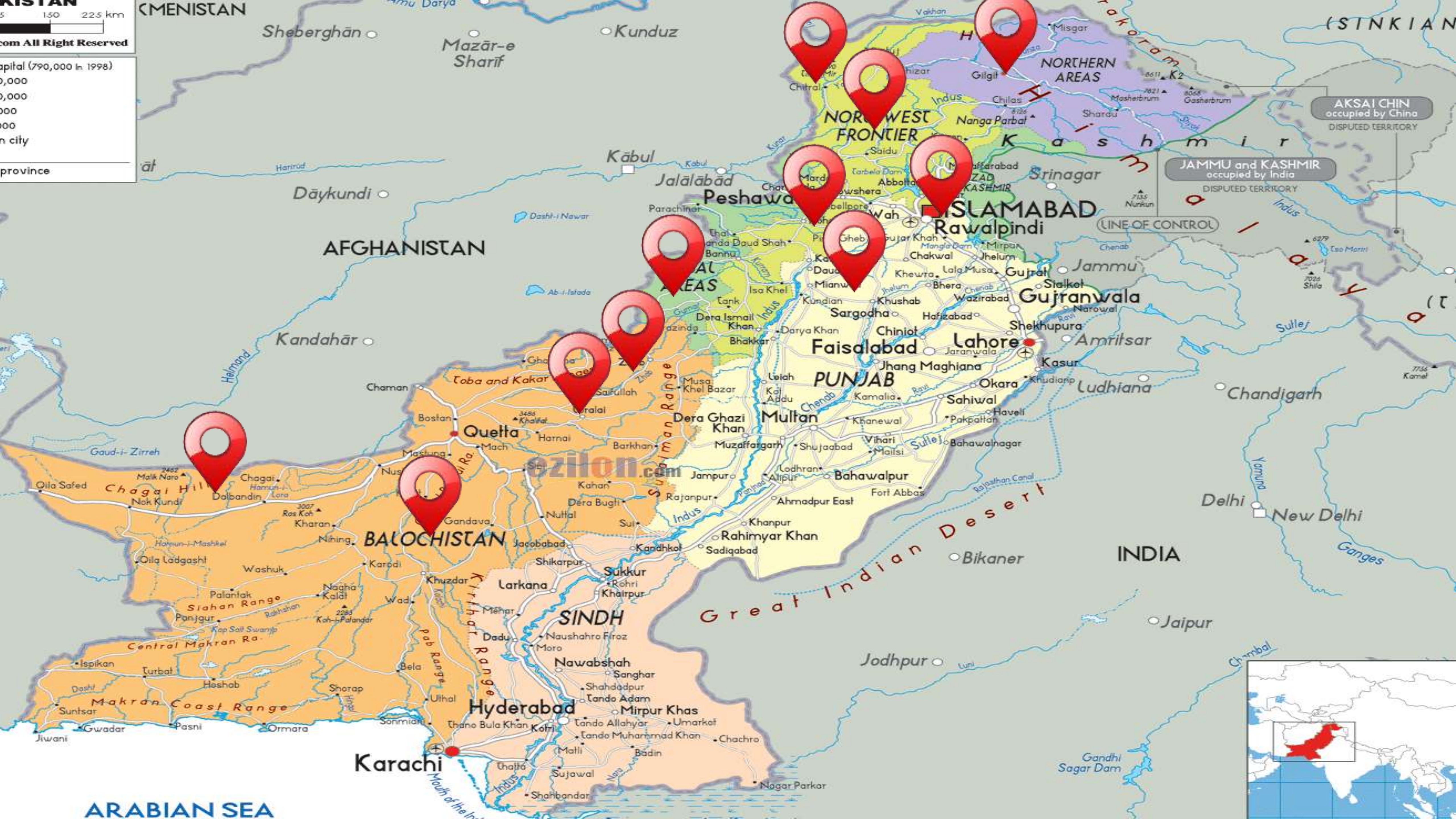
CHROMIUM:
Balochistan

OCCURRENCE OF d – BLOCK ELEMENTS



COPPER:

- Zhob
- Loralai
- Chagai
- North Waziristan
- Gilgit
- Dir
- Chitral



150
225 km
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apital (790,000 in 1998)
city
province
MENISTAN
Sheberghān
Mazār-e Sharīf
Kunduz
Kābul
Jalālābād
Dāykundi
AFGHANISTAN
Kandahār
Chaman
Gaud-i-Zirreh
(SINKIAN
AKSAI CHIN
occupied by China
DISPUTED TERRITORY
JAMMU and KASHMIR
occupied by India
DISPUTED TERRITORY
LINE OF CONTROL
NORTHERN AREAS
Gilgit
Misgar
K2
Chilas
Nanga Parbat
Skardu
Kashmir
Srinagar
Jammu
NORTH WEST FRONTIER
Chitral
Saidu
Peshawar
Parachinar
Abbottabad
Muzaffarabad
ISLAMABAD
Rawalpindi
Wah
Chakwal
Jhelum
Gujrat
Sialkot
Gujranwala
Narowal
Sheikhupura
Lahore
Kasur
Amritsar
Ludhiana
Chandigarh
Bannu
Thal
Isa Khel
Tank
Dera Ismail Khan
Mianwali
Khushab
Sargodha
Chiniot
Faisalabad
Jhang Maghiana
Hafizabad
Okara
Sahiwal
Pakpattan
Bahawalnagar
PUNJAB
Multan
Khanewal
Vihari
Mailsi
Muzaffargarh
Shujaabad
Lodhran
Bahawalpur
Fort Abbas
Ahmadpur East
Khanpur
Rahimyar Khan
Sadiqabad
Dera Ghazi Khan
Jampur
Rajanpur
Bhakkar
Darya Khan
Leiah
Kot Addu
Kamalia
Musa Khel Bazar
Zhob
Qila Saifullah
Loralai
Barkhan
Toba and Kakar
Quetta
Bostan
Harnai
Mach
Mastung
Sibi
Kohlu
Dera Bugti
Nuttal
Sui
Jacobabad
Kandhkot
Shikarpur
Sukkur
Rohri
Khairpur
Larkana
SINDH
Mehar
Dadu
Moro
Naushahro Firoz
Nawabshah
Sanghar
Shahdadpur
Tando Adam
Hyderabad
Mirpur Khas
Tando Allahyar
Umarkot
Tando Muhammad Khan
Chachro
Matli
Badin
Thatta
Sujawal
Shahbandar
Nagar Parkar
Karachi
ARABIAN SEA
BALOCHISTAN
Chagai Hills
Chagai
Dalbandin
Nok Kundi
Qila Safed
Kharan
Nushki
Nihing
Washuk
Qila Ladgasht
Karodi
Khuzdar
Nagha Kalat
Wad
Panjgur
Palantak
Siahan Range
Central Makran Ra.
Makran Coast Range
Ispikan
Turbat
Hoshab
Suntsar
Dasht
Gwadar
Jiwani
Pasni
Ormara
Bela
Shorap
Uthal
Sonmiani
Kirthar Range
Pab Range
Sulaiman Range
Gandava
Great Indian Desert
INDIA
Delhi
New Delhi
Bikaner
Jaipur
Jodhpur
Gandhi Sagar Dam
Indus
Chenab
Jhelum
Ravi
Sutlej
Helmand
ezilon.com

ELECTRONIC CONFIGURATIONS
$ns^2\ (n-1)d^1 – ns^2\ (n-1)d^{10}$

Scandium	Sc	(Z=21)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2 3d^1$
Titanium	Ti	(Z=22)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2 3d^2$
Vanadium	V	(Z=23)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2 3d^3$
Chromium	Cr	(Z=24)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1 3d^5$
Manganese	Mn	(Z=25)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2 3d^5$
Iron	Fe	(Z=26)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2 3d^6$
Cobalt	Co	(Z=27)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2 3d^7$
Nickel	Ni	(Z =28)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2 3d^8$
Copper	Cu	(Z=29)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1 3d^{10}$
Zinc	Zn	(Z=30)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2 3d^{10}$

METALLIC CHARACTER

All transition elements are generally metals and good conductor of heat and electricity.

Mercury is the only metal found in liquid state.

Sc 21

44.956

Scandium

Ti

22

47.867

Titanium

V

23

50.9415

Vanadium

Cr

24

51.996

Chromium

Mn 25

54.938

Manganese

Fe

26

55.845

Iron


Co
27
58.933
Cobalt

Ni 28

58.693

Nickel

Cu 29

63.546

Copper

Zn 30

65.39

Zinc

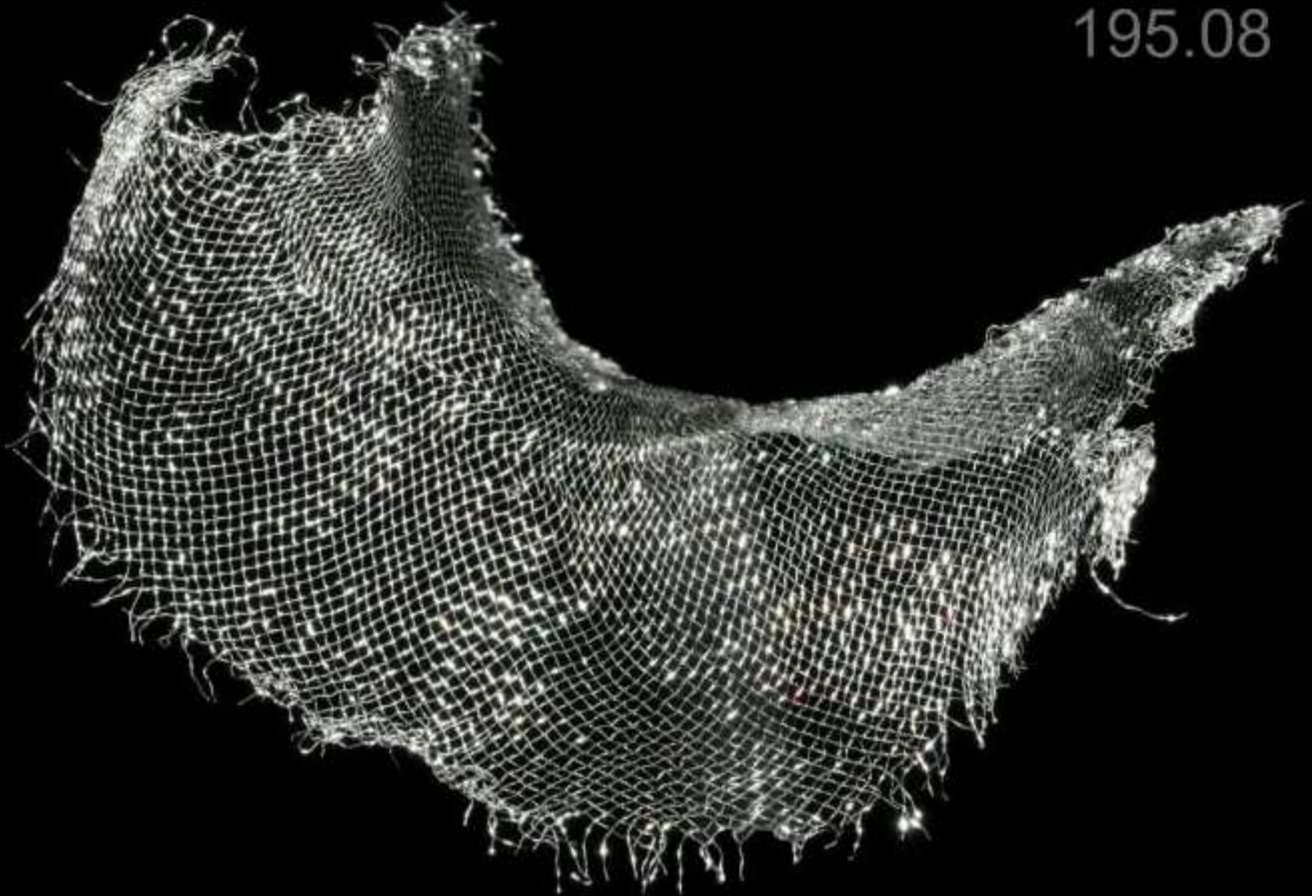
Ag 47

107.87

Silver

Pt 78

195.08



Platinum


Au
79
196.97
Gold

Hg 80

200.59

Mercury

ATOMIC SIZES

The atomic sizes of transition elements decrease to a small extent from left to right.

It is due to increase in nuclear charge without the increase in number of shells.

IONIZATION POTENTIAL

Ionization potential values of d block elements are greater than s block elements and smaller than p block elements.

These elements may form either ionic or covalent compound depending on the conditions.

MELTING AND BOILING POINTS

Melting and boiling points of all transition elements are high except that of Zinc due to complete d sub shell.

High Melting and Boiling points are due to small atomic sizes which give strong inter atomic attraction.

OXIDATION STATES

Transition elements show variable oxidation states in their compounds.

The variation is due to very small energy difference between 3d and 4s orbitals.

As a result electrons of both 3d and 4s orbitals take part in bonding.

OXIDATION STATES

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
$4s^2\ 3d^1$	$4s^2\ 3d^2$	$4s^2\ 3d^3$	$4s^1\ 3d^5$	$4s^2\ 3d^5$	$4s^2\ 3d^6$	$4s^2\ 3d^7$	$4s^2\ 3d^8$	$4s^1\ 3d^{10}$	$4s^2\ 3d^{10}$
			+1					+1	
	+2	+2	+2	+2	+2	+2	+2	+2	+2
+3	+3	+3	+3	+3	+3	+3	+3		
	+4	+4	+4	+4					
		+5	+5						
			+6	+6	+6				
				+7					

COLOR

Transition metals forms colored complex compounds except Zn.

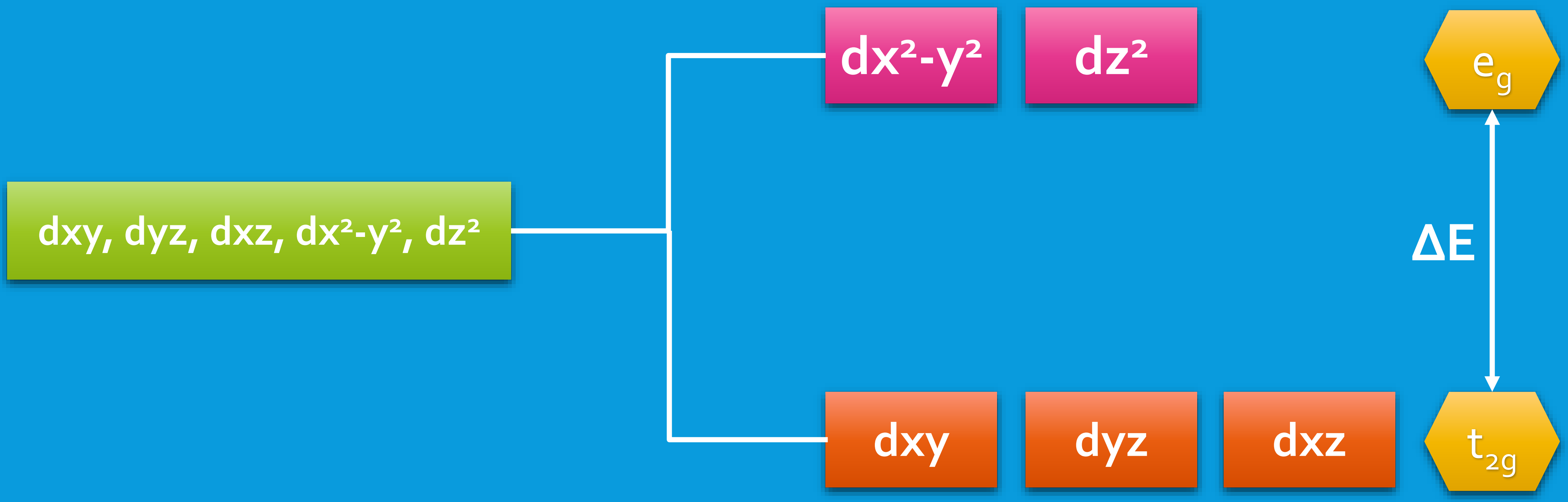
A complex compound has all three types of bonds and formed between a metal atom and one or more ligands.

Color of the complexes are explained by Crystal Field theory.

CRYSTAL FIELD THEORY

- The bonding between metal ion and ligands is electrostatic.
- The ligand surrounding the metal ion creates an electrostatic field.
- This electrostatic field splits the five degenerated d orbitals of metal into two sets or generate orbitals:
  - A higher energy pair dx^2-y^2 and dxz designated as e_g orbitals
  - A lower energy trio dxy, dyz and dxz designated as t_2g orbitals

CRYSTAL FIELD THEORY SPLITTING OF d SUB SHELL



CRYSTAL FIELD THEORY

- The energy difference between e_g and t_{2g} orbitals is equal to the wavelength in visible region.
- By absorbing visible light, an electron may move from lower to higher energy level. The absorbed component of white light is removed and the remaining components are reflected back which gives the color to compound.
- For example Cu^{+2} absorbs red light, hence transmitted light gives blue color

MAGNETIC PROPERTIES

Transition metal compounds are paramagnetic in nature

It is due the presence of unpaired electron in the ions or atoms of the elements.

CATALYTIC PROPERTIES

Transition metals and some of their compounds are generally used as catalyst

The transition elements in some reactions forms unstable intermediate compounds, and in other cases they provide a suitable surface areas where gases are absorbed.

Ni is used for hydrogenation of vegetable oils

Fe is used in manufacture of NH_3

INTERSTITIAL COMPOUNDS

Transition metals forms compounds of indefinite structure and proportion which are called interstitial or non stoichiometric compounds.

The reason is variable oxidation states and defects in their solid structures.

Small atoms such as H, B, C and N can reside within the holes present in the crystal lattice of transition elements.

COMPLEX FORMATION

Transition metals form complex compounds which are called coordination compounds

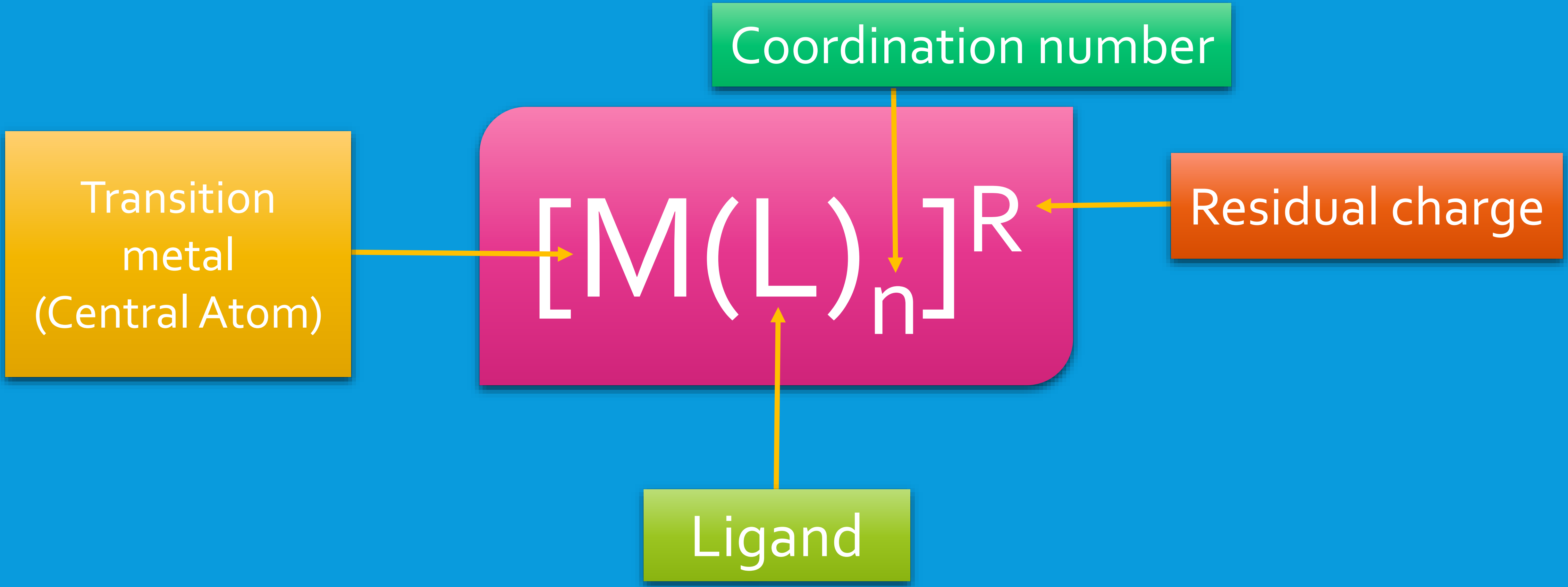
It is due to small and highly charged ions and vacant d orbitals or suitable energies.

These vacant orbitals accepts lone pairs from atoms, ions or molecules called ligand.

TRANSITION METAL COMPLEXES

A compound containing the complex ion or complex molecule in which central metal atom is surrounded by a number of oppositely charged ions or neutral molecules called ligands, is known as a Coordination Compound or Complex Compound.

COORDINATION COMPOUND



COORDINATION COMPOUNDS

- The central atom is always a transition metal.
- A ligand may be an ion or neutral molecule which surrounds the central atom and donates one or more lone pairs.
- The number of ligands surrounding the metal atom is called coordination number.
- The residual charge on complex is the oxidation state of metal and charge of ligands.
- To balance the Residual charge, cations or anions are attached to the complex.

LIGANDS

Ligands are Lewis bases which donates electrons to transition metal ion.

Ligands are classifies as:

i. Mono dentate or uni dentate ligands
ii. Poly dentate or multi dentate ligands

MONO DENTATE LIGANDS

Ligands which contain only one donor atom are called mono dentate ligands.

Examples are:

- H_2O Aquo
- NH_3 Ammine
- CN^- Cyano
- NO_2^- Nitro

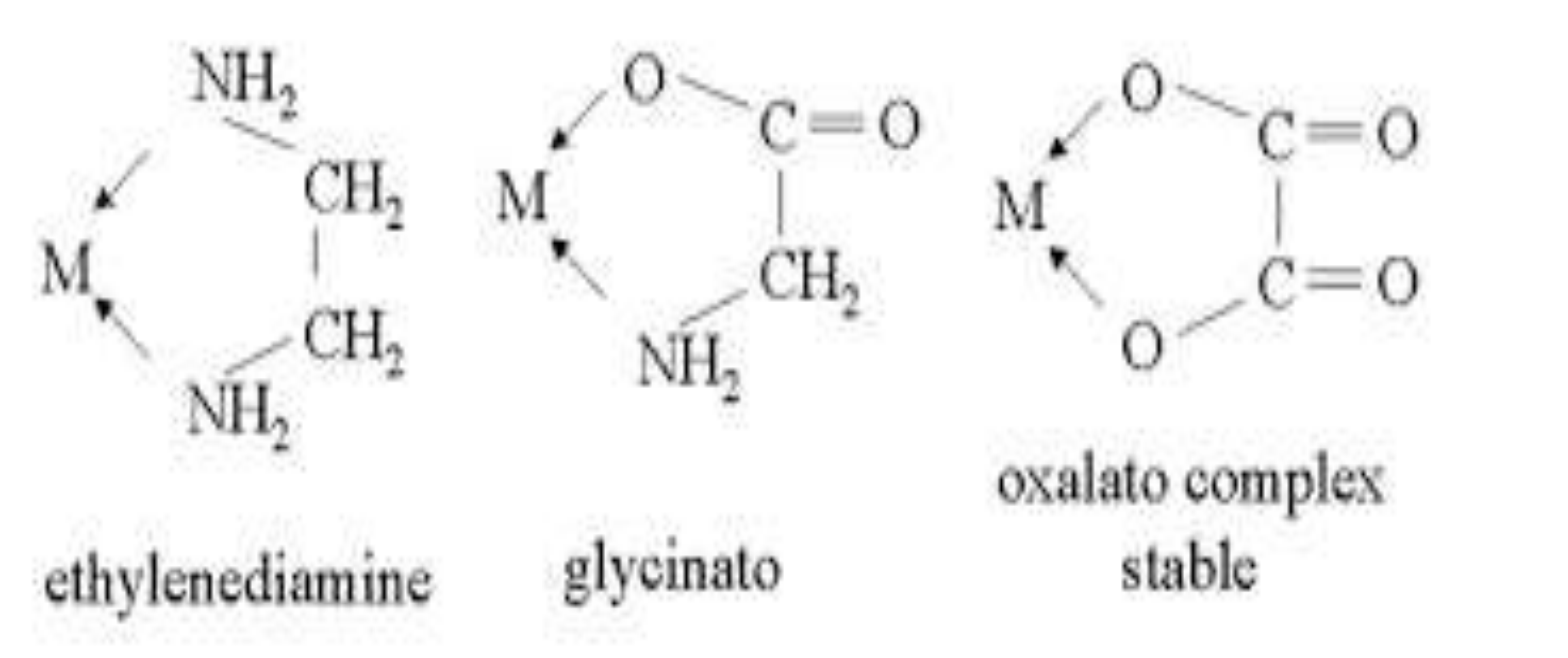
POLY DENTATE LIGANDS

Ligands which contain more than one donor atom are called poly dentate ligands.

They can be classified as:

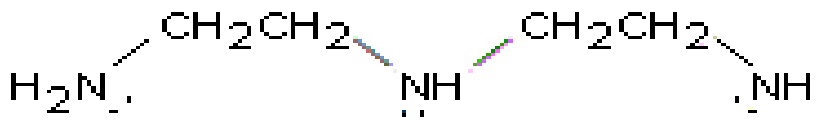
i. Bi dentate ligands
ii. Tri dentate ligands
iii. Tetra dentate ligands
iv. Hexa dentate ligands etc.

EXAMPLES OF BI DENTATE LIGANDS



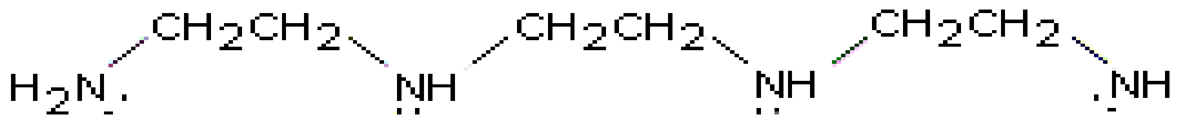
EXAMPLES OF POLY DENTATE LIGANDS

Tridentate Ligand:



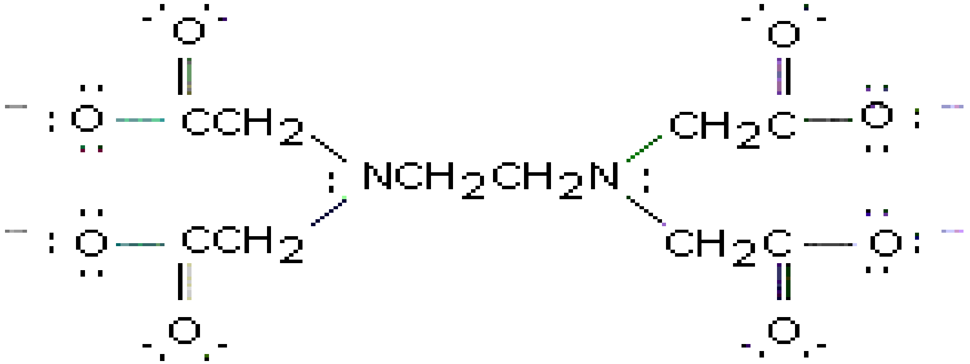
diethylenetriamine (dien)

Tetradentate Ligand:



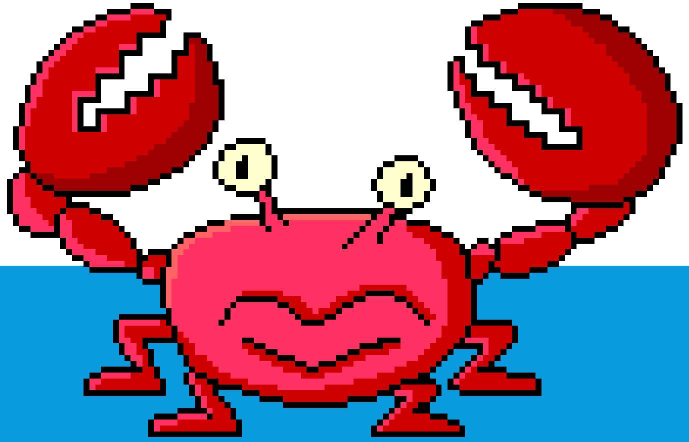
triethylenetetraamine (trien)

Hexadentate Ligand:



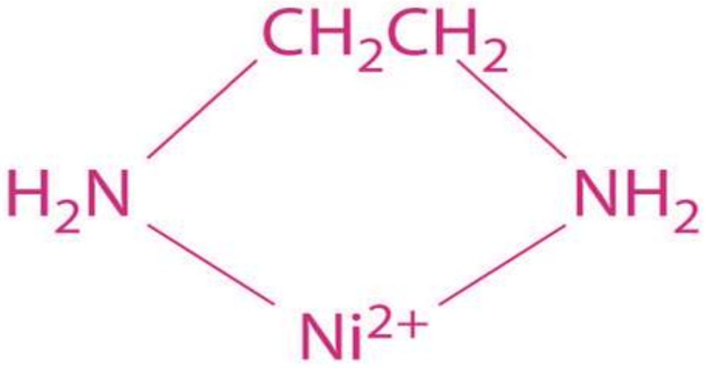
ethylenediaminetetraacetate (EDTA)

CHELATING AGENT

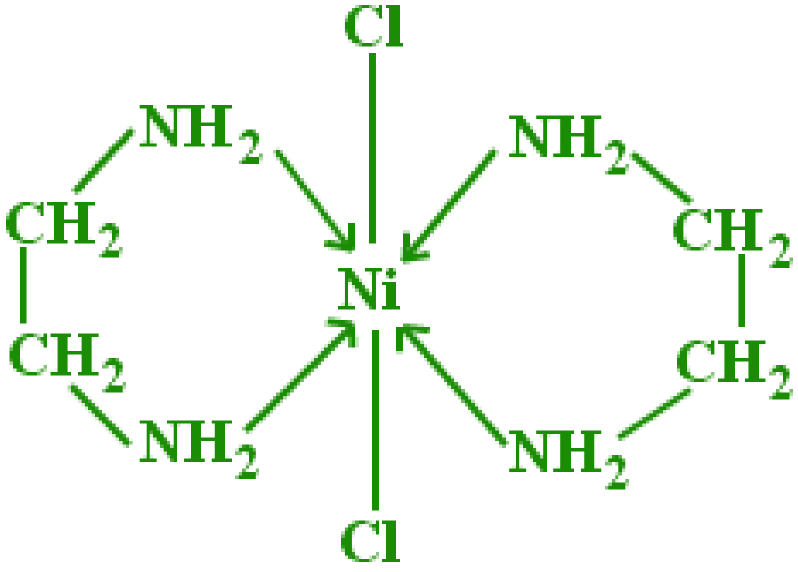


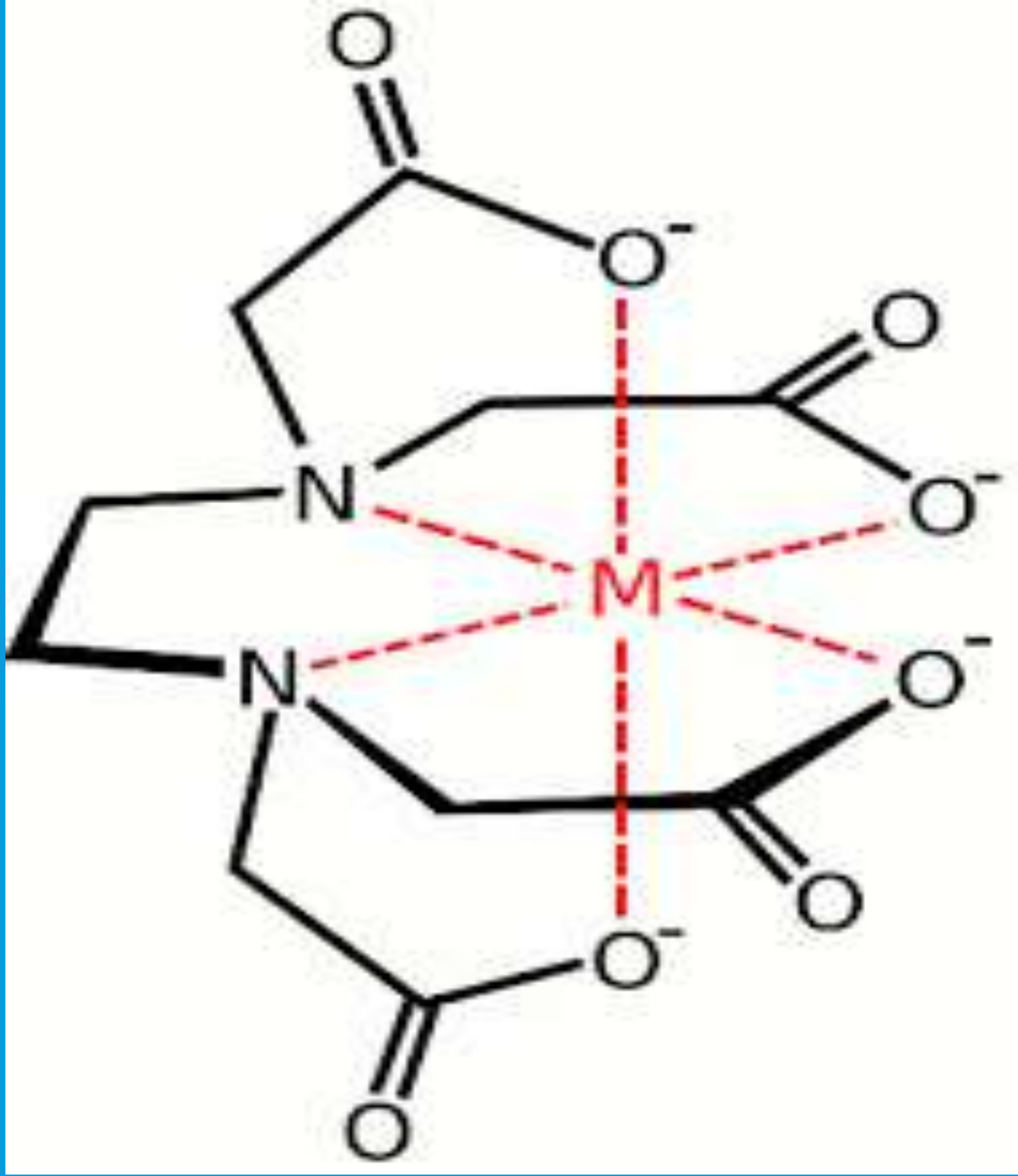
Poly dentate ligands are also called chelating agents.

The chelating agent on coordination with metal atom forms a ring structure called chelates i.e. a Greek word meaning Crab's Claw.



A chelate complex





IUPAC NOMENCLATURE OF COMPLEX COMPOUNDS

- As in simple ionic compounds, Cation is named first and then the anion.
- Ligands are named in alphabetical order.
- Name of negative ligands are written first and then neutral ligands
- The name of the metal comes next.
- The oxidation state of the metal follows, noted by a Roman numeral in parentheses (II, IV).
- When a complex has an overall charge, "ion" is written after it.

RULE 1: IDENTIFY THE COMPLEX TYPE

Complex Cation	$[Co(NH_3)_6]^{+3}$
Complex anion	$[Ni(CN)_4]^{-2}$
Neutral complex	$[Pt(NH_3)Cl_4]$
Coordination compound	$K_4[Fe(CN)_6]$

RULE 2: ANIONIC LIGANDS

Names of the anionic ligands are modified to end in –O.

Molecular Formula	Ligand Name	Molecular Formula	Ligand Name
F^-	Fluoro	OH^-	Hydroxo
Cl^-	Chloro	SO_4^{2-}	Sulfato
Br^-	Bromo	NH_2^-	Amido
I^-	Iodo	NO_2^-	Nitro
O^{2-}	Oxo	NO_3^-	Nitrato
CN^-	Cyano	SCN^-	Thiocyanato-S-; Thiocyanato
CO_3^{-2}	Carbonato	$C_2O_4^{-2}$	Oxalato

RULE 3: NEUTRAL LIGANDS

The names of neutral ligands remain unchanged. Two exceptions are water and ammonia.

Molecular Formula of Ligand	Ligand Name
NH_3	Ammine
H_2O	Aqua
CO	Carbonyl
NO	Nitrosyl
en (H_2N-CH_2CH_2-NH_2)	Ethylenediamine

RULE 4: LIGAND MULTIPLICITY

The number of ligands present in the complex is indicated with the prefixes di, tri, etc. (or sometimes bis, tric, tetrakis, pentakis, etc. for organic ligands)

Number of Ligands	Mono dentate Ligands	Poly dentate Ligands
1	mono	-
2	di	bis
3	tri	tris
4	tetra	tetrakis
5	penta	-
6	hexa	-

RULE 5: NAMING METAL ATOM

- If the overall coordination complex is an anion, the ending "-ate" is attached to the metal center.
- To show the oxidation state, we use Roman numerals inside parenthesis e.g. (I), (II), (III), (IV), (V) etc.

Transition Metal	Latin
Iron	Ferrate
Copper	Cuprate
Tin	Stannate
Silver	Argentate
Lead	Plumbate
Cobalt	Cobaltate

NAMING THE COMPLEXES

GIVE IUPAC NAMES OF THE FOLLOWING TRANSITION METAL COMPLEXES

1. $K_3[Fe(CN)_6]$

Potassium	Hexa cyano	Ferrate (III)

2. $K_4[Fe(CN)_6]$

Potassium	Hexa cyano	Ferrate (II)

3. $Na_3[Co(NO_2)_6]$

Sodium	Hexa nitro	Cobaltate (III)

4. $Na_2[Zn(OH)_4]$

Sodium	Tetra hydroxo	Zincate (II)

First write the name of Cation

Write names of Ligands

Write metal name and oxidation state

GIVE IUPAC NAMES OF THE FOLLOWING TRANSITION METAL COMPLEXES

6. $Ni(CO)_4$

Tetra carbonyl | nickel (o)

7. $[Pt(NH_3)_2Cl_2]$

Dichloro diammine | platinum (II)

8. $[Cr(NH_3)_3Cl_3]$

Tri chloro tri ammine | chromium (III)

9. $[Co(NH_3)_2(en)Cl_3]$

Trichloro (ethylene diammine) diammine | cobalt (III)

Write names of Ligands

Write metal name and oxidation state

GIVE IUPAC NAMES OF THE FOLLOWING TRANSITION METAL COMPLEXES

10. $[Co(NH_3)_6]Cl_3$

Hexa ammine	Cobalt (III)	chloride

11. $[Cr(H2O)_5Br\ ]Br_2$

Bromo penta aquo	Chromium (III)	bromide

12. $[Cu(NH_3)_4]SO_4$

Tetra ammine	Copper (II)	sulphate

13. $[Cu(NH_3)_2(H_2O)_2](NO_3)_2$

Diammine diaquo	Copper (II)	nitrate

Write names of Ligands

Write metal name and oxidation state

Write name of anion

GIVE IUPAC NAMES OF THE FOLLOWING TRANSITION METAL COMPLEX IONS

1. $[Zn(CN)_4]^-$

Tetra cyano | zincate (II) ion

2. $[Co(NH_3)_6]^{+3}$

Hexa ammine | cobalt (III) ion

3. $[Ni(CN)_4]^{-2}$

Tetra cyano | nickelate (II) ion

4. $[Co(en)_2Cl_2]^{+3}$

Dichloro bis ethylene diammine | cobalt (III) ion

Write names of Ligands

Write metal name and oxidation state

END OF LESSON

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