S. Y. B. Sc. CBCS COURSE IN CHEMISTRY

Core Course- (Semester I)

CH - 301 Physical and Inorganic Chemistry

Section: - Only Inorganic Chemistry

A POWERPOINT PRESENTATION FOR S. Y. B. Sc. ON THE TOPIC

ENTITLED

Chapter-3: - “The d-block elements” (L:10, M:20/30)

Online lecture no. -1

BY

Dr. R. K. Chaudhari

Associate Professor, S.V.S.’s Dadasaheb Rawal College, Dondaicha.

Dondaicha. Dist- Dhule. **(M. S.)**

----- September 2021 -----

INORGANIC CHEMISTRY

CHAPTER- The d-Block Elements

ONLINE LECTURE

NO. 1

DATE:- 15 SEPTEMBER, 2021

(9.00A.M.)

Index: -

1) Arrangement of elements
2) Modern periodic law
3) Outline of periodic table
4) Classification of elements based on nature of last electron
5) Classification of elements based on energy levels
6) Inert gases
7) Alkali metals
8) Alkaline earth elements
9) Halogens
10) Chalcogens

Introduction: - Each element differs from other elements in one way or the other. Their compounds also exhibit different characteristics. Therefore, it is difficult to study and remember the properties of individual elements and their compounds. To overcome this difficulty, attempts were made from time to time to group together the elements with similar properties. Thus, knowing the properties of one element, the properties of other elements in that particular group could be known. This "Process of arranging similar elements in one group and separating them from other dissimilar elements is called classification of elements".

A table which has been framed with the help of classification of elements is called periodic table. Periodic table is the tabular arrangement of all the known elements based on periodic law.

Modern Periodic law: -

"Properties of the elements are the periodic function of their atomic numbers".

i.e. When elements are arranged in the increasing order of their atomic numbers, then elements having similar properties are repeated after regular intervals.(That is called periodicity).

The elements showing similar properties are repeated at regular intervals is called periodicity.

Outline of periodic table : -

1) There are 7 horizontal rows called as periods, which are numbered as 1,2,3,...etc.

2) There are 18 vertical columns called as groups corresponding to 16 groups. These groups are numbered as IA, IIA, IIIB,…….VIIB, VIII, IB,IIB,IIIA,…….VIIA and zero. The group VIII in the centre of the table contains three vertical columns.

3) The table may be broadly divided into the following three portions.
   i) The left portion: - From groups IA and IIA. These are highly metals.
   ii) The right portion: - From group IIIA to VIIA, along with zero group. It consists of poor metals, all metalloids and non-metals. All non-metals are placed in the top right hand corner. The elements of zero group are present to the extreme right.
   iii) The middle portion: - From groups IIIB, IVB. VB, VIB, VIIB, VIII, IB, IIB. They include transition elements and inner transition elements. The cause of periodicity lies in the recurrence of similar outer electronic configuration at regular intervals. The intervals are 2,8,8,18,18,32, 32.

Classification of elements into s,p,d,f, block elements

This classification depends upon the type of the orbital (s, p, d, f) into which the last electron (differentiating electron) of the atom enters.

S-block elements last electron enters the s-orbital of their outermost shell.

Elements of IA and IIA groups. General outer electronic confg^{n}. is ns^1 and ns^2

p-block elements last electron enters the p-orbital of their outermost shell

Elements of IIIA to VIIA and zero groups. Their general electronic onfg^{n}. is from ns^2np^1 to ns^2np^6.

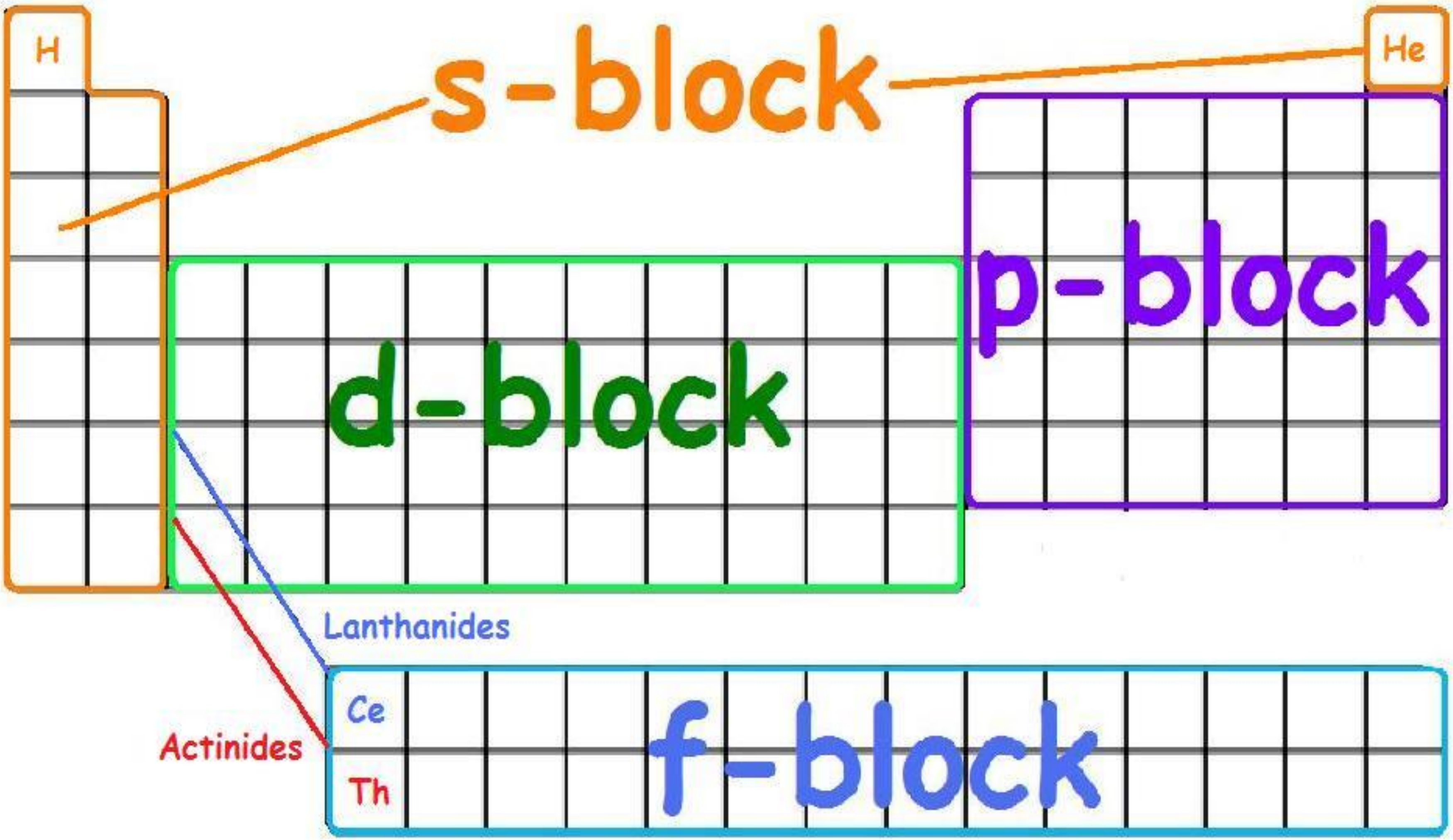
d-block elements last electron enters t he d-orbital of their penultimate shell (last but one)

Elements of IIIB to VIII and from IB to IIB groups. Their general electronic confgn. Is $(n\text{-}1)\ d^{1\text{-}10}\ ns^{0,1,2}$.

f-block elements last electron enters the f-orbital of their prepenultimate shell (inner to penultimate or last but two)

Their general electronic confgn. Is $(n\text{-}2)\ f^{1\text{-}14}$ $(n\text{-}1)\ d^{0,1,2}$, ns^2.

Outline of periodic table



IA																	VIII
1 H	II											III	IV	V	VI	VII	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg	III	IV	V	VI	VII		VIII		I	II	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt									
		* Lanthanides	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	
		+ Actinides	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	

INORGANIC CHEMISTRY

CHAPTER- The d-Block Elements

ONLINE LECTURE

NO. 2

DATE:-2 SEPTEMBER, 2020

TIME: (9.00A.M.)

Classification of elements into s,p,d,f, block elements

This classification depends upon the type of the orbital (s, p, d, f) into which the last electron (differentiating electron) of the atom enters.

S-block elements last electron enters the s-orbital of their outermost shell.

Elements of IA and IIA groups. General outer electronic confg^n. is ns^1 and ns^2

p-block elements last electron enters the p-orbital of their outermost shell

Elements of IIIA to VIIA and zero groups. Their general electronic onfg^n. is from ns^2np^1 to ns^2np^6.

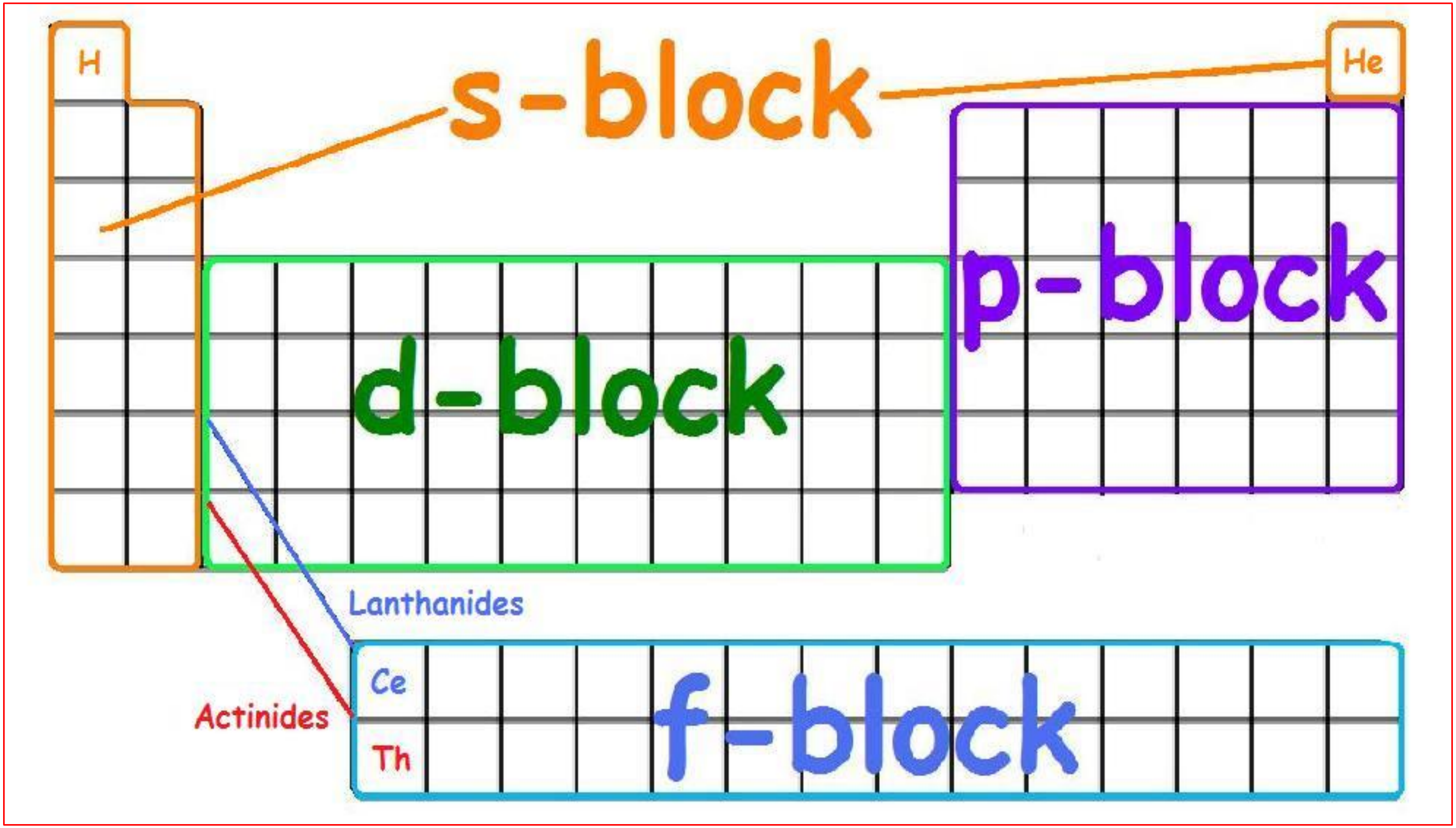
d-block elements last electron enters the d-orbital of their penultimate shell (last but one)

Elements of IIIB to VIII and from IB to IIB groups. Their general electronic confgn. Is $(n-1)\ d^{1-10}\ ns^{0,1,2}$.

f-block elements last electron enters the f-orbital of their prepenultimate shell (inner to penultimate or last but two)

Their general electronic confgn. Is $(n-2)\ f^{1-14}$ $(n-1)\ d^{0,1,2}$, ns^2.

Outline of periodic table



Classification of elements

Inert gases
Noble gases
Zero group elements
$ns^2 np^6$

- 8 electrons in Outermost Shell
- ns^2np^6

Normal elements
Or
Representative elements
S and p-block elements

- Outermost energy level is incompletely Filled
- ns^1 to ns^2np^5

Transition elements
d-block elements

- Their last two energy levels are incompletely filled
- $(n-1)d^1 ns^2$ to $(n-1) d^{10} ns^2$

Inner Transition Elements
f-block elements

- Their last Three energy levels are incompletely Filled
- $(n-2)f^{1-14}$, $(n-1) d^{1 \text{ or } 0} ns^2$

i] Inert gases: -

Ne (10) $\rightarrow 1S^2$, **$2S^2, 2P^6$**

Ar (18) $\rightarrow 1S^2, 2S^2, 2P^6$, **$3S^2, 3P^6$**

He (2) $\rightarrow$ **$1S^2$**

ii] Normal or Representative elements: - (S & P-block)

Na (11) $\rightarrow 1S^2, 2S^2, 2P^6$, **$3S^1$**

Mg (12) $\rightarrow 1S^2, 2S^2, 2P^6$, **$3S^2$**

Al (13) $\rightarrow 1S^2, 2S^2, 2P^6$, **$3S^2, 3P^1$**

Si (14) $\rightarrow 1S^2, 2S^2, 2P^6$, **$3S^2, 3P^2$**

p (15) $\rightarrow 1S^2, 2S^2, 2P^6$, **$3S^2, 3P^3$**

S (16) $\rightarrow 1S^2, 2S^2, 2P^6$, **$3S^2, 3P^4$**

Cl (17) $\rightarrow 1S^2, 2S^2, 2P^6$, **$3S^2, 3P^5$**

iii] Transition elements: - (d-block)

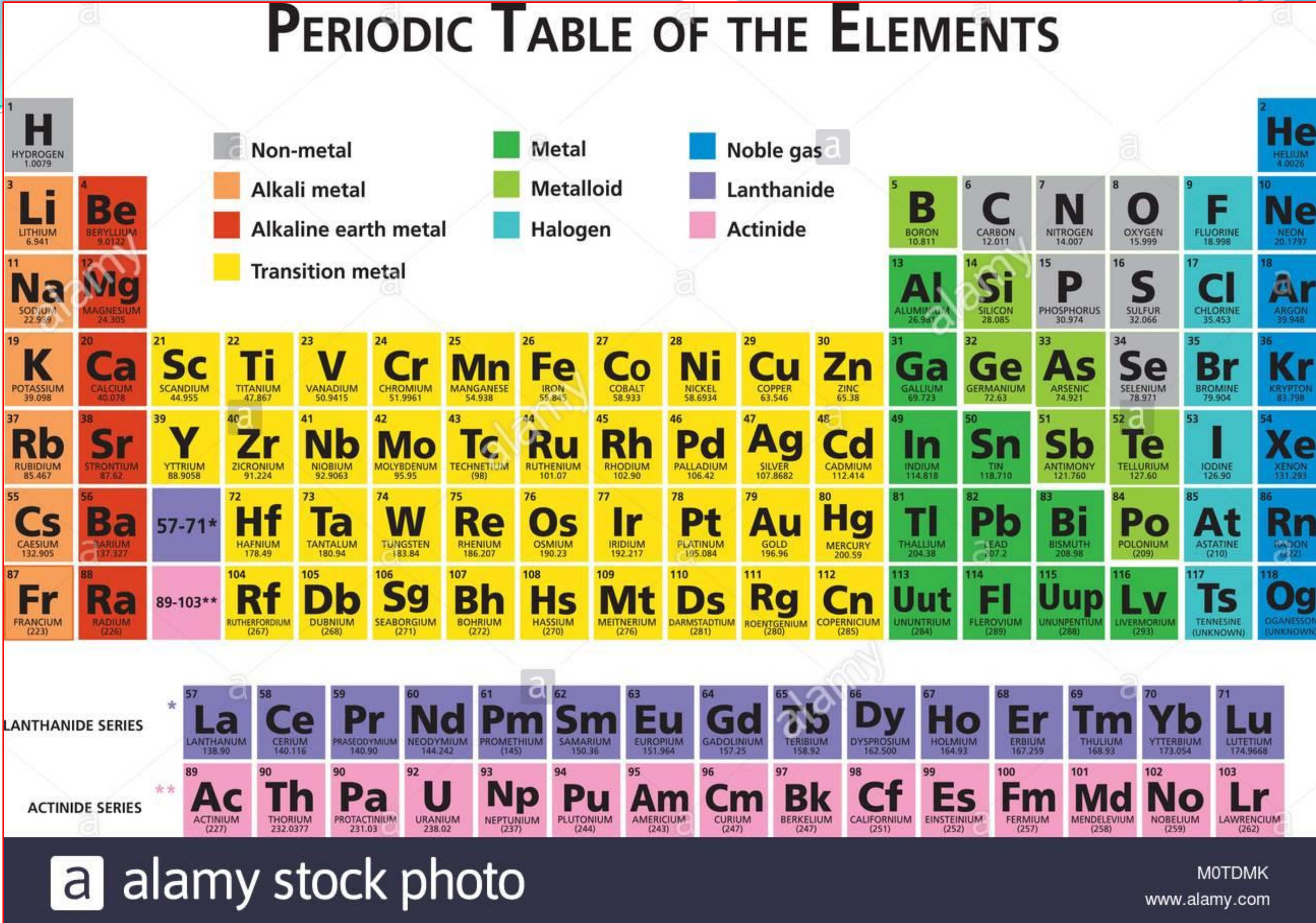
Sc (21) → $1S^2, 2S^2, 2P^6, 3S^2, 3P^6,$ **$\underline{4S^2, 3d^1}$**

Cu (29) → $1S^2, 2S^2, 2P^6, 3S^2, 3P^6,$ **$\underline{4S^2, 3d^9}$**

Zn (30) → $1S^2, 2S^2, 2P^6, 3S^2, 3P^6,$ **$\underline{4S^2, 3d^{10}}$**

iv) Inner transition elements: - (f-block)

La (57) → $1S^2, 2S^2, 2P^6, 3S^2, 3P^6, 4S^2, 3d^{10}, 4P^6, 5S^2, 4d^{10},$ **$\underline{5P^6, 6S^2, 4f^1}$**



PERIODIC TABLE OF THE ELEMENTS
Non-metal
Alkali metal
Alkaline earth metal
Transition metal
Metal
Metalloid
Halogen
Noble gas
Lanthanide
Actinide
1 H HYDROGEN 1.0079
2 He HELIUM 4.0026
3 Li LITHIUM 6.941
4 Be BERYLLIUM 9.0122
5 B BORON 10.811
6 C CARBON 12.011
7 N NITROGEN 14.007
8 O OXYGEN 15.999
9 F FLUORINE 18.998
10 Ne NEON 20.1797
11 Na SODIUM 22.989
12 Mg MAGNESIUM 24.305
13 Al ALUMINIUM 26.981
14 Si SILICON 28.085
15 P PHOSPHORUS 30.974
16 S SULFUR 32.066
17 Cl CHLORINE 35.453
18 Ar ARGON 39.948
19 K POTASSIUM 39.098
20 Ca CALCIUM 40.078
21 Sc SCANDIUM 44.955
22 Ti TITANIUM 47.867
23 V VANADIUM 50.9415
24 Cr CHROMIUM 51.9961
25 Mn MANGANESE 54.938
26 Fe IRON 55.845
27 Co COBALT 58.933
28 Ni NICKEL 58.6934
29 Cu COPPER 63.546
30 Zn ZINC 65.38
31 Ga GALLIUM 69.723
32 Ge GERMANIUM 72.63
33 As ARSENIC 74.921
34 Se SELENIUM 78.971
35 Br BROMINE 79.904
36 Kr KRYPTON 83.798
37 Rb RUBIDIUM 85.467
38 Sr STRONTIUM 87.62
39 Y YTTRIUM 88.9058
40 Zr ZICRONIUM 91.224
41 Nb NIOBIUM 92.9063
42 Mo MOLYBDENUM 95.95
43 Tc TECHNETIUM (98)
44 Ru RUTHENIUM 101.07
45 Rh RHODIUM 102.90
46 Pd PALLADIUM 106.42
47 Ag SILVER 107.8682
48 Cd CADMIUM 112.414
49 In INDIUM 114.818
50 Sn TIN 118.710
51 Sb ANTIMONY 121.760
52 Te TELLURIUM 127.60
53 I IODINE 126.90
54 Xe XENON 131.293
55 Cs CAESIUM 132.905
56 Ba BARIUM 137.327
57-71*
72 Hf HAFNIUM 178.49
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74 W TUNGSTEN 183.84
75 Re RHENIUM 186.207
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82 Pb LEAD 207.2
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84 Po POLONIUM (209)
85 At ASTATINE (210)
86 Rn RADON (222)
87 Fr FRANCIUM (223)
88 Ra RADIUM (226)
89-103**
104 Rf RUTHERFORDIUM (267)
105 Db DUBNIUM (268)
106 Sg SEABORGIUM (271)
107 Bh BOHRIUM (272)
108 Hs HASSIUM (270)
109 Mt MEITNERIUM (276)
110 Ds DARMSTADTIUM (281)
111 Rg ROENTGENIUM (280)
112 Cn COPERNICIUM (285)
113 Uut UNUNTRIUM (284)
114 Fl FLEROVIUM (289)
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57 La LANTHANUM 138.90
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59 Pr PRASEODYMIUM 140.90
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61 Pm PROMETHIUM (145)
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63 Eu EUROPIUM 151.964
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95 Am AMERICIUM (243)
96 Cm CURIUM (247)
97 Bk BERKELIUM (247)
98 Cf CALIFORNIUM (251)
99 Es EINSTEINIUM (252)
100 Fm FERMIUM (257)
101 Md MENDELEVIUM (258)
102 No NOBELIUM (259)
103 Lr LAWRENCIUM (262)
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INORGANIC CHEMISTRY

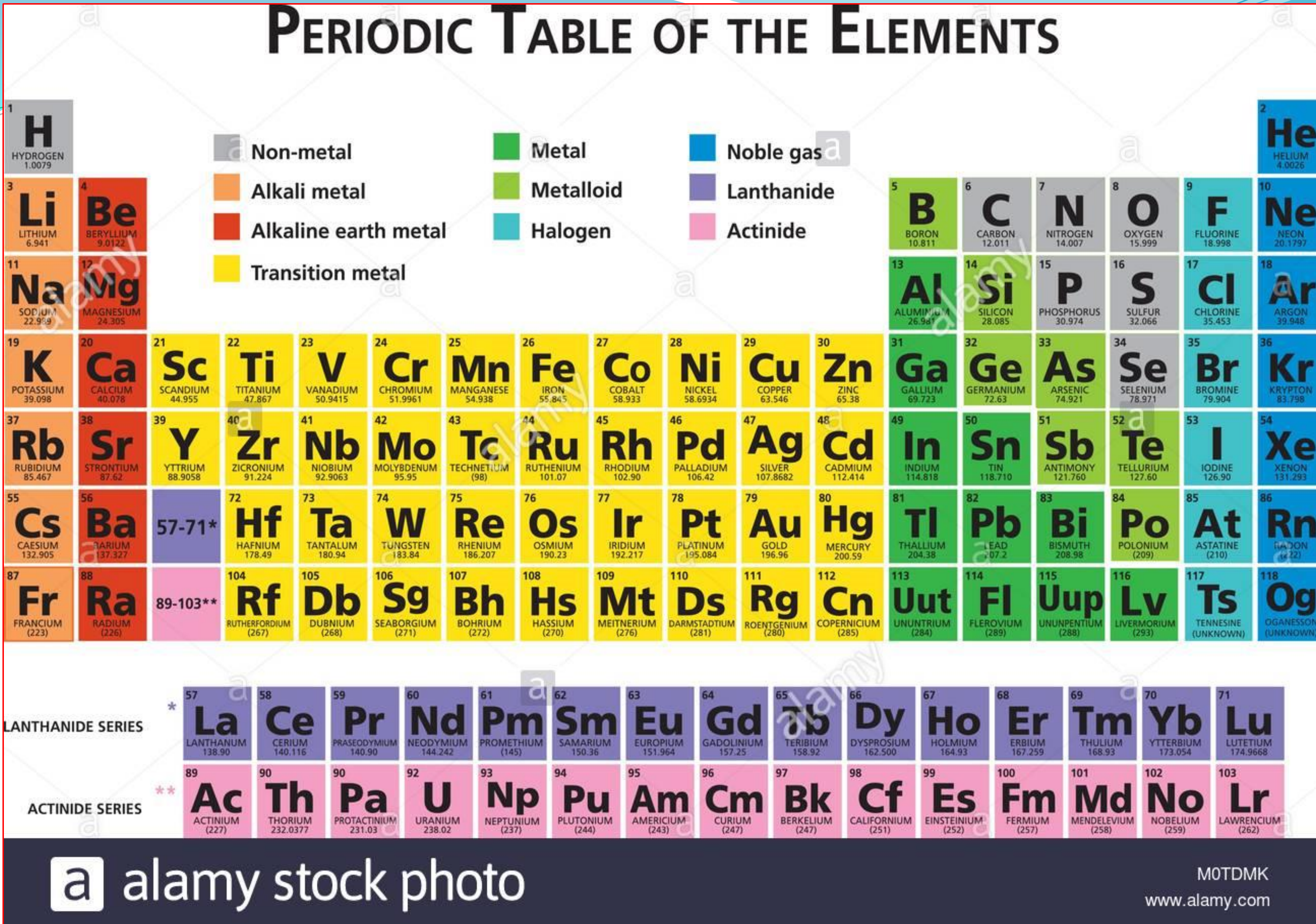
CHAPTER- The d-Block Elements

ONLINE LECTURE

NO. 3

DATE:- 4 SEPTEMBER 2020

TIME: (8.00A.M.)



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$\boxed{{}_{7}N^{13}}$

Alkali metals –IA group elements (Oxides and hydroxides are basic)

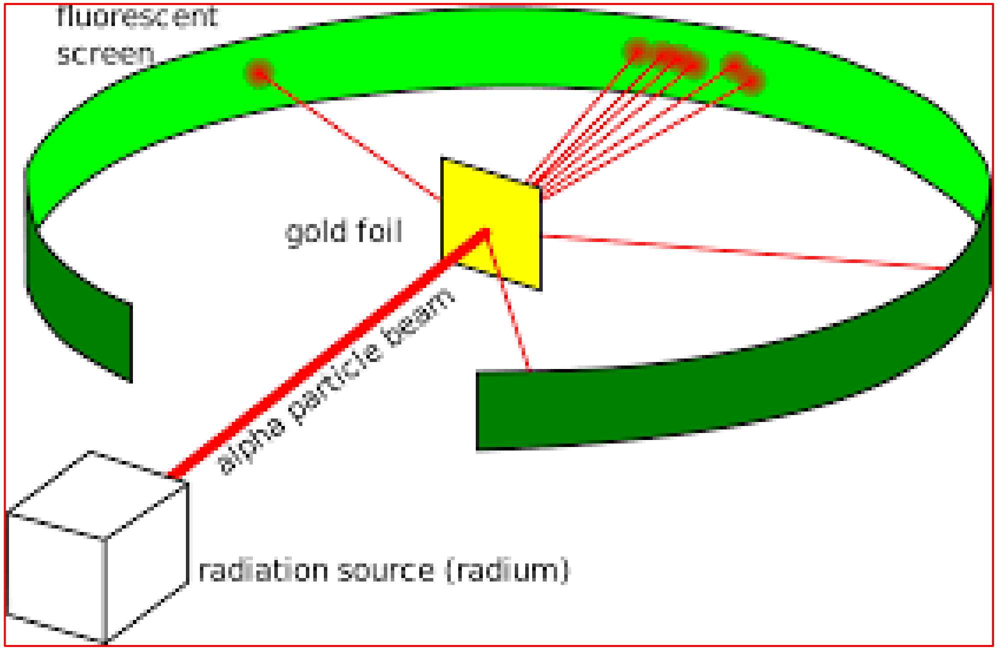
Alkaline Earth metals- IIA group elements (Oxides and hydroxides are basic and stable to fire)

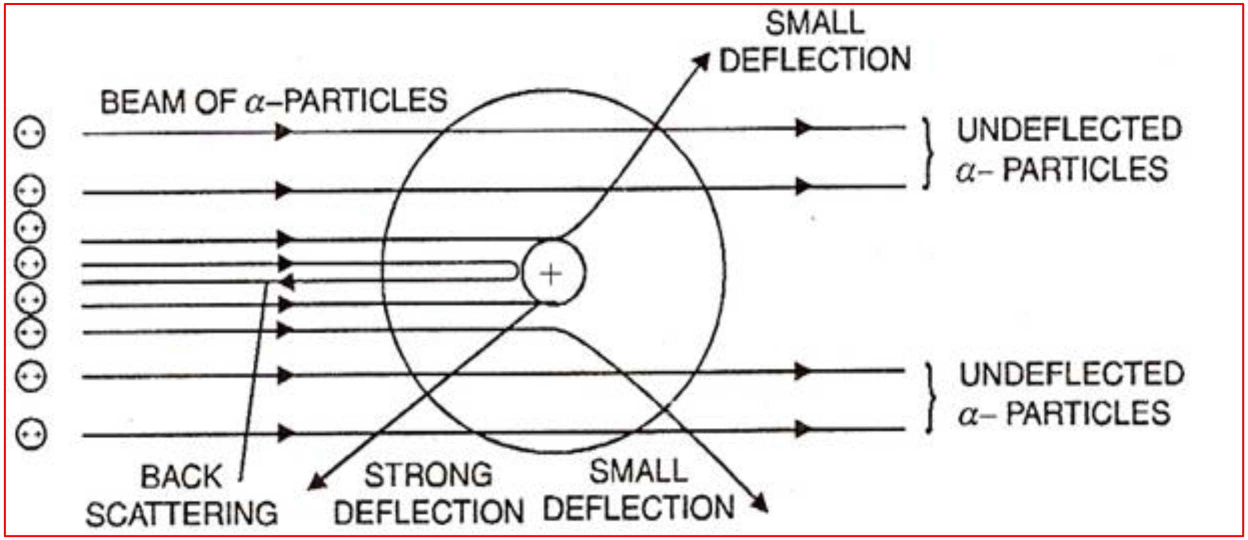
Inert gases-Zero group elements (Octet rule, stable octates)

Halogens-VII A group elements (Salt generaters)

Chalcogens-VIA group elements (Ore forming)

Rutherford's Experiment: -





Rutherfords atomic model: - i) Atom is extraordinarily empty in space.

ii) It consists of a centre called nucleus, compact heavy, mass at centre, size 10^{-12} to 10^{-13} cm.

iii) Positive charge due to protons

iv) Electrons are revolving around and atom is neutral.

Drawbacks: -

i) Repulsion between protons
ii) Gradual fall in energy
iii) Electron cannot trace circular path
iv) Newton's laws not applied.

Bohr's Model: - stationary, non radiating circular orbits, energy constant, energy increases away from nucleus, excitation by absorption of quanta, quantization of angular momentum.

Drawbacks: - i) Fails for many e- ii) Multiplicity of lines iii) Zeeman & Stark effect, iv) Arrangement of e-s v) Excluded motion of nucleus vi) Jumping is not justified vii) Fails to explain bonding.

Sommerfield's Model: -

Possibility of elliptical orbits, Considers motion of nucleus, Noted relativistic variation of mass with velocity at different positions of ellipse.

Quantum numbers: - Gives information about

i) Size of atom

ii) Shape of electron cloud

iii) Orientation of electron

iv) Spin of electron

A) Principal quantum number(n): - Main energy level, size or effective volume of atom. Takes values from n = 1,2,3,…..or K, L, M, N…. Shells. The maximum no. of electrons = $2n^2$.

B) Azimuthal quantum number(l) : - Sub-energy level, shape of electron cloud. Sub-energy levels = n.

Takes values from l = 0 to (n-1).

$l \rightarrow$	0	1	2	3
Orbital $\rightarrow$	s	p	d	f
Electrons $\rightarrow$	2	6	10	14

C) Magnetic quantum number(m_l): - Orientation, disposition, location

$m_l = (2l + 1) = -l$, through 0 to $+l$

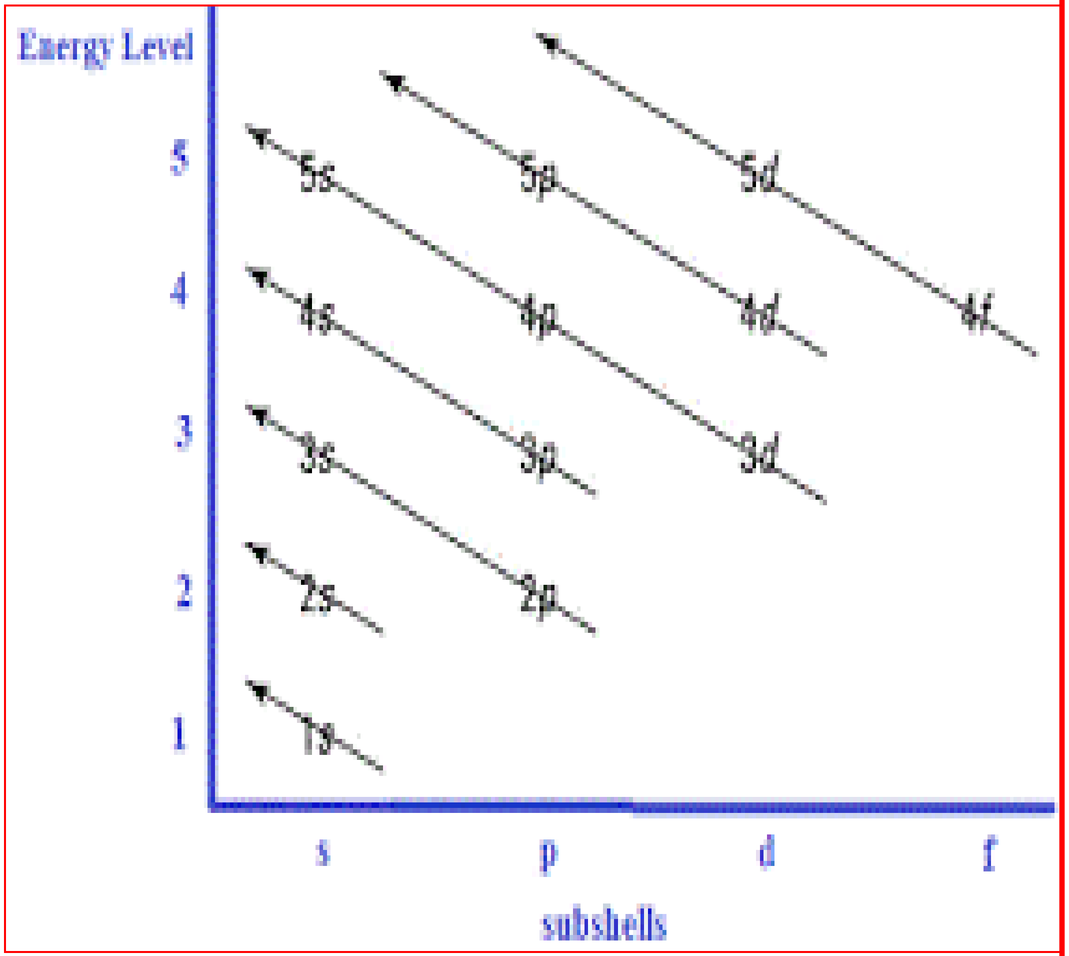
n	l	m_l
1	0 (S)	0 (One)
2	0 (S)	0 (One)
	1 (P)	-1, 0, +1 (Three) i.e. P_x, P_y, P_z
3	0 (S)	0 (One)
	1 (P)	-1, 0, +1 (Three)
	2 (d)	-2, -1, 0. +1, +2 (Five) dxy.dyz, dxz, dx^2-y^2, dz^2
4	0 (S)	0 (One)
	1 (P)	-1, 0, +1 (Three)
	2 (d)	-2, -1, 0. +1, +2
	3 (f)	-3, -2, -1, 0, +1, +2, +3 (Seven)

D) Spin quantum number (m_s): - Electron can revolve either in clockwise or anti-clockwise direction.

$m_s = +\frac{1}{2}$ $m_s = -\frac{1}{2}$

n	l	m_l	m_s	
1	0 (S)	0 (One)	$+\frac{1}{2}$ and $-\frac{1}{2}$	$2e^-$
2	0 (S)	0 (One)	$2e^-$	$8e^-$
	1 (P)	-1, 0, +1 (Three)	$6e^-$	
3	0 (S)	0 (One)	$2e^-$	$18e^-$
	1 (P)	-1, 0, +1 (Three)	$6e^-$	
	2 (d)	-2, -1, 0. +1, +2	$10e^-$	
4	0 (S)	0 (One)	$2e^-$	$32e^-$
	1 (P)	-1, 0, +1 (Three)	$6e^-$	
	2 (d)	-2, -1, 0. +1, +2	$10e^-$	
	3 (f)	-3, -2, -1, 0, +1, +2, +3	$14e^-$	

Aufbau principle: - Electrons will enter into the lowest energy level first, and then in the increasing order of energy. The energy sequence can be determined as:-



The energy sequence is

1S, 2S, 2P, 3S, 3P, 4S, 3d, 4P, 5S,….

Energy of 4S < Energy of 3d

Energy is calculated by $(n + l)$ rule,

For 4S $\rightarrow$ ($n = 4$ and $l = 0$)

$(n+l) = 4+0 = 4$

For 3d$\rightarrow$($n = 3$ and $l = 2$)

$(n+l) = 3+2 = 5$

4 < 5 Hence, Energy of 4S < Energy of 3d.

When $(n+l)$ values are same, then the shell with lower value of n posseses lower energy.

i.e. 3d < 4P , Both have $(n+l) = 5$.

Hunds rule of maximum multiplicity: - If several orbitals of equal energy are available, then electrons are singly filled first, then pairing starts.

e.g. B (At. No. = 5) → $1S^2, 2S^2, 2Px^1$

C (At. No. = 6) → $1S^2, 2S^2, 2Px^1, 2Py^1$

N (At. No. = 7) → $1S^2, 2S^2, 2Px^1, 2Py^1, 2Pz^1$

O (At. No. = 8) → $1S^2, 2S^2, 2Px^2, 2Py^1, 2Pz^1$

F (At. No. = 9) → $1S^2, 2S^2, 2Px^2, 2Py^2, 2Pz^1$

Paulis exclusion principle: - "No two electrons in the same atom, have the identical set of four quantum numbers".

e..g. He (At. No. = 2) → $1S^2$

1st electron	2nd electron
n = 1	n =1
l = 0 (S-orbital)	*l* = 0 (S-orbital)
m*l* = 0	m*l* = 0
ms = + $\frac{1}{2}$	ms = - $\frac{1}{2}$

Principle of extra stability: - If an element have number of electrons in its last orbit is equal to half-filled or full-filled to their capacity, then they acquires more stability. For this purpose, rearrangement of electrons takes place between nearly equal energy orbitals.

e.g. Cr (24) → $1S^2$, $2S^2$,$2P^6$,$3S^2$, $3P^6$,$4S^2$, $3d^4$ (expected)

But, Cr (24) → $1S^2$, $2S^2$,$2P^6$,$3S^2$, $3P^6$,$4S^1$, $3d^5$ (Observed) (Half-filled)

Similarly,

Cu (29) → $1S^2$, $2S^2$,$2P^6$,$3S^2$, $3P^6$,$4S^2$, $3d^9$ (expected)

But, Cu (29) → $1S^2$, $2S^2$,$2P^6$,$3S^2$, $3P^6$,$4S^1$, $3d^{10}$ (Observed) (Full-filled)

INORGANIC CHEMISTRY

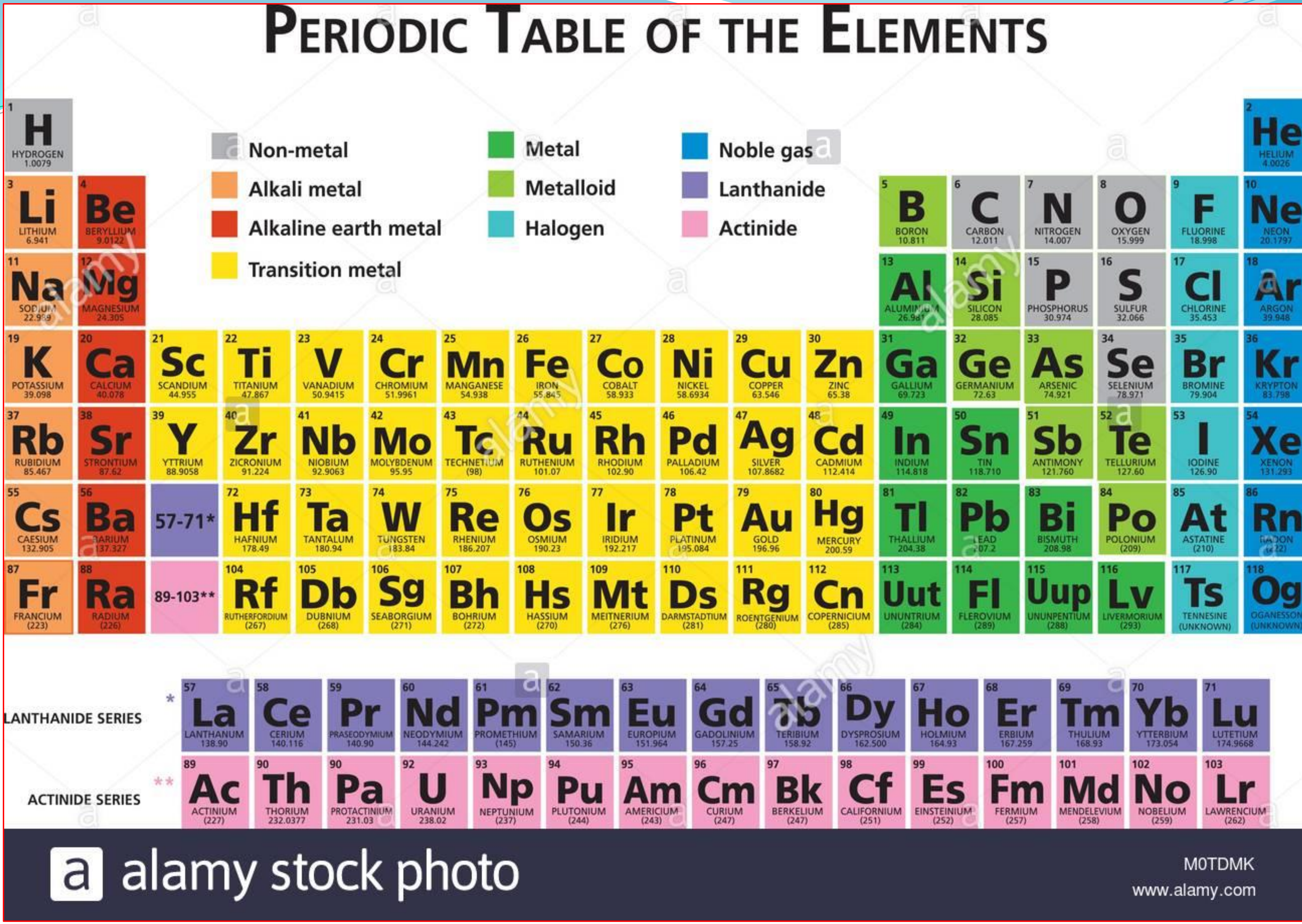
CHAPTER- The d-Block Elements

ONLINE LECTURE

NO. 4

DATE:- 9, SEPTEMBER 2020

TIME: (9.00A.M.)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Lanthanide
Actinide
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38 Sr STRONTIUM 87.62
39 Y YTTRIUM 88.9058
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42 Mo MOLYBDENUM 95.95
43 Tc TECHNETIUM (98)
44 Ru RUTHENIUM 101.07
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Group	III B	IV B	V B	VI B	VII B	VIII B	VIII B	VIII B	I B	II B
At.no./ Element	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn
Confg.	$3d^1 4S^2$	$d^2\ S^2$	$d^3\ S^2$	$d^5\ S^1$	$d^5\ S^2$	$d^6\ S^2$	$d^7\ S^2$	$d^8\ S^2$	$d^{10}\ S^1$	$d^{10}\ S^2$
At.no./ Element	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd
Confg.	$4d^1 5S^2$	$d^2 S^2$	$d^4\ S^1$	$d^5\ S^1$	$d^5\ S^2$	$d^7\ S^1$	$d^8\ S^1$	$d^{10}\ S^0$	$d^{10}\ S^1$	$d^{10}\ S^2$
At.no./ Element	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg
Confg.	$5d^1\ 6S^2$	$4f^{14}$ $d^2\ S^2$	$d^3\ S^2$	$d^4\ S^2$	$d^5\ S^2$	$d^6\ S^2$	$d^7\ S^2$	$d^{10}\ S^0$	$d^{10}\ S^1$	$d^{10}\ S^2$
At.no./ Element	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs Hassium	109 Mt Meithe-Rium			
Confg.	$6d^1 5S^2$	d^2	d^3	d^4	d^5	d^6	d^7			

Introduction: - The d-block elements are called as transition elements because The position and properties are between s-block and p-block elements.

S-block → d-block ← p-block

The general electronic configuration of d-bock elements is **$nS^{0,\,1\text{ or }2}$ $(n\text{-}1)\ d^{1\text{-}10}$.**

Subshells

↓

Completely fillled	Incompletely filled
S^2, P^6, d^{10}, f^{14}	Contains less no. of electrons than their capacity e.g. S^1, $P^{1\text{-}5}$, $d^{1\text{-}9}$, $f^{1\text{-}13}$

The transition elements may be broadly defined as "The elements which have partly filled d or f-subshells in their atoms or ions in their commonly occurring oxidation states are called as transition elements"

e. g. →Sc (21) → Sc (21) → $1S^2$, $2S^2$, $2P^6$, $3S^2$, $3P^6$, **$4S^2$, $3d^1$**

Cu (29) → $1S^2$, $2S^2$,$2P^6$,$3S^2$, $3P^6$,$4S^2$, $3d^9$ (expected)

Cu (29) → $1S^2, 2S^2, 2P^6, 3S^2, 3P^6, 4S^2, 3d^9$ (expected)

But, Cu (29) → $1S^2, 2S^2, 2P^6, 3S^2, 3P^6, 4S^1, 3d^{10}$ (Observed) (Full-filled) (Non-transition)

We know, CuSO4, Here, Cu is as Cu^{+2} and SO_4 as SO_4^{-2}

$Cu \longrightarrow Cu^{+2} + 2e^-$

$29\ e^- \longrightarrow 27\ e^- + 2e^-$

Cu^{+2} (27) → $1S^2, 2S^2, 2P^6, 3S^2, 3P^6, 3d^9$ (partly filled d-orbital)

Hence, Cu is a member of transition elements.

Now, Consider Zn (30) → $1S^2, 2S^2, 2P^6, 3S^2, 3P^6, 4S^2, 3d^{10}$ (d-orbital full filled)

But, We know, ZnSO4, Here, Zn is as Zn^{+2} and SO_4 as SO_4^{-2}

$Zn \longrightarrow Zn^{+2} + 2e^-$

$30\ e^- \longrightarrow 28\ e^- + 2e^-$

Zn^{+2} (28) → $1S^2, 2S^2, 2P^6, 3S^2, 3P^6, 3d^{10}$ (completely filled d-orbital)

Hence, Zn is not a member of transition elements.

Inner transition elements: - (f-block)

La (57) → $1S^2, 2S^2, 2P^6, 3S^2, 3P^6, 4S^2, 3d^{10}, 4P^6, 5S^2, 4d^{10}$, **$5P^6, 6S^2, 4f^1$ (Partly filled f-orbital)**

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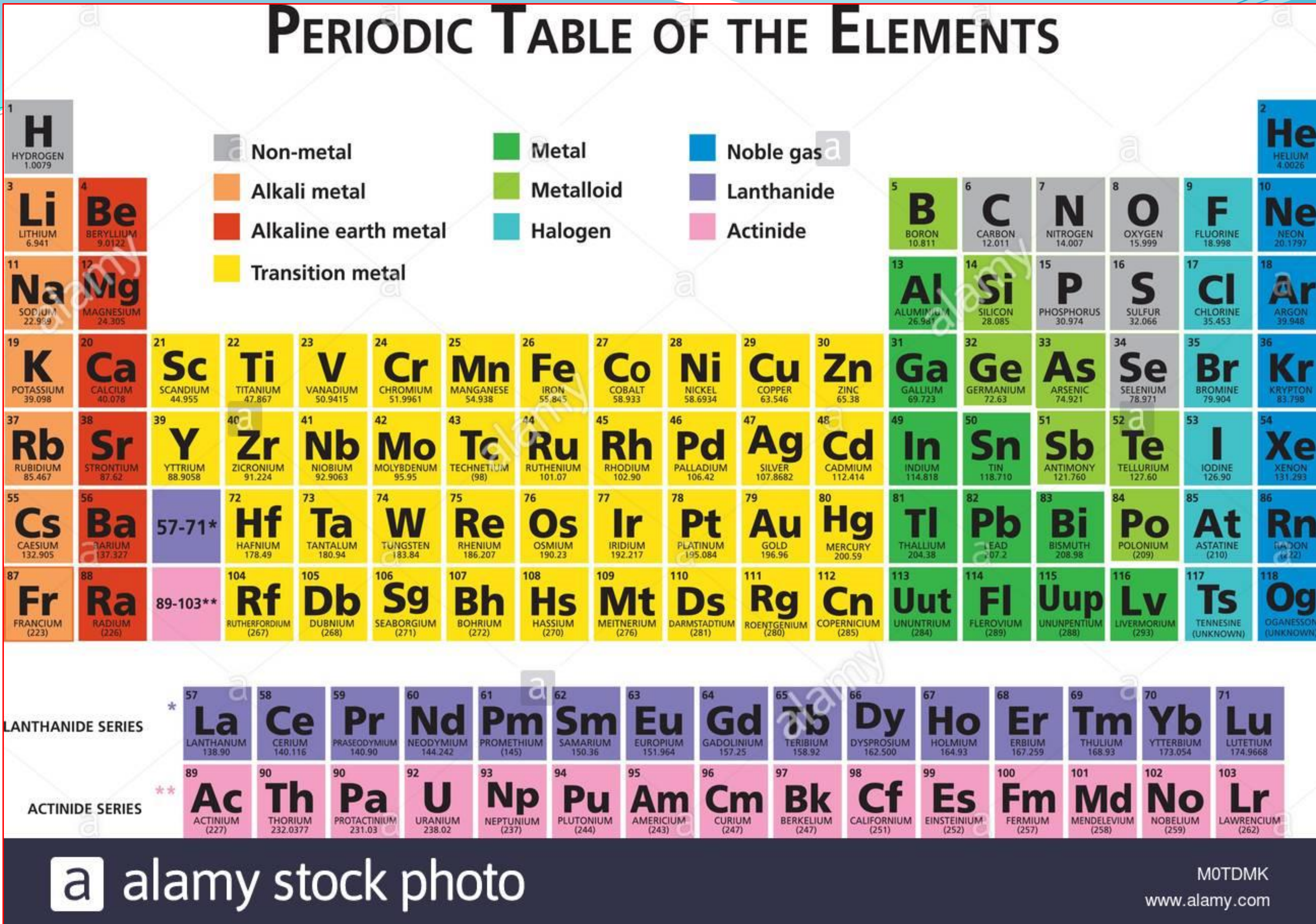
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