

TRANSITION & INNER TRANSITION ELEMENTS



Lecture 2.

Q. 1 – What is the general outermost electronic configuration for the elements lying in the following series.

a. 3d
b. 4d
c. 5d
d. 6d





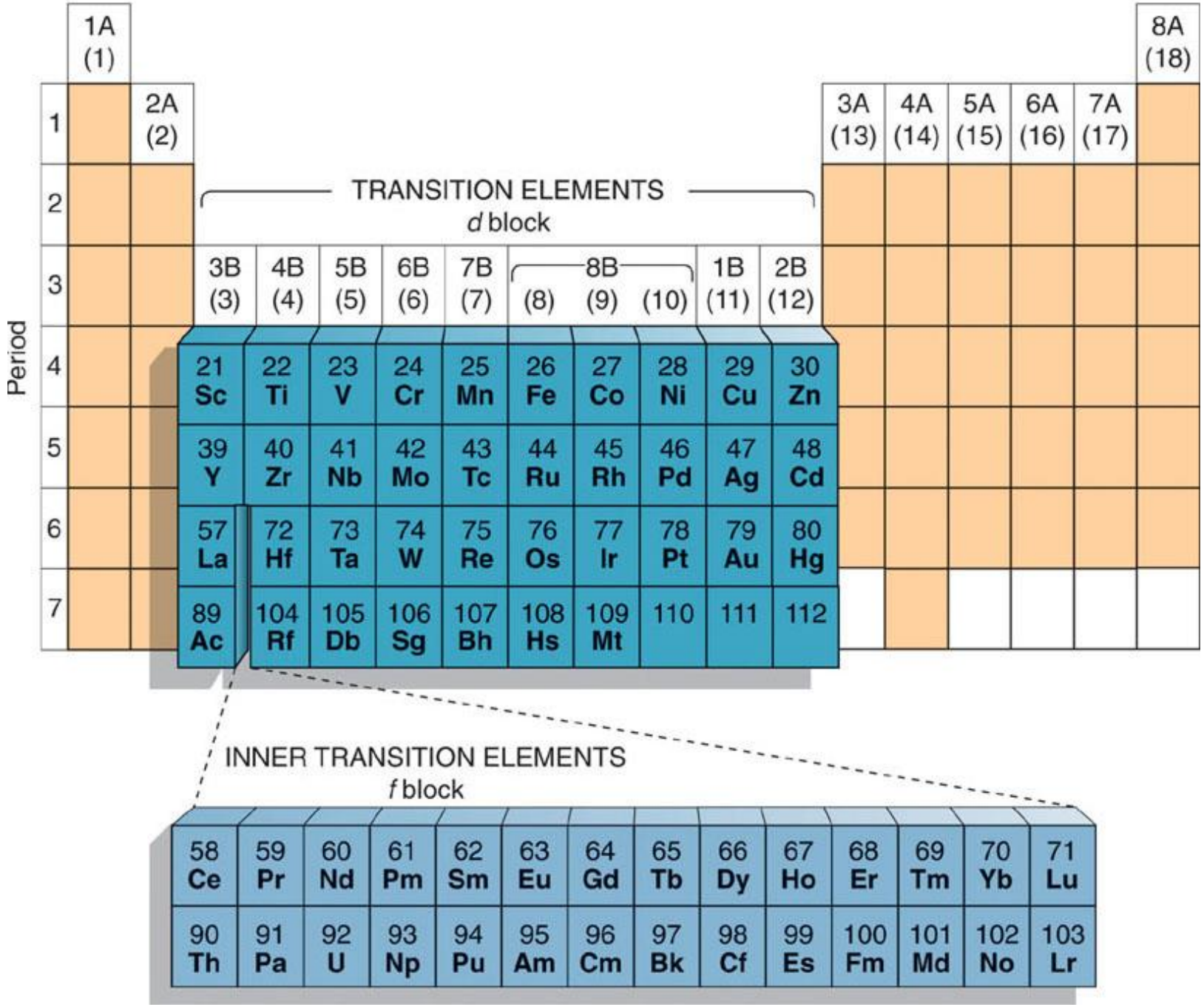
Answer:

1. a. 3d series – [Ar] $4s^{1-2}$ $3d^{1-10}$.

   b. 4d series – [Kr] $5s^{1-2}$ $4d^{1-10}$.

   c. 5d series – [Xe] $6s^{1-2}$ $5d^{1-10}$.

   d. 6d series – [Rn] $7s^{1-2}$ $6d^{1-10}$.


1A (1)
8A (18)
2A (2)
3A (13)
4A (14)
5A (15)
6A (16)
7A (17)
TRANSITION ELEMENTS
d block
3B (3)
4B (4)
5B (5)
6B (6)
7B (7)
8B
(8) (9) (10)
1B (11)
2B (12)
Period
1 2 3 4 5 6 7
21 Sc 22 Ti 23 V 24 Cr 25 Mn 26 Fe 27 Co 28 Ni 29 Cu 30 Zn
39 Y 40 Zr 41 Nb 42 Mo 43 Tc 44 Ru 45 Rh 46 Pd 47 Ag 48 Cd
57 La 72 Hf 73 Ta 74 W 75 Re 76 Os 77 Ir 78 Pt 79 Au 80 Hg
89 Ac 104 Rf 105 Db 106 Sg 107 Bh 108 Hs 109 Mt 110 111 112
INNER TRANSITION ELEMENTS
f block
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
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

Element		Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
Atomic number		21	22	23	24	25	26	27	28	29	30
Electronic configuration											
	M	$3d^1 4s^2$	$3d^2 4s^2$	$3d^3 4s^2$	$3d^5 4s^1$	$3d^5 4s^2$	$3d^6 4s^2$	$3d^7 4s^2$	$3d^8 4s^2$	$3d^{10} 4s^1$	$3d^{10} 4s^2$
	M^+	$3d^1 4s^1$	$3d^2 4s^1$	$3d^3 4s^1$	$3d^5$	$3d^5 4s^1$	$3d^6 4s^1$	$3d^7 4s^1$	$3d^8 4s^1$	$3d^{10}$	$3d^{10} 4s^1$
	M^{2+}	$3d^1$	$3d^2$	$3d^3$	$3d^4$	$3d^5$	$3d^6$	$3d^7$	$3d^8$	$3d^9$	$3d^{10}$
	M^{3+}	[Ar]	$3d^1$	$3d^2$	$3d^3$	$3d^4$	$3d^5$	$3d^6$	$3d^7$	–	–
Enthalpy of atomisation, $\Delta_a H^\ominus$/kJ mol^{-1}		326	473	515	397	281	416	425	430	339	126
Ionisation enthalpy/$\Delta_i H^\ominus$/kJ mol^{-1}											
$\Delta_i H^\ominus$	I	631	656	650	653	717	762	758	736	745	906
$\Delta_i H^\ominus$	II	1235	1309	1414	1592	1509	1561	1644	1752	1958	1734
$\Delta_i H^\ominus$	III	2393	2657	2833	2990	3260	2962	3243	3402	3556	3829
Metallic/ionic	M	164	147	135	129	137	126	125	125	128	137
radii/pm	M^{2+}	–	–	79	82	82	77	74	70	73	75
	M^{3+}	73	67	64	62	65	65	61	60	–	–
Standard											
electrode	M^{2+}/M	–	–1.63	–1.18	–0.90	–1.18	–0.44	–0.28	–0.25	+0.34	-0.76
potential $E^\ominus$/V	M^{3+}/M^{2+}	–	–0.37	–0.26	–0.41	+1.57	+0.77	+1.97	–	–	–
Density/g cm^{-3}		3.43	4.1	6.07	7.19	7.21	7.8	8.7	8.9	8.9	7.1

OXIDATION STATES

- Transition elements exhibit variable oxidation states, due to very small energy difference between (n-1)d & ns sub-shell electrons.
- Both the sub-shell take part in bonding.

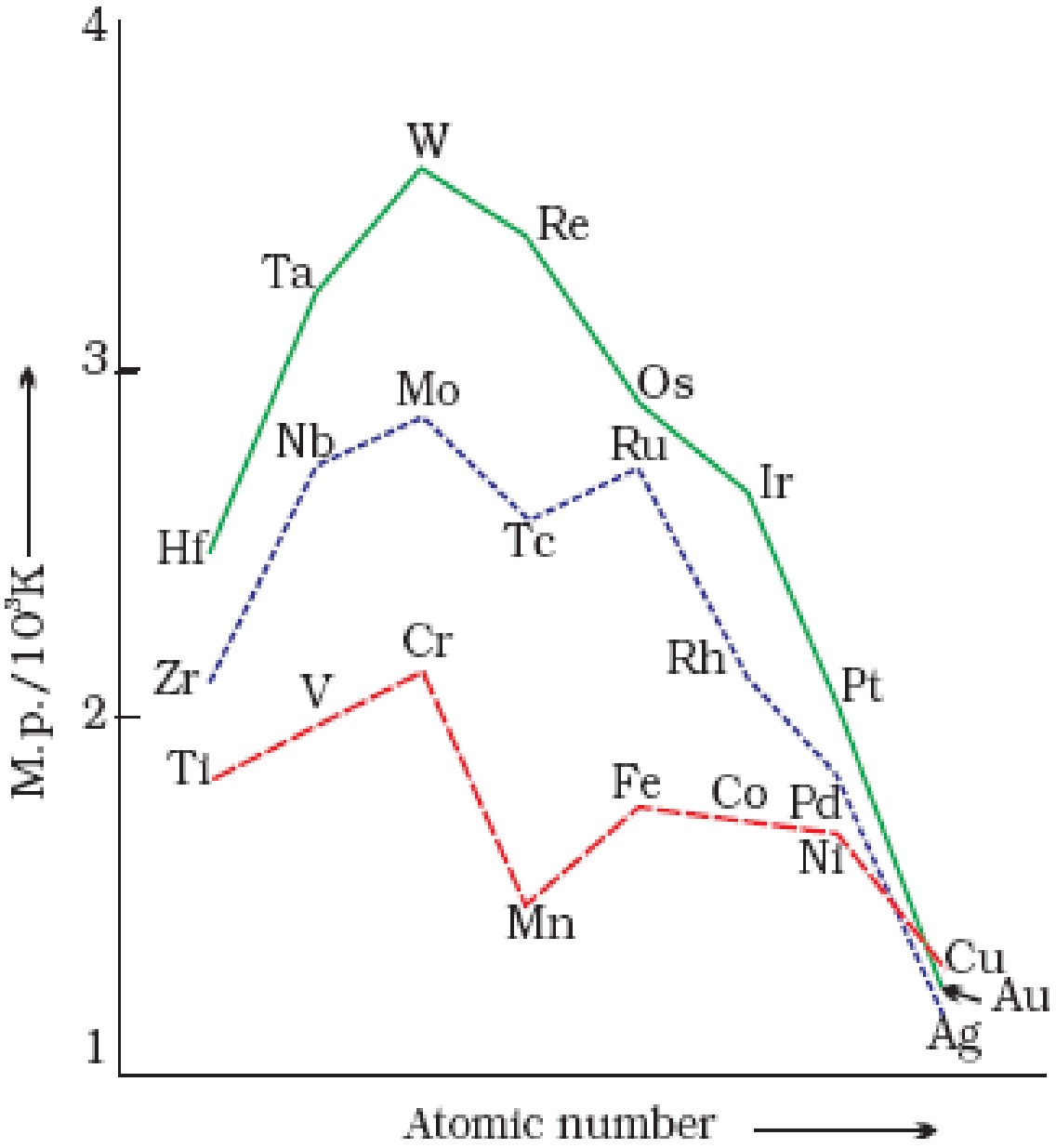
Elements	Outer elecronic configuration	Oxidation states	Elements	Outer electronic configuration	Oxidation states
Sc	$3d^1\ 4s^2$	+2, +3	Fe	$3d^6\ 4s^2$	+2, +3, +4, +5, +6
Ti	$3d^2\ 4s^2$	+2, +3, +4	Co	$3d^7\ 4s^2$	+2, +3, +4, +5
V	$3d^3\ 4s^2$	+2, +3, +4, +5	Ni	$3d^{10}\ 4s^2$	+2, +3, +4
Cr	$3d^5\ 4s^1$	+2, +3, +4, +5, +6	Cu	$3d^{10}\ 4s^1$	+1, +2
Mn	$3d^5\ 4s^2$	+2, +3, +4, +5, +6, +7	Zn	$3d^{10}\ 4s^2$	+2

Oxidation State	3B (3) Sc	4B (4) Ti	5B (5) V	6B (6) Cr	7B (7) Mn	8B (8) Fe	8B (9) Co	8B (10) Ni	1B (11) Cu	2B (12) Zn
0	d^1	d^2	d^3	d^5	d^5	d^6	d^7	d^8	d^{10}	d^{10}
+1			d^3	d^5	d^5	d^6	d^7	d^8	d^{10}	
+2		d^2	d^3	d^4	d^5	d^6	d^7	d^8	d^9	d^{10}
+3	d^0	d^1	d^2	d^3	d^4	d^5	d^6	d^7	d^8	
+4		d^0	d^1	d^2	d^3	d^4	d^5	d^6		
+5			d^0	d^1	d^2		d^4			
+6				d^0	d^1	d^4				
+7					d^0					

- The elements which shows the greatest number of oxidation states occur in or near the middle of the series.
- Manganese, for example, exhibits all the oxidation states from +2 to +7.

Elements	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
Atomic no :	21	22	23	24	25	26	27	28	29	30
Species \ Valence shell Electronic Configuration										
M	$3d^1\ 4s^2$	$3d^2\ 4s^2$	$3d^3\ 4s^2$	$3d^5\ 4s^2$	$3d^5\ 4s^2$	$3d^6\ 4s^2$	$3d^1\ 4s^2$	$3d^8\ 4s^2$	$3d^{10}\ 4s^1$	$3d^{10}\ 4s^2$
$M^{\oplus}$	$3d^1\ 4s^1$	$3d^2\ 4s^1$	$3d^3\ 4s^1$	$3d^5$	$3d^5\ 4s^1$	$3d^6\ 4s^1$	$3d^7\ 4s^1$	$3d^8\ 4s^1$	$3d^{10}\ 4s^0$	$3d^{10}\ 4s^1$
$M^{2\oplus}$	$3d^2$	$3d^2$	$3d^3$	$3d^4$	$3d^5$	$3d^6$	$3d^7$	$3d^8$	$3d^9$	$3d^{10}$
$M^{3\oplus}$	[Ar]	$3d^1$	$3d^2$	$3d^3$	$3d^4$	$3d^5$	$3d^6$	$3d^7$	-	-

MELTING POINT

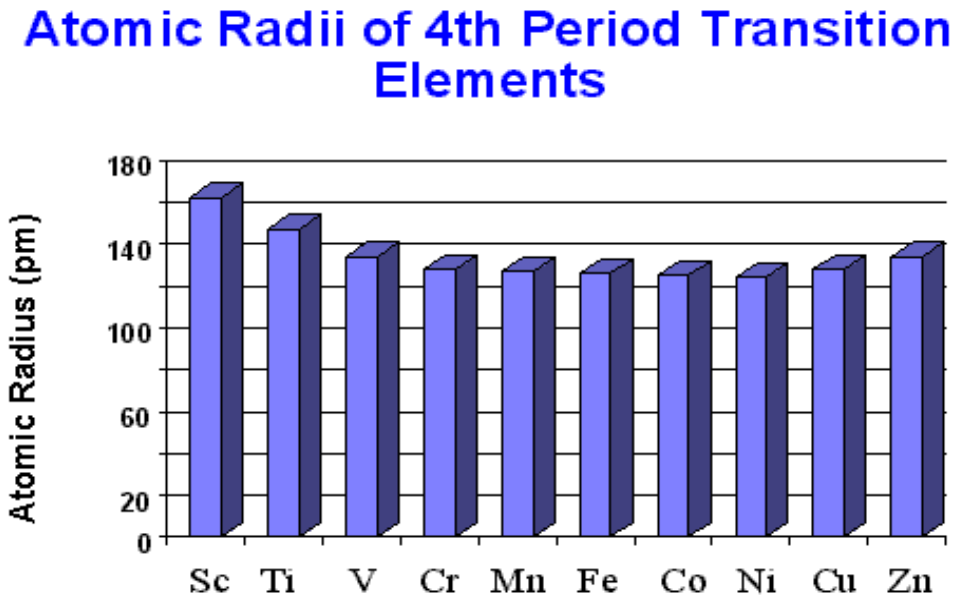


Trends in melting points of transition elements

- Involvement of greater number of electrons from (n-1)*d* in addition to the n*s* electrons in the inter atomic metallic bonding.
- Melting points of these metals rise to a maximum at d^5 except for anomalous values of Mn and Tc and fall regularly as the atomic number increases.
- Melting and Boiling points are high.
- A large number of unpaired electrons take part in bonding so they have very strong metallic bonds and hence high melting & boiling points.

ATOMIC & IONIC RADIUS

- Across a period, nuclear charge increases but the penultimate d-sub shell has poor shielding effect so atomic and ionic size remain almost same .
- New electron enters a d orbital each time the nuclear charge increases by unity.
- Shielding effect of a d electron is not that effective, hence the net electrostatic attraction between the nuclear charge and the outermost electron increases and the ionic radius decreases



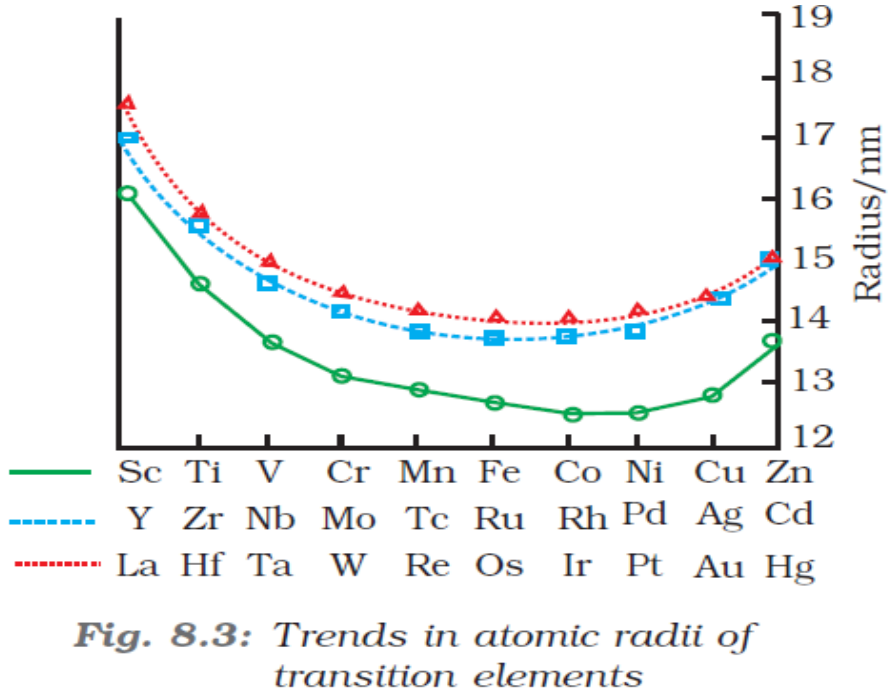


Fig. 8.3: Trends in atomic radii of transition elements

3d< 4d= 5d

Next Lecture:

1. Trends in the properties of D-block elements.

Any Question



“It is not the answer that enlightens, but the question.”

- Eugene Ionesco