Now : Transition element can be defined as follows :

The transition element :

it is the element in which the orbitals of **d** or **f** sublevels occupied with (contain) electrons but incompletely filled in atomic state or in any one of its oxidation states .

Exercise 1 :

can we consider the coinage metals (element of group IB) as transition elements ?

Answer :

Yes , they are transition elements (G.R)

Because the (d) sublevel is completely filled with electrons (d^{10}) in their atomic state **,** but in the oxidation state (2+) or (3+) the sublevel (d) will be incompletely filled (d^{9}) or (d^{8}) .

Atomic state → Oxidation state

$_{29}Cu$: [Ar] $4s^1$, $3d^{10}$ $\xrightarrow{Oxidation(-2e^-)}$ Cu^{2+} : [Ar] $4s^0$, $3d^9$

$_{49}Ag$: [Ar] $5s^1$, $4d^{10}$ $\xrightarrow{Oxidation(-2e^-)}$ Ag^{2+} : [Kr] $5s^0$, $4d^9$

$_{79}Au$: [Ar] $6s^1$, $4f^{14}$, $5d^{10}$ $\xrightarrow{Oxidation(-2e^-)}$ Au^{2+} : [Xe] $6s^0$, $4f^{14}$, $5d^9$

Exercise 2 :

can we consider the metals zinc , cadmium and mercury (metals of group II B) as transition elements ?

Answer :

No , they aren't transition elements (G.R)

Because the (d) sublevel is completely filled with electrons (d^{10}) in both their atomic state and in oxidation state (+2) .

Atomic state → Oxidation state

$_{30}Zn$: [Ar] $4s^2$, $3d^{10}$ $\xrightarrow{Oxidation(-2e^-)}$ Zn^{2+} : [Ar] $4s^0$, $3d^{10}$

$_{48}Cd$: [Kr] $5s^2$, $4d^{10}$ $\xrightarrow{Oxidation(-2e^-)}$ Cd^{2+} : [Kr] $5s^0$, $4d^{10}$

$_{80}Hg$: [Xe] $6s^2$, $4f^{14}$, $5d^{10}$ $\xrightarrow{Oxidation(-2e^-)}$ Hg^{2+} : [Xe] $6s^0$, $4f^{14}$, $5d^{10}$

The general properties of the elements of the first transition series

Look at the following table :

Element	Scandium Sc	Titanium Ti	Vanadium V	Chromium Cr	Manganese Mn	Iron Fe	Cobalt Co	Nickel Ni	Copper Cu
Atomic mass	45	47.9	51	52	54.9	55.9	58.9	**58.7**	63.5
Atomic radius A^o	1.44	1.32	1.22	1.17	1.17	1.16	1.16	1.15	1.17
density g/cm^3	3.10	4.42	6.07	7.19	7.21	7.87	8.70	8.90	8.92

(for illustration only)

1- The atomic mass :

it increases gradually by increasing atomic number (from left to right) **,** but nickel is abnormal (G.R) due to the presence of five stable isotopes of nickel their average atomic mass is **58.7** u .

2- Atomic radius :

The change (decreasing) in atomic radii is very small (from left to right) that means atomic volume in this series is relatively constant specially from chromium to copper (G.R)

this is due to opposite factors **:**

a- first factor : by increasing atomic number the effective +ve charge of nucleus increase so the attraction force of nucleus to electrons increase

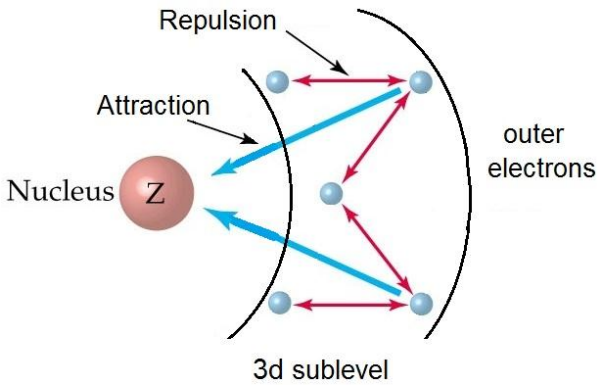
& **that causes decreasing in the atomic radius .**

b- second factor : by increasing atomic number the number of –ve electrons in 3d sublevel increase so the repulsion force between them increase

& **that causes increasing in the atomic radius .**

➲ **As a result of these two opposite factors :**

atomic radii of these elements are relatively constant which explains using them in making alloys (specially substitution alloys) . (G.R)



3- metallic property :

Appears clearly in all elements of the first transition series **, as :**

a- all of them are **solids** **,** having **metallic luster** and **good conductor** for **heat** and **electricity**.

b- melting & boiling points :

they have high melting and boiling points (G.R)

due to the strong metallic bond which is formed by sharing of both 4s and 3d electrons.

NOTE As number of outermost electrons increase , the electric conductivity increase.

c- The density :

They have high density **,** and the density increases by increasing the atomic number (G.R)

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

Due to the increase in the atomic mass **while** atomic volume is relatively constant **.**

Question : **The density of iron is higher than the density of titanium ?** (G.R)

Answer : density = $\frac{\text{mass}}{\text{volume}}$ **,**

bec. the atomic mass of iron is bigger than titanium **,**

while their atomic volume is relatively constant (relatively equal) .

∴ density of iron > density of titanium

d- Chemical activity :

there is variation in the activity of the first transition series **:**

1- Scandium has high chemical activity (scandium replaces hydrogen of water vigorously)

2- Iron has medium chemical activity (iron rusts when exposed to air)

3- Copper has limited chemical activity .

Sc ⟶ Fe ⟶ Cu

high activity — intermediate activity — limited activity