CHEMISTRY

WORKSHEET-9

STEP

A PROJECT BY PUNJAB GROUP

Worksheet-09

(B. Inorganic Chemistry)

Transition Elements

USE THIS SPACE FOR SCRATCH WORK

Q.1 Which of the following is correct formula for general electronic configuration of d-block elements?

A) $(n-1)d^{1-10}\ ns^{1-2}$ C) $(n-1)d^{1-5}\ ns^{1-2}$

B) $(n-1)d^{10}\ ns^{2}$ D) $(n-1)d^{1-10}\ ns^{2}$

Q.2 All of the following transition elements show variable oxidation state EXCEPT:

A) Fe C) Zn

B) Cr D) Cu

Q.3 Mark the incorrect statement about transition elements of 3d-series:

A) All the elements show +2 oxidation state

B) They show variable oxidation because of the involvement of the unpaired d-electrons in addition to s-electrons

C) Fe^{+3} ion is more stable than Fe^{+2} ion

D) First four elements in the highest oxidation state use all of the s and d electrons for bonding

Q.4 Which of the following is the correct electronic configuration of gold (atomic number of Au = 79)?

A) $\left[{}_{54}Xe\right]4f^{14}5d^{10}6s^{1}$ C) $\left[{}_{54}Xe\right]4f^{14}5d^{9}6s^{2}$

B) $\left[{}_{54}Xe\right]4f^{14}5d^{9}6s^{1}$ D) $\left[{}_{54}Xe\right]4f^{14}5d^{10}6s^{2}$

Q.5 Transition elements show all of the following characteristic properties EXCEPT:

A) They are good conductor of heat and electricity

B) Those metals which form coloured compounds must have at least one unpaired electron in d-sub shell

C) Their ions and compounds are coloured in the solid state only

D) They act as a catalyst

Q.6 Which of the following complex ions shows tetrahedral geometry?

A) $\left[MnCl_4\right]^{-2}$ C) $\left[Fe(CN)_6\right]^{-4}$

B) $\left[Cu(NH_3)_4\right]^{+2}$ D) $\left[PtF_6\right]^{-2}$

Q.7 Transition elements mostly show _____geometry.

A) Linear C) Square planar

B) Trigonal bipyramid D) Octahedral

Q.8 Correct name of $\left[Pt(OH)_2(NH_3)_4\right]SO_4$ is:

A) Tetraammine dihydroxo-platinum (IV) sulphate

B) Dihydroxo tetraammine-platinum (V) sulphate

C) Tetra-ammine dihydroxo-platinum (II) sulphate

D) Dihydroxo tetraammine-platinum (IV) sulphate

Q.9 Which of the following transition elements has maximum number of unpaired electrons in its ground state?

A) Mn C) Fe

B) Cr D) Ni

Q.10 In copper sulphate pentahydrate ($CuSO_4.5H_2O$), the number of water molecules attached with Cu^{+2} ion through coordinate covalent bond is:

A) 2 C) 4

B) 3 D) 5

Q.11 In $[Ti(H_2O)_6]^{3+}$, _____ light is absorbed, while most of the blue and red lights are transmitted, therefore the solution of $[Ti(H_2O)_6]^{3+}$ ions looks violet in colour. Violet is a complementary colour of yellow:

A) Yellow C) Blue

B) Green D) Red

Q.12 The catalysts used for the following processes are correctly matched EXCEPT:

Options	Catalysts	Processes	Used to prepare
A)	Fe	Haber's process	NH_3
B)	V_2O_5	Contact process	H_2SO_4
C)	Co	Catalytic oxidation of methane	HCOOH
D)	Pt + Rh	Ostwald's method	HNO_3

USE THIS SPACE FOR SCRATCH WORK

Q.13 3d-series of transition elements contains elements in the range:

A) Sc ----- Zn C) Y ----- Cd

B) La ----- Hf D) Ce ----- Lu

Q.14 Which of the following 3d-series elements shows the highest oxidation state in its compounds?

A) Cr C) Zn

B) Cu D) Fe

Q.15 Which of the following transition metal ions has five unpaired electrons in 3d sub-shell?

A) Zn^{+2} C) Mn^{+2}

B) Sc^{+3} D) Cr^{+3}

Q.16 The number of lone pair of electrons provided by the ligands to the central transition metal atom or ion is called:

A) Oxidation number C) Effective atomic number

B) Coordination number D) Coordination complex

Q.17 All of the following are monodentate ligands EXCEPT:

A) OH^- C) CO

B) CN^- D) N_2H_4

Q.18 Geometry of the transition elements depends upon type of orbital hybridization. Which of the following type of orbital hybridization shows square planar geometry?

A) sp^3 C) dsp^3

B) dsp^2 D) d^2sp^3

Q.19 All the elements of 3d-series show correct electronic configuration EXCEPT:

Options	Elements	Electronic configuration
A)	$_{22}Ti$	$(Ar)3d^24s^2$
B)	$_{29}Cu$	$(Ar)3d^94s^2$
C)	$_{24}Cr$	$(Ar)3d^54s^1$
D)	$_{25}Mn$	$(Ar)3d^54s^2$

Q.20 All of the following first row of the transition elements (3d-series) show the most common oxidation states. Mark the incorrect statement:

Options	Elements	Most common oxidation states
A)	Ti	+3,+4
B)	V	+2,+3,+4,+5
C)	Mn	+3,+5,+6,+7
D)	Fe	+2,+3

Q.21 Which of the following elements are used as a catalyst

USE THIS SPACE FOR SCRATCH WORK

in the chemical reactions?

A) Alkali metals
B) Transition elements
C) Alkaline earth metal
D) Element which form border line compounds

Q.22 Elements of 3d-series generally show which of the following stable oxidation states?

A) +1, +2 C) +4, +5
B) +2, +3 D) +6, +7

Q.23 The correct formula of Tetraammine aqua bromocobalt (III) nitrate is:

A) $Co[Br(NH_3)_4(H_2O)](NO_3)_2$
B) $Co[Br(NH_3)_4(H_2O)Br](NO_3)_2$
C) $Co[Br(H_2O)(NH_3)_4](NO_3)_2$
D) $Co[(NO)(NH_3)_4(H_2O)Br](NO_3)_2$

Q.24 Pair of transition elements which show abnormal electronic configuration in the first 3d-series are:

A) Cr and Ni C) Cr and Cu
B) Fe and Ni D) Cu and Co

Q.25 Scandium has atomic number 21. Which one of the following will be its electronic configuration?

A) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3$
B) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 4p^1$
C) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^1$
D) $1s^2\ 2s^2\ 2p^6\ 3s^2$ 3p6 4s1 $4p^2$

Q.26 The central transition metal atom along with ligands is called:

A) Complex ion
B) Ligand
C) Coordination sphere
D) Complex compound

Q.27 All of the following are typical transition elements EXCEPT:

A) Cr C) Cu
B) Fe D) Zn

Q.28 Transition elements show all of the following properties EXCEPT:

A) They are all metals in true sense
B) They show variable oxidation state
C) They have high melting and boiling points
D) Their ionization energy is less than that of IIA group elements

USE THIS SPACE FOR SCRATCH WORK

Q.29 Which of the following statements is correct about covalent radii in 3d-series of transition elements?

A) It decreases continuously

B) First it decreases then increases rapidly

C) First it decreases in the start, constant in the middle and then increases at the end of series

D) It remains almost constant in the series

Q.30 In moving from left to right in any transition series, the number of unpaired electrons increases upto groups:

A) IIB and IIIB C) VB and VIB

B) IVB and VB D) VIB and VIIB

Q.31 Which groups of transition elements are known as non-typical transition elements?

A) IIB and IIIB C) IVB and VB

B) IB and IVB D) VIB and VIIB

Q.32 All of the following non-metals enter in the interstices of transition metals and impart useful features to them EXCEPT:

A) H C) N

B) B D) Br

Q.33 Mark the incorrect statement about the general characteristic features of 3d-series of transition metals:

A) Binding energy …… depends on unpaired electrons

B) M.Ps and B.Ps …… show irregular trend in 3d-series

C) Diamagnetic substances …… are weekly repelled by the strong magnetic field

D) Ionic radii …… changes in the ionic radii along the series are regular

Q.34 Which of the following transition metal ions shows the strongest paramagnetic behaviour?

A) Fe^{+3} C) Ti^{+3}

B) Cr^{+3} D) Cu^{+2}

Q.35 In alloy steels (substitutional alloys), which of the following transition metal cannot be substituted in place of iron:

A) Cr C) Mn

B) Ni D) Ti

USE THIS SPACE FOR SCRACTH WORK

Q.36 The type of structural isomerism which occurs when the counter ion (the ion outside the square bracket) is itself a potential ligand:

A) Ionization isomerism C) Linkage coordination

B) Coordination isomerism D) Solvate isomerism

Q.37 **In an octahedral geometry having coordination number 6, which of the following shows trans-position:

A) 1 – 2 C) 3 – 4

B) 1 – 3 D) 1 – 4

Q.38 Coordination compounds show which of the following principal types of isomerism:

A) Stereoisomerism C) Both A and B

B) Structural isomerism D) Neither A nor B

ANSWER KEY (Worksheet-09)							
1	A	11	A	21	B	31	A
2	C	12	C	22	B	32	D
3	D	13	A	23	A	33	D
4	A	14	A	24	C	34	A
5	C	15	C	25	C	35	D
6	A	16	B	26	C	36	A
7	D	17	D	27	D	37	D
8	A	18	B	28	D	38	C
9	B	19	B	29	C		
10	C	20	C	30	C		

ANSWERS EXPLAINED

Q.1 **(A)** **d-block** are the **elements** of groups **3, 4, 5, 6, 7, 8, 9, 10, 11** and **12**. They are also known as outer transition elements. Their general electronic configuration is **$(n-1)d^{1-10}\ ns^{1-2}$.**

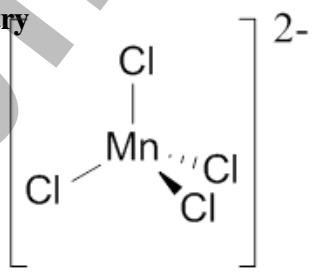
Q.2 **(C)** **Zn** shows **+2** oxidation state only because **Zn^{+2}** has completely filled 3d-sub-shell while other elements of **A, B,** and **D** show variable oxidation state. Such as **Fe (Fe^{+2}, Fe^{+3}), Cr (Cr^{+3}, Cr^{+6}), Cu (Cu^{+1}, Cu^{+2}).**

Q.3 **(D)** In fact **first five elements** are in the **highest oxidation state** and use all of the **s** and **d** electrons for bonding **not first four elements.**

Q.4 **(A)** **$_{79}$Au (gold)** shows the **correct** electronic configuration as **$[_{54}Xe]4f^{14}, 5d^{10}, 6s^{1}$**.

Q.5 **(C)** Transition metal ions and their compounds are **not** only **coloured** in the solid state **but they also show colour** in the **aqueous solution.**

Q.6 **(A)** $[MnCl_4]^{-2}$ shows **tetrahedral geometry**



while others **B) square planar C), tetrahedral and D) shows trigonal bipyramidal geometry.**

Q.7 **(D)** Transition elements mostly show **octrahedral geometry.** The concept of octahedral geometry was developed by **Alfred Werner** to explain the stoichiometries and isomerism in coordination compounds.

Q.8 **(A)** $[Pt(OH)_2(NH_3)_4]SO_4$ correct name is **Tetraammine dihydroxo-platinum (IV) sulphate. Other** options B, C and D **are incorrect.**

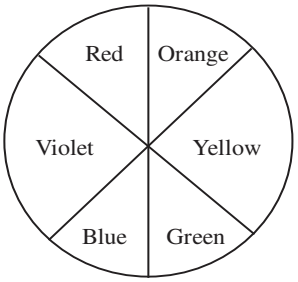
Q.9 **(B)** $_{24}Cr$ (Ar) $\underset{3d}{\uparrow\uparrow\uparrow\uparrow\uparrow}\ \underset{4s}{\uparrow}$.

From the electronic configuration of **Cr** it is clear that it has **maximum 6 unpaired electrons.**

Q.10 **(C)** The number of water molecules attached with **Cu^{+2} ions** through coordinate covalent bond is **4** because it follows effective atomic number rule (EAN rule) and one water molecule is bonded with sulphate ion as shown **$Cu.4H_2O.SO_4.H_2O$.**

Q.11 **(A)** Transition elements show complementary colours as shown in the diagram**. $[Ti(H_2O)_6]^{3+}$** absorbs yellow colour and in return transmits violet colour. So **yellow** and **violet** are **complementary colours.**

- **Complementary colours of each other are shown in the figure.**



Complementary Colours:

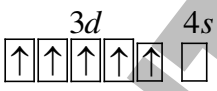
Q.12 **(C)** In fact, **Cu** is used as a catalyst for oxidation of **methane not cobalt.** Lower alkanes when burnt in the

presence of metallic catalyst copper, at **high** temperature and pressure, results in the formation of useful product. Catalytic oxidation of alkanes is used industrially to prepare **higher fatty acids** which are used in **soap** and **vegetable oil industries.**

Q.13 (A) **3d-series** lies in the **4th period** of the periodic table. It contains **10** elements ranges from $_{21}Sc$ **….** $_{30}Zn$. **In the first row of the transition metals, the ten elements that can be found are: Scandium (Sc), Titanium (Ti), Vanadium (V), Chromium (Cr), Manganese (Mn), Iron (Fe), Cobalt (Co), Nickel (Ni), Copper (Cu), and Zinc (Zn).**

Q.14 (A) **Cr shows highest oxidation state in its compound such as in $K_2Cr_2O_7$**

- **In $K_2Cr_2O_7$, Cr shows +6 oxidation state.**

Q.15 (C) $_{25}Mn^{+2}$ **(Ar)** 

. From the electronic configuration of Mn^{+2}, it is clear that there are **five unpaired electrons in 3d-orbitals.**

Q.16 (B) **Examples of Coordination number are shown below.**

Type of orbital hybridization	Geometry	Coordination Number	Complex
sp	**Linear**	2	$[Ag(NH_3)_2]^+$, $[CuCl_2]^-$
sp^3	**Tetrahedral**	4	$[MnCl_4]^{-2}$
dsp^2	**Square planar**	4	$[Zn(NH_3)_4]^{2+}$, $[Ni(CN)_4]^{2-}$
dsp^3	**Trigonal bipyramidal**	5	$[Ni(CN)_5]^{3-}$, $Fe(CO_5)$
d^2sp^3	**Octahedral**	6	$[Cr(H_2O)_6]^{3+}$, $[Fe(CN)_6]^{3-}$

Q.17 (D) **N_2H_4 (hydrazine) NH_2-NH_2.** It is bidentate ligand. It can donate **two** lone pair of electrons.

Q.18 (B) **dsp^2 (Square planar geometry e.g. $[Cu(NH_3)_4]^{+2}$.**

Type of orbital hybridization	Geometry	Coordination Number	Complex
dsp^2	**Square planar geometry**	4	$[Cu(NH_3)_4]^{+2}$

Q.19 (B) In fact $_{29}Cu$ shows abnormal electronic configuration such as **(Ar) $3d^{10}4s^1$**, but **not (Ar) $3d^9 4s^2$.**

Q.20 (C) Common oxidation states shown by **Mn** are **+2, +4, +6, +7** but **not +3, +5.**

Q.21 (B) **Transition elements act as a good catalyst because of**

- **Presence of vacant d-orbital**
- **The tendency to show variable oxidation states**
- **The tendency to form reaction intermediates with reactants**
- **The presence of defects in their crystal lattice**

Examples:

i. **Most of the transition metals [Fe, Ni, Pt]**

ii. **Alloys [Fe - Mo]**

iii. **Compounds [V_2O_3, V_2O_5, MnO_2, Co^{+2} salt] are used as catalysts in various processes.**

Q.22 (B) **Elements of 3d-series generally show stable oxidation state +2 and +3. The elements in the beginning**

of the 3d-series have comparatively +3 more stable oxidation state such as Sc^{+3}, Cr^{+3} whereas the elements at the end of the series mostly show +2 stable oxidation state such as Cu^{+2}, Zn^{+2}, Ni^{+2} etc.

Q.23 (A) The correct formula of Tetrammine aqua bromocobalt (III) nitrate is $Co[Br(NH_3)_4(H_2O)](NO_3)_2$.

Q.24 (C) Cr and Cu show abnormal electronic configuration just to gain stable electronic configuration in 3d-sub shell as shown in the tabular form.

Element	Atomic number	Electronic configuration
Cr	24	$[Ar]3d^5 4s^1$
Cu	29	$[Ar]3d^{10} 4s^1$

Q.25 (C) Scandium has atomic number 21. It has electronic configuration $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^1$.

Q.26 (C) The central transition metal atom along with ligands is called coordination sphere. It is usually placed in square bracket e.g.

$$K_4\left[Fe(CN)_6\right], \left[Cu(NH_3)_4\right]SO_4, \left[Ni(CO)_4\right]$$

In the above examples:

$\left[Fe(CN)_6\right]^{4-}, \left[Cu(NH_3)_4\right]^{2+}, \left[Ni(CO)_4\right]^{0}$ **are anionic, cationic and neutral coordination spheres, respectively.**

Q.27 (D) Zn is non-typical transition element

- It is present in IIB group
- It shows +2 oxidation only
- It does not form coloured compound
- It is diamagnetic in atomic or ionic form
- It does not give borax bead test

Q.28 (D) The elements of 3d-series are known as transition elements because they lie in between s-block elements and p-block elements. When we move from left to right in the periodic table ionization energy increases because nuclear charge increases. That is why ionization energy of 3d-series of transition elements is greater than that of s-block elements but less than that of p-block elements.

Q.29 (C) First it decreases in the start, remains constant in the middle and then increases at the end of the series.

Explanation:

- **At the beginning of the 3d series of transition elements, due to smaller number of electrons in the 3d-orbitals, the effect of increased nuclear charge predominates, and the covalent radii <u>decrease</u>.**
- **Later in the series, when the number of 3d-electrons increase, the increased shielding effect and the increased repulsion between the electrons tend to increase the covalent radii. Somewhere in the middle of the series, therefore, the covalent radii almost remains <u>constant</u>.**
- **At the end of 3d-series of transition elements d-sub shell is completely filled**

and nucleus hold on the valence electrons decreases. As a result atomic radii <u>increases</u>.

Atomic radii of transition elements of 3d-series

Elements	Sc	Ti	V	Cr	Mn	Fe	CO	Ni	Cu	Zn
Atomic radii (pm)	144	132	122	118	117	117	116	115	117	125

Decreases Constant Increases

Q.30 (C) In moving from left to right in any transition series, the number of unpaired electrons increase upto groups VB and VIB. After that pairing takes place and number of unpaired electrons goes on decreasing until it becomes zero at IIB.

Q.31 (A) The transition elements of IIB and IIIB groups are known as non-typical transition elements.

Groups	Non-typical Elements
IIB	Zn, Cd and Hg
IIIB	Sc, Y and La

Properties:

- **They show non-variable oxidation state**
- **They do not form coloured compounds**
- **They do not give "Borax-bead Test"**

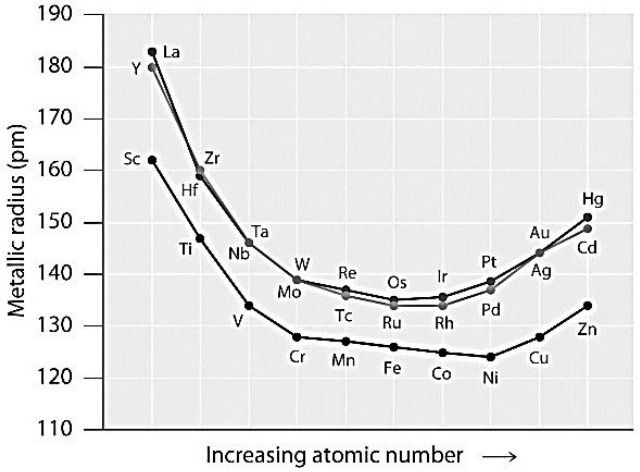
Q.32 (D) When small non-metal atoms like **(H, B, and N)** enter the interstices of transition metals and impart useful features to them, they are **called interstitial compounds.** But **bromine (Br) cannot enter the interstices of transition metals because it has comparatively greater size.**

Q.33 (D) It is incorrect statement. In fact, the correct statement is as follow.

Changes in the ionic radii along the series are much less regular, so that periodic trends in the properties of these ions are difficult to rationalize.

Q.34 (A) Greater is the number of unpaired electrons in 3d-atomic orbitals of transition metal ions, greater is the paramagnetic behaviour. Since Fe^{+3} ion has maximum five unpaired electrons, so that is why it shows maximum paramagnetic behaviour. Other transition metal ions have comparatively less number of unpaired electrons.

Q.35 (D) In alloy steels (substitutional alloys), titanium (Ti) transition metal cannot be substituted in place of iron because it has comparatively greater size (covalent radius), as shown in the graph:



Q.36 (A)

- **IONIZATION ISOMERISM**

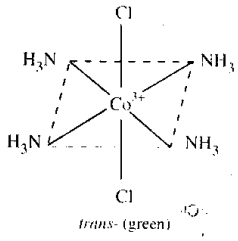
  The type of structural isomerism which occurs when the counter ion (the ion outside the square bracket) is itself a potential ligand.

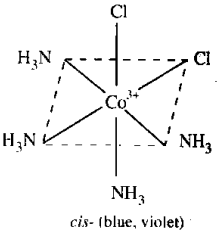
$\left[CoCl_2(NH_3)_4\right]NO_2$ and $\left[CoCl(NH_3)_4(NO_2)\right]Cl$

Ion in solution NO_2^- (no ppt. with $AgNO_3$) **Ion in solution Cl^- (white ppt. with $AgNO_3$)**

- **COORDINATION ISOMERISM**

  This type of isomerism is shown by the compounds which contain complex cation, and a complex anion. Coordination isomerism is caused by the interchange of ligands between the complex cation and complex anion.





- For examples

$\left[Co(NH_3)_6\right]\left[Cr(CN)_6\right]$

and $\left[Cr(NH_3)_6\right]\left[Co(CN)_6\right]$

- **LINKAGE COORDINATION**

  The compounds which have the same molecular formula, but differ in the mode of attachment of ligand to the central atom / ion are called linkage isomes.

- For examples NO_2^- ion, the nitrogen atom as well as the oxygen atom can donate their lone-pairs.

NO_2^- Nitro

$\left[Co(NH_3)_5 NO_2\right]Cl_2$

pentaaminnitrocobalt (III) chloride

and

$O-NO^-$ nitrito

$\left[Co(NH_3)_5 ONO_2\right]Cl_2$

pentaaminenitrocobalt (III) chloride

- **SOLVATE ISOMERISM**

Solvate isomerism is a special form of ionization isomerism. Solvate isomerism occurs when water is present in the inner coordination sphere or outside it.

- For examples $\left[Cr(H_2O)_6\right]Cl_3$ and $\left[CrCl(H_2O)_5\right]Cl_2.H_2O$

Q.37 (D) Ma_4b_2:

- A well known octahedral complex which shows cis-trans isomerism tetraaminedichloridecobalt (III).
- Two isomers of this complex are cis-form (violet) and trans-form (green).
- The structures of these two isomers are shown below in figure $[Co(NH_3)_4(NO_2)_2]^+$ is example of $[Ma_4b_2]$ type octahedral complex which shows geometrical isomerism.

Q.38 (C): Coordination compounds show the following principal types of isomerism

- Stereoisomerism
- Structural isomerism

REF. QUESTION # 20

Below is a table of the oxidation states that the transition metals can or cannot form. As stated in the boxes, the "No" indicates that the elements are not found with that oxidation state. The "Rare" signifies the oxidation states that the elements are rarely found in. Lastly, the "Common" identifies the oxidation states that the elements readily found in.

Element Symbol	Atomic Number	+1	+2	+3	+4	+5	+6	+7
Sc	21	No	Rare	Common	No	No	No	No
Ti	22	No	Rare	Rare	Common	No	No	No
V	23	Rare	Common (black)	Common (green)	Common (blue)	Common (yellow)	No	No
Cr	24	Rare	Common	Common (most stable)	Rare	Rare	Common	No
Mn	25	Rare	Common (most stable pink/red)	Common (purple/red)	Common	Rare (blue)	Common (green)	Common (purple)
Fe	26	Rare	Common (ferrous)	Common (ferric)	Rare	Rare	Rare	No
Co	27	Rare	Common	Common	Rare	Rare	Rare	No
Ni	28	Rare	Common	Rare	Rare	No	No	No
Cu	29	Rare	Common (blue/green)	No	No	No	No	No
Zn	30	No	Common	No	No	No	No	No

STEP

A PROGRAM BY PUNJAB GROUP