Alloys :→

when two metals are heated together or a metal is mixed with a non metallic element, then one of the following will occour.—

(i) An ionic compound may be formed.

(ii) An interstitial alloy may be formed.

(iii) An substitutional alloy may be formed.

(iv) A simple mixture may result.

Interstitial alloys :→

The structure of many metals in a closed packed lattice of spherical atoms or ions. Therefore many tetrahydral and octahedral holes may result. If the element added has small atoms, they can be accommodated in this holes without altering structure.

invading

of metal. the invading atoms occupy interstitial positions in the metal lattice instead of replacing the metal atoms. such alloys are called interstitial alloys. the chemical composition of compounds of this type may vary over wide range depending on how many holes are occupied. these are formed by wide range of metals with hydrogen boron, nitrogen and other elements.

the most important factor is the size of invading atom. for octahedral holes to be occupied the radius ratio of smaller atom by the larger atom should be in the range of 0.414 - 0.732 and for tetrahedral holes it should be 0.225 - 0.414.

the invasion of interstitial site does not significantly alter the metal structure and it still ~~conde~~ conducts heat & electricity. However, filling some of the holes has a considerable effect on the physical properties particularly the hardness, malleability and ductility of the metal. this is because filling of the voids make it much more difficult for one layer of metal ion to slide over another.

for eg. interstitial borides, carbides, and nitrides are extremely inert chemically, have very high melting point's and are extremely hard. steel contains upto 2% carbon which makes it harder and brittle. when steel is heated, the solids form - austenite which can be hot rolled out or pressed into any required shape. the properties of steel can be changed by annealing and tempering. cast iron contains more than 2% carbon. Iron carbide is extremely hard and brittle.

Substitutional Alloy:→

If two metals are completely miscible with each other then one atom may replace another at random in the lattice and they can form a continuous eq range of solid sol^n. such are called substitution alloys eq Cu/Ni, Cu/Au, K/Rb, K/Cs, Rb/Cs.

Hume-Rothery has shown that for metals to form continuous solid solution or for complete miscibility, the following rules must be followed.

(1) The two metals must be similar in size and their metallic radii must not differ by more than 14-15%.

(2) Both metal must have same ~~meta~~ crystal structure.

(3) The chemical properties of a metals must be similar, in particularly the no of valance-electrons should be the same. for eq→ let us consider an alloys of Cu and Au. the metallic radii differ

Only by 12.5% both has CCP lattice and both have similar properties. The two metals are therefore completely miscible. Similarly K and Rb size difference is 9.3%. Rb and Cs size difference is 8.9% and hence they are completely miscible. But Li and Na size differ is 22.4%. Na and K are 22%. and hence they are not miscible.

If only one or two of these rules are satisfied then random substitutional solid will occour. For eg. consider an alloys of Sn and Pb (solder). The radii differ by 8% and have similar propterties but they differ in their structures. and hence they will form random substitutional alloys. The similiar behaviour is found with Na-K alloys, and Al-Cu alloys. In other cases where only a limited range of solid solutions are formed. The larger tendency of the different metal to form compounds instead of solution is important. In such cases intermetallic phases exist, each of which behaves as a compound of the constituent metal. For eg:→ In the Cu-Zn system, the metallic radii differ by 7%, but they have different structure (Cu CCP and Zn HCP) and they also have different no of valance electrons. So only a limited range of solid solutions is expected but the atom have a strong tendency to form compounds and the different structure may be distinguished as (Zn

α (Zn – 0 – 35%)

β (45 – 45% Zn)

γ (50 – 65% Zn)

ξ (82 – 88% Zn)

η (97 – 100% Zn)

According to Hume-Rothery β-phase occurs in the alloys where the ratio of valence e^-'s to the no of atoms is 3:2, γ-phase occours when the ratio is 21:13. And η phase occurs when the ratio is 7:4.

eg: 3:2 → β-phase — Cu, Zn, Cu_3Al, $CoZn_3$, Ag_3Al..

21:13 → γ phase — Cu_5Zn, Cu_9Al_4, $Na_{31}Pb_8$.

7:4 → η phase — $CuZn_3$, Cu_3Si, Ag_5Al_3, Au_5Al_3.

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