Coagulation or Flocculation or Precipitation.

"The phenomenon of the precipitation of a colloidal solution by the addition of the excess of an electrolyte is called **coagulation or flocculation**." **or**

"The stability of the lyophobic sol is due to the presence of charge on colloidal particles. If the charge is removed, the particles will come nearer to each other and thus, aggregate or flocculate and settle down under the force of gravity. This phenomena is known as **coagulation or flocculation**."

The coagulation of the **lyophobic sols** can be carried out by following methods.

(1) **By electrophoresis:**In electrophoresis the colloidal particles move towards oppositely charged electrode. When these come in contact with the electrode for long these are discharged and precipitated.

(2) **By mixing two oppositely charged sols:**When oppositely charged sols are mixed in almost equal proportions, their charges are neutralized. Both sols may be partially or completely precipitated as the

mixing of ferric hydroxide (+ve sol) and arsenious sulphide (–ve sol) bring them in precipitated form. This type of coagulation is called **mutual coagulation** or **material coagulation.**

(3) **By boiling:**When a sol is boiled, the adsorbed layer is disturbed due to increased collisions with the molecules of dispersion medium. This reduces the charge on the particles and ultimately they settle down to form a precipitate.

(4) **By persistent dialysis:**On prolonged dialysis, the traces of the electrolyte present in the sol are removed almost completely and the colloids become unstable.

(5) **By addition of electrolytes:**The particles of the dispersed phase i.e., colloids bear some charge. When an electrolyte is added to sol, the colloidal particles take up ions carrying opposite charge from the electrolyte. As a result, their charge gets neutralized and this causes the uncharged, particles to come closer and to get coagulated or precipitated. For example, if $BaCl_2$ solution is added to As_2S_3 sol the Ba^{2+} ions are attracted by the negatively charged sol particles and their charge gets neutralized. This lead to coagulation.

(6) **Hardy schulze rule:**The coagulation capacity of different electrolytes is different. It depends upon the Valency of the active ion are called flocculating ion, which is the ion carrying charge

opposite to the charge on the colloidal particles. "According to Hardy Schulze rule, greater the Valency of the active ion or flocculating ion, greater will be its coagulating power"thus, Hardy Schulze law state:

(i) The ions carrying the charge opposite to that of sol particles are effective in causing coagulation of the sol.
(ii) Coagulating power of an electrolyte is directly proportional to the Valency of the active ions (ions causing coagulation).
For example to coagulate **negative sol** of As_2S_3, the **coagulation power** of different cations has been found to **decrease** in the order as, $Al^{3+} > Mg^{2+} > Na^+$
Similarly, to coagulate a **positive sol** such as $Fe(OH)_3$, the **coagulating power** of different anions has been found to **decrease** in the order: $[Fe(CN)_6]^{4-} > PO_4^{3-} > SO_4^{2-} > Cl^-$

(7) **Coagulation or flocculation value**

"The minimum concentration of an electrolyte which is required to cause the coagulation or flocculation of a sol is known as **flocculation value**."

Or

"The number of millimoles of an electrolyte required to bring about the coagulation of one litre of a colloidal solution is called its **flocculation value**."
Thus, a more efficient flocculating agent shall have lower flocculating value.

Flocculation values of some electrolytes

Sol	**Electrolyte**	**Flocculation value** (mM)	**Sol**	**Electrolyte**	**Flocculation value** (mM)
As_2S_3 (-vely charged)	$NaCl$	51.0	$Fe(OH)_3$ (+ vely charged)	KCl	9.5
	KCl	49.5		$BaCl_2$	9.3
	$CaCl_2$	0.65		K_2SO_4	0.20
	$MgCl_2$	0.72		$MgSO_4$	0.22
	$MgSO_4$	0.81			
	$AlCl_3$	0.093			
	$Al_2(SO_4)_3$	0.096			

		$Al(NO_3)_3$	0.095			

Note:Coagulating value or flocculating value $\propto \frac{1}{\text{coagulatin g power}}$.

(8) **Coagulation of lyophilic sols**

(i) There are two factors which are responsible for the stability of lyophilic sols.

(ii) These factors are the charge and solvation of the colloidal particles.

(iii) When these two factors are removed, a lyophilic sol can be coagulated.

(iv) This is done (i) by adding electrolyte (ii) and by adding suitable solvent.

(v) When solvent such as alcohol and acetone are added to hydrophilic sols the dehydration of dispersed phase occurs. Under this condition a small quantity of electrolyte can bring about coagulation.

Note:Hydrophilic sols show greater stability than hydrophobic sols.