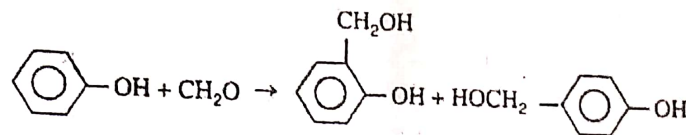


Q.37. Write notes on :

- (a) Phenol-formaldehyde resins (b) Urea-formaldehyde resins  
(c) Epoxy resins (d) Polyurethanes.

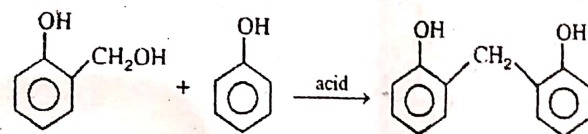
Ans. : (a) Phenol-formaldehyde resins (Bakelite) are produced by the interaction of phenol and formaldehyde. The reaction is catalysed either by acids or bases. The nature of polymer formed depends upon the type of catalyst and ratio of reactants—

The Step-I is the formation of methylol derivatives by a direct condensation—



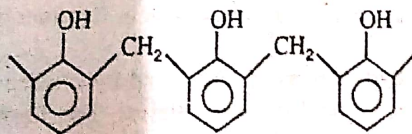
Two or three formaldehyde molecules may add to a phenol molecule depending upon ratio of formaldehyde and phenol. However, the methylol (-CH<sub>2</sub>OH) groups add at *o*- & *p*-positions.

The Step-II is the condensation of -CH<sub>2</sub>OH group of phenol with *o*- or *p*-position of another phenol in the presence of an acid or base—



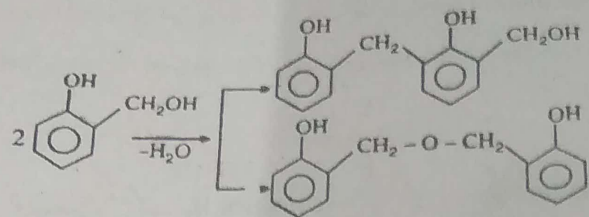
Finally following two types of phenol-formaldehyde resins are formed—

(i) If the ratio of formaldehyde to phenol is less than 1 : 1 and if an acid catalyst is used, the methylol derivatives condense with phenol to form dihydroxydiphenyl methane with the removal of water. Further condensation gives linear low mol. wt. polymer called *novolaks*—

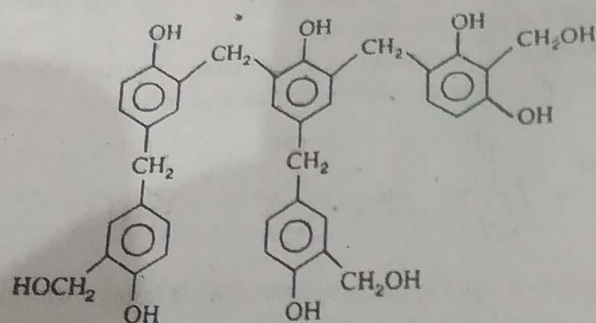


In novolaks, phenol molecules are attached by -CH<sub>2</sub>- bridges in random *o*- & *p*-positions. In novolaks, there are not more than ten phenolic groups, corresponding to mol. wts. upto about 1000. Novolaks are permanently fusible & soluble. They can be converted to a cross-linked resin by heating with an alkaline solution of formaldehyde.

(ii) With an alkaline e.g.  $\text{Na}_2\text{CO}_3$  catalyst and a molar ratio of formaldehyde to phenol greater than 1 : 1 the phenol alcohols condense to a low mol. wt. polymers called *resols* in which phenol molecules are attached either by  $-\text{CH}_2-$  or by  $o$ -linkages—



Resols are fusible and soluble. On heating, they give a hard insoluble and infusible resin.



Resol resin.

An alcoholic solution of one stage phenol-formaldehyde resin is used for laminating paper, wood etc. These resins are cheap & have good mechanical properties. They have good dielectric properties, hence they are used in electronic industry. They are also used in demineralization and softening of hard water.

(b) **Urea-formaldehyde resins** are produced by condensing urea & formaldehyde in presence of acid or base catalyst. The first step is the formation of methylol groups—

