$$R_p = k_p \frac{N}{2} [M] \quad \text{(11)}$$

N = number of ~~polymer~~ particles per cubic centimeter of aqueous phase

k_p = homogeneous Propagation rate constant

$[M]$ = Monomer concentration in the polymer particle.

Degree of polymerization →

$$\bar{x}_p = k_p [M] \quad \text{— 10-2}$$

k_p = Propagation constant.

$$\bar{x}_c = \frac{\bar{x}_i}{N} \quad \text{— 10-3}$$

$\bar{x}_i$ = rate of generation of Primary radicals.

$$\overline{X_n} = \frac{\bar{x}_p}{\bar{x}_c} = \frac{k_p [M]}{\bar{x}_i / N}$$

$$\overline{X_n} = \frac{k_p N [M]}{\bar{x}_i} \quad \text{— 10-4}$$

Kp-Smith and Ewart

$$r_i = N = K\left[\frac{r_i}{\mu}\right]^{0.4}\left(a_s[E]\right)^{0.6} \quad \text{---} 10.5$$

where K = constant with a value between 0.4 and 0.5 μ_s = is the rate of increase in volume of a Polymer particles.

a_s = is the interfacial area occupied by an emulsifier molecules

$[E]$ = Soap or emulsifier concentration.

Unit - cgs.

Ans From the given data given below for the emulsion Polymerization Styrene in water at 60°C

(a) Calculate the rate of Polymerization

(b) Show that the number average degree of Polymerization $\bar{X}_n = 3.52 \times 10^3$

(c) ~~Number of~~ Estimate the no of Polymer chain in each data.

$k_p = 176 \text{ mol}^{-1} s^{-1}$

$S \approx 10^{12}$ radicals $cc^{-1} s^{-1}$

$N \approx 10^{13}$ particles cc^{-1}

$[M] \approx 10 M$.

Latex particle size $= 0.10 \mu m$

Particle density $= 1.2 g/cc$

Solution $R_p = k_p \frac{N}{2} [M]$

$k_p = \frac{176 \, l}{mol \cdot s} =$

$176 \left(\frac{1000 cc}{l} \right) \left(\frac{1}{mol \cdot s} \right)$

$= 1.76 \times 10^5 \frac{cc}{mol \cdot s}$

$[M] = 10 M$

$10 \frac{mol}{l}$

$10 mol \left(\frac{1 \, l}{1000 cc} \right)$

$= 10^{-2} \text{ mol } cc^{-1}$

$N = 10^{13} \frac{\text{Particles}}{cm^3}$

$= 10^{13} \left(\frac{\text{Particle}}{cm^3} \right) \left(\frac{1 mol}{6.023 \times 10^{23} \text{ Particles}} \right)$

$= 1.66 \times 10^{-11} \frac{mol}{cm^3}$.

$$R_p = \frac{1.76}{2} \times 10^5 \frac{cm^3}{mol \cdot s} \left(1.66 \times 10^{-11} \frac{mol}{cm^3}\right)\left(10^{-2} \frac{mol}{cm^3}\right)$$

$$= 1.46 \times 10^{-8} \text{ mol } cc^{-1} s^{-1}$$

$$\bar{r}_n = k_p N \frac{[M]}{q_i}$$

$$q_i = 5 \times 10^{-12} \frac{\text{radicals}}{cm^3 s} = \frac{1 \text{ mol}}{6.023 \times 10^{23} \text{ radicals}}$$

$$= 8.30 \times 10^{-12} \frac{mol}{cm^3 s}$$

$$\bar{r}_n = \left(1.76 \times 10^5 \frac{cm^3}{mol \cdot s}\right)\left(1.66 \times 10^{-11} \frac{mol}{cm^3}\right)$$

$$\left(10^{-2} \frac{mol}{cm^3}\right)\left(\frac{10^{12}}{8.30} \frac{cm^3 \cdot s}{mol}\right)$$

$$= 3.52 \times 10^3$$

(c) Volume of particles $= \frac{4}{3} \pi r^3$

$$r = 0.05 \mu m = 0.05 \times 10^{-4} cm$$

$$= 4.19 r^3$$

$$= 4.19 \times (5 \times 10^{-6} cm)^3$$

$$= 5.24 \times 10^{-16} cm^3$$

Density of each particle = 1.2 g/cc

Mass of each part = $1.2 g/cm^3 (5.24 \times 10^{-16} cm^3)$

$= 6.29 \times 10^{-16} g$

$\rho = \frac{M}{V}$

Mw of styrene = 104

$6.29 \times 10^{-16} g \left(\frac{1 g\ mol}{104 g}\right)$ monomer unit

6.05×10^{-18} g mol monomer unit

$= 6.05 \times 10^{-18}$ g mol monomer unit

$\left[6.023 \times 10^{23} \frac{\text{monomer}}{\text{g mol monomer}}\right]$

$= 3.64 \times 10^6$ mono

$X_n = 3.5 \times 10^3$

3.52×10^3 monomer per chain

Chains Per Particle

3.64×10^6 monome

103×10^3 chain

$\left[\frac{10^3 \text{ chains}}{3.25 \text{ mono}}\right.$

103×10^3 chain