Numericals on polymer chapter(Number average molecular weight Mn & Weight average molecular weight Mw & polydispersity index)

1) **Number average molecular weight (Mn):**

It is defined as the total mass of all the molecules in a polymer divided by the total number of molecules present.

$Mn = \sum NiMi / \sum Ni$ (Ni = No. of molecules) (Mi= Mass of molecules)

2) **Weight average molecular weight (Mw):**

When the molecular weight is averaged according to the weight of molecules of each type, Mw is obtained.

$Mw = \sum NiMi^2 / \sum NiMi$

Where Ni is the number of molecules of molecular weight Mi

3) **Polydispersity Index**

It is defined as the ratio of weight average molecular mass (Mw) & number average molecular mass (Mn).

PDI = Mw/Mn

Q.1 if polymer sample has population as:

10 molecules of molecular mass=5000, 20 molecules of molecular mass = 7500

20 molecules of molecular mass = 10,000, 25 molecules of molecular mass = 15,000

20 molecules of molecular mass = 20,000, 5 molecules of molecular mass=25,000.

Calculate its number average & weight average molecular mass & polydispersity index.

Solution:

Number average molecular weight Mn = $\sum NiMi / \sum Ni$

= 10*5000+20*7500+20*10,000+25*15,000+20*20,000+5*25,000/ 10+20+20+25+20+5

= 1.3 * 10^6 / 100

= 13,000

Weight Average molecular weight (Mw) =$\sum NiMi^2 / \sum NiMi$

= 10 * $(5000)^2$ + 20*$(7500)^2$ + 20 * $(10,000)^2$ + 25 * $(15,000)^2$ + 20 * $(20,000)^2$ + 5 *$(25000)^2$ /1.3*10^6

= 20125 * 10^6 / 1.3*10^6

= 1.548 * 10^4

Polydispersity index :

= Mw/Mn

= 1.548 * 10^4 / 13,000

= 1.191

Q.2 In a polymer, there are 100 molecules of molecular weight 100, 200 molecules of molecular weight 1000 & 300 molecules of molecular weight 10,000. Find Mn, Mw & PDI.

Solution:

Mn = 5350

Mw = $\sum N_i M_i^2 / \sum N_i M_i$

$= 100 * (100)^2 + 200 * (1000)^2 + 300 * (10{,}000)^2 / 3.2 * 10^6$

$= 10^6 + 2 * 10^8 + 3 * 10^{10} / 3.2 * 10^6$

$= 9437.81$

Mw= 9437.81

PDI= Mw/Mn = 9436.81/5350 = 1.76

Q.3 A polymer has the following composition: 100 molecules of molecular mass 1000, 200 molecules of molecular mass 2000, & 500 molecules of molecular mass 5000. Calculate the number & weight average of molecular weight & the polydispersity index.

Solution:

Mn= = $\sum N_i M_i / \sum N_i$

$= 100 * 1000 + 200 * 2000 + 500 * 5000 / 100 + 200 + 500$

$= 30{,}00000 / 800$

$= 3.75 * 10^3$

Mw = $\sum N_i M_i^2 / \sum N_i M_i$

$= 100 * (1000)^2 + 200(2000)^2 + 500 * (5000)^2 / 3 * 10^6$

$= 1.34 * 10^{10} / 3 * 10^6$

$= 4.46 * 10^3$

PDI = Mw/Mn

$= 4.46 * 10^3 / 3.75 * 10^3$

$= 1.189$