Membrane science and technology has come a long way since its origin in the 1960s and is now accepted as a part of available separations technologies in the process industries. But the promise it offers of low cost, highly specific separations has still not been fully realised. Making membrane is still an art rather than science and construction of large scale process plant remains fraught with uncertainty, except in areas such as biotechnology, food processing and water treatment where extensive process know-how has been developed.

Membrane science and engineering have become very successful in developing increasingly economic technologies for the recovery of potable water from seawater and in the purification and disinfection of water. Although there are examples of the successful application of gas membrane technology, it is probably still too early to rank membrane technology alongside more conventional gas processing technologies for large scale use.

Because the world in the 21st century is faced with a number of significant processing challenges and these will require large scale economic operation, it is suggested that the attention of membrane researchers could profitably be directed to these areas. They include separation of CO₂ from the burning of fossil fuels, the provision of adequate quality water for urban environments and the treatment of waste water to protect the environment.

It is appropriate at this time to evaluate where future opportunities lie for membrane technology and where there will be substantial community support for R&D effort. This is not to say that fundamental work should not proceed in the hope of major breakthroughs. But it is fair to comment that we know enough
about membrane science and technology to see where it has optimum application, where new work is needed, and where there are significant opportunities if technological problems can be overcome. There are real lessons to be learned from examining how well the development of membrane technology parallels that of other separation technologies and what have been the principal drivers for significant developments in these technologies.

The principal problems facing the world in this century are:

(i) The impact of global warming
(ii) Meeting increasing demands for energy
(iii) Provision of adequate supplies of water in developed and developing countries
(iv) Sustainable minerals processing
(v) Protection of the environment.

Water treatment is one of the great success stories of membrane technology. Reverse osmosis now accounts for half of the installed new capacity for seawater desalination, micro filtration and nanofiltration have both made in roads for the purification and disinfection of drinking water and have replaced more conventional technologies.

The challenges for the membrane industry is to see whether membrane technology can offer the long term solution to the world’s water needs, both by supplying an inexpensive process and offering a high degree of reliability. The ultimate challenge is to provide for safe recycle of water, overcoming cultural taboos by technology that satisfies all members of society. What is being talked of is a range of membrane-based plants at a scale hitherto unenvisioned.

Those active in membrane science have probably reflected often on the “ultimate” membrane. This is a membrane that will have a high permeability and bring about the desired separation with a high degree of precision. With such a
membrane, the challenge then becomes one of managing the process conditions on either side of the membrane so that concentration polarization or fouling effects are minimized by good fluid mechanics, chemistry and mass transfer management. The choice of trans-membrane pressure then becomes a question of providing sufficient driving force to attain a desirable permeability.

For membranes designed for liquid phase separations, especially the removal of dissolved and suspended species from water, membrane effectiveness depends on the existence of micron or submicron pores, assisted by local charge to repel ionic species. It still remains unclear what is the primary separation mechanism in tight reverse osmosis membranes.

Conceptually, at least, it should be possible to design a membrane with a very high pure water permeability but at the same time having high rejection capabilities for ionic or non-ionic species. Like a gas separation membrane, this membrane would have zones of molecular dimensions of high permeability surrounded by zones which repelled ionic or charged species and induced a local environment rich in the permeating species. The challenge for the membrane scientist is therefore to develop new membranes based on an understanding of the rejection and transfer characteristics which are sufficiently thin to require a minimum trans membrane pressure to allow them to function effectively.

The ultimate challenge is to design membranes that will operate at high temperatures and have high mechanical stability. Latest generation ceramic membranes offer promise here as they confer the benefit of high permeability and can be aggressively cleaned. It is argued that the real challenges for membrane technology lie in addressing some of the large-scale problems facing society in the next 30 years.

In future, the largest market for membrane will continue to be water treatment, with sales to manufacturers of consumer water purification equipment
becoming more important. In addition, as both the physical and chemical means of cleaning membranes continue to improve, the average life span of the membranes is lengthening, thus reducing replacement sales.

Biomedical applications are by far the most relevant use of synthetic membranes. Membranes are used in medical devices such as hemodialysers, blood oxygenators and controlled drug delivery systems. There is however a substantial effort focused on the development of the membrane for the next generation of artificial organs, such as artificial liver or artificial pancreas. In this device, as in other novel vehicles for the delivery of the cell and gene therapy, synthetic membranes are combined with living cells to form so-called biohybrid organs.

The liquid – liquid electrochemistry to be a versatile tool in the characterization of drug properties with relevance to drug delivery and pharmacokinetics. While the bare interface between two immiscible electrolyte solutions enables the determination of partition coefficients for both the neutral and charged species of ionisable compounds, a.c electrochemical measurements can be combined with theoretical models to reveal the membrane activity of variable classes of therapeutics. The sensitivity of capacitance measurements to detect charges in membrane activity, induced by minor alterations in structure, holds promise for future applications in this field of biosensing.

Membrane technologies continue to offer considerable promise. Perhaps it is time for the membrane research fraternity to examine the future path of the technology and its alignment to major international process challenges where good science and clever engineering can be utilized to produce reliable and economic solutions.
Summary

The steady deteriorating conditions of human life in civilized areas have much diminished the number of those who once considered the chief aim of science to be the unlimited subjugation and transformation of nature. The main importance of science, of course, never lay in this area and in the process of seeking a more thorough understanding of nature. Scientists have constantly imitated nature, especially, living nature. This direction appears even more promising at the present time, since the artificial tools, materials or processes, developed are not only useful in themselves but, in addition provide models which on investigation provide a deeper understanding of the natural phenomena.

Transport phenomena in membrane has acquired considerable significance during the last few decades because of its direct impact in desalination, ion sensor techniques, fuel cell technology nanotechnology, electrical storage batteries, medicine and several other processes. The investigators from various disciplines e.g. chemists, chemical engineers, physicists and biologists have contributed extensively, although the aims and the starting points have been quite different.

The number of recent published research papers and reviews has witnessed a rapid growth in the development and use of model membranes for carrying out investigations of various aspects of bio-electric phenomena. A number of investigators have developed simple, well defined and stable model membranes, lipid bilayer membrane have been considered as the most realistic model except for few shortcomings. Parchment paper, which mimic some of the functional properties of electrolyte cell and gastric mucosal membranes, have been used to study the rectification phenomena in biological systems and in some other physico-chemical studies. Inorganic precipitate membranes, owing to their stability at higher temperatures, ion exchange power and strong adsorption
characteristics have been used in many processes of nuclear and chemical
technology and electro synthesis of organic compounds in some non conducting
media.

Many of the processes occurring in nature involve membrane transport.
Some of the functions performed by such membranes appear to be unique, as well
as efficient and it could be possible to prepare synthetic membrane of similar
properties. Furthermore, knowledge of synthetic membranes with a view to
understand the changes which occur in biological ones is the main interest of the
authors. However, the main object is the examination of the extent to which
electroanalytical method may be applied to answer the questions concerning the
physical chemistry of ion transport across membranes.

Model and biological membranes are studied simultaneously by using the
recently developed theories. Biological membranes with the exception of cell
membranes, are thin sheets of tissue that cover various organs of body and plants.
Of the hundreds of biological membranes, one of the more familiar is the mucous
membrane. The mucous membrane functions as a barrier to keep toxic
components contacting one side of the membrane from tissue on the other side but
allows transport of species essential for that tissue. Model or synthetic membranes
are sub-classified by composition, functions, structure and form. Composition
refers to the material used to make the membrane i.e., organic or inorganic
polymer. Functional classification of membranes includes gas separation, water
desalination, dialysis etc. Form denotes whether the membrane is a film hollow
fiber tube, or coating.

In this thesis, an effort has been made to characterize the hen egg (Gallus
saneratii) shell biological membrane and newly developed parchment supported
lead tungstate ion exchange model membrane, prepared from inorganic
precipitates, when placed in contact with aqueous electrolyte solutions. The
parameters governing membrane phenomena have been derived from membrane potential, bi-ionic potential, membrane conductance and membrane impedance measurements. The thesis has been presented into following chapters. It is based on the more general approach to membrane transport extended using the non-equilibrium thermodynamics.

Chapter-I is the general introduction describing the previous studies related to the present work and the history of membrane science and technology, viz. its origin, development and further fragmentation into a highly sophisticated discipline which makes its presence felt in almost every modern and cutting-edge technology, directly affecting the welfare of mankind.

Chapter-II, describe the general purpose of the present work, development, chemical characterization and applications that would be feasible for electrochemical studies.

Chapter-III is devoted to basic properties of model and biological membranes and existing artificial and biomembrane models. This portion also gives an idea about the general structure of the model and biological membranes with the help of Scanning electron microscopy (SEM), Transmission electron microscopy (TEM) and Fourier transform Infrared spectroscopy (FTIR). The investigation reveals that lead tungstate membrane is composed of dense aggregation of smaller particles and formed pores probably with non-linear channel with fully inter connected particles are irregularly condensed and adopt a heterogeneous structure comprising masses of various size. Infrared spectra gives percentage structural probability of many similar compounds.

Hen egg shell membrane has been found to have greater amount of protein studded in the comparatively lesser amount of lipid. In the light of the above it may be hypothesized that a greater part of protein content of the membrane is devoted to pores and channels. Which are a part and parcel in the passage of ions
across the membrane. Thus it is further concluded that lipid content might be providing a framework to the protein which is largely channels and pores. The infrared spectra gives percentage structural probability with similar compounds like N- (Isobutoxymethyl) Acrylamide and chitin.

Chapter-IV depicts the basic theories of membrane phenomena based on the principles of non equilibrium thermodynamics. Electrochemical characterization of membranes is of vital importance from the point of view of determination of their suitability for many applications of practical interest. Electrochemical studies of biological and model membranes are totally based on certain widely accepted theories of non equilibrium thermodynamics. Various theoretical equations have already been derived by various workers in order to evaluate important parameters governing the membrane phenomena regarding their electrochemical characterization. Basically various approaches are taken into account by the author for the establishment of recent theories for membrane potential, bi-ionic potential, membrane impedance etc, which are based on the experimental measurements for the characterization of the membranes.

In this way this chapter is restricted towards the various approaches as:

1. Irreversible Thermodynamics Approach:

   The linear phenomenological analysis is a powerful tool to characterize membrane transport processes on the basis of non equilibrium thermodynamics. A variety of non equilibrium thermodynamic theories on the membrane transport processes have been developed to investigate material transport phenomena arising across membranes. These membrane theories are useful to describe quantitatively the selective transport performance is some particular membrane samples by evaluating the linear phenomenological coefficients from the available experimental data. However, there seem to be some uncertain factors, even now in the generalized correlations of phenomenological coefficients with membrane
properties such as permeability, selectivity, polymeric and charged structures, and phase behaviour of membrane substances. The theory of irreversible thermodynamics processes has been very successful in treating many sorts of irreversible phenomena.

II. Chemical Engineering Approach:

This approach used to describe membrane transport is based on turning the NP equations of motion inside out. These equations, known as Stefan-Maxwell equations, account for the motion of the centre of mass of the membranes system and remove a source of concentration dependence that measures diffusion coefficient will otherwise show when measured in a laboratory co-ordinate system. A characteristic feature of this method, as with the entirely consistent irreversible thermodynamic approach, is the large number of transport parameters which take into account interacting among moving and static components.

III. Activation Barrier Kinetic Approach:

This theory treats transport processes as barrier controlled kinetic events occurring sequentially in space within the membrane. The advantage of the so called kinetic analysis of membrane transport is that it provides an overview without the introduction of specific models for forces and system functions. On the new parameters are introduced and are related to the other better known quantities.

Absolute Reaction Rate theory:

The rate theory describes process of diffusion in the chemical reaction in terms of elementary jumps over energy barriers and can be used to represent the process of permeation in as much detail or with as much accuracy as desired. The permeant encounters energy maxima (barriers) and minima (wells) in its journey from one side of the membrane to the other. The energy maxima represents the energies of the transition states, and diffusion state, these unfavourable loci can be
represented by single jumps over the corresponding barriers. The progress over each barrier is proportional to the number of ions attaining the energy, needed to cross the barrier. In this process, the rate constant $k_i$ for crossing over a barrier was related to standard Gibb's free energy of activation $\Delta F^*$ by the appropriate equation.

$$k_i = A_i e^{-\frac{\Delta F^*}{RT}}$$

This equation was further extended in terms of activation energy $E_a$, enthalpy change $\Delta H^*$ and the entropy change $\Delta S^*$ of activation to calculate the values of these parameters, that is, $E_a$, $\Delta H^*$ and $\Delta S^*$. The size dependence on the magnitude of $E_a$, $\Delta F^*$ and $\Delta H^*$ represented that a larger ion was having more difficulty to cross the membrane rather than a small one. This type of variation was explained by considering the precaution of energy peaks and wells and also by comparing the height of energy barrier, that is, the difference between outer wells and peaks.

IV. Phenomenological Equation of Motion Approach:

This widely applied theory of transport is based on the NP flux equation. In its most general form, it is consistent with irreversible thermodynamic flux.

$$I = F \sum_i Z_i \bar{J}_i - \left( \frac{\partial^2 \psi}{\partial x \partial t} \right)$$

Use of NP equations in steady state uniform (constant composition) electrolyte leads to all of the classical transport relations. The most extensive study of techniques, based on Pleijels procedure for integration of the standards NP equation system applicable to liquid junctions and ion-exchange membranes.
V. Membrane Potential:

In living cells an electrical potential difference exists between the cytoplasm and the extracellular medium, with the inside of the cell being negative with respect to outside. The potential is called resting potential. It may very considerably between different types of cells, but it is always smaller than 100 mV. The resting potential is caused by the unequal distribution of ions in the inside and outside solutions on both sides of the plasma membrane surrounding the cell. Therefore, the resting potential is also called membrane potential.

It has been recognized that membrane charge and its density are among the most important factors which characterize membranes. Various theoretical approaches have been made to calculate electrical potential across charged membranes. These have been treated on the basis of the idealized theory of TMS and its refinements and the kinetic approach based on the theory of absolute reaction rate.

(i) Teorell- Meyer- Sievers (TMS) Theory:

The earliest efforts towards developing a membrane model was by Michaelis, who considered that the charge on the membrane was due to adsorption of one kind of ion, later Teorell, Meyer and Sievers developed a theory of membrane with charges fixed in the lattice. In the TMS theory there is an equilibrium process at each solution-membrane interface which has formed analogy with the Donnan equilibrium. In addition there is an internal salt diffusion potential which was first represented by the Henderson equation and later by the more nearly correct Plank expression. Further assumptions made are (a) the cation and anion mobilities and fixed charge concentration are constant throughout the membrane phase and are independent of the salt concentration and (b) the transference of water may be neglected.
The important point emerging from the application of TMS theory is that the mobility ratio goes through a change considerable in some cases in the membrane phase. Usually in the case of cation selective membrane (values of $\bar{X}$ high) $(\bar{\mu} / \bar{\nu})_{\text{solution}}$ in dilute solutions and only when the membrane is in equilibrium with concentrated solutions does $(\bar{\mu} / \bar{\nu}) \rightarrow (\mu / \nu)_{\text{solution}}$. In view of this the approach of TMS is unreliable to evaluate charge density $\bar{X}$ for ion-exchange membranes which have a high concentration of $\bar{X}$ as found in this study, due to the fact that the change in the values of the factor $(\bar{\mu} / \bar{\nu})$ is not drastic as it is with membranes of high charge density. The limitations of this conceptually useful theory which has stimulated both theoretical and experimental work, are applicable only to idealized system and this should be borne in mind when it is applied to analyse membrane phenomena.

(ii) Altug and Hair Theory:

Altug and Hair method is principally based on Teorell's model. This alternative method of plotting the membrane potential data may be expected to give $\bar{X}$ values different from those given by TMS method. It is not very realistic to use the solution mobility values for the ratio $\mu / \nu$ in the calculations. It is believed that the approach of Altug and Hair may some times overestimated $\bar{X}$ in comparison to TMS method.

(iii) Kobatake and Nagasawa Theory:

In Kobatake's and Nagasawa's method of charge density evaluation, the derivations are based on the thermodynamics of irreversible process which has its own limitations. They have claimed that their data of membrane potential on an oxidized collodion membrane, as well as those of previous workers, are fitted quite accurately by the equation derived by them. They have also stated that no such agreement with experiment was obtained in terms of the earlier theory of
TMS. These theoretical predictions from the Kobatake membrane potential equations are borne out satisfactorily by my experimental results. So it may safely be concluded that Kobatake's and Nagasawa's approaches for charge density evaluation based on thermodynamics of irreversible processes are more accurate as compared to earlier theories of membrane potential.

(iv) Aizawa Theory:

The Aizawa et al. method is an extended form of Nagasawa et al. approaches for charge density evaluation. The Aizawa et al. access is also based on thermodynamics of irreversible processes. This is also a good method for the evaluation of thermodynamically effective fixed charge density.

VI. Bi-Ionic Potential:

A steady electromotive force of a bi-ionic cell containing two electrolytes AX and BX separated by a membrane is called the bi-ionic potential (BIP). This potential is a measure for the selectivity of a membrane for the ions of the same sign and has been the subject of many theoretical and experimental studies. The mathematically rigorous equations were derived on the basis of the thermodynamics of irreversible processes by Scatchard and Helfferich. In their derivations, however, they considered only a perfectly cation selective membrane separating two mixtures of 1:1 electrolyte with a common anion, i.e. neglected the effect of flow of anion of the BIP. Moreover, these types of treatment did not provide information about the actual mechanism which produces observed BIP for the membrane which arises between solutions of an electrolyte of different concentrations separated by a uniform membrane. Teorell-Meyer-Sievers derived a first theoretical equation based on the fixed charge membrane model. Also, Toyoshima integrated flow equations provided by thermodynamics of irreversible processes under the appropriate assumptions for the mobilities and activity coefficients of small ions in the membrane phase to derive an equation for the
membrane potential and found the derived equation agreed with typical experimental data with porous membranes covering wide ranges of concentration of external solutions.

Chapter V deals with the characterization and evaluation of effective fixed charge density of the lead tungstate parchment supported membrane and hen egg \((Gallus saneratii)\) shell biological membrane from membrane potential measurements using various 1:1 electrolyte at different concentrations. The parchment supported membrane was prepared by the method of interaction adopted by Beg et al.. Hen egg shell membrane was separated from freshly laid down hen egg. The following approaches have been utilized for the evaluation of thermodynamically effective fixed charge density of membranes (i) Teorell-Meyer-Sievers (TMS) method, and its modified form by Altug and Hair (ii) the method developed by Kobatake and co-workers (iii) the method of Nagasawa et al. and (iv) Aizawa et al. method based on the principle of nonequilibrium thermodynamics.

The values of membrane potential measured across lead tungstate membrane with the use of chlorides of potassium, sodium and lithium were all positive at lower concentrations, when the membranes were used to separate electrolytes (dilute solution side taken as positive). However, at higher concentration of sodium and lithium chlorides respectively, membrane potential observed were negative. This means that membranes were a little bit anion selective at very higher electrolyte concentration. Moreover, the membrane potential values increase across the lead tungstate membrane with the dilution of electrolyte solutions. The membrane potential values observed across hen egg shell membrane using various 1:1 electrolyte solutions were negative at all concentration which confirms the anion selectivity of the membrane.
For the evaluation of effective fixed charge density, Teorell-Meyer and Sievers (TMS) derived a theoretical equation for membrane potential when a charged membrane separates different concentrations of an electrolyte by considering a diffusion potential within the membrane and two interfacial potentials at the membrane-solution interfaces. The membrane potential equation, thus derived has been generally accepted and widely used for the evaluation of effective fixed charge density and mobility ratio of the ions within the membranes by the plotting method. The method gave quite satisfactory results.

In TMS method and its modified form by Altug and Hair, the values of (a) Donnan potentials \( \pi_1 \) and \( \pi_2 \), (b) Diffusion potential \( \phi_2 - \phi_1 \) and (c) Donnan distribution ratios \( r_1 \) and \( r_2 \) have been calculated and used for charge density evaluation.

In Kobatake et al. method, the most important assumptions are about the activities, \( a_+ \) and \( a_- \), of ions in the membrane phase which can be represented by \( a_+ = c_+ \) and \( a_- = c_- \) where \( c_i \) is the concentration of the negative ion species. Kobatake's equation contains various parameters namely \( \alpha \), \( \beta \) and \( \bar{X} \) which have been evaluated using a model and biological membranes.

The theory of membrane potential developed by Nagasawa et al. and Aizawa et al. based on the thermodynamics of irreversible processes were also applied for the evaluation of thermodynamically effective fixed charge density of the membranes. Comparison between various theories have been discussed in brief. The results of all these investigations show, that the experimentally determined membrane potential data with these systems of membranes, fit quite accurately in the equations of Kobatake, Altug, Nagasawa, and Aizawa. The values of effective fixed charge densities evaluated from different methods gave identical values.
Chapter VI describes the determination of the selectivity of the membranes for cations by using the values of bi-ionic and conductivity measurements across the parchment supported lead tungstate and hen egg (Gallus saneratii) biological membranes for various combinations of 1:1 electrolytes. Moreover, the selectivity of the membranes was determined by three widely used methods namely: bi-ionic method, one-sided addition method and absolute reaction rates method. Bi-ionic method involves the measurements of electrical potential by keeping the same concentration on the two sides of the membrane. Which were measured across the parchment supported lead tungstate membrane and hen egg shell membranes using various concentrations. The intra-membrane permeability ratio of cations were derived using the plotting method. Conductivity of the membranes in contact with single electrolyte were also determined experimentally in order to evaluate selectivity of the membranes using the predetermined values of intra-membrane permeability ratio. The equation for permeability ratio, selectivity constant and the ratio of the individual ionic mobilities derived recently by Sandblom and Eisenman from the macroscopic laws of irreversible thermodynamics was used to evaluate various membrane parameters. It was found that the theoretical and observed values of BIP, are closer to each other thereby confirming the applicability of Toyoshima's equation to this system of model and biological membranes. The selectivity sequence of both the membranes for the cations were of the following order; K\textsuperscript{+} > Na\textsuperscript{+} > Li\textsuperscript{+}.

In one sided addition method bi-ionic potentials were carried out by keeping the concentration of one of the electrolytes (AX) constant and varying the concentration of other electrolyte (BX) and then by keeping the concentration of electrolyte BX constant and varying that of AX. Utilizing the best equations of Wilson, Wyllie and Ilani and the data of BIP, effective fixed charge density, the evaluated values confirmed the selectivity sequence of membrane alkali metal
ions as : K$^+$>Na$^+$> Li$^+$, which on the basis of Eisenman-Sherry model of membrane selectivity point towards the weak field strength of the charge groups attached to the membrane metrix. Perfect Donnan exclusion of coions was realized in the dilute limit of the external solution.

In Absolute reaction rates method the selectivity of model ions of the membranes was also tested in terms of the values of various activation parameters like, $E_a$, $\Delta F^*$, $\Delta H^*$ and $\Delta S^*$, which were predicted on the basis of rate theory. The parameters $\Delta S^*$, the entropy of activation represents the mechanism of ion permeation in terms of electrolyte diffusion with partial immobility causes the selectivity behaviour of membrane of metal ions, the partial mobilities were increasing with increase of density of charge on the permeant. This conclusion was in good agreement with the most recent finding of Marcus, who established that the transitional immobilization of entropy of solvents follow the sequence; Li$^+$>Na$^+$>K$^+$ resulting in the selectivity sequence of the membranes for alkali metal ions as : K$^+$>Na$^+$>Li$^+$.

Chapter-VII is related to membrane characterization using impedance measurements of parchment supported lead tungstate model membrane and hen egg (Gallus saneratii) shell biological membrane under various conditions of bathing electrolyte concentration and applied oscillator frequency in order to understand the mechanism of ionic transport through these membranes. The results are interpreted in terms of changes produced in the electrical double layer at the membrane/electrolyte interfaces.

A Universal LCR Bridge-921 has been used to measure the electrical resistance ($R_x$) and capacitance ($C_x$) across lead tungstate and hen egg shell membranes equilibrated with different concentrations of sodium chloride solution at different frequencies by maintaining the temperature of the system at 25±0.1$^\circ$C. On the basis of these reported experimental data, a comparison of
charge carrier of the membrane has been carried out. Using some simple models of Lakshminarayanaiah and Shane the theoretical values of electrical resistance, capacitance and impedance were determined in the form of $R_m$, $C_m$ and $Z$. Thus comparison of experimentally observed and theoretical evaluated values of electrical resistance, and electrical capacitance of the membranes confirm their existence.

The electrical double layer at the membrane/solution interface has been utilized in several studies to account for various membrane behaviour. Here it is considered in the studies of impedance characterization of the membranes. The calculated values of interfacial double layer capacitance of these membranes are in agreement with my earlier findings of membrane potential measurements with lead tungstate and hen egg shell membranes as well as agreement with Tien and Ting for bilayer lipid membranes that the electrical double layers at that interfaces control the diffusion processes, at least in dilute concentrations ranges.

Chapter-VIII highlights the uses of membrane science and technology in various discipline and industries namely, food and biotechnology industries, leather and textile industry, dairy Industry, medical sector, reverse osmosis, bioreactors, biomedical devices and various others.