# CHAPTER - V

## SUMMARY AND CONCLUSION

We devote few pages in this chapter to summarize the work reported here. We also try to conclude that the present work gives more accurate information compare to so many approximations devised. We also try to show the short comings of some of the approximation and how far we have successeded in reducing the short comings of the approximations. We conclude through the calculation of the cross sections the utility of the methods used and how it provides more information without going into the computational complexity. Eventhough the conclusions drawn in the course of the discussion on the previous chapters, the final recapitulation of the various results obtained/arrived at during the entire study gives us an opportunity to access the successs/failures in meeting the targets set up at the begining of the research. Hence, in what follows, a general summary of the thesis, the important conclusions and some suggestions for further work are high lighted.

A basic approach common to all the problems studied in the thesis is the high energy methods applied or studied in the scattering theory. Generally, the energy of incidence for the electron is considered above 100 eV and in some cases the energy

is stretched down to lower values due to specific reasons like the non -availability of data at very high energies. We have considered the atomic targets such as hydrogen, helium, lithium and neon atom. Through out the work reported we deal with the elastic scattering of electrons by the various target atoms mentioned above. The computer is made use of extensively, but only to generate the numerical results from the analytical expressions. Most of the final results are given in terms of standard integrals which are given in appendix. A list of the symbols used in thesis are standard and they are given and described in so many reference books and research articles. All the results reported here are in the form of graphs and tables and the adequate comparisons are made.

In the first chapter, the choice and approach to the various problems studied in the thesis are briefly introduced. To summarise the first chapter, a brief introduction on the background of the study, the experimental aspects, the significance and motivation for the present work and an approach to the problems considered are covered. We started with the basic equation of potential scattering and then the following approximation are given special attention.

(i) The first Born Approximation

(ii) The Glauber approximationn

(iii) The Eikonal approximation

(iv) Eikonal -Born series method

In chapter II we have discussed the HHOB approximation in detail and the mathematical forms. The HHOB approximation of Yates (1979) is relatively new and computationally simple. In this analysis the well known generalized Born series description of the collision process is transformed into a more convenient form. Thereafter the approximate formula are developed through a partial expansion of the free particle Green's function. The primary purpose of the HHOB analysis was to develop an alternative high energy expansion of differential scattering cross section in terms of reciprocal powers of $k_i$ through $O(k_i^{-2})$ which is computationally tractable yet derived from analogously treated second and third Born terms. A second consideration has been the anamalous behaviour of the small angle high energy differential cross section in electron -atom collisions. This was applied to $e^-$ - H and $e^-$ - He scattering (Rao and Desai 1981,1983). This was extended for $e^-$ - Li scattering (Suja and Desai, 1986,1988). It was found that there is a fair amount of agreement in the cross sections measured for the process mentioned above. To improve upon the accuracy in the cross section we applied the refinement in the HHOB theory by means of including certain low lying energy states in the calculation. And then the refinement is studied for the process mentioned above. We find that there is a improvement in the results of the cross sections calculated. We calculate the cross section for the energy range 100 to 700 eV, we also conclude that as the energy of incidence increases the agreements gets

better for the small angular region up to 5Ø - 6Ø deg. Further, we also conclude that if one still include certain s- state or p-states in the calculation the discrepancy can still be made less. This also suggests that we need not to go for the higher order terms calculation and one can avoid the computational complexity. We also conclude,

(i) the results of the refinement in the HHOB theory applied to study $e^-$ - H , $e^-$ - He and $e^-$ - Li atoms scattering are quite comparable up to 5Ø deg or so, thereafter for large scattering angle results are overestimated.

(ii) If one puts $\beta_i$ = Ø, the average excitation energy parameter, in the HHOB approximation the corresponding GES terms will be obtained.

(iii) We replace also third Born term by the third Glauber term.

(iv) In the process of studying the $e^-$ - Li atom scattering, the Li atom is considered as three electron system.

(v) We include the exchange for the process of $e^-$ - H and $e^-$ - He atom scattering. Where as in case of of the $e^-$ - Li atom scattering process the exchange is not included. Gien (1981) had shown that the DCS with and without exchange is not having much difference. But in our openion, one should incorporate the effect of exchange in the calculation.

In third chapter we discuss in detail the process of $e^-$ - Ne atom scattering using the HHOB theory. We report here also the

differential cross section for the energy range 100 to 700 eV. We also find that as the energy of incidence increases the results improves further. It was concluded by so many that to have more accurate information one should know the exact wave function of the target atom. We calculate the wave function of the neon atom using Roothan - Hartree -Fock wave method, where we used the table of Clementii -Roetii for the orbital calculation. After having the more accurate wave function for the target atom like neon we also considered neon as ten electron system. While doing the calculation we include all the cross terms in the calculation. Hence whatever is the contribution of the cross terms are but they are included in the calculation. Further there is no divergence problem in the evaluation of the scattering amplitude in the HHOB theory. We used the experimental value of the excitation energy $\beta$ in the calculation. We use the simple Fourier transform of the interaction potential so that we can obtain a simple analytical form of equation. We have not included the exchange but one should incorporate the effect of exchange. It was concluded that the exchange for the energy range in which the calculation is performed does not make much difference. We find that there is a better agreement in the results obtained for the cross sections measured. We find that up to 50 deg the agreement is better but as the scattering angle increases further the results diverge but still comparable. We conclude that since the neon atom is heavy and completely filled atom in its outer most

orbit, and the interaction becomes strong for the energy range in which the calculation is performed. It is the nature of the HHOB approximation that it does give accurate measurement of cross section for the small scattering angle but it does poor for the large angle scattering angle. We also conclude that at large scattering angle the effect of polarization and absorption are to be handled very carefully. To conclude we find that there is better agreement over all for the intermediate and high energy region for the small scattering angle.

In fourth chapter we employ the two -potential method to study the $e^-$-Ne atom scattering. We discussed in detail the method of partial wave analysis and calculation of the phase shift. We also discuss the behavior of the phase shift for large l (fixed k) and for high k (fixed l ). We try to over come the short comings of the HHOB approximation of Yates (1979) to study the $e^-$ - Ne atom scattering at large scattering angle region. Because it is well known fact that Born approximation gives better results for the weaker interaction potential. We treat the calculation of the phase shifts exactly. We aimed to formulate the improvement of the HHOB approximation, particulary for large scattering region. The partial wave summation was taken with a view to account for the infinite number of partial waves. For this purpose, the method suggested by Jhanwer et al (1978) was used, which involves the exact Born phase shifts and their comparison. We negelcted here the third Born term for few reasons discussed in detail at the end

of the chapter IV. The present two -potential method gives better agreement over the entire angular region. However, this type of reasonable comparison asserts that the improvements whatsoever obtained are due to the approximation introduced and not due to the inclusion or exclusion of any particular term. The main attraction of the present two -potential method in the HHOB approximation is that it gives reasonably good agreements even at low energies, for the entire angular range. In light of the above discussion, the conclusion can be drawn that the two -potential method in the HHOB apprroximation as derived, improves the basic HHOB approximation of Yates (1979). Further, the avoiding the computational complexity in the calculation of the phase shifts is self starting. The divergence problem get eliminated automatically due to the presence of the $\beta$ term.

The present method of evaluating the wave function , calculation of the phase shifts for large number of partial waves, and the two -potential method in the HHOB approximation can be extended further for any target atom. One can repeat the calculation of the $e^-$ - Ne atom scattering by applying the refinement in the HHOB approximation and one can see that the results will definately improve further. With the results produced through such refinement one can again apply the two -potential method and the accuracy can be improved further avoiding the computational complixity in the calculation.