Chapter 1 INTRODUCTION

"This chapter lays the groundwork for scattering theory by exploring the diverse of cross sections that represent the probability of various scattering events. It elucidates the far-reaching impact of scattering phenomena, highlighting its significance across a wide range of scientific and industrial domains. Furthermore, it provides a rigorous and comprehensive review of previous research focused on electron collision processes in atomic and molecular components. This review encompasses both experimental and theoretical investigations, offering valuable insights into the current state of knowledge in this domain".

1.1 Introduction

The understanding of scattering phenomena and its application has become increasingly important due to rapid technological advancements in recent decades. The formal study of electron scattering by atomic and molecular systems emerged with the advent of quantum mechanics in the early 20th century. A pioneering milestone was the Franck-Hertz experiment in 1914, which provided the first evidence for the quantization of atomic energy levels. Another landmark study by Ramsauer uncovered the "Ramsauer-Townsend minimum," a distinctive feature in low-energy electron scattering. The observation of resonances in low-energy collisions further enriched the field. These early investigations sparked significant interest in scattering physics, leading to numerous experiments exploring electron interactions with diverse targets. The discovery of “electron diffraction” through crystals in 1923 by Thomson, Davisson, and Germer provided crucial support for the wave-particle duality of matter. Advancements in technology, such as electron microscopy and diffraction techniques, have revolutionized scattering experiments, enabling in-depth investigations of molecular structures and properties. Further investigations into fundamental forces and possible new physics resulted from the 2012 discovery of the Higgs Boson and other interactions of high energetic particles, which validated the mechanism for mass in the Standard Model.

The intricate dynamics of electron interactions provide a crucial foundation for modeling the complex chemical processes that occur within plasmas and a wide range of real-world phenomena. Low-temperature plasmas (LTPs) have become indispensable tools across diverse scientific and technological domains. Their applications span semiconductor manufacturing, the elimination of harmful volatile organic compounds, surface modification for enhanced mechanical properties, and understanding the complex chemistry occurring at the walls of nuclear fusion reactors [1]. Accurate determination of gas densities from mass spectrometry relies on precise knowledge of ionization CSs, which are essential for flame sampling and Knudsen-cell thermochemical studies. Furthermore, a comprehensive understanding of various scattering cross sections for electron -molecule encompassing ionization, excitation, and dissociation processes are paramount in diverse applications. These include plasma-assisted etching of microstructures, where precise control over plasma chemistry is crucial for achieving high-resolution patterns and intricate feature geometries, and high-quality thin-film deposition, where the manipulation of electron-induced reactions dictates film properties [2].

1.2 Electron: A remarkable investigative tool

Electrons, as fundamental constituents of matter, serve as exceptional probes for investigating the structure and properties of atoms and molecules. Electron collisions with various target species drive a multitude of natural phenomena, from the auroras that illuminate the polar skies to the intricate chemical processes occurring in interstellar space. Electrons play a crucial role in scattering phenomena due to their unique properties, and their interaction with other particles provides valuable information about the structure, composition, and properties of the molecules. It is the fundamental subatomic particles which carry a negative charge and no internal structure. Free electrons of varying energies can be easily generated in the states of matter. Electron collisions with other particles and molecules are the most common and well-known of all such events. Consequently, an electron serves as the most suitable and highly responsive tool for investigating the atomic configuration and material properties of substances. Compared to other charged particles, electrons may be able to acquire the amount of energy needed with a smaller potential difference due to their low mass. The investigated energy range is easily accessible by simply propelling electrons there. Thus, in this way electrons proved to be a reliable and easy to operate probe . So that in this present thesis we have report the results of electron interaction with several molecular processes.

1.3 Electron collision processes and unit system

During scattering, when a free projectile like an electron hits a target (atom or molecule), a lot of different kinetic events happen. Based on this result, it could then be broken down into two parts:

i. **Elastic collision:**
   The kinetic energy remains unchanged before and after collision.

ii. **Inelastic collision**:
   An amount of energy of the projectile is transferred to excite or modified the internal structure of the target.

1.3.1 The essential collision processes

A figure 1.1 provides a schematic representation [3,4] of a typical scattering experiment. A well-defined beam of projectiles, denoted as 'A', is incident upon a stationary target, 'B', which may consist of an atom or a molecule. The interaction between the incident particles and the target gives rise to scattering phenomena, whereby the projectiles are deflected from their

original trajectories. This scattering process can be characterized by various parameters, including the scattering angle and the energy transfer between the colliding entities.

The incident beam contains almost no energy. It may be avoided since the collision with the incident particles is so tiny.

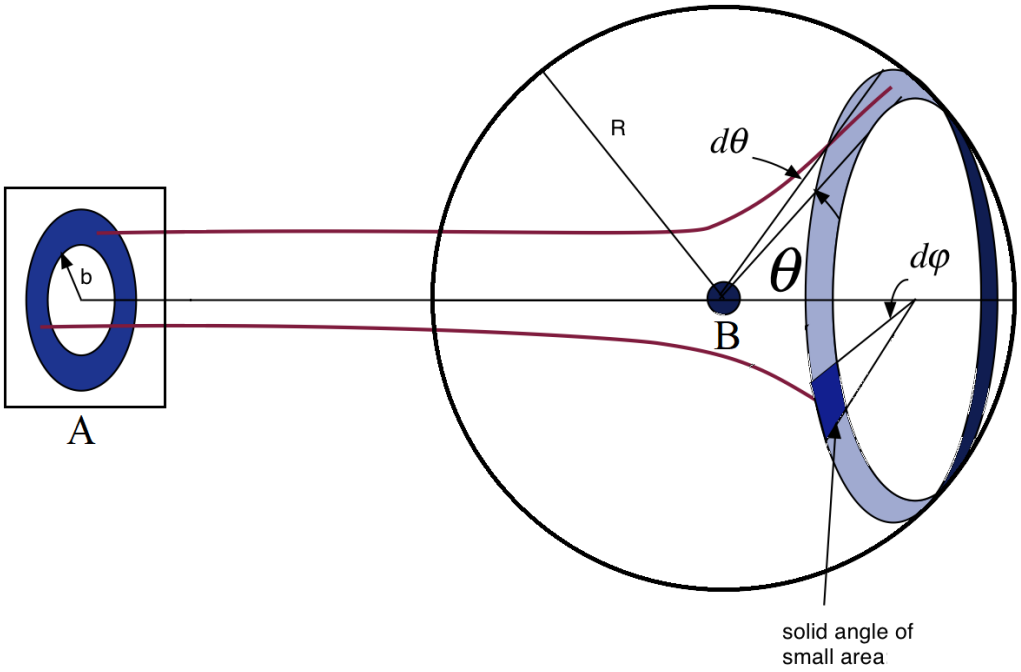

Figure 1.1 Diagrammatic representation of scattering event

The separation of the target molecule from incoming particle is greater than de Broglie wavelength. Each target scatterer functions are acts independently in the experimental settings [5]. Particles are scattered in all 360 degrees by the effective field of the target; some of the dispersed particles are collected and analysed by a detector located far away from the direction of the incoming beam, while the vast majority of undeflected particles pass undetected. Several possible dispersion processes are illustrated:

- **Elastic collision**

This is a type of collision where no energy is lost. Both the Kinetic energy and momentum of the colliding particles involved remain the same before and after the collision.

$$P + Q \rightarrow P + Q$$

Illustration:

$$e^- + XY_3 \rightarrow e^- + XY_3$$

Here, 'e^-' indicates electron and 'XY_3' for any molecule.

Inelastic collision

In the inelastic scattering, when two energetic particles P and Q are interact with each other, resulting in a change in the internal quantum states of one or both. This modification of internal states indicates an energy exchange between the colliding particles that results into new states and compounds of the target molecule via allowed chemical pathways. Consequently, the total kinetic energy does not remains the same, although the total momentum remains constant.

$$P + Q \rightarrow P^* + Q$$
$$P + Q \rightarrow P + Q^*$$
$$P + Q \rightarrow P^* + Q^*$$

Illustrations:

i. Electronic excitation: $e^- + AB_3 \rightarrow e^- + AB_3{}^*$
ii. Rotational excitation: $e^- + AB_3(j) \rightarrow e^- + AB_3(j')$
iii. Vibrational excitation: $e^- + AB_3(v) \rightarrow e^- + AB_3(v')$
iv. Parent excitation: $e^- + AB \rightarrow 2e^- + AB_3^+$
v. Dissociative ionization: $e^- + AB_3 \rightarrow 2e^- + AB_2^+ + B$
vi. Electron attachment: $e^- + AB_3 \rightarrow AB_3^-$
vii. DEA: $e^- + AB_3 \rightarrow AB^- + B_2$

1.3.2 Atomic unit system (a.u.)

The area of atomic and molecular physics deals with phenomena on a scale vastly smaller than our everyday perception. To get a sense of this scale, the unit length in these systems is comparable to the Bohr radius ' a_o', which defines the typical size of a hydrogen atom approximately 5.29×10^{-11} m. Given these incredibly small magnitudes, atomic units (a.u.) are employed to provide a more convenient framework for expressing quantities.

The system of units in which Charge of electron (e) is equal to the mass of electron (m_e) = $\hbar$ (where, $\hbar = \frac{h}{2\pi}$, h = Planck's const.) = $4\pi\varepsilon_0 = 1$ (where ε_0 = free space's permittivity). The Speed of Light, $c \cong 137$ Hartree.

The unit system in a. u. determined as follows:

$p = \hbar k = k = \frac{2\pi}{\lambda} (a_0^{-1})$;

$E\ (\text{Energy}) = \frac{\hbar^2 k^2}{2m} = \frac{k^2}{2} (a_0^{-2})$

For this system,

1 atomic unit of energy in Hartree and is equal to 27.2114 eV.

1 atomic unit of energy in Rydberg is equivalent to $\frac{1}{2} a.u.$ in Hartree = 13.6057 eV.

Moreover, Total CSs are described in a.u. as: Total CSs are expressed in $a_0^{\ 2}$ or $\pi a_0^{\ 2}$ or cm^2.

With the exception of specific instances, we have used $Å^2$ as the unit of estimation for CSs throughout this thesis.

1.4 Cross sections for scattering processes

The results of both theoretical calculations and scattering experiments are often reported as unique quantities called "Cross sections (CSs)." Probability of an occurrence is calculated using cross-sections. This chapter discusses several different kinds of cross sections.

1.4.1 Differential

Our focus now shifts to the elastic process, in which dN particles are scattered in a solid angle ($\Delta\Omega$) over a time Δt. It is possible to define the relationship between the incoming flux (F).

$$\Delta N \propto \Delta\Omega t F \tag{1.1}$$

$$\Delta N = \frac{d\sigma(\theta,\varphi)}{d\Omega} \Delta\Omega \Delta t F \tag{1.2}$$

The differential CSs (DCS) for elastic scattering are the ratio of the scattered intensity to the incident intensity, written as $\frac{d\sigma(\theta,\phi)}{d\Omega}$. This indicates the number of scattered particles per solid angle is measured by DCS, and it displayed in figure 1.1. So, we get the following equation 1.1.

$$\frac{d\sigma}{d\Omega} = \frac{\Delta N}{\Delta\Omega\, \Delta t F} \tag{1.3}$$

We can write from C. J. Joachain [3],

$$\frac{d\sigma}{d\Omega} = |f(\theta,\varphi)|^2 \tag{1.4}$$

The scattering amplitude is represented in the above equation as $f(\theta,\varphi)$.

1.4.2 Momentum transfer (Q_M)

The amount of forward momentum an electron loses as it crosses the target medium is measured by the momentum transfer CSs (MTCS). For low-energy, MTCS is defined as

$$Q_M = \int f(1-cos\theta)\frac{d\sigma}{d\Omega}d\Omega \tag{1.5}$$

Above equation 1.5, the amount $(1-cos\theta)$ represents the projectile momentum gained during the elastic contact in the resultant direction procedure.

1.4.3 Elastic (Q_{el}) and inelastic (Q_{inel})

The total or integral elastic CSs can be calculated by taking integration of differential CSs over each solid angle $(d\Omega)$.

$$Q_{inel} = \int \frac{d\sigma}{d\Omega}(\Omega)d\Omega \tag{1.6}$$

It can be written as,

$$Q_{el} = \int_0^{\pi}\int_0^{2\pi}\frac{d\sigma}{d\Omega}(\theta,\phi)\sin\,\theta\cdot d\theta\cdot d\phi \tag{1.7}$$

The Q_{el} is purely elastic in the absence of any inelastic processes. As a result, in order to estimate the Q_{el}, we must consider all inelastic channels. A scattering phenomenon may encompass a diverse array of unique inelastic interactions, which are characterized by beyond the elastic interactions. In addition to elastic processes, diverse inelastic processes including such as vibrational, rotational, and electronic phenomena, may manifest during a scattering event. The CSs pertaining to these inelastic processes is termed the inelastic cross sections denoted by Q_{inel}.

1.4.4 Ionization (Q_{ion})

Total inelastic CSs is the root cause of the particle losses that occur in the outgoing channel when incident particles are lost. This loss can be rationalized by adding up all of the separate electronic excitations and ionization processes. Each of these mechanisms is being monitored and will be explained in its own right as follows:

$$Q_{inel} = \Sigma Q_{exc} + Q_{ion} \tag{1.8}$$

The subsequent element in equation 1.8 describes all valid ionization phenomena that transition from an excited state to a stable state.

1.4.5 Summed excitation($\sum Q_{exc}$)

From equation 1.8, the initial component ΣQ_{exc} represents the sum of all excitation CSs, encompassing every potential pathway of electronic excitation. These phenomena exemplify the discrete realization of all permissible electron transitions.

1.4.6 Total (Q_T)

The Q_T (total CSs) are obtained through summed of total Q_{el} and Q_{inel} shown in equation 1.9. This highlights the relevance of all possible pathways in the collision process. The Q_T shows the probability that an incident electron will make contact with a target particle. Thus,

$$Q_T = Q_{el} + Q_{inel} \tag{1.9}$$

1.4.7 Rotational (Q_{rot})

In the aforementioned equation 1.9, exclusively delineates the spherical interactions. By employing the spherical potential, the methodology of "Partial Wave Analysis(PWA)" is utilized to address the Schrodinger equation. This methodological approach is particularly effective for atomic systems due to their absence of a permanent dipole moment. Conversely,

in the context of molecular systems, which possess either a permanent dipole moment or a quadrupole moment, it is imperative to consider nonspherical potentials and the corresponding cross sections (CSs). In the scope of our analysis, rotational cross sections become notably significant primarily at lower energy levels, as indicated by Q_{rot}.

1.4.8 Grand total CSs

The overall calculation of CSs is formed from the sum of the total CSs produced by both spherical and non spherical encounters, as outlined by ΣQ_{TOT}[6]. Q_{rot} represents rotational cross sections representing non spherical effects, while Q_T represents the spherical portion.

$$\Sigma Q_{TOT} = Q_T + Q_{rot} \tag{1.10}$$

1.5 Prior work on electron collisions

Several theoretical and experimental methods are used to obtain varieties of CSs. In an experimental study, the financial allocation towards equipment, the reliability of findings, and the time required to obtain the results are measured concern for the scientist. Our examination is made more difficult because of the object reactivity and limited lifespan of the target. Theoretical methods are required to produce the data that cannot be obtained from experiments (such as radicals and compounds that are difficult to arrange in gaseous form, complex molecules, and targets with large molecular sizes).

Investigating electron collisions and determining scattering CSs requires a diverse toolkit of experimental and theoretical methods. However, experimental studies face challenges such as high instrumentation costs, ensuring data reliability, and limitations in the achievable data acquisition rates. Furthermore, certain targets like reactive radicals, molecules difficult to vaporize and complex biomolecules, pose significant experimental hurdles that require theoretical approaches.

1.5.1 Experimental techniques

The major equipment was utilized, for studying electron impact collisions with target, generally consists of the following key components:

- An electron source, commonly referred to as an electron gun, generates high-energy electrons utilizing a selective probe.

- An automated apparatus is employed to produce the target gas and quantify its number density.
- A configuration is established to facilitate the introduction of the target gas and electrons into the collision chamber, wherein the scattering interactions take place.
- A detector assembly is responsible for monitoring the scattered electrons, and measuring the angular distribution alongside the energy dissipation.

A survey of the relevant published material [5,7,8] reveals that there are various distinct kinds of electron collision research, which can be broken down as follows:

- Electron swarm experiments
- Electron beam experiments
- A hybrid approach that combines both methods

Swarm experiments facilitate the measurement of three primary types of cross sections: electron attachment, inelastic, and momentum transfer. These experiments are particularly effective at low impact energies, especially 1 eV or lower, where they have made significant contributions, mainly in the range below a few tens of an eV. Several favourable factors in swarm experiments make these measurements easier to perform compared to beam experiments. However, for higher energy ranges, from 1 eV upwards, beam experiments are more reliable and effective for capturing detailed scattering processes.

1.5.2 Theoretical Studies

In association with a substantial array of experimental entities, there is a vast number of theoretical groups that are engaged in examining the interactions between electrons and both atomic and molecular frameworks.

The “Spherical complex optical potential” known as “SCOP”, utilized in the computations of the CSs in order to account for the challenges that were encountered in the experiments [9]. Several other groups have demonstrated successful utilization of the SCOP [9–12]. There are two useful quasi techniques that can be utilized in the process of computing the electron induced ionization CSs for compounds: (1) “Binary-Encounter-Bethe (BEB)” technique developed by “Kim and Rudd” [13,14] and (2) “Deutsch-Mark (DM) formalism” [15,16]. Both these methods are validated to estimate total ionization CSs of atoms before being applied to the study of neutral molecule compounds.

In the BEB theory, the Bethe CSs and the Mott CSs are merged. This theory displays high incident energy properties. The notion known as BEB is a shortened version of BED, which stands for "binary encounter dipole."

The Mott CSs technique [17] is used to denote the hard impact phenomena that occurs between two "free" electrons, the CSs of Rutherford is used to bring the effects of electron exchange into consideration.

The Bethe CSs formula [18] takes into consideration the dipole interactions that occur in soft impact processes. These interactions include the fast incident electrons. The BED concept uses a straightforward equation for the “Optical Oscillator Strength (OOS)” based on the finding of the H atom & He atom, and the H_2 molecule. This equation is based on the oscillator strength of an optical oscillator. Both the BEB and the BED hypotheses are dependent on a number of variables that were unearthed through either experiments or the investigation of ion wave functions and objectives.

The calculations beginning from both theoretical models typically show an excellent matching with experimental data at incident energy levels ranging from threshold to several keV. In a number of cases, the deviation from experimental results is limited to a maximum of 5 to 15%, and the BED approach performs marginally better than the BEB model. In the BED model was developed by Khare and Coworker [19,20] to describe long range dipole interactions, the Bethe CSs were used.

The DM method for determining atomic ionization CSs was initially developed by Deutsch and Mark [21], and it was later modified and extended on a number of different occasions. According to the DM method, the atomic Q_{ion} is defined as the sum of all the partial Q_{ion} that are associated to the emission of a single electron from a certain atomic subshell [15]. Although, both these methods are successful in determining ionization processes, they have inherent drawbacks.

Joshipura and his colleagues [22] derived the “Complex Scattering Potential ionization contribution (CSP-ic)” methodology to estimate total ionization CSs (TICS) by making use of total inelastic CSs. The improved CSP-ic technique was developed by Vinodkumar and colleagues [23].

1.6 Applications of electron-scattering

The study of electrons collision with other particles has a wide variety of applications in the fields of astrophysics and astrochemistry, plasma science, industry, and biological sciences. Some of these applications are included below:

1.6.1 Astrochemistry

Titan's thick, hazy atmosphere, primarily composed of nitrogen and methane, undergoes a continuous cycle of photochemical reactions initiated by solar ultraviolet radiation, cosmic rays, and Saturn's auroral electrons. These energetic particles collide with atmospheric molecules, breaking them apart and leading to the formation of a diverse range of organic compounds. The resulting complex chemistry gives Titan's atmosphere its distinctive orange-brown color.

The chemical pathway involves the photolytic dissociation of N_2 and CH_4, which is followed by the gas phase formation of nitrile and hydrocarbon monomers. Subsequent polymerization reactions produce larger molecules, eventually leading to the condensation and aggregation of solid organic aerosols. These aerosols, considered the most complex extraterrestrial organic compounds discovered within our solar system, ultimately precipitate onto Titan's surface.

Numerous laboratory investigations have attempted to simulate and analyze this intricate atmospheric chemistry, aiming to replicate and understand the complex organic synthesis occurring in Titan's atmosphere [25].

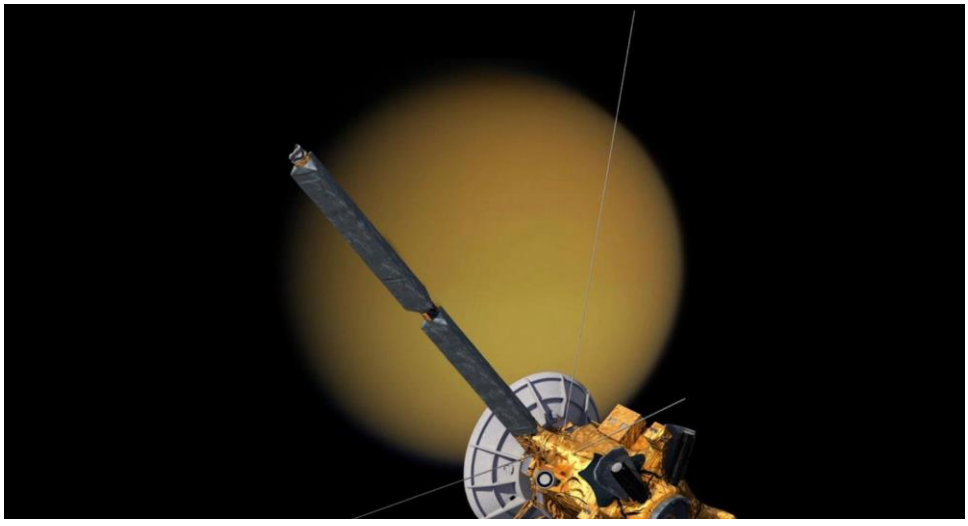

Figure 1.2 Cassini approaching Titan's atmosphere

The plasma apparatus known as PAMPRE was used to investigate the aerosols [25] by analysing the constituents polymers. The research purpose of the PAMPRE is to replicate the composition of the atmosphere of Titan, particularly the chemical reaction that results in the production of aerosols, by simulating the production of lab counterparts of these aerosols. A spectroscopic instrument mounted on the Cassini spacecraft identified that tholins are synthesized within the atmospheric layers of Titan at altitudes exceeding one thousand kilometers. The sensors that are now being used on the Cassini/Huygens mission (NASA/ESA) have uncovered a large number of heavy molecules and ions, in addition to a variety of other novel chemical processes that occurs on Titan's atmosphere [26].

1.6.2 Atmospheric science

In contrast to photon driven processes that occur in the ionosphere, the process of ionization in the atmosphere is said to be driven by high-energy particles that are emitted by the Sun as well as by cosmic radiation. This information comes from the field of atmospheric physics. Based on scientific investigations [27,28], these particulates may contribute to the processes of cloud generation and alterations in climate. Nonetheless, a relationship between the depletion of ozone and the influence of ultraviolet rays is also expected [29].

As a result, it is essential to investigate into the ways in which electrons interact with higher aeronomic elements in the atmosphere, as well as the ways in which they ionize and form total CSs.

The captivating atmospheric phenomena observed across our solar system, from the auroras in the polar skies to the subtle electro glow enveloping the gas giants, share a common thread: electron-induced excitation and fluorescence. These displays, including UV emissions from plasma toroid and icy moons are evidence of electron collisions influencing atmospheric dynamics. These energetic electrons are colliding with atoms and molecules in the upper atmospheres, transfer energy and elevate these particles to excited states. As these excited species transition back to their lower energy levels, they emit photons of light, giving rise to the stunning visual spectacles we observe. This fundamental mechanism of electron-driven excitation and fluorescence underscores the far-reaching impact of these subatomic particles on the atmospheric fabric of our solar system.

Figure 1.3 Electrons induced excitation and fluorescence of auroras

1.6.3 Plasma physics

In any plasma, one of the most significant processes is the ionization of atoms and molecules, which is induced by the impact of electrons. Several applications based on the electron-assisted ionization CSs of substances are listed below.

- Plasmas for use in operations that take place at low temperatures
- Fusion at the plasma edge
- Gas discharges
- The atmosphere of comets, as well as the interplanetary and stellar environments
- Radiation chemistry
- Mass spectrometry research
- Chemical examination

The unusual nature of matter that is known as low-temperature plasmas (LTP) [30] can be broken down into the following components: neutral particles, atoms, radicals, ions, and electrons. Low temperature plasmas (LTP) have normal electron energies that ranging from a few electron volts to 10 eV due to low ionization, but in arc discharges, they can surpass tens of percent. This is because low temperature plasmas have little ionization. These electrons have such a high level of energy that they are able to generate photons, charged substances, excited states, and radicals [30].

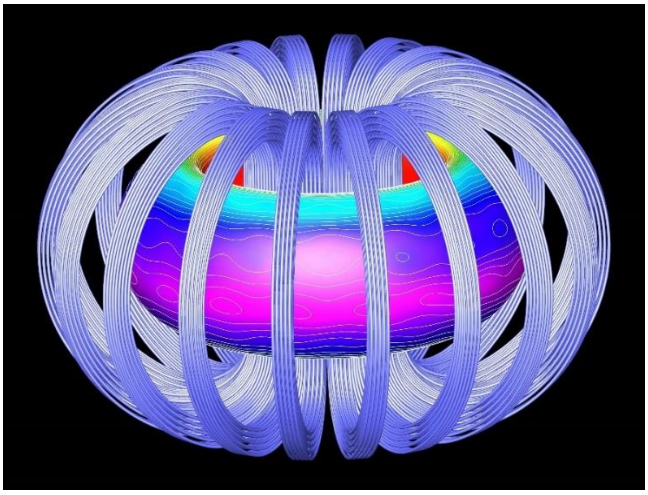

Figure 1.4 Plasma fusion reactor

When the pressure is low, the space charge sheaths of the plasma interface accelerate and produce ions fluxes with different energies that can range from a few eV to hundreds of eV [30]. Ion fluxes facilitate a diverse array of material alterations, encompassing processes includes deposition, etching, sputtering, and activation of materials for application in microelectronic devices and surgical instruments. The microwave, arc, and inductively coupled plasma discharges form the foundation for the industrial uses of plasma [30]. These discharges function almost at the same level of thermodynamic equilibrium as one another. Although the electron temperature (Te) exceeds that of both heavy particles and gaseous components, the predominant number of "low temperature plasmas (LTPs)" exhibit deviations from thermodynamic equilibrium at this particular temperature [31, 32]. LTP emitters make it possible to expose even the most thermally sensitive materials to plasma species that exhibit significant reactivity in a manner that is both efficient and non-destructive.

The comprehensive microelectronics industry, which serves as the technical underpinning of contemporary society, becomes practicable. For instance, through the well-known "plasma surface interaction" that collects and eliminates un-useful materials at nanoscale during the production of microprocessors [33]. Microelectronics is the industry that lays the technical foundation for modern society. Plasma therapy was developed as a result of a favourable interaction between plasma and surfaces [34], which comprised liquids, organic tissues, and wounds in addition to other surfaces. In dusty plasmas containing particles or aerosols, LTPs can interact beneficially with internal plasma interfaces [35].

1.6.4 Radiation biology

The discovery of secondary electrons with energy below 20 eV can disrupt single as well as double strands of DNA. Its study provides deeper insight and in-depth view to the damaging done by harmful radiations to living tissues and cells [36]. As a result, there is an immense amount of interest in the concept of electron scattering with biomolecules. Several experimental and theoretical groups have been attempts to understanding various mechanisms concerning electron induced DNA damage caused by "High energy ionizing radiation(HEIR)" by direct and indirect processes like ionization, electronics excitation , rotational and vibrational excitation [37].

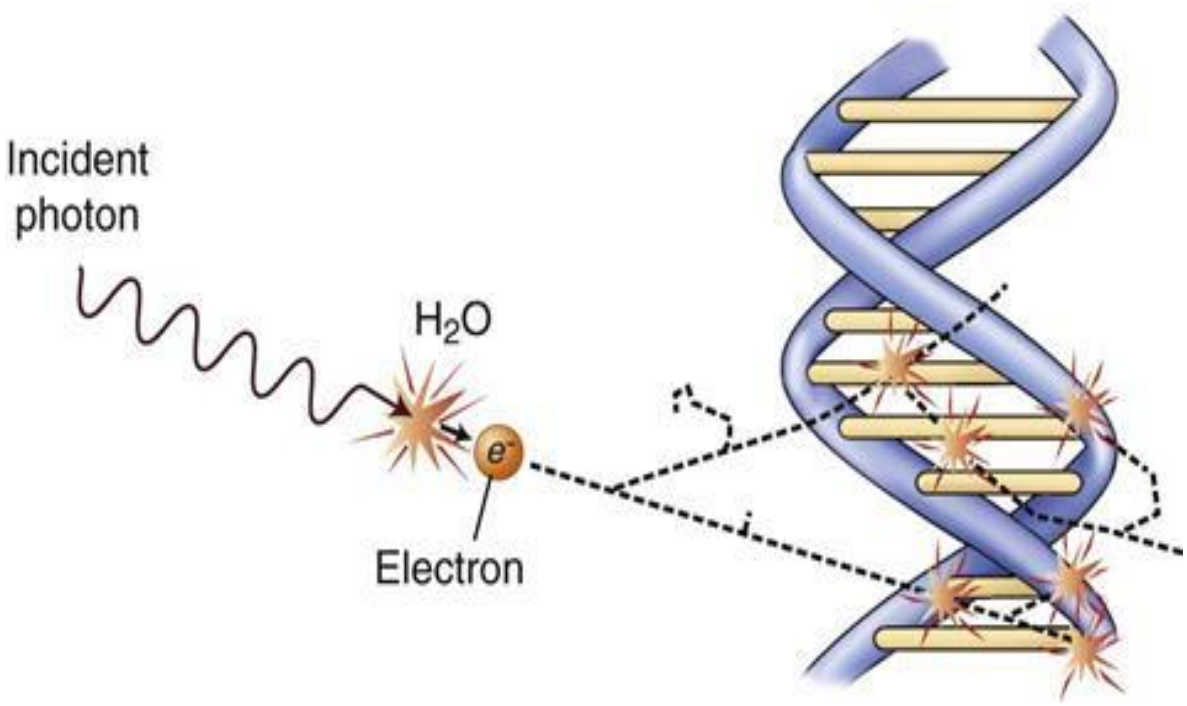

Figure 1.5 Strand break of DNA

Tetrahydrofuran often known as THF, is the most essential configuration of the furanose ring and is responsible for joining the phosphate groups that make up the DNA foundation. Fundamentally, it is the molecular counterpart or analogous structure to the deoxyribose unit, which is considered the most basic building block. In order to simulate such an essential structure, it is possible to use a chain of THF molecules that are connected to phosphate group and DNA strands [38].

Numerous biomolecules incorporate constituents that encompass heterocyclic atoms or elements with analogous chemical properties. The cyclic structure of five-membered

heterocyclic organic compound known as furan, which has the chemical formula C_4H_4O. Furan has the ability to function as a simplified copy of a more complicated molecule that plays a crucial role in the body [39].

1.6.5 Industrial relevance

Electrical discharges are used in a wide-variety of applications, from modifying materials (like in ion implantation and semiconductor etching) to creating thin films and purifying the air. To accurately model and simulate these discharges, total collision cross-sections are particularly important. This is because they provide valuable information about how electrons and ions recombine and how easily charged particles move within the discharge. Total CSs influence electron-ion recombination and reaction velocity, they play an essential part in the comprehension and modelling of the processes that occur during an electrical discharge. The process of applying plasma cutting for nanometric designs in semiconductor fabrication remains a significant challenge. In the manufacturing of semiconductors, various plasma activities produce radicals, atomic and molecular molecules, which are recognized as being a key chemical component. For the purpose of accurately simulating these contemporary plasmas, it is necessary to have access to a vast databank containing both elastic and inelastic CSs for each component of the plasma.

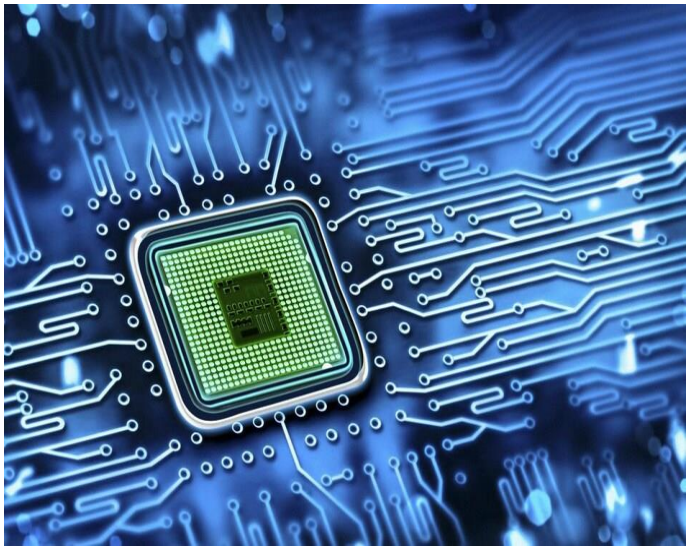

Figure 1.6 Semiconductor manufacturing

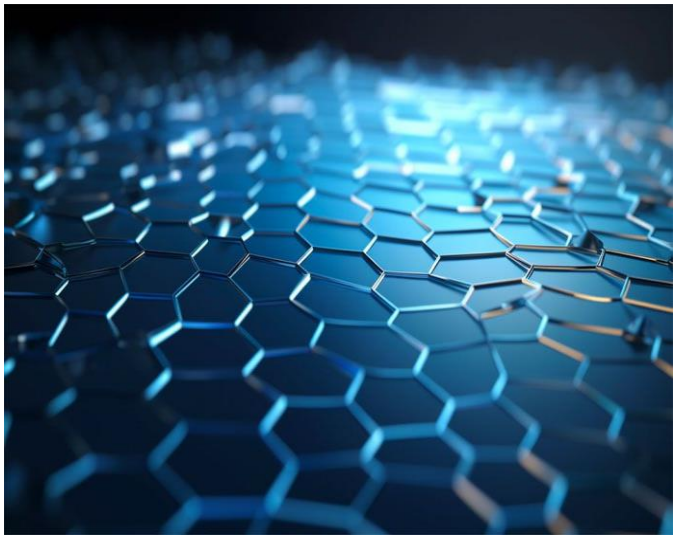

Figure 1.7 Nanofabrication

The investigation of electron -molecule interactions has resulted in the advancement of innovative industrial techniques e.g. nano-fabrication. Techniques driven by low energy electrons exhibit potential for the creation of chemically synthesized nanoparticles on surfaces, which are significant for applications including protein immobilization in biochips and the production of materials shaped like nanoparticles [40]. Chemical lithography relies on the excellent kinetics of chemical reactions made possible by the dissociative electron attachment of a specific bond [41].

1.7 Outline of present study

In this study theoretically estimates the CSs of a variety of atoms and complex molecules with an accuracy. Since there is such a wide range of data requirements in the semiconductor industry and beyond. So, our suggestions are quite relevant to current studies. While more precise theories do exist, they are limited by factors like target size and energy range. The accurate "R-matrix" method, for estimating resonances and calculating CSs, may be useful for small molecules. However, their effective energy range is rather narrow (10 eV). The cross sections of large compounds cannot be accurately calculated using this method.

Inelastic and Elastic CSs are calculated in full using the standard SCOP method. Then, a semi-empirical technique is used to derive the total Q_{ion}. It is possible that there are shortcomings in our formalism for calculating the Q_{ion}. However, the concept of CSP-ic, leads the pack among the many methods currently employed to calculate total Q_{ion} [42] due to its high reliability and

speed. We present our theoretical approaches, computations, findings, and discussions in the following chapter.

1.8 Chapter Summary

We have provided a brief overview of electron assisted molecular processes in this chapter. The chapter also describes, electron is an essential prob in the scattering phenomena. The uses of electron-atom/molecule scattering, including astrochemistry, atmospheric science, plasma physics, Radiation biology and Industrial relevance have also been emphasized. We present our theoretical calculations, findings, and discussions in the following chapter.

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