PREFACE

The theoretical and experimental studies on the interaction of \( \gamma \)-radiation with matter have been receiving great attention since the early days of the development of the subject. The Compton effect is one of the most important processes among the different types of interactions. This is well established in the history of pedagogics of physics as a significant contribution to the development and acceptance of quantum theory. Since the discovery of Compton effect and its explanation, a large amount of work has been done to study the incoherent (Compton) scattering of \( \gamma \)-rays by electrons.

Studies on the K shell differential incoherent scattering cross sections and angular distribution of incoherently scattered photons have not been carried out at small angles and low photon energies where the effects of electron binding shows up prominently due to experimental difficulties. Therefore, to understand the effect of electron binding on total incoherent scattering cross sections, one has to rely on accurate measurements of total atomic cross sections and accurate theoretical/experimental estimates of photoelectric and Rayleigh scattering cross sections.
In the present studies the total atomic cross sections are determined at seven $\gamma$-ray energies in the range of 84 to 661.6-keV for five elements ($Z = 6, 13, 29, 49, 82$) using a new method developed in this laboratory. The new method is the result of systematic investigations undertaken by the author to study the narrow-beam-collimated geometry condition. The percentage resolution of the scintillation spectrometer is studied by interposing carbon, aluminum, copper, tin and lead absorbers of different thicknesses $t$ between the source and the detector at all the $\gamma$-ray energies used in this experiment. For each of these thicknesses $\gamma$-ray attenuation coefficients $\mu$ are measured using the counting sequence of Conner et al (1970). The results show that the percentage resolutions and attenuation coefficients remain fairly constant for values of $\mu t < 1$. This implies that the number of multiple scattered photons reaching the detector is negligible and the narrow-beam-collimated geometry condition is preserved, when the thickness of the sample used satisfies the above criterion. The present investigations indicate that the criterion $\mu t < 1$ would greatly improve the measured $\gamma$-ray attenuation coefficients.

From the measured values of $\mu$, the theoretical sum of Rayleigh scattering and photoelectric cross sections is subtracted to get the total incoherent scattering cross
sections $\sigma_b$. The percentage deviations $(\Delta\%)_{KN}$, $(\Delta\%)_{TF}$ and $(\Delta\%)_{HF}$ of $\sigma_{KN}$, $\sigma_{TF}$ and $\sigma_{HF}$ from $\sigma_b$ values respectively are calculated. Here $\sigma_{KN}$, $\sigma_{TF}$ and $\sigma_{HF}$ are the cross sections calculated on the basis of Klein-Nishina formula, Thomas-Fermi model and Hartree-Fock model respectively. Values of $(\Delta\%)_{KN}$ are found to increase with decrease in energy and increase in $Z$ indicating electron binding effects. The values of $(\Delta\%)_{TF}$ and $(\Delta\%)_{HF}$ are considerable at low $\gamma$-ray energies and high $Z$ elements. These are attributed to inherent limitations in the models.

The thesis embodies the above work and contains six chapters. The content of each chapter is outlined briefly in the following paragraphs.

In Chapter 1, is given a brief historical account of incoherent scattering cross sections and electron binding, a survey of experimental studies and motivation for the present work.

Chapter 2 deals with the summary of the types of interaction of $\gamma$-radiation with matter with special reference to incoherent scattering process.

In Chapter 3, the methods of estimating theoretical photoelectric cross sections $\sigma_{pe}$, Rayleigh scattering cross sections $\sigma_R$, theoretical integral free electron
scattering cross sections $\Sigma_{\text{KN}}$ using Klein-Nishina formula, and theoretical integral bound electron cross sections $\Sigma_{\text{TF}}$ and $\Sigma_{\text{HF}}$ using Thomas-Fermi and Hartree-Fock models respectively are described.

A survey of experimental studies of $\gamma$-ray attenuation coefficients is given in Chapter 4. The geometrical set-up used in the present investigations is described. A brief account of the absorbers, $\gamma$-ray sources and detecting system is given. The calibration of the spectrometer and experimental procedure adopted in the measurement of $\gamma$-ray attenuation coefficients are described. The $\gamma$-ray attenuation coefficient $\mu$ and percentage resolution of the spectrometer determined as a function of sample thickness are presented. From the results the criterion $\mu t < 1$ is established. The $\gamma$-ray attenuation coefficients determined using the sample thickness such that $\mu t = 0.2$ to 0.4 for all the energies and elements under investigation are given and compared with the values of Conner et al (1970). Lastly the errors associated with the measured attenuation coefficients are discussed.

The total incoherent scattering cross sections $\Sigma_b$ extracted from the experimentally determined total atomic cross sections are given in Chapter 5.
In Chapter 6, the $\sigma_b$ values are compared with the values of $\sigma_{KN}$, $\sigma_{TF}$ and $\sigma_{HF}$. The percentage deviations ($\Delta \%$)$_{KN}$, ($\Delta \%$)$_{TF}$ and ($\Delta \%$)$_{HF}$ of $\sigma_{KN}$, $\sigma_{TF}$ and $\sigma_{HF}$ values from $\sigma_b$ value respectively are given. These results are discussed and interpreted in the light of electron binding. Possible conclusions are drawn on the basis of the experimental findings and the systematics of the deviations.