ABSTRACT

This thesis reports on the study of equilibrium and pre-equilibrium emission in some nuclear reactions induced by $\alpha$-particles. The thesis is divided into five chapters.

A brief introduction to the subject of nuclear reactions and its importance in understanding the physics of the nucleus is given in chapter I. The details of nuclear reaction mechanism are still not well understood. There is Bohr's compound nucleus picture on one hand, while many experiments have indicated the presence of direct reaction mechanism on the other. At moderate energies, incident particle may not necessarily coalesce immediately with the target nucleus but instead it is possible that a number of collisions may take place prior to the establishment of thermodynamic equilibrium. There is finite probability that a particle or a nuclei be emitted after each one of these collisions. Particles or nuclei emitted in this way are called pre-equilibrium particles. There is increasing interest to look into nuclear reaction mechanism via pre-equilibrium emission of particles. Since knowledge of excitation functions for reactions of the type $(\alpha, xnynz\alpha)$ is a powerful tool for the study of nuclear reaction mechanism, a programme of measuring excitation functions for $\alpha$-induced reactions in the energy range $\approx 10-40$ MeV is undertaken. Since high spin states are populated in $\alpha$-induced reactions, study of these reactions gives considerable
information about angular momentum effects in nuclear reactions. Besides, these reactions are also important for application in applied sciences. Excitation functions for eighteen α-induced reactions are measured covering a relatively wide mass region from 59 to 197. For some reactions measurements are done for the first time.

Experimental technique and details of measurements are described in chapter II. Experiments are done at the Variable Energy Cyclotron Centre (VECC), Calcutta (India). The stacked foil technique is used in the present measurements. The post-irradiation analysis is carried out using high resolution gamma detection. In general, cross-section for a given reaction is determined from the observed intensities of various γ-rays arising from the same residual nucleus. Final cross-section value is taken as the weighted average of individual cross-sections for the same reaction. These measurements are tabulated at the end of chapter II. The relative intensities of the γ-rays arising from the same residual nucleus are also measured and are compared with the literature data as a check.

Several models have been proposed to account for the microscopic description of nuclear reactions. Weisskopf-Wigner and Hauser-Feshbach models deal with the equilibrium decay, while Intranuclear Cascade Model, Harp-Miller-Berne Model, exciton Model and Hybrid/Geometry Dependent Hybrid models consider the pre-equilibrium emission of particles.
These models are discussed in chapter III.

Two different computer codes, ALICE/LIVERMORE 82 and ACT are used to calculate the excitation functions theoretically. These codes are based on WE/HF models for equilibrium part of calculations, while pre-equilibrium contributions are simulated by the hybrid/ exciton models respectively. Details of these computer codes are given in chapter IV.

Chapter V deals with the analysis of presently measured excitation functions. Measured excitation functions are compared with the literature data, if available and also with those calculated theoretically. Present analysis indicates that the shape and the magnitude of the excitation function depend sensitively on the angular momentum distributions of the compound system and the residual nucleus. Angular momentum effects are also visible in the variation of isomeric cross-section ratio with incident energy. The present study shows a preference for the first chance neutron emission over the charged particles. Pure compound reaction mechanism can not explain the high energy tails of the measured excitation functions and a proper admixture of equilibrium and pre-equilibrium processes is needed to reproduce the experimental excitation functions in full energy range. Choices of six exciton state (5-particles and 1-hole) for the initial
configuration of the compound system and the FM value of 430 MeV^3 are found to favour a projectile independent prescription for two body residual average interaction matrix element. The pre-equilibrium fraction is found to depend on the excitation energy and mass number of the compound system. Excitation energy per nucleon of the compound system appears to be an important parameter governing pre-equilibrium decay.