Preface

The cross sections measurements of the neutron induced reactions are of considerable importance for technological applications such as nuclear reactor technology, dosimetry, medicine and industry. Also, they play a significant role in advance GEN-IV nuclear reactor physics and astrophysics fundamental research. More specifically, the experimental cross section data are necessary when the nuclear models need to be checked and their input parameters be accurately determined. The cross sections of isomeric states provide important supplementary information for the study of the compound nucleus de-excitation mechanism due to the fact that their population directly depends on the spin of the levels from which the isomeric states are fed and on the spin distribution in the continuum. Therefore, it is necessary to obtain new extremely accurate nuclear data covering a wide energy range.

In the present thesis work, the cross sections of the Vanadium, Copper, Rhodium, Selenium and Antimony elements were measured experimentally at different neutron energies, whereas the Titanium and Chromium cross sections were studied theoretically using statistical reaction code. The $(n, 2n)$ and (n, p) reactions cross sections were measured via the activation technique relative to the $^{27}\mathrm{Al}(n, \alpha)^{24}\mathrm{Na}$ reference reaction cross sections taken from the IRDFF-II database. The quasi-monoenergetic neutrons were produced via the $^{7}\mathrm{Li}(p, n)$ reaction, the primary protons beams were delivered by the 14UD MV Pelletron accelerator of the institute BARC-TIFR facility at Mumbai, India. Al monitor foils along with targets were activated to determine the incident neutron flux. After the end of the irradiations the induced activities of the reaction products were measured using a high resolution high purity germanium (HPGe) spectrometry system. In framework of the present work, a covariance analysis methodology was implemented for the determination of the $(n, 2n)$ and (n, p) reactions cross section uncertainties at different neutron energies. The covariance data are required to correctly assess uncertainties in design parameters in nuclear data applications of Vanadium, Antimony and Selenium isotopes. The correction factors due to the low energy neutron contribution, the self-attenuation of the γ-ray and correction factor due to geometry are considered in the measurements of the cross sections.

Statistical model calculations were performed using the reaction codes TALYS (ver. 1.9) and EMPIRE (ver. 3.2.3) from the reaction threshold to the neutron energy of 25 MeV.

Additionally, the effects of various combinations of the theoretical nuclear level densities (NLDs), optical model potentials (OMPs), preequilibrium models (PEs), and γ-ray strength functions (γ-SFs) were considered for the reproduction of experimental data. The input parameters needed in theoretical calculations to reproduce the present and previous measurements were taken from the RIPL-3.0 database. The present experimental results are compared with the previous measurements taken from the EXFOR database, evaluations of the ENDF/B-VIII.0, JEFF-3.3, JENDL-4.0/HE, CENDL-3.2, TENDL-2019, and FENDL-3.2 libraries, and with the theoretically calculated values based on TALYS and EMPIRE codes. Furthermore, the cross sections of the (n,p) and $(n,2n)$ reactions were estimated within the neutron energies of 14–15 MeV using different systematic formulas. These estimated cross sections by various systematic formulas were compared with the available experimental data.

Thus, the purpose of the present thesis is the experimental and theoretical study of the cross sections of the ^{48}Ti$(n,p)^{48}$Sc, ^{51}V$(n,p)^{51}$Ti, ^{52}Cr$(n,p)^{52}$V, ^{65}Cu$(n,p)^{65}$Ni, ^{76}Se$(n,p)^{76}$As, ^{77}Se$(n,p)^{77}$As, ^{78}Se$(n,p)^{78}$As, ^{80}Se$(n,p)^{80}$As, ^{103}Rh$(n,2n)^{102}$Rh, ^{121}Sb$(n,2n)^{120}$Sb and ^{123}Sb$(n,2n)^{122}$Sb reactions, as well as the independent experimental and theoretical cross section determination for the ground and isomeric states of the ^{103}Rh$(n,2n)^{102}$Rh^{m,g}, ^{121}Sb$(n,2n)^{120}$Sb^{m,g} and ^{123}Sb$(n,2n)^{122}$Sb^{m,g} reactions. Although the experimental results of present work are measured at energies where no previous data were available in the literature database. It was found that, the measurement of the present work follows the trend of the literature and evaluated data. Statistical model calculations with default and adjustment of the models combination reproduces the shape of the excitation function. Theoretical calculation using input parameters adjustments sets the limit for the level density parameters used in the present work. The present data will help to understand the nuclear reaction theory (models) in higher energy regions and improve the evaluated nuclear data evaluation that is needed for fundamental nuclear applications.

The entire thesis is divided into seven chapters as follows:

Chapter 1: Introduction

Chapter 2: Experimental Details

Chapter 3: Data Analysis

Chapter 4: Theoretical Details and Estimations