Table of Contents

Acknowledgement *I*

List of Tables *VIII*

List of Figures *XIII*

List of Abbreviations *XIX*

Preface *XX*

1. Introduction----------1

1.1 Overview----------1

1.2 Nuclear database----------5

1.2.1 Experimental Nuclear Reaction Data (EXFOR)----------5

1.2.2 Evaluated Nuclear Data File (ENDF)----------6

1.2.3 Reference Input Parameter Library (RIPL-3) ----------7

1.2.4 National Nuclear Data Center (NuDat. 2.8) ----------8

1.3 Literature survey and uncertainties in the nuclear data----------9

1.3.1 Vanadium and Copper----------9

1.3.2 Selenium----------10

1.3.3 Antimony and Rhodium----------11

1.3.4 Chromium and Titanium----------13

1.4 Motivation and objective----------15

1.5 Outline of the thesis----------15

Bibliography

2. Experimental Details----------19

2.1 Neutron Facility (14 UD Pelletron-Linac accelerator at BARC-TIFR) -----19

2.2 Neutron Source----------20

2.3 Target details----------22

2.4 Neutron irradiations set-up----------24

2.5 HPGe detector set-up----------25

2.6 Off-line γ-ray spectrometry method----------29

Bibliography

3. Data analysis----------32

3.1 Neutron energy calculation----------32

3.2 Efficiency and energy calibration of the HPGe detector----------34

3.2.1 Energy calibration of the HPGe detector----------34

3.2.2 Efficiency calibration of the HPGe detector----------36

3.3 Offline γ-ray activity measurements----------38

3.4 Measurements of the neutron activation cross sections----------43

3.4.1 Reference cross sections----------45

3.4.2 Estimation of the correction factors----------46

3.5 Uncertainties in the cross section's measurements----------48

3.5.1 Covariance analysis----------49

3.6 Neutron induced $(n, 2n)$ and (n, p) reactions cross section using the systematic formulae----------60

Bibliography

4. Theoretical Details and Estimations----------65

4.1. Introduction----------65

4.2. Types of nuclear reaction mechanisms----------65

4.2.1 Compound nucleus reactions----------66

4.2.2 Pre-equilibrium reactions----------68

4.2.3 Direct reactions----------68

4.3. Theoretical Models for Nuclear Reactions----------69

4.3.1 The Hauser Feshbach theory----------70

4.3.2 The optical potential models----------71

4.3.3 The pre-equilibrium models----------71

4.3.4 The γ-ray strength functions----------73

4.3.5 Nuclear Level Density (NLD) Models----------73

4.3.5.1 The phenomenological level density models----------74

4.3.5.2 Microscopic level densities----------77

4.4. Nuclear reaction simulation codes----------78

4.4.1. TALYS (ver. 1.9) code----------78

4.4.2. EMPIRE (ver. 3.2.3) code----------80

Bibliography

5. Neutron induced $(n,2n)$ reaction cross section for ^{103}Rh, ^{121}Sb and ^{123}Sb isotopes----------86

5.1 Introduction----------86

5.2 Theoretical calculations using the EMPIRE and TALYS codes for the Antimony (Sb) and Rhodium (Rh)----------88

5.3 Results and discussion of Antimony (Sb) and Rhodium (Rh)--------91

5.3.1 Antimony (Sb)----------92

5.3.1.1 $^{121}Sb(n,2n)^{120}Sb^{m}$, $^{121}Sb(n,2n)^{120}Sb^{g}$ and $^{121}Sb(n,2n)^{120}Sb$ reactions----------92

5.3.1.2 $^{123}Sb(n,2n)^{122}Sb^{m}$, $^{123}Sb(n,2n)^{122}Sb^{g}$ and $^{123}Sb(n,2n)^{122}Sb$ reactions----------96

5.3.1.3 Isomeric cross section ratio----------101

5.3.2 Rhodium (Rh)----------102

5.3.2.1 $^{103}Rh(n,2n)^{102}Rh^{m}$, $^{103}Rh(n,2n)^{102}Rh^{g}$ and $^{103}Rh(n,2n)^{102}Rh$ reactions----------103

5.3.2.2 Isomeric cross section ratio----------107

5.4 Cross section semi-empirical formulae and results of systematic formulae----------108

5.5 Summary and conclusions----------109

Bibliography

6. Neutron induced (n,p) reaction cross section for ^{76}Se, ^{77}Se, ^{78}Se, ^{80}Se, ^{48}Ti, ^{51}V, ^{52}Cr, and ^{65}Cu isotopes----------114

6.1 Introduction----------114

6.2 Theoretical calculations using the EMPIRE and TALYS codes for the ^{48}Ti, ^{51}V, ^{52}Cr, ^{65}Cu and Se----------117

6.2.1 Calculation of (n,p) reaction cross section using TALYS code----------117

6.2.2 Calculation of (n,p) reaction cross section using EMPIRE code----------120

6.3 Results and discussion of Se, Cu, V, Ti and Cr Elements----------121

6.3.1 Selenium (Se)----------122

6.3.1.1 The $^{78}Se(n,p)^{78}As$ excitation function----------122

6.3.1.2 The $^{78}Se(n,p)^{78}As$ excitation function----------123

6.3.1.3 The $^{78}Se(n,p)^{78}As$ excitation function----------125

6.3.1.4 The $^{78}Se(n,p)^{78}As$ excitation function----------126

6.3.2 The $^{65}Cu(n,p)^{65}Ni$ excitation function----------128

6.3.2.1 Comparison of experimental and evaluation data----130

6.3.2.2 Comparison of the experimental data with the theoretical values based on the TALYS and EMPIRE codes using default and adjusted parameters----------131

6.3.3 The $^{52}Cr(n,p)^{52}V$ excitation function----------138

6.3.4 The $^{51}V(n,p)^{51}Ti$ excitation function----------141

6.3.5 The $^{48}Ti(n,p)^{48}Sc$ excitation function----------151

6.4 Cross section semi-empirical formulae and results of systematic formulae----------154

6.5 Summary and conclusions----------158

Bibliography

7. Summary, conclusions and future work----------165

7.1 Summary and conclusions----------165

7.2 Future work----------169

A. Appendix----------171

B. List of Publications----------182