A comprehensive spectral study of multiply ionized indium atoms (In III-VI) have been presented in this thesis. The analysis of these four ion of indium is based on the indium spectra which were recorded on a number of spectrographs; a 3-m normal-incidence vacuum spectrograph at St. Francis Xavier University, Antigonish, Canada with triggered spark source and 10.7-m grazing and normal incidence spectrographs at the National Institute of Standards and Technology (NIST), Washington D.C, USA with triggered spark and sliding spark sources, 3-m grazing incidence spectrograph at Institute of Spectroscopy, Troitsk, Moscow and 1.5-m Wadsworth grating spectrograph at Aligarh Muslim University, India with an open spark source covering different wavelength region of investigation. Additional spectral wavelength data was supplemented from K. S. Bhatia's thesis (available online) which covers the wavelength range from 400-9000 Å. Therefore, spectral wavelength region from 190-9000Å was made available for the present study.

The atomic structure calculations of these ions were performed by the Hartree–Fock method with relativistic corrections (HFR) with the use of the RCN-RCN2-RCG chain of the Cowan code programs. The extensive calculations for each indium ion (In III-VI) were made individually with the Cowan's code package using a set of interacting configurations. The Cowan program includes a routine for least-squares fits (LSF) of the Slater integrals ($E_{av}$, $F^k$, $G^k$, $\zeta$ and $R^k$) to improve the agreement between calculated and experimentally determined energy levels. A summary of the work carried out in each indium spectra (In III-VI) is briefly described here.

The third spectrum of indium (In III) or (In$_{2+}$) is Ag I isoelectronic sequence with electronic distribution [Kr] 4d$^{10}$5s and 2S$_{1/2}$ as ground level. The calculations were performed using Cowan’s codes with superposition of configurations including 4d$^{10}$ns (n=5-12), 4d$^{10}$nd (n=5-9), 4d$^{10}$ng (n=5-9), 4d$^9$(5s$^2$+5p$^2$), 4d$^9$s(5d+6s) configurations for even parity system and 4d$^{10}$np (n=5-9), 4d$^{10}$nf (n=4-7), 4d$^{10}$nh (n=6-9), 4d$^9$5snp (n=5-11), 4d$^9$5snf (n=4-12), 4d$^8$s$^2$5p for odd parity matrix. There are total of 51 configurations included in our calculations.
The earlier reported levels of one electron type configurations $4d^{10}n\ell$ ($n\ell = 5p-8p$, 6s-12s, 5d-9d, 4f-6f, 5g-7g) have been confirmed with minor improvements in their level values, while the partially known levels of three electron configurations like $4d^95s5p$ and $4d^95p^2$ have been revised and extended with 3 new level values of $4d^95s5p$ and four new level values of $4d^95p^2$ configurations. Moreover, all 23 levels of $4d^95s5p$ configuration and 20 levels of $4d^95p^2$ are now known experimentally. The study of $4d^95s5p$ and $4d^95p^2$ configurations together complemented each other. The transition from these configurations cover the vast wavelength region from 490 Å to 6520 Å. A total of 91 levels from both parities in In III have now been established, 23 of them being new. A total of 247 lines have been identified out of which seventy two are new.

The fourth spectrum of indium (In IV) or In$^{3+}$ is a member of the palladium isoelectronic sequence. It has the ground configuration $4p^64d^{10}$ with $^1S_0$ as the ground level. We have studied the excited configurations $4p^64d^9n\ell$ ($5s-8s$, 5p-7p, 5d-6d, 4f-6f), $4p^64d^85s^2$ and $4p^64d^85s5p$. In the process, we confirmed all the reported levels of $4d^9(5s+6s+7s+5p+5d)$, $4d^85s^2$ and only J=1 levels of $4d^9(6p+7p+4f+5f+6f)$ configurations connecting to the ground $^1S_0$ level. We revised four levels with J=1 of $4d^85s^2$, $4d^97s$, $4d^96f$ and $4d^97p$ configurations and also added 30 new levels belonging to $4d^95d$, $4d^96p$, $4d^75f$ configurations. Seven levels of $4d^96d$ configuration were reported earlier without any designation. However, we confirmed only one level with our present data and the remaining six levels did not give satisfactory transitions and were therefore, revised. All the 18 levels of $4d^96d$ configuration have now been established. Total 52 new levels have been established. Ryabtsev et al. confirmed our findings and extended a few more configurations like $4d^98s$ and $4d^85s5p$. They reported 56 levels of $4d^85s5p$ and $4d^98s$ configurations. A total of 180 levels in In IV have now been established. Five hundred sixty eight lines have been identified out of which one hundred twenty four are new. All these identified transitions covers the wavelength region from 260 Å to 4445 Å. The Ionization Potential of In IV is found to be $450921.7 \pm 86.0$ cm$^{-1}$ ($55.9072 \pm 0.0107$ eV) by Ritz extrapolation using three member series of $4d^9ns^3D$. This value is $3722$ cm$^{-1}$ higher than the earlier reported value.
The spectrum of four-time ionized indium (In V) is a member of the Rh I isoelectronic sequence. It has the ground configuration $4p^64d^9$ with $^2D_{5/2}$ being the ground most level. Total of 21 configurations $4p^64d^9$, $4p^54d^{10}$, $4p^64d^8n\ell$ ($n\ell=5s-7s$, $5p-7p$, $5d-7d$, $4f-7f$), $4p^64d^7n\ell^2(n\ell=s^2,p^2)$ and $4p^64d^75s(5p+4f)$, $4p^64d^75p(4f+6p)$ belonging to even and odd parity system were included in HF calculations which were not considered all together in earlier works. The earlier reported wavenumbers of transition $4p^64d^95p \rightarrow 4p^64d^9(5d+6s)$ were inconsistent with the corresponding reported wavelengths. We removed this inconsistency in wavelength with our new and accurate measurements. The earlier reported levels of $4p^64d^8(5s+5p+6p+5d+4f)$ configurations have been confirmed with minor improvement and established 18 new energy levels of $4p^64d^8(5f+7p)$ and added 28 new energy levels in the $4p^64d^8(5d+6s)$ configurations. The analysis of In V covers the wavelength region from 200 Å to 1580 Å. A total of 232 energy levels have now been established in In V, based on the identification of 873 spectral lines. In the process we establish, 46 new energy levels and classify 193 new spectral lines.

The sixth spectrum of indium (In VI), is isoelectronic with Ru I. However, the ground state configuration of Ru I ($4d^75s$) is different from that of In VI ($4p^64d^8$). The ground configuration $4d^8$ comprises of nine energy levels. For the analysis of this spectrum, we included all possibly interacting configurations from both parities $4d^8$, $4p^54d^9$, $4d^7n\ell$ ($n\ell\rightarrow5s$, $6s$, $5p$, $6p$, $5d$, $6d$, $4f$, $5f$), $4d^6n\ell^2(n\ell^2\rightarrow5s^2$, $5p^2$) for our C.I. calculations. All these configurations have open d-shell involving singlet, triplet and quintet terms making energy level structure very complex. The transitions to the ground states fall in very short wavelength region. Particularly for this ion, the lower wavelength data was mostly recorded at 10.7-m grazing incidence spectrograph at National Institute of Standards and Technology (NIST), Gaithersburg, USA. The spectra on our plates show very nice ionization separation of In VI lines. The reported levels of $4p^64d^8$, $4p^64d^75p$, and $4p^74d^85s$ configuration have been confirmed with full satisfaction. We have added 80 new energy levels in the $4p^64d^8$-$4p^64d^7(4f+6p)$ transition array. In VI covers wavelength region from 195 Å to 1510Å. Transitions between excited configurations $4p^64d^75s$-$4p^64d^75p$ fall relatively in higher wavelength region, helped to improve level values during optimization. A total of 238 energy
levels have now been established in In VI. The total numbers of identified lines in In VI are 1063 out of which 206 are new.

The observed energy levels in each spectrum were optimized with a least squares level optimization method using LOPT program within a level of one standard deviation and the corresponding Ritz wavelengths with uncertainties were generated.

With final optimized energy parameters (Slater parameters), we re-calculated the energy levels, wavelengths, transition probabilities, oscillator strengths and cancellation factor. These parameters can well be used for the study of next higher member of the isoelectronic sequence. In summary, **741 energy levels** have been established based on **2756 identified lines** in which 201 levels and 595 lines are new in the analyses of In III-VI. Our spectral data is very rich that contains around **8000 spectral lines** belonging to various ionization stages of indium. Only about 35% of lines have been indentified in this work. Therefore, fair possibilities of future studies on the higher ions of indium as well as many higher configurations of lower ions exist.

In the appendix, we reproduced a few sample spectra used in the present analysis.