6.1 Overall Conclusions

In this study, thermodynamic properties of Bi-In-Sn system were investigated employing two techniques i. e. EMF measurements and calorimetric techniques. EMF measurement was carried out using molten salt electrolyte along three of the section (x_{Sn}/x_{Bi} is 0.5, 1 and 2) with varying the composition of indium in the temperature range of 723-855K. Partial properties of the above system was calculated from the activities determined at various temperatures. Integral properties were calculated by using Darken's treatment of the ternary systems. Mixing enthalpies of the above system and boundary binary systems were also carried out using drop calorimetric technique. Seta ram MHTC96 line evo drop calorimeter was used for the determination of mixing enthalpy. The NIST standard sapphire was used as the calibration material. CALISTO data acquisition software were used for the data acquisition and processing.

The following results were obtained from the EMF measurement of Bi-In-Sn system in Chapter 3.

- The activity of Indium shows negative deviations from ideality in the whole concentration range.
- Combining the binary data for In-Bi, In-Sn and Bi-Sn, alloys with the ternary data in this study, iso-activity curves in whole composition range of ternary system are obtained.
- By extracting data from G^{XS} vs composition curves, isomolar excess Gibbs free curve has been obtained. The excess molar free energy curves are oriented towards In-Bi binary side.
- Excess molar Gibbs free energy obtained by Darken's equations is compared with data obtained by R-K-Muggianu model calculations for the one of the ternary sections i.e. $x_{Bi/XSn}$ = 0.5 at 813 K. The

experimental values are in good agreement with the values obtained from Gibbs energy model calculations.

It was essential to carry out the measurements of enthalpy mixing for the binary alloys for the calculation of the ternary thermodynamic properties. Therefore, measurements of mixing enthalpy for the binary systems: Bi-In, Bi-Sn and In-Sn were taken up using the drop calorimetric technique in the same temperature range as it is done for the ternary Bi-In-Sn system. Following results were obtained from the chapter 4:

- The integral enthalpy of mixing of the binary Bi-Sn, Bi-In and In-Sn system were measured over the entire composition range by drop solution calorimetry at 767, 813 and 855 K.
- The enthalpy of mixing of Bi-Sn system has been found to be endothermic in nature while that of Bi-In and In-Sn show exothermic in nature. The maxima in the enthalpy curves were found at x_{Sn}~0.56 at 767,813 and 855 K for Bi-Sn system. But for Bi-In system minima in the enthalpy curves were found in the range of compositions x_{In}~ 0.40-0.50.
- A slight temperature dependency of enthalpies of mixing has been observed in boundry binary Bi-Sn, Bi-In and In-Sn system.
- The enthalpy of mixing values obtained experimentally have been used to determine the binary interaction parameters in Bi-Sn, Bi-In and In-Sn system at 767, 813 and 855 K by Redlich – Kister polynomial and the same is presented in this thesis.

Later in chapter 5 Drop calorimeter (MHTC-96) has been used to measured mixing enthalpy of In-Sn-Bi system. Because determination of enthalpy of mixing by

calorimetric technique is much more reliable than any other techniques. The following major conclusions are obtained from the calorimetric studied:

- The measurements were carried out for three different cross sections at three different Temperature 767, 813 and 855 K. all measured mixing enthalpy shows exothermic nature.
- Enthalpies of mixing have been observed to be almost temperature independent for the cross sections $(Sn_{0.33}Bi_{0.67})_{1-x}$ In_x, $(Sn_{0.50}Bi_{0.50})_{1-x}In_x$ and $(Sn_{0.67}Bi_{0.33})_{1-x}In_x$ in the temperature range of 767-855K.
- The comparison of the experimental data with the literature has been attempted by the authors. That is in line with poor experimental data for the given error limit.
- Iso-enthalpy curves at 813 K shows that all the curves are oriented towards the Bi-In binary system due to more negative enthalpies of mixing values of Bi-In binary system.
- Experimental data sets were treated by Redlich – Kister – Muggianu polynomial and the ternary interaction parameter were obtained by least square fitting.