The infrared and Raman spectra (3200 to 50 cm$^{-1}$) of the gas, liquid or solution, and solid have been recorded of isocyanocyclopentane, $c$-$C_5H_9NC$. FT-microwave studies have also been carried out and 23 transitions were recorded for the envelope-axial (Ax) conformer. Variable temperature (-55 to -100$^\circ$C) studies of the infrared spectra (3200 to 400 cm$^{-1}$) dissolved in liquid xenon have been carried out. From these data, both the Ax and envelope-equatorial (Eq) conformers have been identified and their relative stabilities obtained. The enthalpy difference has been determined to be 102 ±10 cm$^{-1}$ (1.21 ±0.03kJ mol$^{-1}$) with the Ax conformer the more stable form. The percentage of the Eq conformer is estimated to be 38 ±1% at ambient temperature. The conformational stabilities have been predicted from ab initio calculations by utilizing several different basis sets up to aug-cc-pVTZ from both MP2(full) and density functional theory calculations by the B3LYP method. Vibrational assignments have been made for the observed bands for both conformers with initial predictions by MP2(full)/6-31G(d) ab initio calculations to obtain harmonic force constants, wavenumbers, infrared intensities, Raman activities and depolarization ratios for both conformers. The heavy atom distances (Å): C≡N = 1.176; C-N= 1.432; C-C$_\beta$, C$_\gamma$= 1.534; C$_\beta$-C$_\gamma$, C$_\gamma$= 1.542; C$_\gamma$-C$_\gamma$= 1.554 and angles (°): ∠C-N= 177.8; ∠C$_\beta$C-N= 110.4; ∠C$_\beta$CC$_\beta$= 102.9; ∠CC$_\beta$C$_\gamma$= 103.6; ∠C$_\beta$C$_\gamma$C$_\gamma$= 105.9. The results are discussed and compared to the corresponding properties of some related molecules.