drupole has virtually 100% transmission. Even more important is the efficiency of the CID process which occurs in the center quadrupole. In an earlier investigation of the low-energy CID process in a triple quadrupole system (*2*), three expressions were developed to describe the efficiency. The collection efficiency is the ratio of the ion flux at the exit of the quadrupole to that at the entrance. With no collision gas present, there is 100% collection. At 2×10^{-4} torr collision gas pressure, the collection efficiency ranges from 50% for light ions like $CH_4^{+\cdot}$ up to 75% for heavier ions which are less prone to scatter. The strong focusing of the quadrupole field minimizes scattering losses. The fragmentation efficiency is the fraction of the ion flux at the exit of the center quad that is due to fragment ions. At 2×10^{-4} torr, fragmentation efficiency ranges from 15% to 65% for various compounds (*2*). As the collision gas pressure is increased, the fragmentation efficiency for all compounds approaches 100% due to multiple collisions, but the collection efficiency decreases due to scattering. The overall CID efficiency, which is the product of the collection and fragmentation efficiencies, exhibits a maximum at some intermediate pressure. The collection efficiency as a function of collision gas pressure for the dissociation of $CH_4^{+\cdot}$ from methane is shown in Figure 6. The fragmentation efficiences for the production of the CH_3^+ and $CH_2^{+\cdot}$ ions are also shown.

Several factors other than collision gas pressure can affect the efficiency of the CID process (*2*). The larger the molecular diameter of the collision gas, the more efficient the CID. Ion axial energy and ion internal energy also affect the CID process. A more detailed study of these effects is in progress (*11*).

Sensitivity. The overall sensitivity of the instrument can be estimated from the product of the efficiencies of the individual processes. The source efficiency and the transmission through the three quads (without collision) are 2×10^{-5} and 10^{-2} respectively. The fragmentation efficiency is a function of the ion and fragment selected, but from Figure 6 it is seen to be about 0.1 for $CH_4^{+\cdot} \rightarrow CH_3^+$. The overall efficiency is 2×10^{-8}, that is, two CH_3^+ ions reach the detector per 10^8 CH_4 molecules passing through the source. The detection system can measure the current due to one ion per sec which is an average current of 5×10^{-13} A. For methane, then, a current of 4×10^{-10} A will be produced from a sample flux of 1 pg per sec.

The ultimate detection limit depends on the system sensitivity, the