5.1: Vacuum System

All mass spectrometers operate at very low pressure (high vacuum). This reduces the chance of ions colliding with other molecules in the mass analyzer. Any collision can cause the ions to react, neutralize, scatter, or fragment. All these processes will interfere with the mass spectrum. To minimize collisions, experiments are conducted under high vacuum conditions, typically 10^{-2} to 10^{-5} Pa (10^{-4} to 10^{-7} torr) depending up on the geometry of the instrument. This high vacuum requires two pumping stages. The first stage is a mechanical pump that provides rough vacuum down to 0.1 Pa (10^{-3} torr). The second stage uses diffusion pumps or turbomolecular pump s to provide high vacuum. ICR instruments have even higher vacuum requirements and often include a cryogenic pump for a third pumping stage.

The pumping system is an important part of any mass spectrometer and the control software will allow the user to turn the pumps off and on and monitor the pressure in different parts of the spectrometer. The pumpdown sequence for turning on a spectrometer starts by operating the roughing pumps to establish the initial vacuum and check for major leaks. After the roughing pumps get the system down to a pressure of approximately 0.1 Pa the high vacuum pumps are turned on to establish operating pressure. This sequence is more important with diffusion pumps for the high vacuum system because they do not tolerate atmospheric pressure.

The vacuum system will also include different types of gauges for measuring pressure in different parts of the system. Thermocouple or convectron gauges are used with the roughing pumps to measure pressure down to 0.01 Pa. Ion gauges are used to measure high vacuum down to 10-8 Pa but they cannot be used above 0.1 Pa. To protect the ion gauges and other high voltage electronics the instrument will typically include an interlock system that does not allow power to these components until the roughing pumps have reduced the pressure below a certain threshold. If there is a leak or loss of vacuum the interlock will also turn off power to these systems to protect the components. The thermocouple gauges are normally located at the entrance to any mechanical pumps and ion gauges are normally located in the source and analyzer regions. Depending on the ionization method additional pressure gauges may also be used to monitor the ionization system or any collision regions.