

Here we introduce the commonly referenced variables which will be discussed in further detail.

## 1 Variables in IMS

The variables which will be introduced can be grouped into three distinct categories: instrument-state, mass, and measured quantities.

### 1.1 Instrument-State Variables: $(L, V, E)$ and $(N, T, P)$

$L$  is the length of the drift space and  $V$  is the voltage drop across the drift space. The electric field for a traditional linear drift tube is constant and equivalent to  $E = \frac{V}{L}$ .  $N$  is the number density of the drift gas. If the drift gas is considered ideal then  $N = N_0 \cdot \frac{P \cdot T_0}{P_0 \cdot T}$ , where  $T_0 = 273.15$  K,  $P_0 = 760$  torr, and  $N_0 = 2.687 \cdot 10^{19} \text{cm}^3$  (the number density of an ideal gas at STP).

### 1.2 Mass Parameters: $(m, M, q = Ze)$

$m$  and  $M$  correspond to the ion and drift gas masses respectively and  $q$  corresponds to the charge of the ion.

### 1.3 Measured Quantities: $(t_d, v_d)$

$t_d$  is the drift time required for an ion swarm to traverse the length of the drift space  $L$ . This terminal velocity is called the drift velocity ( $v_d$ ). The drift velocity of a given ion population is equivalent to  $v_d = \frac{L}{t_d}$  where the length is often predetermined and the drift time is measured.

## 2 Ion Mobility ( $K$ )

The mobility ( $K$ ) of an ion swarm is important and related to the drift velocity of an ion where  $K = \frac{v_d}{E}$ . The central observation is that if an electric field ( $E$ ) is applied to ions dispersed in gas, the ions move with a characteristic average terminal velocity ( $v_d$ ) in the direction of the field. The mobility  $K$  is defined as the ratio of the velocity to the field strength and is traditionally reported in units of  $\text{cm}^2\text{V}^{-1}\text{sec}^{-1}$ .

## 3 Five Underlying Assumptions of IMS

1.  $n \ll N$ : Ions have a much lower number density than neutrals (additionally, mutual coulombic repulsion of ions is unimportant, ion-ion collisions unimportant, and each neutral encounters 0 or 1 ion during a mobility experiment).
2. Collisions are instantaneous.
3. Three-body collisions are rare.

4. Ions reach a terminal velocity defined by  $v_d = KE$  (vacuum and "low" pressures excluded from consideration).
5. Ion-neutral reactions and clustering may be ignored (in real experiments clustering is common).