incidence. To simplify our discussion we will model collision cross sections as though they were constant.

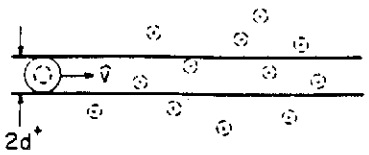
This is a reasonably good approximation for collisions between molecular gas particles. It treats the particles as though they are hard spheres of radius r^+.[9] Hard spheres collide when their centers approach one another to the distance $d^+ = 2r^+$. Thus the effective cross section for collisions between like and unlike hard spheres is

$$\sigma^+ = \pi(d^+)^2 \qquad\qquad \sigma^+_{12} = \pi\left(\frac{d^+_1 + d^+_2}{2}\right)^2$$

Values for the hard sphere diameter and collision cross section of a number of atoms and molecules are listed in Table IIIE-2 at the end of this unit. The frequency with which collisions occur and the average distance between them can be approximated by studying the motion of a fictitious "collision" particle whose radius equals the molecular diameter.

Example 5. Determine the frequency with which a particle of radius d^+ moving at the mean particle speed $\hat{V}$ would encounter stationary point particles of number density n_v. What would be the average (or mean free) time and average distance (or mean free length) between these encounters?

The model process for this determination is shown at right. The moving particle encounters the stationary point particles at a frequency equal to the number of points per unit time within the cylinder through which it passes.



$$\nu_c = \sigma^+ \hat{V} n_v$$

[9]The hard sphere radius can be defined as the minimum in the pair interaction potential, see Unit ICS.

Ans. 8. The rms speed is defined in terms of the average energy. Thus,

$$V_{rms} = \left(\frac{2\hat{\varepsilon}_{el}}{m^*_e}\right)^{\frac{1}{2}} = \left[\frac{2\cdot(3/5)\varepsilon^\circ_F}{m^*_e}\right]^{\frac{1}{2}} = \left[\frac{2\cdot(3/5)m^*_{el}V^2_F}{m^{*2}_e}\right]^{\frac{1}{2}} = \left(\frac{3}{5}\right)^{\frac{1}{2}} V_F$$

Ans. 9.

$$\hat{V}_{el} = \int_0^\infty V\,\rho_{el}(V)dV = \frac{3}{V^3_F}\int_0^{V_F} V\,V^2\,dV = \frac{3}{4}V_F$$

Ans. 10. From its definition, with $\varepsilon^\circ_F = k\theta_F$

$$V_F = \left(\frac{2k\theta_F}{m^*_e}\right)^{\frac{1}{2}} = \left[\frac{2\cdot 1.380\cdot 10^{-23}\text{J/(elect K)}\cdot 8.44\cdot 10^4\text{K}}{9.109\cdot 10^{-31}\text{kg/elect}}\right]^{\frac{1}{2}} = 1.60\cdot 10^6\text{m/s}$$

$$V_{el} = \frac{3}{4}V_F = \frac{3}{4}\cdot 1.60\cdot 10^6\text{m/s} = 1.20\cdot 10^6\text{m/s}$$

$$V_{rms,el} = \left(\frac{3}{5}\right)^{\frac{1}{2}} V_F = \left(\frac{3}{5}\right)^{\frac{1}{2}}\cdot 1.60\cdot 10^6\text{m/s} = 1.24\cdot 10^6\text{m/s}$$