1 Cognitive reasoning in the chemical sciences 1.3

1.1 Review

1. Chapter 13 introduces the concept of **collision frequency**, the frequency with which a particle collides with other particles in a fixed unit of time.

   (a) Find the proportionality relationship between collision frequency and V assuming n, T and p are constant.

   (b) Find the proportionality relationship between collision frequency and n assuming V, T and p are constant.

   (c) Find the proportionality relationship between collision frequency and r, where the gas is composed of monoatomic atoms, which are hard spheres with radius r. Assume n, T and V are constant.

   (d) Find the proportionality relationship between collision frequency and v with constant n, r, and V.

   (e) Combine the above and suggest the proportionality relationship between collision frequency and v, n, r, and V.

   (f) Find the equality between v and m and T.

   (g) Plug this equality in the above proportionality and find the proportionality relationship between collision frequency and T, m, n, r, and V.

   (h) State the above as an equality using a new constant K_{cf}.

2. Chapter 13 introduces the concept of the **mean free path**, the average distance a molecule travels between two consecutive collisions.

   (a) Find the proportionality relationship between the mean free path and V assuming n, T and p are constant.

   (b) Find the proportionality relationship between the mean free path and n assuming V, T and p are constant.

   (c) Find the proportionality relationship between the mean free path and r, where the gas is composed of monoatomic atoms, which are hard spheres with radius r.

   (d) Give a formula for the mean free path of an ideal gas in terms of n, V, r and T, using a new constant K_{mfp}

3. We now find a formula for the total number of collisions in a fixed unit of time on a wall and the surface area, A.

   (a) Is there a relationship between the total number of collisions, in a fixed unit of time, on a wall and r, the radius of the molecule assuming n, V, T, A, and m are constant?

   (b) What is the relationship between the total number of collisions, in a fixed unit of time, on a wall and A, assuming n, r, T. V and m are constant?

   (c) What is the relationship between the total number of collisions, in a fixed unit of time, on a wall and V, assuming n, r, T. A and m are constant?

(d) What is the relationship between the total number of collisions, in a fixed unit of time, on a wall and n, assuming n, r, T. A and m are constant?

(e) What is the relationship between the total number of collisions, in a fixed unit of time on a wall, and v, assuming n, r, T, A, and V are constant?

(f) What is the relationship between the total number of collisions in a fixed unit of time on a wall and T and m, assuming n, r, V, are A are constant?

(g) Give a formula for the relationship between the total number of collisions in a fixed unit of time on a wall in terms of n, m, V, A and T.

4. The **effusion** problem: Give a formula for the number of molecules which leave through a hole of area A in the side of a flask and n, m, V, A and T.

5. In a flask of volume V, there are n_A moles of gas molecule A and n_B moles of gas molecule B. Whenever molecule A meets molecule B and the two of them have at least a certain critical amount of energy $E_{activation}$, then molecules A abd B react to form the new indossoluble molecule AB. Assume the temperature is constant and hence both v and the fraction of A+B with the critical energy $E_{activation}$ are fixed. Give a formula for the number of molecules AB formed in a time t as a function of t, n_A, n_B, and V. This is called a **second order reaction**.

6. Same problem, but now three gas molecules A, B, and C must simultaneously come together to form ACB. Introduce n_C. Give a formula for the number of molecules ACB formed in a time t as a function of t, n_A, n_B, n_C and V. This is called a **third order reaction**.