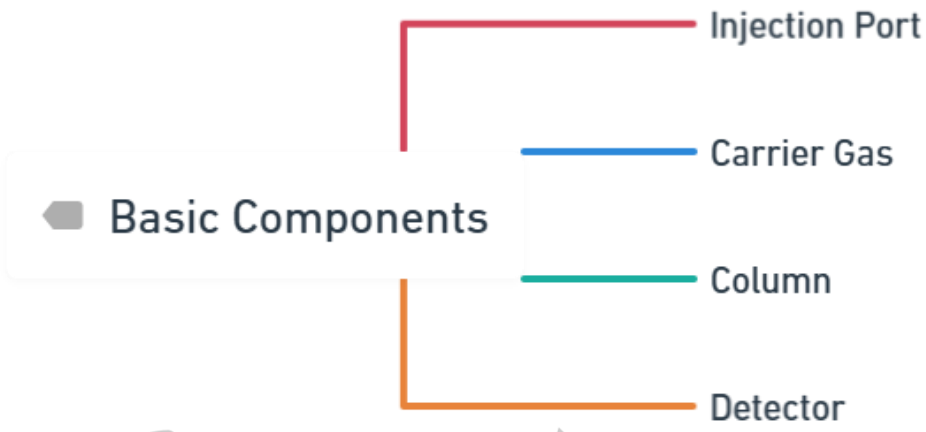
Gas chromatography

Introduction & Theory of Gas Chromatography

Definition

- Gas Chromatography (GC) is an analytical technique used to separate, identify, and quantify compounds in a mixture based on their volatility and interaction with a stationary phase.

Basic Components



1. **Injection Port:** Where the sample is introduced, usually vaporized into a gaseous state.
2. **Carrier Gas:** An inert gas (like helium, hydrogen, or nitrogen) that pushes the sample through the column.
3. **Column:** A long, coiled tube where separation occurs. The inside of the column is coated with a stationary phase, which can be a liquid film or a solid support.
4. **Detector:** Detects compounds as they elute (come out) from the column. Common detectors include the Flame Ionization Detector (FID) and the Thermal Conductivity Detector (TCD).

Principle

- The sample is vaporized and introduced into the GC.
- As the sample travels through the column, individual compounds interact differently with the stationary phase, leading to varying travel times.
- More volatile compounds or those with lesser interaction with the stationary phase will elute faster, while less volatile compounds or those with more interaction will elute slower.

Applications

- Widely used in pharmaceuticals, petrochemicals, environmental testing, and food and beverage industries.
- Analyzes volatile and semi-volatile compounds with high precision and sensitivity.

Components

1. **Injection Port:** Introduces the sample, usually vaporized at a high temperature.

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2. **Mobile Phase:** An inert gas (e.g., helium, nitrogen, or hydrogen) that carries the vaporized sample compounds through the column.
3. **Column:** A coiled tube where separation occurs, either packed with a solid stationary phase or coated with a liquid stationary phase.
4. **Detector:** Records the amount of compound exiting the column, providing data to quantify and identify components.

Separation Mechanism

- **Partitioning:** Compounds in the sample partition between the mobile phase (carrier gas) and the stationary phase within the column.
- **Differential Interactions:** Each compound interacts differently with the stationary phase, causing variations in travel speeds.
    - **More Volatile/Less Interaction:** Elute faster.
    - **Less Volatile/More Interaction:** Elute slower.

Retention Time (RT)

- The time taken for a compound to travel from the injection port to the detector.
- It's characteristic of a compound under specific GC conditions.
- The area under each peak in a chromatogram correlates to the concentration of the compound.

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Factors Affecting Separation

1. Column Temperature:

- High temperatures increase elution rates but reduce resolution.
- Temperature programming optimizes separation and reduces analysis time.

2. Carrier Gas Flow Rate:

- Affects separation and elution times.

3. Stationary Phase:

- Influences separation based on interactions with analytes.

4. Column Dimensions:

- Length, diameter, and film thickness impact efficiency and retention times.

Instrumentation in Gas Chromatography

1. Sample Introduction System

- **Injection Port**: Heated port for sample introduction and vaporization.
- **Auto-samplers**: Automates sample introduction for precision and high throughput.

2. Mobile Phase (Carrier Gas) System

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- **Carrier Gas Cylinder**: Supplies inert gas (helium, hydrogen, or nitrogen).
- **Pressure Regulators and Flow Controllers**: Maintain constant flow rate and desired pressure.

3. Columns

- **Packed Columns**: Wider columns with solid stationary phase (used in older systems).
- **Capillary Columns**: Narrow columns with stationary phase coated on walls, offering higher efficiency.

4. Oven

- Provides temperature control for the column.
- Operates at constant or programmed temperatures for improved separation.

5. Detectors

- **Flame Ionization Detector (FID)**: Measures ions from sample combustion.
- **Thermal Conductivity Detector (TCD)**: Detects changes in thermal conductivity.
- **Electron Capture Detector (ECD)**: Sensitive to halogenated compounds.
- **Mass Spectrometer (MS)**: Identifies compounds by mass-to-charge ratio.

6. Data Handling System

- Computer interface for instrument control, data acquisition, and analysis.
- Software aids in peak identification, integration, quantification, and reporting.

7. Additional Components

- **Split/Splitless Injector**: Allows partial or full sample introduction.
- **Backflush System**: Reverses flow to remove heavy or unwanted materials after analysis.

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Derivatization in Gas Chromatography

What is Derivatization?

- Chemical modification of a compound to form a derivative more suitable for GC analysis (improved volatility, thermal stability, and detectability).

Why is Derivatization Needed?

1. Enhance Volatility:

- Converts non-volatile or high boiling point compounds into more volatile derivatives.

2. Improve Thermal Stability:

- Prevents decomposition of compounds that are unstable at GC analysis temperatures.

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