— University of Mosul —
College of Petroleum & Mining Engineering

Analytical Chemistry

Lecture …(1)….

Petroleum and Refining Engineering Department

Lecture 1: Introduction to Analytical Chemistry for Petroleum Engineering

1: What is Analytical Chemistry?

Analytical chemistry is the science of finding out **what substances are in a material** (qualitative analysis) and **how much of each substance is present** (quantitative analysis). It uses **instruments and laboratory methods** to do this.

Two Main Types of Analytical Chemistry:

Type	Purpose	Example in Petroleum
Qualitative Analysis	Tells you **what is in the sample**	Detecting benzene in reformate using GC-MS
Quantitative Analysis	Tells you **how much is in the sample**	Measuring % of sulfur in diesel using XRF

Table 1: Summary of Analytical Chemistry Roles in Petroleum Industry

Stage	Analytical Role
Exploration	Elemental analysis of core samples
Production	Monitoring of water content in crude oil
Refining	Sulfur analysis in intermediate streams
Product Quality	Determination of octane/cetane numbers
Environmental	Detection of VOCs in effluents

Example: Identification of benzene and toluene in reformate streams using GC-MS (qualitative); quantifying H_2S in LPG using ASTM D2420 (quantitative).

Table 2: Key Analytical Methods in Refinery Operations

Analytical Technique	Measured Parameter	Petroleum Application
Gas Chromatography (GC)	Hydrocarbon composition	Reformate analysis
UV-Vis Spectroscopy	Aromatic content	Gasoline quality
X-Ray Fluorescence (XRF)	Sulfur content	Diesel sulfur testing
Titration	Acid/Base number	Lube oil stability
ICP-OES	Trace metals (e.g., V, Ni, Fe)	Crude oil corrosion control

4. Role of ASTM and IP Standards

Why Standards Matter:

Standards are like **rules** that everyone follows to make sure that everything is **consistent** and **safe**. Here's why they are so important:

1. **Ensure Consistency:**
    - Imagine you are sending a sample of **gasoline** from one refinery to another. To make sure both refineries test it the same way, they both follow the same **standards**. This means that the test results will be the same no matter where it is tested.
2. **Avoid Legal Problems:**
    - If a product, like gasoline, is tested and found to have too much **sulfur**, it can cause serious **legal problems**. Standards help prevent this by making sure the gasoline has the right amount of sulfur.
3. **Make International Trade Easy:**
    - Different countries trade **gasoline, diesel, and jet fuel**. If every country follows the same standards, then it's easy for the products to be traded without worrying about differences in testing methods.

Common ASTM Tests for Petroleum Products:

These are **important tests** used to measure the quality of petroleum products:

1. **D86 – Distillation Curve (Boiling Points):**
   - This test checks the **boiling points** of different parts of the petroleum product. It helps determine the best way to separate the **gasoline**, **diesel**, and other products during refining.

   Numerical Example:

   - If gasoline boils at temperatures between **40°C to 200°C**, this helps the refinery know at what temperature to separate it from other products.
2. **D445 – Kinematic Viscosity:**
   - This measures how **thick** or **thin** the product is. If it's too thick, it won't flow well, and if it's too thin, it won't lubricate the engine properly.

   Numerical Example:

   - A **diesel fuel** might have a **viscosity of 2.5 cSt (centistokes)**. This tells us how thick or thin it is. For reference, **thicker** oils have a viscosity higher than **3.0 cSt**, and **thinner oils** have a viscosity **lower than 1.0 cSt**.
3. **D4294 – Sulfur by XRF (X-Ray Fluorescence):**
   - This test measures how much **sulfur** is in the product. Too much sulfur in fuel is bad for the environment.