— University of Mosul —
College of Petroleum & Mining Engineering

Analytical Chemistry

Lecture …(5)….

Petroleum and Refining Engineering Department

Concentration Expressions and Analytical Interpretation in Petroleum Industry

II. Common Expressions of Concentration

Expression	Unit	What It Means	Where Used	Example from Industry
Percentage	% (v/v or w/w)	Parts per hundred (volume or weight based)	GC, titration	Gasoline with 5% benzene means 5 liters of benzene in 100 liters of fuel
Parts per million	ppm (mg/kg)	One part in a million parts	XRF, ICP-OES, GC	Sulfur in diesel = 10 ppm → 10 mg in 1 kg of fuel
Parts per billion	ppb (ug/kg)	One part in a billion parts	ICP-OES	Lead in fuel = 25 ppb → 25 micrograms in 1 kg
Molarity	mol/L	Moles of substance in one liter	UV-Vis spectroscopy	Not commonly used in refinery, mostly in lab-based chemical testing
Normality	eq/L	Reactive equivalents per liter	Titration (acid/base)	Used in determining acid number using KOH or other bases
mg KOH/g	-	mg of KOH needed to neutralize 1 gram of oil	Titration	Used engine oil = 6.73 mg KOH/g → Needs replacement

✅ Conversion Basics:

- **1 ppb = 0.001 ppm**
- **1 ppb = 1 microgram (µg) per kilogram (kg)**

✏️ Formula:

$$\text{ppb} = \frac{\text{Mass of Solute (µg)}}{\text{Mass of Solution (kg)}}$$

🧪 Example 1: Nickel in Crude Oil (ICP-OES Technique)

- Lab report: Nickel = **900 ppb**
- This means:

$$900\ \mu g \text{ of Nickel per kg of crude} = 0.9\ mg/kg = 0.9\ ppm$$

Formula:

$$\text{Molarity (M)} = \frac{\text{Moles of solute}}{\text{Liters of solution}}$$

Example 1: Iron in Produced Water

Lab result: $Fe^{3+} = 0.02$ mol/L
Means:
There are **0.02 moles** of iron ions in every **1 liter** of produced water.

📄 **Why it matters:**
If $Fe^{3+} > 0.01$ mol/L → iron can form **solid $Fe(OH)_3$**, which may:

- Block pipes
- Damage equipment

📏 Formula (for Normality):

$$\text{Normality (N)} = \frac{\text{Equivalents}}{\text{Liters of solution}}$$

Where It's Used in Oil & Gas:

In refineries, we use Normality in **titration tests** to check oil quality:

1. **Acid Number** – tells us how acidic or oxidized the oil is
2. **Base Number** – tells us how well the oil can protect engines from acids

 The stronger the base (higher N), or the more volume used →
The higher the **Acid Number** → the more acidic (oxidized) the oil is.

Real Petroleum Example:

You test **used lube oil** from a gas compressor:

- You use **1.2 mL** of **0.1 N KOH** to neutralize **1 gram** of oil.

$$\text{Acid Number} = \frac{1.2 \times 0.1 \times 56.1}{1} = 6.73 \text{ mg KOH/g}$$

Example Question:

GC shows:

- Hexane = 40%
- Benzene = 6%

Regulation says benzene must be < 1%.

Is the sample acceptable?