

Introduction to Forensic Chemistry

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Key concepts, techniques, and applications for the forensic scientist

1. What Is Forensic Chemistry?

Aspect	Description
Definition	Application of chemical principles and analytical techniques to identify, quantify, and interpret physical evidence from crime scenes, legal investigations, and regulatory matters.
Goal	Provide objective, scientifically valid data that can be presented in court to support or refute hypotheses about criminal activity.
Scope	• Drug analysis (illicit substances, pharmaceuticals) • Toxicology (poisons, alcohol, drugs of abuse) • Trace evidence (fibers, paints, explosives, gunshot residues) • Environmental forensics (soil, water, pollutants) • Document and ink analysis • Arson investigation (accelerants)

2. The Forensic Chemistry Workflow

1. Evidence Collection

- Proper packaging (paper for dry evidence, glass for liquids)
- Chain-of-custody documentation

2. Preliminary Examination (Screening)

- Visual inspection, odor assessment, preliminary tests (e.g., color tests for drugs).

3. Sample Preparation

- Extraction (solid-phase, liquid-liquid, Soxhlet, microwave)
- Derivatization (if required for GC or MS)
- Filtration/centrifugation

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4. Instrumental Analysis

- Choose technique based on volatility, polarity, required sensitivity.

5. Data Evaluation

- Compare with reference standards, databases, or literature.
- Use statistical tools (e.g., chemometrics) for pattern recognition.

6. Interpretation & Reporting

- Relate findings to the case hypothesis.
- Write clear, concise reports with uncertainty estimates.

7. Court Presentation

- Prepare visual aids, expert testimony, and be ready for cross-examination.

3. Core Analytical Techniques

Technique	Principle	Typical Applications	Strengths	Limitations
Gas Chromatography (GC)	Separation of volatile compounds on a capillary column; detection by FID, ECD, or MS.	Drugs, solvents, accelerants, fire debris.	High resolution, fast analysis of volatiles.	Requires volatility; non-volatile compounds need derivatization.
Liquid Chromatography (LC)	Separation of non-volatile or thermally labile compounds; detection by UV-Vis, FLD, or MS.	Pharmaceuticals, metabolites, explosives, dyes.	Handles polar, high-MW analytes; no volatilization needed.	Longer run times; sometimes lower separation efficiency than GC.

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Technique	Principle	Typical Applications	Strengths	Limitations
Mass Spectrometry (MS)	Ionization ? mass? to?charge measurement; provides molecular weight & structural info.	Identification of unknowns, confirmation of drugs, toxins.	High specificity, can be coupled with GC/LC.	Expensive, requires skilled operation.
Fourier Transform Infrared Spectroscopy (FTIR)	Molecular vibrations absorb IR radiation; produces a characteristic spectrum.	Polymers, paints, fibers, inks, explosives.	Rapid, minimal sample prep, non ?destructive.	Limited for complex mixtures; overlapping bands.
Raman Spectroscopy	Inelastic scattering of monochromatic light; provides vibrational information.	Paint chips, glass, drugs, pigments.	Minimal sample prep, works through containers, complementary to FT?IR.	Fluorescence interference;