Ch 420 - Final Exam Outline
Spring 2004

- **Statistics**
  - histograms
  - Gaussian distributions
  - mean and standard deviation (know how to calculate these)
  - accuracy and precision
  - normal error curves
  - 1 and 2-sided distributions
  - using the area under the normal error curve to calculate probabilities

- **UV-Vis Spectroscopy**
  - qualitatively know the electromagnetic spectrum including direction of increasing energies, frequencies, and wavelengths
  - know how to use the equations \( \nu = \lambda / \lambda \) and \( E = h\nu \)
  - understand how an electron can change energy levels
  - electronic, vibrational and rotational energy levels
  - know the color wheel and how to determine what colors are absorbed by a molecule
  - basic parts of a UV-Vis spectrometer
  - applications to forensics - identification
  - applications to forensics - quantification
    - transmittance: \( T = P / P_0 \)
    - absorbance: \( A = -\log(P/P_0) \)
    - Beer-Lambert law: \( A = \varepsilon bc \)
    - calibration curves - blank and replicates
    - limit of detection LOD = \( 3\sigma_b / \text{slope} \)

- **The Arson Investigation**
  - Chemistry and Behavior of Fire or Explosion - Fire and the Fire Tetrahedron
    - Fuel
    - Heat
    - Oxygen
    - Chemical Chain Reaction
  - Accelerants and sampling
  - Accelerant recovery from debris (laboratory procedure)
  - Gas Chromatography-Mass Spectrometry (GC-MS) - know the basic parts of the instrument such as the oven, injection ports, columns, ionization chamber, quadrupole, electron multiplier detector
  - Total Ion Chromatograms (TIC) and Selected Ion Chromatograms (SIC)
  - Accelerant Classification System (do not memorize)
  - Know the major compounds found in gasoline, turpentine, and kerosene
  - Difference in the TIC between standard and evaporated samples
  - From the Arson Lab - questions from the article "Chemical Analysis of Fire Debris", Wolfgang Bertsch, *Analytical Chemistry News & Features*, September 1, 1996, p. 541A.
- **Gunshot Residue Analysis**
  - Priming mixture - lead styphnate primary explosive, \( \text{Ba(NO}_3\text{)}_2 \) oxidant, \( \text{Sb}_2\text{S}_3 \) fuel, lead-free primer = diazo-dinitrophenol (DDNP)
  - Smokeless powder - single-based (nitrocellulose) and double-based (nitrocellulose + nitroglycerin)
  - Stabilizer = diphenylamine
  - Detection of gunshot residue on hands - dermal nitrate test = nitrates + diphenylamine + \( \text{H}_2\text{SO}_4 \) → blue color
  - Netron Activation Analysis (NAA) and Atomic Absorption Spectroscopy - know generally how these techniques work
  - Gunshot Residue Analysis by GC-MS - know the cold column injection procedure
  - Solid Phase Extraction (SPE)

- **The Determination of Alcohol**
  - Basic properties of ethanol (polar, b.p. = 78.5 °C, low vapor pressure = 60 Torr)
  - Widmark ratios
  - Alcohol in the Circulatory and Pulmonary Systems
  - Henry’s Law and blood/air = 2100
  - Collection of Blood Samples - fluoride (F⁻) and EDTA anticoagulants, fluoride (F⁻) preservative
  - Analysis for Alcohol in Blood by Headspace GC-MS
  - Analysis for Alcohol in Breath - Breathalyzer vs. the Intoxilyzer, false positives

- **Forensic Applications of Infrared Spectroscopy**
  - Basics of IR Spectroscopy
    - where in the electromagnetic spectrum
    - wavenumbers
    - normal modes
    - infrared spectrum
    - Fourier Transform IR (FTIR)
  - Diffuse Reflectance Infrared Fourier Transform Spectrometry (DRIFTS)
  - Attenuated Total Internal Reflectance (ATR) Spectrometry
  - Applications of DRIFTS and ATR
  - Infrared Microscopy and it’s Applications
    - Transmission versus Reflectance configuration
    - Cassegrainian optics
    - ATR accessory
    - Example applications – fibers, paints, questioned documents


**Forensic Identification of Controlled Substances**

- Controlled Substances Act - schedules, substances found in certain forms = whole plant, tablets & capsules, general unknowns
- Schedule of Controlled Substances *(don’t memorize)*
- The General Unknown:
  - preliminary visual examination
  - weighing of all exhibits
  - selection of representative samples
  - screening tests = spot tests *(know)*
  - microscopic tests
  - spectrophotometric tests
  - separation tests
  - confirmatory tests
  - quantitative analysis
  - other tests

**Restoring Serial Numbers in Metal Objects**

- physical and chemical basics if using steel (like in the lab)

**Luminol and Chemiluminescence**

- definition of chemiluminescence, singlet vs. triplet states
- Detection of Latent Bloodstains Using Luminol
  - oxidation in base
  - product formed in excited electronic state
  - fluorescence at 425 nm (blue)
  - oxidants (sodium borate, etc) and auxiliary oxidants (hemoglobin, etc)
- Synthesis of luminol - *(don’t memorize reaction)* but know the purpose of each reagent and where it acts chemically
- False positives and their elimination

**Atomic X-Ray Spectrometry**

- Emission of X-Rays – Electron Beam Source
- Continuum and Line Sources
- Line Spectra (K, L, M...)
- Origin of X-Ray Line Spectra
- Radioactive Sources
- Absorption Spectra, Mass Absorption Coefficient, and Beer’s Law
- X-Ray Fluorescence
- Diffraction and Bragg’s Law
- Photon Counting
- Wavelength Dispersive versus Energy Dispersive Instruments

**Recent Topics in Forensic Chemistry**

- X-Ray Fluorescence: Colored polyethylene bags, Trace Elemental Analysis of Drugs of Abuse
- Homeland Defense: Electronic Noses (PowerPoint Lecture) – chromophore quenching sensors, fiber-optic bead sensors, SAW detectors