DAILY LOG FOR CHEMISTRY/DETECTOR PORTION OF MEDICINAL PLANTS OF THE SOUTHWEST 2003

Note: The separate individual activity lesson plans are appended at the end of this portion of the report. They are consecutively numbered 1 - 24

Day 1

Separations:

- Introduction – need for separation for medicinal plants (Activity 0)
  - Enrichment/Concentrate
  - Quantitative
  - Qualitative identification
- Introduction to Separation Techniques
  - Separation Methods based on Phase Equilibria (Karger)
  - Separation Methods based on Rate Processes (Karger)
  - Particle Separation Methods (Karger)
- Procedures in the Laboratory
  - Keeping a Notebook (Zubrick)
  - Safety First, Last, and Always (Zubrick)
- Caffeine, the compound of choice to separate, purify and quantitate.
  - Introduction (Pavia)
  - Isolation of Caffeine from Tea: Method (Pavia)
  - Tea Extract (Activities 0/1)
- Thin Layer Chromatography – an initial means to resolve an herbal mixture
  - Introduction
  - Thin Layer Chromatography of Vegetables (Activity 2)
  - Thin Layer Chromatography of Caffeine (Activity 3)

Day 2

- Extraction and Thin Layer Chromatography of Carrot Pigments (Activity3)
  - R_f calculation
  - Identification of pigments
- Liquid-Liquid Extraction. Isolation of Caffeine from Tea. Continuation (Activity 1)
- Melting Point – a preliminary physical test
  - Introduction (Zubrick and Hill)
  - Actual caffeine extract. Melting Point Experiment (Activity 4)
- Infrared Spectroscopy – a preliminary compound analysis
  - Introduction
  - Actual caffeine extract. Infrared Spectroscopy of Caffeine (Activity 5)
- Thin Layer Chromatography - continuation
  - Actual caffeine extract. Thin Layer Chromatography of Caffeine (Activity 3)
- Crystallography – a preliminary visual characterization
  - Introduction
  - Shapes of different minerals. Crystallography (Activity 6)
  - Actual caffeine extract. Crystallography (Activity 6)

Day 3

- Elutropic Series – to make better chromatographic solvent choices (especially TLC)
  - Definition
  - Tables
- Recrystallization – a preliminary purification of crystals
  - Introduction

        - Isolation of Caffeine from Tea. Continuation (Activity 1)
        - Actual caffeine crystals:
            - Melting point Experiment (Activity 4)
            - Crystallography (Activity 6)
            - Infrared spectroscopy of caffeine (Activity 5)
            - Gas Chromatography/ Mass Spectroscopy first use of GC/MS since presence and purity established (Activity 7)
                - Test results next day
- Separation of Mixtures
    - Separation of an artificial mixture (Activity 8)
- Bioassay
    - Introduction
    - Caffeine Bioassay (Activity 9)
        - Sea monkey (shrimp)
        - Serial dilution
    - 24 hours test period (see next day)

Day 4

- Supercritical Fluid Extraction – first introduction to a "green", efficient method of extraction
    - Introduction
- Gas Chromatography / Mass Spectrometry
    - Introduction
    - Results:
        - Gas Chromatogram of caffeine standard
        - Mass Spectrometry Spectra of caffeine standard
        - Calibration curve of caffeine
        - Groups samples of caffeine crystals obtained
    - Actual chromatogram result
- Bioassay
    - Results and discussion: Previous caffeine Bioassay (Activity 9)
- Visit Dr O'Connell's laboratory
    - Supercritical Fluid Extraction (Activity 10)
    - Gas Chromatography/ Mass Spectrometry (Activity 7)

Day 5

- Acid base (Activity 11)
    - Concept
    - Relation to medical plants
        - Buffer solutions to selectively extract
        - Color

Day 6

- Plant Extraction Protocol – from plant to detection, full cycle.
    - Explanation
    - Students designed them. Work in groups and shared

- Dr. O'Connell's group protocol to compare

Chemical Fundamentals:

- Atoms and Molecules
    - Introduction
    - Charge (Activity 12)
- Check- In. Laboratory room 191, Chemistry and Biochemistry Department
    - Safety First, Last, and Always (Zubrick)
    - Set up 2 reflux apparatus
    - Reflux Distillation Plant Extraction Procedure

Day 7

- Chemical Bonds
    - Ionic and covalent bond. http://www2.gasou.edu/chemdept/general/molecule/polar.htm
    - Shapes and molecules and polarity, marshmallow (Activity 13)
- Intermolecular Forces
    - http://www2.gasou.edu/chemdept/general/molecule/forces.htm
    - Various forces
    - Affect solubility and mode of detection
- Valence Shell Electron Pair Repulsion Theory (VSEPR)
    - Introduction http://www2.gasou.edu/chemdept/general/molecule/vsepr.htm
    - Tutorial: http://www2.gasou.edu/chemdept/general/molecule/tutorial/co2/frame2a.htm
    - http://www.chem.purdue.edu/gchelp/vsepr/cmp2.html
- Lewis Structure
    - Introduction http://www2.gasou.edu/chemdept/general/molecule/lewis.htm
    - Piece together relation of Lewis dot to VSEPR to polarity to solubility
    - Use chemical models kit to show structures, shapes and polarities
- Perform: Reflux Extraction. Hexane and Methanol. C. B. Room 191 (Activity 14)
    - Reflux Plant Extraction Procedure
        - Two steps: Methanol and hexane

Day 8

- Dipole Moment
    - Introduction
    - Values Table, (CRC.)
- Solubility
    - Solubility of Liquids (Activity 15) – matrix of solvents combinations;
        - Note: Students predicts were done first
- Harvest and prepare group plant material

Day 9

Detection:

- Physical Phenomenon that are involved with compound identification
    - Introduction
        - All physical phenomenon are transduced to an electrical signal

- Heat Transfer
    - Transfer of energy (Activity 16)
    - Compare and discuss results on board
- Thermal Conductivity Detector
    - Introduction
    - Wheatstone Bridge Demonstration (Activity 17)
    - Diagram: http://www.chem.vt.edu/chem-ed/sep/gc/detector/tcd.html
- Ions Close the Circuit
    - Introduction
    - Ions conduct Electricity Demonstration (Activity 18)

Day 10

- Flame Ionization Detector
    - Introduction
    - Diagram: http://www.chem.vt.edu/chem-ed/sep/gc/detector/fid.html
- Properties of Gas Chromatography Detectors
    - Definition of:
        - Limit of Detection
        - Linear Range
        - Sensitivity
    - Comparative values for the above in a table form
      http://eep.stanford.edu/seepweb/cee373/lect5.pdf
- Light. Electromagnetic Spectrum
    - Introduction
        - Frequency
        - Energy
        - Wavelength
    - Constructive and destructive waves
        - Spring and slinky (Activity 19)

Day 11

- Continuation of Light
    - Widely used detection method (AA, Spec 20 , IR, etc)
        - Scan of Kool-Aid solutions. Spectronic 20 (Activity 20)
- Continuation of Extractions (Activity 14)

Day 12

- Continuation of Light
    - Calibration Curve (Kool-Aid spec 20) (Activity 20)
    - Concentration of Kool-Aid unknown. Spectronic 20 (Activity 20)
- Review Electromagnetic Radiation
  http://olympusmicro.com/primer/java/interference/
- Review for Intermolecular and Intramolecular Forces
    - Table provided that compare the forces.
      http://virtual.yosemite.cc.ca.us/webbg/Chem101/Ch11lecture/IntermolecForces.htm

- Chirality – Phenomenon very prevalent in therapeutic medicine
    - Introduction – plants make exclusively only one enantiomer
    - Polarized Lenses Demonstration. Chirality (Activity 21)
    - Tour and lecture on polarization with Dr. Dennis Johnson. Room 191 Chemistry and Biochemistry Dept. (Activity 21)

Day 13

- Atomic Spectra and Atomic Structure Methods and Introduction (Nelson)
    - Flame test. Atomic Spectra (Activity 22)
    - Spectroscope Geisler Tubes. Atomic Spectra (Activity 22)
- Home made: Polarimeter Box Demonstration (Activity 21)
- Session in laboratory room 191
    - Perform Reflux Extraction. Methanol and Hexane (Activity 14)
    - Prepare SFE thimble (Activity 10)
    - Check-Out laboratory 191

Day 14

- Photoelectric Effect
  http://www.lewport.wnyric.org/mgagnon/Photoelectric_Effect/photoelectriceffect1.htm
  http://www.shsu.edu/%7Echm_tgc/sounds/flashfiles/pee.swf
- Electric Fields and magnetic fields
    - Introduction
    - Comb with stream of water demonstration.
- Magnetic Field affects stream of ions or current
    - Introduction
    - Cathode Ray Tube Demonstration with External Magnets
- Refraction Index, RI
    - Introduction
    - Refractive Index Demonstration
        - D.D. Water
        - Dilute sugar solution
        - Concentrated sugar solution
        - Vacuum pump oil
- Electric current induces magnetic field. (Activity 23)
- Movement in magnet field induces current. (Activity 24)
- Mass Spectrometry
    - Introduction
    - Ion trap
    - M.S, Spectra interpretation of some molecules
- Conclusion: test for learning/acquiring concepts.
    - Game of technical words
        - Picture drawing
        - Poem
        - “Charades”

INQUIRY BASED PEDAGOGY / 0

CAFFEINE EXTRACTION FROM TEA LEAVES

Select a Plant	**Do an actual extraction** from the tea leaves (do this via the traditional way followed by the Pavia method)	**Pedagogy:** Discuss, organize observations, predict trends, define separation; all of this as it pertains to **extraction**	**Verification** of Concentrate Compare to pure caffeine standard	**Pedagogy:** Discuss, organize observations, predict trends, define product verification; all of this as it pertains to **Compound verification**	Physiological potential of the caffeine extract	Discuss vocabulary words from Pavia Introduction
Start with a plant (tea) Is there a reason for this choice?	-Gravimetric analysis, weigh the plant material (useful for % extraction later in procedure -Extract whatever with hot water -Separate caffeine from whatever -Ponder, discuss, evaluate the method of extraction and verification of concentrate *See Column 4 for extra guide (Zubrick)*	What did you do and why? Examples: -H_2O versus CH_2Cl_2 Hot versus cold Time	-Gravimetric analysis again (weigh it) for %extract -Melting point -Bulk crystal Microscopy -Infra-red spectroscopy Chromatography *Use J. W. Zubrick Manual: "The Organic Chem Lab Survival Manual, A student's Guide to techniques"*	What did you do and why? Examples: -Is any one method sufficient? -Are all methods as easy to use? -What is a standard? -So are there advantages and disadvantages to any of the methods?	Bioassay: used shrimp (sea monkey) exposed to different concentration of caffeine The shrimp were observed under the microscope next day to assess bioactivity	Bold faced vocabulary words in Pavia's handout

TEA EXTRACT / 1

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
1) Extraction and purification of caffeine.	1) Multiple compound extraction from tea leaves, liquid-solid technique. 2) Extract caffeine from the mixture, liquid-liquid extraction 3) Purify caffeine crystals by re-crystallization	Solubility Polarity Aqueous and organic phase Alkaloids Liquid-liquid extraction Liquid-solid extraction	Experiments are all hands-on Isolation of caffeine from tea leaves. Handouts 1 Caffeine introduction (Pavia) 2 Caffeine method (Pavia) 3 Caffeine Chemistry (Pavia)	1) Weigh tea leaves 2) Crude extraction of caffeine and other compounds from tea leaves. 3) Extract caffeine from aqueous mixture; liquid-liquid 4) Remove the solvent 5) Verification using: * TLC [TLCC] * Crystallography [CRYST] * M.P [MP] * IR [IR] 6) Recrystallization of the extract 7) Gravimeter 8) Verification using: * TLC * Crystallography * M.P * IR * GC/MS [GC/MS]	For 7 groups: 250 g Dry tea leaves 200 g Calcium carbonate 8 500 mL round-bottomed flask equipped with a condenser 50 Fast filter paper 8 Büchner funnel 8 500 mL separatory funnel 2 L Methylene chloride 500 mL acetone 500 mL petroleum ether 7 250 mL EM flask 7 250 mL side arm flask 7 Glass funnel 7 100 mL beaker 7 spatula 25 weigh paper or boat 500 g Anhydrous magnesium sulfate 100 g Cotton Boiling stones Latex hose 8 Hot plates GC/MS Mel-temp apparatus Stereoscopes IR	1) Find acceptable value for melting point of caffeine

TE

THIN LAYER CHROMATOGRAPHY OF VEGETABLES / 2

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
Vegetable pigments can be separated on TLC plates, due to a compound's affinity for the stationary or mobile phase. -Compounds that migrate slowly are attracted to the plate sorbent (stationary phase). -Compounds that migrate quickly are less attracted to the sorbent, and more attracted to the mobile phase solvent	To visualize the separation of pigments in spinach and carrot extracts using TLC method. Pigments that may be seen include carotene, pheophytin b, chlorophyll a, chlorophyll b, and xanthophylls	Adsorption Capillary action Mobile phase Stationary phase Elutropic solvent Plate sorbent Solvent/Plate affinity Polarity R_f value Solvent front	Tactile exercise Thin Layer Chromatography of vegetables (spinach and carrot) Handouts Thin Layer Chromatography of vegetables	Students are to: 1.Cut out TLC plates ≅ 2.5 x 10 cm. 2.Place a pencil line ≅ 1-2 cm from the bottom of the plate. 3.Spot 5 µl of the spinach / carrot extract on the TLC plate. Allow spot to dry then apply a second 5µl. 4. Place TLC plate into developing chamber with 5 mL mix 70:30 hexane: acetone. 5.Wait until solvent is approximately 1 cm from the top of the plate, before removing TLC plate from chamber. 6. Visualize spots and determine the location of each compound. Activity: 1. Thin Layer chromatography of spinach and carrot	2.5 x 10 cm TLC plates (7) Pencil (7) Developing Chamber (2) Micropipettor (7) Micropipette tips (14) Solvent (70:30 v : v) hexane: acetone (5 mL) Spinach leaf / Carrot	The spinach experiment is a pre-lab demonstration, while the carrot experiment is a post lab reinforcement. In the carrot experiment students are to predict which of the given compounds are present in the carrot extract, identify which of the pigment compounds are separated on the TLC plate, and why they are located at that spot.

TLCV

THIN LAYER CHROMATOGRAPHY OF CAFFEINE / 3

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
Extracts can be separated on TLC plates, due to a compound's affinity for the stationary or mobile phase. -Compounds that migrate slowly are attracted to the plate sorbent (stationary phase). -Compounds that migrate quickly are less attracted to the sorbent, and more attracted to the mobile phase solvent.	To visualize the separation of analytes, particularly caffeine, in a tea leaf extract; using TLC method	Adsorption Capillary action Mobile phase Stationary phase Elutropic series Plate sorbent Solvent /Sorbent affinity Retention factor	Tactile exercise Thin Layer Chromatography of Caffeine Handout Thin Layer Chromatography of Caffeine	Students are to: 1.Cut out TLC plates ≅ 2.5 x 10 cm. 2.Place a pencil line ≅ 1-2 cm from the bottom of the plate. 3.Spot 5 μl of both the tea extract and caffeine standard on the TLC plate. Allow spots to dry, and repeat two more times. 4.Place spotted TLC plate into developing chamber. 5.Wait 5-10 min. for spots and solvent to migrate before removing. 6.Remove plate and place on heated hot plate to dry (dries quickly). 7.Use UV lamp (254 nm) to visualize spots. Determine the location of caffeine from the tea extract, by comparison with the caffeine standard, and find its retention factor. Activity: 1. Thin Layer Chromatography of Caffeine	- 2.5 x 10 cm TLC plates (7) - Hot plate (2) - Pencil (7) - Developing Chamber (2) - UV lamp (2) - Micropipettor (7) - Micropipette tips (14) - Solvent (19:1 v:v) Ethyl Acetate: MeOH (200 ml) - Caffeine std. (in MeOH) - Tea Extract	Chlorophyll experiment. Spinach will be extracted in a pre-lab demo/activity, resulting in the separation of chlorophyll and other pigment compounds. Carrots will be extracted, using the same method, as a post-lab reinforcement; yielding different compounds Have students determine which spot is caffeine, from the tea extract, based on comparison with the standard.

TLCC

MELTING POINT EXPERIMENT / 4

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
Compounds melt at well defined temperatures Impurities will alter the melting point; impurities will cause the well-defined m.p. of the pure compound to change to a melting point "range" Boiling points are also affected by impurities	To measure melting points of substances, To use the m.p. as a preliminary compound verification method To use the m.p. as a preliminary indication of compound purity (the melting point of a pure compound versus a contaminated sample	Melting point Purity of sample Intermolecular forces	Handouts The Melting Point Experiment (Zubrick) Melting point (Hill) Activity is hands-on Identification and verification	Use of the "Mel-Temp" apparatus Traditional compounds (benzoic acid) Mainly to practice loading the capillary tubes and making a measurement (training) Pure caffeine versus first crude extract Caffeine after recrystallization Actual herb extract	Capillary tubes Mel-Temp apparatus Benzoic acid Pure caffeine Post activity reinforcement: Packets of sugar Packets of salt Thermometers	The effect of impurities: Check out the effect of salt or sugar on the b.p. of water and quasi-quantitate by packets of material Predict (organize) a list of compounds in order of increasing m.p. and rationalize (intermolecular forces) WILL RE-VISIT AFTER WEEK 2

INFRARED SPECTROSCOPY OF CAFFEINE / 5

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
1) Identify and verify caffeine. 2) Verification techniques. 3) Comparison of working substances to standards. 4) IR will identify functional chemical groups	To compare the IR spectra of the caffeine standard vs. extracted sample. To identify the functional groups with IR	IR radiation Absorption of light Molecular vibration IR spectrum Molecules functional Groups Wavenumber Instrumentation Standard	Experiments are Hands-on Identification and verification Handouts 1 Table functional. Groups transmittance (primary clues) 2 Operation of the PE 1720 FTIR	1) Preparation of sample 2) Preparation of IR cards 3) Get IR spectrum 4) Identification of functional groups	For 7 groups: FT-IR Perking Elmer 1720X (Chemical and Biochemical building) 10 Disposable IR cards	1) Look for the caffeine molecule and the IR spectrum of it. 2) IR assignments of functional groups 3) Compare band assignment with caffeine standard 4) IR spectra of standard and group samples

IR

CRYSTALLOGRAPHY / 6

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
Compounds have diagnostic bulk physical properties, which are used to identify them One such property is the crystalline structure of condensed matter, including organic herbal compounds	Using stereoscope, students are able to see the physical shape of a mineral; which is governed by its internal structure, and does not change with size. Organic compounds, even herbal compounds, will have a crystalline structure that will be observed microscopically.	Minerals Crystal Cleavage	Handouts Morphology of crystals (Hurlbut and Klein) Tactile exercise	1.Obtain a set of macroscale minerals, identify and record their shape. 2. Using a nail or your finger, chip a small piece of the larger macroscale minerals. Use the stereoscope to make observations of the piece's shape.	- Stereoscope - Mineral samples: NaCl $CaCO_3$ (calcite) $CaSO_4.2H_20$ (gypsum) $NaAlSi_3O_8$ (albite) $C10H_8$ (naphthalene) Mineral sample kit (Curtis Monger) - Nail	Make a list of other physical properties that might be used to identify compounds.

CRYST

GAS CHROMATOGRAPHY – MASS SPECTROMETRY / 7

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
Compounds in complex mixtures can be separated using gas chromatography, a technique which involves a column (stationary phase) and a carrier gas (mobile phase). In addition, a temperature gradient can be used to expedite the separation process. Mass spectrometry can be used for mass discrimination	Resolve multiple compounds from a mixture prior to identification and quantitation. Identification and quantitation can also be done on a modern GC/MS; therefore this too will be the objective	Vapor pressure Stationary phase Temperature gradient Polarity Carrier gas Intermolecular interactions	Handouts Lab tour, show actual instrument and individual components as much as is possible	Plant extract in a solvent is to be analyzed by GC/MS. The sample is injected and analyzed by GC/MS	Functioning GC/MS 40 ml vials w/cap	Interpret the chromatogram: Retention times, resolution, peak shape, solvent peak? Interpret the mass spectrum: compound identification and the probability, parent peak, base peak, logical losses

GC/MS

SEPARATIONS OF AN ARTIFICIAL MIXTURE / 8

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
Physical and chemical means con be used to separate components of a mixture	1) For students to utilize as many separation techniques a. Sublimation (naphtha) b. Decantation (pepper) c. Filtration (salt) d. Drying (sand) 2) For students to use their imagination and skills, including group dynamics that they learned the previous week. To plan and execute a separation scheme	Separation Evaporation Decantation Filtration Drying Sublimation	Hands-on, in the lab using chemical apparatus Separation of Mixtures Group Doodle-board	Lab. In which students will separate all four components and determine % losses (inquiry based) So stop periodically to compare, organize, predict, ??? ????? Can you guess where logical stops are needed?	The mixture (7 @ 3grams) 7 crucibles 7 beakers 7 funnels Filter paper 7 hot plates Salt Pepper Naphtha Sand + Individual needs, give this assignment ahead of the activity for them to design (predict?)	To create a problem which utilizes as many of the learned techniques as possible ???? Need more help with the "problem" Write the assignment that I will give them

SEP

CAFFEINE BIOASSAY / 9

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
A drug may possess anti-septic, analgesic, anti-biotic and other useful properties, although, it could also induce death. The effect of a drug is dependant on the concentration of active com-pounds in a particular dose.	To measure the concentration of caffeine, at which half the population of Brine shrimp in a petri dish are killed, in a 24- hour period. To observe Brine shrimp under a stereoscope. To make serial dilutions.	LC_{50} LD_{50} Bioassay Concentration	Tactile exercise Caffeine Bioassay Handout Caffeine Bioassay	Each group is to: 1. Obtain a 20,000 ppm solution of caffeine. Make serial dilutions of 2,000 ppm, 200 ppm, 20 ppm, and 0 ppm in 10 ml, using D.I.H_2O. 2. Obtain 5 petri dishes. Label each dish with a different concentration of caffeine, ensuring all 5 concentrations are represented. 3. Place ≅ 5 ml of Brine shrimp in each petri dish. 4. Place 0.5 ml of each concentrated solution into its respective dish. Mix contents, and allow to sit for ≅ 24 hours 5. After 24 hours, count the number of dead shrimp in each dish, using a microscope, and record in a notebook. Note the concentration at which ≅ half the population appears to be dead.	Stereoscope (7) 3 ml plastic bulb-pipettors (7) Macropipettor (7) Macropipette tips Petri dishes (35) Brine shrimp D.I. H_2O Centrifuge tubes (35) Sharpie (7)	Given the LD_{50} of 3 different compounds, students are to calculate the lethal amount of each compound for their own body weight.

SUPERCRITICAL FLUID EXTRACTION / 10

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
Substances can exist in the supercritical fluid state. This happens in special zones (beyond the critical point) at elevated pressures and temperatures. Carbon dioxide is such a material that achieves supercritical conditions under elevated pressure Carbon dioxide is a useful non-polar extracting solvent in the supercritical state (benign) Some traditional solvents are NOT green and difficult	Extraction of the chemical components of natural products using CO_2 as a supercritical solvent	Supercritical fluid Polarity Pressure Carbon dioxide	Lab tour Handout: Phase diagram	Prep samples to be extracted Extract caffeine from tea leaves, DEMO week 1 Extract compounds from their herb	Extraction thimbles and vials w/cap and septa Mortar and pestle to grind plants organ Diatomaceous earth to dilute and fill the thimble Spatula Analytical balance SFE apparatus	Find phase diagrams for different substances Compare the various phase diagrams (especially water!)

ACID / BASE / 11

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
Solvated H^+ is the acid HA is a molecule Acids and bases are opposites and complementary Acids (bases) react differently, including color, solubility, etc.	To discuss acidity and basicity as it relates to medicinal plants: solubility, color, usefulness in SELECTIVE separation (e.g., the carbonate in the caffeine extraction)	Acid Base Bronsted Lewis Solvated Hydronium ion Alkaloids Ammonia	Handouts	Lecture In the future, possible titration, maybe even as a demo	Overheads	Categorize compounds as acids or bases Possibly use K_a values to assist in acid/base assignments

ATOMS AND MOLECULES AND CHARGES / 12

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
Atoms are the chemical building blocks of the universe Molecules/compounds are "combinations of atoms," small whole number ratios of atoms (John Dalton)	Present the subatomic nature of the atom to understand structure and physical/chemical properties: Rutherford JJ Thompson Charges are an inherent property of the domains of the atom To understand "electrostatic forces" and their role in polarity	Nucleus Electron Dipole Induced dipole Polarizability Vector Conduction Induction Repulsion Attraction	Handouts Charge (Kanim) Hands-on Charge Models, atoms with nucleus and "orbitals" to depict fundamental electron and nucleus domains Hands-on activity to qualitatively and quasi-quantitative measure the effects of charge (distance, charge)	Use activity borrowed from Dr. Steve Kanim for electrostatic interactions: repulsion, attraction, induction, conduction, vectors, superposition	Atoms with nucleus and electron orbitals, atomic numbers 1-8 Electrostatic kit (activity outline and exercises (Steve Kanim) rabbit fur, silk cloth, acrylic rod, glass rod, stands, ring clamps, thread, pith balls with aluminum foil, insulating wooden rods, electroscopes, tape, markers	The electrostatic activity has "problems" Define the vocabulary words and present to all the workshop participants

AMCH

MOLECULAR SHAPES AND DIPOLES / 13

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
Nature dictates certain shapes of molecules A model for the shapes is VSEPR	To write very simple Lewis dot structure models Knowing the number of paired electrons (bonding and non-bonding), predict a molecular shape	G.N. Lewis dot structures Trigonal -hedron Tetrahedral Octahedral Polar Symmetrical Bonding pair Non-bonding pair	Handouts Hands-on activity to build chemical geometric structures using VSEPR principals Web page animations of the shapes and the associated dipole moments Draw dipole vector diagrams	Use marshmallows and toothpicks to build chemical geometric structures using VSEPR principals Use this technique to build the symmetrical structures first (all white marshmallows) Then, use colored marshmallows to represent asymmetrical molecules and non-bonding electrons	Large white marshmallows for central atom Smaller white and colored marshmallows to represent bonded atoms Toothpicks to represent electron pairs, both the bonding electron pairs and the non-bonding electron pairs	Do some of the tetrahedral shapes with the NICE CHEMICAL MODELS Assign molecules to calculate the dipole moments

REFLUX EXTRACTION / 14

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
Reflux is a process whereby the solvent vapors are condensed and re-circulated back to the heated vessel. The reflux method can be used for continuous extraction (e.g., plant material) since fresh solvent is continuously being recycled past the plant material – Soxhlet	Extraction of compounds from plant organs using a reflux extraction apparatus	Solvent Polarity Soxhlet Condenser Reflux Thimble Extract Intermolecular forces Boiling point	Activity is hands-on Reflux distillation plan extraction procedure Handout Reflux distillation plan extraction procedure	Sample preparation Set up reflux apparatus Extraction of plant constituents from plant material using 2 different solvents, methanol and hexane, for the solvent extraction Demonstration of a Soxhlet extraction.	Per group: 2 condensers 2 mortar and pestle 2 Round bottom flasks 2 condenser 2 Heating mantles 2 Rheostat 3 hoses Boiling stones Hexane Methanol 2 Ring stand A very detailed schematic of Soxhlet apparatus	From an unlabeled diagram/schematic of an extraction apparatus, label the components. For each labeled component, describe the function of each

REFLUX

SOLUBILITY / 15

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
1) Molecules have dipole moment. 2) The dipole affect polarity of molecules 3) Similar polarity are miscible, different polarity are immiscible	To test mutual solubility of liquid solvents. To test the relative solubility of pairs of solvents from the list provided	Dipole moment Polar Non polar Miscible Immiscible Solubility Dielectric constant Intermolecular forces	Experiment is hands-on 1 Experiment: Solubility of liquids Handouts 1 Solubility of liquids	1) See the solubility of a matrix of seven solvents	For seven groups: 150 test tubes Rack Acetone Diethyl Ether Hexane Isopropanol Methanol Toluene DI water 5 mL pipette 10 mL graduated cylinder	1) Predict solubility of pair of solvents on matrix

TRANSFER OF ENERGY / 16

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
Energy always moves from a hot body (more energy) to the cold body (less energy). Heat (energy) transfer occurs by: -Conduction -Convection -Radiation	To observe the transfer of heat from a hot body (heated beaker of H_2O) to a cold body (vial of room temperature H_2O) by monitoring the temperature of each, as they come into contact with each other.	Conduction Convection Radiation Blank	Tactile exercise Plotting of data Handout Graph. paper	Students are to: 1. Measure 400 ml of D.I. H_2O into two 500 ml beakers. 2. Place ≅ 10 ml of D.I. H_2O into one SFE vial. 3. Put a thermometer into each of the three containers. 4. Heat both beakers of H_2O to boiling. 5. Using oven mitts, carefully remove both beakers from the hot plate. 6. Place the SFE vial, with H_2O, into one of the beakers. The other beaker is to remain as is, open to the ambient temperature. 7. Predict what will occur in each container, and write down in notebook. Monitor the temperature of each thermometer and take note every minute.	Hot Plate (7) 500 ml beaker (14) Test tube (7) Thermometers (21) Oven mitts (6) Ring stand Buret dual clamp to hold thermometer Graph paper Stop watch	Students are to provide examples of each type of heat transfer, describing the direction in which energy is moving.

TENERG

WHEATSTONE BRIDGE / 17

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
Universal detector Most commonly used detector in gas chromatography is based on a Wheatstone Bridge, Thermistors are used instead of regular resistors to register the thermal conductivity of gases in gas chromatography. Heat will increase the resistance in a thermistor, that will force the current flow to follow another direction and therefore go through the bridge.	To demonstrate the current flow through the bridge by heating up a thermistor. The thermal conductivity of gases through the use of a Wheatstone Bridge as a signal amplifier.	Heat Current Flow Wheatstone Bridge Thermistor Signal Amplifier	Handouts Wheatstone Bridge Demonstration	Gather around a Wheatstone Bridge set up with a voltmeter and apply heat to the thermistors Watch how the current changes as heat is applied, and how the current amplifies when more than one thermistor is heated.	Large visual Wheatstone Bridge Set up. or 4 thermistors Wire Solder Soldering iron Voltmeter 9 V battery	Use Wheatstone bridge as a detector for GC Label and draw and color the entire circuit

WBRIDGE

IONS AND A CLOSED CIRCUIT / 18

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
An electrical circuit is just that, a completely closed loop where electrons can move The circuit is a translation of electric charges via a "wire," for example. A break or gap in a circuit stops current or the flow of electrons in the circuit If the gap is small, it can be bridged with ions or charged particles that can migrate from one pole of the gap to the other	To show E=iR (Coulombs Law) to show E, i, and R in a circuit to show the gap and stop the current to bridge the gap with ions and re-establish the current	Coulomb Resistance Current Circuit Ions	Light bulb model that "lights-up" when the solution will conduct current Show-and-tell with an actual GC to show the principle (jet tip and collector tube)	Use the light bulb model that "lights-up" when the solution will conduct current, has ions that can migrate in solution Use an actual GC-FID to show the application of the principle. If possible, try to do the same with ions in the GC-FID	An old GC-FID (HP) to show the principle of detection Circuit to show E=iR Resistors, battery source, ammeter Light bulb to conduct current with ionic solutions (DD water, tap water, salt, sugar, alcohol, acid)	E=iR calculations Given an FID schematic, color in the circuit. Label the different components and describe their function Given a list of solutions, which will conduct current

WAVE BEHAVIOR / 19

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
Waves can be described with frequency, amplitude and wavelength Wave energy E is quantized (nodes) Waves can superimpose (constructive and destructive)	To play with constructive and destructive interferences To measure frequency for nodes 2, 3, 4 Compare quantized energies	Quantized Frequency Nodes Energy Constructive Destructive Wavelength	Hand-on activity in groups Spring Activity Calculation of E and frequency http://olympusmicro.com/primer/java/interference/	Use slinky to show constructive and destructive interferences Use spring at 2 distances (to simulate 2 different wavelengths) and measure frequency in time for node 2, 3, 4 Use web page activity to demonstrate wave behavior	Slinky Spring Stop watch Report sheet	Where is wave behavior exhibited or used in detection schemes (UV-Vis, polarimeter, NMR, IR, gravity, etc)

WAVE

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UV-VIS ON A SPEC-20 / 20

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
Compounds absorb photons, photons of a particular energy (or wavelength or wavenumber or frequency) This Absorption phenomenon is used to monitor and measure compounds The absorption of photons by compounds is directly related to the concentration of the compound	To use a Spec-20 spectrophotometer to measure the absorbance of a sample To find the optimal wavelength on the Spec-20 for a given solution (Kool-Aid in this case); this is the ε in the A= ε bc equation. Using a given Kool-Aid, scan the spectrum every 10 units of wavelength (if possible, will compare to the spectrum of a UV-Vis scanning instrument. Make a concentration calibration curve of a given Kool-Aid and then measure the unknown concentration of a Kool-Aid	Photon Absorption Calibration curve Wavenumber Wavelength Frequency	Activity in completely hands-on Student Activity for Spec-20 Handouts: Student Activity for Spec-20 Graph paper	See the worksheet for this activity Kool-Aid on a Spec-20 Find best wavelength Calibration curve Find unknown concentration	Kool-Aid (3 different colors, e.g., red, yellow, and blue Delivery pipettes to make serial dilutions Volumetric flasks to make serial dilutions Test tubes to fit the Spec-20 (one for each calibration point plus the blank) A pre-labeled graph for the plot of Absorbance versus concentration in ppm's (max Absorbance ~.8) and concentrations in the same order of magnitude	Compare to another serial dilution that has already been performed (brine shrimp in this case) Draw a block diagram of the Spec-20 and label each part and discuss its function

UV

CHIRALITY / 21

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
Chiral molecules rotate the plane of polarized light The rotation is linear to concentration	Show that chiral compounds exhibit optical activity by use of a polarimeter Chiral compounds in personal herbs (if found)	Stereochemistry Optically Active Plane of Symmetry Plane polarized light Levorotatory Dextrorotatory Achiral Chiral Chirality Chiral centers Polarization Polarimeter Oscillation (light) Specific Rotation Sample Concentration Sample Path Length Wavelength	(2 day activity) Handouts PowerPoint Presentation Handout from the web http://www.creation-science-prophecy.com/amino/ http://www.rod.beavon.clara.net/chirlit.htm http://www.cem.msu.edu/~reusch/VirtualText/sterism2.htm#isom12 Tactile: Demonstration of polar filters Build polarimeter Use chemical molecular Kits	(2 day activity) Dr. Dennis Johnson Lab Tour and lecture on Polarization and the Polarimeter with actual test samples (Draw/build compound models) Sugars that rotate plane of polarized light: Fructose Amino Acids that rotate plane of polarized light: Proline Calculation of specific rotation for two compound above (Experimental specific rotation was less than 1% error)	Polarimeter Fructuose and proline sample compounds 6 Groups per Sample Tested Standard Operating Procedure (short description with PowerPoint presentation and Dr. Johnson Lecture) Chemical molecular Kits Polar Lenses Overhead Projector (in lecture room) Home-made polarimeter in a box with solar cell detector and flash light source	Mathematical exercises with given parts of specific rotation [α] equation for practice: Identify chiral molecules from worksheet

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EMISSION SPECTRA / 22

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
Atoms and molecules have a unique spectrum Prism and diffraction grating can be used to disperse light in a spectrum	To compare the emission lines of different metals under a thermal (flame) excitation and electrical excitation.	Properties of light Electromagnetic radiation Wavelength Frequency Monochromatic light Electromagnetic spectrum Diffraction grating Prism Emission of light Absorption of light Ground state Excited state	Experiments are all hands-on 1 Experiment: flame test 2 Experiment: spectroscope Handouts 1 Atomic Spectra and Atomic Structure Introduction (Nelson) 2 Atomic Spectra and Atomic Structure Method (Nelson)	1) See the emission spectrum of sodium, strontium, potassium, barium, calcium and lithium 2) Flame test of different metals 3) Graf spectral lines 4) Predict an unknown	For seven groups: 100 mL 6M HCl 10 mL 0.1 M $CaCl_2$ 10 mL 0.1 M liCl 10 mL 0.1 M NaCl 10 mL M $SrCl_2$ 10 mL M KCl 10 mL 0.1 M $BaCl_2$ 7 Bunsen burner & hoses 7 Nichrome wire loops 25 diffraction grating 1 Dark room 1 Spectroscope Geisler tubes High-voltage power supply with lamp holder	1) Look for the emission spectra of the metals tested. 2) Compare the lab. observed emission spectra vs. the researched one

ES

INDUCING A MAGNETIC FIELD / 23

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
A magnetic field is created by a moving point charge. When a point charge (q) moves with a velocity, v, it produces a magnetic field B Use the right-hand rule to determine the direction of the magnetic field due to a long, straight current carrying wire. The magnetic field lines encircle the wire in the direction of the fingers of the right hand when the thumb points in the direction of the current. A solenoid is made by tightly coiling a current carrying wire. A uniform magnetic field is generated inside of the coil	To demonstrate that moving electrons (point charges) create a magnetic field in a current carrying wire	Point Charge Electron Vector Magnetic field Tesla Biot-Savart Law: the source of the magnetic field is a moving charge qv or a current element I*dl* just as the charge (q) is the source of the electrostatic field. Solenoid Armature	Tactile exercise Simple motor Handouts: Simple motor	Oersted's Experiment: effects of a current carrying wire on a compass.	Oersted's apparatus (needs fixing, rotate the plane of the coil Solenoid kit Copper wire ring Straight copper wire Compass D cell battery D cell holder Model clay Iron fillings 5 ft Magnet wire 8 in 18 ga Wire Bar magnet Nail Pliers	Make a simple motor

IMF

INDUCING ELECTRIC CURRENT / 24

Concept	Objective of activity	Vocabulary	Stimulus	Activity	Equipment	Reinforcement Activity
Magnetic fields can produce a current though a wire	An exploratory experiment where the students study the effect of a magnetic field on a solenoid. Create a generator by using the simple motor made in the previous lab exercise	Magnetic field Ampere	Tactile Handouts	Produce a small electrical current that can be detected using a microammeter by using a solenoid and a rumen magnet	Solenoid Rumen magnet Microammeter Iron filings	Predict the magnetic field lines of a solenoid and compare to actual using iron filings Also, predict what is happening to the magnetic field lines during induction