Laboratory Technical Manual for CHEMTREK

Small-Scale Experiments
for General Chemistry

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INTRODUCTION

To calculate the quantities of solutions you will need for your total number of students it is assumed, if students fill their own microburets, they will each use 3 mL regardless of how much they really need because the 24-well tray holds 3.5 mL per well. Sometimes students will need more than one well-full.

If you fill microburets for the students, it requires 3.5 mL per microburet and you need 1 microburet per student in the class.

We have tried this and we have found, that if classes are large or you have multiple sections, it is much more satisfactory for students to be responsible for filling their own microburets.

Teaching of good transfer technique becomes very important early in the semester and students will then continue to have good techniques throughout the year.

Solutions are dispensed from a central location, called "reagent central," in each room. We use 250 mL drop-dispensing bottles by Nalgene, series 2411 or 2420. These are low-density poly-ethylene and are also available in smaller sizes. General supplies are also placed nearby in an appropriate container.

For instruction on how to make microburets, etc., see appropriate chapter in the lab manual. Be sure to save the cut-off ends to make microstirrers and caps.

Paper towels are needed at all times.

Microtowels are soft toilet paper.

Distilled or de-ionized water is used for all solutions.
Student Kit:

The following items were put together as a kit which the students purchase. The kit is to be used for the entire year. By purchasing these items in large quantities, it is usually possible to get a discount price which we pass on to the students. We feel that student ownership provides the benefit of new equipment that can be kept in as good condition as the student desires.

1. 1 - pair scissors: 7" Dura-Sharp
   or comparable

2. 1 - 1/4" paper punch

3. 1 - 12" plastic ruler: clear

4. 1 - plastic magnifier: 3x/5x (p 36, 241 Edmund Scientific)

5. 1 - "Lab top": this consists of a 8 1/2" x 11 " sheet protector with a plastic insert(see below), white sheet of paper and black construction paper(4 1/2" x 4 ") assembled together.

6. 1 - plastic insert: this is white fluorescent light covers, 2 x 4', smooth on one side, available at lumber yards. Cut it so that it fits inside the sheet protector.

7. 1 - pair tweezers

8. 1 - tissue culture plate, 96-well, round bottom, #76-311-05; ICN Biomedicals

9. 3 - microstrip, 1 x 12 well, Labsystems, #9502-13500P

10. 1 - tissue culture plate, 96-well, flat bottom, 25860-96; Corning

11. 1 - tissue culture plate, 24-well, flat bottom,29443-952; Corning

12. 1 - petri dish and cover, disposable plastic, 100 x 15 mm

13. 10 - thin-stem plastic transfer pipets

You may not substitute brands on the 96-well round-bottom tissue culture plates because the straws will not fit others.

General Supplies

1. thin-stem pipets plastic transfer (4 mL)

2. 9" pipet plastic transfer (7 mL)

3. Petri dish, disposable 100 x 15

4. Weigh boat, disposable micro, 1 5/8" sq.

5. Bottles, drop dispensing Nalgene, low-density polyethylene, 250 mL 2420-0250

6. Bottles, drop dispensing, Nalgene, polypropylene, blue caps

7. Hydrion test paper, wide range pH 1 - 11 or 2-12

8. Tissue culture well plates, Corning
   24-well flat 29443-352
   96-well flat 25860-96

B. Per room

1. Analytical balances (At least to 1 mg)

2. Hot plate

3. An easy way to supply hot water is in a 30-cup automatic coffee pot.

4. Drying oven (something that can be at 75¡C, 80¡C, 110¡C)

1 Microwave oven (if possible)

6. Clock with second hand

7. Overhead projector (if available)

8. Centrifuges (Chapter 17)

9. Spectrophotometers (Chapter 21)

10. Lasers (Chapter 2)

C. For the technician

1. Analytical balance

2. pH meter

3. Paper cutter (24 inch)

Specific Supplies

ICN Biomedicals
330 Hyland Ave.
Costa Mesa, CA. 92626
800-854-0530

1. Linbro Titertek microplates, 96-well, nonsterile without cover 76-311-05

National Scientific Company
975 Progress Circle
Lawrenceville, GA 30245
800-332-3331

1. Small vials, pk/200 C 4015-96

2. SepCapTM closures C 4015-97
small size, available in colors
(these fit super jumbo straws)

SPECIFIC SUPPLIES (cont.)

Philips Discrete Products
811 East Arquea Avenue
Sunnyvale, CA 94088-3409
800-234-7381

Distributor: Call Philips and ask for the distributor nearest you. Minimum order 1000.

1. Silicon temperature sensors
KTY 83-110

VACTEC, Inc.
10900 Page Blvd.
St. Louis, MO 63132
314-423-4900

Distributors are Allied Electronics or Newark Electronics

1. VT-203, Type O, CdS, photosensor

John Fluke Mfg. Co. Inc.
P.O. Box C9090
Everett, WA 98206

1. Fluke 75 multimeter or other digital multimeter of similar type and quality (needs an impedence > 10 M ohms).

Local distributors should be available:

1. Sweetheart, super-jumbo translucent straws, 7 3/4" 823T

2. Sweetheart, slim straws, 7 3/4" 721T
Note: Any slim straw is satisfactory

3. boxes for Spectroscopy

For other items and suppliers see individual experiment.

GENERAL SUPPLIERS

Baxter Healthcare Corporation
Scientific Products Division
1430 Waukegan Road
McGaw Park, Il 60085-6787
312-689-8410

Curtin Matheson
9999 Veterans Memorial Division
Houston, TX 77038-2499
800-650-0650

VWR Scientific
P.O. Box 7900

San Francisco, CA 94120
800-932-5000

Sargent-Welch
7400 North Linder Avenue
P.O. Box 1026
Skokie, Il 60077-1026
800-323-4341

Fisher Scientific
50 Fadem Road
Springfield, NJ 07081
800-766-7000

Glass Warehouse
P.O. Box 1039
Millville, NJ 08332-8039
800-833-0410

Ask for the address and telephone number of the local branch office nearest you.
CHEMICALS
Absolute ethanol
Acetic acid, glacial
Acetone

Alizarin yellow R
Alumina, 8-14 mesh

Aluminum chloride, 6H2O

Aluminum nitrate, Al(NO3)39H2O

Aluminum wire, 19 or 20 gauge
(Also available at local hardware stores)

Amaranth dye (red #2)

Ammonia, concentrated (15 M)
Ammonium acetate
Ammonium chloride
Ammonium sulfate
Ammonium thiocyanate
Ascorbic acid
Barium chloride, 2H2O
Barium diphenylamine sulfonate
Barium nitrate
Bismuth nitrate
Boric acid
Bromocresol green, sodium salt

Bromocresol purple, sodium salt
Bromothymol blue, sodium salt

Cadmium nitrate, 4H2O

Calcium carbonate
(or use ground eggshell)
Calcium chloride
Carbon tetrachloride
Ceric ammonium sulfate, 2H2O
Chloroform

Chromatography paper:
Whatman #1, 48 x 57 cm

Whatman #3, by the roll, 1" wide
Chromium nitrate, 9H2O

Citric acid
Copper foil, .005"
Copper chloride
Copper nitrate, 3H2O
Copper sulfate, 5H2O
Copper wire, .02"
Corks, #2 probably
2,6 Dichloroindophenol
Dichloromethane
Diffraction grating
Dimethylglyoxime
Disodium hydrogen phosphate
Dithizone (diphenylthiocarbazone)
Dowex 50W-X8 ion exchange resin
Dyes, F D & C

Red #3, #40, Blue #1, #2, Green #3,

Yellow #5, #6
EDTA, disodium salt
Eriochrome black T
Ethanol, 95%
Ferric chloride, 6H2O
Ferric nitrate, 9H2O

Ferroin (1, 10 phenanthroline ferrous sulfate solution)
Ferrous ammonium sulfate, 6H2O
Ferrous sulfate, H2O
Filter paper: Whatman #41, any size

Whatman #3, 9 cm
Freon 11

Freon 12
Fructose
Glass rod, 4 mm
Glass tubing, 5 mm, 6 mm, 8 mm
Glucose
Glycerine
Glycine
Hexane
Hydrochloric acid, concentrated (12M)

Hydrogen peroxide (or buy 3% from drug store)
Lead acetate
Lead foil, .008"
Lead nitrate
Lithium chloride
Litmus paper (neutral, or red and blue)
m-Cresol purple
Magnesium ribbon
Magnesium sulfate, 7H2O
Manganese nitrate, 50% solution
Mercury (I) nitrate
Mercury (II) nitrate
Methyl orange, sodium salt
Methylene blue
Nichrome wire, 26 gauge
Nickel nitrate, 6H2O
Nicotine
Nitric acid, concentrated

pH test paper strips, wide range (1-11 or 2-12)
Phenolphthalein, disodium salt
Phosphoric acid, 85%
Phytic acid, sodium salt hydrate
Pipets, micro, disposable, 1-5 microliter
Pipets, Pasteur, disposable, 9 inch
Potassium bromide
Potassium chloride
Potassium chromate
Potassium dichromate
Potassium dihydrogen phosphate
Potassium ferrocyanide
Potassium hydroxide
Potassium iodide
Potassium nitrate
Potassium nitrite
(can substitute sodium nitrite)
1-Propanol
Resin, XAD, 200 mesh (see Chapter 21)
Rubber stoppers (Chapter 12)
Rutin

Stoppers, Serum septa, 16 x 25 mm
Silica gel, 100-200 mesh
Silver nitrate
Silver wire, .5 mm (24 gauge)
Sodium acetate
Sodium bicarbonate
Sodium bismuthate
Sodium carbonate
Sodium chloride
Sodium citrate
Sodium dithionite
Sodium hydroxide solution, 0.100 M
Sodium hydroxide
Sodium nitrate
Sodium phosphate, Na3PO4 á 12H2O
Sodium sulfate
Sodium sulfite
Sodium thiosulfate, Na2S2O3 á 5H2O
Starch, soluble potato
Strontium chloride
Sulfuric acid, conc.
Syringes, 10 cc (no needle)

1 cc, with 25 gauge, 5/8" needle
Thioacetamide
Tin (II) chloride, SnCl2 ¥ 2H2O
Tin foil, .005"
Tincture of green soap

Tris (hydroxymethyl) amino methane (called Trizma base, Sigma)
Tubing, latex, 1/4" (1/16" wall)
Tubing, Tygon, 1/8" ID, 1/4" OD
Violet #1 dye (no longer available)
Zinc foil, 0.010"
Zinc nitrate, 6 H2O
Zinc sulfate
Zincon dye, (80%)

Local Shopping List

Aluminum beverage cans, empty

Aluminum foil: regular and heavy duty

Baking soda

Batteries, 9V

Beer

Beets, red, canned

Bleach

Candles

Cereals: Product 19¨ and Total¨

Clothespins, spring type, wood

Club soda

Cornstarch

Cotton Swabs

Cups, plastic, transparent

- 3 oz. bathroom refill
- 9 oz. tumbler
- 2-cup measuring

Cups, styrofoam, 6 oz.

- Detergents: Cheer¨, Tide¨, and Joy¨ or Dawn¨ liquid
- Drano¨, crystal

Eggs

- Electrical leads, about 15 inches, with alligator clips both ends

Face cream

Fishing line
Flowers: red and blue
(eg. geraniums, petunias)

Food dyes

- Fruits: grapefruit, lemons, limes, oranges, pomegranates, cranberries, etc.
- Fruit juices: apple, grapefruit, lemon, lime, orange

Gelatin, unflavored

Glycerine

Ice

Industrial products that contain Freons -probably not available

Ink, red permanent

Juicers

Knives, paring

Koolaid¨: lemon-lime

Labels or label paper

Light bulbs, 60W (and socket)

Lighter fluid

Liver (or animal blood) Ð optional

Matches

Mineral waters: Evian¨, Perrier¨, and a variety of USA

Motor oil, nondetergent

Motor oil, used

Nails, small brads, ungalvanized

Pens: Flair¨ pens

Sheaffer¨, ink cartridge type

Permanent marker type, fine point

Pencils, #2

Pencil leads: .5 mm 6H (or 5H)

.9 mm HB

Pins, sewing, #17 or so

#20 with plastic heads

Polyester fiber, pillow-fill

Razor blades, single edge

Red cabbage

Red roses

Resistors

Rocks: granite, gypsum, limestone, marble, quartz, road dust, concrete

Rubber bands

Seeds: corn, peas, soybean, other legumes, coffee

Soap, Ivory Snow¨

Staplers, small (eg., Tot¨)

Staples to fit

Styrofoam, 1 inch thick (craft store)

Sugar

Tape: electrical, masking 3/4", transparent 1/2"

Tea: regular

Thread, sewing

Thumb tacks

Tincture of green soap (from a pharmacy)

Tobacco, pipe

Tofu

Toilet paper, facial quality

Toothpicks, plastic (hors d'oeures)

Twine, heavy cotton (cablecord)

Vitamin C tablets, 100 mg.

Washing soda

Water: local well and lake

Welding rod, 0.06"

White vinegar

Yogurt, plain

Zinc tablets

Per Student, first semester

Following is an approximate list of what each student will need. Many items can be recycled. Be sure to check each experiment for items that may be needed only once. This list does not include filled, labelled microburets.

2	6 oz. styrofoam coffee cups (these will need to be replaced periodically)
3	SepCapTM vials & caps
3	Thin-stem transfer pipets
1	Wash Bottle
1	96-well microreaction tray, U shape
1	96-well microreaction tray, flat bottom
2	24-well tray & lid
3	1 x 12 well microstrips
2	15 x 100 mm plastic petri dish & lids
6	Microburets (pulled-out thin stems)
1	3 oz. Solo¨ clear plastic bathroom refill cup or 2 oz. Solo transparent souffle cups if available.
1	SepCapTM, hole through it (we use red for visibility)
1	SepCapTM cap
1	Slim straw, Sweetheart¨
1	Micro or small weigh boat
1	Microstirrer (can make their own)
1	Thin-stem pipet, cut off

1 Clothespin, wood, spring type

2 Electrical leads with alligator clips both ends

1 Scorer, file, or glass cutter

1 Coke can, cut for chimney

2 2-dram shell vials & caps (or similar)

1 Thermometer

20 Super-jumbo Sweetheart¨ straws

Per Student, second semester

16 Small SepCapTM vials with caps

1 96-well tray, round bottom

1 96-well tray, flat bottom

2 24-well tray

2 1 x 12 well microstrips

3 Cut-off (large drop) microburet

3 Small-drop (pulled) microburet
Thin-stem pipets

3 6 oz. styrofoam coffee cup

1 9 oz. transparent plastic tumbler

1 3.5 oz. transparent plastic (bathroom) cup

1 Micro stirrer

2 Washbottle

10 Super jumbo straws

3 Slim straws

2 Electrical leads

1 Petri dish with lid

2 Petri dishes with hole in lids

1	Slurry pipet
1	Plastic scoop
1	10 mL syringe
2	Clothespins
1	Cut-out soft drink can
1	Scorer or file
1	Matches
1	SepCapTM cap with hole in it
*2	100 mL beakers
*1	100 mL graduated cylinder
*1	Condensor
*1	5 mL pipet
*1	Pipet bulb
*1	Bunsen burner
*1	Ring stand
*1	Ring
*1	Wire guage
*1	Clamp (3-prong, preferable)
*1	100 mL volumetric flask and stopper
*1	125 mL Erlenmeyer flask
*2	Rubber stoppers, 1-hole
1	#0 porcelain casserole
1	1/2" test tube brush
1	Test tube rack
4	Test tube clamps
12	Test tubes, 12 x 75 mm
1	2 mL rubber bulb (Pasteur pipet)
1	2 inch watch glass
1	250 mL beaker
1	10 mL graduated cylinder
2	4 inch glass stirring rods, 4 mm
2	Spectrometer tubes
1	Wash bottle

*Optional: See Chapter 12 for comment.

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Next

Chapter One: The System

Chemicals:

1. Glucose
   40 grams glucose
   100 mL 95% ethanol
   Dilute to 1 L with distilled water
   Make fresh

2. Sodium hydroxide (600 mL)
   40 grams per liter

3. Methylene blue (10 mL)
   0.3% in 50% ethanol

Supplies:

1. Each room will need:
   ice
   clock with second hand
   beaker of cold water
   microtowels (soft toilet paper)
   hot water

Preparation for Classtime:

Each student will need a freshly prepared vial. Our vials are 6-dram, screw-cap glass vials. We are using Nalgene caps. (20 mm 2150-0200) These vials hold 20-25 mL. Any glass container that does not leak will work. Adjust the volumes according to the size bottle. About 1/2 full is O.K.

To prepare the vials:
Set up 2 burets: 1 for glucose
1 for NaOH

Just prior to classtime:
Buret 5 mL each solution into vial; add
2 drop MB; cap tightly; mix gently.
Cover with towel to protect from light.

Note: It is NOT necessary to use a buret. A graduated cylinder is fine. Burets are easier and faster.

Each Student Will Need:

2 - 6 oz. styrofoam coffee cups

1 - Box matches

3 - Small SepCapTM vials and caps

1 - Thin-stem pipet

1 - Wash bottle

1 - Freshly prepared vial

From Student's Kit:

Lab top

Hand lens

Tweezers

Next

Chapter Two: Spectroscopy

Chemicals:

1. 3 Sets dry salts, small amount in a small bottle

   $CaCl_2$, $CuCl_2$, $SrCl_2$, KCl, NaCl, LiCl

2. Unknowns: Use the above salts

Supplies:

1. The boxes are 11 1/8" x 8 3/4 " x 2"
   #1182

   Colorado Box & Display Company
   510 Lookout Mountain Road
   Golden, CO 80401
   303-526-1700

   Lots of sizes will work just as well. Box needs to be 4 1/2" wide, 7 " long, 1" deep or larger, and easy to cut.

   You can even make your own from poster board (not white).

2. Diffraction grating, cut 3/4" square
   12" x6" sheets: #E40,267

   Edmund Scientific
   101 E. Gloucester Pike
   Barrington, NJ 08007-1380
   (609) 573-6250

   OR

   for higher quality(but more expensive):
   Arbor Scientific
   P.O. Box 2750
   Ann Arbor, MI 48106-2750
   1-800-367-6695

   item #33-0980: mounted slides

   Also need grating mounted in slide mounts if using laser

3. Nichrome wire, 26 gauge (0.0159"), nickel-chrome, cut pieces
   1 1/2" - 2" long

4. Tape:
   1/2" Scotch tape
   Black electrical tape
   Masking tape

5. Single-edge razor blades
   1 per student (recycle)

6. Scorers or file
   1 per student (recycle)

7. Corrugated cardboard, 5" - 6" square
   1 per student (recycle)

8. Small corks

9. transparency rulers(easy to cut)

10. acetate sheets, cut 1" x 2"
    red, yellow, blue, green

Per Room:

11. Light sources: 1 each
    Candle
    60W light bulb
    Fluorescent

12. Bunsen burners

13. Discharge tubes:
    Ne, Hg, Ar, He, N_2 ,H_2

    Central Scientific Company (CENCO)
    11222 Melrose Avenue
    Franklin Park, IL 60131-1364
    800-262-3626
    OR
    Edmund Scientific

14. Coil to fire the discharge tubes, as available, 2 - 3 preferable

15. Laser (if available)

16. "Projection.screen"(if.using.laser)
    These are a wooden framework with a white poster board cover, make your own.

17. Super jumbo straws

18. 96-well microreaction trays

From Kit:

Scissors

Office

Punch

Ruler

Next

Chapter Three: Small Scale Techniques and the Absorption of Light

Chemicals:

1. 95% ethanol

2. Solutions of Schilling¨ food dyes:
(1 box)
   a. Green (.07%)
      2 drops per 100 mL
   b. Blue (.07%)
      2 drops per 100 mL
   c. Yellow #5 (.105%)
      3 drops per 100 mL
   d. Blue unknown
      1 drop per 100 mL
   e. For color deficient students:
      Red: 3 drops/100 mL (.105%)
   f. Orange unknown
      1 drop red, 2 drops yellow/100 mL

3. Lime soft drink
   1 gram lemon-lime Koolaid¨ per 100 mL

Supplies:

1. 5 mm (O.D.) soft glass tubing,
   cut 5 cm long

2. Cotton cable cord, heavy duty, cut about 3 inches long

3. Thin-stem pipets

4. Cotton swabs

5. Microstirrers (one per student)
   To make: Use the ends cut from the thin-stem pipets when making micro-burets. Cut about 3 inches long. Warm in microburner (plastic becomes clear; don't heat too much). Flatten with fingertips. To increase visibility, it can be filled with colored water (food dye). Close open end same as before. Save the narrow diameter pieces for Chapter 18.

Per Room:

1 Spectrophotometer with cover removed (Instructors will need a copy of the optical system schematic)

Box to collect the micropipets and cut off ends the students have made

Balances

Per Student:

1 - 6 oz. styrofoam coffee cup

1 - Weigh boat

1 - Wash bottle

1 - Microstirrer

Matches

From Kit:

1 - 24-well tray

1 - 96-well tray, round bottom

3 - 1x12 well microstrips

Hand lens

Lab top

Scissors

Next

Chapter Four: The Use and Abuse of Aluminum and Its Compounds

Chemicals:

1. 1.4 M potassium hydroxide
   78.5 grams KOH per liter

2. 9 M sulfuric acid
   Wear apron, goggles!! Slowly, with constant mixing
   500 mL distilled water in a 1 L plastic beaker
   Slowly add 500 mL conc H_2SO_4
   Cool to room temp.
   Make up to volume with water

3. 0.5 M barium chloride
   122 grams $BaCl_2.2H_2O$ per liter

4. 95% ethanol
5.
5. Crystal Drano

6. Alum (for seed crystals)

Supplies:

1. Aluminum foil
   Cut pieces 1 x 2" (each student needs 1 piece)
   Check weight: needs to be about 0.05 grams

2. Whatman #41 filter paper circles
   1/4" office punch to make the circles
   One piece of 12.5 cm filter paper will make 100 circles

3. Sewing pins, #17

4. Small corks, #1 or #2

5. Super jumbo straws

6. Roll of soft toilet paper

7. pH test paper strips, wide range
   pH 1-11
   Cut strips into small pieces (7 per strip)

8. Aluminum beverage cans

9. Ice

10. Burner supplies (Chap. 3)

    Glass tubing

    Cotton twine

11. Weigh boats:
    Use the bulb of the practice thin-stems saved from Chapter 3.
    Cut the bulb in half lengthwise along the seam.

Per Room:

Source of hot water
Balances

Per Student:

3 - Microburets, unlabelled

1 - Microstirrer

1 - 3 oz. clear plastic Solo¨ cup

2 - 6 oz. styrofoam coffee cups

1 - Plastic weigh boat

1 - SepCapTM cap with hole in it
Using a glass rod, carefully burn a hole in the cap without melting the sides.

1 - Straw spatula

1 - Slim straw

Matches

1 - Wash bottle

From Kit:

1 - 24-well tray

1 - 96-well tray, round bottom

1 - petri dish

Scissors

Lab top

Hand lens

Office punch

Next

Chapter Five: Instruments -- What They Do and What They Don't

Supplies:

1. Super jumbo straws

2. Thin-stem pipets

3. Box of pins, stainless, #20
4. #2 pencils (for those who don't have a pencil)

5. Temperature sensors (for the T.A. to distribute, 1 per student)
   Bend into U-shape

6. Carbon filament resistors (for the T.A. to distribute)
   Radio Shack: 500 per package, 1/4 watt carbon film, 5% tolerance
   To read the resistance: Put the gold band on the right. Read thefirst 2 colors, eg., green = 5, red = 2. The resistance is 52 x the multiplier color, which is the third band: eg., yellow = 10^4 resistance = 520000 ohms
   Use only those resistors between 5000 ohms and 1 megaohm.

7. Digital multimeters with signout sheets
   Each student needs 1 meter.

The instructor will sign out the meters plus 1 temperature sensor and 1 resistor per student. The students will be required to turn in the sensor and the resistor when they turn in the meter.

Per Room:

Hot water

Ice

Per Student:

1 - 9V battery (does not need to be full strength)

2 - Electrical leads with alligator clips

2 - 6 oz. styrofoam coffee cups

1 - Thermometer

1 - Box matches

1 - Wash bottle

From Kit:

1 - 24-well tray

1 - 96-well tray, round bottom

Scissors

Ruler

Hand lens

Office punch

Next

Chapter Six: Thermochemistry and Solar Energy Storage
(revised)

Chemicals:

1. Sodium thiosulfate, pentahydrate
   Provide a bottle with a wide mouth lid for easy access to scoop

Supplies:

1. Calorimeters: syrofoam cup
2. Large granite river rocks, about 1 1/2" diameter, 5 per student. Put these in the oven.
3. Super jumbo straws
4. Box of #20 pins
5. Digital multimeter per student Students must sign for!
6. Temperature sensor per student (in a box for instructor to hand out)
   These are to be returned with the meter.
7. 15 mL nalgene vial
8. String

Per Room:

1. Oven set at about 75 EC for the rocks
2. Hot water bath per room (Approx. 80 EC - suspend thermometer in bath)
3. Clock
4. Balances

Per Student:

1 - Microcalorimeter: styrofoam cup

2 - Electrical leads with alligator clips

1 - Straw

1 - Thin-stem pipet

1 - Thin-stem scoop

1 - SepCapTM cap

1 - 15 mL nalgene vial

1 - Wash bottle

From Kit:

Scissors

Ruler

Next

Chapter Seven: Solutions and Reactions

Chemicals:

1. 0.3 M aluminum chloride
   72.4 g $AlCl_3C6H_2O$ per liter

2. 0.2 M sodium carbonate
   21.2 g Na_2CO_3 per liter

3. 0.2 M lead nitrate
   66 g $Pb(NO_3)_2$ per liter

4. 1 M ammonia
   67 mL conc NH_3 per liter

5. 0.2 M copper sulfate
   50 g $CuSO_4C5H_2O$ per liter

6. 1 M sodium hydroxide
   40 grams NaOH per liter

7. 1 M sulfuric acid
   400 mL H_2O, carefully add 25 mL conc H_2SO_4

8. 1 M nitric acid
   325 mL H2O + 25 mL conc HNO_3

9. 1 M hydrochloric acid
   500 mL + 50 mL conc HCl

10. 0.2 M potassium iodide
    33.2 g KI per liter

11. 0.1 M barium chloride
    24.4 g $BaCl_2C2H_2O$ per liter

12. 0.1 M ferric chloride
    10 mL conc HCl + 27 g $FeCl_3C6H_2O$ per liter

13. 0.1 M silver nitrate
    17 grams $AgNO_3$ per liter

14. 0.2 M sodium phosphate
    76 g $Na_3PO_4C12H_2O$ per liter

15. .02% Markow-Thompson Universal indicator

Dissolve the following in water as one solution:

a. m-Cresol purple .0038%
b. Methyl orange, sodium salt .0028%
c. Bromocresol green, sodium salt .0019%
d. Bromothymol blue, sodium salt .0038%
e. Phenolphthalein, disodium salt .0038%
f. Alizarin yellow R .0056%

16. Starch solution
20 grams soluble potato starch: make a runny paste with cold water
Pour into about 500 mL boiling
water with stirring
Add 1.7 g KI, dissolve
Dilute to 1 liter

Note: When the experiment is finished, discard the solution and wash the bottles!! It molds and will ruin the container. Make fresh each semester.

17. Dry salts in plastic containers
a. KI
b. $Pb(NO_3)_2$

18. Set of unknowns: use original solutions

19. Set of cation unknowns Use nitrate salts of the individual cations
a. Use original solutions for:
1) $Pb(NO_3)_2 = Pb^{2+}$
2) $HNO_3 = H^+$
3) $AgNO_3 = Ag^+$
b. Use the following solutions for:
1) .3M $Al(NO_3)_3 = A1^{3+}$
112.5 g $Al(NO_3)_3.9H_2O$ per liter
2) .3M $NaNO_3 = Na^+$
25.5 g $NaNO_3$ per liter
3) .2M $Cu(NO_3)_2 = Cu^{2+}$
48.3 g $Cu(NO_3)_2.3H_2O$ per liter
4) .1M $Ba(NO_3)_2 = Ba^{2+}$
26.1 g $Ba(NO_3)_2$ per liter
5) .1M Fe $(NO_3)_3 = Fe^{3+}$
10 mL conc HNO_3 and 40.4 g
$Fe(NO_3)_3$ C9 H_2O per liter

20. Set of anion unknowns
    a. Use original solutions for:
        1) $KI = I^-$
        2) $Na_2CO_3 = CO_3^{2-}$
        3) $NaOH = OH^-$
        4) $Na_3PO_4 = PO_4^{3-}$
    b. Use cation unknown solution for:
        1) $NaNO_3 = NO_3^-$
    c. Use the following solution for:
        1) .2M $Na_2SO_4 = SO_4^{2-}$
           64.4 g $Na_2SO_4C10H_2O$ per liter
        2) .2M $NaCl = Cl^-$
           .7 g NaCl per liter

21. Unknown sets of 5 (original solutions)
    Set 1: $AlCl_3$; NH_3; $AgNO_3$; Na_2CO_3; HCl
    Set 2: NH_3; $CuSO_4$; $Pb(NO_3)_2$;
    H_2SO_4; $BaCl_2$
    Set 3: $BaCl_2$; $AgNO_3$; KI;
    H_2SO_4; Na_2CO_3
    Set 4: KI; $Pb(NO_3)_2$; NaOH;
    $AlCl_3$; HNO_3
    Set 5: $FeCl_3$; KI; $AgNO_3$;
    HNO_3; NH_3
    Set 6: NaOH; $AgNO_3$; HCl; $CuSO_4$; $Pb(NO_3)_2$

Per Room:

1. Waste containers
2. Microtowels (1 roll)
3. Cotton swabs (800 per 100 students)

Per Student:

1 - 24-well tray with set of labelled, small drop microburets: $AlCl_3$; Na_2CO_3; $Pb(NO_3)_2$; NH_3; $CuSO_4$; NaOH; H_2SO_4; HNO_3; HCl; KI; BaCl2; $FeCl_3$; $AgNO_3$; Na_3PO_4; UI; starch/KI

1 - 6 oz coffee cup

1 - Straw spatula (Cut a slim straw in half at an angle; snip off sharp tip.)

1 - Microstirrer

5 - Empty microburets (pulled)

1 - Wash bottle

1 - Cut off thin-stem

From Kit:

1 - 24-well tray

Lab top

Magnifying glass

Tweezers

Scissors

Next

Chapter Eight: An Introduction to Acids and Bases

Chemicals:

1. Standardized hydrochloric acid, 2.0M
   173 mL conc HCl per 1 liter solution
   a. Dilute 10 mL to 200 mL volumetrically
      Pipet 10 mL into Erlenmeyer flask
      Add 3-4 drops phenolphthalein
      Titrate with 0.10000 M NaOH(commercial)
   b. Dilute the original solution appropriately so that it is 2.0M

2. 0.10 M hydrochloric acid
   Dilute 50 ml of 1.b to 1 liter volumetrically

3. Unknown hydrochloric acid
   Dilute 150 mL of 1.b above to 1 liter volumetrically (0.30M)

4. 0.1000 M sodium hydroxide
   Purchase commercially

5. Red cabbage extract
   Tear a head of red cabbage into small pieces
   Place in glass beaker and cover with 95% ethanol
   Bring to a boil, 2-3 minutes boiling
   Filter and allow to evaporate to about 1/6 volume, freeze to store
   Dilute 25 mL concentrated extract with 75 mL water

6. Red rose extract. Call your local greenhouses to see if you can get cull roses.
   Remove the petals from the roses, place in a glass beaker
   Cover with 95% ethanol, bring to a boil for 1-2 minutes, filter
   Allow to evaporate to about 1/5, will need to be filtered again, freeze to store
   Dilute with water, needs to be pink (dark)

Note: To check the color of 5 and 6 do section B of the experiment. You need good color changes that are not too dark.

7. 0.03% bromothymol blue
   0.03 grams bromothymol blue, sodium salt per 100 mL

8. Finely powdered eggshell
   Carefully remove all membranes from the eggshell and wash the shell with distilled water
   Place the shells in a beaker in a drying oven at 110ûC for 15 minutes to dry
   Grind the dry shells in a mortar with a pestle to a very fine powder (like powdered sugar)
   Dry in the oven for about 5 minutes and place in a bottle with a tight lid

9. 95% ethanol

10. Fruit juices: orange, lime, lemon from supermarket

11. 1 M sodium hydroxide
    40 grams per liter, volumetrically

Supplies:

1. Filter paper
   Use scraps from the paper chromatography exp. (chap. 18)
   Cut pieces 1/2" x 1 1/2"

2. Microburner supplies (recycle from chap 3)
   5 mm glass tubing, cut 2 inches long
   Cotton string, cut 3 inches long

3. Thin-stem pipets

4. Weighing scoops:
   Cut the bulb of a thin-stem in half lengthwise along the seam. (Use the thin-stems that broke when pulling the microburets or are otherwise not usable for microburets that you have saved.)
   Leave a short stem for a handle if possible.
   Cut off the round end so that the bulb is shaped like a scoop.

Per Room:

Hot water
Balances

Per Student:

1 - Clothespin

1 - Microstirrer

1 - Weighing scoop

1 - Waste cup, 6 oz styrofoam coffee cup

1 - Slim straw spatula (cut straw at an angle)

1 - Thin-stem pipet

1 - Super jumbo straw

3 - Microburets

1 - Wash bottle

From Kit:

1 - 24-well tray, empty

1 - 96-well tray, round bottom

2 - 1 x 12 cell well strips

Lab top

Hand lens

Scissors

Tweezers

Next

Chapter Nine: Halogens and Their Compounds

Chemicals:

1. 1 M hydrochloric acid
   86 mL per liter

2. 0.1 M hydrochloric acid
   8.6 mL concentrated per liter

3. Bleach, full strength

4. Bleach, 50%
   Dilute the full-strength bleach 1:1

5. 0.1 M potassium iodide
   16.6 grams per liter

6. 0.03% bromocresol green
   .03 grams bromocresol green, sodium salt per 100 mL water
   Add dilute (1M) H2SO4 until solution is just orange

7. Starch/KI solution
   Mix 20 grams soluble starch with cold water to make a runny paste
   Pour into about 500 mL boiling water with stirring
   Add 17 grams KI, stir until dissolved
   Dilute to 1 liter
   When experiment is finished, be sure to discard all unused solution. Make fresh each semester

8. 2 M ammonia
   In the hood: 135 mL conc per liter

9. Saturated sodium chloride
   Called "Brine"
   360 grams per liter
   Dispense in wash bottles

10. 0.02 M silver nitrate
    3.397 grams silver nitrate per liter, in a volumetric flask

11. 0.1 M sodium chloride
    5.8443 grams NaCl in a 1 liter volumetric flask

12. 0.1 M potassium bromide
    11.9 grams KBr per liter

13. 1% potassium chromate
    10 grams K_2CrO_4 per liter

14. 0.01 M sodium thiosulfate
    1.5811 grams $Na_2S_2O_3$ per 1 liter volumetric flask

15. Acetic acid, 5 %
    50 mL glacial acetic per liter, or use vinegar

16. Section B dye:
    .03% Bromocresol green, sodium salt
    (use in green form)

    .03 grams Bromocresol green, sodium salt per 100 mL.

Supplies:

1. #20 sewing pins

2. Aluminum foil
   Cut 1 1/2" x 3"

3. Filter paper
   Cut 1" x 2"

4. .9 mm HB pencil leads
   3/4"-1"

5. Cotton swabs

6. Microtowels

7. Whatman #41 filter paper circles
   Use a 1/4" office punch to make the circles

8. Super jumbo straws

Per Room:

1. Empty bleach bottle so they can read the label

2. 9V batteries
   Do not need to be full strength; but not less than 7V

Per Student:

1 - Microstirrer

3 - Empty microburets

1 - Waste cup (6 oz coffee cup)

1 - Wash bottle

2 - Electrical lead with alligator clips

1 - SepCapTM cap

From Kit:

1 - 24-well tray

2 - 1 x 12 well strips

1 - Petri dish

Lab top

Scissors

1/4" office punch

Tweezers

Ruler

Next

Chapter Ten: Natural Waters

Chemicals:

1. EDTA, 2×10^{-4} M
   .0744 grams EDTA, Na salt, $2H_2O$ per liter
   Use a volumetric flask
   Store in plastic bottle

2. $MgSO_4$, 1.0×10^{-3} M
   0.2464 grams MgSO4C7H_2O per liter
   Use a volumetric flask
   Store in plastic bottle

3. Calcium chloride, 1×10^{-3} M
   0.1110 grams $CaCl_2$ per liter

4. 2% tincture of green soap
   Dilute the commercial soap, 2 mL per 100 mL solution

   Sargent Welch
   7400 North Linden Avenue
   P.O. Box 1026
   Skokie, Illinois 60077-1026
   (800-323-4341)

5. Stock solution of 0.005 M $MgSO_4$:
   1.232 g $MgSO_4C7H_2O$ per liter

6. Buffer: NH_3/NH_4Cl/MgEDTA
   1. 100 mL 0.005 M $MgSO_4$ in 1000 mL Erlenmeyer flask
   2. Add 10.8 grams NH_4Cl and dissolve
   3. Add 30 mL conc. (15 M) NH_3
   4. Add small amount Eriochrome Black T indicator
   5. Add about 40 mL 0.01M EDTA and some water
   6. Titrate to endpoint with 0.01 M EDTA (sky blue, no red left)
   7. Do not overtitrate!
   8. Titration needs to be slow as approach endpoint
   9. Dilute to 1 liter with distilled water

7. Buffer: NH_3/NH_4Cl
   NH4Cl: 10.8 grams dissolved in about 500 mL water
   Add 30 mL conc. NH_3 to above after the salt has dissolved
   Dilute to 1 liter with water

8. Hydrochloric acid, 1 x 10^{-4} M
   Dilute 1 mL of 0.1 M HCl (Chapter 8) to 1 liter

9. Eriochrome Black T, 0.03% in water Make fresh daily

10. Mineral waters
    Put these in 250 mL dropping bottles
    Save the empty bottles to be put out for student inspection of labels
    a. Foreign waters:
       Evian¨ Perrier¨ (need to remove the CO_2)
    b. USA waters:
       Your choice (read the label, they need to contain some solids).

11. Local well waters:
    Some need to be hard (20-30 grains per gallon)

12. Commercial water conditioners
    - Arm & Hammer¨ super washing soda
    - Calgon
    - Also set out the box so that the students can read the label

13. Ion exchange resin, Dowex 50W-X8
    Put some in a crystallizing dish with a lot of water and a thick-stem pipet: This is a 9-inch plastic transfer pipet, cut off, leaving about 3 inch stem

14. Box of small pieces of rock:
    - Break the rock with a hammer, sieve through a 1/16" needlepoint plastic
    - Save the large pieces to be broken again
    - Sieve the small pieces through window screen to get rid of the powder
    - Discard the powder, box the small pieces
      1. Limestone
      2. Gypsum
      3. Granite

Supplies:

1. Aluminum foil Cut 2" x 3" (each student needs 1 piece)

2. Wide range indicator paper
   Cut in small pieces, 7 per strip

Per Room:

1. Hot plates or coffee warmers

2. Ice

3. Q-tips

4. Toilet paper

Per Student:

- 5 - Microburets, small drop
- 1 - Microburet, large drop
- 1 - Microstirrer
- 2 - 2-dram shell vials with caps (or any small vial)
- 1 - Wash bottle
- 1 - 6 oz styrofoam coffee cup
- 1 - Straw spatula

From Kit:

- 1 - 24-well tray
- 3 - 1 x 12 well strips
- 1 - Petri dish
- Tweezers
- Hand lens
- File protector
- Plastic insert
- Black background

Next

Chapter Eleven: Vitamin C

Chemicals:

1. Sulfuric acid mixture
   - 100 mL 0.01 M EDTA
   - 80 mL glacial acetic acid
   - 5.62 mL conc H_2SO_4
   - Dilute to 1 liter with water

2. Vitamin C standard
   .500 grams ascorbic acid per liter + EDTA (about .1 g)
   Use volumetric flask, make fresh each day

3. 2, 6 dichloroindophenol
   - 0.250 grams dye
   - 0.210 grams sodium bicarbonate
   - Per liter
   - Use volumetric flask

4. Fruits (1 each per section):
   orange, lime, lemon, grapefruit

5. Cereals (a small box will suffice)
   Total® and Product 19®
   Need 1 flake per student

6. Vitamin C tablets, 100 mg

7. 0.1 M sodium hydroxide
   4 grams per liter

8. 5×10^{-3} M Fe^{2+}
   1.96 grams $Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$
   and 5 mL conc. H_2SO_4 per liter
   Make fresh each semester

Supplies:

1. Filter paper circles
   1/4" office punch
   #541 or #41 Whatman filter paper

2. Box of super jumbo straws

3. Wide range pH paper

Per Room:

1. Balances
2. Paring knives
3. Juicers, 1 per fruit
4. Two-cup measuring cups, plastic (see-through preferable), 1 per fruit
5. 4 100 mL plastic graduated cylinders, 1 per fruit
6. 1 each: lime, lemon, orange, grapefruit
7. 3 plastic funnels
8. paper towel filter paper(4 1/2" x 4 1/2")

Research Project:

1. 5×10^{-3} M Cu^{2+}
   To make 250 mL: .31 grams $CuSO_4.5H_2O$
2. 5×10^{-3} M Fe^{3+}
   To make 250 mL: 3 drops conc HCl (use thin-stem pipet, uncut)
   .34 grams $FeCl_3C6H_2O$
   Make fresh each semester
3. Dry ascorbic acid
4. EDTA (dry)
5. Glassware and supplies on demand

Per Student:

1 - Weighing boat

1 - SepCap™ cap with hole

1 - 6 oz styrofoam coffee cup

1 - Microstirrer

5 - Microburets

1 - Wash bottle

4 - Cut-off (large drop) microburets

From Kit:

3 - 1 x 12 well microstrip

1 - 96-well tray, round bottom

1 - 24-well tray

Lab top

Scissors

Office punch

Per Room for Instructor:

(To prepare the commercial vitamin C tablet solution for Section C.)

1. 1000 mL volumetric + stopper
2. 400 mL beaker
3. Glass stirring rod
4. Wash bottle

Next

Chapter Twelve: Alcohol Abuse - Chemical Tests for Intoxication

Chemicals:

1. Potassium dichromate
   Dissolve 4.00 grams $K_2Cr_2O_7$ in 500 mL water
   Carefully add, with stirring, 500 mL conc. H_2SO_4
   Cool to room temperature
   Dilute to 1 Liter with water

2. 1.00 wt % standard ethanol solution 12.67 mL absolute ethanol per liter volumetric

3. Variety of beer samples

4. Blood samples (optional)
   You can get blood from a packing or slaughter house or from liver (supermarket)
   3 parts blood; 1 part 1.0% ethanol

5. Urine samples (optional)
   Make an artificial sample with an alcohol concentration that will match one of the standards that the students have made.
   For example: 3 parts water; l part 1.0% ethanol

Supplies:

1. Cotton swabs

2. Permanent marking pens

3. Rubber bands (eg., 2 1/2" x 1/32" x 1/8", #31)

4. Make vial stands, enough for 1 per student. Styrofoam is available at craft stores, etc. in 1" thick pieces.

   1. Cut styrofoam 1 inch wide by 8 inches long
   2. Mark long edge at 1.5 cm intervals
   3. Using a pencil, make an indentation at about a 35° at each mark, deep enough to hold the small vial.

5. (Optional)

   Make the apparatus for Section D, Step 6, one per setup (see diagram, page 235)
   You need:
   a. 1-hole rubber stopper to fit the Erlenmeyer flask
   b. 1-hole rubber stopper to fit the condensor
   c. Piece of soft glass tubing, 5 inches long to fit the rubber stoppers. (We use 6 mm OD tubing.)

d. Bend the glass tubing at an angle of about 70-75^{o}
e. Firepolish both ends
f. Insert one end in one stopper and the other end in the other stopper.

6. Microtowels

Per Room:

1. Oven set at 80^{o}C

2. Waste containers
(Note: you can use a Vitamin C solution to reduce the $Cr_2O_7^{2-}$ to Cr^{3+} for disposal)

3. Box of baking soda

Per Student:

1 - Wash bottle

16 - Small SepCapTM vials with caps

1 - Microstirrer

1 - Waste cup

1 - Cut-off (large drop) microburet

1 - Small drop (pulled) microburet

1 - 6 oz. styrofoam coffee cup

1 - Styrofoam stand

1 - 3 oz. plastic cup

(Optional) The following is needed for Section D. One or two sets should be sufficient.

2 - 100 mL beakers

1 - Condensor with tubing

1 - 5 mL pipet

1 - Pipet bulb

1 - 100 mL graduated cylinder
(or 50 mL)

1 - Bunsen burner, ring stand, ring, and wire gauze

1 - Matches

1 - Clamp to hold the condensor

1 - 100 mL volumetric flask with stopper

2 - Rubber stoppers with glass tubing connectors

1 - 125 mL Erlenmeyer flask

From Student Kit:

1 - 96-well tray, round bottom

1 - 24-well tray

1 - 1 x 12 well strip

Lab top

Next

Chapter Thirteen: Kinetic Blues

Chemicals:

1. 0.2 M fructose
   36.032 grams per liter - volumetric
   Make fresh each semester

2. 0.5 M sodium hydroxide
   20.00 grams per liter - volumetric

3. 0.02% methylene blue in 50% ethanol 0.20 grams per liter 50% ethanol, volumetric
   Note: Use 500 mL 95% ethanol plus 500 mL water

Supplies:

1. Labelled microburets
   MB NaOH fructose

Per room:

1. Box of thin-stem pipets
2. Box of super jumbo straws
3. Box of slim straws
4. Clock with second hand
5. Black marking pen
6. Intense light source, eg., overhead projector
7. Ice

Per Student:

1 - 24-well trays with labelled microburets

1 - Small SepCap™ vial and cap

2 - SepCap™ caps

1 - Waste cup

1 - Microstirrer

2 - Styrofoam coffee cups, 6 oz.

2 - Electrical leads

1 - Temperature sensor

1 - Wash bottle

1 - Digital multimeter

From Kit:

1 - 24-well tray

1 - 96-well tray, round bottom

1 - 1 x 12 well microstrip

Lab top

Scissors

Hand lens

Office punch

Ruler

Tweezers

Next

Chemicals:

Solutions 1 - 5 need to be made 1 M and standardized, then make volumetric dilution to the desired molarity.

1. 1 M HCl (use phenolphthalein)
   86 mL conc. HCl per liter

2. 1 M H_3PO_4 (use bromocresol green)
   68 mL 85% H_3PO_4 per liter

3. 1 M H_2SO_4 (use phenolphthalein)
   56 mL conc. H_2SO_4 per liter

4. 1 M CH_3COOH (use phenolphthalein)
   57 mL glacial acetic acid per liter

5. 1 M NH_3 (use methyl red)
   68 mL conc. NH_3 per liter
   Restandardize each semester

Dilute the above standardized solutions volumetrically to make solutions 1–5 below for the experiment:

1. 0.05 M HCl

2. 0.04 M H_3PO_4

3. 0.05 M H_2SO_4

4. 0.05 M CH_3COOH

5. 0.05 M NH_3
   Make fresh each semester

6. 0.05 M sodium bicarbonate
   4.2004 grams $NaHCO_3$ per liter volumetric

7. 0.05 M citric acid
   9.6065 grams per liter volumetric

8. 0.05 M sodium acetate
   4.1015 grams CH_3COONa per liter volumetric

9. 0.010 M sodium hydroxide
   Dilute commercial 0.100 M NaOH
   Make fresh each semester

10. 0.03% methyl orange, sodium salt in water

11. 0.03% phenolphthalein, disodium salt in water Store in glass bottle.

12. 0.03% bromothymol blue, sodium salt in water

13. 0.03% bromocresol green, sodium salt in water

14. Markow - Thompson universal indicator in water (.04%) Weigh each of the following indicators, a - f. All 6 solids are then put together in ONE solution.

    a. m-Cresol purple, 0.0075%

    b. Methyl orange, sodium salt, 0.0057%

    c. Bromocresol green, sodium salt, 0.0038%

    d. Bromothymol blue, sodium salt, 0.0075%

    e. Phenolphthalein, disodium salt, 0.0075%

    f. Alizarin yellow R, 0.0112%

15. Buffer solutions

    •Use a pH meter to check for accuracy.

•Add enough acid or base to obtain the desired pH.

•Dilute to 100 mL (final volume) with water.

•A few crystals of thymol will preserve the buffers.

a. pH 1.0
25 mL 0.2 M KCl
67 mL 0.2 M HCl

b. pH 2.0
25 mL 0.2 M KCl
65 mL 0.2 M HCl

c. pH 3.0
7.4 mL 0.2 M Na_2HPO_4
92.6 mL 0.1 M citric acid

d. pH 4.0:
38.1 mL 0.2 M Na_2HPO_4
61.9 mL 0.1 M citric acid

e. pH 5.0
51 mL 0.2M Na_2HPO_4
49 mL 0.1 M citric acid

f. pH 6.0
62.5 mL 0.2 M Na_2HPO_4 37.5 mL 0.1 M citric acid

g. pH 7.0
82.2 mL 0.2 M Na_2HPO_4
17.8 mL 0.1 M citric acid

h. pH 8.0
97.2 mL 0.2 M Na_2HPO_4
2.8 mL 0.1 M citric acid

i. pH 9.0
50 mL0.1 M H_3BO_3/KCl
11 mL0.2 M NaOH

j. pH 10.0
50 mL 0.1 M H_3BO_3/KCl
22 mL 0.2 M NaOH

k. pH 11.0
50 mL 0.2 M Na_2HPO_4
18 mL 0.2 M NaOH

l. pH 12.0
25 mL 0.2 M KCl
6 mL 0.2 M NaOH

16. Stock solutions for the buffers

a. 0.2 M HCl: 17.2 mL per liter

b. 0.2 M KCl: 14.8 grams per liter

c. 0.1 M citric acid: 19.2 grams anhydrous per liter

d. 0.2 M Na_2HPO_4: 53.6 grams $Na_2HPO_4 \cdot 7H_2O$ per liter

e. 0.1 M H_3BO_3/KCl: 6.2 grams H_3BO_3, 7.5 grams KCl per liter

f. 0.2 M NaOH: 8 grams per liter

Supplies:

1. Thin-stem pipets
2. Transparent tape

For Instructor Demonstration:
(See Section A)

1. Simple conductivity apparatus
2. 0.1 M HCl
3. 0.1 M CH_3COOH
4. 0.1 M NaOH
5. 0.1 M NH_3
6. Distilled H_2O
7. White Vinegar
8. Sugar
9. Salt
10. 8 100 mL beakers

Per Room:

Balances

Per Student:

From Student Kit:

2 - 1 x 12 well microstrip

1 - 96-well tray, flat bottom

1 - 24-well tray

Lab top

3 - Microburets 2 - Large drop (cut-off) microburet 2 - 6 oz. styrofoam coffee cups 1 - Weigh boat 1 – Microstirrer 1 – Wash bottle	

Next

-

Chapter Fifteen: Redox Equilibria and Electrochemistry

Chemicals:

1. 1 M copper sulfate
   249.7 grams $CuSO_4 \cdot 5\ H_2O$ per liter

2. 1 M zinc sulfate
   287.5 grams $ZnSO_4 \cdot 7H_2O$ per liter

3. 1 M tin (II) chloride
   Dissolve 226 grams $SnCl_2 \cdot 2H_2O$ in 170 mL conc. HCl
   Dilute to 1 liter with water
   Make fresh each semester

4. 1 M magnesium sulfate
   246 grams $MgSO_4 \cdot 7H_2O$ per liter

5. 1 M lead nitrate
   331.2 grams $Pb(NO_3)_2$ per liter

6. 1 M iron (II) sulfate
   10 mL conc. H_2SO_4 and 278 grams $FeSO_4 \cdot 7H_2O$ per liter
   •Doesn't keep very well; if solution turns brown, discard. Solution should be green.

7. 1 M aluminum chloride
   241.4 grams $AlCl_3 \cdot 9H_2O$ per liter

8. 0.1 M silver nitrate
   17 grams $AgNO_3$ per liter

9. 1 M potassium nitrate
   101 grams per liter

10. 0.2 M dimethylglyoxime
    12 grams per liter 95% ethanol

11. 3% hydrogen peroxide

12. 1 M ammonium thiocyanate
    76 grams per liter

13. 1 M sulfuric acid
    56 mL conc. H_2SO_4 per liter
    Carefully add the acid to the water with stirring.

14. 0.06 M ferrous ammonium sulfate in 1 M sulfuric acid
Use a volumetric flask:
22.528 grams $Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$ per liter, dissolved in 1 M H_2SO_4

15. 0.01 M ceric ammonium sulfate in 1 M sulfuric acid
Use a volumetric flask:
6.326 grams $Ce(NH_4)_4(SO_4)_4 \cdot 2H_2O$ per liter, dissolved in 1 M H_2SO_4

16. 0.002 M potassium dichromate in 1 M sulfuric acid
Use a volumetric flask:
0.588 grams $K_2Cr_2O_7$ per liter,
dissolved in 1 M H_2SO_4

17. Ferroin indicator
Purchased 0.025 M 1,10-
phenanthroline ferrous sulfate solution
•Dilute 1 part indicator with 2 parts water

18. Diphenylamine sulfonate indicator
•Dissolve: 0.16 grams barium diphenylamine sulfonate in 100 mL water
•Add: 0.5 grams Na_2SO_4
•Filter: Whatman #42

19. Metals: cut 1/4" square
(Metal foils are available from VWR.)

a. Copper foil; .005" thick

b. Zinc foil; .010" thick
A good source:
Strem Chemicals, Inc.
Dexter Industrial Park
7 Mulliken Way
Newburyport, MA. 01950-4098

c. Lead foil; .008" thick

d. Tin foil; .005" thick

e. Magnesium ribbon

f. Iron wire or nails
You can get ungalvanized nails at a hardware store.

g. Aluminum foil
Can use heavy duty foil from grocery store.

h. Silver wire, 24 gauge
A good source is:
D. F. Goldsmith
907 Pitner Avenue
Evanston, Illinois 60202
(ph. 312-869-7800)

We require the students to recycle the Ag.

20. Lead metal strips
Cut 1/4" x 1"

21. Aluminum foil, heavy duty
3 inches square

22. Whatman 3 mm chromatography, 2 cm square This comes in a roll 2 cm x 100 m.

23. Filter paper, 1/2" x 2"
Use the scraps from Chapter 18.

Supplies:

1. Whatman #3, 9 cm

2. Cotton swabs

3. Pencil lead
.5 mm 6H leads, approx. 1 inch long

4. Copper wire
0.02" diameter, cut approx. 1 inch long

5. Digital multimeters
Plus spring clip attachment. If you do not have the attachments, the electrical leads used for the first part of the experiment will work.

6. Microtowels

7. Waste containers

8. A few nickels

Per Student:

3 - Empty large drop microburets

1 - Petri dish

1 - 9V battery

2 - Electrical leads

1 - Wash bottle

1 - Waste cup

From Student Kit:

2 - 24-well trays

2 - 1 x 12 well microstrips

Lab top

Tweezers

Hand lens

Scissors

Ruler

Next

Chapter Sixteen: Acid Deposition

Chemicals:

1. 0.5 M sodium sulfite
   79.6 grams Na_2SO_3 per liter
   Make fresh each semester

2. 2 M sulfuric acid
   112.4 mL conc. H_2SO_4 per liter

3. 0.5 M potassium nitrite
   42.6 grams KNO_2 per liter
   Make fresh each semester

4. 0.5 M barium chloride
   122 grams $BaCl_2 \cdot 2H_2O$ per liter

5. 2 M ammonia
   135.1 mL conc. NH_3 per liter

6. 3% hydrogen peroxide
   Keep in refrigerator when not using

7. 2% starch/ 0.01 M potassium iodide
   20 grams soluble starch
   Make a paste with cold H_2O
   Pour into about 500 mL boiling water
   Add 1.7 grams KI
   Dilute to 1 liter
   Make fresh each semester

8. 0.03% bromocresol green, Na salt
   0.03 grams per 100 mL

9. Red cabbage solution
   Bring red cabbage pieces to a boil in 95% ethanol
   Boil 2-3 minutes
   Filter
   Allow ethanol to evaporate until volume is approximately 1/5 the original volume. Freeze to store
   Dilute with water, approx. 1: 5

10. 0.01 M sodium bicarbonate
    .84 grams $NaHCO_3$ per liter

11. 0.001 M sodium bicarbonate

Dilute (10) 100 mL per liter or 0.084 grams per $NaHCO_3$ per liter

*12. 6 M hydrochloric acid
To 100 mL H_2O, add 100 mL conc. HCl

*13. 6 M ammonia
To 90 mL H_2O, add 60 mL conc. NH_3

*#12 and #13 need to be made fresh for the week (NOT every day) and containers need to be kept separate from other reagents and from each other.

14. 2 flowers, e.g. red roses, geraniums, petunias (or other blue or red flowers)

15. Red cabbage

16. a. Marble, b. Concrete, c. Quartz pieces
    1. Break with a hammer
    2. Sieve through fine screen (window)
    3. Sieve through plastic mesh (counted cross-stitch, about 10 mesh)
       Use this fragment
    4. Save the large pieces to be broken again
    5. Wash the fragments and bottle when dry

    d. Marble dust
       Use the fragment from (2) above

    e. Road dust

    f. Alumina, 8-14 mesh

    g. Magnesium, small pieces

17. Lake waters with sediment

18. Spring water samples

    a. Evian¨

    b. Perrier¨

Supplies:

1. Scotch tape

2. Q-tips

3. Straight pins

4. Micro towels

5. Detergent for washing petri dishes

6. Labelled microburets, 1 per student
   a. .01 M $NaHCO_3$
   b. KNO_2
   c. Na_2SO_3
   d. H_2SO_4
   e. 2 M NH_3
   f. Starch/KI
   g. BCG
   h. .001 M $NaHCO_3$
   i. cabbage

   The 2 M NH_3, 6 M NH_3 and 6 M HCl need to be capped; solutions need to be fresh

8. Ice

9. Waste containers

Per Student:

2 - 6 oz. styrofoam coffee cup

1 - Microstirrer

1 - Cut-off thin-stem

1 - 24-well tray with labelled microburets

4 - microburets

1 - Straw spatula

1 - Wash bottle

From Kit:

1 - 24-well tray

2 - Petri dishes

Lab top

Hand lens

Tweezers

Next

Chapter Seventeen: Semi-Micro Qualitative Analysis and Metal Ions

Chemicals:

The solutions are dispensed in 250 mL dropping bottles, except the conc. (15M) HNO_3. Dry salts are dispensed in a small bottle. We push a micro-spatula through a cork for each dry salt. We use 3 sets of reagents for each room (except the 15 M HNO3).

1. 3 M ammonium acetate
   231.2 grams per liter

2. 6 M ammonium chloride
   320 grams per liter (sat.)

3. 1 M ammonium thiocyanate
   76 grams per liter

4. 0.2 M dimethylglyoxime
   12 grams per liter ethanol (95%)

5. 3% hydrogen peroxide
   Dilute purchased 30%

6. 0.2 M lead acetate
   76 grams per liter

7. 0.5 M potassium chromate
   97.1 grams per liter

8. 0.2 M potassium ferrocyanide
   84.5 grams $K_4Fe(CN)_6 \cdot 3H_2O$ per liter

9. 0.2 M stannous chloride
   Dissolve 45.0 g $SnCl_2 \cdot 2H_2O$ in 170 mL conc. HCl
   Dilute to 1 liter with water
   Add solid tin to preserve

10. 5% thioacetamide
    50 grams per liter

11. Conc. HCl

12. Conc. HNO_3

13. Conc. NH_3

14. 6 M acetic acid
    345 mL glacial per liter

15. 6 M HCl
500 mL conc. per liter

16. 6 M HNO_3
390 mL conc. per liter

17. 6 M NH_3
405 mL conc. per liter

18. 6 M NaOH
240 grams per liter

19. KNOWN SOLUTION
To make 1 liter of solution:
(10 mg ion conc. per mL)

15.8 grams $AgNO_3$
14.0 grams $Hg_2(NO_3)_2 \cdot 2H_2O$ + 11 mL conc. HNO_3
16.0 grams $Pb(NO_3)_2$
16.7 grams $Hg(NO_3)_2 \cdot 1/2H_2O$
37.5 grams $Cu(NO_3)_2 \cdot 3\ H_2O$
27.5 grams $Cd(NO_3)_2 \cdot 4H_2O$
77.0 grams $Cr(NO_3)_3 \cdot 9H_2O$
72.5 grams $Fe(NO_3)_3 \cdot 9H_2O$ + 2 mL conc. HNO_3
50.0 grams $Ni(NO_3)_2 \cdot 6H_2O$
46.0 grams $Zn(NO_3)_2 \cdot 6H_2O$
42.4 mL $Mn(NO_3)_2$ 50% solution

Dissolve the above 11 salts all together in one solution.

20. Make a Group III only solution also
To make 1 L of solution use:

77.0 grams $Cr(NO_3)_3 \cdot 9H_2O$
72.5 grams $Fe(NO_3)_3 \cdot 9H_2O$ + 2 mL conc. HNO_3
50.0 grams $Ni(NO_3)_2 \cdot 6H_2O$
46.0 grams $Zn(NO_3)_2 \cdot 6H_2O$
42.4 mL $Mn\ (NO_3)_2$ 50% solution
Dissolve the above 5 salts together in one solution.

21. Individual solutions for unknowns
These solutions are used to make the unknown samples (30 mg ion per mL) To make 500 mL solution:

a. $AgNO_3$; 24 grams

b. $HgNO_3 \cdot H_2O$; 21 grams + 6 mL conc. HNO_3

c. $Pb(NO_3)_2$; 24 grams

d. $Hg(NO_3)_2 \cdot H_2O$; 25.5 grams

e. $Cu(NO_3) \cdot 3H_2O$; 57 grams

f. $Cd(NO_3)_2 \cdot 4H_2O$; 41.2 grams

g. $Cr(NO_3)_3 \cdot 9H_2O$; 117 grams

h. $Fe(NO_3)_3 \cdot 9H_2O$; 108 grams + 2mL conc HNO_3

i. $Ni(NO_3)_3 \cdot 6H_2O$; 75 grams

j. $Zn(NO_3)_2 \cdot 6H_2O$; 69 grams

k. $Mn(NO_3)_2$; 63 mL (50%)

22. Dry Salts
$(NH_4)_2SO_4$, ammonium sulfate
$NaBiO_3$, sodium bismuthate
$Na_2S_2O_4$, sodium dithionite

23. Litmus paper
Cut in small pieces

24. Dithizone paper
Whatman 3 mm chromatography paper (Chap. 15)
Dip strips in a solution of 0.1 g dithizone in 100 mL acetone
Allow to dry, cut into pieces
Store in a tightly closed bottle (brown). It will keep 6 months or more.

Per Room:

1. Labels
2. Matches
3. #2 corks
4. Centrifuges
5. Extra test tubes
6. 2 microburners per hood

7. Box of 9 inch disposable (glass) Pasteur pipets

8. Waste jars

Per Student:

1 - #0 casserole with cork handle

1 - Each ring stand, ring, wire gauge, burner, matches

1 - 1/2" test tube brush

1 - Test tube rack

4 - Test tube clamps

12 - Test tubes (12 x 75 mm or size to fit centrifuges)

1 - 250 mL beaker

2 - 4 inch stirring rods (4mm)

1 - 2 inch watch glass

1 - 2 mL rubber bulb

1 - 10 mL graduated cylinder

2 - Thin-stem pipets

1 - Waste cup

1 - Wash bottle

Unknowns (1 per student):
Three cations per unknown. 10 - 12 drops of each cation will give the student enough unknown for 3 trials.

The following pages contain the case studies and references that we use with the unknown samples. We randomly number the case studies and then make unknown samples to match. The unknowns contain three cations chosen from the list of possibilities. The student is given the opportunity to choose a case study and is then given the corresponding unknown sample to analyze. Each of the 11 cations must be accounted for, as being either present or absent in the unknown. When the analysis has been finished, a report form is turned in to the instructor. The instructor grades the report, and then gives the reference, including the actual contents of the sample, to the student. The case study and the reference are to be included in the student's laboratory report. You may make copies as needed or rewrite.

Cation concentration is recommended to be 10 mg cation per mL. The solutions are therefore made at 30 mg/mL to allow for dilution when mixed together in the unknown sample. Following are the possible

cations. Use any combination of three cations to prepare the unknown sample.

1. Ni^{2+}, Zn^{2+}, Pb^{2+}, Ag^{+}, Fe^{3+}, Mn^{2+}, Cr^{3+}, Cd^{2+}
2. Cu^{2+}, Cd^{2+}, Hg^{2+}, Pb^{2+}, Ni^{2+}, Zn^{2+}, Ag^{+}, Cr^{3+}
3. Cu^{2+}, Cr^{3+}, Cd^{2+}, Pb^{2+}, Hg_2^{2+}
4. Fe^{3+}, Ni^{2+}, Zn^{2+}, Mn^{2+}, Cr^{3+}, Pb^{2+}, Cu^{2+}
5. Ag^{+}, Pb^{2+}, Hg^{2+}, Cr^{3+}, Fe^{3+}, Cu^{2+}, Hg_2^{2+}, Ni^{2+}, Zn^{2+}
6. Zn^{2+}, Ni^{2+}, Cr^{3+}, Fe^{3+}, Ag^{+}
7. Ni^{2+}, Mn^{2+}, Fe^{3+}, Cu^{2+}, Zn^{2+}
8. Pb^{2+}, Zn^{2+}, Cr^{3+}, Hg^{2+}
9. Ag^{+}, Cr^{3+}, Cd^{2+}, Fe^{3+}, Ni^{2+}, Pb^{2+}, Zn^{2+}
10. Zn^{2+}, Fe^{3+}, Cr^{3+}
11. Ni^{2+}, Cr^{3+}, Fe^{3+}
12. Fe^{3+}, Cu^{2+}, Cd^{2+}
13. Fe^{3+}, Zn^{2+}, Hg_2^{2+}, Hg^{2+}
14. Cu^{2+}, Cd^{2+}, Hg^{2+}
15. Zn^{2+}, Pb^{2+}, Cu^{2+}, Ni^{2+}
16. Cr^{3+}, Cu^{2+}, Fe^{3+}, Cd^{2+}
17. Fe^{3+}, Zn^{2+}, Mn^{2+}
18. Pb^{2+}, Cd^{2+}, Ni^{2+}, Zn^{2+}, Hg^{2+}
19. Zn^{2+}, Cu^{2+}, Fe^{3+}, Ni^{2+}, Mn^{2+}
20. Pb^{2+}, Ag^{+}, Cu^{2+}, Cd^{2+}, Zn^{2+}, Hg^{2+}

21. Zn^{2+}, Cd^{2+}, Pb^{2+}, Hg^{2+}

22. Pb^{2+}, Fe^{3+}, Zn^{2+}

23. Pb^{2+}, Ag^{+}, Zn^{2+}, Cd^{2+}

24. Pb^{2+}, Ni^{2+}, Cd^{2+}, Zn^{2+}, Fe^{3+}

25. Pb^{2+}, Cd^{2+}, Fe^{3+}, Hg^{2+}

26. Pb^{2+}, Cd^{2+}, Cu^{2+}, Zn^{2+}, Hg^{2+}

27. Pb^{2+}, Cu^{2+}, Ag^{+}, Hg^{2+}

28. Ag^{+}, Pb^{2+}, Cu^{2+}, Ni^{2+}, Zn^{2+}

29. Zn^{2+}, Cu^{2+}, Fe^{3+} Ni^{2+}, Mn^{2+}

30. Pb^{2+}, Cd^{2+}, Zn^{2+}, Mn^{2+}, Fe^{3+}, Hg^{2+}

31. Ni^{2+}, Mn^{2+}, Fe^{3+}, Cu^{2+}, Zn^{2+}, Pb^{2+}, Ag^{+}

32. Cu^{2+}, Zn^{2+}, Fe^{3+}, Pb^{2+}, Ni^{2+}, Cr^{3+}

33. Fe^{3+}, Zn^{2+}, Cr^{3+}, Pb^{2+}, Cd^{2+}

34. Pb^{2+}, Zn^{2+}, Cd^{2+}, Mn^{2+}, Ni^{2+}, Cr^{3+}, Cu^{2+}, Fe^{3+}

35. $Fe^{3}{}_{+}$, Zn^{2+}, Cr^{3+}, Pb^{2+}

36. Ag^{+}, Pb^{2+}, Zn^{2+}, Cr^{3+}, Cu^{2+}, Fe^{3+}, Mn^{2+}, Ni^{2+}

37. Ag^{+}, Zn^{2+}, Ni^{2+}, Hg^{2+}, Pb^{2+}, Fe^{3+}, Cr^{3+}

38. Fe^{3+}, Mn^{2+}, Ni^{2+}, Zn^{2+}

39. Cu^{2+}, Zn^{2+}, Mn^{2+}

40. Zn^{2+}, Ni^{2+}, Mn^{2+}, Cr^{3+}, Fe^{3+}, Ag^{+}, Cu^{2+}, Pb^{2+}, Hg^{2+}, Cd^{2+}

41. Zn^{2+}, Fe^{3+}, Cr^{3+}, Cu^{2+}, Ni^{2+}, Mn^{2+}

42. Zn^{2+}, Cu^{2+}, Fe^{3+}, Ni^{2+}, Mn^{2+}, Pb^{2+}, Ag^{+}, Cd^{2+}, Hg^{2+}

43. Ag^{+}, Pb^{2+}, Mn^{2+}, Ni^{2+}

44. Mn^{2+}, Fe^{3+}, Cr^{3+}, Zn^{2+}

45. Cu^{2+}, Mn^{2+}, Zn^{2+}, Cd^{2+}

46. Hg^{2+}, Mn^{2+}, Zn^{2+}

47. Fe^{3+}, Mn^{2+}, Cu^{2+}, Cr^{3+}

CASE NUMBER 1

With the aim of revitalizing Britain's failing oyster production industry, a new oyster hatchery was established at Conway, North Wales in 1966. Using a tested scheme for hatching and larval production, the unit was set up under controlled commercial conditions using filtered estuary water for the tanks containing adult breeding stock, and filtered water in separate tanks for larvae released by the breeding stock. After rearing for about 8 weeks, the larvae settle as spat and are transferred to growing trays in the shallow estuary. A continuous water flow is maintained in the breeding and growing tanks by pumping from an intake at the narrow river end of the tidal region. Since the operating and growing conditions had been proved before the unit was established, a "settling" rate of spat of about 60% was expected as normal. Yet, in a curious and at first unexplained way, the unit suffered cyclic failures in which larval mortality was sometimes close to 100%. Three years of careful water analysis on this type of sample pointed up the problem.

REFERENCE: (i) The Toxic Metals, A. Tucker, Ballantine Books, N.Y., N.Y., 1972, p. 151.
(ii) H. Elderfield, L. Thornton, J. S. Webb, "Heavy Metals and Oyster Culture in Wales", Marine Pollution Bulletin, 2, 3, 1971.

CASE NUMBER 2

Ornithologists estimate that in the single massive "kill" of seabirds in the Irish sea in the autumn of 1969, between 50,000 and 100,000 seabirds died. Most of them were Guillemots, although razorbills and puffins were also among the 17,347 birds recorded after being washed up on the shores of Britain. In spite of comprehensive investigation no specific cause emerged. Indeed it was concluded that the deaths were the result of a combination of factors; the time of year, with the birds weakened after moult; a period of unusually stormy weather for August and September, which had made feeding difficult; the direct effects of starvation on the ability to survive; and the mobilization of various accumulated poisons through loss of flesh. Among these poisons were high concentrations of polychlorinated biphenyls (widely used industrial solvents). This finding was itself disturbing and quite unexpected by ornithologists. No less unexpected, and perhaps more sinister, was the indication of high levels of contamination by a whole range of toxic metals. There was no uniform distribution, but simply a scatter of findings, which showed that from time to time during their lives these birds had been feeding on marine organisms severely contaminated by the types of substances in this sample.

REFERENCE: The Seabird Wreck of 1969 in the Irish Sea, edited by M. W. Holdgate, Natural Environment Research Council.

CASE NUMBER 3

"Another group of chronic disorders may arise from accumulation of one or more non-essential or abnormal trace elements, which man in his infinite wisdom has mined from the earth and spread over its surface. Exposures to them are new, not more than 5,000 years old, but in the last century they have become much wider and heavier, especially during the last 50 years. If homeostatic mechanisms for these elements had not developed during the last half million years because of very low human exposures (ie., lack of need) or were poorly developed because of fairly low exposures, it is unlikely that modern man has evolved them. If not adapted, some of these trace elements, absorbed and accumulating in the tissues with age, may cause biochemical abnormalities leading to disease. They can enter food in amounts larger than "normal" from processing, packages and cases, be dissolved by soft water from pipes, be inspired from air polluted by industrial wastes and automobile exhausts." Your sample contains some of these materials.

REFERENCE: H. A. Schroeder, "Some Prospects for Research on Biologically Active Trace Elements",Trace Substances in Environmental Health, I (Proceedings of University of Missouri's 1st Annual Conference on Trace Substances in Environmental Health), 1967, p. 21.

CASE NUMBER 4

"In studying the biological role of trace elements, we should naturally like to know which of them are essential and which of them are merely accidental inclusions in the tissues of the body. Our success in answering this straight forward question depends on the extent to which we can improve the sensitivity of chemical analysis. Unless we can detect an element and measure its distribution among the tissues of the body, it is unlikely that we shall ever be able to say anything meaningful about its biological purpose. Trace element studies also illuminate and extend the humanist tradition on which modern science is based, for they remind us emphatically of the importance of man in relation to his environment and of the importance of observation (rather than tradition and superstition) as the basis of speculation which leads to scientific advance." Your sample contains some of the biologically important trace elements now under study.

REFERENCE: J. M. A. Lenihan, "Technology and Humanity", Trace Substances in Environmental Health, I (Proceedings of University of Missouri's 1st Annual Conference on Trace Substances in Environmental Health), 1967, p. 141.

CASE NUMBER 5

The following is a quote from a recent book, "The Toxic Metals", by A. Tucker (Ballantine Books 1972). "Further, it is very noticeable that the toxicities of metals (and other environmental contaminants) seem always to be considered singly, a hangover from the laboratory necessity to produce unambiguous figures for lethality in experimental biological systems. Such an assessment has no relevance to the real environmental situation. Contaminants never occur singly, are often additive or even synergistic in their effects and present a gross insult of great complexity and perhaps of enormously enlarged potential for damage. While it is true that all living systems, through their ability to break down poisonous substances into reusable chemical building blocks, have great power of detoxification, provided that the system does not become overloaded. The toxic metals cannot be broken down this way. They do not degrade." Your sample contains a mixture of metal cations typical of those found in a polluted river.

REFERENCE: The Toxic Metals, A. Tucker, Ballantine Books, N.Y., N.Y., 1972, p. 209.

CASE NUMBER 6

Much recent research in trace elements studies has been directed towards elucidating which specific trace elements are essential to life. Smith noted recently that conventional methods of animal experimentation may not produce deficiencies of trace elements required in nanogram (10-9 g) levels, since the animal obtains adequate quantities from non-dietary sources. Such contaminating sources are: cages, food, cups, litter, water bottles, and atmospheric dust. A controlled environment system was developed to prevent such contamination using modified isolators and techniques originally developed from germ free studies. The system provides a barrier against airborne contamination. This was accomplished using thin film plastic isolators supplied with filtered air. The supporting equipment including cages, water bottles, food cups and weighing device were completely plastic minimizing contamination from these sources. Your sample contains materials that certainly would be contaminant arising from a normal animal cage environment.

REFERENCE: J. C. Smith, Trace Substances in Environmental Health, II (Proceedings of University of Missouri's 2 nd Annual Conference on Trace Substances in Environmental Health), 1968, p.223.

CASE NUMBER 7

Recently, in a paper entitled (The Role of Trace Metals in Chemical Carcinogenesis - Asbestos Cancers", D. B. Lowe et al, proposed the following interesting hypothesis concerning asbestos and lung cancer. Asbestos per se plays a passive role in carcinogenesis; the active role is taken by the trace metals with which it is associated. Benzpyrene, or related polycyclic aromatic hydrocarbons, derived from external environmental sources (eg., packing) or from asbestos itself is the carcinogen. Whether cancer develops depends on the residence time of the unmetabolized benzpyrene in the host and the inherent susceptibility of the host. Trace metals commonly associated with lung cancer should inhibit the metabolism of benzpyrene, thus increasing the residence time. Trace metals naturally occurring in the host should accelerate the metabolism, thus ridding the lung of the carcinogen. Your sample contains the metal ions suggested (in the paper by Lowe) as playing a role.

REFERENCE: J. R. Dixon, D. B. Lowe, D. E. Richards, H. E. Stokinger, Trace Substances in Environmental Health, II (Proceedings of University of Missouri's 2nd Annual Conference on Trace Substances in Environmental Health), 1968, p. 141.

CASE NUMBER 8

Metal-binding compounds are being used with increasing frequency for the treatment of many diseases, even though the basis for their use does not always involve the complexing ability of the compound. Even when used for intentional binding of certain metals in vivo, treatment is not always successful. Of the large number of chelating (binding) compounds developed during the past few years, most have had very limited use in biologic applications but a few (eg., BAL - 2, 3-dimercaptopropanol, EDTA - ethylene diamine tetraacetic acid, penicillamine - b, b-dimethylcysteine) have been found to be beneficial in eliminating excessive accumulations of toxic metals from the body. Your sample contains a mixture of types of metals (cations) that have yielded to chelation therapy.

REFERENCE: J. T. McCall, K. G. McLennan, N. P. Goldstein, R. V. Randall, Trace Substances in Environmental Health, II (Proceedings of University of Missouri's 2nd Annual Conference on Trace Substances in Environmental Health), 1968, p. 127.

CASE NUMBER 9

The U. S. Geological Survey is collaborating with the Environmental Health Center of the University of Missouri to provide a description of the natural trace element environment of Missouri for use in their epidemiological studies. The success of such a study will depend to some extent, on the recognition of unnatural or artificial geochemical effects. Because sampling of much of the bedrock geology must of necessity take place in road cuts where bedrock is best exposed, the influence of highway environment on the trace element content of the roadside landscape needs evaluation. Unusual accumulations of Pb in soils and vegetation along highways have been demonstrated in many studies (eg., studies by Cannon and Bowles in Colorado and Maryland demonstrated noticeable increases in Pb contents of plants adjacent to thoroughfares). Such accumulation of Pb in soils and plants adjacent to roadways is generally ascribed to contamination by combustion products of leaded gasoline. Little work has been undertaken however, with regard to possible changes of metal abundance in general in roadside materials. A recent paper by Connor et al analyzed roadside samples for the cations present in your sample.

REFERENCE: J. J. Conner, J. A. Erdman, J. D. Sims, R. J. Ebens, Trace Substances in Environmental Health, IV (Proceedings of University of Missouri's 4th Annual Conference on Trace Substances in Environmental Health), 1970, p. 26.

CASE NUMBER 10

The relationship between the environment and human health and disease, notably between iodine levels and goiter incidence and between water fluoride levels and the prevalence of dental caries and mottled enamel, are highly convincing and are supported by abundant experimental evidence. Numerous other links between the environment and disease of a more serious nature have been proposed. Differential mortality from cancer of the stomach in different parts of England and Holland has been correlated with soil type, and the highest prevalence of total cancer and stomach cancer has been related to particular types of soil in New Zealand. More recently a high inverse correlation has been demonstrated between the selenium status of several states of the USA, as indicated by the average selenium content of different forage crops, and the age and sex-adjusted death rates of the population of those states. It should be emphasized that these associations rest heavily upon correlation rather than causation. This problem has been examined with great thoroughness and conviction by Hill who maintains that an association needs to be studied from nine different viewpoints. These are strength, consistency, specificity, temporality, biological gradient, plausibility, coherence, experiment and analogy. Your sample liquid contains cations which have also been suggested as being connected (in trace amounts) to human and animal health.

REFERENCE: E. J. Underwood, Trace Substances in Environmental Health, IV(Proceedings of University of Missouri's 4th Annual Conference on Trace Substances in Environmental Health), 1970, p. 9.

CASE NUMBER 11

There is now abundant evidence that the growth, health and well-being of man and his domesticated animals are determined, among other things, by the amounts and proportions of the various trace elements to which they are exposed. Intakes of these elements come from ingestion with the food and drinking water and from inhalation of the environmental air. In most circumstances the food provides an overwhelming proportion of total exposure. This does not mean that the water supply and the atmosphere cannot be significant sources of these elements in some areas, or that these sources should not be critically considered in any overall assessment of geographical and geochemical factors affecting health and disease. Indeed, high natural levels of fluoride in the water supplies in many parts of the world have been incriminated as the cause

of endemic fluorosis in man and animals and controlled artificial fluoridation of the water supplies has been exploited widely as a means of reducing the incidence of another tissue in man, dental caries. Some of the other trace elements that are important to man and animals are present in your unknown sample.

REFERENCE: E. J. Underwood, Trace Substances in Environmental Health, IV (Proceedings of University of Missouri's 4th Annual Conference on Trace Substances in Environmental Health), 1970, p. 3.

CASE NUMBER 12

The metal cations present in this sample were recently analyzed for by means of a laser used as a sampling device. In 1962 the laser was proposed as a sampling tool for use in conjunction with emission spectrography by Brech et al. They pointed out that the laser could be used to vaporize a small, precisely defined region of a biological surface, such as teeth, and thereby prepare it for further excitation required for emission spectrography. In 1963 Rosan used this technique to seek metals in dried sections of brain and pancreas. They reported that as little as 10-10 moles of some biologically active cations could be detected, and they emphasized the heterogeneity of biological target areas. Wilson has reported a case of calcinosis cutis in which the laser microprobe was used to sample the skin lesion.

REFERENCE: A. Yunice, E. F. Perry, H. M. Perry, Jr., Trace Substances in Environmental Health, II (Proceedings of University of Missouri's 2nd Annual Conference on Trace Substances in Environmental Health) 1968.

CASE NUMBER 13

Widespread anger developed in Kyushu, Japan during the Minamata affair and, when it became known that the Minamata chemical plant was involved in the release of the wastes, those deprived of a living by the fishing ban and those whose families had suffered casualties several times attacked the factory. Neither the local nor central governments would pay the compensation that was demanded, and at no time have the factory authorities admitted that they were in any way responsible. In Nov. 1959 about 3000 fishermen and other peasant workers stormed the factory, but were eventually beaten off by police. Those identified as leaders of the attack were brought to trial and punished. Finally, local politicians intervened and after negotiations (by its own experiments the company then knew its effluents were to blame) the company agreed to pay token damages. Relatives of adult victims received the equivalent of $250, and those of infant victims $75. In exchange the company denied liability in any way and further demanded that those receiving compensation should sign a document which precluded all action for further compensation even if "at some future time the Minamata disease is proven to be the result of waste water from the plant". The waste liquid analyzed like the type of liquid you have.

REFERENCE: The Toxic Metals, A. Tucker, Ballantine Books, N.Y., N.Y., 1972, p. 44.

CASE NUMBER 14

Recently a U. S. Geological Survey Study was made of elements in soils and other surficial materials taken at a depth of approximately 8 inches at locations about 50 miles apart throughout the conterminous U. S. The samples were analyzed for 30 chemical elements by spectrographic and chemical methods. The analysis of the 863 samples provide for the first time estimates of average abundances of the elements in the United States soils. The chemical data were plotted on maps to show the variation in soil compositions. The most striking feature of the variation map patterns is the sharp contrast between the chemistry of soils of the Eastern and Western states. Another notable feature displayed by the patterns is the paucity of most elements in soils from the Atlantic and Gulf Coastal Plains. Smaller scale features of possible significance can also be

observed, but the low sampling density makes interpretation difficult. Your sample contains some of the main elements the survey chemists were interested in.

REFERENCE: H. T. Shacklette, Trace Substances in Environmental Health, IV (Proceedings of University of Missouri's 4th Annual Conference on Trace Substances in Environmental Health), 1970, p. 69.

CASE NUMBER 15

The increased interest in outdoor recreation within recent years has focused much attention on the quality of the nation's rivers and streams. This situation has been especially true in several areas of Idaho because of pollution by one of Idaho's oldest industries, mining. Due to the complex pollution problem, a broad based study program supported primarily by the Idaho Bureau of Mines and Geology was established to collect, analyze and interpret water quality information from one of Idaho's major rivers which has received mining waste for over 80 years. The Coeur d'Alene River system of northern Idaho is divided into 3 components: the North Fork which supports a healthy aquatic community, the South Fork which has received mining wastes and has been devoid of aquatic life, and the Main Stem which has been affected by the condition of the South Fork. Samples collected from the Coeur d'Alene River over a 16 month period indicate that some metals are above the toxic limits for fish survival. The recent research has also shown that raw sewage discharged into the South Fork throughout its reach is the source of a complex pollution problem. Your liquid sample contains some of the metals discovered to be in high concentrations in the South Fork.

REFERENCE: L. L. Mink, R. E. Williams, A. T. Wallace, Trace Substances in Environmental Health, IV (Proceedings of University of Missouri's 4th Annual Conference on Trace Substances in Environmental Health), 1970, p. 69.

CASE NUMBER 16

In a recent study planned and evaluated by the staff of the Consumer and Food Economics Research Division, the Division of Agricultural Research Service USDA, in the autumn of 1966, 6,000 lunches were collected from 300 schools in 19 states. The lunches were then analyzed for vitamin and trace element content. Schools and states were selected to represent the United States as a whole and the five geographic regions of the National School Lunch Program. During 1964-65 schools in the Southeast served 50 million more lunches than were served in the Midwest, the region with the next highest number. Each day when the lunches were collected any inedible material present, such as chicken bones, was removed from the food. The total edible portion was carefully transferred to containers and frozen for subsequent shipment in the frozen state to the laboratory for analysis. At the lab the lunches were weighed, transferred to a large stainless steel blender and homogenized. One composite was made of all 20 lunches from each school. All composites were kept in frozen storage until analyzed. It was found that the contents of certain trace metals were low, in comparison with current estimates of dietary needs or usual intake as found in other research. Your liquid sample contains some of the trace (here in large quantity) metals that the USDA study was concerned about.

REFERENCE: E W. Murphy, B. K. Watt, L. Page, Trace Substances in Environmental Health IV (Proceedings of University of Missouri's 4th Annual Conference on Trace Substances in Environmental Health), 1970, p. 194.

CASE NUMBER 17

Secondary metabolites consist of an enormous diversity of natural products, narrowly restricted in taxonomic distribution, without known function in growth of the producer cells, and which are formed for a

short period of time by microbial cells that have recently stopped dividing. Of the many thousands of secondary metabolites that have been characterized chemically, those of most interest are compounds toxic either to various microbial species (ie., antibiotics) or to cells and tissues of plants, animals or man (ie., toxine, hallucinogens, etc.). The range of concentrations of trace metals and phosphate, as well as of pH values, temperature and oxygen tension is considerably narrower for efficient production of secondary metabolites than is the range tolerated for growth of the producer microorganisms. Certain trace metal concentrations are especially important in both natural and laboratory environment for secondary metabolism of species of Bacillus, other bacterial genera and also species of yeasts and molds. Trace metals are critical for the production of the bacterial toxins of Pseudonomas, tetanus, diphtheria, staphylococcal food poisoning and dysentary. Trace metal concentrations also control the synthesis of such fungal products as aflatoxin, malformin, fusarial wilt, lysergic acid and ergotamine. The probable site of action of the metals involves transcription or translation of the toxin synthetases. Your liquid sample contains some of the metal cations which are thought to be important in toxigenesis (the production of toxins).

REFERENCE: E. D. Weinberg, Trace Substances in Environmental Health IV (Proceedings of University of Missouri's 4th Annual Conference on Trace Substances in Environmental Health), 1970, p. 233.

CASE NUMBER 18

The major concern of air pollution control and research has been and still is primarily with the so-called "major" pollutants such as sulfur oxides, particulate matter, ozone and related oxidants and carbon monoxide. Interest has been rising, however, about the health hazards of trace substances and a number of research projects are now under way. Although the National Air Sampling Network has been routinely monitoring some 15 trace elements for over a decade, the results have been inconsistent and little attention has been paid to them or use made of them for studies of health effects. A number of potentially toxic elements have been identified in occasional samples of air, but next to nothing is known about their concentrations or chemical form. A major problem in evaluation of the role of airborne elements is that very little is known about ecological cycles from air to food chains and water supplies. In order to adequately plan epidemiologic studies of health effects and in order to intelligently institute standards for control such information is urgently needed. Your liquid sample contains metals that could possibly be transferred from the air environment to the water environment.

REFERENCE: R. E. Carroll, Trace Substances in Environmental Health III (Proceedings of University of Missouri's 3rd Annual Conference on Trace Substances in Environmental Health), 1969, p. 227.

CASE NUMBER 19

The extreme biological consequences of even small changes in the concentrations of the trace elements as well as the very small amounts which are required suggests that their action can only be that of vital links in enzyme systems. The patterns of trace element interaction vary considerably. One element may enhance the function or utilization of another. The interactions may be direct with one element substituting for another, forming compounds with properties disadvantageous to the animal. An element may change the micro-environment, perhaps a change in ion concentration, with resulting attention in the metabolic pathways of a second element. The possibility of interaction becomes almost infinitely complex when elements are integral parts of the same system with both being essential! A deficiency of one element blocks the functioning of the system and the second element is unable to complete the necessary metabolic reaction. One of the many remaining unsolved problems of the metabolism of trace elements in animals concerns the fact that in deficiency conditions, clinical evidence, often severe manifestations, may be exhibited while the level of the trace elements within individual tissues of the animal remain at significant levels. Your liquid

sample contains metal cations thought to interact strongly in biological systems.

REFERENCE: G. K. Davies, Trace Substances in Environmental Health III (Proceedings of University of Missouri's 3rd Annual Conference on Trace Substances in Environmental Health), 1969, p. 135.

CASE NUMBER 20

The following passage was taken from "Water Wasteland" (a Nader Report): "But outfall measurements by themselves may not detect all the pollutants going into a stream, ... in fact outfall measurements without plant inspections are still grossly inefficient. As one Federal investigator pointed out to the Task Force:

Most industries run all their wastes from many different processes together into a single stream sometimes before the discharge point. If you can get into the plant, you can analyze the wastes from different processes to find out their content. But if you can only measure at the effluent outfall, you have to separate out the different constituents. For example, GM (General Motors) has combined wastes in their discharge point. Knowing that plating wastes contain, say cyanide, etc., we would run chemical tests for these elements. But if we could get in the plant and discover that they don't have that particular process, or they run those wastes out somewhere else, we could eliminate that test. That would cut your analysis by more than half in most cases." Your liquid sample contains the cations that would be typical of those in an outfall from a large metal fabrication factory.

REFERENCE: Water Wasteland, A Nader Report, 1971, p. 242.

CASE NUMBER 21

"The Kumanoto investigators got down to their work with commendable speed. Giving first priority to a two-pronged attack aimed at plotting the distribution of the disease and identifying its cause, the scientists set about eliminating one by one the naturally occurring diseases and the compounds whose poisonous symptoms, although in some ways similar, did not fully tie in with those of the Minamata victims. By this time, September - October 1956, events along the coast were giving a decisive lead. Not only cats, but other domestic animals began to go mad and die, the fish in Minamata Bay began to be washed up dying on the shores, and the wild birds which ate them, particularly carrion crows, began to stagger, convulse and die in large numbers. The "disease" was spreading fast. By November, having eliminated contagious encephalitis and other naturally occurring diseases, the study group turned to the possibility of some kind of heavy metal poisoning. The distribution of the disease revealed it to be concentrated primarily along the coast and, with the fish dying, it took no great leap of imagination to suggest a connection between the two. The field of search, although it went on properly to include an examination of drinking water, and of the sewage system, began to narrow down." You can narrow it down much further by analyzing your liquid sample which contains trace metals which could have been responsible for the disease!

REFERENCE: The Toxic Metals, A. Tucker, Ballantine Books, N.Y., N.Y., 1972, p. 21.

CASE NUMBER 22

REINHART v. LANCASTER AREA REFUSE AUTHORITY WELLS (Water Pollution). 201 Pa Super 614, 1931 2d 670-676

This action arose as a result of filling operations on land owned by defendant McFalls and leased by him to the other defendant, Lancaster, for the purpose of dumping refuse thereon. Plaintiffs are appealing the

grant of a judgment now for the defendants following verdicts for money damages in plaintiff's favor in 2 actions of trespass brought for contamination of wells located on their respective properties. The court here reversed the judgment and held that the defendants, in bringing polluted material, particularly items such as garbage, red paint, etc., which might permeate the earth and resist filtration, failed to use due care in handling such material when they placed it in close proximately to plaintiff's land and wells, of which they were aware, and into excavations they had made below the surface of the land, and then compressing it into the ground by running trucks over it. Since they had received general warnings about the results of this operation, the effect on the percolating waters was reasonably foreseeable. The well water might analyze like your liquid sample! Produce evidence for the plaintiff.

REFERENCE: Selected Water Resources Abstracts 2, #3, W69-00845.

CASE NUMBER 23

Rapid development of uranium mining in the Elliot Lake area, Ontario, caused widespread radiological and sewage pollution of the Serpent River system. The widely used acid leaching process of uranium ore treatment produces large amounts of waste, both solid and liquid. For each ton of ore, nearly one ton of tailings and at least two tons, and as much as five tons, of water, acids, trace metals and neutralizers are produced. Not all the uranium and none of the radium-226 is extracted from the ore, so the tailings piles contribute some radioactivity to water passing through them. Some lakes and streams contain more than the safe amount of radium. Leaks in the refining systems also contribute to pollution. All sewage is treated but lake and stream pollution by increased oxygen demand and an increase of nutrients is common and has made one former swimming area obnoxious. No fish can live in Angel and Home Lakes, and algae are present in excessive amounts. Your liquid sample contains the type of cations to be expected in waste liquors from acid ore extraction.

REFERENCE: Selected Water Resources Abstracts, W69-01165.

CASE NUMBER 24

"Just as in the marine environment there are certain organisms which, because they are highly efficient at concentrating metals, can be used as pollution indicator species, so do some plants rapidly concentrate metals from the atmosphere. Indeed some kinds of moss are much more efficient at this than anything man has yet devised. Their unique properties as a kind of exchange resin capable of concentrating at very high efficiency all metallic elements were first exploited as a means of assessing contamination by scientists in Sweden who, alerted by the mercury problem, decided to survey the whole country for airborne contaminants. Such a task might seem virtually impossible, but the value of indigenous natural "sniffers", continually concentrating airborne metals, meant that long-averaged samples of metallic exposure could be obtained simply by analyzing judiciously selected samples on one common species of moss. Air contamination gradients discovered by this method in Sweden showed that, in all probability, the major sources of airborne metallic contamination lay outside the country's own borders, thus raising a controversy about Europe's high industrial chimney philosophy that will not be easily or cheaply resolved." Your liquid sample contains metals (as cations) that are thought to arise as air pollutants and finish up, via fallout, in aquatic systems."

REFERENCE: (i) The Toxic Metals, A. Tucker, Ballantine Books, N.Y., N.Y., 1972, p. 167.
(ii) A. Ruhling, G. Tyler, J. of Applied Ecology 8, 497, 1971.

CASE NUMBER 25

Scientifically and historically, the lack of adequate estuarial studies has arisen because estuary conditions fall into neither of the established areas of aquatic study - freshwater and marine. Dynamically and ecologically, estuaries differ widely, but they share the common fate of being used as open sewers for the disposal of all manner of untreated effluent. And they are dying. Even vast and biologically rich brackish areas like Chesapeake Bay (which might seem large enough to digest any insult), are seriously threatened. But any meaningful evaluation of the situation, whether designed to define present environmental conditions and hazards or to delineate safe latitudes for industrial development, requires a very expensive investment of skilled manpower. Marine biologists cannot work alone in these regions where land and freshwater meet the sea and tidal action. They need the support of fresh water biologists, chemists and biochemists, hydrographers, sedimentologists and geochemists. Industry cannot or will not mount such operations and it is only just dawning on governments that for survival, they are essential. Your liquid sample contains metal ions that have been recently studied in order to elucidate their action on estuarial environments.

REFERENCE: The Toxic Metals, A. Tucker, Ballantine Books, N.Y., N.Y., 1972, p. 155.

CASE NUMBER 26

The following quote was taken from the Nader Report called "Vanishing Air".

"Air pollution (and its fallout on soil and water) is a form of domestic chemical and biological warfare. The efflux from motor vehicles, plants, and incinerators of sulfur oxides, hydrocarbons, carbon monoxide, nitrogen oxides, particulates and trace metal contaminants amounts to compulsory consumption of violence by most Americans. There is no full escape from such violent ingestions, for breathing is required. This damage, perpetuated increasingly in direct violation of local, state and federal law, shatters people's health and safety but still escapes inclusion in the crime statistic. "Smogging" a city or town has taken on the proportions of a massive crime wave yet federal and state statistical compilations of crime pay attention to muggers and ignore "smoggers". As a nation which purports to apply law for preserving health, safety and property, there is a curious permissiveness toward passing and enforcing laws against the primary polluters who harm our society's most valued rights." Your liquid sample contains metal cation fallout that arose from industrial atmospheric contamination.

REFERENCE: Vanishing Air, (A Nader Report), 1971.

CASE NUMBER 27

The calendar of the Limbourgs and indeed their entire cycle in the Tres Riches Heures has become in our time one of the most famous of all works of art, even though, until recently, nearly everyone has known it only in reproductions that blur its subtle light and color or its perfect detail. Such wide popularity is absolutely exceptional for an illuminated manuscript that is closed in a library rather than, like other forms of painting, displayed in a public place. So familiar are the miniatures of the Limbourgs that we may be surprised to learn that they disappeared for 3 centuries, without apparently leaving, during the time, any record of appreciation whatsoever. We know that the Duc de Berry and the painters of the day greatly prized the miniatures. The appraisers of the Duke's estate fixed a relatively high price for the manuscript, which had been only half completed at his death in 1416; and still in the early sixteenth century Flemish illuminators paid tribute to the calendar pictures by imitating figures and entire compositions. Thereafter, like medieval art in general, the manuscript disappeared from history. In 1856 the perceptive founder of the museum at Chantilly bought it from an Italian family. The beautiful colors used in Tres Riches Heures were made from a variety of natural sources, eg., rocks, plants. Your liquid sample contains metal cations, derivatives of which were used by the illuminator of Tres Riches Heures, Paul Limbourg.

REFERENCE: Tres Riches Heures, Original Reproductions (1968).

CASE NUMBER 28

Acid mine drainage, almost all of it from coal mines, pollutes an estimated 10,000 miles of streams in the U. S. An estimated 60 to 70% of the drainage comes from abandoned mines, and about 85% of that amount comes from exhausted underground mines. Mine drainage can be alkaline as well as acidic, but acid drainage is the more serious problem. The formation of acid mine water involves initially the oxidation of pyrite to form in a series of chemical reactions, sulfates, sulfuric acid, iron oxides and probably other compounds. Water that enters the mine dissolves oxidation products, and the resulting acidic solution, which may now contain compounds of several different metals, runs eventually into surface waters. Three forms of oxidation are believed to be involved: chemical, electrochemical, and bacterially catalyzed. The key to the overall rate of oxidation is the reaction of exposed pyrites with moist air. One means of dealing with acid mine water is to prevent or minimize its formation at the source, and this is being practiced by industry. Measures that can be used include flooding or sealing, to prevent air from entering the mine and oxidizing the pyrite. Your liquid sample contains metal ions that might be found in water drainage from an old mine.

REFERENCE: Cleaning Our Environment: The Chemical Basis for Action, American Chemical Society, Washington, D.C., USA, 1969.

CASE NUMBER 29

A great deal remains to be learned about trace element function and toxicity in animals and plants. There are yawning gaps in present knowledge of trace element-water-soil-plant-animal interrelationships. Even when considering a single soil type, local water, a single plant species, one trace element and one species of animal, the complexities are enormous. A host of variables, including the availability of major nutrients, climate and soil acidity, the state of maturity of both plant and animal, the availability of all other trace elements and the form of other elements such as sulfur, have to be included in the picture. In practice the situation is even more daunting for seldom, if ever, are relationships confined to single species. While deficiency disease and symptoms of poisoning tend to show up fairly rapidly in animals such as sheep and cattle which are confined to specific areas, enormous variations of trace element uptake can be produced by commonplace activities, such as fertilizer treatment of soil, for fertilizers may be rich in a potentially toxic trace element, and in any case may lead to major changes in the pattern of plant growth. Different plants have different trace element uptake. Quite apart from leading to marked variations in the availability of trace elements to a feeding animal, plants may also contain other biologically active compounds which block the utilization of important trace elements within the animal. Your liquid sample contains some of the cations which have been found to be important in animal nutrition.

REFERENCE: The Toxic Metals, A. Tucker, Ballantine Books, N.Y., N.Y., 1972, p. 143.

CASE NUMBER 30

The term trace-element comprises some 25-30 elements which were, because of the coarseness of analytical techniques, detected in amounts so small that they were described simply as "traces" in early analysis of living tissues. With advances in technique and in the understanding of the biological roles of some metals, there has been a tendency in the English-speaking countries to refer to the essential metals as micronutrients, thus splitting off a small and as yet incomplete group from the others which are either benign or poisonous. This sounds tidy but may be misleading for, in nature, things tend to be much too complicated to be compressed into simplistic categories. Cross interferences, such as blocking or potentiating ability, can in differing circumstances transfer a metal from one category to another. The micronutrient may be capable

of poisoning the system, and the toxic element may be better tolerated in some circumstances than in others. One at least, arsenic, although traditionally regarded as the most potent of metallic poisons, is of relatively low mammalian toxicity when compared to some of the other trace elements. Your liquid sample contains several metal cations that are now regarded as being extremely important in biological systems.

REFERENCE: The Toxic Metals, A. Tucker, Ballantine Books, N.Y., N.Y., 1972, p. 140.

CASE NUMBER 31

Certain trace elements which are strongly associated with air pollution sources in the Lake Michigan basin may be contributing significantly to lake water pollution by an atmospheric fallout route. A partial inventory of air pollution emissions for 30 trace elements has been made for the Chicago, Milwaukee, and northwest Indiana metropolitan areas, based on available published information, and compared with natural and pollution stream trace element inputs. Evidence indicates that the atmosphere may be the major source of several trace metals in Lake Michigan. Moreover, the evidence suggests that air pollution probably exceeds expected unpolluted stream inputs for many additional elements in Lake Michigan, highlighting the need for more comprehensive chemical data to quantify the evaluation. Your liquid sample contains several of the cations that appear to constitute fallout into aquatic systems from the atmosphere.

REFERENCE: J. W. Winchester, G. D. Nifong, "Water Pollution in Lake Michigan by Trace Elements from Pollution Aerosol Fallout", Michigan University, Ann Arbor. (from Selected Water Resources Abstracts, W71-08764).

CASE NUMBER 32

At present some 86 fossil fuel plants are discharging their thermal effluents into the waters abounding the east coast. By 1980 power needs will require 200 billion gallons of water per day or approx. one sixth of our annual nationwide runoff and nearly 32% of all power stations will be adjacent to various estuaries. By the year 2000, utility companies will be utilizing almost twice the national fresh water runoff and a lifetime supple of either 10 million tons of uranium or 100,000 million tons of coal. Advanced nuclear reactors, highly more efficient, will be needed to ensure the safety of our waterways. Fossil-fueled plants are approx. 40% efficient, whereas nuclear fueled plants tend to be less efficient, at 33%. A 1000 mw nuclear fueled plant will utilize nearly 1.3 billion gallons of water per day. Though one plant may raise the temperature only a few degrees within a limited area from the discharge canal, an accumulation of heated effluent from multiple units could prove disastrous for many miles, especially during critical periods of the year. Your liquid sample contains cations that probably would constitute waste effluent (besides thermal pollution) from a power plant.

REFERENCE: Selected Water Resources Abstracts, W71-00255.

CASE NUMBER 33

One of the greatest earthquakes of all time struck south-central Alaska on March 27, 1964. In some coastal areas, local subsidence was superimposed on regional tectonic subsidence to heighten the flooding damage. Ground and surface waters were measurably affected by the earthquake, not only in Alaska but throughout the world. Much new and corroborative basic geologic and hydrologic information was accumulated in the course of the earthquake studies, and many new or improved investigative techniques were developed. Chief among these were the recognition that lakes can be used as giant tiltmeters, the refinement of methods for measuring land-level changes by observing displacement of barnacles and other sessile organisms, and the relating of hydrology to seismology by world-wide study of hydroseisms in surface

water bodies and in wells. Your liquid sample contains cations which increased in concentration in lakes as a result of earthquake activity.

REFERENCE: E. B. Eckel, "The Alaskan Earthquake, March 27, 1964, Lessons and Conclusions", Geological Survey, Washington, D. C. (from Selected Water Resources Abstracts W71-03706).

CASE NUMBER 34

In 1968 the Canada Center for Inland waters undertook a systematic monitoring of Lakes Ontario, Eric, Huron and Superior in a study of the major and trace elements. The data gathered on major elements during the period July to November, 1968, were examined and the results compared on a lake-wide basis with earlier compilations to appraise recent trends and changes in the composition of these waters. Because the concentrations of all major ions for which data are available in Lake Superior have not changed for the last 70-80 years, their levels are apparently controlled by the runoff from the drainage basin and that lost through St. Mary's River. Chloride and sulfate have increased in Lake Michigan and Lake Huron. This increase is most likely caused by human activities. In Lakes Erie and Ontario all the major ions except bicarbonate and magnesium have shown a dramatic increase since 1910. Previous to that the lakes were essentially unaffected by human activities. The median values of minor elements are generally below 10 micrograms/liter in the Great Lakes. Sorption by oxides of manganese, etc., and by suspended organic and inorganic material seems a plausible mechanism for the removal of minor elements from the lakes. Your liquid sample contains some of the cations that were monitored in this particular study.

REFERENCE: Selected Water Resources Abstracts W71-05883.

CASE NUMBER 35

Soil erosion and sediment deposition in urban areas are as much an environmental blight as badly paved and littered streets, dilapidated buildings, billboard clutter, inept land use, and air, water and noise pollution. In addition, sediment has many direct and indirect effects on streams that may be either part of or very remote from the urban environment. Sediment, for example, is widely recognized as a pollutant of streams and other water bodies. Much of the disturbed soil in urban construction areas erodes and becomes sediment in streams; the sediment damages water control works and aquatic habitat, degrades water quality, increases flood damages, and lowers the environmental attractiveness. During the process of stabilization of an area after construction, streams tend to erode their beds and banks as a result of increased runoff. Documentation of erosion sources and amounts, of sediment concentration in runoff, of stream channel changes, and of the location and amounts of deposition together with an economic analysis of sediment damages and a pertinent research program provides the knowledge needed to find the best solutions to a wide variety of existing and future urban sediment problems. Your liquid sample contains metal ions thought to be of paramount importance in water pollution arising from urban erosion.

REFERENCE: H. P. Guy, "Geological Survey Circular", 601-E, 1970, (from Selected Water Resources Abstracts W71-00393).

CASE NUMBER 36

Spend liquor (steel industry pickling waste) is an aqueous solution containing from about 0.5 to 10% acid, perhaps 12% iron and several other metals. Either undissolved or in solution, if discharged untreated to a waterway it is a three fold menace, first for its acid content, second for its iron content, and third for its content of other metals. Depending on the chemical and physical form of the metals, the liquor may turn the waste muddy brown, deposit slime, and exert a strong oxygen demand. Huge amounts of pickling acid, 35 to

40 lbs. for every ton of steel, are used in the finishing operations. It is estimated that 8 to 15 gallons of spend liquor are produced per ton of steel pickled. Since 50,000,000 tons of steel are pickled each year, spend liquors are produced at a rate of half a billion gallons per year. They are essentially six types of approaches that can be taken for the disposal of spend pickle liquor: (1) discharge to a waterway, (2) deep well disposal, (3) neutralization, (4) hauling by contractor, (5) recovery processes, (6) regeneration processes. The fact that a few of the available recovery and regeneration methods are in actual use in the steel industries seems to be a reflection not so much on the technical uncertainties of these methods but of the fact that much simpler if less effective ways of disposal are still open, consistent to whatever local regulations are in effect. Your liquid sample constitutes the type of waste water (spend liquor) a typical steel pickling plant might put out.

REFERENCE: Environmental Science and Technology, 4, 5, 1970.

CASE NUMBER 37

The "New Lead Belt" of southeast Missouri, predicted to be one of the largest lead deposits in the world, extends from just west of Ellington on a due north line to Vibinnum. At present this area is one of sparse population and relative wilderness, with rugged hills and swift, crystal-clear streams. It was anticipated that the lead mining activity would stimulate a sharp increase in industrial activity in this area. Here then was a potential "before-after" study in pollution. It was presumed that this intense mining activity could cause significant contamination in the stream waters by heavy metals, notably primary ore metals. Analytical methods for such metals have been developed using atomic absorption spectroscopy. The data obtained from these analyses have been arranged in histograms and critically analyzed. The background concentrations were established to 4-6 ppb (parts per billion) for several of the metals. Both short and long term contamination was identified by using data distributions. Your liquid sample contains metal ions of importance in this particular "New Lead Belt" pollution study.

REFERENCE: N. H. Tibbs, "The Background Concentrations of Metals in Streams on the New Lead Belt, Missouri", Missouri University. (from Selected Water Resource Abstracts W71-04182).

CASE NUMBER 38

The quantity and quality of drainage waters were significantly altered following deforestation of a northern hardwood's watershed ecosystem. Annual water runoff exceeded the expected value (based on undisturbed watershed) by 39% during the first water year after deforestation and by 28% during the second. Deforestation resulted in large increases in concentrations of all major ions except ammonium, sulfate, and carbonic acid. Sulfate was the only major ion that decreased after deforestation. In undisturbed watershed, stream water has a pH of about 5.1 from sulfuric acid, whereas after deforestation it became a nitric acid solution of pH 4.3 enriched in metallic ions and dissolved silica. The increase in nitrate concentration in precipitation may somewhat increase air pollution. Greatly increased export of dissolved nutrients from deforested ecosystems was due to an alteration of the ecosystem nitrogen cycle. Increased availability of nitrate and hydrogen ions resulted from nitrification. Total new export of dissolved inorganic substances was 14-15 times greater than from natural ecosystems. The deforestation experiment resulted in significant pollution of the drainage stream with nitrate concentration exceeding the maximum recommended for drinking water. A bloom of algae appeared each summer. This liquid sample contains material (in cation form) found in runoff from a deforested watershed.

REFERENCE: Selected Water Resources Abstracts, W71-01489.

CASE NUMBER 39

Of all the dams built by rich nations for poor nations hoping to grow richer that way, the one built by Soviet Russia for Egypt is in a class of its own. The High Dam at Aswan is the biggest and most expensive in the world. It made the late President Nasser's political fortune, but spread such ecological havoc that his country may never get over it. The dam, built without sluices, traps approx. an annual 100 million tons of Nile sediment "containing volcanic materials which produce the most fertile soil on earth". Since practically all cultivated soil in Egypt was formed and nourished by the sediment, for which no adequate man-made substitute has been devised, the lack of it strikes at the heart of Egyptian agriculture. Without the Nile sediment, much of Egypt's six million cultivated acres need chemical fertilizer already. In fact, agriculture is now absorbing 2,350,000 tons of artificial fertilizer so far. Two-thirds of it, according to Egyptian and World Bank calculations, is the amount needed to make up for lost fertility and mineral content once supplied by the silt. The cost of just this much comes to upwards of a hundred million dollars a year, cutting about a fifth of the average income from the yield per acre, quite a cut for a farmer earning perhaps $75 a year. This is a recurrent, annual expense for eternity. Your liquid sample contains cations important in the Nile Delta agriculture.

REFERENCE: Our Chemical Environment, J. C. Giddings, M. B. Monroe, Canfield Press (Harper and Row), San Francisco, 1972.

CASE NUMBER 40

Earth is a metal rich planet in a metal poor universe. The core of our planet, by all evidence is mainly metal. The crust of the earth is nearly one quarter metal. This metal-laden spaceship is a mere speck, all but lost in a vast universe composed principally of the non-metals hydrogen and helium. Metals may not dominate outer space but they dominate the chemical space of the periodic table. Of 105 known elements, 83 are metals. Many of the heavy metals have a voracious chemical appetite for sulfur. They are largely combined with sulfur in the earth's natural ore bodies and when they inadvertently enter a living organism they relentlessly seek out the sulfur of that organism's enzymes. The crucial catalyst-regulators of life chemistry are dotted with sulfur atoms, and they become the natural targets of heavy metals. The subsequent chemical bonding between enzyme, sulfur, and the heavy-metal intruders destroys enzyme function and then sickens and kills. For us the rich metal environment of earth is a two-edged sword. The positive side has long been recognized. Only recently have we been made aware of the negative side: some metals, when released widely to the environment, can be dangerous and ecologically disrupting. Your liquid contains biologically important cations.

REFERENCE: Our Chemical Environment, J. C. Giddings, M. B. Monroe, Canfield Press (Harper and Row), San Francisco, 1972.

CASE NUMBER 41

Present programs for controlling potential threats to health from new substances and technological innovations are doomed to failure because we lack the scientific knowledge to provide a sound basis for control. Current testing techniques have been developed almost exclusively for the study of acute, direct toxic effects. In contrast most untoward effects of the technological environment are delayed and indirect...yet little is being done in schools of medicine and public health or in research institutes or government laboratories to develop the kind of knowledge that is needed for evaluating long-range effects on man of modern ways of life. There is no need to belabor the obvious truth that while modern science has been highly productive of isolated fragments of knowledge, it has been far less successful in dealing with the complexity of natural phenomena, especially those involving life. In order to deal with problems of organized complexity it is therefore essential to investigate situations in which several interrelated systems function in an integrated manner. Multifactorial investigations will naturally demand entirely new conceptual

and experimental methods very different from those involving only one variable which have been the stock in trade of experimental science during the past 30 years and to which there is an increasing tendency to limit biological research. Your liquid sample contains cations that are known to exhibit interrelated functions in biological systems.

REFERENCE: R. Dubos, Medical Tribine, Oct 28, 1964.

CASE NUMBER 42

Recent research in the solid-waste area has focused on developing methods that may alleviate serious water pollution problems for the nearly 20,000 metal-plating and coating facilities across the nation. Electroplating and metal finishing wastes are significant stream pollutants - either directly, owing to their content of toxic and corrosive materials such as cyanide, acids and metals, or indirectly, owing to the deleterious effect of these components on sewage treatment systems. Bureau of Mines researchers have shown that reducing an organic-cyanide electroplating waste with formaldehyde (HCHO) will cause certain metals to coprecipitate while destroying all of the poisonous cyanides. Another method which is even more promising employs two plating waste solutions to recover metals. Processes have also been developed for recovering expensive metals from cuttings and grindings left over when "super-alloy" jet engine parts are machined. Such scrap containing a variety of metals has a metal content worth nearly $1000 per ton. It is regularly sold to overseas markets for far less because of the high cost of separating and recovering the metals by methods now available in the U. S. Your liquid sample contains metal ions typical of those generated in the electroplating industry and which normally finish up in aquatic systems.

REFERENCE: C. B. Kenahan, Environmental Science and Technology, 5, 594, 1971.

CASE NUMBER 43

The Bureau of Mines has recently been active in researching methods for reclaiming valuable materials from mining, metallurgical, chemical, and industrial processing operations. This work not only includes salvage and reuse, but also stabilizing nonusable mineral waste. A large scale effort has been made to stabilize the waste tailing piles from mining operations that have no utilization values. These wastes are often air, water and land pollution sources. Successful chemical and vegetative techniques have been demonstrated on uranium mill tailing piles. Thirty four acres of uranium leach plant residues, located on the Navajo Indian Reservation in Arizona have been effectively stabilized against wind erosion using a low cost chemical method developed by Bureau scientists. In Durango, Co., another 13 acre plot of waste uranium tailings was stabilized under vegetative cover. West Virginia University developed a process for producing rock wool insulation from coal ash slag, a waste product from coal-fired central power plants. Commercially competitive structural concrete blocks have also been fabricated. Stanford University researchers (under a Bureau grant) demonstrated the technical and economic feasibility of producing stream cured calcium silicate bricks from California gold mine waste. Your liquid sample contains metal ions that are common in waste liquid effluents from mining and metallurgical operations.

REFERENCE: C. B. Kenahan, Environmental Science and Technology, 5, 594, 1971.

CASE NUMBER 44

About 3.6 million tons of solid wastes are generated each year in the U. S. Agricultural wastes constitute nearly two-thirds of the total, and mineral wastes account for most of the rest. Mineral wastes, not including the large amounts of overburden removed in surface mining but including those wastes generated by mining, processing and utilization of all minerals and fossil fuels amount to about 30% of the total

wastes. Fuels account for only 125 million tons, or about 3% of all solid wastes generated. The last complete survey of mining operations in the U. S. indicated that in 1964 about 3.2 million acres of land had been disturbed by surface mining. Of this total about 41% resulted from coal production. As yet only a few tenths of 1% of the total land area of the U. S. has been disturbed by surface mining. The effects of such mining on the environment, however, vary widely and depend upon such factors as the type of mining, characteristics of overburden, steepness of terrain, amount of rainfall and temperature. Where land reclamation is not practiced water pollution from acid mine drainage and silt damage occur. It is possible, however, to prevent much of this damage through proper land reclamation, adequate drainage and planting to achieve soil stabilization. In the principal coal mining areas the average costs of completely reclaiming coals land range from $169 to $362 per acre, an average cost of 4 to 8 cents per ton. Your liquid sample contains metal ions leached from mine tailings in a coal mining area.

REFERENCE: A. Mills, H. R. Johnson, H. Perry, Environmental Science and Technology, 5, 30, 1971.

CASE NUMBER 45

The presence of trace elements in public water supplies has long been of interest to physicians, public health chemists, biologists and others alike. For some, this interest has been due to the beneficial effects exhibited by certain trace elements. For others, interest is related to the threats to human health posed by the presence of minute amounts of toxic elements. The list of those elements already recognized as important water quality parameters lengthens as research into the basic character of water quality progresses. Through the use of highly sophisticated instrumentation such as emission spectroscopy, activation analysis and more recently, atomic absorption spectrophotometry, it is now possible to determine accurately smaller and smaller concentrations of these trace elements. This painstaking research is of the utmost practical significance because it provides the essential information that enables health authorities to establish realistic limits or tolerable concentrations of the various elements in drinking water. The physiological significance of each trace element found in water must be evaluated in terms of the total human environment. The amount tolerable in water is often dictated both by the intrinsic potency of the substance as well as by its possible occurrence in other areas such as the atmosphere and in foods. Your sample contains cations for which the USPHS recently revised water quality standards.

REFERENCE: J. F. Kopp, Trace Substances in Environmental Health III (Proceedings of University of Missouri's 3rd Annual Conference on Trace Substances in Environmental Health), 1969, p. 59.

CASE NUMBER 46

The coastal margin -- the ribbon of land and water where people and oceans meet and are profoundly influenced by each other -- has only recently come to be recognized and treated as a valuable and perishable resource. It is actually a complex of unique physical resources: estuaries and lagoons, marshes, beaches and cliffs, bays and harbors, islands and spits and peninsulas. In the year 2000 half of the estimated 312 million population of the U. S. will live on 5% of the land area in three coastal urban belts: the megalopolises of the Atlantic, the Pacific and the Great Lakes. Along with the people will come an intensification of competing demands for the limited resources of the narrow fragile, coastal zone. To make matters worse, the coastal resource is shrinking under the pressure of natural forces (hurricanes have caused $5 billion in damage to the U. S. economy in the past 15 years) and human exploitation and neglect. More than a tenth of the 10.7 million square miles of shellfish-producing waters bordering the U. S. is now unusable because of pollution. Dredging, drainage projects and even chemical mosquito control programs are having devastating effects on fish and other aquatic life. The amount of industrial waste reaching the oceans will increase sevenfold within a decade. Your liquid sample contains cations that have recently been detected in large amounts in waste

water pouring into the Savannah River.

REFERENCE: E. Wenk Jr., Scientific American, September, 1969., p. 83.

CASE NUMBER 47

Areas of anomalous metal content in soils and plants have been shown to be associated with several kinds of geologic environment. The following table shows excesses and deficiencies to be expected in areas marked by geochemical differentiation.

	Unique Geologic Environments	Possible Deficiencies in Geologic Unit	Possible Excess in Geologic Unit
a)	Limestones	Mo, Sr, Ca, Mg	P, K
b)	Drift (Glaciated)	Zn, Sr, Mo, Co, B, Mg Ti, Fe, Cr, Ni, Zn, Pb P, I	
c)	Peat bogs	Cu (unavailable)	Zn, Cu, Pb, Cd
d)	Serpentine	N, P, Ca, Mo, Mn	Ni, Cr, Mg, Fe
e)	Uranium deposits Colorado Plateau		U, V, Se, Mo

Your liquid sample contains metal ions thought to be deficiencies in coastal plain sands.

REFERENCE: H. L. Cannon, Trace Substances in Environmental Health, III (Proceedings of University of Missouri's 3rd Annual Conference on Trace Substances in Environmental Health), 1969, p.21.

Next

Chapter Eighteen: Chromatography - Paper and Liquid Chromatography

Chemicals:

We dispense #1 and #2 in 500 mL bottles with a 1-hole rubber stopper and a 9 inch plastic pipet

1. 1-propanol/water
   2 parts 1-propanol plus 1 part water
   (eg. 1000 mL 1-propanol plus 500 mL water)
   Note: You can use 2-propanol instead of 1-propanol.

2. Hexane

3. Food dyes: 1% in water
   a. Red #3
   b. Red #40
   c. Blue #1
   d. Blue #2
   e. Yellow #5
   f. Yellow #6
   g. Green #3

   Food dyes are available in 3 oz. sample sizes from:

   Seltzer Chemicals, Inc.
   5931 Priestly Drive
   Carlsbad, CA 92008-3861
   (619-438-0089)

   7 dyes, 2 grams each ($15.00 plus $2.00 shipping) are available from:

   Rainbow Colors
   203-871-2033

4. You can make your own shades from the following chart of typical color formulations. Choose a few.

Shade	FD&C Dye	% of Blend
Orange	Yellow #5	95
	Red #40	5
Cherry	Red #40	99
	Blue #1	1
Strawberry	Red #40	95
	Red #3	5
Lemon	Yellow #5	100
Lime	Yellow #5	95

	Blue #1	5
Grape	Red #40	80
	Blue #1	20
Raspberry	Red #3	75
	Yellow #6	20
	Blue #1	5
Butterscotch	Yellow #5	74
	Red #40	24
	Blue #1	2
Chocolate	Red #40	52
	Yellow #5	40
	Blue #1	8
Caramel	Yellow #5	64
	Red #3	21
	Yellow #6	9
	Blue #1	6
Cinnamon	Yellow #5	60
	Red #40	35
	Blue #1	5
Peach	Red #40	60
	Yellow #6	40
Cheddar Cheese	Yellow #5	55
	Yellow #6	45
Tea, Cola	Yellow #5	70
or Root Beer	Red #40	25
	Blue #2	5

---

5. Commercial food dyes (grocery store)

6. Buffers
   Use a pH meter for accuracy, adding only enough NaOH to reach the desired pH.
   Dilute to 100 mL with water.
   A few crystals of thymol will help preserve the solutions.
   a. pH 7.0
      50 mL 0.1 M KH_2PO_4
      29 mL 0.1 M NaOH

   b. pH 8.0
      50 mL 0.1 M KH_2PO_4
      46 mL 0.1 M NaOH

   c. pH 9.0

50 mL 0.1 M H_3BO_3/KCl
21 mL 0.1 M NaOH

d. pH 10.0
50 mL 0.1 M H_3BO_3/KCl
44 mL 0.1 M NaOH

e. pH 11.0
50 mL 0.2 M Na_2HPO_4
36 mL 0.1 M NaOH

7. Stock solutions for buffer
   a. 0.1 M KH_2PO_4: 13.6 grams per liter
   b. 0.2 M Na_2HPO_4: 28.4 grams per liter

   c. 0.1 M NaOH: 4 grams per liter

   d. 0.1 M H_3BO_3/KCl: 6.2 grams H_3BO_3, 7.5 grams KCl per liter

8. Nicotine standard
   1% in water **HANDLE WITH CARE**
   Few drops permanent red ink

9. Dragendorff's reagent (shelf life is 2 weeks or more)
   a. 0.21 grams $Bi(NO_3)_3$ in 10 mL water (not soluble)

   b. 4 grams KI in 10 mL water

   c. 20 mL glacial acetic acid

   Mix a, b, c and add 100 mL water.

10. Silica gel 100-200 mesh (100 grams)

11. 0.05 wt.% bromocresol purple, sodium salt

12. Dye mixture A in water (make fresh each semester)
    0.02% violet #1
    (Since this has gone to press, Violet #1 is no longer available. We are attempting to find a substitute. Until then, methyl red sodium salt can be used)
    0.05% blue #1
    0.05% red #2 (Amaranth)

13. Dye mixture B in water (make fresh each semester)
    0.02% violet #1
    (Since this has gone to press, Violet #1 is no longer available. We are attempting to find a substitute. Until then, methyl red sodium salt can be used.)
    0.05% blue #1
    0.05% yellow #5

14. 0.1 M acetic acid

5.7 mL glacial acetic acid per liter

15. 30% ethanol
    700 mL water, 300 mL 95% ethanol

16. Beet extract
    Can use fresh beets or juice from canned beets

17. Cigarette extract
    •Weigh 8 grams tobacco and place tobacco into an Erlenmeyer flask

    •Add .2 grams $Ba(OH)_2$, 100 mL chloroform, 100 mL water

    •Stopper flask and shake vigorously for 3-4 minutes

    •Filter the extract using Whatman #41
    •Seperate-save lower layer
    •Evaporate extract to dryness

    •Dissolve the residue in 20 mL H_2O. Add enough $Ba(OH)_2$ to make the solution basic (approx. pH 8-9). The solution may need to be filtered again.

Supplies:

1. Flair® pens (all colors available)

2. Staplers, eg., Tot® or other small stapler

3. Staples to fit

4. Sheaffer® ink cartridge pens for the nicotine standard and cigarette extract
   •Use a microburet to remove the ink from the cartridge and wash. (I recommend red ink cartidges, but is not necessary)

   •Fill the cartridge with the nicotine standard or cigarette extract

   •Make sure the pens are writing

   •If you prefer, the cigarette extract can be dispensed in a small container such as one well of a 1 x 12 well microstrip and the students use a plastic applicator to apply the shots to the chromatography paper.

   •Whether you use the pen or the plastic applicator, the student needs to touch the tip to the paper long enough to allow the sample to transfer to the paper. Spotting the cigarette extract twice is probably necessary to get a good chromatograph.

   •Take the pens apart when experiment is finished, wash the nibs, empty the cartridges

5. Applicators for spotting the chromatograms: Use the thin, pulled out stem scraps cut from the pulled microburets. (This is the part with the very small diameter that you saved from Chapter 3). Cut pieces about 1 1/2 inches long. Each student needs one, but they are easily lost. Paper applicators are also acceptable.

If you did not save these, or do not have enough, you can make them easily by pulling the stem of the thin-stem pipet to its maximum length.

Plastic toothpicks also work well for spotting the dyes.

6. Chromatography paper, Whatman #1 48 x 57 cm
   Cut pieces 2 " x 7"
   Save the scraps to use in other experiments. Each sheet will cut 28 pieces, need 8 sheets per 100 students.

7. Super jumbo straws

8. Slim straws

9. Punched circles
   Whatman #3 filter paper, 1/4" office punch

10. Permanent marking pen, black, fine point

11. Use 9 inch Beral® plastic pipets:
    a. Slurry pipets (1 per student): cut approximately 4 inches off the stem
    b. Plastic scoop (1 per student): cut approximately 4 inches off the stem: cut end of the bulb off at an angle to make a scoop

12. Polyester fiberfill
    Available at department stores, used to fill pillows

13. To make the pump syringe
    a. 10 cc plastic syringe without needle

    b. 1/8" I. D. Tygon tubing (1/4" O.D.)
       •Warm in microburner and pull slightly so it will fit tightly inside the super jumbo straw.
       •Keep tension applied until cool
       •Cut in two at the narrow part and then cut each piece about 2-3" long
       •Attach the unpulled end to the syringe where the needle would normally be
       •Check to make sure the pulled end will fit inside the super jumbo straw

<u>Per room</u>:

1. Clock

<u>Per student</u>:

1 - 9 oz. plastic tumbler

1 - Thin-stem pipet

1 - Super jumbo straw

1 - Wooden clothespin

1 - SepCap™ cap, transparent (with small hole in it)

2 - 3 oz. plastic cups

1 - Plastic scoop

1 - Slurry pipet

1 - Pump syringe

1 - Slim straw

1 - Wash bottle

From Student Kit:

1 - Petri dish

1 - 96-well tray, round bottom

1 - 24-well tray

1 - 1 x12 well microstrip

Scissors

Office Punch

Ruler

Next

Chapter Nineteen: Gas Chromatography

Chemicals:

1. Activated Tide®
   Place in drying oven at 150EC for 4 hours. Store tightly capped bottle.

2. We use 50 mL Erlenmeyer flasks fitted with serum septa (16 x 25 mm)
   •Place a small quantity of liquid or gas in the flask and quickly cap.
   •The Freons will probably need to be replenished each day.
   a. Freon 11
   b. Freon 12
   c. Dichloromethane
   d. Chloroform
   e. Carbon tetrachloride
   A good source for Freon 11 and 12 is your local Union Carbide dealer

3. Industrial products
   Read the labels to see what propellant is used.
   Contact (electrical) cleaners, refrigerants, eg.

4. Unknowns
   You can mix the chemicals in 2 above

5. Unknowns for Section G.
   Use a fixed quantity of something inert to the experiment, like charcoal starter fluid. For each unknown add a known quantity of methylene chloride.
   For example:
   1 thinstem full of charcoal starter fluid plus 3 drops CH_2Cl_2
   These unknowns probably need to be made fresh everyday.

Supplies:

1. Copper wire, 0.020" diameter
   Cut pieces 13-14 inches long
   (The piece they cut off should be long enough to make the 3 turn coil for Section F.)

2. Soft glass tubing, 8 mm O.D.
   Carefully cut at 20 cm long (1 per setup, recycle)
   Firepolish lightly so that the inside diameter is not diminished

3. Latex tubing, 1/4" with 1/16" wall

   (a) 24 inch pieces (to connect to the gas source)

   (b) 2 cm pieces (1 per setup)

4. Pasteur pipets, 9 inch, disposable glass
5. Polyester fiber (Chapter 18)
6. Super jumbo straws
7. Clock with second hand
8. Cadmium sulfide light detector (you may want to omit this section).
9. Multimeter
10. Graduated plastic 1.0 mL syringe with 5/8", 25 gauge Luer-lock needle
11. Small corks, #00 (optional)

Per Student:

The student should sign for Items 8, 9 and 10.

1 - 20 cm glass-tubing, 8 mm O.D.

1 - Latex tubing, 24 inches

1 - Latex tubing, 2 cm

1 - Scorer, glass cutter or file

1 - 3 oz. plastic cup

1 - Matches

2 - Clothespins, wood

1 - Plastic scoop (Chapter 18)

1 - Cut-out soft drink can (Chapter 10)

From Student Kit:

Tweezers

Scissors

Office punch

Next

Chapter Twenty: Surface Chemistry - Bubbles and Films

Chemicals:

1. 95% ethanol in wash bottles

2. Soap solutions for surface tension study (need several different ones)

   a. 1% Joy®

   b. Other concentrations, brands and types, such as:
   .5% Joy
   .1% Joy
   1% Dawn

3. Soap solution for bubbles and films:
   2500 mL water
   50 mL glycerine
   250 mL Joy® liquid detergent (or Dawn®)

4. Lighter fluid

5. Motor oil (non-detergent)

6. Used motor oil
   You can get this when you change the oil in your car.

7. Mineral oil

8. Detergent for cleaning glassware

Supplies:

1. Super jumbo straws

2. Narrow capillary tube
   We are using disposable micro-pipets, 1-5 microliters (Pyrex, 7099U)

3. Cotton swabs

4. Plastic toothpicks

5. Aluminum wire (19 or 20 gauge)
   cut 13 inches, 1 per student, available from Sargent Welch

6. Spool of sewing thread

7. Glass pieces (or rigid plastic)
   Used cleaned TLC plates work nicely
   (5 x 10 cm, eg.) (or window glass)

8. Thumb tacks

9. Big bubble machine
   We have one of David Stein's "Bubble Thing". The book, "The Unbelievable Bubble Book" by John Cassidy, is included with this and contains the recipe for the soap. (local bookstore)

10. Wire frames
    We use 0.06" welding rod
    Cut the pieces 1 1/2" long and solder the corners
    Attach a 6" handle
    We have cubes, pyramid shapes, circles (3 circles attached in a 3 sided confirmation), 2 triangles put together, etc. Use your imagination.

11. Ice

12. Fishing line

13. Cotton string

14. Waste container

Per Room:

1. Good lighting is needed to do Section B. The angle for viewing the surface of the water in the petri dish is important. Use the hand lens.

   The students could raise the petri dish by placing 4 straws in the 96-well tray on which to place the plastic background or they could use a ring on a ringstand (normally used for Bunsen burners) to hold the plastic surface. The height is therefore adjustable.

   If this is not sufficient to be able to see the spectra on the surface, try placing a 60 W light bulb close to the work area.

2. Bucket for the soap for the bubble machine.

Per Student:

1 - Cut-off microburet

1 - Glass rod, 4 mm, 8-9 inches

2 - Glass sheets

1 - Thin-stem pipet

1 - 9 oz. plastic tumbler (or 400 mL beaker)

1 - Wash bottle

From Student Kit:

1 - 96-well tray, round bottom

1 - 24-well tray

1 - Petri dish

Scissors

Office punch

Lab top

Ruler

Hand lens

Next

Chapter Twenty One: Natural Products Chemistry - Anthocyanins as Food Dyes

Chemicals:

1. White vinegar (from grocery store)
   5% vinegar = 50 mL glacial acetic per liter

2. Ethanol, 95%

3. Red cabbage extract (Chapter 8)

4. Red roses extract (Chapter 8)

5. Red beet juice

6. 1% solution of FDC red #3 or red #40

7. Buffer solutions (Chapter 14) pH 1 through 11

8. .1 HCl/ethanol
   8.6 mL conc. HCl per Liter
   95% ethanol

9. To make paper circle anthocyanins:
   See Section C, Step 5 of the laboratory experiment in "Chemtrek"
   (13 circles per student).

10. 3% hydrogen peroxide

11. 0.5 M sodium sulfite
    79.6 grams per liter

12. 3 M hydrochloric acid
    250 mL conc. HCl per liter

13. 2 M ammonia
    135 mL conc. NH_3 per liter

14. 0.1 M hydrochloric acid
    8.6 mL conc. HCl per liter

15. pH 8.0 tris buffer
    Tris (hydroxymethyl) amino methane called Trizma base (Sigma Chemicals)
    Tris is destructive to the electrode; do not leave the electrode in the solution; do meter readings quickly.
    500 mL 0.1 M Tris (12.114 grams per liter)
    Add 0.1 M HCl (approx. 292 mL) to pH 8.0 with pH meter
    Dilute to 1 liter

16. Rutin

17. 1 M hydrochoric acid
86 mL conc. HCl per liter

18. Magnesium ribbon
Cut small pieces (about 1/4")

19. a. A non-colored, carbonated beverage (eg., club soda)

b. Plain yogurt

c. Unflavored plain gelatin

d. Cornstarch

e. Hot herb tea

f. Generic face cream

20. Fine-mesh resin
200 mesh, XAD

21. Benedict's Reagent
Dissolve 173 grams sodium citrate and 100 grams of anhydrous sodium carbonate in 750 mL water. Stir, filter, and to the filtrate slowly add a solution of 17.3 grams of copper sulfate (pentahydrate) in 100 mL water. Dilute to a total volume of 1 liter with water.

22. Cation exchange resin (Chapter 10).

Supplies:

1. Red cabbage

2. Various flower petals and fruits,
eg., red rose, petunia, geranium,
radish, eggplant, grape

3. Super jumbo straws (300)

4. Polyester fiberfill

5. Filter paper circles (100)
Whatman #3 (Chapter 18)

6. Filter paper circles
Whatman #41

7. Filter paper pieces

Approx. 1" x 2"

8. Pins
9. Cotton swabs
10. Ice

Per Room:

1. Microwave oven or hot plate
2. Spectrometer (several per room, as availability allows)

Per Student:

4 - Labelled, filled microburets

2 - Thin-stem pipets

1 - Microstirrer

1 - 3 oz. plastic cup

Small beakers (optional, see A. 8)

1 - Plastic column tip (hole in)

1 - SepCap[a] vial and cap

1 - Clothespin

1 - Slim straw

2 - Spectrometer tubes (we use Kimax test tubes, 13 x 100 mm)

1 - Wash bottle

From Student Kit:

1 - 24-well tray

1 - 1 x 12 well microstrip

1 - 96-well tray, round bottom

1 - 96-well tray, flat bottom

1 - Petri dish

Scissors

Paper punch

Tweezers

Hand lens

Lab top

Next

Chapter Twenty Two: Coordination Chemistry and Nutritonal Deficiency

Chemicals:

1. Standard zinc solution (10.0 mg L^{-1} Zn^{2+})
   0.0440 grams $ZnSO_4 \cdot 7H_2O$ per liter, volumetric

2. Zincon dye (100mg L^{-1})
   0{2[a(2-hydroxy-5-sulfophenylazo)benzilidene]-hydrazino}
   benzoic acid, sodium salt (80%)

   0.125 grams zincon per liter pH 9 buffer, volumetric
   Use the H_3BO_3/KCl/NaOH pH 9 buffer from Chapter 18

3. Zinc unknown
   Can use any dilution of #1 that the students have in their calibration (A.3), eg., $9H_2O$: 1 Zn^{2+}, $8H_2O$: $2Zn^{2+}$, etc.

4. pH 9 buffer
   H_3BO_3/KCl/NaOH buffer (Chapter 18)

5. Zinc tablet unknown
   See Secton B. 6 of Chemtrek

6. Section C. 1
   A choice of solutions:
   Tea
   Juice from Tofu
   Apple juice
   Phytic acid, dodecasodium salt
   0.02 g per 100 mL
   Lemon juice

7. Solid foods:
   Tofu, soybeans, peas, corn
   Other choices could include: fruits, spinach, grapes, other legumes, coffee beans, etc.

Supplies:

1. Cotton swabs
2. Super jumbo straws

3. Slim straws

4. Thin-stem pipets

5. Labeled, filled microburets of each of the solutions from 6 above. Set 1 tray each at reagent central.

6. Multimeters

7. CdS photocell

8. Filter paper circles
Whatman #41

Per Student:

1 - Large drop microburet

1 SepCapTM cap with hole

1 - Slim straw

1 - Microstirrer

1 - Microburet

2 - Wire leads with alligator clips

1 - Wash bottle

From Student Kit:

3 - 1 x 12 well microstrips

1 - 24-well tray

1 - 96-well tray, round bottom

Scissors

Office punch

Lab top

Back to Small-Scale Science Center Main Page

ENZYME KINETICS

CHEMICALS

1.) .5% Starch (must be soluble potato starch-litner)
MAKE FRESH
a. Weigh out starch (.5 grams per 100 mL)
Add enough cold water to make into a runny paste
b. Add to ~75 mL boiling water
c. Bring to boil for 2 minutes
d. Bring to volume with boiling water using a grad. Cylinder
e. Pour back into beaker and bring to boil again for 1 minute

2.) .05% a-amylase
MAKE FRESH
.05 grams a-amylase per 100 mL $CaCl_2$ solution

3.) Calcium Chloride Solution
2.92 grams NaCl (.05M) per liter
.56 grams $CaCl_2$ (.005M)

4.) I_2 Solution
(15 mg I_2 per 100 ml .1M KI)
.15 grams I_2 + 17 grams KI per liter

5.) Buffer Solutions (pH 4,5,7,8,9)
a. Make a solution of .2M H_3PO_4
14 mL 85% H_3PO_4 per liter
b. Titrate 500 mL .2M H_3PO_4 with 1M NaOH to desired pH (use pH meter)

6.) Teas (Black abd Green)
1 teabag per 150 mL boiling water; boil for 2 minutes/steep

7.) Other Starches (eg. Arrowroot, Rice Corn)
follow directions as for potato starch

SUPPLIES

1.) 24 well tray with 7 large drop microburets labelled:

.05PPA	SAMPLE
STARCH	WATER
BUFFER	CaCl2

2.) Styrofoam cup
3.) 1 oz cup
4.) Microstirrer
5.) Thermometer
6.) Rubberbands
7.) Thin stem pipets
8.) Wash Bottle
9.) Silica gel
10.) **Filter Sep**Cap

FROM KIT

Lab Top
24-well tray
1x12-well strips or
96-well flat bottom tray

PER ROOM

Clock
Ice
Hot Plate: with 600 mL water in beakers @ 70°C and 90°C