FIRE WRITING

TOPIC Introductory demonstration 1 **DEMO #** 11.Intro1

REFERENCE A Demo A Day, Volume 2: Another Year of Chemical Demonstrations, p. 23

EQUIPMENT Large sheet of porous (non–coated) paper to make a "WELCOME" sign
Cotton swab
Tape (to suspend paper from blackboard)
Matches
Wooden splint

CHEMICALS 100 mL of saturated potassium nitrate (KNO_3)

PROCEDURE Wet a cotton swab with potassium nitrate and use the swab to write "WELCOME" on the paper. The letters must be continuous and at least $^3/_8$" wide. Allow the paper to dry thoroughly. On the day of the demonstration, suspend the paper from a blackboard with tape. Touch a glowing hot wooden splint to the start of the message. The message will be traced out by the glowing paper.

INVISIBLE INK MESSAGE

TOPIC Introductory demonstration 2 **DEMO #** 11.Intro2

REFERENCE Chemical Curiosities: Spectacular Experiments and Inspired Quotes, p. 95

EQUIPMENT
long sheet of absorbent paper
large piece of cardboard (larger than the sheet of paper)
adhesive tape
2 – atomizer spray bottles
paint brush (1/2" to 1" wide)
3 – large beakers

CHEMICALS
10 g of ferric chloride
2 g of ammonium thiocyanate
5 g of potassium ferr**o**cyanide (CARE: not ferr**i**cyanide)

PROCEDURE Dissolve 10 g of ferric chloride in 200 mL of water. Use this solution to paint a welcoming message such as " CHEMISTRY RULES!" on the paper, in such a way that "CHEMISTRY" is separated from "RULES!" by at least 8–10 inches, and allow to dry overnight. Using adhesive tape, attach the paper to the large sheet of cardboard to act as a stiff backing.

Dissolve 2 g of ammonium thiocyanate in 200 mL of water and put into one atomizer. Dissolve 5 g of potassium ferrocyanide in 200 mL of water and put into the second atomizer. Spray the left side of the message with potassium ferrocyanide to reveal the word "CHEMISTRY" in dark blue. Spray the right side of the message with ammonium thiocyanate to reveal the word "RULES!" in blood–red colour.

POP BOTTLE CANNON

TOPIC Introductory demonstration 3 **DEMO #** 11.Intro3

REFERENCE Jim Hebden

EQUIPMENT 750 mL plastic pop bottle (no bigger!)
10 cm x 10 cm square of aluminum foil
rubber stopper to fit bottle
tesla coil

CHEMICALS methanol

PROCEDURE Roll up the aluminum foil into a tube and insert into the pop bottle. Add about 5 mL of methanol to the bottle, stopper and shake a few times. Turn on the tesla coil and let a spark jump from the tip of the coil to the piece of aluminum foil inside the bottle. A satisfying explosion will bounce the rubber stopper off the ceiling.

Use this to get the attention of the class on the first day. Three such bottles make a "three gun salute" to welcome students to Chemistry 11.

The methanol vapour and oxygen form an explosive mixture which is ignited by the spark. Before you decide to make it "bigger and better" you should know that adding pure oxygen to the bottle gives a blast which is almost deafening and is strongly advised against because it shreds the bottle into fragments which can cut students standing 20 feet away.

A SIMULATED "ACID IN YOUR EYE" ACCIDENT

TOPIC The need for safety goggles **DEMO #** 11.I.1

REFERENCE A Demo A Day: A Year of Chemical Demonstrations, p. 10

EQUIPMENT
Large petri plate
Overhead projector
Permanent marker (black preferred)
Dropping pipet

CHEMICALS
6 M HCl (hydrochloric acid)
Raw egg (white only)
50 mL of saturated $NaHCO_3$ (sodium bicarbonate)

PROCEDURE Draw a large eye on the bottom of the petri plate, place the petri plate on the overhead projector and place the egg white in the petri plate. [Both egg white and the eye's pupil are protein gels.] Place several drops of acid on the egg white; it instantly becomes opaque. Adding some baking soda neutralizes the acid but does not undo the damage to the egg white. NaOH solutions work the same way but the opaque area continues to expand for several hours!

WHY WORRY ABOUT SAFETY? IRA REMSEN'S FIRST EXPERIMENT

TOPIC Working with dangerous chemicals **DEMO #** 11.I.2

REFERENCE Twenty Demonstrations Guaranteed to Knock Your Socks Off! Volume II, p. 5, variation

EQUIPMENT 1 L flask, with a stand and clamp to hold the flask
one hole stopper to fit flask, fitted with a glass tube and rubber tubing
1 L graduated cylinder and 40 cm of 6-8 mm OD glass tubing
100 mL graduated cylinder (for nitric acid)
safety goggles

CHEMICALS penny
60 mL concentrated nitric acid

PROCEDURE Almost fill the 1 L graduated cylinder with water and place the 40 cm glass tube into the cylinder. The 40 cm glass tube should go to the bottom of the 1 L graduated cylinder when connected to the rubber tubing leading to the flask. Set up the stand and clamp so the flask can be supported vertically while allowing the rubber tubing to connect to the glass tube in the graduated cylinder.

[Read the following to the class. Tell them that they must record all their observations.]

Ira Remsen was a 19th century chemist who recorded his observations on the first experiment he ever did, before he had learned anything about safety in the Chemistry laboratory. He wrote

While reading a textbook of chemistry, I came upon the statement "nitric acid acts upon copper." I was getting tired of reading such absurd stuff, and I was determined to see what it meant. Copper was more or less familiar to me, since copper cents were then in use.

[Hold up a copper penny]

I had seen a bottle marked nitric acid on a table in the doctor's office where I was then "doing time."

[Put on goggles and hold up a stock bottle of concentrated nitric acid. Read some of the warnings on the side.]

I did not know its peculiarities, but the spirit of adventure was upon me. Having nitric acid and copper, I had only to learn what the words "act upon" meant. The statement "nitric acid acts upon copper" would be something more than mere words. In the interest of knowledge, I was even willing to sacrifice one of the few copper cents then in my possession. I put one of them on the table, opened the bottle marked nitric acid, poured some of the liquid on the copper and prepared to make an observation.

[Explain that for safety reasons you are doing the experiment a bit differently than Remsen did. Remove the stopper and pour about 60 mL of acid into the flask. Tilt the flask and slide in the penny. Replace the stopper and clamp the flask in place. Allow 4-5 students at a time to get a closer look. After a couple of minutes, continue reading.]

But what was this wonderful thing which I beheld? The cent had already changed, and it was no small change either! A green–blue liquid foamed over the cent and over the table. The air in the neighbourhood of the performance became coloured dark red. A great coloured cloud arose. This was disagreeable and suffocating. How should I stop this? I tried to get rid of the objectionable mess by picking it up and throwing it out of the window. I learned another fact. Nitric acid not only acts upon copper, but it acts upon fingers. The pain lead to another unpremeditated experiment. I drew my fingers across my trousers and another fact was discovered. Nitric acid acts upon trousers. Taking everything into consideration, that was the most impressive experiment and, relatively, probably the most costly experiment I have ever performed. It was a revelation to me. It resulted in a desire on my part to learn more about that remarkable kind of action. Plainly, the only way to learn about it was to see its results, to experiment, to work in a laboratory.

[When the reaction has stopped, ask one student to describe the penny – its gone – and have students hypothesize where it went. After 5–10 minutes another observation is made: the water travels up the glass tube and into the flask. The resulting solution in the flask is turquoise blue and the brown gas in the flask fades.]

INDICATOR SPONGE

TOPIC The need for clean work benches **DEMO #** 11.I.3

REFERENCE A Demo A Day: A Year of Chemical Demonstrations, p. 182

EQUIPMENT Cellulose sponge
Rubber gloves
Large container to hold sponge and solution

CHEMICALS 1 g of congo red indicator
100 mL distilled water
100 mL of 1 M acetic acid
100 mL of saturated sodium hydrogen carbonate (about 10 g / 100 mL)

PROCEDURE Dissolve about 1 g of congo red in about 100 mL of distilled water. Soak the sponge with the congo red solution and ring out the sponge using rubber gloves. Let the sponge sit in the liquid overnight, squeeze out the liquid and allow to dry completely. Rinse with fresh water a few times and the sponge is ready for use.

Students are often careless about cleaning up their benches, especially at the start of the year. Clean up a little 1 M acetic acid and saturated sodium hydrogen carbonate from the bench to show students what happens when the sponge is used to clean up acidic or basic solutions.

U–TUBE WITH UNEQUAL ARMS

TOPIC Density of water vs alcohol **DEMO #** 11.II.1

REFERENCE Jim Hebden

EQUIPMENT Big U-tube (14–18 mm glass tubing or 1/2" tygon tubing, about 18 in high)
stand and 2 clamps

CHEMICALS ethanol or methanol
water

PROCEDURE Clamp the U–tube with the bend downward. Fill the tube about 1/2 full of water and then carefully, so as to minimize mixing, pour alcohol into one side arm until the tube is almost full. The result will be a U–tube having liquid at a higher level on one side than on the other.

Demonstrate that there is no blockage by gently blowing into one side arm and showing that the liquid can move freely.

What is Happening:

Normally, a U-tube has liquid at the same height in each arm because the mass of the liquid in each arm pushes down equally (otherwise the liquid would move) and therefore requires equal heights of liquids. The alcohol has a lower density than the water and therefore a greater volume of alcohol is required to have the same mass as a lesser amount of water. Hence, more alcohol must "pile up" to equal the downward push of the smaller amount of water.

THE MYSTERIOUS SUNKEN ICE CUBE

TOPIC Density of ice vs water or alcohol **DEMO #** 11.II.2

REFERENCE Chemical Demonstrations: A Sourcebook for Teachers, Volume 2, p. 15

EQUIPMENT 2 – 250 mL beakers

CHEMICALS two ice cubes
500 mL of ethanol or methanol
500 mL of distilled water

PROCEDURE Half–fill one beaker with alcohol and half–fill the other with distilled water before presenting the beakers to the class. Have a student drop one ice cube into each beaker.

The ice in water floats (density of ice = 0.9 g/mL, density of water = 1.0 g/mL) whereas the ice in alcohol sinks (density of alcohol = 0.79 g/mL). Ask students to explain what must be happening.

A DENSI–TEE

TOPIC Golf ball in a density gradient **DEMO #** 11.II.3

REFERENCE Twenty Demonstrations Guaranteed to Knock Your Socks Off! , p. 38

EQUIPMENT Large graduated cylinder (1 L or 2 L)
golf ball
cellophane
elastic band

CHEMICALS salt (coarse grain is fine)
saturated salt water
water

PROCEDURE Add enough salt to make a layer occupying the bottom 10% of the cylinder. Fill the cylinder roughly one–quarter full of saturated salt water. Use a large spoon or modified coat hanger to gently lower the golf ball into the salt solution. Slowly trickle water down the side of the cylinder so as to create the minimum disturbance of the salt water layer. When the liquid is within 1–2 cm of the top, cover the top with cellophane held in place with an elastic band.

If left undisturbed for a period of several weeks and months, the salt dissolves and creates a saturated solution having a density greater than that of the golf ball. As a result, the ball starts to rise higher in the solution.

What is Happening:

The golf ball is less dense than saturated salt water, so that it floats on the salt water, but is less dense than pure water, causing the ball to sink in the water. Since the pure water is floating on the salt water, the golf ball floats in the middle of the combined solution. As the two layers mix by slow diffusion of the liquid layers into each other, more salt dissolves and increases the proportion of saturated salt water present, slowly raising the ball in the cylinder.

INACCURATE METER STICK

TOPIC Accuracy vs precision **DEMO #** 11.II.4

REFERENCE A Demo A Day: A Year of Chemical Demonstrations, p. 15

EQUIPMENT 1 regular meter stick
1 meter stick that has the 1st cm cut off in such a way that the new end resembles old end

CHEMICALS —

PROCEDURE Have two students measure the length of some object, such as an 8 1/2 x 22" piece of copy paper. One will use the regular meter stick and the other the "altered" stick. Make sure no one notices the alteration to one stick. Have another pair of students make the same measurement.

Discuss the difference between "precision" (reproducibility) and accuracy (getting the correct value). The shortened stick is precise but not accurate.

WHAT'S A MENISCUS?

TOPIC Different meniscus curves **DEMO #** 11.II.5

REFERENCE A Demo A Day – A Year of Physical Science Demonstrations, p. 19

EQUIPMENT
5 — 12 x 100 mm test tubes (the tubes must be very clean and dry)
5 – size 00 rubber stoppers
razor blade
wax
glass funnel
10 mL graduated cylinder
food colouring

CHEMICALS
3 mL of mercury
3 mL of distilled water
3 mL of acetone
3 mL of ethanol
3 mL of hexane

PROCEDURE Use the funnel to put 3 mL of mercury in a test tube. Stopper the test tube securely and use the razor to cut the stopper flush with the top of the test tube. Seal the tube by inverting it and dipping it into a centimetre depth of melted wax. Repeat the process for distilled water, acetone, ethanol and hexane.

Fill a 100 mL graduated cylinder with coloured water such that the top of the water falls on a reference line and the bottom of the meniscus falls half way between two reference lines. Have several students read the volume and keep the value to themselves. Then compare the values obtained and discuss the concept of "precision" when the values are found to vary from student to student.

Students should examine the various sealed test tubes and see that the meniscus curves downward in mercury and upward to varying degrees with the other liquids. Discuss how to read the meniscus value of a liquid.

CONSISTENCY

TOPIC Experimental uncertainty **DEMO #** 11.II.6

REFERENCE A Demo A Day, Volume 2: Another Year of Chemical Demonstrations, p. 14

EQUIPMENT
glass medicine dropper
thin stem plastic pipet
micro tip plastic pipet
thin stem plastic pipet with thin end cut off
light box
test tube rack
3 – 13 x 100 mm test tubes

CHEMICALS
phenolphthalein indicator
25 mL of 0.1 M sodium hydroxide
25 mL of 0.1 M hydrochloric acid

PROCEDURE Count 25 drops of hydrochloric acid into each of 3 different test tubes. Add 2 drops of phenolphthalein to each tube.

Titrate each tube with sodium hydroxide solution using a different pipet. Count the number of drops required to reach the end point and compare the results.

This demonstration shows the necessity of performing an experiment in a consistent manner. Different people using different equipment often report different results.

THINK TUBE

TOPIC Hypothesizing **DEMO #** 11.III.1

REFERENCE A Demo A Day: A Year of Chemical Demonstrations, p. 46

EQUIPMENT "Think tube", constructed as per instructions in reference

CHEMICALS —

PROCEDURE Ask students to draw how the tube is constructed, as follows. Take a sheet of paper, divide it into two columns and divide each column into four horizontal rows. In each row, the first column should show what they observe and the second column should be their hypothesis of how the cords are connected inside of the tube.

Experiment 1: Starting with the lower right ball pulled down, pull the upper right ball up and then pull the lower right ball down again.

Experiment 2: Pull the lower left ball down.

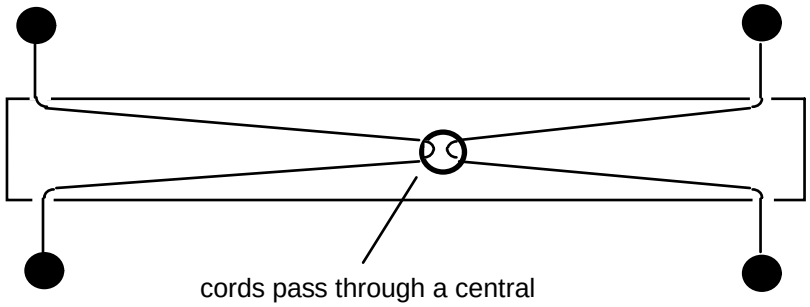
Experiment 3: Pull the upper left ball up and then pull the lower left ball down.

Experiment 4: Pull the upper right ball up.

Ask students to suggest other "experiments".

What is Happening:

The tube is constructed as follows.



FLAMING VAPOUR RAMP

TOPIC Density of a vapour **DEMO #** 11.

REFERENCE Twenty Demonstrations Guaranteed to Knock Your Socks Off! Volume II, p. 59

EQUIPMENT votive candle or candle of similar size
erlenmeyer flask, 1– 2 L size, with one hole stopper to fit
matches
6 foot length of aluminum angle bracket or evestrough
Optional: tall stand and clamp arrangement to hold angle bracket / evestrough at a 20° angle to the floor (or just invert a lab stool)

CHEMICALS 5–10 mL of hexane

PROCEDURE Twenty minutes before performing the demonstration, pour 5–10 mL of hexane into the flask and place the one–hole stopper on top. This allows hexane vapour to fill the flask and displace the air.

Light the candle and clamp the angle bracket / evestrough (or prop it up on an inverted stool or hold it from **beneath**) at a 20° angle to the floor, with bottom end resting in front of the lit candle.

Remove the stopper and gradually pour the vapour down the trough, tipping the flask a bit at a time, but don't allow the unevaporated liquid to pour out. Be prepared to have the fumes catch fire. As the flame races up the trough, you may want to take the flask away to prevent the fire from going into it. (If the flame does make it back into the flask, it will just burn harmlessly at the mouth because of an inadequate oxygen supply, which is a neat demonstration by itself!) The flaming ramp will go out by itself in a few seconds.

SLIME : CROSS–LINKED GLUE

TOPIC Physical properties **DEMO #** 11.III.3

REFERENCE Twenty Demonstrations Guaranteed to Knock Your Socks Off! , p. 20

EQUIPMENT
2 L soda bottle
ring stand and ring
drinking straw
100 mL beaker
250 mL beaker
large test tube
strong stirring rod

CHEMICALS
Elmer's™ glue
sodium borate (borax)

PROCEDURE NOTE: This can be very effective as a minilab that everyone in the class does.

Dissolve 1 g of borax in 15 mL of water in a 100 mL beaker. In a 250 mL beaker, mix thoroughly EXACTLY 20.0 mL of water and EXACTLY 21.8 g of glue. Pour the borax solution into the diluted glue (if not all the borax has dissolved, decant only the solution into the glue mixture) and stir slowly for 20 s. Remove the slime from the beaker, place it on the bench and knead it to a workable consistency (it is OK to get it on your hands). Demonstrate its properties as follows.

- **Stretchability:** Show what happens when the slime is stretched quickly and when it is stretched slowly.
- **Viscosity:** Cut off the top half of a 2 L soda bottle and set it upside down in the ring stand. Place the slime in the funnel and time how long it takes for the first drop to reach the table.
- **Resilience:** Shape the slime into a ball and show that it can bounce.
- **Inflatability:** Form the slime into a ball around the end of a straw and inflate it by gently and slowly blowing into the straw (pinch the slime together around the straw to prevent air from leaking out the sides).

THE VAPOUR PRESSURE OF ACETONE AND n–BUTANOL

TOPIC VP of acetone and n–butanol **DEMO #** 11.III.4

REFERENCE Jim Hebden

EQUIPMENT water manometer (includes stand, glass U–tube filled with coloured water, rubber tubing to connect to a two hole stopper. One hole contains a glass tube to connect to the water manometer; the other hole contains a short glass tube connected to a 10 cm length of latex tubing fitted with a tubing clamp)
2 – 125 mL erlenmeyer flasks
2 – small syringes, with needles (1, 2 and 5 mL sizes are fine)
1 piece of paper towel

CHEMICALS n-butanol (5–10 mL)
acetone (5–10 mL)

PROCEDURE Connect an empty flask (containing a small piece of paper towel in its bottom to volatilize the liquid faster) to the water manometer. Squeeze the rubber tubing near the closed clamp to show students how sensitive the device is to pressure changes. Inject a 1 mL sample of n–butanol through the rubber tubing into the flask. The water levels move very little, indicating a low vapour pressure.

Using a different flask, repeat with acetone. The pressure immediately starts to increase dramatically. (The tubing clamp may have to be opened to avoid water being pushed out the end of the manometer.)

Conclusion: different liquids have different vapour pressures — acetone's is high and n–butanol's is low.

Extension: Point out that acetone's BP is 56^{o}C and n-butanol's BP is 117^{o}C. Ask students to suggest the relationship between BP and vapour pressure. (Substances with lower BP's have higher VP's.)

THE EFFECT OF TEMPERATURE ON VAPOUR PRESSURE

TOPIC Temperature and vapour pressure **DEMO #** 11.III.5

REFERENCE A Demo A Day, Volume 2: Another Year of Chemical Demonstrations, p. 120

EQUIPMENT mercury manometer (**OR** see alternative method, below)
125 mL erlenmeyer flask
syringe
small piece of paper towel
two hole stopper to fit flask. One hole with glass tubing to fit to manometer (via rubber tubing); the other hole fitted with a short length of glass tubing attached to a 10 cm length of rubber
ice bath for flask
hot water bath for flask (can just be hot tap water)

CHEMICALS acetone (5–10 mL)

PROCEDURE Connect the empty flask (containing a small piece of paper towel in its bottom to volatilize the liquid faster) to the manometer and inject about 3–5 mL of acetone. Record the pressure.

Place the flask in the ice bath and note that the vapour pressure quickly drops.

Place the flask in the hot water bath and note that the vapour pressure rises dramatically.

Conclusion: vapour pressure increases with temperature.

Alternative Method: Use a water manometer and inject samples with intermediate vapour pressures, such as methanol (VP is half of acetone's) or ethanol (VP is one quarter of acetone's).

DENSITY VERSUS VISCOSITY

TOPIC Density vs. viscosity **DEMO #** 11.

REFERENCE commonly known

EQUIPMENT 1 m glass or clear plastic tube (20–25 mm OD), sealed at lower end
tall stand with two clamps to hold tube vertically
rubber stopper to fit top end of tube
several small (5–6 mm) ball bearings
magnet to retrieve ball bearing from tube

CHEMICALS hexane (about 300 mL)
glycerine (about 300 mL)
dense organic liquid such as carbon tetrachloride, trichloroethane or dichloromethane (anything that has a density greater than 1.26 and is insoluble in water)

PROCEDURE Note: If stored with a tight fitting stopper, this demonstration can be reused year after year with no change or addition of liquids.

Clamp the tube upright to a tall stand. Fill the bottom third of the tube with the densest liquid. Tilt the tube and carefully pour the glycerine down the tube until about two–thirds full. Allow the glycerine time to finish draining down the side. Finally, fill the tilted tube to within a few centimetres of the top and stopper well. Note that plastic wrap may be needed to protect rubber stoppers from absorbing the hexane and swelling. Also note that wooden corks are quite porous and allow the hexane to evaporate during the course of a year.

Gather the class around and have someone drop a ball bearing into the tube on the count of three. This is a wonderful example of a "discrepant event" because the ball bearing falls very quickly through the hexane and lazily falls through the glycerine and again plummets quickly through the bottom layer. After the ball passes through the first two layers, students have formed an unconscious hypothesis that the denser the liquid, the greater the viscosity. The action of the ball in the third layer shatters that hypothesis and usually elicits numerous startled giggles from the class.

Conclusion: density is NOT related to viscosity. For example, thick globules of crude oil float ON TOP of salt water.

DIFFUSION OF AMMONIA AND HYDROGEN CHLORIDE

TOPIC Gas diffusion 1 **DEMO #** 11.III.7

REFERENCE commonly known

EQUIPMENT 12 mm OD glass tube, 10 inches long. Paint the back half of the outside of the tube black.
two thin end Berol pipets
cotton batting (enough to plug both ends of the glass tube)
stand and clamp
grease pencil or marker

CHEMICALS concentrated ammonia (about 5 mL)
concentrated hydrochloric acid (about 5 mL)

PROCEDURE Clamp the glass tube horizontally, about one quarter of the way from one end. Make sure the unpainted front part of the tube can be seen by the class. Plug the ends with about 1 cm length of cotton batting. Hold the pipet containing NH_3 close to the end of the tube nearest the clamp and the pipet containing HCl close to the other end. Simultaneously squirt about 5–8 drops of each liquid into the cotton at either end.

After about 30 seconds a thin white line is seen inside the tube, perpendicular to the long axis. Quickly mark the point at which the line is first seen.

Measure and record the distance from the point at which the white line is seen to the point at which each gas was injected.

Conclusion: Ammonia travels farther than hydrogen chloride in the same time and therefore travels faster. Show students how to calculate the molecular mass, using the periodic table. Ask what relationship appears to exist between the velocity of a molecule and its mass. (The smaller the molecular mass, the faster the molecule travels.)

Incidentally, the ratio of the distances will be very close to the square root of the inverse of the ratio of the masses. That is:

$$\frac{\text{distance travelled by } NH_3}{\text{distance travelled by HCl}} = \sqrt{\frac{\text{molecular mass of HCl}}{\text{molecular mass of } NH_3}} = \sqrt{\frac{36.5\ \text{u}}{17.0\ \text{u}}} = 1.47$$

PRODUCING TWO GASES FROM AMMONIUM CHLORIDE

TOPIC Gas diffusion 2 **DEMO #** 11.III.8

REFERENCE Chemical Demonstrations: A Sourcebook for Teachers, Volume 2, p. 38

EQUIPMENT 25 x 200 mm test tube
glass wool
red litmus paper
blue litmus paper
bunsen burner and flint striker
stand and clamp to hold test tube at an angle above the bunsen burner

CHEMICALS 10 g of ammonium chloride, NH_4Cl

PROCEDURE Fill the large test tube about 1/4 full of ammonium chloride and insert a plug of glass wool at the top of the tube. Moisten strips of red and blue litmus. Heat the ammonium chloride over the bunsen burner and place one strip of each of moistened red and blue litmus paper over the mouth of the test tube. The red litmus turns blue because of the production of basic ammonia. With additional heating, the blue litmus turns red because of the production of acidic hydrogen chloride. The lighter ammonia arrives at the litmus before the heavier hydrogen chloride does.

EFFECT OF TEMPERATURE ON DIFFUSION RATE

TOPIC Temperature versus diffusion rate **DEMO #** 11.III.9

REFERENCE commonly known

EQUIPMENT 2 – 250 mL erlenmeyer flasks
2 – one hole stoppers to fit flasks, each fitted with a glass tube that extends 5 cm above the stopper and extends to within 3–4 mm of the bottom of the flask

CHEMICALS a few crystals of potassium permanganate

PROCEDURE Put about 100 mL of cold water in one flask and 100 mL of hot water in the other flask. Insert the stopper and glass tube in each flask. Wait 30 seconds to allow currents to slow in the liquids. Simultaneously drop one crystal of potassium permanganate into the top of each glass tube. The colour will spread much faster in the hot water.

If students are not shown or told that one flask has hot and one has cold water, ask them to suggest a reason why the colour in one flask is spreading out faster.

Conclusion: The higher the temperature, the higher the diffusion rate.

EXPANSION OF SHAVING CREAM IN A VACUUM

TOPIC Relationship between P and V **DEMO #** 11.III.10

REFERENCE commonly known

EQUIPMENT Vacuum pump
bell jar with vacuum base
large petri plate supported over three pieces of wood (to avoid plugging of air exit hole)
vacuum hose

CHEMICALS can of shaving cream

PROCEDURE Put a generous daub of shaving cream in the petri plate, put bell jar over plate base, turn stopcock to off, connect vacuum pump to bell at stopcock and turn on pump. Open stopcock and watch shaving cream swell up and completely fill inside.

***What is happening*:**

The shaving cream is full of gas bubbles in equilibrium with the gas pressure of the atmosphere pushing down on the bubbles. When the air is removed, the bubbles expand.

SOLUTIONS, COLLOIDS AND SUSPENSIONS

TOPIC Solutions, colloids and suspensions **DEMO #** 11.III.11

REFERENCE A Demo A Day, Volume 2: Another Year of Chemical Demonstrations, p. 182

EQUIPMENT laser pointer (preferable) or pencil flashlight
3 — 600 mL beakers
stirring rod

CHEMICALS 25 g of sucrose (table sugar)
7 g of unflavoured gelatin
10 g of clay
1125 mL of distilled water
375 mL of boiling water

PROCEDURE Ahead of time:

- prepare a SOLUTION by dissolving 25 g of sugar in 500 mL of water.
- prepare a COLLOID by sprinkling 7 g of gelatin in 125 mL of cold water, to soften the gelatin, and then adding 375 mL of boiling water, with thorough stirring, to dissolve the gelatin.
- prepare a SUSPENSION by stirring 10 g of clay into 500 mL of water.

Ask students to compare each sample for clarity and the presence of something settling out. Demonstrate the Tyndall effect by shining a laser pointer or pencil flashlight beam through the liquid. Show students what happens when each sample is filtered.

ELEMENTS, MIXTURES AND COMPOUNDS

TOPIC Elements, mixtures & compounds **DEMO #** 11.III.12

REFERENCE A Demo A Day: A Year of Chemical Demonstrations, p. 20

EQUIPMENT 8 – plastic petri plates
30 small bolts or machine screws
35 hex nuts to fit bolts / screws
25 washers to fit bolts / screws

CHEMICALS —

PROCEDURE Assemble and number 8 petri plates containing the following.

Plate 1 = 5 nuts
Plate 2 = 5 bolts + 5 nuts + 5 washers
Plate 3 = 5 bolts with nuts attached
Plate 4 = 5 bolts with nuts attached + 5 bolts with washers and nuts attached
Plate 5 = 5 bolts
Plate 6 = 5 nuts + 5 washers
Plate 7 = 5 bolts with washers and nuts attached
Plate 8 = 5 washers

Ask students which petri plates represent elements, which represent mixtures, which represent compounds, which represent binary compounds and which represent ternary compounds.

ODOUR AND COLOUR EATER

TOPIC Physical Separation Methods **DEMO #** 11.III.13

REFERENCE A Demo A Day – A Year of Physical Science Demonstrations, p. 167

EQUIPMENT
funnel
filter paper to fit funnel (15 cm)
stand with ring and clay triangle
600 mL beaker
2 – 250 mL beaker

CHEMICALS
5 tablespoons of activated charcoal
blue food colouring
distilled water

PROCEDURE Set up the filter paper in the funnel and place in the clay triangle on the ring stand. Put the activated charcoal in the filter paper.

Add a few drops of food colouring to 400 mL of water. Pour half of the coloured water through the charcoal and into a 250 mL beaker. Keep the other half of the coloured liquid as a control. Pour the filtered liquid through the charcoal several times until the liquid is colourless. This demonstration shows how charcoal can act as a deodorizing and decolorizing agent.

IMMISCIBLE LIQUIDS IN HERO'S FOUNTAIN

TOPIC Immiscibility **DEMO #** 11.III.14

REFERENCE A Demo A Day – A Year of Physical Science Demonstrations, p. 42

EQUIPMENT Fountain Connection
2 – 1 L soda bottles

CHEMICALS 1 L mineral oil
1 L distilled water
food colouring

PROCEDURE Fill one 1 L bottle completely full of mineral oil and affix the Fountain Connector to this bottle. Fill the other 1 L bottle with distilled water that has been coloured with some food colouring.

Quickly invert the bottle of water and affix it to the other end of the Fountain Connector. (Some water will escape.)

To operate, simply set the unit on the table in such a way that the water–filled bottle is on top.

CLOSED SYSTEM DISTILLATION APPARATUS

TOPIC Distillation **DEMO #** 11.III.15

REFERENCE Twenty Demonstrations Guaranteed to Knock Your Socks Off! Volume II, p. 43

EQUIPMENT passion meter / hand boiler toy (available from Flinn Scientific or novelty shops)
dewar flask (to contain dry ice)

CHEMICALS dry ice

PROCEDURE Manipulate the hand boiler until all the coloured liquid is in the "upper" bulb. With the toy inverted, immerse the "upper" bulb in dry ice and acetone. After a minute or two, colourless liquid will be present in the cold bulb. The upper bulb also gets very cold and should be warmed by cupping in the hand in order to keep liquid distilling over to the lower bulb.

Distillation depends on having a large difference between the temperatures of the liquid to be distilled and the liquid in the "receiving vessel". Normal distillation involves increasing the vapour pressure of the liquid to be distilled and lowering the vapour pressure in the receiving vessel. This demonstration lowers the vapour pressure in the lower bulb to the extent that the vapour in the upper bulb condenses into the lower bulb. As the endothermic evaporation process takes place in the upper bulb, the bulb cools.

A SIMPLE SEPARATION OF COBALT AND NICKEL SALTS

TOPIC Solvent Extraction **DEMO #** 11.III.16

REFERENCE Chemical Curiosities: Spectacular Experiments and Inspired Quotes, p. 108

EQUIPMENT
250 mL separatory funnel
ring and stand
2 – 25 mL graduated cylinders
100 mL graduated cylinder

CHEMICALS
100 mL of 2–butanone (methyl ethyl ketone)
2 vials containing 0.6–0.7 g potassium thiocyanate, KSCN
100 mL 1% $CoCl_2$ (1.0 g $CoCl_2 \cdot 6H_2O$ / 100 mL)
100 mL 4% $NiCl_2$ (4.0 g $NiCl_2 \cdot 6H_2O$ / 100 mL)

PROCEDURE Mix 25 mL of 1% $CoCl_2$ and 25 mL of 4% $NiCl_2$ in a separatory funnel. The resulting solution is almost grey. Add 100 mL of 2–butanone and then 0.6–0.7 g of KSCN. After shaking, two phases separate out: the lime green lower phase is $Ni(H_2O)_6^{2+}$ in water; the deep blue upper phase is $Co(SCN)_4^{2-}$ dissolved in the organic layer.

RADIAL CHROMATOGRAPHY

TOPIC Chromatography **DEMO #** 11.III.17

REFERENCE Twenty Demonstrations Guaranteed to Knock Your Socks Off! , p. 6

EQUIPMENT a variety of black felt tip pens (with the pens and caps labelled A, B, C, D ...)
15 cm filter papers
a few filter papers cut into eighths
250 mL beakers
sharp–pointed scissors

CHEMICALS —

PROCEDURE NOTE: Do this as a class minilab.

Make a 2–3 mm hole in the centre of a filter paper with scissors. Roll up a filter paper wedge to make a wick that fits into the centre hole. Use two or three pens to make an alternating pattern of concentrated dots (A–B–A–B– or A–B–C–A–B–C–A–) in a circle about 1 cm in radius around the centre hole. Half fill the beaker with water, dry the lip of the beaker, push the wick into the underside of the centre hole and place the wick into the centre of the beaker. Within about 10–15 minutes, the "solvent front" will advance to within about 1–2 cm of the outer edge of the filter paper. At that point, take out the filter paper and let it dry. A beautiful flower–like pattern should form.

What is Happening:

Each ink is composed of several different coloured chemicals. The chemicals each have a different tendency to "stick" to the paper and resist being moved. At the same time, each chemical has a different tendency to dissolve in the solvent and be dragged by the solvent as the solvent moves. As the solvent is absorbed through the paper, the differing tendencies to stick to the paper "trade off" with the differing tendencies to move with the solvent, causing each coloured chemical to move at a different rate along the paper, spreading the chemicals out.

HOARFROST IN A GLASS

TOPIC Sublimation of benzoic acid **DEMO #** 11.III.18

REFERENCE Chemical Curiosities: Spectacular Experiments and Inspired Quotes, p. 316

EQUIPMENT 1 L erlenmeyer flask
watch glass
stand, ring and gauze pad
bunsen burner and flint striker
small plant or branch, attached to a wire so as to sit upright in the bottom of the flask

CHEMICALS benzoic acid (about 10 g)

PROCEDURE Put about 10 g of benzoic acid in the flask. Place the plant and wire in the bottom of the flask in such a way that the plant stands upright. Next, place a watch glass over the mouth of the flask and place the flask on the gauze pad on the ring stand. Use a small flame to heat the bottom of the gauze pad. In a short time a white "hoar frost" of sublimed benzoic acid starts to cover the plant.

TYPES OF KINETIC ENERGY

TOPIC Kinetic energy types **DEMO #** 11.III.19

REFERENCE Chemistry 13 News, November 1976, p. 13. Modified by Jim Hebden

EQUIPMENT —

CHEMICALS —

PROCEDURE Have four student volunteers come to the front of the room. They will be pretending they are water molecules. Draw a large water molecule on the board, with two H's below and the central O at the top of an inverted V–shape. Hold your arms out at an angle and point out that each fist represents an "H" and your head represents an "O".

The four students will stand with arms out at an angle. One will simply walk back and forth with extended arms, representing TRANSLATIONAL KINETIC ENERGY. One will simply rotate in a circle with arms extended, representing ROTATIONAL KINETIC ENERGY. One will wave his/her arms up and down, changing the H–O–H angle and representing one kind of VIBRATIONAL KINETIC ENERGY. The last student will simultaneously move both fists first closer to their shoulders, bending the elbows, and then farther from their shoulders by straightening the arms, changing the O–H bond length and representing another kind of VIBRATIONAL KINETIC ENERGY.

As a grand finale that the class will remember for a long time, the teacher can go to one side of the front of the room and point out that most water molecules possess several types of kinetic energy simultaneously. Then hold arms outstretched at a 45^{o} angle to the side, starting to move arms up and down ("wig-wag" motion), then simultaneously introduce the arm-stretching motion, then start to rotate and finally, while waving, stretching and rotating, run to the other side of the room. This spectacle can be ended with a satisfying "splat" (outraised arms to prevent a broken nose) on the opposite wall. Wild applause follows.

DEHYDRATING ACTION OF SULPHURIC ACID: A TWIST

TOPIC Anhydrous copper sulphate **DEMO #** 11.IV.1

REFERENCE A Demo A Day, Volume 2: Another Year of Chemical Demonstrations, p. 87

EQUIPMENT large test tube (25 x 150 mm)
stand and clamp

CHEMICALS about 20 mL of concentrated sulphuric acid
large crystal of cupric sulphate, $CuSO_4 \cdot 5H_2O$

PROCEDURE Fill the test tube half full of acid and clamp it to the stand. Carefully add the crystal of copper sulphate. Over a period of several minutes the blue colour disappears and anhydrous white copper sulphate forms.

A CHEMICAL GARDEN

TOPIC Colours of ions **DEMO #** 11.IV.2

REFERENCE Chemical Curiosities: Spectacular Experiments and Inspired Quotes, p. 23

EQUIPMENT
1 L beaker
250 mL sodium silicate
cover glass for the beaker

CHEMICALS crystals (as large as possible) of as many as possible of:
- aluminum chloride (white membrane)
- cobalt (II) chloride (dark blue membrane)
- chromium (III) chloride (dark green membrane)
- copper (II) chloride (light blue–green membrane)
- iron (III) chloride (yellow and brown membrane)
- manganese (II) chloride (white and pale pink membrane)
- calcium chloride (white membrane)
- nickel (II) nitrate (green membrane)
- potassium permanganate (violet membrane)

PROCEDURE Dilute 250 mL of sodium silicate with an equal volume of distilled water. Drop crystals of the chosen salts so they evenly cover the bottom of the beaker. **NOTE:** Do not put too many colours in the same beaker or they will give an unattractive jumbled mess. Also, be aware that potassium permanganate tends to colour the solution a dark obscuring purple, so use very little amounts of this chemical, if any. Cover the beaker so as to leave the solution undisturbed. After a short while a colourful garden with lush vegetation is formed.

SYNTHESIS OF MERCURY (I) IODIDE AND MERCURY (II) IODIDE

TOPIC Law of multiple proportions **DEMO #** 11.V.1

REFERENCE Chemical Demonstrations: A Sourcebook for Teachers, Volume 1, p. 157

EQUIPMENT large mortar and pestle
orange tote tray to contain spills
spatula
disposable gloves

CHEMICALS 10.0 g of mercury
2 — 6.35 g portions of powdered iodine

PROCEDURE In a fume hood: Place 10.0 g of mercury in a large mortar. Slowly add, with constant grinding, a 6.35 g portion of powdered iodine. A green powder, mercury (I) iodide, is formed.

$$2\ Hg(l) + I_2(s) \rightarrow Hg_2I_2(s)$$

Add the second 6.35 g portion of iodine and continue to grind the mixture until a red–yellow powder, mercury (II) iodide, is formed.

$$Hg_2I_2(s) + I_2(s) \rightarrow 2\ HgI_2(s)$$

EQUAL VOLUMES OF GASES HAVE DIFFERENT MASSES

TOPIC Avogadro's Hypothesis **DEMO #** 11.V.2

REFERENCE A Demonstration–A–Day ... For High School Chemistry, p. 3

EQUIPMENT 2 balloons

CHEMICALS can of Freon (such as Dust–Off®, from camera stores, used to dust off photographic negatives)

PROCEDURE Blow up one balloon with air and the other balloon with Freon. The balloon containing air floats gently to the floor, while the one fill with Freon drops like a stone.

This demonstration shows that equal volumes of two different gases can have different masses.

MOLAR MASS SAMPLES

TOPIC Molar mass **DEMO #** 11.V.3

REFERENCE commonly known

EQUIPMENT several small bottles with caps
wax, to seal the liquid samples permanently
cube made from poster board, 28.2 cm on each edge. If possible, have one side that opens up so that nine 2 L pop bottles can be put into the cube (and still have space available). This cube has a volume of 22.4 L.

CHEMICALS Into the bottles place samples of various common chemicals, such as

- 18.0 g of water
- 46.0 g of ethanol
- 27.0 g of aluminum
- 342.0 g of sucrose
- 207.2 g of lead
- 55.8 g of iron
- 32.1 g of sulphur
- 74.0 g of butanol

PROCEDURE Hand the samples around so students can experience the fact that different substances have different molar masses. Point out that both the aluminum and lead samples have the same number of atoms and ask why the sample of lead is much heavier — students should understand that the individual atoms of lead are more massive than the atoms of aluminum.

Point out that the cube can hold 2.0 g of hydrogen or 32.0 g of oxygen at 0^{o}C and 1 atm pressure.

MISTY SMOKE RINGS

TOPIC Molar mass of air vs CO_2 **DEMO #** 11.V.4

REFERENCE Twenty Demonstrations Guaranteed to Knock Your Socks Off! Volume II, p. 57

EQUIPMENT 7–11™ Slurpee™ cup with lid

CHEMICALS dry ice (3–4 pucks)

PROCEDURE Half–fill the cup with water, drop in one or two 20 g chunks of dry ice and put the lid on the cup. Tilt the cup slightly and give a few small, quick squeezes to the sides of the cup. The rate at which the dry ice is subliming seems to be a critical factor, as is the stillness of the air in the room. When the conditions are right, the smoke rings last for several seconds and follow graceful projectile arcs and then, as they approach a table top, they hover momentarily as they spread themselves out and dissipate. A dark background helps to bring out the details.

Because carbon dioxide has a molar mass of 44 g and air has an average molar mass of 29 g, the smoke rings are heavier than air and eventually sink after being formed.

A "MOLE" OF CO_2

TOPIC Molar volume of CO_2 **DEMO #** 11.V.5

REFERENCE A Demo A Day, Volume 2: Another Year of Chemical Demonstrations, p. 148

EQUIPMENT balance
large plastic bag (clear is better; must hold at least 23 L) and twist–tie

CHEMICALS 44 g of dry ice

PROCEDURE Weigh out 44 g of dry ice and quickly seal it into the bag to avoid ice formation. Set the bag in plain view for the rest of the class. This visibly shows the large volume change during the sublimation process.

SOLUTIONS OF MOLES

TOPIC Molarity **DEMO #** 11.V.6

REFERENCE A Demo A Day: A Year of Chemical Demonstrations, p. 138

EQUIPMENT 2 L plastic soda bottle
1 L beaker
several stuffed moles (see reference for pattern)

CHEMICALS —

PROCEDURE Make up 3 stuffed moles from the pattern. Also make an extra mole that is cut in half and connected together with Velcro®. Cut the top of the plastic bottle about 3/4 of the way around so as to create a "flip top" lid.

Introduce the concept of molarity. Put one of the moles in the 1 L beaker and explain that this creates a solution of 1 mole per litre. Continue to add moles to the beaker to create higher concentrations.

Take the 2 L bottle and again add moles. Introduce the concept of fractional moles by ripping apart the Velcro® mole and adding the front half of the split mole. The back half can also be used or left as "molasses".

Reproduce the pattern in the reference and let students make their own moles for extra credit. Students could be allowed to bring their moles to tests as mascots.

IT'S ONLY ONE PART PER MILLION

TOPIC Parts per million **DEMO #** 11.V.7

REFERENCE A Demonstration–a–Day **...** For High School Chemistry**,** p**.** 30

EQUIPMENT 1 L volumetric flask
100 mL graduated cylinder
10 mL graduated cylinder
dropping pipet
250 mL beaker

CHEMICALS 0.1 g $KMnO_4$

PROCEDURE Dissolve 0.1 g of potassium permanganate in 100 mL of water in a 250 mL beaker**.** This solution is 1 part per 1000**.** Transfer the solution to a 1 L flask and dilute to exactly 1 L**.** This solution is 1 part per 10 000**.** Pour out 10 mL of the solution**,** empty the remaining contents of the volumetric flask down the sink and wash flask out well**.** Put the 10 mL of saved solution into the flask and redilute to 1 L**.** This solution is 1 part per million**.** Notice that the solution is visibly coloured and point out that they would probably not want to drink this solution**,** even if the chemical concentration "is only one part per million"**.**

NONADDITIVITY OF VOLUMES : 1 + 1 < 2

TOPIC Volumes are not conserved **DEMO #** 11.VI.1

REFERENCE A Demo A Day: A Year of Chemical Demonstrations, p. 120

EQUIPMENT 1 m length of 12–15 mm OD glass tubing, sealed at one end (or a gas burette or a regular burette)
stopper to fit tube

CHEMICALS green food colouring
58 mL acetone
42 mL water

PROCEDURE Mix some food colouring into the water and fill the tube 40% full with coloured water. Tilt the tube and carefully add the acetone so as to create the least mixing possible and completely fill the tube. Have students note that acetone has a lower density than water and is on top. Stopper the tube so that no air bubbles exists at the top.

Invert the tube back and forth to mix the contents. Ask students what the bubble inside is. If they say "air", point out that the ends are sealed. Eventually, they should understand that the bubble is a vacuum bubble (aside from vapours).

Ask if there should be a "Law of Conservation of Volume". Point out that the water molecules fit in between the acetone molecules, giving a reduced volume.

THE ALUMINUM–IODINE REACTION

TOPIC Synthesis reaction 1 **DEMO #** 11.VI.2

REFERENCE Chemical Curiosities: Spectacular Experiments and Inspired Quotes, p. 31

EQUIPMENT 3–5 ceramic pads
evaporating dish

CHEMICALS powdered aluminum (aluminum flour)
powdered iodine
distilled water in a squirt bottle

PROCEDURE Place the evaporating dish on several ceramic pads in an operating fume hood. Mix roughly equal volumes (about a spoonful) of aluminum and iodine thoroughly in the evaporating dish. When ready, add a few drops of water into the middle of the pile of chemicals. After about one minute, purple iodine fumes are given off and then the mixture bursts into flames. Brown iodine fumes will coat the inside of the fume hood (and will sublime within an hour). The glowing residue is dialuminum hexaiodide — when cold, the compound is white.

As an historical note, during the Falkland Islands war between Great Britain and Argentina, the Argentineans fired a French–made Exocet missile at a British ship, causing the ship to start burning. The heat of the fire ignited the aluminum superstructure. Attempts to put out the blaze with water only increased the flames and the ship eventually sank. The American navy, which was experimenting with aluminum superstructures, immediately withdrew all craft with aluminum structures and replaced the aluminum with a more suitable metal.

THE GLOWING TEST TUBE

TOPIC Synthesis reaction 2 **DEMO #** 11.VI.3

REFERENCE Chemical Demonstrations: A Handbook for Teachers of Chemistry, Vol 2: p. 59

EQUIPMENT large test tube
Meker burner and flint striker
test tube holder

CHEMICALS calcium metal; freshly–cut, about the size of a match head
powdered sulphur

PROCEDURE Place a freshly–cut match–head size piece of calcium metal in the test tube. Add enough powdered sulphur to cover the calcium. Darken the room and then heat the test tube, gently at first and then strongly, with the Meker burner. A strongly exothermic reaction (that will partially melt the tube) creates a bright glow as the elements combine to produce calcium sulphide.

DEHYDRATION OF SUCROSE

TOPIC Decomposition reaction **DEMO #** 11.VI.4

REFERENCE commonly known

EQUIPMENT 250 mL beaker
very strong stirring rod
several ceramic heating pads

CHEMICALS enough sugar to fill a 250 mL beaker 3/4 full
about 100 mL of concentrated sulphuric acid

PROCEDURE In a fume hood, fill a 250 mL beaker 3/4 full of sugar. Carefully pour about 100 mL of concentrated sulphuric acid on top of the sugar and stir quickly but carefully until the acid has penetrated to the bottom of the beaker. Remove the stirring rod, carefully wash it off and wait. Within a minute, a long black "snake" of carbon emerges from the beaker. Guide the emergence with the stirring rod so that the column does not fall over.

The decomposition of sucrose, $C_{12}H_{22}O_{11}$, into carbon, water and heat produces a block of carbon with an enormous surface area (several hundreds of square metres). Point out that a French chemist during the 1800's thought that the decomposition could be reversed and tried for years to mix carbon (charcoal) with water in the presence of various catalysts to make sugars — unsuccessfully. He believed that $C_{12}H_{22}O_{11}$ was actually $C_{12}\bullet 11H_2O$. That is, sugar was a hydrate of carbon and gave us the name "carbo(n)hydrate".

REACTION BETWEEN SILVER NITRATE AND COPPER

TOPIC Metal ion single replacement **DEMO #** 11.VI.5

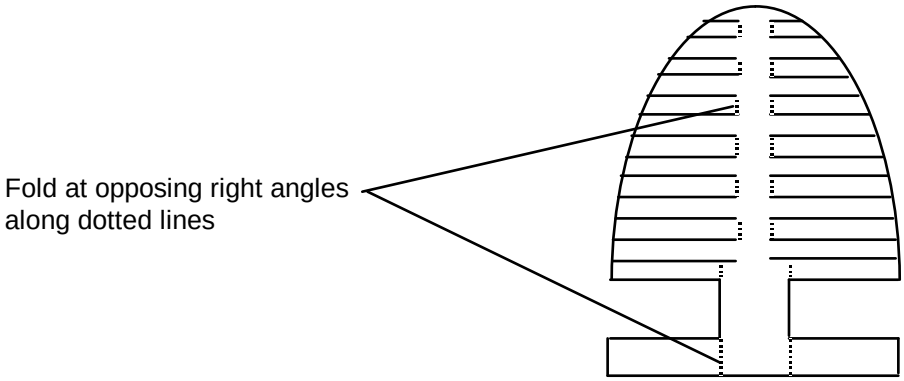
REFERENCE commonly known

EQUIPMENT 250 mL beaker
45 cm of thick copper wire (use emery cloth to clean outside)

CHEMICALS 150 mL of 0.1 M silver nitrate, $AgNO_3$

PROCEDURE Make a large open coil out of the wire in such a way that most of the wire is in the lower half of the beaker and a small hook is left to loop over the lip of the beaker and keep the wire from resting on the bottom. Remove the wire. Pour about 150 mL of 0.1 M silver nitrate into the beaker and then insert the wire. Almost instantly the wire is discoloured and after about 30 minutes a beautiful growth of silver crystals forms. The solution also turns blue as copper (II) ions are formed.

Christmas variation: Use a piece of copper sheet to make an evergreen–shaped "tree" (as shown below). When placed in a diluted silver nitrate solution, a beautiful silver tree is formed!



SINGLE REPLACEMENT OF HALOGENS

TOPIC Halogen ion single replacement **DEMO #** 11.VI.6

REFERENCE commonly known

EQUIPMENT
3 – 25 x 200 mm test tubes
one–hole stopper to fit test tube
10 cm of glass tubing to fit one–hole stopper
about 40–50 cm of rubber tubing to fit glass tubing
fritted glass gas bubbler (fish tank bubbler) or pipet with small end
10 mL graduated cylinder
25 mL graduated cylinder

CHEMICALS
25 mL fresh 5% NaOCl ("bleach")
10 mL concentrated hydrochloric acid, HCl
10 mL of 0.5 M sodium bromide, NaBr
Optional: 5 mL of hexane

PROCEDURE Insert the 10 cm piece of glass tubing into the one–hole stopper. Place 25 mL of bleach in a 25x200 mm test tube and insert the one–hole stopper. Connect the rubber tubing to the glass tube in the stopper and connect the gas bubbler. Half–fill the second 25 x 200 mm test tube with distilled water and place the gas bubbler / small–end pipet in the water. IN A FUME HOOD: Remove the stopper from the test tube containing bleach, pour the hydrochloric acid into the bleach and quickly re–stopper (CARE: it gushes quickly!) to generate chlorine gas and create "chlorine water" according to the following reaction.

$$HOCl + HCl \rightarrow Cl_2 + H_2O$$

The resulting chlorine water should have a definite yellow tint and there will probably be a yellow gas layer above the water. Place about 1 mL of chlorine water in a large test tube and add about 5 mL of 0.5 M sodium bromide. The orange colour of bromine results from the following reaction.

$$2\ NaBr + Cl_2 \rightarrow 2\ NaCl + Br_2$$

Optional: Half–fill an 18 x 150 mm test tube with the newly–created bromine solution. Add 5 mL of hexane, stopper and shake. The hexane layer on the top will be coloured orange–red by the preferential dissolving of bromine into the hexane layer.

REACTION BETWEEN SILVER NITRATE AND SODIUM CHLORIDE

TOPIC Double replacement **DEMO #** 11.VI.7

REFERENCE commonly known

EQUIPMENT 2 – small test tubes (to fit centrifuge)
centrifuge

CHEMICALS about 3 mL of 0.1 M sodium chloride, NaCl
about 3 mL of 0.1 M silver nitrate, $AgNO_3$ (OR, see alternate version, below)

PROCEDURE This is an ideal opportunity to introduce the use of a centrifuge, if this has not already been done.

Mix equal amounts of silver nitrate and sodium chloride in a test tube. A curdy white precipitate is formed. Divide the solution and precipitate equally among two test tubes. Centrifuge the mixtures to show that a precipitate is formed.

Alternate version: Use equal volumes of 0.1 M $Fe(NO_3)_3$ and 0.1 M NaOH to get a gelatinous red–brown precipitate of $Fe(OH)_3$.

NONADDITIVITY OF VOLUMES: 1 + 1 > 2

TOPIC Acid–base neutralization **DEMO #** 11.VI.8

REFERENCE A Demo A Day, Volume 2: Another Year of Chemical Demonstrations, p. 140

EQUIPMENT
2 – 500 mL volumetric flasks
1 L volumetric flask
funnel
25 mL graduated cylinder
dropping pipet

CHEMICALS
500 mL of 2 M hydrochloric acid (stored in 500 mL flask)
500 mL of 2 M sodium hydroxide (stored in 500 mL flask)

PROCEDURE Pour the sodium hydroxide (1 mol) into the 1 L volumetric flask, using a funnel, and then, with constant swirling, pour in the hydrochloric acid (1 mol). Mix well. The volume in the 1 L flask will now be greater than 1 L. Pour off the extra liquid from the 1 L flask into the 25 mL graduated cylinder and note that the extra volume is close to 18 mL.

$$\underset{1\text{ mol}}{HCl} + \underset{1\text{ mol}}{NaOH} \rightarrow \underset{1\text{ mol}}{NaCl} + \underset{1\text{ mol}}{H_2O}$$

While it is tempting to "make a big deal" about this extra volume (about 1 mol of water), the closeness to 18 mL is simply a wonderful coincidence.

GROWLING GUMMY BEAR

TOPIC Combustion **DEMO #** 11.VI.9

REFERENCE Chemical Curiosities: Spectacular Experiments and Inspired Quotes, p. 35

EQUIPMENT
25 x 200 mm test tube
ring stand
clamp
bunsen burner and flint striker
fume hood

CHEMICALS
10 g of potassium chlorate
one "gummy bear" candy

PROCEDURE In a fume hood, put 10 g of potassium chlorate into a large PERFECTLY DRY AND PERFECTLY CLEAN test tube and clamp the tube near the top, at a 45^{o} angle, above a bunsen burner. The fume hood must be operating and the mouth of the test tube should not face toward the front of the fume hood.

Melt the potassium chlorate and quickly drop in a gummy bear. A spectacular reaction ensues, in which a bright violet glow is emitted (flame test for potassium ions) and the gummy bear is burned to a tiny fragment of carbon. This one is a must!

SPARKLER IN PURE OXYGEN

TOPIC Combustion of iron **DEMO #** 11.VI.10

REFERENCE Chemical Demonstrations: A Handbook for Teachers of Chemistry, Vol 2: p. 43

EQUIPMENT
bunsen burner and flint striker
crucible tongs
large flask; 1 or 2 L is best
stopper to fit flask
sand
rubber tubing

CHEMICALS
Source of oxygen, such as a cylinder of oxygen
steel wool

PROCEDURE Put sufficient sand in the flask to cover the bottom to a depth of about 1 cm (to protect the flask). Fill the flask with oxygen and stopper the flask. Using tongs, ignite a piece of steel wool in a bunsen flame, remove the stopper from the flask and drop in the burning steel wool. The iron will burn like a sparkler.

CANDLES NEED GRAVITY TO BURN

TOPIC Combustion requires gravity **DEMO #** 11.VI.11

REFERENCE Chemical Demonstrations: A Handbook for Teachers of Chemistry, Vol 2, p. 158

EQUIPMENT candle
very large jar with lid
matches

CHEMICALS —

PROCEDURE Drop melted wax inside the jar and attach a 5–10 cm candle to the inside bottom.

Light the candle, put the lid on, and have students note that the candle can stay burning for a considerable length of time. Then take off the lid and re–admit air. Have one student stand on a bench and have another student ready to catch the jar when it is about a meter from the floor. Light the candle inside the jar and hand the jar to the student on the bench, who will put the lid on and drop the jar into the hands of the student below. Students should be able to note that the candle flame goes out as the jar is falling.

When a candle burns, the combustion products are carried away by the flame and oxygen enters from below. In the absence of gravity, the combustion products accumulate around the burning wick and the flame is extinguished.

MAGNESIUM BURNS AND BURNS

TOPIC Combustion of magnesium **DEMO #** 11.VI.12

REFERENCE A Demo A Day – A Year of Physical Science Demonstrations, p. 152

EQUIPMENT
4 L glass pickle jar
200 g of aquarium gravel
bunsen burner and flint striker
crucible tongs
heavy gloves
safety shield

CHEMICALS
tank of carbon dioxide (or carbon dioxide generator)
10 cm of magnesium ribbon

PROCEDURE Place 200 g of aquarium gravel in the bottom of the pickle jar. The gravel serves as a heat sink and prevents cracking the jar. Fill the jar with carbon dioxide. Fold the magnesium ribbon in half. Using a pair of crucible tongs, ignite the magnesium, quickly take the top off the jar and drop the burning ribbon into the exact centre of the jar. The class should be instructed not to look directly at the burning magnesium. The magnesium will burn with an intense sooty flame.

Note that it is almost impossible to put out a magnesium fire because magnesium burns in:

oxygen $2\ Mg + O_2 \rightarrow 2\ MgO$.

steam $Mg + 2\ H_2O \rightarrow Mg(OH)_2 + H_2$.

carbon dioxide $2\ Mg + CO_2 \rightarrow 2\ MgO + C$.

silicon dioxide (sand) $2\ Mg + SiO_2 \rightarrow 2\ MgO + Si$.

BOND FORMATION IS AN EXOTHERMIC REACTION

TOPIC Crystallization is exothermic **DEMO #** 11.VI.13

REFERENCE commonly known

EQUIPMENT class set of 18 x 150 mm test tubes (one tube for pair of students)
large beaker to act as a water bath
hotplate
large stirring rod
stoppers to fit test tubes

CHEMICALS sodium thiosulphate pentahydrate ($Na_2S_2O_3 \bullet 5H_2O$). A container of sodium thiosulphate crystals must be available.
distilled water

PROCEDURE **For teaching purposes, it is more effective if the preparation of the melted crystals is done the day before being used.** Fill each test tube about 3/4 full of sodium thiosulphate crystals and wet the top crystals by adding about 2–3 mL of distilled water. (The added water prevents premature crystallization when the liquid cools.) Melt the crystals by placing the test tubes in a hot water bath. When melted, stir with a large stirring rod so as to completely mix the contents. Take care not to get any of the solution around the inside of the mouth of the test tubes, wiping with a damp paper towel to clean the inside if necessary. Stopper the tubes and let them cool completely, undisturbed.

To perform the demonstration: Tell the students to carefully take one test tube per pair of students, as well as one crystal of sodium thiosulphate. They must not jar or tilt the tube. Have the students briefly touch the bottom outside of the tube, to sense the initial temperature. Then, while one student holds the top of the test tube, so as to leave a clear view of the contents, the other student removes the stopper, "plops" in the crystal and replaces the stopper. The contents will solidify quickly, as if watching time–lapse photography of frost freezing on a window. **Beautiful and mesmerizing!** Tell students to touch the test tube in the area of the solidified portion after about one minute. (It will be quite warm.) When finished, students must wash their hands since they have touched a chemical (although it is not particularly toxic).

Point out that the heat being given off was put into the crystals as kinetic energy the day before and was stored as potential energy. Any excess energy was given off as kinetic energy, allowing the contents to cool. The addition of energy broke the bonds holding the thiosulphate molecules together in crystal form and allowed the liquid state to form. The cooled liquid sodium thiosulphate "forgets" how to form its somewhat complicated crystal structure and remains as a supersaturated liquid. When the crystal of sodium thiosulphate is added, it supplies a "template" of the crystal structure and the liquid quickly crystallizes. As the molecules bond together and form a crystal, the potential energy stored in the liquid is released as kinetic energy, completing the energy cycle.

CHEMICAL COLD PACK — AN ENDOTHERMIC PROCESS

TOPIC Endothermic reaction **DEMO #** 11.VI.14

REFERENCE A Demo A Day: A Year of Chemical Demonstrations, p. 41

EQUIPMENT 250 mL beaker
thermometer
stirring rod

CHEMICALS 50 g of ammonium nitrate, NH_4NO_3
50 mL of distilled water

PROCEDURE This demonstration uses equal masses of water and ammonium nitrate; 50 g is chosen as a reasonable amount. Place 50 mL of water in a 250 mL beaker and take the temperature. Quickly add 50 g of ammonium nitrate and stir until the lowest temperature is reached. The temperature drops by about 30°C.

EVAPORATION — AN ENDOTHERMIC PROCESS

TOPIC Evaporation is endothermic **DEMO #** 11.VI.15

REFERENCE A Demo A Day – A Year of Physical Science Demonstrations, p. 67

EQUIPMENT
4 – thermometers
4 – paper clips
4 – very small elastic bands
4 – cotton balls
3 – labels
ring stand, with clamp and support rod held horizontally
3 – 100 mL beakers
small household fan or operating fume hood

CHEMICALS
5 mL of ethanol
5 mL of acetone
5 mL of distilled water

PROCEDURE Attach a cotton ball to the tip of each thermometer by means of an elastic band. Suspend each thermometer from the support rod by means of a bent paper clip hooked through the end of the thermometer. Label each thermometer as one of "control", "water", "alcohol" or "acetone". If a small fan is not available, this assembly should be placed at the front end of a fume hood which can have a sliding glass shield lowered in front.

Record the initial temperature of each thermometer, which should be the same. Loosen the clamp and lower each thermometer into its respective liquid, raise the clamp and allow the liquids to evaporate. The evaporation is accelerated by either blowing air from a fan or placing the assembly in a fume hood, lowering the glass shield until the bottom of the shield is just above the tips of the thermometers and turning on the fume hood. Leave fan / fume hood on for one minute and record the lowest temperature shown by each thermometer. The lowest temperature should be associated with acetone, since it is most volatile, followed by the alcohol and finally water. The temperature of the control should be more or less unchanged.

EXTENSION: Place a watch glass on an automatic balance, add 1 mL of water to the watch glass and record the loss in mass due to evaporation in 1 minute. Repeat with a clean watch glass for ethanol and then acetone. The acetone will display the greatest loss in mass.

EXOTHERMIC REACTION

TOPIC Exothermic reaction **DEMO #** 11.VI.16

REFERENCE commonly known

EQUIPMENT 250 mL beaker
stirring rod
thermometer

CHEMICALS 30 g of sodium hydroxide pellets
30 mL of water

PROCEDURE This demonstration uses equal masses of water and sodium hydroxide; 30 g is chosen as a reasonable amount. Wear protective gloves because of both the hazard associated with the high temperature and the hot caustic solution. Place 30 mL of water in a 250 mL beaker and take the temperature. Quickly add 30 g of sodium hydroxide and stir until the highest temperature is reached. The temperature increases by about 70^{o}C.

PENNIES NEW AND OLD

TOPIC Stoichiometry of hydrogen production **DEMO #** 11.VII.1

REFERENCE Twenty Demonstrations Guaranteed to Knock Your Socks Off! Volume II, p. 3, variation

EQUIPMENT Fuji® film canister (or equivalent)
1 L soda bottle
equipment tray (able to hold at least 1–2 L of water)
1 – post 1982 U.S. Penny
stand and ring (the ring should be able to go around the 1 L soda bottle.

CHEMICALS 50 mL of 6 M hydrochloric acid

PROCEDURE Poke a small hole in the lid of the film canister using a nail. Fill the film can 3/4 full of 6 M HCl. Set up the ring and stand in the equipment tray. Fill a 1 L soda bottle completely full of water.

Weigh a post–1982 U.S. Penny (about 2.6 g). Point out to students that U.S. pennies are made of 95% zinc with a very thin coating of copper. File 3 or 4 notches around the rim of the penny, drop the penny into the acid–filled film can, snap on the lid and invert the canister over the top of the soda bottle. Now turn the entire can–bottle assembly upside down and secure it with the ring on the stand. The canister will now be on the bottom and the bottle will fill snugly but not tightly over the lid of the film can. As hydrogen is produced, the water is displaced from the bottle.

Have students predict the volume of hydrogen that will be produced by the zinc in the penny and mark their predictions on the side of the bottle.

Although a penny has a volume of less than 1/2 mL, the volume of hydrogen gas produced is about 900 mL.

$$\text{Volume} = 2.6\ \text{g coin} \times \frac{95\ \text{g Zn}}{100\ \text{g coin}} \times \frac{1\ \text{mol Zn}}{65.4\ \text{g Zn}} \times \frac{1\ \text{mol } H_2}{1\ \text{mol Zn}} \times \frac{22\,400\ \text{mL}}{1\ \text{mol } H_2} = 920\ \text{mL}$$

LIMITING QUANTITIES

TOPIC Limiting quantities **DEMO #** 11.VII.2

REFERENCE A Demo A Day, Volume 2: Another Year of Chemical Demonstrations, p. 86

EQUIPMENT
10 mL graduated cylinder
5 – latex balloons
5 – 18 x 150 mm test tubes
test tube rack

CHEMICALS
50 mL vinegar (or 5% acetic acid)
4 g sodium bicarbonate, $NaHCO_3$

PROCEDURE To five different latex balloons use a powder funnel to add 0.18 g, 0.35 g, 0.70 g, 1.00 g and 1.70 g of $NaHCO_3$. Add 10.0 mL of vinegar to each of five different 18 x 150 mm test tubes.

Attach one powder–containing balloon, in order of mass of powder, to each test tube containing vinegar. Lift the balloons one at a time to allow the reactants to mix. Tube 4 has more or less stoichiometric quantities of each reactant.

Discuss the results, pointing out that tubes 1, 2 and 3 have the sodium bicarbonate as the limiting reactant and in tube 5 the vinegar is the limiting reactant.

CALCULATING THE MOLAR MASS OF THE ISOTOPE DEUTERIUM

TOPIC Isotope of Hydrogen **DEMO #** 11.VIII.1

REFERENCE Jim Hebden

EQUIPMENT 0.01 g balance
1 – 10 mL pipet
2 – 100 mL beakers, one labelled H_2O and the other labelled D_2O

CHEMICALS Bottle of deuterium oxide
Bottle containing about 50 mL of distilled water

PROCEDURE Pipette exactly 10.0 mL of heavy water into a beaker and find the mass of the heavy water. Return the heavy water to its bottle (it is much too expensive to waste). Rinse the pipet and pipet exactly 10.0 mL of distilled water into the second beaker and find the mass of the water.

Calculate ratio: Heavy water is $\frac{\text{mass of heavy water}}{\text{mass of distilled water}}$ times heavier than H_2O (about 1.11)

Molar mass of H_2O = 2 x 1.0 + 16.0 = 18.0 g

Heavy water = D_2O

Molar mass of D_2O = (ratio) x 18.0 g = about 19.9 g

Molar mass of D = $\frac{1}{2}$ [(about 19.9 g) – 16.0] = (**about 1.95 g**)

Conclusion: "D" is an isotope of hydrogen having a mass of 2.

NEON LIGHT

TOPIC Emission spectrum of neon **DEMO #** 11.VIII.2

REFERENCE A Demonstration–a–Day **...** For High School Chemistry**,** p**.** 46

EQUIPMENT Old neon sign from sign company specializing in neon signs
Tesla coil

CHEMICALS —

PROCEDURE Touch one end of the neon light with an operating Tesla coil**.** A bright red light emission from neon is seen near the metal electrodes**;** the colour then changes depending on the coating inside the glass tube**.** (Argon lights give a blue emission**.**)

PLASMA TUBES AND SPHERES

TOPIC Plasma sphere **DEMO #** 11.VIII.3

REFERENCE Twenty Demonstrations Guaranteed to Knock Your Socks Off! Volume II, p. 53

EQUIPMENT vacuum pump, with transparent Tygon™ vacuum tubing
electrical tape
ring stand and clamp
tesla coil
coat hanger
large round–bottom flask (thick–walled, no cracks, 2 L or larger is best)
2–hole stopper to fit flask (it may be better to drill the holes to the required sizes)
5–6 cm of glass tubing to fit 2–hole stopper
vacuum grease
strong clamp to close off vacuum tubing, or a stopcock
Optional: neodymium magnet

CHEMICALS —

PROCEDURE Cut the straight portion off the bottom of a coat hanger and bend one end into a small smooth loop. Trim the rod so that it can extend from the centre of the round bulb of the flask to the mouth of the flask. Use sandpaper to clean the straight end for about 2–3 cm. Wrap the rod in electrical tape, leaving the loop and 1 cm at the other end exposed.

Insert the tip of the tesla coil into one of the holes in the rubber stopper, from the wide end of the stopper, and then jam the straight tip of the metal rod into the other end of the same hole. The rod should be far enough in to make firm contact with the tip of the tesla coil but not so far as to protrude out the other end of the stopper and cause an air leak. Insert the piece of glass tubing into the other hole in the stopper, from the wide side, leaving 3 cm of glass protruding so as to be able to attach the vacuum tubing. Insert the rubber stopper into the flask (use a little vacuum grease) and clamp the flask in an inverted position.

Explain the setup to the class. Everyone should wear safety goggles in case of an implosion. Darken the room, turn on the tesla coil and turn on the vacuum pump. After a while, sufficient vacuum will have been created to show a small plasma effect. Move your hand over the bulb of the flask to show how you can act as a ground for the plasma. Then, when a full vacuum has been achieved, turn off the pump and disconnect it from the tubing to prevent the pump from acting as a ground for the discharge. The full plasma effect will now be displayed. If the plasma disappears quickly, there is a vacuum leak that must be found and corrected. When finished, try admitting a small amount of air and notice the effect on the plasma as more and more pressure is restored.

The plasma consists of ions and stripped–off electrons. The stripped electrons strike other atoms and ionize and energize them. The resulting gas is a conducting collection of ions and electrons. The blue and red colours are due to ionization of nitrogen and oxygen molecules, as seen in the Northern Lights.

EXTENSION: When the plasma is operating fully in the sphere, place one hand on the sphere and pick up one end of a fluorescent tube. The tube lights from the electricity passing through you. Let a student touch the other end of the fluorescent tube, which will glow brighter as a result of being grounded. If the other end is touched to a metal faucet, instead of a student, the bulb glows brighter still. Point out that the fluorescent tube will actually glow if it is simply placed near the tesla coil, without touching.

FURTHER EXTENSION: As the white plasma goes down the transparent tubing toward the vacuum pump, bring a strong (neodymium) magnet near the tubing and notice how the ions are affected by the magnetic field – this is the operating principle behind cyclotrons.

ABSORPTION SPECTRA ON THE OVERHEAD PROJECTOR

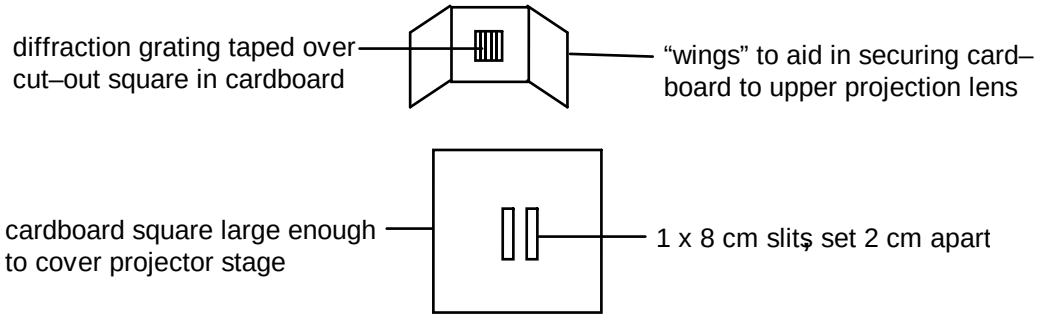
TOPIC Absorption spectra of solutions **DEMO #** 11.VIII.4

REFERENCE A Demo A Day, Volume 2: Another Year of Chemical Demonstrations, p. 56

EQUIPMENT overhead projector
6.5 x 6.5 cm sheet of diffraction grating
cardboard with 6 x 6 cm square cut in middle (see below)
petri dish
cardboard square large enough to cover entire overhead stage, with slits (see below)

CHEMICALS 20 mL of 0.010 M potassium permanganate, $KMnO_4$ (freshly made)
20 mL of 0.10 M copper (II) nitrate, $Cu(NO_3)_2$
20 mL of 0.10 M iron (III) chloride, $FeCl_3$
20 mL of water with food colouring

PROCEDURE Prepare the two pieces of cardboard as shown below.



Tape the large square of cardboard over the projector stage. Tape the diffraction grating over the hole in the small piece of cardboard with wings and then tape this assembly over the upper projection lens.

Darken the room and turn on the projector. Two continuous spectra should be seen on the screen. Over one slit put a petri dish. Pour the 0.010 M potassium permanganate solution into the dish. The spectrum of the permanganate ion will now be projected as one or more dark bands within a continuous visible spectrum. Repeat with other solutions.

ELECTRONEGATIVITY, ATOMIC DIAMETER, MELTING TEMPERATURE AND IONIZATION ENERGY

TOPIC Trends in atomic properties **DEMO #** 11.VIII.5

REFERENCE Jim Hebden

EQUIPMENT 4 copies of periodic table (representative elements); see Chem 11 Demos.Appendix
4 pieces of 3/4" plywood (slightly larger than periodic table sheets)
clear MacTac™
white glue
3/16" drill
3/16" cork borer
needle files (to smooth holes)
5 — 4 foot lengths of 3/16" dowelling
4 different colours of bright enamel paint (yellow, red, blue and green work well)
centimetre ruler
fine saw (an X–Acto saw works very well)
sandpaper

CHEMICALS —

PROCEDURE Glue one copy of each of the periodic tables labelled ELECTRONEGATIVITY, MELTING TEMPERATURE, IONIZATION ENERGY and ATOMIC RADIUS to each of four separate pieces of 3/4" plywood. Drill 3/16" holes to a depth of 1/2" centred above each symbol in the tables (note that not all holes have to be drilled in each table; consult the Table Of Atomic properties that follows). Use needle files to smooth the holes. Cover the entire top of each periodic table/plywood with clear MacTac. Use a 3/16" cork borer to punch a hole through the MacTac into each hole.

Take the ELECTRONEGATIVITY board and push a piece of 3/16" dowel into the hole drilled for "H". Use a pencil to mark the position at the top of the hole on the dowel. Remove the dowel and mark off a further 4.4 cm on the dowel (see the Table Of Atomic Properties that follows). Cut off the dowel at the 4.4 cm mark and smooth the end with sandpaper. Repeat this process for the other atoms in this and the other periodic tables.

A dummy table with drilled holes is useful to hold the pieces of cut dowelling while painting. Paint the dowels for each table the same colour, different from the colours for the other tables.

TABLE OF ATOMIC PROPERTIES

EN = electronegativity , Rad = atomic radius , MP = melting point , IE = ionization energy
The "Radius" refers to the ATOMIC RADIUS, except where that value is unavailable or misleading. In these cases, the van der Waals radius is used and indicated by a (v) or the covalent radius is used and indicated by a (c).

The values given for the electronegativity, radius, melting point and ionization energy are simply convenient values in centimetres and are proportional to each other in a given column.

Element	EN	Rad	MP	IE	Element	EN	Rad	MP	IE
H	4.4	2.34	0.04	3.94	As	4.36	3.63 (c)	3.27	2.84
He	0	3.66 (v)	0.00	7.18	Se	5.1	3.51 (c)	1.47	2.82
Li	1.96	4.56	1.36	1.54	Br	5.92	3.43	0.80	3.42
Be	3.14	3.40	4.65	2.70	Kr	0	5.94 (v)	0.35	4.05
B	4.08	2.49	7.72	2.40	Rb	1.64	7.43	0.94	1.21
C	5.1	2.28	11.46	3.26	Sr	1.9	6.45	3.13	1.65
N	6.08	2.13	0.19	4.21	In	3.56	4.5 (c)	1.29	1.68
O	6.88	1.95	0.16	3.94	Sn	3.92	4.2 (c)	1.52	2.13
F	7.96	2.13	0.16	5.04	Sb	4.1	4.23 (c)	2.71	2.50
Ne	0	4.8 (v)	0.07	6.24	Te	4.2	4.11 (c)	2.17	2.61
Na	1.86	4.61	1.11	1.49	I	5.32	4.00	1.16	3.03
Mg	2.62	4.8	2.77	2.21	Xe	0	6.48 (v)	0.48	3.51
Al	3.22	4.29 (c)	2.80	1.73	Cs	1.58	7.96	0.90	1.13
Si	3.8	3.51	5.05	2.36	Ba	1.78	6.52	3.0	1.51
P	4.38	3.3 (c)	0.95	3.04	Tl	3.24	5.11	1.73	1.77
S	5.16	3.12	1.16	3.00	Pb	4.66	5.25	1.80	2.15
Cl	6.32	2.97	0.52	3.75	Bi	4.04	4.65	1.63	2.11
Ar	0	5.73 (v)	0.25	4.56	Po	4	5.01	1.58	2.44
K	1.64	6.81	1.01	1.26	At	4.4	0	1.73	2.79
Ca	2	5.92	3.34	1.77	Rn	0	0	0.61	3.11
Ga	3.62	3.75 (c)	0.91	1.74	Fr	1.4	8.1	0.9	1.2
Ge	4.02	3.66 (c)	3.63	2.29	Ra	1.78	6.69	2.92	1.53

PERIODICITY OF CHLORINE

TOPIC Reactions between halogens **DEMO #** 11.VIII.6

REFERENCE A Demo A Day, Volume 2: Another Year of Chemical Demonstrations, p. 176

EQUIPMENT 2 – 25 x 150 mm test tubes
2 – stoppers to fit test tubes

CHEMICALS 10 mL of hexane
20 mL of 0.1 M KBr
20 mL of 0.1 M KI
20 mL of chlorine bleach

PROCEDURE Put 20 mL of 0.1 M KBr in one test tube and 20 mL of 0.1 M KI in the second test tube. Add 10mL of bleach and 5 mL of hexane to each test tube, stopper and shake. CARE: the hexane may build up pressure and pop the stopper off. The free halogens will accumulate in the upper hexane layer. Point out to students that the bleach releases free chlorine in solution.

$$Cl_2(aq) + 2\ Br^-(aq) \rightarrow 2\ Cl^-(aq) + Br_2(aq)$$

red-brown

$$Cl_2(aq) + 2\ I^-(aq) \rightarrow 2\ Cl^-(aq) + I_2(aq)$$

pink-purple

IONS NEED TO GET TOGETHER

TOPIC Reactions in solid vs. aqueous state **DEMO #** 11.IX.1

REFERENCE A Demo A Day, Volume 2: Another Year of Chemical Demonstrations, p. 70

EQUIPMENT
125 mL flask
mortar and pestle
16 x 100 mL test tube
plug of cotton batting
rubber stopper to fit test tube
funnel

CHEMICALS
about 25 g of lead (II) nitrate
about 50 g of potassium iodide
20 g of copper (II) sulphate pentahydrate, $CuSO_4 \cdot 5H_2O$

PROCEDURE Three days previous to this demonstration, fill a 16 x 100 mL test tube about 40% full of lead (II) nitrate and, with NO mixing, add an equal volume of potassium iodide on top. Stuff in a piece of cotton to prevent mixing if the test tube is shaken, and add a rubber stopper.

Have students observe that there is a yellow interface between the lead (II) nitrate and potassium nitrate, where a small amount of yellow lead (II) iodide has formed.

Add about 15 g of copper (II) sulphate and about 20 g of potassium iodide to a 125 mL flask and shake the mixture. Students should note that no reaction appears to take place. Pour the mixture into a mortar and grind vigorously with a pestle. The mixture turns brown and starts to give off iodine fumes. Make students aware of the effort needed to cause the reaction.

Add a few grams of copper (II) sulphate to the flask and add a few grams of potassium iodide. Add water and note the immediate formation of a brown product, CuI_2 and I_2.

$$4\ KI + CuSO_4 \rightarrow CuI_2 + K_2SO_4 + I_2$$

VARIATION: Into a test tube place a few grams of solid lead (II) nitrate and add a few grams of solid potassium iodide. Stopper and shake for a minute. The result is a yellow solid formed in the solid state: lead (II) iodide.

GLASS IS SOLUBLE IN WATER

TOPIC Solubility **DEMO #** 11.IX.2

REFERENCE Chem 13 News, November 1976, p. 18

EQUIPMENT mortar and pestle
2 — 2 cm pieces of soda glass tubing (NOT PYREX!)
piece of paper large enough to cover the top of the mortar

CHEMICALS phenolphthalein solution

PROCEDURE Poke a hole in the piece of paper large enough to put the handle of the pestle through. Place the piece of glass tubing in the mortar, cover with the paper and gently break the glass into small shards. Thoroughly grind the glass into a fine powder. Show students that the transparent glass is now a white powder. Add a few drops of phenolphthalein to the powdered glass and show students that the phenolphthalein turns bright magenta. The significance of this colour change is that soda glass contains sodium carbonate, which is a base, and that the glass dissolves sufficient extently to make the phenolphthalein indicator dye basic. To underline this fact, drop phenolphthalein solution on a piece of unpowdered glass and see that no colour change occurs. The increased surface area of the powder allows sufficient sodium carbonate to dissolve and affect the phenolphthalein.

MULTIPLY–SATURATED SOLUTION

TOPIC Saturated solutions **DEMO #** 11.IX.3

REFERENCE Jim Hebden

EQUIPMENT two 600 mL beakers (or two 1 L clear glass bottles, with caps)
stirring rod (if no magnetic stirrer available)
Optional, but very handy: Magnetic stirrer, with stirring bar

CHEMICALS 100 mL distilled water
about 180 g of sucrose, $C_{12}H_{22}O_{11}$
about 140 g of ammonium nitrate, NH_4NO_3
about 120 g of anhydrous sodium acetate, $NaCH_3COO$
about 30 g of potassium bromide, KBr

PROCEDURE **This demonstration should last for many years if tightly capped (sealed with wax).**

Note: The following procedure assumes a magnetic stirrer is available. If one is unavailable, use a clear glass 1 L bottle and shake the contents occasionally. The process may then require a period of several days unless you shake the bottle constantly for several hours.

Saturating with sucrose: Add about 100 g of sucrose to 100 mL of water and stir until dissolved. Add another 10 g of sucrose and stir until dissolved. Continue adding 10 g portions until solid remains undissolved after 2 hours of stirring. (Saturation is reached at about 160 g. For this demonstration it is not important that the solution be exactly saturated with each solid, only that not much more of each solid can dissolve.) At this point, let any solid particles settle and pour off as much of liquid as possible into either another 600mL beaker or another 1 L bottle. At this point, the liquid should be a transparent and somewhat viscous.

Saturating with ammonium nitrate: Add about 50 g of ammonium nitrate to the mixture and stir to dissolve. Continue adding 10 g porions until solid remains undissolved after 2 hours of stirring. (Saturation is reached at about 130 g.) At this point, let the solid particles settle and pour off as much of the liquid as possible into either another 600 mL beaker or another 1 L bottle. The liquid should now be transparent and quite viscous.

Saturating with sodium acetate: Add about 50 g of sodium acetate and stir to dissolve. The white powder has a tendency to simply sit on top of the liquid and may have to be stirred using a spatula to "wet" the powder and to "mush" the occasional lump of powder which resists dissolving. As before, continue with 10 g additions until undissolved solid remains after 2 hours of stirring. (Do not try to add the theoretically possible amount of sodium acetate – about 110 g – or you may cause precipitation of sodium nitrate.) As before, let the liquid settle – this may take quite a while – and pour off as much clear liquid as possible. The resulting liquid should be transparent and will be extremely viscous.

Saturating with potassium bromide: Add about 10 g of potassium bromide and stir to dissolve. Continue adding 5 g portions until saturated (about 25 g). Do not add excessive amounts at any time or precipitation of potassium nitrate may occur. The final product will have a tar–like consistency.

Comment: Students often mistakenly believe that if a solution is saturated with one substance, it is no longer able to dissolve any other substance. This demonstration should shatter that belief.

Moles of H_2O present in 100 g	= 5.56 mol
Moles of $C_{12}H_{22}O_{11}$ present in 160 g	= 0.47 mol
Moles of NH_4NO_3 present in 130 g	= 1.63mol
Moles of $NaCH_3COO$ present in 110 g	= 1.34 mol
Moles of KBr present in 25 g	= 0.21 mol
Moles of solids (combined)	= 3.65mol

Therefore, the moles of water outnumber the moles of the dissolved substances.

SUPERSATURATED SOLUTION

TOPIC Supersaturated solution **DEMO #** 11.IX.4

REFERENCE A Demo A Day: A Year of Chemical Demonstrations, p. 143

EQUIPMENT 500 mL florence flask

CHEMICALS 100 g of sodium acetate trihydrate, $NaCH_3COO \cdot 3H_2O$
10 mL distilled water

PROCEDURE Prepare the solution well ahead of time by adding 100 g of sodium acetate trihydrate to a very clean (and preferably completely scratch–free) 500 mL florence flask, adding 10 mL of distilled water and heating until the solid is completely dissolved. Make sure that no solid is left on the sides or neck of the flask. Stopper and let cool to room temperature or below.

To perform the demonstration, either cool the solution in an ice bath for fifteen minutes and give the flask a violent shake to cause the contents to immediately solidify OR while at room temperature, drop in a single crystal of sodium acetate trihydrate and watch the solution solidify within 2–3 seconds.

Variation: Place a few crystals of sodium acetate trihydrate in the middle of a clean and dry tote tray. Then slowly pour the supersaturated solution out of the flask onto the crystal, forming an impressive tall "tower" of glistening white solid!

IONIC CRESCENDO

TOPIC Conduction in ionic solutions **DEMO #** 11.IX.5

REFERENCE Twenty Demonstrations Guaranteed to Knock Your Socks Off! Volume II, p. 53

EQUIPMENT 9 V battery, with battery clip
9 V piezo buzzer (available from Radio Shack)
insulated solid hookup wire
Plastic petri plate
plastic dropping pipet
electrician's tape

CHEMICALS potassium permanganate
distilled water

PROCEDURE Remove 1 cm of insulation from the end of two 60 cm lengths of wire. Straighten the lengths of wire so that the bare ends are in the middle of the bottom of the petri plate, 1–2 cm apart, extend up the side of the plate, down the outside and continue for another 20–40 cm. Connect one wire to a terminal of the piezo buzzer and the other wire to one terminal of the battery. Use another length of wire to connect the other terminal of the battery to the other terminal of the piezo buzzer. Wrap electrician's tape around the perimeter of the petri plate to hold the wires firmly in place.

Cut the bulb of a plastic pipet in half (to make a funnel) and cut off the tip to create a 2–3 mm diameter tube.

Place the apparatus on a light box or overhead projector and fill the petri plate with distilled water. Once the water has stopped swirling, position the funnel directly over the gap between the ends of the wires and drop in one 1-1.5 mm crystal of potassium permanganate. As the pink circle expands to fill the gap between the wires, the volume of the buzzer increases.

DO FROZEN SOLUTIONS CONDUCT ELECTRICITY?

TOPIC Solid ionic solutions don't conduct **DEMO #** 11.IX.6

REFERENCE Chemical Demonstrations: A Sourcebook for Teachers, Volume 2, p. 134

EQUIPMENT U–tube (made by bending a 15 cm length of 10 mm pyrex glass tubing into a 2–3 cm diameter curve)
conductivity apparatus
250 mL beaker
stand and clamp (to hold top of U–tube)
dry ice slurry (crushed dry ice mixed with acetone to make a slurry)

CHEMICALS 100 mL of 10% ammonium chloride (dilute 10 g of NH_4Cl to 100 mL)

PROCEDURE Clamp the U–tube to the stand and fill the tube almost full of ammonium chloride solution. Place one electrode of the conductivity apparatus into either arm of the U–tube. Show that the light bulb on the conductivity apparatus glows brightly, indicating a conducting solution. Lower the U-tube into a 250 mL beaker filled with a dry ice / acetone slush and observe the light gradually extinguish as the ammonium chloride solution freezes.

HYDROGEN BONDING

TOPIC Hydrogen bonding 1 **DEMO #** 11.IX.7

REFERENCE A Demo A Day, Volume 2: Another Year of Chemical Demonstrations, p. 158

EQUIPMENT 5 – 250 mL bottles, with lids
wax (optional)

CHEMICALS 100 mL of distilled water
100 mL of hexane
100 mL of ethanol
100 mL of ethylene glycol
100 mL of glycerine

PROCEDURE Fill each bottle with 100 mL of one of the liquids, cap it and label it. For a permanent display, seal the lids with wax.

Gently rotate one of the bottles so that the liquid inside begins to swirl. Time how long it takes for the vortex to disappear. Repeat with the other bottles, taking care to rotate each bottle for the same length of time.

The expectation, if done carefully, is that the glycerine takes the shortest time to stop rotating, then the ethylene glycol, water, ethanol and hexane.

Point out that the greater the degree of hydrogen bonding, the shorter the length of time. The structures of the chemicals are shown below.

glycerine = $CH_2(OH)–CH(OH)–CH_2(OH)$
ethylene glycol = $HOCH_2CH_2OH$
water = HOH
ethanol = CH_3CH_2OH
hexane = $CH_3CH_2CH_2CH_2CH_2CH_3$

THE UPHILL BUBBLE

TOPIC Hydrogen bonding 2 **DEMO #** 11.IX.8

REFERENCE Twenty Demonstrations Guaranteed to Knock Your Socks Off! Volume II, p. 53

EQUIPMENT 2 – popsicle sticks
2 – 1.1 m lengths of cotton string
bubble wand
container of soapy water (tote tray)

CHEMICALS —

PROCEDURE Connect each end of each length of string to a popsicle stick, with the strings 4 cm apart on the sticks. When the strings are stretched apart by the popsicle sticks, a rectangle 4 cm by 100 cm is created.

Dip the assembly into a bucket of soapy water and with the help of an assistant stretch the string to create a large horizontal film (keep the string taut to counteract the tendency of the string to pull in at the sides).

Blow a 10 cm bubble and catch it on the rectangular film. When the bubble has fused onto the film, tilt the ramp at an angle so that the bubble glides downhill. Just before the bubble reaches the end, use a dry finger to pop the soap film between the bubble and the lower stick. With that side of the film gone, the strong hydrogen–bonding forces involved cause the bubble to be attracted to the uphill film and the bubble glides uphill to the top stick.

THE METHANE MAMBA

TOPIC Hydrogen bonding 3 **DEMO #** 11.IX.9

REFERENCE Twenty Demonstrations Guaranteed to Knock Your Socks Off! , p. 46

EQUIPMENT source of natural gas
1–2 m of rubber tubing to fit gas nozzle
#3 rubber stopper (one hole)
glass tubing (6 mm diameter) to fit stopper, 9 cm long
funnel made from the top half of a 2 L plastic soda bottle
ring stand and large iron ring support (5 in diameter)
test tube clamp
candle taped securely to the end of a meter stick
matches

CHEMICALS 300 mL of 3% (by volume) Dawn® dishwashing detergent

PROCEDURE Insert the glass tubing into the rubber stopper until equal lengths of the tubing protrude from either end of the stopper. Insert the stopper into the neck of the funnel. Clamp the funnel neck to the ring stand and stabilize the open top end of the funnel with the 5 inch ring. Connect the rubber tubing to the glass rod protruding from the bottom of the funnel and drape the hose over the part of the ring nearest the stand. (This prevents leak–back from the funnel to the gas outlet.) Connect the other end of the tubing to a gas jet.

Pour 300 mL of 3% Dawn into the funnel. The top of the glass tubing should be between 15 and 18 mL below the surface of the soapy water. With no flames nearby, turn the gas jet on full. A column of methane bubbles should grow lazily upward, becoming about 2–3 m high in about 5 minutes. The hydrogen–bonding between water molecules provides the tension that holds adjacent bubbles together.

NOTES:

1. Fine tune the column of bubbles by adjusting the flow rate of natural gas, the position of the glass tubing and the depth of liquid in the funnel. The best situation has a mixture of large and small bubbles. Too many large bubbles makes the column too buoyant and the bubbles pinch off; too many small bubbles gives a foam which simply overflows the funnel. The ideal column is just barely less dense than air, so as to support its weight but with little upwards tug.

2. The column can be made to arch by placing a few drops of water on the top of the column; a similar effect occurs if the column grows for a long time so that methane diffuses out and air diffuses in.

3. If the gas is turned off, a hand full of bubbles can be scooped away with wet hands, placed on a lab bench several meters away, and ignited with a candle attached to the end of a meter stick.

POLAR / NONPOLAR LIQUIDS

TOPIC Polar / nonpolar liquids 1 **DEMO #** 11.IX.10

REFERENCE A Demo A Day: A Year of Chemical Demonstrations, p. 114

EQUIPMENT
2 – burettes, with stands and clamps
2 – 250 mL beakers
plastic strip or rubber rod
piece of fur or wool cloth

CHEMICALS
100 mL distilled water
100 mL hexane

PROCEDURE Fill one burette with water and one with hexane. Place a 250 mL beaker underneath each burette. Charge the plastic or rubber by rubbing it with a piece of fur or cloth. Open the stopcock on the water burette until a fine, unbroken stream is obtained. Hold the charged plastic/rubber close to the stream of water and observe the bending of the water stream. Repeating the experiment with the hexane burette shows no effect since hexane is nonpolar.

IMMISCIBLE LIQUIDS

TOPIC Immiscible liquids **DEMO #** 11.IX.11

REFERENCE A Demo A Day: A Year of Chemical Demonstrations, p. 21

EQUIPMENT 2 – 1 L plastic soda bottles (clear), with caps
Tape to seal caps on bottles, or wax

CHEMICALS 500 mL of colourless baby oil
250 mL of ethanol
500 mL of 1,1,1–trichloroethane (TCE)
250 mL of distilled water
food colouring (any noticeable colour)

PROCEDURE In one bottle, mix 250 mL of ethanol and 250 mL of distilled water, colour with food colouring and add 500 mL of colourless baby oil. In the second bottle, put 500 mL of water, coloured with food colouring, and add 500 mL of TCE. Cap the two bottles tightly. Seal with tape or melted wax to make sure none of the liquid can evaporate from one year to the next.

Keep the water–TCE bottle out of student sight. Allow students to play with the water–baby oil bottle by turning it over, shaking it, etc. After a few days of allowing students to play with it, replace the first bottle with the water–TCE bottle and see how long it takes students to realize the coloured layer is now on top. Discuss why the difference might occur.

SALTING OUT — MAKING LIQUIDS IMMISCIBLE

TOPIC Immiscibility **DEMO #** 11.IX.12

REFERENCE A Demo A Day: A Year of Chemical Demonstrations, p. 142

EQUIPMENT magnetic stirrer
600 mL beaker and stir bar

CHEMICALS 150 mL distilled water
150 mL methanol
100 g of potassium carbonate, divided into four 25 g samples

PROCEDURE Add 150 mL of water and 150 mL of methanol to a 600 mL beaker. Stir the beaker using a magnetic stirrer. Dissolve 25 g of potassium carbonate and when it is completely dissolved add another 25 g portion. Let the solid dissolve and continue with the remaining 25 g portions. Distinct layers will become visible.

Although water and methanol are miscible, the addition of potassium and carbonate ions causes a competition with the methanol for water molecules. Eventually, as the concentration of added ions increases and ties up the water molecules, the methanol is forced out of solution.

HOW TO DISSOLVE POLYSTYRENE FOAM

TOPIC Like dissolves like **DEMO #** 11.IX.13

REFERENCE Chemical Curiosities: Spectacular Experiments and Inspired Quotes, p. 315

EQUIPMENT Magnetic stirrer, with stirring bar
2 L beaker
large bag of polystyrene packing chips

CHEMICALS 400 mL of acetone

PROCEDURE Rapidly stir 400 mL of acetone in the 2 L beaker. As the foam chips are added, they rapidly dissolve. Students are usually amazed at the large volume of chips that can be reduced to a substantially smaller volume.

Polystyrene foam is a polymeric material that traps a huge volume of air. Acetone is a slightly polar organic solvent that is able to form London forces that interrupt the London forces that hold the adjacent strands of the polymer together.

POLAR / NONPOLAR DISKS

TOPIC Polar / nonpolar liquids 2 **DEMO #** 11.IX.14

REFERENCE A Demo A Day: A Year of Chemical Demonstrations, p. 115

EQUIPMENT
250 mL flask with stopper to fit
Index card
Hole punch
Soft pencil

CHEMICALS
75 mL distilled water
75 mL hexane

PROCEDURE Completely blacken one side of the index card using the soft pencil. Then cut out several dozen disks from the card stock, using the paper punch.

Pour 75 mL of distilled water into a 250 mL flask and carefully pour 75 mL of hexane on top of the water, so that students can see the hexane is on top. Suggest to students that you are going to make them an offer: if the paper disks are added to the mixture in the flask and more white sides face up after shaking the mixture, the next test will be as simple as possible. If more black sides face up, the next test will be a "stinker". Shake the flask and let them observe the result. (Almost every disk at the water–hexane interface has its black side up.)

Explanation: Paper is made from cellulose, which is a polar substance having many OH groups. These OH groups are attracted to the lower water side (like dissolves/attracts like) due to hydrogen bonding. On the upper side, the nonpolar graphite is more attracted to the nonpolar hexane.

LATEX POLYMER

TOPIC Hydrocarbon polymer **DEMO #** 11.X.1

REFERENCE A Demo A Day: A Year of Chemical Demonstrations, p. 268

EQUIPMENT 1 L beaker
protective gloves
Ziplock® bag (optional)

CHEMICALS 50 mL of latex solution
500 mL of 1 M acetic acid (or common white vinegar)

PROCEDURE Pour 500 mL of 1 M acetic acid into the beaker and pour 50 mL of latex into the acetic acid. The latex instantly cross–links into a rubbery compound. Put on protective gloves and squeeze the vinegar out of the latex. CARE: The latex often forms a protective membrane on the outside with unreacted liquid latex in the middle, so avoid squirting blobs of liquid latex onto the floor when squeezing the acetic acid out of the solid. The solid can be molded into a ball.

Latex is a colloidal suspension of rubber particles coated with a protein. Adding an acid to the suspension causes the protein to be hydrolysed and the rubber particles to coagulate.

TEFLON TAPE

TOPIC Alkyl halides **DEMO #** 11.X.2

REFERENCE Twenty Demonstrations Guaranteed to Knock Your Socks Off! Volume II, p. 33

EQUIPMENT Teflon tape (available at the plumbing department of stores)
permanent marker pens
scissors
paper towels
Scotch® tape

CHEMICALS —

PROCEDURE Note: Teflon is polytetrafluoroethylene, —$(CF_2CF_2)_n$— . This activity works well as a "gather around" activity for a small group but is better as an individual activity with a larger group.

Cut a 15–20 cm sample of Teflon tape.

1. Gripping the entire ends firmly, stretch the tape just a little widthwise. What do you observe?
2. Stretch it again, lengthwise. What do you observe? Repeat steps 1 and 2.
3. Slowly pull on the tape lengthwise until it breaks (use as much force as is needed).
4. Slowly pull on the tape widthwise until it breaks (use as much force as is needed).

Get a new piece of tape and a permanent marker.

5. Have a partner hold the tape taut on a folded piece of paper towel while you write a short message very lightly on the tape.
6. Wrap a 1 inch long piece of Scotch® tape around the end in such a way that half of the Scotch® tape is attached to the front of the teflon tape and the other half of the Scotch® tape is wrapped around to the back of the teflon tape.
7. Stretch the teflon tape width–wise in several places so as to distort the message. At this point the message should be distorted to the point of non–recognition.
8. Have someone else pull the teflon tape length–wise so as to reveal the message. The tape can be re–distorted again.

[The fibres in teflon tape are aligned parallel to each other and are very strong, so the tape does not stretch length–wise. Because the fibres are held next to each other by weak London forces, the tape stretches almost indefinitely sideways.]

DOUBLE BONDING

TOPIC Reactions of double bonds **DEMO #** 11.X.3

REFERENCE A Demo A Day: A Year of Chemical Demonstrations, p. 111

EQUIPMENT 4 – large test tubes, with rubber stoppers to fit
test tube rack

CHEMICALS bromine water
hexane (or other saturated hydrocarbon)
cyclohexene (or other unsaturated hydrocarbon)
2 different salad oils (or bacon fat)

PROCEDURE Pour about 20 mL of each of hexane, cyclohexene and the two salad oils into separate test tubes.

Add about 10 mL of bromine water to each test tube, stopper the tubes and shake. The aqueous layer is on the bottom. If the lower layer is colourless, the bromine has reacted with double bonds in the liquid on top; if the bottom layer is still coloured, there are no double bonds in the organic liquid.

UNDERWATER FIREWORKS

TOPIC Chlorination of acetylene **DEMO #** 11.X.4

REFERENCE Twenty Demonstrations Guaranteed to Knock Your Socks Off! , p. 33

EQUIPMENT
2 L graduated cylinder
250 mL flask
1 – hole stopper to fit 250 mL flask
glass tubing to fit rubber stopper (5–6 cm)
thin glass tubing (3–5 mm OD), about 10 cm longer than the graduated cylinder
Tygon™ tubing to fit glass tubing
fume hood

CHEMICALS
100 mL of 6 M hydrochloric acid
2–3 pebble–sized pieces of calcium carbide
10 mL of sodium hypochlorite bleach

PROCEDURE Use a hot bunsen burner, Meker burner or glass torch to create a small reverse bend at the tip of the long glass tube. Place the long tube in the graduated cylinder, bent tip down, and attach Tygon™ tubing to the top of the glass tube. Insert a short piece of glass tubing into the one–hole stopper and attach the other end of the Tygon™ tubing to the top of the short glass tube. Fill the graduated cylinder with tap water to within 1 cm of the top (to prevent gases collecting at the top of the cylinder).

In a fume hood, put 100 mL of 6 M HCl into the 250 mL flask and add 10 mL of bleach to the flask. Without shaking the flask, immediately stopper it with the one–hole stopper. Move the assembly out of the fume hood, into a well ventilated area, and add 2–3 pebble–sized pieces of calcium carbide to the water in the graduated cylinder. Turn down the lights, gently swirl the flask, and manoeuvre the glass tube at the bottom of the cylinder so that the chlorine bubbles collide and react with the acetylene bubbles.

The overall reaction is $C_2H_2 + 2\ Cl_2 \rightarrow C_2H_2Cl_4 + \text{energy}$.
The highly reactive chlorine attacks the triple bond and adds across the bond.

NYLON FORMATION

TOPIC "Polyamide" polymers **DEMO #** 11.X.5

REFERENCE Chemical Demonstrations: A Handbook for Teachers of Chemistry, Vol 1, p. 213

EQUIPMENT
250 mL beaker
3 stirring rods
latex gloves
long forceps or tweezers
wooden dowel (1-2" diameter)

CHEMICALS
Solution A: 6.0 g of 1,6-diaminohexane (also called hexamethylenediamine) + 2.0 g of sodium hydroxide in 100 mL water (If necessary, place the bottle in 50°C water to melt the solid)
Solution B: **NOTE– prepare this solution the morning of the demonstration and keep well stoppered.** 4.0 mL of sebacoyl chloride dissolved in 100 mL of hexane
50:50 acetone–water mixture to wash nylon when finished

PROCEDURE Pour 100 mL of solution A into a 250 mL beaker. Carefully pour 100 mL of solution B on top of the liquid in the beaker. Use the forceps to bring some of the nylon formed at the liquid–liquid interface up to the surface, attach the nylon to the wooden dowel and "wind" the continuous thread of nylon into a skein by rolling the dowel. Use gloves to handle all solutions. Wash the product with water and then with 50:50 acetone–water mixture to dry the product and remove any residual reactants.

***What is Happening*:**

Sebacyl chloride has a reactive chlorine atom at each end of a long carbon chain, while 1,6–diaminohexane has a reactive "amino" group at both ends of a long carbon chain. When the reactants are mixed, a double replacement reaction occurs in which a chloride is removed from a sebacyl chloride molecule and a hydrogen atom is removed from an amino group on the 1,6–diaminohexane, linking the two molecules together. This "head–to–tail" linking continues indefinitely, creating a single molecule which can be metres or even kilometres long.

FINGERPRINT DETECTIVE

TOPIC Developing fingerprints with ninhydrin **DEMO #** 11.X.6

REFERENCE A Demo A Day: A Year of Chemical Demonstrations, p. 77

EQUIPMENT
fine mist spray bottle
hot plate
paper
rubber gloves

CHEMICALS
0.5% solution of ninhydrin (0.25 g ninhydrin in 50 mL of distilled water)
samples of pure amino acids, if available

PROCEDURE On a piece of paper smear some samples of amino acids (if available) and some nice heavy fingerprints.

Wear gloves when handling ninhydrin or ninhydrin solutions (TOXIC). In a fume hood, spray the paper lightly, but thoroughly, with ninhydrin solution. Dry the paper. When dry, hold the paper about 10 cm over a hot plate, taking care not to scorch the paper. The amino acids and fingerprints will appear pink.

ESTERS AS NATURAL PERFUMES

TOPIC Ester formation **DEMO #** 11.X.7

REFERENCE Chemical Curiosities: Spectacular Experiments and Inspired Quotes, p. 308

EQUIPMENT
25 x 150 mm test tubes
bunsen burner and flint striker
test tube holder
dropping pipettes
ring, stand and gauze pad

CHEMICALS
concentrated sulphuric acid
1–pentanol (n–amyl alcohol)
2–pentanol (sec–amyl alcohol)
methanol
ethanol
3–methylbutanoic acid (isovaleric acid)
benzoic acid
salicylic acid
anthranilic acid
acetic acid

PROCEDURE

Amyl Acetate: Mix 4 mL of 1–pentanol and 4 mL of acetic acid in a large test tube and carefully add 1–2 mL of concentrated sulphuric acid. Warm the mixture for a short time in a bunsen burner. Cautiously smell the ester, which smells like banana or pear.

Isoamyl Valerate: In a fume hood, mix 3 mL of 2–pentanol, 3 mL of isovaleric acid and 1 mL of concentrated sulphuric acid in a large test tube. Warm the mixture for a short time in a bunsen burner. Cautiously smell the ester, which smells like pineapple.

Methyl Benzoate: Place 1 g of benzoic acid, 4 mL of methanol and 1.5 mL of concentrated sulphuric acid in a test tube and warm gently. After a while a pleasant– smelling compound is formed; the common name is “niobe oil”.

Ethyl Benzoate: Place 1 g of benzoic acid, 4 mL of ethanol and 1.5 mL of concentrated sulphuric acid in a test tube and warm gently. After a while a product smelling like cloves is formed.

Methyl Salicylate: To a test tube add 2 g of salicylic acid, 4 mL of methanol and 4 drops of concentrated sulphuric acid. Heat for 6–7 minutes in a boiling water bath. After a short while the smell of oil of wintergreen is produced.

Methyl Anthranilate: To a test tube add 2 g of anthranilic acid, 4 mL of methanol and 4 drops of concentrated sulphuric acid. Heat for 6–7 minutes in a boiling water bath. After a short while the smell of orange blossoms is produced.