Demonstrations for Middle Schools Chemistry

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(Labs better suited to a longer session or smaller groups are indicated in green)

1.0 Middle School Chemistry, Lab list from Science in Motion

1.1. Chromatography lab (paper and radial) – separate marker colors using alcohol and water
1.2. Flame test lab – identify metal salts by flame color
1.3. Isotopes of pennies lab – measure the mass of container of pennies from varying years (1981 and earlier are Cu, 1982 and later are Cu/Ni alloy)
1.4. M&M's half-life simulation – use candy to introduce statistics
1.5. Microdensity of plastics – compare density of common plastics in water and alcohol
1.6. Moisture content in popcorn – measure mass of popcorn before and after popping for water loss
1.7. pH of household liquids lab – compare litmus paper and pH meters of household products
1.8. Red cabbage lab – use boiled red cabbage as universal indicator to test pH

2.0 Other tested demonstrations that perform well in the field

2.1. Pots of fire – burning metal salts in methanol to demonstrate flame colors
2.2. Lucigen – chemoluminescence (and fluorescence)
2.3. Electric pickle – pickle glows when connected to a source of electricity
2.4. Methanol cannon – burning methanol to result in shooting a cannon
2.5. Chernobyl reaction – nothing radioactive, just burning magnesium metal in a block of dry ice
2.6. Disappearing rainbow – acid/base indicators

Selected activities for a younger audience

2.7. 2.1 Super-absorbent polymer – polymer demo
2.8. Slime – polyvinyl alcohol and borax polymer demo
2.9. Human polymers: linked via hands vs. linked via elbows with the challenge of negotiating a course between chairs in a hallway as a demonstration of flexibility differences. Conductivity difference via passing a ball along a chain of children all facing one way vs. a chain with successive blocks of three facing one way and then the other ...

3.0 Atmospheric physics and phase transitions

3.1. Gas expansion upon warming (balloon on pop bottle standing in hot water)
3.2. Gas contraction upon cooling (soda can implosion, or milk jug collapse)
3.3. Hot air rises (steam)
3.4. Cool air drops (dry ice vapour)

3.5. Concept of density: floating diet coke vs. sinking coke
3.6. Formation of rain on bottom of jar containing dry ice, above bowl of steaming water.
3.7. Freezing water floats (pour a little liquid nitrogen into water) (survival of hibernating frogs below ice)
3.8. Freezing point depression: lower the temperature of water vs. salt-water by adding dry ice (frogs don't freeze as readily as surrounding water)
3.9. Green balloons, fill with water, salt water, sugar water tie closed, draw eyes and limbs, drop in ice-water bath. Scoop them out with spoons and squeeze them (wear knit gloves).
3.10. Compare volume of 1 mole water (18 ml in grad. cylinder) vs. vol of one mole of steam (24.5 L (25 °C and 1 Atm) = 6.4 galons (3.8 l/Gal)
3.11. Measurement of the volume of a mole of gas based on sublimation of dry ice.
3.12. Distilling water out of grape juice
3.13. Heat capacity of water vs. latent heat of freezing (or boiling)
3.14. Boltzmann demo: shaking table at an angle and marbles shaking over a grid: photograph and do statistics: population vs. height.
3.15. Iodine gas density vs. height in a column, and its dependence on Temp.

4.0 Acids and bases in your kitchen and cabinet

4.1. Red cabbage juice (anthocyanin) pH indicator.
4.2. Positive controls: vinegar and baking soda solution as known acids and bases.
4.3. List of substances in the kitchen that may be acids or bases: OJ, LJ, apple juice, TUMs
4.4. Concept of a buffer: milk
4.5. Extreme acids and bases: to be handles with EXTREME care: chlorox, ammonia, make 10-fold dilutions.
4.6. Discussion of household hazards and articulation of the fact that chemistry happens everywhere, including the home.
4.7. Neutralization of vinegar with baking soda, show recipe for scones or cornbread: make a batch, note the recipe says not to combine wet components with dry until the last minute (why ?)
4.8. Alternately: sour cream pie: foaming upon addition of baking soda.
4.9. CO_2 in breath: blow bubbles in red cabbage juice and watch it become acidic.
4.10. Acidity of fresh and spoilt food, via acidity of solution at the start of yeast growth vs. at the end. (milk vs. yogurt).

5.0 How sweet it is: Solubility, crystallization and boiling point elevation in fudge making

5.1. Hands-on: solubility of sugar in cold water vs. hot water. Contest to see which group can generate the densest sugar solution. (Plot density vs. T)
5.2. Temperature change upon dissolving sugar in water (endothermic)
5.3. Boiling T of water vs. temperature of fudge syrup (the latter just keeps rising, why ? (water keeps evaporating so the solution keeps getting more concentrated)

5.4. Cooling from different top temperatures: low T -> syrup, higher T -> sap, higher-T still-> fudge very high T -> hard candy (a glass) or super saturated solution that crystallizes.
5.5. To obtain fudge, we must prevent formation of large crystals: poison crystallization, cool fast and mechanically disrupt crystals. Crystallization game with foam squares and trapesoids.
5.6. Make fudge with and without added corn syrup.
5.7. Pour fudge too early, on time and too late from a constant top temperature.

6.0 Let there be light: Energy conversions, photosynthesis, chemoluminescence, fluorescence, phosphorescence, absorbance.

6.1. Bleaching of red construction paper.
6.2. Look at light that passes through a prism after or without prior passage through a solution of riboflavin, or β carotene or retinal (a pigment that children will find relevant and interesting).
6.3. Lucigen reaction Energy released as light. Light sticks.
6.4. Fluorescence, transfer of energy from one colour of light to a lower-energy colour. Dish detergent and fluorescein.
6.5. Phosphorescence: delayed . . . . Fluorescent beads.
6.6. In life: burning sugar: burn a marshmallow, balance the equation. The 'secret' ingredient: O_2
6.7. Yeast reaction ± O_2, ± sugar, ± yeast.
6.8. gun cotton
6.9. Discussion: Energy is utterly essential for you. You derive energy from food, this energy derives ultimately from sunlight (a few exceptions exist). Sunlight is basically our friend. The global greenhouse challenge can be addressed by the same photosynthesis reaction that feeds life. Feel good about learning about the science of the problem, and about being part of the solution by growing some vegetables.

7.0 Molecular interactions at a material level: Oil and Water (and soap)

7.1. Shake tomato juice with a white (not yellow) vegetable oil and compare the oil layer colour with that of oil that has not been mixed with the tomato juice. Ditto for carrot juice.
7.2. Diffusion experiment (leave for the class to monitor over time). Layer one drop of blue food colouring on the top of a column of sugar/water. Monitor spread of blue into the sugar/water as a function of time, and as a function of temperature. Sugar is dissolved in the water to make the water denser than the food colouring, allowing the latter to layer crisply on top. Graduated cylinders are used to house the columns of sugar/water. A very nice extension is to have one column immersed in ice-water to keep it cold and the other at room temperature. This demonstrates very nicely that diffusion (and molecular motions are faster at higher temperature.
7.3. Distillation of water from grape juice.
7.4. Separation of oil and water: water will not clean oil off a glass. Use of soaps allow the two to get along.

7.5. Molecules that like to get along: chromatography of water solutions up coffee filter paper (resolution of dyes in black magic marker). Non-migration of oil. Try oil on nylon ?
7.6. Diffusion in conjunction with molecular attraction: baby diaper weight gain upon soaking with water vs. soaking with salt water.

8.0 Biological Chemistry

8.1. Discussion of photosynthesis, Balance the *net* equation.
8.2. Capture of energy in light sunburn (goldenrod paper).
8.3. What is a pigment ? Something that absorbs light but is not changed upon doing so (recycles). Extract pigments from leaves, paper chromatography. Look at light that passes through a prism after or without prior passage through a solution of riboflavin, or β carotene or retinal.
8.4. Shake tomato or carrot juice with pale oil and monitor transfer of the fat-soluble pigment out of the water phase into the oil phase by comparing the color of the oil phase with that of the starting oil.
8.5. The big chemical energy reaction: Combustion:
8.6. In life: burning sugar: burn a marshmallow, balance the equation. The 'secret' ingredient: O_2
8.7. Yeast reaction ± O_2, ± sugar, ± yeast.
8.8. Big-picture implications: the energy crisis and climate change.
8.9. Energy is utterly essential for you. You derive energy from food, this energy derives ultimately from sunlight (a few exceptions exist). Sunlight is basically our friend. The global greenhouse challenge can be addressed by the same
8.10.
8.11. GFP-expressing bacteria ± IPTG, fluorescence
8.12. Test for class: Germinate seeds in dark box vs. under light. Illumination turns on photosynthetic genes.
8.13. Effect of prior irradiation with black light (mutation and production of some differently coloured colonies (eg rhodococcus or other cyanobacteria.)
8.14. Selection of a culture of irradiated cyanobacteria or rhodoccocus by photosynthetic growth in liquid and then replating: much smaller prepresentation of mutants after a round of selection.