BC SCIENCE INSTITUTE
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Some demonstrations to support the Chemistry portion of the Physical Science Units of the new BC Science 9 and 10 Curriculum

NOTE: ***CARE SHOULD ALWAYS BE TAKEN WHEN WORKING WITH CHEMICALS, HEAT, AND GLASSWARE. BE SURE TO ALWAYS PRACTICE SAFE LABORATORY TECHNIQUES AND ADHERE TO THE CONDITIONS AND CAUTIONS ASSOCIATED WITH HANDLING AND DISPOSING OF EACH CHEMICAL AS PER THE SUPPLIER'S M.S.D.S. SHEET.***

Investigating the properties of the gaseous state of matter can offer some fine opportunities for demonstrations.

1. To demonstrate that gases do indeed have mass and take up space, generate some CO_2 gas by carefully pouring vinegar onto a healthy amount of baking soda in the bottom of a 2 L beaker. As CO_2 is a heavy gas, it will collect in the bottom of the beaker as long as you pour the vinegar in slowly. Now place a paper bag on a digital scale and tare it. Carefully "pour" the CO_2 gas into the bag and watch the scale record the mass increase as the carbon dioxide gas flows into the bag. Remember to pour slowly.

2. You can further confirm the presence of CO_2 by using the gas to extinguish a candle flame. Place a short candle on a watch glass in the bottom of a 1 L beaker and light it with a splint. Carefully pour the CO_2 gas from the beaker above into this beaker and the candle will go out. (There are a number of variations of this and one can be found in the accompanying handout from Flinn Scientific.)

3. To show that there is space between gas molecules, but not between liquids or solids, suck air into a large syringe fitted with a valve on the end. Close the valve and note that the plunger can be depressed as the gas molecules are squeezed closer together. This can't be done if you fill the syringe with water as the molecules are already in contact with each other.

4. Trapped gases function well as insulators because of the space between the molecules. Styrofoam and polyurethane are both good examples of insulators. Polyurethane foam production kits can be purchased from science supply companies such as Boreal/Northwest and show quite readily how the production of the foam traps gas and takes up much more space than the two liquids which are reacted together.

5. You can also show how little space a polymer like polystyrene actually takes up by removing the gas trapped in Styrofoam. Just place a Styrofoam cup in a small specimen dish containing acetone to a depth of a cm or two. As the Styrofoam dissolves, the evolution of the trapped gas is evident. Left to dry, the Styrofoam cup will have been reduced to a small flat disk of polystyrene. This can also be applied to the organic chemistry section of the new Science 10 Curriculum.

6. You can demonstrate the movement of gas particles by placing several watch glasses or small specimen dishes around the classroom and adding a few mL of perfume or even household ammonia to each. Within a few minutes, most of the students in the room will notice the smell as the molecules enter the gaseous phase and diffuse throughout the room.
WARNING*: If using household ammonia, do not allow the students to smell the solution directly from the watch glasses or specimen dishes.*

7. The movement of ions in the liquid phase can easily be seen by placing a large specimen dish on the overhead projector with water to a depth of a few cm in it. In the center of the dish, add a few crystals of $KMnO_4$. Leave the overhead on as you teach through the lesson. The students will see the dark purple colour of the $KMnO_4$ spread throughout the water as the ions move through the liquid phase.

8. The collapsing soft drink can is a dramatic demonstration showing the effects of air pressure on the outside of a can when the water vapour in the can cools. Boil a few cm of water in a pop can on a hot plate. Using tongs, immediately invert the can and plunge it into an ice water bath.

9. Another related activity involves a balloon inflating *inside* of a Florence flask. Set up two hot plates. Place a balloon over the end of a Florence flask containing a few ml of water. Heat the water to boiling and observe as the balloon inflates as pressure inside the flask increases. On a second hot plate, boil water in a second open flask. When the water boils in the second flask, remove the flask from the hot plate, pour out the water and quickly place the balloon from the first flask over the second flask. The balloon will inflate inside the second flask as the pressure drops due to the cooling gas.

You can accommodate aspects of both the Science 9 and 10 curricula by generating hydrogen and oxygen in some dramatic ways.
10. Oxygen
Squirt a healthy amount of liquid dish soap into a 1 L graduated cylinder to a depth of a couple of cm. Then carefully pour in about 50 mL of 30% hydrogen peroxide. *Be sure to handle this with care and use gloves and goggles – it is a powerful oxidizing agent and can cause severe burns*. To catalyze the decomposition of the H_2O_2 into oxygen gas and water, pour in about 50 – 80 mL of a concentrated solution of KI (the concentration is not critical – a couple teaspoons dissolved to make the solution is fine). Immediately, a column of soap bubbles filled with oxygen gas will rise up and over the edge of the cylinder. Dim the lights and plunge a glowing splint into the foam to show how oxygen gas will cause the splint to re-ignite. This should be done over a spill tray or in a sink as it does make a bit of a mess. The products of the demo can safely be rinsed down the drain with plenty of water.
This can be tied into the Science 10 curriculum by discussing how the KI catalyst affects the reaction rate and by classifying the reaction as decomposition. The generation of elemental oxygen, the production of a gas as evidence of a chemical change, and the behaviour of a glowing splint in the presence of oxygen all work well for the grade 9 PLO's.

11. Hydrogen
Secure a large specimen dish or beaker. Add a good amount of water and then quite a lot of liquid dish soap. Cover the bottom of a 1 L Erlenmeyer flask with mossy zinc and add 200 – 300 mL of 3 M HCl. Place a stopper fitted with a glass tube connected to some rubber tubing over the opening in the flask. The reaction will immediately begin producing hydrogen gas. Submerge the tubing in the water and secure the tubing so that it remains submerged. Observe as soap bubbles filled with H_2 gas form. WARNING: *Under no circumstances should the hydrogen gas coming from the end of the rubber tube be ignited directly. It could back flash into the generator and cause the flask containing the acid to shatter. For this reason, students should never be permitted to perform this demonstration.*
Collect a bunch of the bubbles by scooping them into your hand and ignite this with a burning splint. You'll see a yellow flash and hear a little "boom" as the hydrogen ignites. Trust me, it doesn't hurt. The effect is more dramatic in a darkened room.

12. Flame Test Activities are always popular with students. A demo version of this can be done using a series of watch glasses, Pyrex Petri dishes, or even "tea light" candle holders. Rather than igniting various salts dissolved in methanol, which does add an element of risk, a safer and easier option is to place about a teaspoon of "Purell" hand cleaning gel on each of five watch glasses (or tea light holders). To each of these add a small amount of a different chloride salt including NaCl, $SrCl_2$, LiCl, KCl, and $CuCl_2$ and stir a little with separate stirring rods or wooden splints. Ignite each with a burning splint and observe the different colours characteristic of the metal ions present. As with methanol, the ethanol in the gel burns with an almost invisible flame. *As always, be careful when using open flames and this demonstration is probably best done in a fume hood.*
This supports not only the Science 9 curriculum, but also works as an example of combustion reactions called for in reaction classification in grade 10.

13. A knowledge of aspects of ionic and covalent is required in both Science 9 and 10. Some good quality model kits can be purchased to demonstrate both molecules and the arrangement of ions in a crystal lattice. A nice model of a sample of a NaCl using alternating magnetic spheres is available from Boreal/Northwest and can give students a good idea in 3D of what an ionic lattice involves. If you then compare that to a model of an HCl molecule (or any molecular model built using, for example, a "Molymod" kit, students can clearly see that the two formulae mean different things – namely the ionic formula simply represents a ratio of cations to anions, whereas the covalent formula represents a neutral independent unit that actually exists. Molymod makes very good plastic model kits that stand up to years of student use.

14. Crystals of table salt can be viewed quite nicely under a microscope and allow students to get a glimpse of the tiny crystals that we often don't think about.

Evidence of chemical change in the Science 9 curriculum can be combined nicely with writing, balancing, and classifying chemical reactions in the Science 10 chemistry unit.
15. To show colour change, neutralization reactions, and examples of chemical indicators at work, the "Milk of Magnesia" demonstration contained the accompanying Flinn Scientific package works very well.

16. The iodine clock reaction is always a favourite with students and the sudden appearance of the deep blue works well for the colour change aspect of chemical change. You can also remove the blue colour by pouring in a little of the diluted laundry bleach mentioned in the demo below.

17. To show exo- and endothermicity in chemical change, a multitude of possibilities exist. A modified piezoelectric barbeque igniter fitted to a 35 mm film canister makes a nice way of detonating a small amount (4- 5 drops) of methanol which quickly vaporizes in the canister. Educational Innovations (www.teachersource.com) sells the ready-made apparatus. On a larger scale, swirl 5 – 10 mL of ethanol inside a clean plastic milk jug, empty *all* of the alcohol out, and lay the jug on its side on a long counter. The residual ethanol vapour can then be lit by bringing a burning splint taped to the end of a metre stick next to the opening of the jug. The jug will shoot across the counter giving a off a nice blue flame and making an impressive "whoosh" noise. The effect is even better when done in a darkened room.
This combustion reaction also demonstrates the effect on the increase of surface area on reaction rate, particularly when compared with a few mL of methanol burning slowly on a watch glass.
WARNING: *A safety screen is recommended for this and make sure that the jug will not launch in the direction of any student.*

18. A safe version of the "thermite" reaction can nicely demonstrate the exothermic nature of this single replacement reaction. This demonstration is also detailed in the Flinn package. Be sure to read the safety information before doing the demonstration.

19. A short length of magnesium ribbons held with tongs in a Bunsen flame will ignite and give off an intense white light while it burns and leave a white powder of MgO which clearly differs from the original metal. This is a great demo showing emission of heat and light.
WARNING: *As the combustion of the magnesium produces ultra violet light, the burning ribbon should be held inside a large glass beaker. The glass will absorb most of the UV light. Also, students prone to epileptic seizures should not look directly into the light, even when it's inside the beaker. Additionally, the burning ribbon should be held over piece of wire gauze with a ceramic coating as the flame is quite hot.*

20. Another nice exothermic demo involves the following: unroll some fine steel wool and hold the top of the roll with a pair of tongs. Touch the bottom of the roll with the electrodes of a 9V battery. The steel wool will ignite and burn up its entire length. This demonstration also shows nicely how the rate of a reaction (in this case the combustion of iron) can be increased by increasing the surface area of one of the reactants. (It's also a good way to light a campfire!)
WARNING: *This should be done over a fire retardant surface or in a fume hood. It will generate a lot of heat and smoke.*

21. Exothermicity involving light emission can be shown using light sticks and also the oxidation of luminol. There are various manifestations of luminol reactions, but a quick one follows. Dissolve 0.23 g of luminol in 500 mL of a 0.1 M NaOH solution. To a 50 – 80 mL sample of this solution in a 250 mL flask, add an equal amount of laundry bleach diluted 1:10 with water. The bleach will oxidize the luminol in an exothermic reaction releasing a very cool blue light, but not heat. In a darkened room, the pale blue glow of the mixture will remain for a few seconds and always goes over well with students.
WARNING: *As luminol is a toxic substance, this demonstration should only be performed by a teacher.*

22. Also contained in the Flinn Scientific booklet is a great exothermic demonstration entitled "The Flaming Vapour Ramp". This also works as an example of a combustion reaction, of how surface area increases reaction rates, and even as a safety demo showing the potential of ignition of flammable vapors. Be sure to read the safety information before doing the demonstration.

23. A super *endothermic* demonstration involves the following: Place a small pool of water onto a short section of 2 x 4 wood. Into a 250 mL beaker, mix equal amounts (2-3 tablespoons each) of solid $Ba(OH)_2 \cdot 8H_2O$ and solid NH_4SCN. Record the reading on a thermometer (room temperature) and then place the beaker on the water and carefully stir the solids together with the thermometer until the mixture becomes liquid – about 20 or 30 seconds. One of the products is water and another is ammonia gas so you will notice the smell as the mixture liquefies. The real cool (pardon the pun) thing, though is the fact that the reaction is so endothermic that after about 30 seconds, the thermometer will read about minus 15^{o} C, and the beaker will be frozen to the block of wood. This is another class favourite.
WARNING: *The mixture contains dissolved barium ions and is therefore toxic. You can precipitate these heavy metal ions out by adding a good excess of* Na_2SO_4 *while stirring. The resulting mixture can then be disposed of safely.*

24. Production of a gas as evidence of a chemical change can be demonstrated using several of the demos mentioned above, but a good demonstration including that and several other evidences "all in one" involves the single replacement reaction of solid aluminum with an aqueous solution of copper(II) chloride. Place about two tablespoons of the salt into a 1000 mL beaker and add about 500 mL of water. The aqueous solution of $CuCl_2$ will be a deep blue colour. A loosely crumpled or rolled sheet of aluminum foil is then held under the surface of the solution with a thermometer as the reaction proceeds to show the intense release of heat. Several other things happen as well: aluminum dissolves and brown solid copper forms; the blue colour is replaced by a gray which eventually goes colorless if enough aluminum has been added; a gas is produced as hydrogen is the product of another single replacement reaction where aluminum also replaces hydrogen ions present in the original copper solution. This is a good way to show that, very often, more than one piece of evidence of a chemical change will occur in the same reaction vessel.
WARNING: *Be careful not to fill the beaker too full or add too much* $CuCl_2$ *as this is a very energetic reaction. Also, the* $CuCl_2$ *is toxic and gloves should be worn while dispensing it.*

25. Formation of a precipitate can be shown with any number of combinations of ionic solutions which generate a low-solubility salt as the product. For example, combining the clear colourless aqueous solutions of KI and $Pb(NO_3)_2$ will produce the bright yellow PbI_2 precipitate. If you would prefer to not work with heavy metal ions in solution, combining solutions of Na_2CO_3 or K_2CO_3 and $CaCl_2$ will generate the white precipitate $CaCO_3$.
WARNING: *As heavy metal ions such as lead are toxic, make sure to precipitate out all of the excess* Pb^{2+} *ions from the final solution by adding a good excess of the KI before disposal.*

26. Another piece of evidence of a chemical change could also be called "evidence of polymerization" and this also lends itself well to the organic chemistry component of the Science 10 curriculum. Students enjoy seeing the production of some cool polymers like "Polyox Slime" "Artificial Snow" and the "Diaper Polymer". Polyox slime is a self-siphoning gel and after showing students this property of the polymer, it works well to also show them the "polymer bead" demonstration. These beads are available from Educational Innovations and Flinn Scientific and help students visualize the makeup of organic polymers. Artificial Snow and the Diaper Polymer both involve the production of sodium polyacrylate which lends itself nicely to a demonstration format. These are also available for purchase from Educational Innovations and Boreal/Northwest.

Few other disciplines beyond chemistry lend themselves as well to the myriad of possibilities available to educators to capture the attention of and fascinate their students through demonstrations.
Always remember however that a good demo is a safe demo and that a "wow" factor should never be purchased at the expense of safety.

Good luck with the new curricula and always remember that …

Science Rocks and Chemistry Rules!

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