Experiment 1 - "Thinking Metric"

Reagents -

None

Special Equipment -

meter sticks
8½" x 11" pieces of paper
string and scissors
rectangular objects such as boxes or blocks
pieces of chalk
nickel coins
100 tablets (aspirin, vitamin) or other small objects
pebbles, rubber stoppers, or metal shot

Suggestions and Precautions -

The key is to have the students "think metric" rather than to stress conversions.

Prelaboratory Questions -

1. For: allow for easier importation and exportation of trade products.
   Against: expense of conversion; resistance to re-education.
2. mile, kilometer, meter, foot, inch, centimeter, micron, Angstrom.
3. barrel, cubic foot, gallon, liter, milliliter, cubic milliliter.
4. The density is less than that of water.
5. Overall density, including air cavity, is less; otherwise greater. Bodies can be made to float or sink depending on chest expansion.

Observations and Results -

Part 3- Source of discrepancy - balance is off; personal error. A gram is about a fifth of a nickel's mass. Imagine a nickel that is cut into five pieces. Average weight.
Part 4- Wood samples of same kind? - yes; samples of different wood? - no. Relative densities of wood and water - density of wood is less than that of water. Wood would float on mercury because wood's density is less than 13.6 g/ml.

Questions and Problems -

1. $24 \text{ gal} \bullet \frac{3.7851}{1 \text{ gal}} = 90.841$

2. $\frac{110 \text{ km}}{\text{hr}} \bullet \frac{1 \text{ mi}}{1.609 \text{ km}} = 68.4 \text{ mi/hr}$

3. 2.5 cm • 12 cm • 20 cm = 600 cu cm; 600 g water

4. 4 years • 186,300 mi/sec • 60 sec/min • 24 hr/da • 365 da/yr = 23,500,000,000,000 miles

5. wt (lb) ÷ 2.2 lb/kg

6. 60 min/hr x 24 hr/da x da/10 cda = 144 min/cda

   365 day/yr x 1 kda/1000 da = 0.365 yr/kda

7. (a) Probably safe
   (b) 0.5 L/sec x 60 sec/min x 60 min/hr x 8 hr = 14,400 L
   (c) 14,400 L x 1.2 g/L = 17,280 g; 12,200 g = 12.2 kg
   (d) 17,280 g x 1/106 = 0.017 g of X; 17 mg of X
   (e) Move information needed

Experiment 2 - "Molecular Motion - The Particulate Nature of Matter"

Reagents -	Each Student	100 Students
methyl salicylate, $C_8H_8O_3$	need 0.5 ml per demonstration	
hydrochloric acid, HCl, 12 M		500 ml
ammonium hydroxide, NH_4OH, 15 M		500 ml
acetone, C_3H_6O	1 ml	100 ml
sodium chloride, NaCl	4 g	400 g
p-dichlorobenzene, $C_6H_4Cl_2$	0.25 g	25 g
iodine, I_2	0.3 g	30 g
potassium permanganate, $KMnO_4$	0.2 g	20 g

Special Equipment -

watch glass (for group experiment)
hot plate (for group experiment)
time piece with second hand (for group experiment)
chalk
string and meter stick
60 cm x 2 cm glass tube (for demonstration)
cotton plugs (for demonstration)
thermometer, °C
lined, white paper

Suggestions and Precautions -

To avoid pre-release, bring the correct amount of oil of wintergreen in a closed vial and drop it directly onto the watch glass on a heated hotplate. Have no drafts in the room (open windows, hood drafts, etc.). Use only small crystals of iodine or the vapor will cause problems in the room. Define the size of a small pea.

Prelaboratory Questions -

1. Molecules of perfume vaporize and travel across the room to sensory cells in the nose.
2. The intermolecular distance in a gas is much greater.
3. Solids: touching each other in a regular three-dimensional patter. Liquids: random arrangement with molecules in close contact with each other.
4. Faster. More energy is being added to the system.
5. Slower.
6. Although their speed is great, because of collisions they travel by a circuitous route.

Observations and Results -

Part 1- Explain how the odor came: Vaporized molecules traveled by means of a zig-zag course due to molecular collisions. Difficult if you assume matter is continuous; could say matter travels in a continuous ray. You would expect ammonia to travel faster because its

molecular mass is less, thus its velocity will be faster. Suggest several explanations - different sensitivities of noses; drafts or different air circulation patterns. How does this experiment prove: The product (NH_4Cl) was formed in the air above the liquid levels of the reactants - therefore, the reactant molecules had to travel through the air.

Part 2- How do you know - because acetone evaporates faster (disappears faster). What do relative rates of evaporation - the attractive forces between water molecules is greater than the forces between acetone molecules. Explain this observation - as those molecules with higher energies vaporize first, molecules with lower energy (the cooler ones) are left behind. Suggest a reason why molecules - in a concentrated solution there are many particles which get in the way of the water molecules escaping, thus increasing the amount of energy (and increasing the boiling point) needed to vaporize the solvent.

Part 3- Solid mothballs activated your nose because molecules vaporized from the solid and then diffused through the air to the nose.

Part 4- Typical pathway for a particle:

Questions and Problems -

1. colorless
2. bluish purple
3. yes - sound is the displacement of air molecules and it travels in waves from the point where the sound originated to the eardrum - the displaced molecules displace other molecules, which eventually lead to collision with the ear drum. This sets off nerve impulses which the brain interprets as a particular sound.
4. (a) yes; no change in matter
   (b) no; odor is transfer of molecules – matter lost
5. Molecules in one cup, 7.5×10^{24} . Volume of oceans, $2.8 \times 10^{20} L$. Fraction of molecules from original cup times molecules in cup:

   $$\frac{0.25L}{2.8x10^{20}L} \times 7.5 \times 10^{24} \text{ molecules} = \text{about 7,000 molecules original}$$

6. Each received, 7×10^{23} atoms / 7×10^{9} persons = 1×10^{14} atoms/person
   \$.01/1×10^{4} atoms = \$$1 \times 10^{-6}$/atom
   1×10^{14} atoms/person x 1×10^{-6} \$/atom = \$$10^{8}$ = 100 million dollars

Experiment 3 - "What Is a Chemical Reaction?"

Reagents -	Each Student	100 Students
iron dust, Fe (reagent, free of sulfur)	1 g	100 g
sulfur, S	1 g	100 g
carbon disulfide, CS_2 (demonstration)	5 ml	
hydrochloric acid, HCl, 6 M	0.5 ml	50 ml
camphor, $C_{10}H_{16}O$	0.2 g	20 g
copper sulfate, $CuSO_4$, solution, 0.1 M	1 ml	100 ml
potassium chromate, K_2CrO_4, solution, 0.1 M	0.5 ml	50 ml
lead acetate, $Pb(C_2H_3O_2)_2$, solution, 0.1 M	0.5 ml	50 ml
calcium carbonate, $CaCO_3$	0.1 g	10 g
acetic acid, $HC_2H_3O_2$, 1 M	1 ml	100 ml
saturated calcium hydroxide, $Ca(OH)_2$, solution	2 ml	200 ml
iron nail	1/student	100 nails

Special Equipment -

magnet
mortar and pestle
plastic straw

Suggestions and Precautions -

Use only reagent iron dust which is essentially free of sulfur. Inform the students that a faint odor of H_2S from the reaction of iron with HCl is due to contamination with sulfide. The camphor should be heated sufficiently to melt it but not enough to make it burn or physical and chemical changes will be confused.

Prelaboratory Questions -

1. Change in appearance, change in odor.
2. (a) fermenting sugar; (c) burning wood; (e) cooking meat; (h) rusting iron.
3. They get used up (consumed) and changed into different substances.
4. Convenience, clarity and brevity; a chemical reaction is what actually takes place - an equation is a written statement of that occurrence.
5. endothermic: absorbs heat (energy); exothermic: evolves heat.
6. Attractive (electrostatic) forces which hold the atoms in a molecule together. Bonds are broken and new bonds formed.

Observations and Results -

Part 1- This proves that the change which occurred with CS_2 was physical because the sulfur was recoverable in its original form. Two simple tests are magnet for iron and solubility in CS_2 for sulfur. $Fe + S \rightarrow FeS$. Formula for this gas: H_2S. The fact that the gas formed when treating the heated iron-sulfur mixture with acid had a different odor than the gas