ChemStart

Unleashing the Scientist in you

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1 FOREWORD

I wish I had a tool like this kit when I was at high school. This is for two main reasons, firstly, it would have helped me experience a laboratory environment and would have prepared me for university education. Secondly, it would have been an absolute pleasure to carry out an experiment and watch its reactants turn to products and change colour before my very eyes! I experienced this once. I was watching TV at home during holidays one day, on the program they performed the glycerine fire spontaneous reaction (experiment 3). Before going back to school at the beginning of a new term, I made sure to buy glycerine. When I got to school I checked to see if there was potassium permanganate, which there was. I called a few of my mates around and conducted the experiment and it worked! How wonderful physical science seemed. This was another confirmation that science is too cool not to pursue.

This manual has been put together with that thought and feeling in mind, hoping to pass it on to other young potential scientists out there.

I hope you enjoy each and every reaction and lesson in here as much as I enjoyed putting it together. Just to mention, I learned all the different reactions from different sources, they are not my own making.

Happy science exploring!!!

2 FIRST THINGS FIRST: SAFETY

This section of the manual is the most important of all. Please take care to follow the rules carefully.

GENERAL RULES

1. Conduct yourself in a responsible manner at all times with the kit.
2. Follow all written and verbal instructions carefully. If you do not understand a direction or part of a procedure, rather wait to ask your teacher at school on send us a message using our contact details.
3. Never work alone, always have someone older that you around.
4. Perform only those experiments in the kit. Unauthorized experiments are not allowed.
5. Do not eat food, drink beverages, or chew gum while conducting experiments.
6. Horseplay, practical jokes and pranks are dangerous and prohibited
7. Be prepared for your work. Read all procedures thoroughly before starting with any experiment.
8. Always work in a well-ventilated area.
9. Observe good housekeeping practices. Work areas should be kept clean and tidy at all times.
10. Dispose of all chemical waste properly as indicated in the manual.
11. Keep hands away from face, eyes, mouth, and body while using chemicals or lab equipment. Wash your hands with soap and water after performing all experiments.
12. Experiments must be personally monitored at all times. Do not wander around the room.

CLOTHING

1. Protective gear has to be comfortable
2. Any time chemicals, heat, or glassware are used, wear safety goggles. NO EXCEPTIONS TO THIS RULE!
3. Contact lenses may not be worn.
4. Dress properly during an experiment. Long hair, dangling jewellery, and loose or baggy clothing are a hazard. Shoes must completely cover the foot. No sandals to be worn when conducting experiments.

ACCIDENTS AND INJURIES

1. If there is a spillage, wash with water.
2. If a chemical should splash in your eye*(s)* or on your skin, immediately flush with running water for at least 20 minutes.

HANDLING CHEMICALS

1. All chemicals in the kit are to be considered dangerous. Avoid handling chemicals with fingers. When making an observation, keep at least 1 meter away from the reaction. Do not taste, or smell any chemicals.
2. Check the label on all chemical bottles twice before removing any of the contents. Take only as much chemical as you need.
3. Never return unused chemicals to their original container.

HANDLING GLASSWARE AND EQUIPMENT

1. Never handle broken glass with your bare hands. Use a brush and dustpan to clean up broken glass.
2. Do not immerse hot glassware in cold water. The glassware may shatter.

HEATING SUBSTANCES

1. Do not operate a hot plate by yourself. Take care that hair, clothing, and hands are a safe distance from the hot plate at all times. Use of hot plate is only allowed in the presence of an adult.
2. Never look directly into a container that is being heated.

3 KEEPING A LABORATORY NOTEBOOK

A laboratory notebook is one of the most valuable pieces of writing you can own. With it you can duplicate your work, find out what happened, and figure out where things went wrong

1. The notebook must be bound permanently. No loose pages are allowed
2. Use waterproof ink! Never pencil! Pencil will disappear with time. Never erase! Just draw one line through your errors so that they can still be seen. Never cut any pages out of the notebook!
3. Leave a few pages at the front for a table of contents.
4. Write down what you have done. Not what the manual says to do in the lab book.
5. Note all observations: colour changes, temperature rises, explosions, anything that occurs. Also write any reasonable explanation why whatever happened, occurred.
6. Never skip pages
7. List the IMPORTANT chemicals you'll use during each reaction. You should include USEFUL physical properties: the name of the compound, molecular formula, molecular weight, melting point, boiling point, density etc.

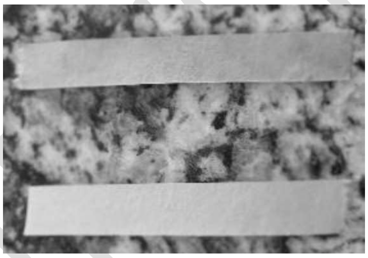
4 CONTENTS

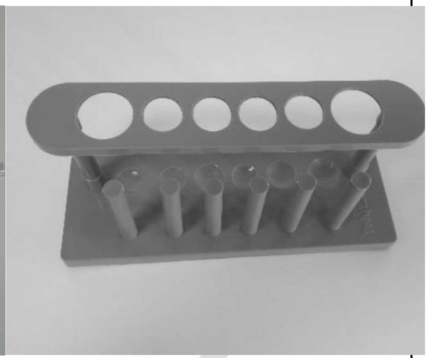
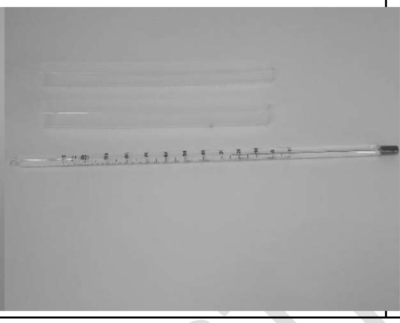
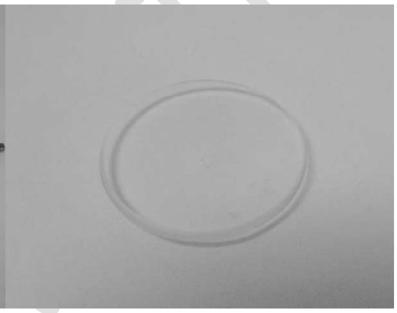
Chemicals:

Acetic acid* Exp: 99(10ml), 10 (10ml), 31 (2ml), 52 (2ml) **Experiment to be conducted outdoors!**	Acetone Exp: 5	Ammonium chloride* Exp: 20
Ammonium dichromate Exp: 22	Ammonium hydroxide* Exp: 6 (10ml), 31(1ml), 37(1ml) **Experiment to be conducted outdoors**	Barium hydroxide Exp: 20
Benzoic acid Exp: 33	Calcium acetate Exp: 51	Cobalt chloride Exp: 18
Cobalt sulphate Exp: 37	Copper carbonate Exp: 6	Copper chloride Exp: 25
Copper sulphate Exp: 18 (1g), 24 (1g), 35 (1g)	Dextrose Exp: 1	Ethanol Exp: 8 (5ml), 22 (1ml), 27 (2ml), 44 (2ml), 51 (20ml), 52 (2ml)
Hydrochloric acid Exp: 19	Indophenol solution Exp: 15	Iron trichloride Exp: 18
Isopropanol Exp: 17 (5ml), 46 (5ml)	Lead nitrate Exp: 36	Litmus paper Exp: 32
Luminol Exp: 34	Magnesium ribbon Exp: 27 **Do not look directly into the flame!**	Methanol Exp: 43
Methylene blue solution Exp: 1	Nickel nitrate Exp: 18	Potassium alum Exp: 38
Potassium iodide Exp: 2 (1g), 11 (0.5g), 36 (0.5g)	Potassium permanganate Exp: 3* (2g), 30 (0.1g)	Salicylic acid Exp: 43
Sodium acetate Exp: 16	Sodium bicarbonate Exp: 9 (3g), 10 (1g), 19 (2g), 37 (0.2g), 52 (1g)	Sodium hydroxide Exp: 1 (0.5g), 28 (1g), 30 (2g), 31 (0.5g), 34 (1g), 37 (0.2g), 48 (5g)
Sodium polyacrylate Exp: 4	Sodium silicate Exp: 8 (20ml), 18 (30ml)	Strontium chloride Exp: 23
Sulphuric acid Exp: 6 (6ml), 21 (2ml), 31 (0.5ml), 43 (2ml)		

Experiments with the * are to be conducted in a well ventilated area, preferably outdoors. This is due to either the nature of the reaction, the reactants or the products formed.

Lab-ware: Beaker, Chromatographic paper, Erlenmeyer flask with rubber stopper, Latex gloves, Litmus paper, Measuring cylinder, Syringe with needle, Pasteur pipettes, Safety glasses, Spatula, Stirring rod, Test tube holder, Test tubes, Thermometer, Watch glasses

Beaker-plastic x2 	Chromatographic paper 3 strips of white paper	Erlenmeyer flask with stopper 
Latex gloves 	Litmus paper 	Measuring cylinder 50 cm³ 
Syringe with needle 	Pasteur pipette 	Safety glasses 

Spatula	Stirring rod	Test tube holder
		
Test tubes x4	Thermometer	Watch glasses x4
		

Items not included in the kit

The following items are not included in the kit but are essential for the experiments. These are intended to show that indeed science is not limited to the class room but is all around and we interact with it on a daily basis.

Apple juice	Baking powder	Balloons x2	Bleach
Cabbage-red	Cooking oil	Cotton wool	Coloured pens
Coca-Cola	Dish washing soap	2Eggs	Food colouring
Glycerine	Herbal tea	Hydrogen peroxide	Ice in water
Iron nails	Leaf with leaflets	Mentos sweets	Milk -full cream
Orange juice	Polystyrene cups	Table salt	Sparkling water
Sugar	Tablet-effervescent	Tea-normal	Tomato
Vinegar			

LET THE FUN BEGIN!

1 CHEMICAL KINETICS

Kinetics is the study of how fast a chemical reaction will make products from reagents. As reagents are transformed into products in a chemical reaction, the amount of reagents will decrease and the amount of products will increase. The rate of the reaction can be determined by measuring the concentration of reactants or products as a function of time. In some cases, it is possible to use a simple visual clue to determine a reaction rate. Thus, if one of the reactants is coloured but the products are colourless, the rate of the reaction can be followed by measuring the time it takes for the colour to disappear. Reactions involving the organic dye methylene blue provide a convenient example to study reaction rates.

Factors that affect how fast the reaction proceeds include: -

- The concentration of reagents
- The surface area of the reagents
- The temperature of the reaction
- The presence of a catalyst
- The pressure under which the reaction occurs

Imagine you are making a cup of tea using hot and cold water. The hot cup of tea when you stir the sugar inside, will be homogenous much quicker than the cold cup of tea when the stirring action takes place.

1.1 EXP.1: The 'blue bottle' experiment

APPARATUS:	**REAGENTS**
▪ Safety glasses ▪ Gloves ▪ 100 cm³ Erlenmeyer flask with stopper ▪ Spatula ▪ Pasteur pipette ▪ Measuring cylinder ▪ 100 cm³ beakers x 2 ▪ Stirring rod	▪ 0.5 g sodium hydroxide (NaOH) ▪ 2 g dextrose ($C_6H_{12}O_6$) ▪ 0.1% methylene blue in ethanol

PREPARATION:

To make sodium hydroxide solution: solution A

- Place half a spatula (0.5 g) sodium hydroxide into a beaker
- Measure 50 cm^3 of water and pour on sodium hydroxide (this solution becomes warm as it mixes)
- Stir till dissolved

To make dextrose: solution B

- Place ¾ of a spatula (2 g) dextrose into another beaker
- Measure 50 cm^3 of water and pour on the dextrose
- Stir till dissolved

To make solution C ▪ Into 10 cm^3 of solution B, add 10 cm^3 water
METHOD: 1. Into the Erlenmeyer flask, pour 15 ml of solution B. Then add 5 drops of methylene blue solution and 15 cm^3 of solution A. 2. The resulting blue solution will turn colourless after about 5 minutes. 3. Stopper the flask 4. Shake the flask vigorously so that air dissolves in the solution. 5. The colour will change to blue. This will fade back to colourless over a few minutes. 6. Repeat steps 1-5 but replacing solution B with solution C and note how long it takes for the blue colour to disappear. The more shaking, the longer the blue colour will take to fade. The process can be repeated for over 20 cycles. After some hours, the solution will turn yellow and the colour changes will fail to occur
CLEAN UP: Flush all the prepared and used chemicals down the drain and wash with a large amount of water.
WHAT IS GOING ON Methylene blue (abbreviated MB) exists in two forms, a reduced form and an oxidized form, that have different colours. The reduced form of methylene blue (MBred) is colourless, while the oxidized form (MBox) is blue. The reduced form can be converted to the oxidized form by simply shaking it with oxygen in air (Equation 1). The oxidized form, in turn, can be converted back to the reduced form by treatment with a reducing agent, such as dextrose. Reactions involving the two forms of methylene blue are sometimes called clock reactions, because they involve a very sudden colour change that is easy to time. MBred + O_2 *(g)* → MBox Equation 1 Colourless Blue The rate of reaction of the blue, oxidized form MBox with dextrose and sodium hydroxide to give the colourless, reduced form MBred (Equation 2) can be studied by measuring the time needed for the blue colour to disappear. MBox + dextrose + NaOH *(aq)* → MBred Equation 2 Blue Colourless

DID YOU KNOW?

Sodium hydroxide is also known as lye or caustic soda

Sodium hydroxide is used in in the manufacture of pulp and paper, textiles, soaps and detergents and is used as a drain cleaner.

Dextrose in one form of sugar. A common form of sugar is sucrose which is used as table sugar. Dextrose is used as a sweetener in packaged and processed foods. It is known to enhance and stabilize food colourings, and can also extend the shelf-life of packaged foods.

QUESTIONS

How does the reaction speed change with increase/decrease in: -

- Concentration of the reactants?
- Temperature?

1.2 EXP.2: The elephant toothpaste

APPARATUS:	REAGENTS
▪ Test tubes x 2 ▪ 100 cm^3 beakers x2 ▪ Spatula ▪ Stirring rod	▪ 1g potassium iodide (KI) ▪ Dishwashing soap ▪ 10 cm^3 9% (30 vol) hydrogen peroxide (H_2O_2) ▪ Food colouring

PREPARATION:

To make 10% potassium iodide solution: solution A

- Place half a spatula 1 potassium iodide into a beaker
- Measure 10 cm^3 of water and pour on the potassium iodide
- Stir till dissolved

To make 5% potassium iodide solution: solution B

- Dilute 5 cm^3 of solution A with 5 cm^3 of water

METHOD:

1. Take 2 test tubes and in each add 5 cm^3 of hydrogen peroxide
2. In each test tube, add 2 drops of dishwashing liquid and food colouring and mix
3. add 2 cm^3 solution A in the first test tube and 2 cm^3 solution B in the second test tube
4. note the observation

CLEAN UP:

Flush all the prepared and used chemicals down the drain and wash with a large amount of water.

WHAT IS GOING ON

The overall equation for this reaction is:

$$2\ H_2O_2(aq) \rightarrow 2\ H_2O(l) + O_2(g)$$

However, the decomposition of the hydrogen peroxide into water and oxygen is catalysed by the iodide ion. $$H_2O_2(aq) + I^-(aq) \rightarrow OI^-(aq) + H_2O(l)$$ $$H_2O_2(aq) + OI^-(aq) \rightarrow I^-(aq) + H_2O(l) + O_2(g)$$ The dishwashing detergent captures the oxygen as bubbles. Food colouring colours the foam. The heat from this exothermic reaction is such that the foam may steam. If the demonstration is performed using a plastic bottle, you can expect slight distortion of the bottle from the heat.

2 SPONTANEOUS REACTIONS

A reaction is said to be spontaneous if it occurs without being driven by some outside force. There are two driving forces for all chemical reactions. The first is enthalpy, and the second is entropy. Entropy is a measure of the disorder of a system, and systems tend to favour a more disordered system: nature tends toward chaos. Spontaneous reactions occur without outside intervention. They may occur quickly, like the combustion of hydrogen in a hydrogen bomb for example, or slowly, like when graphite (a form of carbon) turns to diamond.

It is also defined as a time-evolution of a system in which it releases free energy and moves to a lower, but thermodynamically more stable state of energy. In rare cases though, an external trigger may be required at the beginning of the process to start it. But once it starts, it continues on its own. This is complete opposite to non-spontaneous reaction, wherein some external factor has to continuously come into play to make sure that the process continues.

The direction of a spontaneous process is determined by the laws of thermodynamics, which govern the relations between states of energy in a closed system. Even though spontaneous and non-spontaneous reactions are possible, only the former occurs naturally, while the latter has to be triggered and supported.

The reactions can either be endothermic meaning they require energy to proceed or exothermic which means they emit energy as they proceed.

2.1 **EXP. 3: Glycerine fire**

APPARATUS:	**REAGENTS**
▪ Safety glasses ▪ Gloves ▪ Spatula ▪ Metallic plate ▪ Pasteur pipette ▪ 100 cm^3 beaker ▪ Stirring rod	▪ 2 g potassium permanganate ($KMnO_4$) ▪ 1 ml glycerol [glycerine] ($C_3H_8O_3$)