TITLES OF EXPERIMENTS UNDER EACH TOPIC IN THE SYLLABUS

PROPERTIES OF MATTER

1. *Investigating the relationship between mass and length of pipe*
2. *Investigating the effect of temperature on molecular motion*
3. *Boiling water and the motion when water is cooling (convectional currents)*
4. *Investigating the effect of impurities on boiling points of substances.*
5. *Investigating the effect of impurities on melting points of substances*
6. *Investigating the diffusion of potassium permanganate in water*
7. *Diffusion of copper sulphate solution in water*
8. *Diffusion of nitrogen dioxide*
9. *Investigating how size of particles affect the rate of diffusion*
10. *Investigating the effect of temperature on the rate of diffusion*
11. *Investigating Boyle's Law*
12. *Investigating Charles' law*
13. *Investigating the relationship between temperature and volume(Charles' Law)*
14. *Investigating Pressure Law*
15. *Measuring lung pressure using manometer*

ELEMENTS AND CHEMICAL BONDING

16. *Identification of covalent and ionic substances using melting points*
17. *Identification of covalent and ionic compounds using conductivity*
18. *Investigating the existence of partial charges (polarity) in covalent substances through conductivity test*
19. *Determining the reactivity series of group 1 metals using reaction with water*
20. *Verifying if a metal belongs to group 1*
21. *Displacement reactions of halogens: chlorine, bromine, iodine*
22. *Dehydration of common sugar (sucrose) by concentrated sulphuric acid*

CHEMICAL REACTIONS

23. *Investigating the reaction between hydrochloric acid and sodium carbonate*
24. *Determining the formula of a compound using masses of reactions*
25. *Determining the percentage composition of carbon in sucrose (common sugar)*
26. *Preparing a solution from a standard solution (250ml 2m NaOH solution from a 3m NaOH solution)*
27. *Preparation of 250 cm^3 of 1 m copper sulphate solution from hydrated copper sulphate crystals*
28. *Determining the concentration of hydrochloric acid ($HCl_{(aq)}$) using titration*
29. *Determining the concentration of sodium hydroxide ($NaOH_{(aq)}$) using titration*
30. *Investigating endothermic and exothermic reactions (I)*
31. *Investigating endothermic and exothermic reactions (II)*
32. *Investigating exothermic and endothermic reactions (III)*
33. *Determining how much heat a spirit burner can supply*
34. *Investigating how temperature changes when ice is heated*
35. *Finding out whether different liquids have different heat capacities*
36. *Determining the reactivity series of metals using displacement reactions*
37. *Investigating the effect of acidity on percentage corrosion of iron*
38. *Investigating the effect of basicity on percentage corrosion of iron*
39. *Investigating the conditions of rusting*

40. *Investigating the factors that affect rusting*
41. *Electroplating a nail with copper*
42. *Purifying copper using electrolysis*
43. *Identifying acids and bases using universal indicator*
44. *Investigating the strength of bases using conductivity*
45. *Investigating the strength of acids using conductivity*
46. *Investigating the effect of acidity and basicity on electric current*
47. *Comparing the conductivities of potassium nitrate and potassium chloride*

FORCES AND MOTION

48. *Investigating the effect of the distance of load from fulcrum (effort arm) on effort applied.*
49. *Investigating hook's law*
50. *Investigating the effect of mass on depression*
51. *Determining the average speed of an athlete*

ORGANIC CHEMISTRY

50. *Distinguishing alkane from alkene*
51. *Distinguishing alkane from alkanol using sodium test*
52. *Distinguishing alkane from alkanol using solubility test*
53. *Distinguishing alkane from carboxylic acid using conductivity*
54. *Distinguishing alkane from carboxylic acid using solubility test*
55. *Distinguishing alkane from carboxylic acid using sodium test*
56. *Distinguishing alkane from carboxylic acid using litmus test*
57. *Distinguishing alkane from carboxylic acid using phenolphthalein indicator acid test*
58. *Distinguishing smaller alkene from bigger alkene using rate of reaction*
59. *Distinguishing an alkene from an alkanol using bromine test*
60. *Distinguishing alkene from alkanol using solubility test*
61. *Distinguishing alkene from alkanol using sodium test*
62. *Distinguishing alkene from carboxylic acid using solubility test*
63. *Distinguishing alkene from carboxylic acid using conductivity*
64. *Distinguishing alkene from carboxylic acid using sodium test*
65. *Distinguishing alkene from carboxylic acid using litmus test*
66. *Distinguishing alkene from carboxylic acid using phenolphthalein indicator acid test*
67. *Distinguishing an alkene from carboxylic acid using bromine test*
68. *Distinguishing smaller alkanol from a bigger alkanol using solubility test*
69. *Distinguishing alkanol from carboxylic acid using phenolphthalein indicator acid test*
70. *Distinguishing alkanol from carboxylic acid using litmus test*
71. *Distinguishing alkanol from carboxylic acid using conductivity*
72. *Investigating fermentation of sugar by yeast*
73. *Separating a mixture of ethanol and water*
74. *Oxidation of ethanol to ethanoic acid by acidified potassium dichromate(vi)*
75. *Investigating the effect of carboxylic acids on acid-base indicators*
76. *Formation of esters (reaction of ethanol and ethanoic acid)*
77. *Identifying organic substances using flow diagram*
78. *Identifying families of organic compounds*

ELECTRICITY, MAGNETISM AND ELECTROMAGNETIC INDUCTION

79. *Investigating total resistance in parallel and series*
80. *Investigating voltage in series circuit*
81. *Investigating voltage in parallel*
82. *Investigating the dependence of brightness of bulbs on voltage using series and parallel*

circuits

83. *Investigating the dependence of brightness of bulbs on voltage using different number of cells*
84. *Investigating the relationship between the length of a wire and the current passing through it*
85. *Investigating the relationship between length of a wire and its resistance*
86. *Determining the length of nichrome wire equivalent to resistance of 1.7Ω*
87. *Investigating the relationship between the length of a wire and the voltage across it.*
88. *Investigating how a magnet can be made using stroking method (single touch)*
89. *Investigating how a magnet can be made by stroking method (double /divided touch)*
90. *Investigating demagnetization of magnets by hammering*
91. *Investigating demagnetization of magnets by heating*
92. *Investigating the magnetic effect of electric current*
93. *Investigating the direction of electric field lines around a current carrying conductor*
94. *Investigating electromagnetic induction /Lenz's law*
95. *Investigating how a diode functions in a circuit*
96. *Investigating how a transistor functions in a circuit (I)*
97. *Investigating how a transistor functions in a circuit (II)*
98. *Identifying a diode, insulator and a resistor*

OSCILLATIONS AND WAVES

99. *Investigating the effect of length on frequency of vibration of a pendulum*
100. *Investigating the effect of the angle between string arms on frequency of an oscillating pendulum*
101. *Investigating the effect of mass on frequency of vibration of an oscillating pendulum*
102. *Investigating the effect of type of material of string on frequency of vibration of an oscillating pendulum*
103. *Investigating the effect of amplitude on frequency of vibration of an oscillating pendulum*
104. *Investigating the effect of length on frequency of vibration of a spiral spring*
105. *Investigating the effect of mass on frequency of vibration of an oscillating spiral spring*
106. *Investigating the effect of type of material of spring on frequency of vibration of an oscillating spiral spring*
107. *Investigating the effect of amplitude on frequency of vibration of an oscillating spiral spring*
108. *Investigating the effect of length on frequency of an oscillating cantilever*
109. *Investigating the effect of mass on frequency of vibration of an oscillating cantilever*
110. *Investigating the effect of type of material of string on frequency of vibration of an oscillating cantilever*
111. *Investigating the effect of amplitude on frequency of vibration of an oscillating cantilever*
112. *Whether sound waves require a medium for their propagation*
113. *Investigating the differences between the speeds of two sounds traveling through different media (metal and air)*
114. *Determining the focal length of a converging lens using graph method (1)*
115. *Determining focal length of a converging lens using graph method (2)*
116. *Determining focal length of converging lens using graph method (3)*
117. *Determining focal length of a converging lens using mirror method*
118. *Determining focal length of a converging lens using rough method*
119. *Investigating the effect of object distance (u) on image distance (v)*
120. *Investigating the effect of object distance (u) on magnification (m)*

121. *Investigating the effect of object distance on position and characteristics of the image formed by a converging lens*
122. *Investigating how a pure spectrum can be formed from white light*

NUCLEAR CHEMISTRY

123. *Investigating how thickness of sheet of plastic can be controlled during manufacture using radiation*
124. *Identifying alpha, beta and gamma radiation using an electroscope*

DENSITY

125. *Determining the density of a liquid (water and paraffin)*
126. *Determining density of a liquid using another liquid of known density*
127. *Identifying a metal using density*

SEPARATING MIXTURES

128. *Separating a mixture, w, of solids x (soluble in carbon tetrachloride only), Y (soluble in water only) and z (insoluble in both carbon tetrachloride and water)*
129. *Separating a mixture of sand, naphthalene and alcohol*
130. *Isolating components of dyes of two brands of soap*
131. *Investigating the removal of water of crystallization from salts*
132. *Determining how much water is found in a sample of hydrated copper sulphate*

1 DESCRIPTIVE QUESTIONS

PROPERTIES OF MATTER

1. You are given the following materials; PVC pipe (80cm), a triple beam balance and a cutter. Describe an experiment that can be carried out to determine the relationship between the length and the mass of PVC pipes.
2. Given a candle and matches, how can you show the relationship that exists between temperature and molecular motion.
3. Describe an experiment that can be carried out to demonstrate convectional currents given the following materials: source of heat, water in a Pyrex beaker, tripod stand, potassium permanganate crystals and a wire gauze.
4. Describe an experiment that you can carry out to determine the effect of impurities on the boiling point of a substance. In your description, show all the materials that you may need.
5. Describe an experiment that you can carry out to determine the effect of impurities on melting point of a substance. In your description, show all the materials you may need.
6. Show a thorough plan for investigating the diffusion of potassium permanganate crystals in water.
7. Design an experiment that can be used to investigate the diffusion of copper sulphate crystals in water. Show all the materials that you may need.
8. Describe an experiment that can be carried out to investigate the diffusion of nitrogen dioxide gas given the following materials only; copper chips, concentrated nitric acid, water, gas jars (2), measuring cylinder (5ml), beaker (100ml).
9. You are given the following materials; concentrated ammonia solution, concentrated hydrochloric acid, cotton wool, dry glass tube (open on both ends), stoppers (2) and pins (2). Design an experiment that can be carried out to determine the effect of size of particles on the rate of diffusion.
10. Describe an experiment that can be carried out to determine the effect of temperature on the rate of diffusion using the following materials only; beaker (150ml), thistle funnel, potassium permanganate crystals, a pair of tweezers, cold water and hot water.
11. Show using a thorough procedure how Boyle's law can be investigated. Show all the materials you may need.
12. Design an experiment that can be carried out to show the relationship between temperature and volume of a gas at constant pressure given the following materials only; syringe, beaker, thermometer, water, source of heat, tripod stand, wire gauze, clamps(2) and clamp stands (2).
13. Describe an experiment that can be carried out to find out the relationship between volume and temperature when the pressure is constant using the following materials only: small balloon, small volumetric flask, large beaker, hot water.
14. Design an experiment that can be used to verify pressure law. Show all the materials that you may need.
15. Describe an experiment that can be carried out to determine how a manometer is used to measure gas pressure.

ELEMENTS AND CHEMICAL BONDING

16. Describe an experiment that can be carried out to identify an ionic and covalent compounds given the following materials: substances A and B (one is covalent and the other is ionic, but not necessarily in that order), evaporating dishes(2), tripod stand, wire gauze, source of heat (may be a candle, spirit burner, etc)
17. Describe an experiment that can be carried out to identify an ionic and covalent compounds using the following materials: beaker, carbon rods (2), connecting wires (3), ammeter, cells (2) in a holder, compounds A and B (one is covalent and the other is ionic but not necessarily in that order).
18. You are given the following materials: beaker (100ml), carbon rods (2), connecting wires (4), bulb in a holder, cells (2) in a holder, switch, sugar solution, dilute sulphuric acid, H_2SO_4, distilled water. Design an experiment that can be carried out to investigate partial charges in covalent substances.

19. Describe the procedure of an experiment which can be used to identify group 1 metals using the following materials: Petri dishes (3), water, group 1 metals labeled A, B and C.
20. Describe an experiment that can be used to construct a reactivity series for halogens using the following materials; potassium chloride solution(1M) in a beaker, potassium bromide solution(1M) in a beaker, potassium iodide solution(1M) in a beaker, chlorine water in a beaker, iodine in a beaker, bromine in a beaker and test tubes (3)
21. Design an experiment that can be used to investigate the dehydration of sucrose (common sugar) using concentrated sulphuric acid. Include all the necessary materials you may need

CHEMICAL REACTIONS

22. You are given the following materials: U-shaped glass tubing / rubber tubing, test tubes (2), thistle funnel, lime water, saturated sodium carbonate solution, hydrochloric acid, rubber bung, litmus solution. Design an experiment that can be used to investigate the reaction between hydrochloric acid and sodium carbonate.
23. How can the formula of magnesium oxide be determined experimentally? In your description, include all the materials and the calculations needed to find the formula.
24. Describe an experiment that can be carried out to determine the percentage composition of carbon in sucrose [common sugar, $C_{12}H_{22}O_{11}$] using heating method.
25. Show how 250ml of 2M NaOH solution can be prepared given the following materials: measuring cylinder (100ml), volumetric flask (250ml) with a stopper, distilled water, standard solution (3M NaOH solution), balance.
26. Explain how 500cm^3 of a 0.2 M sodium Chloride solution can be prepared using sodium chloride crystals. The explanation should include all the necessary mathematical calculations. (Relative atomic mass of Na = 23 and Cl = 35).
27. Describe an experiment that can be used to prepare 250cm^3 of 1M copper sulphate solution from hydrous copper sulphate crystals. Show all the materials you may need.
28. Determine the concentration of $HCl_{(aq)}$, given the following materials: 0.1M $NaOH_{(aq)}$, measuring cylinder, phenolphthalein indicator, $HCl_{(aq)}$ (unknown concentration), conical flask, clamp, clamp stand and burette.
29. Determine the concentration of $NaOH_{(aq)}$, given the following materials: 0.2M $HCl_{(aq)}$, measuring cylinder, phenolphthalein indicator, $NaOH_{(aq)}$ (unknown concentration), conical flask, clamp, clamp stand and burette.
30. You are given the following materials; test tubes (2) in a rack, a measuring cylinder, stirring rod, thermometer, spatula, tap water and substances A and B. Design an experiment that can be carried out to determine which of the processes, A + water and B + water, is endothermic and which is exothermic.
31. Describe an experiment that can be used to investigate endothermic and exothermic reactions using the following materials only; thermometer, test tubes (2) in a rack, a piece of magnesium ribbon, potassium hydrogen carbonate or sodium hydrogen carbonate, dilute hydrochloric acid solution, spatula or tea spoon and a measuring cylinder.
32. You are given the following materials; test tubes in a rack (2), measuring cylinder (5cm^3), thermometer, spatula/ tea spoon, sodium hydroxide pellets ($NaOH_{(s)}$), hydrochloric acid ($HCl_{(aq)}$, 1M), ammonium nitrate crystals ($NH_4NO_{3(s)}$), distilled water. Describe an experiment that can be used to investigate endothermic and exothermic reactions.
33. Describe an experiment that can be carried out to determine the heat gained by water from burning spirit. In your description, show all the materials that you may need.
34. You are given the following materials; ice blocks, beaker, thermometer, source of heat (burner or candle), glass stirrer, tripod stand. Describe an experiment that can be used to investigate how temperature changes when ice is heated.
35. Design an experiment that can be carried out to investigate whether different liquids have different heat capacities using the following materials: water, paraffin, methylated spirit, source of heat, large container, identical empty tins / identical beakers (3), matches, thermometer (3), beam balance, 2 litres tin, a large trough, stop watch, glass stirrers.
36. Describe an experiment that can be carried out to construct displacement table for the following metals: iron, copper, zinc and magnesium using iron sulphate solution, copper sulphate solution, zinc sulphate solution and magnesium sulphate solution. In your description, show all the materials you may need.
37. Describe an experiment that can be carried out to determine the relationship between acidity and percentage corrosion. In your description, show all the materials you may need.

38. Describe an experiment that can be carried out to determine the relationship between basicity and percentage corrosion. In your description, show all the materials you may need.
39. Describe an experiment that can be carried out to determine the conditions of rusting. In your description, show all the materials you may need.
40. Describe an experiment that can be carried out to determine factors which affect rusting using the following materials only: test tubes (4), iron nails (4), dilute sodium hydroxide, dilute hydrochloric acid, dilute sodium chloride solution and distilled water.
41. Describe an experiment that can be carried out to electroplate an iron nail with copper. In your description, show all the materials you may need.
42. Describe an experiment that can be carried out to show how copper can be purified using electrolysis. In your description, show all the materials you may need.
43. Design an experiment that can be used to identify acids and bases using universal indicator. In your description, show all the materials you may need.
44. Design an experiment that can be used to investigate the strength of bases using conductivity. In your description, show all the materials that you may need.
45. Design an experiment that can be used to investigate the strength of acids using conductivity. In your description, show all the materials that you may need.
46. Describe an experiment that can be used to show the effect of basicity and acidity on conductivity given the following materials: 1M $HCl_{(aq)}$, 1M $NaOH_{(aq)}$, beaker, carbon rods (2), cells (2) in a holder, connecting wires (3) and ammeter.
47. You are provided with the following materials; measuring cylinder (50ml), stirrer, beakers (2) (100ml), carbon rods (2), potassium nitrate crystals, potassium chloride crystals, cells (2) in a holder, connection wires (3), ammeter. Describe an experiment that can be carried out to find the differences in the conductivity of potassium nitrate and potassium chloride.

FORCES AND MOTION

48. You are given the following materials; a spring balance, 500g mass, a metre rule, a nail and a G-clamp. Describe an experiment that can be carried out to investigate the effect of distance of load from fulcrum (load arm) on effort applied.
49. Design an experiment that can be used to investigate Hook's law using the following materials only; spiral spring, clamp, clamp stand, ruler (30cm), masses (20g, 40g, 60g,80g and 100g)
50. Given the following materials: metre rule (1), blocks (2), 30cm rule (1), masses (100g, 150g, 200g and 250g), describe an experiment that can be carried out to investigate the effect of mass on depression.
51. Describe an experiment that could be carried out to determine the average speed of an athlete given the following materials. In your description, show all the materials that you may need.

ORGANIC CHEMISTRY

52. Describe an experiment that can be carried out to distinguish alkane from alkene using bromine test. In your description, show all the materials that you may need.
53. Describe an experiment that can be carried out to distinguish alkane from alkanol using sodium test. In your description, show all the materials that you may need.
54. Describe an experiment that can be carried out to distinguish alkane from alkanol using solubility test. In your description, show all the materials that you may need.
55. Describe an experiment that can be carried out to distinguish alkane from carboxylic acid using conductivity test. In your description, show all the materials that you may need.
56. Describe an experiment that can be carried out to distinguish alkane from carboxylic acid using solubility test. In your description, show all the materials that you may need.
57. Describe an experiment that can be carried out to distinguish alkane from carboxylic acid using litmus test. In your description, show all the materials that you may need.
58. Describe an experiment that can be carried out to distinguish alkane from carboxylic acid using phenolphthalein indicator test. In your description, show all the materials that you may need.
59. Describe an experiment that can be carried out to distinguish a smaller alkene from a bigger alkene using rate of reaction. In your description, show all the materials that you may need.

60. Describe an experiment that can be carried out to distinguish alkene from alkanol using bromine test. In your description, show all the materials that you may need.
61. Describe an experiment that can be carried out to distinguish alkene from alkanol using solubility test. In your description, show all the materials that you may need.
62. Describe an experiment that can be carried out to distinguish alkene from alkanol using sodium test. In your description, show all the materials that you may need.
63. Describe an experiment that can be carried out to distinguish alkene from carboxylic acid using solubility test. In your description, show all the materials that you may need.
64. Describe an experiment that can be carried out to distinguish alkene from carboxylic acid using conductivity test. In your description, show all the materials that you may need.
65. Describe an experiment that can be carried out to distinguish alkene from carboxylic acid using sodium test. In your description, show all the materials that you may need.
66. Describe an experiment that can be carried out to distinguish alkene from carboxylic acid using litmus test. In your description, show all the materials that you may need.
67. Describe an experiment that can be carried out to distinguish alkene from carboxylic acid using phenolphthalein indicator test. In your description, show all the materials that you may need.
68. Describe an experiment that can be carried out to distinguish alkene from carboxylic acid using bromine test. In your description, show all the materials that you may need.
69. Describe an experiment that can be carried out to distinguish a smaller alkanol from a bigger alkanol using solubility test. In your description, show all the materials that you may need.
70. Describe an experiment that can be carried out to distinguish alkanol from carboxylic acid using phenolphthalein indicator test. In your description, show all the materials that you may need.
71. Describe an experiment that can be carried out to distinguish alkanol from carboxylic acid using litmus test. In your description, show all the materials that you may need.
72. Describe an experiment that can be carried out to distinguish alkanol from carboxylic acid using conductivity test. In your description, show all the materials that you may need.
73. Design an experiment that can be carried out to investigate fermentation of sugar by yeast. In your description, show all the materials you may need.
74. With the aid of a well labeled diagram, describe an experiment that can be done to separate a mixture of ethanol and water. In your description show all the materials you may need.
75. You are given the following materials: Ethanol, Potassium dichromate, Dilute sulphuric acid (0.1M), A test tube in a rack, Droppers (2), Syringe (5ml), Test tube holder, Burner and matches. Describe an experiment that can be carried out to investigate the oxidation of ethanol to ethanoic acid.
76. Describe an experiment that can be carried out to investigate the effect of carboxylic acids on acid / base indicators. In your description, show all the materials you may need.
77. Design an experiment that can be used to investigate the formation of esters using the following materials only; test tube (Pyrex), beaker (Pyrex, 400ml), cold finger, retort stand and clamp, tripod stand and gauze, Bunsen burner and matches, measuring cylinder ($20cm^3$), ethanoic acid, ethanol, concentrated sulphuric acid, tap water, anhydrous sodium carbonate
78. Construct a flow diagram that could be used to identify acetic acid, ethanol, hexane and hexene, using tests that make use of distilled water, bromine solution, sodium hydroxide solution and phenolphthalein indicator.
79. Given the following materials only: dilute sodium hydroxide, phenolphthalein indicator and bromine solution in dropper bottles, four test tubes (in a rack) containing substances P, Q, R and S, and distilled water in a wash bottle, describe an experiment that can be done to identify families of organic compounds.

ELECTRICITY, MAGNETISM AND ELECTROMAGNETIC INDUCTION

80. Describe an experiment that can be carried out to determine the total resistance in parallel and in series circuits. In your description, show all the relevant materials.
81. Design an experiment that can be used to show that voltage in series is shared. In your description, show all the relevant materials.
82. Design an experiment that can be carried out to show that voltage in parallel is the same. In your description, show all the relevant materials.

82\. Describe an experiment that can be done to show that brightness of bulbs depends on voltage. In your description, show all the relevant materials.

83. Describe an experiment that can be carried out to determine the effect of length of a resistor wire on the current passing through it.
84. Describe an experiment that can be carried out to determine the effect of length of resistor wire on its resistance.
85. Describe an experiment that can be carried out to determine the length of nichrome wire to be used to make a 1.7Ω resistor.
86. Describe an experiment that can be done to determine the relationship between the length of a wire and the voltage across it. In your description, show all the materials you may need.
87. Design an experiment that can be used to show that a magnet can be made by stroking.
88. Design an experiment that can be used to show that a magnet can be demagnetized by hammering. In your description, show all the materials you may need.
89. Design an experiment that can be used to show that a magnet can be demagnetized by heating. In your description, show all the materials you may need.
90. Describe an experiment that can be used to demonstrate magnetic effect of electric current. In your description, show all the materials you may need.
91. Describe an experiment that can be used to investigate the direction of electric field lines around a current carrying conductor using the following materials only; cardboard, thick copper wire (connector wire), switch, cells (4) in a holder, and a plotting compass
92. Describe an experiment that can be carried out to demonstrate how induction of EMF can be achieved in a conductor wire using the following materials: U-shaped magnet, conductor wires and galvanometer.
93. Describe an experiment that can be used to investigate how a diode functions in a circuit. In your description, show all the materials you may need.
94. Describe an experiment that can be used to investigate how a transistor functions in a circuit. In your description, show all the materials you may need.
95. With the aid of a diagram, describe an experiment that could be done to identify unknown substances W, X and Y given that they are a diode, an insulator and a resistor but not necessarily in that order.

OSCILLATIONS AND WAVES

96. Describe an experiment that can be carried out to determine the effect of length on frequency of an oscillating pendulum. In your description, show all the materials you may need.
97. Describe an experiment that can be carried out to determine the effect of mass on frequency of an oscillating pendulum. In your description, show all the materials you may need.
98. Describe an experiment that can be carried out to determine the effect of type of material on the frequency of an oscillating pendulum. In your description, show all the materials you may need.
99. Describe an experiment that can be carried out to determine the effect of amplitude on frequency of an oscillating pendulum. In your description, show all the materials you may need.
100. Describe an experiment that can be carried out to determine the effect of length on frequency of an oscillating spiral spring. In your description, show all the materials you may need.
101. Describe an experiment that can be carried out to determine the effect of mass on frequency of an oscillating spiral spring. In your description, show all the materials you may need.
102. Describe an experiment that can be carried out to determine the effect of type of material on the frequency of an oscillating spiral spring. In your description, show all the materials you may need.
103. Describe an experiment that can be carried out to determine the effect of amplitude on frequency of an oscillating spiral spring. In your description, show all the materials you may need.
104. Describe an experiment that can be carried out to determine the effect of length on frequency of an oscillating cantilever. In your description, show all the materials you may need.
105. Describe an experiment that can be carried out to determine the effect of mass on frequency of an oscillating cantilever. In your description, show all the materials you may need.
106. Describe an experiment that can be carried out to determine the effect of type of material on the frequency of an oscillating cantilever. In your description, show all

the materials you may need.

107. Describe an experiment that can be carried out to determine the effect of amplitude on frequency of an oscillating cantilever. In your description, show all the materials you may need.
108. With the aid of a well labeled diagram, describe an experiment which can be used to find out if sound waves require a medium for their propagation.
109. Describe an experiment that can be carried out to determine the differences in speeds of 2 sounds traveling in 2 different media (metal and air). In your description, show all the materials you may need.
110. Describe graph method of determining the focal length of a convex (converging) lens.
111. Describe mirror method of determining focal length of a convex (converging) lens.
112. Describe rough method of determining focal length of a convex (converging) lens.
113. Design an experiment that can be used to determine the effect of object distance on image distance. In your description, show all the materials you may need.
114. Design an experiment that can be used to determine the effect of object distance on magnification. In your description, show all the materials you may need.
115. Design an experiment that can be used to determine the effect of object distance on position and the characteristics of the image formed by a converging lens. In your description, show all the materials you may need.
116. Describe an experiment that can be carried out to show how a pure spectrum of white light can be produced. In your description, show all the materials you may need.

NUCLEAR PHYSICS

117. Describe an experiment that can be carried out to show that thickness of a sheet of plastic could be controlled during manufacture using radiation.
118. Design an experiment that can be used to determine alpha, beta and gamma radiation using an electroscope. In your description, show all the materials you may need.

DENSITY

119. How can density of paraffin and water be determined? In your description, show materials and procedure. Use the results to discuss the law of floatation.
120. Given the following materials; triple beam balance, water of density 1g/cm^3, cooking oil, clear, empty bottle, describe how you can determine the density of the cooking oil.
121. A shiny metal is suspected of being one of the following, aluminium, tin or nickel. Describe an experiment that can be used to identify it given the following materials; the metal to be identified, a well calibrated beaker (100ml), water and a chart showing densities of the three metals (aluminium: 2.7g/cm^3, tin: 7.3g/cm^3 and nickel: 8.7g/cm^3)

SEPARATING MIXTURES

122. A mixture W contains 3 substances X, Y and Z which are all solids. Substance X is soluble in carbon tetrachloride, substance Y is soluble in water but is insoluble in carbon tetrachloride. Substance Z is insoluble in both solvents. Describe how you would obtain pure samples of X, Y and Z
123. Sand was accidentally introduced in a solution of naphthalene in alcohol. Describe with the aid of diagrams how you would obtain pure samples of sand, naphthalene and alcohol from the mixture.
124. A new brand of soap is found to cause skin irritation when used. An old brand of the same soap did not cause skin irritation. A chemist decides to compare the components of the dyes of the two brands of soap to see if they are different. Describe an experiment that could be done to isolate the components of the dyes.
125. Describe an experiment that be done to demonstrate how water of crystallization can be removed. In your description, show all the materials that you may need.
126. You are provided with hydrated copper sulphate, an evaporating basin, a gas burner, a triple beam balance and wire gauze. Describe an experiment that can be carried out to determine the percentage of water found in the hydrated copper sulphate

2 PROPERTIES OF MATTER

INVESTIGATING THE RELATIONSHIP BETWEEN MASS AND LENGTH OF PIPE

Materials: PVC pipe (80cm), triple beam balance, a cutter

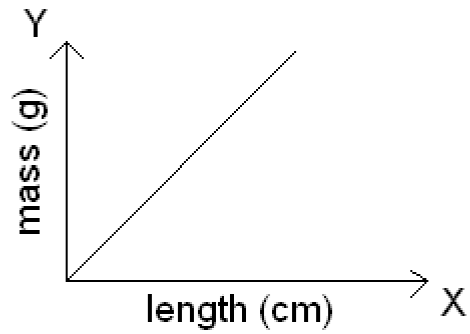
Procedure: a. cut the following lengths of the pipe using the cutter; 5cm, 10cm, 15cm, 20cm, 25cm.
b. Measure the mass of each length of pipe and record in the table of results below.

TABLE OF RESULTS

Length of pipe (cm)	0	5	10	15	20	25
Mass of pipe (g)						

If the mass changes as the length is increased, then there is a relationship between the mass and the length of the pipe. Expectedly, the mass will increase as the length is increased i.e. mass is directly to the length.

To visualize the direct relationship clearly, a graph of mass of pipe against length of pipe can be drawn. The graph will look like the one shown below.



INVESTIGATING THE EFFECT OF TEMPERATURE ON MOLECULAR MOTION

Materials: candle and matches

Procedure: a. light the candle and wait for 5 minutes
b. observe what happens to the candle wax. Record the observation in the table of results
c. put off the flame and wait for 5 minutes.
d. observe what happens to the candle wax. Record the observation in the table of results

TABLE OF RESULTS

TEST	OBSERAVTION
Heating candle for 5 minutes	
Cooling candle for 5 minutes	

The candle wax will turn from solid to liquid, showing that the particles have broken free from their fixed positions. They are now able to move from one place to another and their speed is increased. All this is happening because of the heat supplied i.e. the heat is converted to kinetic energy of the particles and this makes the particles to move freely.

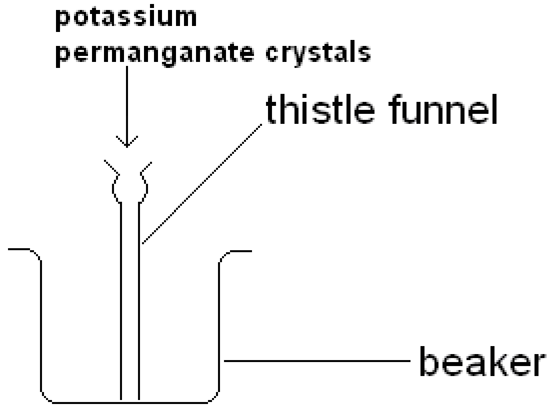
After 5 minutes of cooling, the candle wax turns back from liquid to solid and the particles no longer move freely. This shows that the particles have lost the kinetic energy which they gained. The only movement in this case will be vibration about fixed positions.

BOILING WATER AND THE MOTION WHEN WATER IS COOLING (CONVECTIONAL

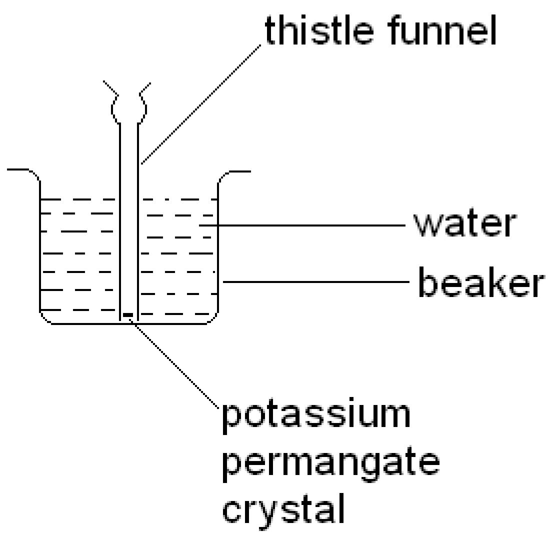
CURRENTS)

Materials : beaker (150ml), glass tubing, heat source, potassium permanganate crystals, a pair of tweezers

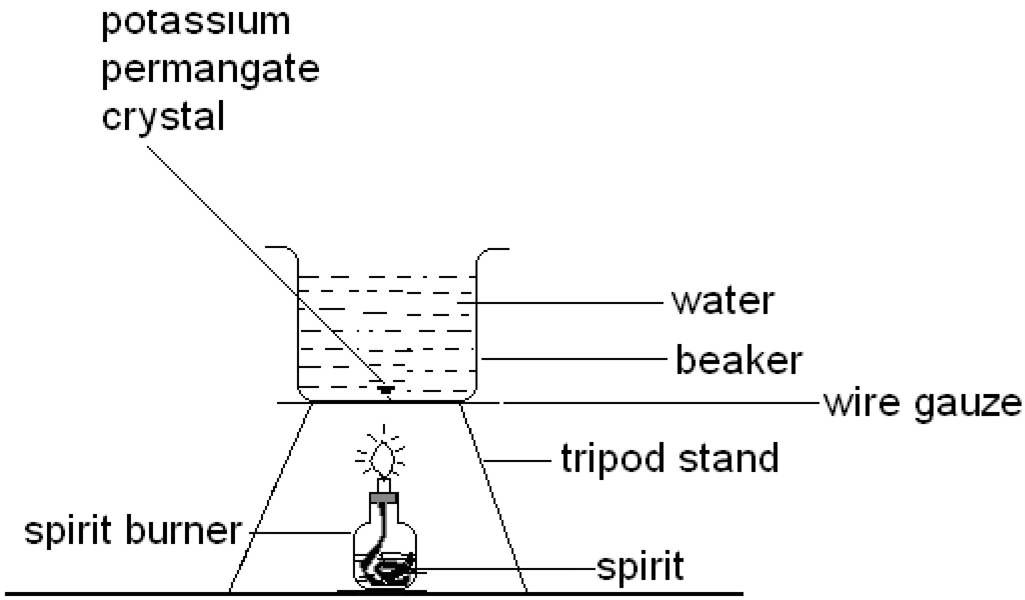
Procedure: a. put the thistle funnel into the beaker and slide a few crystals of potassium permanganate into the beaker through the thistle funnel as shown below



b. pour water into the beaker with the thistle funnel still in the same position as shown below

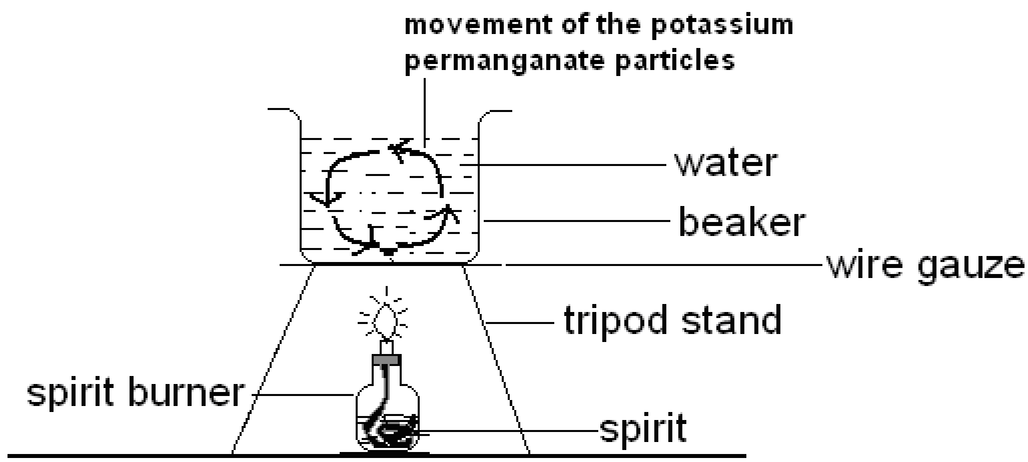


c. remove the tube without disturbing the crystal



d. heat the beaker for 10 minutes
e. observe the movement of the potassium permanganate particles as they are taken by the water. Draw, using arrows, the direction of the movement of water particles as they are taking the potassium permanganate crystals along with them.
f. let the water cool and observe what happens. Draw, using arrows, the direction of the movement of water particles as they are taking the potassium permanganate crystals along with them.

Expectedly, as the water is being heated, the observation will be like the one shown in the figure below



As the water is being cooled, it is expected that the observation will be like the one observed when the water is heated.

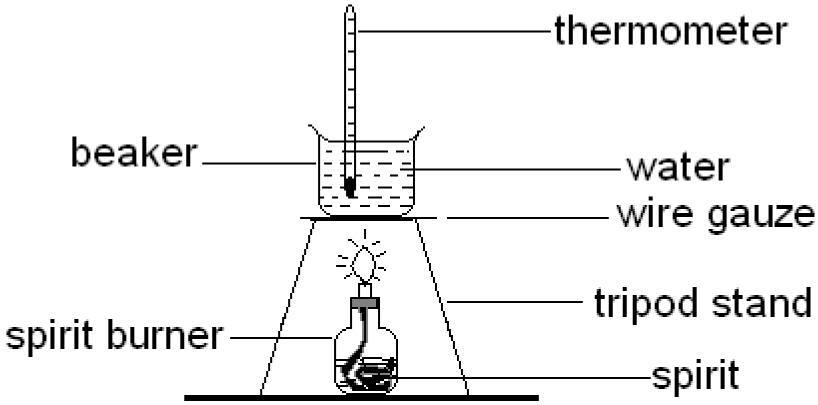
The observation is as shown because as the water is heated at the bottom of the beaker, its density decreases i.e. its density becomes less than that of the water on top of it. Therefore it rises and the water on top, which has high density, sinks. The water at the bottom and at the top exchange places and this process goes on and on.

As the water is cooling, the same thing happens. The water at the top cools faster due to direct contact with air and sinks to replace the water at the bottom which rises because of its low density.

INVESTIGATING THE EFFECT OF IMPURITIES ON BOILING POINTS OF SUBSTANCES.

Materials: water (50ml) in a Pyrex beaker, salt (NaCl), glass stirrer, Bunsen burner, thermometer, tripod stand, glass rod, water bath.

Procedure: a. set up the apparatus as shown below



b. heat the water until it boils.
c. note the boiling point and record in the table of results
d. remove the burner and dissolve some salt in the water.
e. heat the water again until it boils
f. note the boiling point and record in the table of results.

TABLE OF RESULTS

SBSTANCE	BOILING POINT
Pure water	
Water + salt	

g. compare the boiling points and make a conclusion.

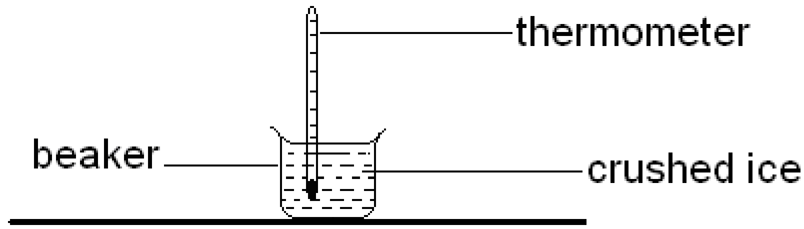
If the boiling points are different, it means impurities, in this case salt, has an effect on the boiling point of a substance.

In fact, the boiling point increases. This happens because there is need of extra heat to be absorbed by the impurity particles, and to overcome the pressure that impurity particles on the surface of the liquid exerts downward on the liquid.

INVESTIGATING THE EFFECT OF IMPURITIES ON MELTING POINTS OF SUBSTANCES

Materials: ice, beaker, thermometer, glass rod, table salt, glass stirrer.

Procedure: a. crush the ice using the glass rod and put it into a beaker.
b. set up the apparatus as shown below



c. let the ice melt and record the melting point in the table of results
d. repeat steps (a) to (c) with the ice mixed with table salt

TABLE OF RESULTS

SUBSTANCE	MELTING POINT
Pure ice	
Ice + table salt	

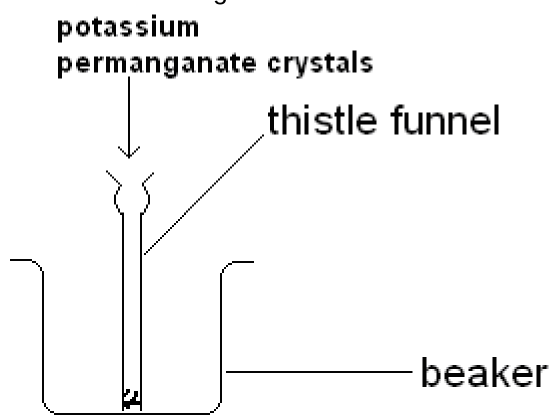
If the melting points are different, it means that salt, which is an impurity, affects the melting point of ice. Objectively, it means that impurities affect the melting points of substances.

In fact, the impurities will lower the melting points of substances. This is so because the impurity particles act as obstacles between any 2 particles in the substance. This weakens the forces acting in between the particles of the substance; hence the particles are easily separated by heat.

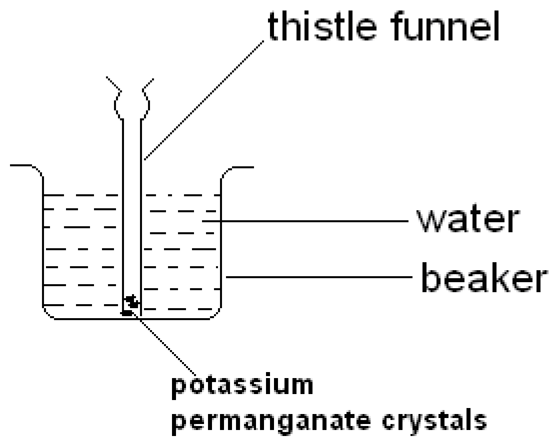
DIFFUSION OF POTASSIUM PERMANGANATE CRYSTALS IN WATER

Materials: potassium permanganate crystals, Beaker (250ml), water, thistle funnel

Procedure: a. put the thistle funnel into the beaker and slide a few crystals of potassium permanganate into the beaker through the thistle funnel as shown below



b. pour water into the beaker with the thistle funnel still in the same position as shown below



c. carefully, remove the thistle funnel.
d. leave the beaker standing for 10 minutes (do not shake, swirl or stir) and observe what happens.

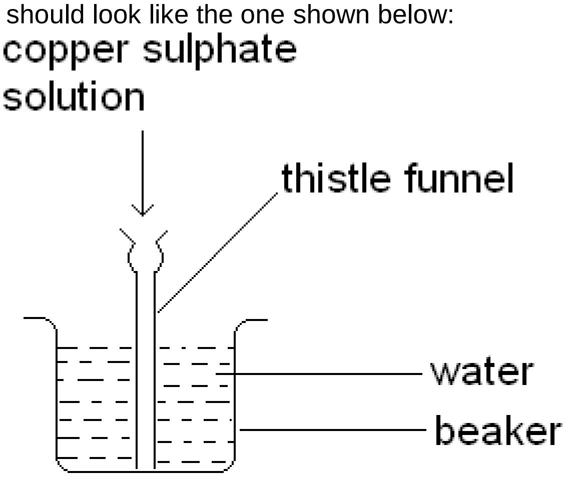
Expectedly, the pink colour of the solution will fill the whole beaker showing that the potassium permanganate particles have moved from the highly concentrated region (the source) to the region of low concentration (the area where there was water particles only) i.e. the potassium permanganate particles have diffused.

If temperature is increased, the diffusion can be even faster i.e. the brown colour of the potassium permanganate crystals can fill the whole beaker within a very short period of time..

DIFFUSION OF COPPER SULPHATE SOLUTION IN WATER

Materials: 5 Molar Copper Sulphate solution (50 ml), Beaker (250ml), water, thistle funnel

Procedure: a. dip the thistle funnel into the beaker and fill the beaker with water up to the 150 ml mark. The set up should look like the one shown below:



c. pour Copper Sulphate solution into the beaker through the thistle funnel.
d. carefully, remove the thistle funnel.
e. leave the beaker standing (do not shake, swirl or stir) and observe what happens.
f. after sometime (about 20 minutes), observe how the particles of copper sulphate solution have diffused into the water.

Expectedly, the blue colour of the solution will fill the whole beaker showing that copper sulphate particles have moved from the highly concentrated region (the source) to the region of low concentration (the area where there was water particles only) i.e. the copper sulphate particles have diffused . Note that the copper ions are responsible for the blue colour.

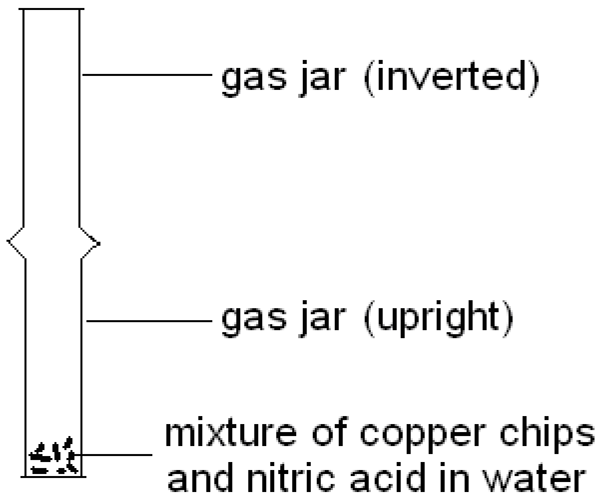
If temperature is increased, the diffusion can be even faster i.e. the blue colour of the copper ions can fill the whole beaker within a very short period of time.

DIFFUSION OF NITROGEN DIOXIDE

Materials: copper chips, concentrated nitric acid, water, gas jars (2), measuring cylinder (5ml), beaker (100ml).

Procedure: a. put some copper chips in a gas jar
b. prepare a mixture of concentrated nitric acid (5ml) and water (5ml) in a beaker.
c. pour the mixture on the copper chips in the gas jar
d. invert another gas jar over the gas jar containing the mixture.

The set up should look as shown below



e. wait for 10 minutes and then observe what happens in the gas jars

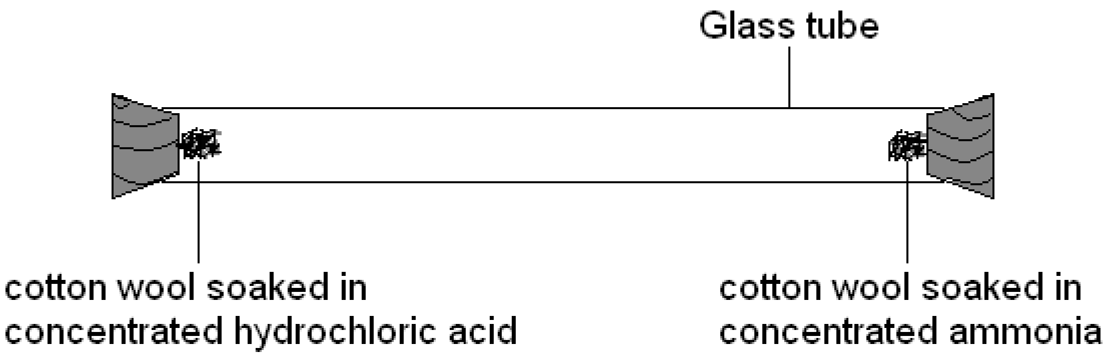
It is expected that a gas, nitrogen dioxide will be produced from the mixture in the lower gas jar i.e. it will be formed in situ ($Cu_{(s)}$ + NH_3 + $H_2O \rightarrow NO_{2(g)}$ + $Cu(OH)_2$). After 10 minutes, the nitrogen dioxide gas (brown in colour) will fill the 2 gas jars showing that the gas particles have moved from the highly concentrated area (the source) to the area of low concentration (the upper part of the lower gas jar and the gas jar over it) i.e. the gas particles have diffused

INVESTIGATING HOW SIZE OF PARTICLES AFFECT THE RATE OF DIFFUSION

Materials: concentrated ammonia solution, concentrated hydrochloric acid, cotton wool, dry glass tube, stoppers (2), pins (2).

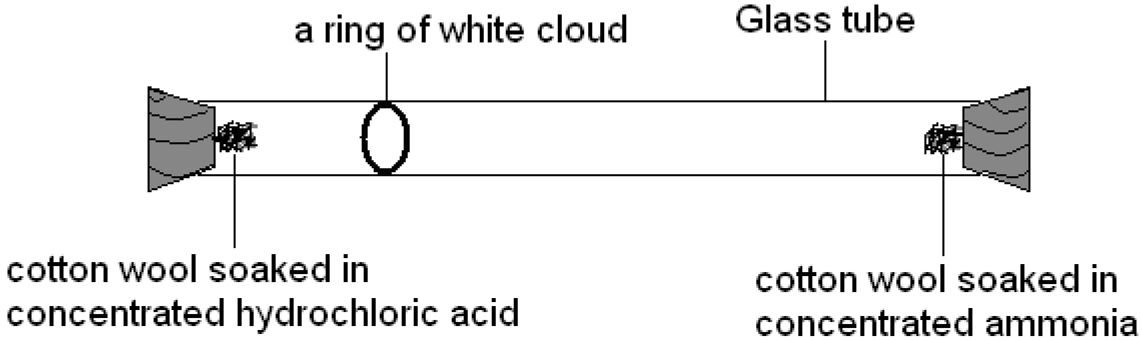
Procedure: a. soak some cotton wool in concentrated ammonia solution and another in concentrated hydrochloric acid.

b. pin the cotton wool to the stoppers on both ends of dry glass tube as shown in the set up below.



c. observe what happens in the test tube after 2 minutes

Expectedly, a ring of white cloud will form close to the cotton wool soaked in concentrated hydrochloric acid as shown below



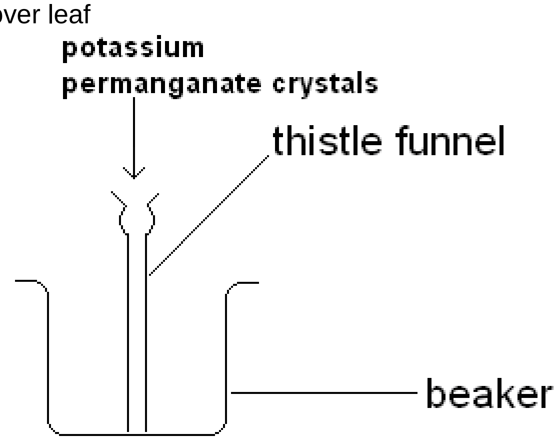
This means that ammonia particles travel faster than does the hydrogen chloride particles. One would expect it to be so because ammonia particles are lighter (RFM of 17g/mol) than hydrogen chloride particles (RFM of 36.5g/mol).

It can therefore be concluded that lighter particles have high rate of diffusion than heavier particles i.e. size of particles affect the rate of diffusion.

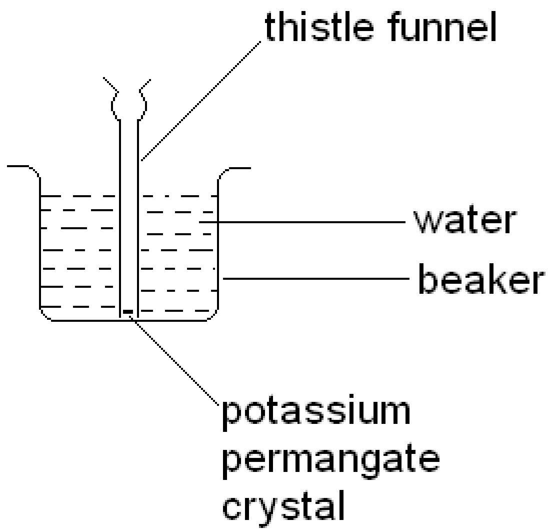
INVESTIGATING THE EFFECT OF TEMPERATURE ON THE RATE OF DIFFUSION

Materials: beaker (150ml), thistle funnel, potassium permanganate crystals, a pair of tweezers, cold water, hot water

Procedure: a. put the thistle funnel into the beaker and slide a few crystals of potassium permanganate into the beaker through the thistle funnel using the pair of tweezers as shown over leaf



b. pour water into the beaker with the thistle funnel still in the same position as shown below



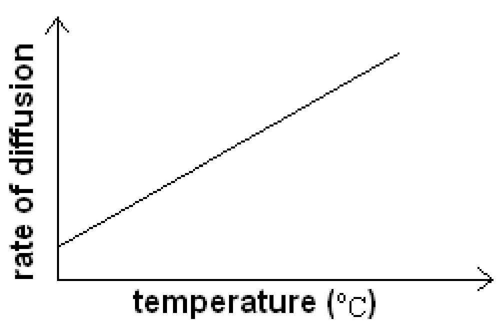
c. remove the funnel without disturbing the crystals
d. wait for 1 minute and note the movement of the potassium permanganate particles in the beaker. Record the observation in the table of results
e. repeat steps (a) to (d) with hot water .

TABLE OF RESULTS

CONDITION	OBSERVATION
Cold water	
Hot water	

Expectedly, after 1 minute, the potassium permanganate particles will diffuse slowly when cold water is used i.e. the beaker will not be fully filled up with the pink colour of the potassium permanganate particles. On the other hand, after the same period of time, 1 minute, the particles will diffuse faster when hot water is used i.e. the whole beaker will be fully filled up with the pink colour. This shows that if the temperature is high, the speed of the particles is also high hence high rate of diffusion at higher temperatures and lower rate of diffusion at lower temperatures.

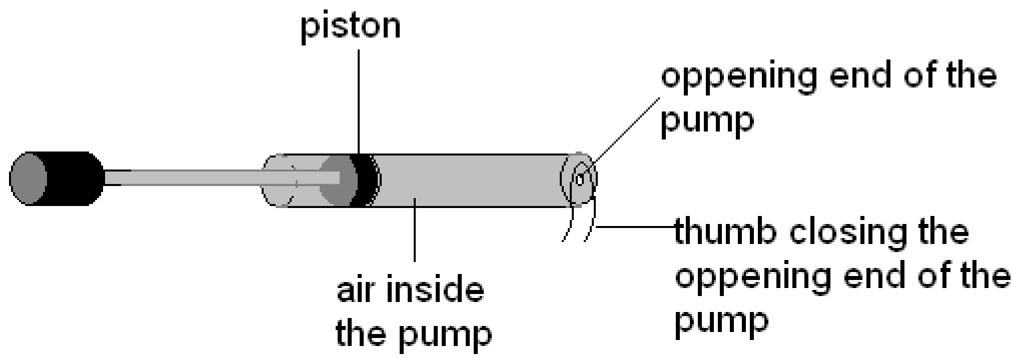
The relationship between temperature and rate of diffusion can be shown using a graph as below



INVESTIGATING BOYLE'S LAW

Materials: a bicycle pump

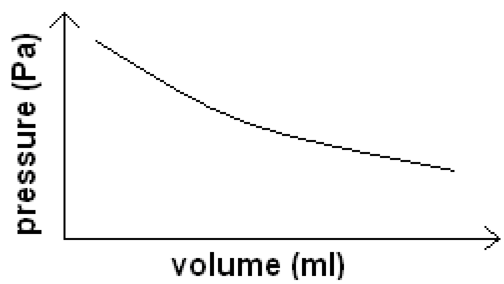
Procedure: a. pull the piston of the pump outwards so that there is space inside the pump.
b. press the opening end of the pump harder using the tip of the thumb as shown in the diagram below



c. press the piston harder into the pump, making sure that no air goes out of the pump through the opening, which has been closed by the thumb.
d. observe what happens to the space containing air inside the pump and record in the space below

Observation ____

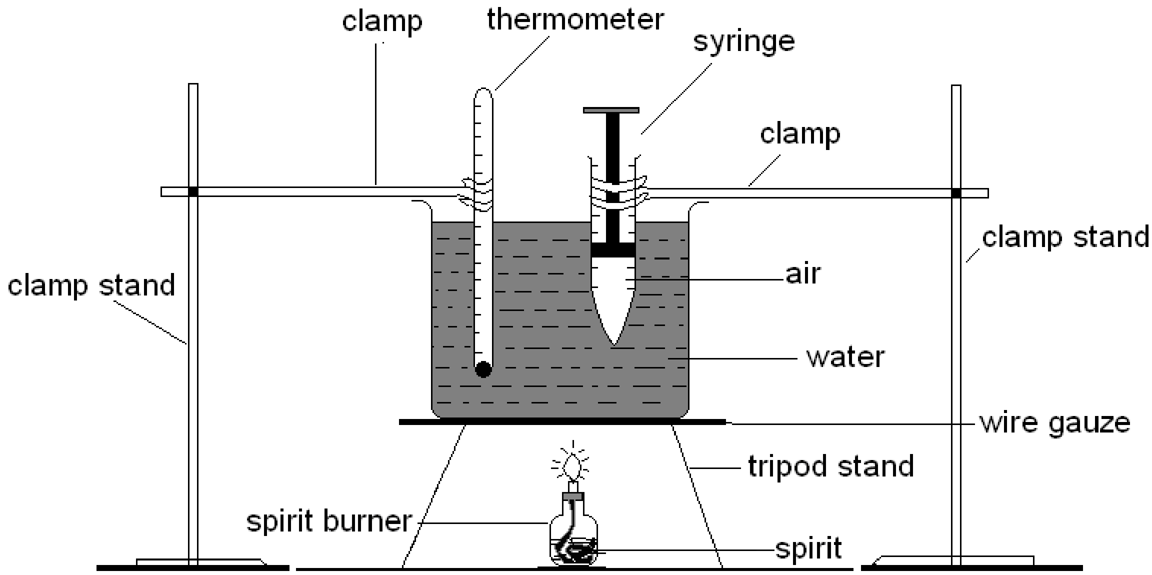
Expectedly, the piston will still move inwards although no air is getting out. This shows that the air is just squeezed. As the piston is being pushed inwards, pressure of the air inside the pump mounts and there is no space for the air to go out, hence the spaces between the particles of the air decrease so that the space occupied gets smaller i.e. volume decreases. The relationship is that as the pressure is increasing, the volume is decreasing. This relationship is summarized in a statement called Boyle's Law, which states that volume is inversely / indirectly proportional to volume at constant temperature. To visualize the relationship between pressure and volume clearly, a graph like the one shown below can be drawn



INVESTIGATING CHARLES' LAW

Materials: syringe, beaker, thermometer, water, source of heat, tripod stand, wire gauze, clamps(2) and clamp stands (2).

Procedure: a. set up the apparatus as shown below



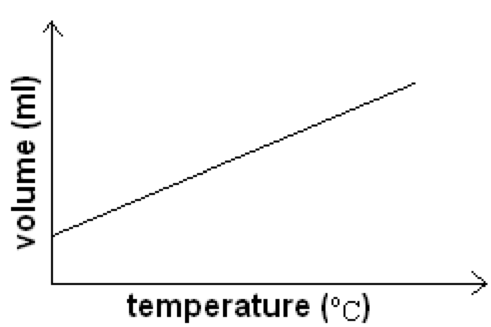
b. note the initial volume of the syringe and the initial reading of the thermometer and record in the table of results
c. heat the beaker for 10 minutes.
d. observe what happens to the volume of the gas in the syringe and the thermometer reading
e. records the observations in the table of results

TABLE OF RESULTS

Thermometer readings (^oC)		Volume of the syringe	
Initial temperature	Final temperature	Initial volume	Final volume

If the piston of the syringe moves upwards (the volume of the air inside the syringe increases) and the temperature also increases, then there is a direct relationship between the temperature and volume. Note that the pressure (atmospheric pressure) and mass of the air inside the syringe are constant. This relationship is a law known as Charles' Law. The law states that volume of a fixed mass of gas is directly proportional to its absolute temperature if the pressure is kept constant. The temperature is absolute because it is the scientific scale of temperature.

A graph can help in visualizing the relationship clearly. The graph looks like the one below

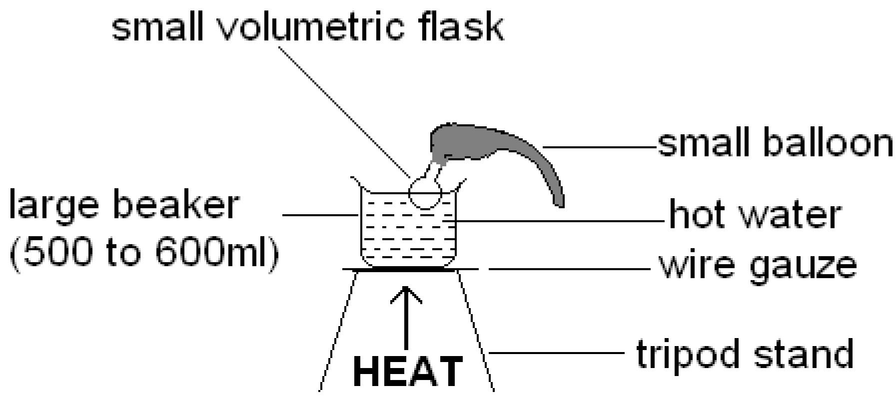


AN ALTENATIVE TO THE EXPERIMENT ABOVE IS GIVEN BELOW

INVESTIGATING THE RELATIONSHIP BETWEEN TEMPERATURE AND VOLUME (CHARLES' LAW)

Materials: a small balloon, flask (150 ml), pyrex beaker (600 ml), tap water, source of heat and tripod stand with a wire gauze.

Procedure: a. arrange the apparatus as shown below

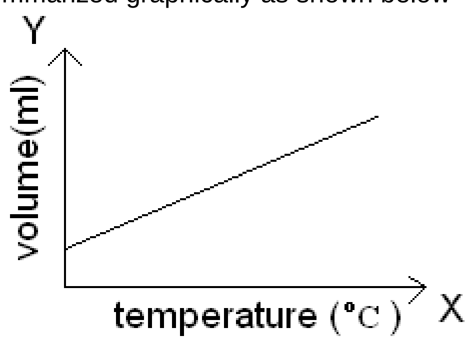


b. allow the water in the beaker to boil and observe what happens to the balloon.
c. record your observation below
observation ____

If the volume of the balloon increases as the heat is applied, then there is an effect of temperature on volume.

As the temperature increases, volume also increases and as the temperature decreases, volume also decreases i.e. volume is directly proportional to temperature.

The relationship can be summarized graphically as shown below

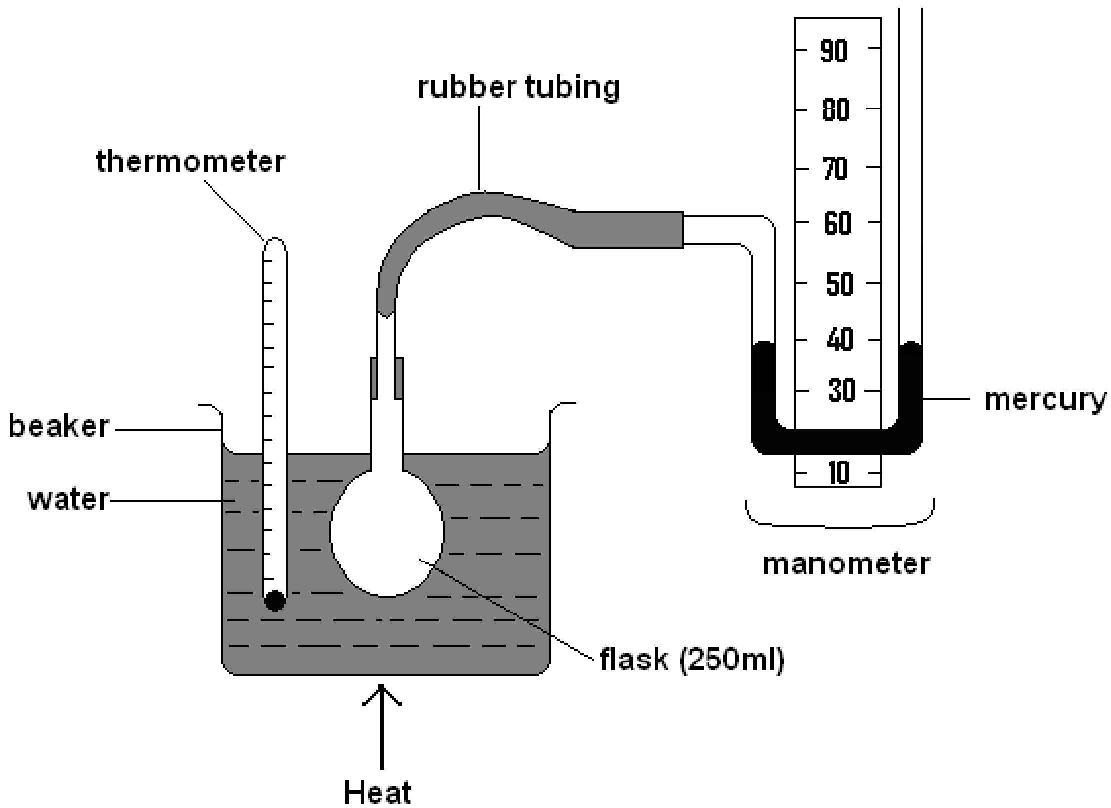


This relationship is a law called Charles' Law. The law states that pressure is directly proportional to temperature at constant pressure.

INVESTIGATING PRESSURE LAW

Materials: a manometer, thermometer, beaker (600ml), rubber tubing, volumetric flask(250ml), source of heat.

Procedure: a. set up the apparatus as shown in the diagram over leaf

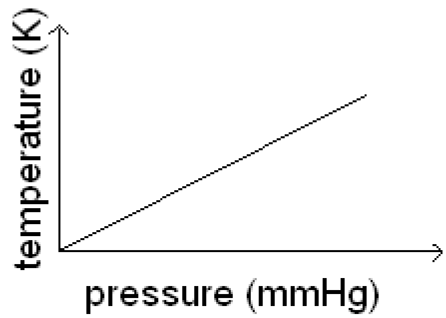


b. note the initial difference in the levels of the mercury columns in the manometer and the initial thermometer reading and record in the table of results
c. heat the water in the beaker
d. note the changes in the levels of the mercury column of the manometer when the thermometer reading is 30^oC and record in the table of results
e. repeat step (d) for thermometer readings, 40 ^oC, 60 ^oC, 80 ^oC and 100 ^oC.

TABLE OF RESULTS

Thermometer reading (^oC)	Difference in mercury column (mmHg)
Initial reading	
30 ^oC	
40 ^oC	
60 ^oC	
80 ^oC	
100 ^oC	

It is expected that as the temperature is increasing, the mercury column on the right hand arm of the manometer will be increasing; hence the difference in the mercury column will also be increasing. But the difference in the mercury column is a measure of pressure; hence pressure increases as the temperature increases i.e. pressure is directly proportional to temperature. A graph of temperature against pressure can be drawn to illustrate the relationship clearly i.e.

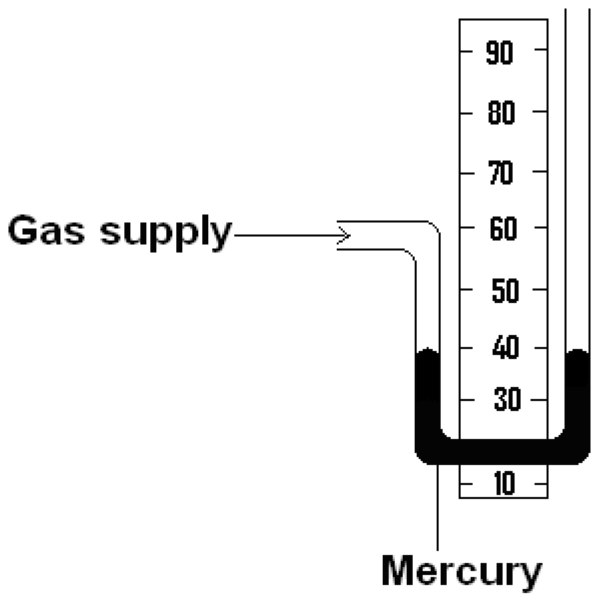


This relationship is a law known as Pressure law. The law states that pressure is directly proportional to temperature at constant volume.

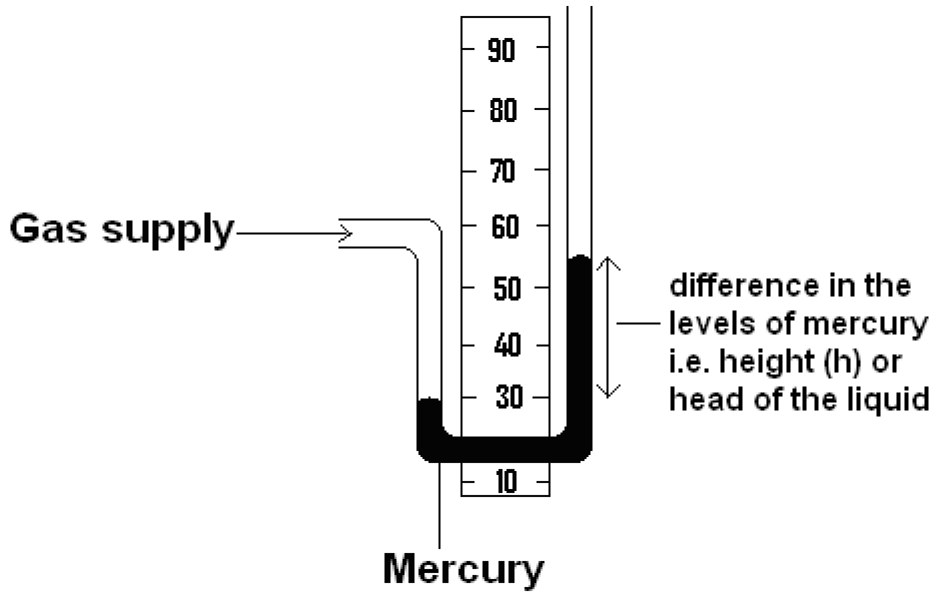
MEASURING LUNG PRESSURE USING MANOMETER

Materials: Mercury, U-shaped transparent glass / plastic tubing and a ruler

Procedure: a. set up the apparatus as shown in the figure below.



b. note the difference in the levels of mercury (height of mercury (h)) in the two arms of the manometer i.e. mercury column and record in the table of results.
c. blow into the manometer, note the difference in the levels of mercury in the two arms of the manometer i.e. mercury column.



d. complete the table by filling the height(h) of mercury i.e. mercury column in millimeters and translate it to meters.

TABLE OF RESULTS

Height of mercury (h) / mercury column	
Mm	M

e. calculate the lung pressure using the formula below:

Lung pressure = atmospheric pressure + pressure due to mercury column / height of mercury (h)
= atmospheric pressure + dhg

Where d is density of the liquid in kg/m^3; h is height or depth of the mercury in meters; g is the force due to gravity with the value of 10N/Kg and the pressure is expressed in Pascals (Pa).

(Hint: density of mercury is 13.546 kg/m^3; at normal pressure and temperature (NTP) mercury barometer will have a mercury column of 760 mm)

Sometimes the pressure is expressed in mmHg especially for higher pressures and mmH_2O if the pressure is not that high. (water can be used in a manometer if the pressure is not that high)

IDENTIFYING COVALENT AND IONIC SUBSTANCES USING MELTING POINTS

Materials: identical evaporating dishes (2), substances A and B (one is covalent and the other one is ionic but not necessarily in that order), source of heat, spatula.

Procedure: a. put a spatulaful of substance A into one evaporating dish and heat it for 1 minute. Note whether it melts or not and record the results in the table of results.

b. put a spatulaful of substance B into the other evaporating basin and heat for 1 minute. Note whether it melts or not and record your results in the table of results

TABLE OF RESULTS

Substance	Observation
A	
B	

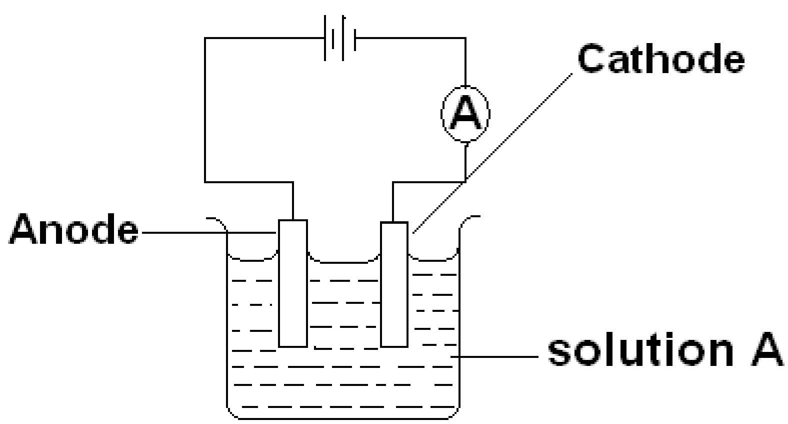
From the results, the substance which has melted / melted faster has low melting point and the one which takes time to melt / does not melt within the time limit given has high melting point.

Since covalent substances have low melting points and ionic substances have high melting points, it means that the substance which has low melting point in the experiment is covalent and the one which has high melting point is ionic.

IDENTIFYING COVALENT AND IONIC COMPOUNDS USING CONDUCTIVITY

Materials: conducting wires (3), an ammeter, beaker with holed rid, carbon rods (2), power supply, solutions A and B (one is sodium chloride [common salt] solution and the other is sucrose [common sugar] solution but not necessarily in that order).

Procedure: a. connect the circuit as shown in the figure below



b. read and record the ammeter reading in the appropriate space in the table of results

c. replace solution A with solution B (remember to rinse the electrodes with distilled water followed by solution B)

d. read and record the ammeter reading in the appropriate space in the table of results

TABLE OF RESULTS

Solution	Ammeter reading
A	
B	

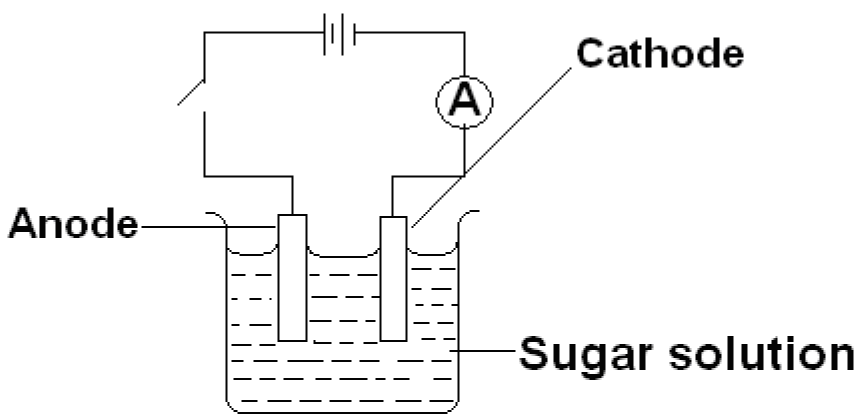
The solution which registers a reading is ionic and the one which does not register a reading is covalent. This is so because ionic substances dissociate in water to give out ions which can conduct electric current while covalent substances do not dissociate in water to give out ions which can conduct electric current

If the solution conducts, it means that it is salt and if it does not conduct it means it is sugar. This is so because salt is ionic and sugar is covalent.

INVESTIGATING THE EXISTENCE OF PARTIAL CHARGES (POLARITY) IN COVALENT SUBSTANCES THROUGH CONDUCTIVITY TEST

Materials: beaker (100ml), carbon rods (2), connecting wires (4), bulb in a holder, cells (2) in a holder, switch, sugar solution, dilute sulphuric acid, H_2SO_4, distilled water

Procedure: a. arrange the apparatus as shown below



b. close the switch and observe whether the bulb gives light or not. Record the observation in the table of results.
c. pour out the sugar solution from the beaker and rinse the electrodes with distilled water followed by dilute sulphuric acid)
e. fill the beaker with dilute sulphuric acid.
f. close the switch and observe whether the bulb gives light or not. Record the observation in the table of results (put a tick or a cross where appropriate in the table)

TABLE OF RESULTS

Test solution	Bulb gives light
Sugar solution	
Dilute sulphuric acid	

Conduction in liquids is by ions. Substances which dissociate into ions in water are those which are polar i.e. those which have partial charges. Therefore, the solution of which the bulb gives light in the experiment is polar (it has partial charges and has dissociated into ions which made it possible to conduct). On the other hand, the solution which does not conduct is non polar since it is not able to give out ions for conduction.

Expectedly, the sugar solution will not conduct since it is non polar while sulphuric acid will conduct since it is polar i.e. H_2SO_4 dissociates into H^+ and SO_4^{2-} which can conduct in solution form.

DETERMINING THE REACTIVITY SERIES OF GROUP 1 METALS USING REACTION WITH WATER

Materials: group 1 metals; potassium, lithium and sodium (the metals are labeled 1, 2 and 3 but not necessarily in that order), petri dishes (3) and water in a beaker.

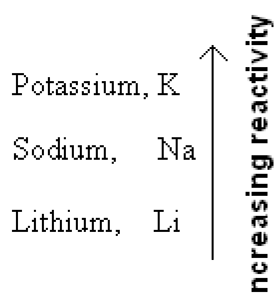
Procedure: a. put a considerable amount of water in the petri dishes
b. put a piece of metal 1 in one of the dishes
c. observe and record what happens in the appropriate space in the table of results.
d. repeat steps (b) and (c) for metals 2 and 3 using the other 2 dishes

TABLE OF RESULTS

Metal	Observation
1	
2	
3	

Expectedly, one of the metals will react most vigorously by producing flame of fire and smoke. Another one will produce smoke, but will not produce fire. The last one will produce neither smoke nor fire. It will just react with a fizzing sound. These expected results show that there will be a trend in the reactivity of the metals This means that the one which produces fire and smoke is the most reactive seconded by the one which produces smoke only, and the one which does not produce fire nor smoke is the least reactive. In fact, these will be potassium (K), sodium (Na) and lithium (Li) respectively

The order of reactivity will be as shown below



VERIFYING IF A METAL BELONGS TO GROUP 1

Materials: forceps, Bunsen burner, water in a glass dish, a knife, a metal

Procedure: a. try to cut the metal with a knife
b. observe what happens (is it easily cut or not?) and record the observations in the table of results.
c. drop a small piece of the metal in the dish containing water.
f. observe what happens (whether the reaction is vigorous or not, and whether the metal floats on the water or not) and record the observations in the table of results.

TABLE OF RESULTS

Test	Observation
Metal cut with a knife	
Metal dropped in water	

The metal belongs to group 1 if the following observations are made:
If the metal is

- Easily cut by a knife

- Reacts vigorously with water (a group 1 metal reacts vigorously with water to produce a metal hydroxide and hydrogen gas)
- Floats on water (a group 1 metal is less dense than water)

DISPLACEMENT REACTIONS OF HALOGENS: CHLORINE, BROMINE, IODINE

Materials: potassium chloride solution(1M) in a beaker, potassium bromide solution(1M) in a beaker, potassium iodide solution(1M) in a beaker, chlorine water in a beaker, iodine in a beaker, bromine in a beaker, test tubes (3)

Procedure: a. quarter -fill each of the test tubes with the three metal salts (potassium chloride, potassium bromide and potassium iodide)
b. add a little chlorine water to each of the test tubes
c. observe any changes ; tick where a reaction takes place and cross where reaction has not taken place in the table of results below
d. repeat steps (b) and (c)

TABLE OF RESULTS

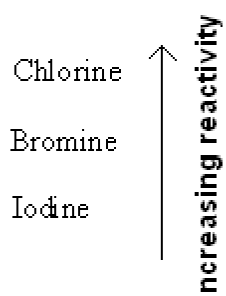
Solutions	**Potassium chloride**	**Potassium bromide**	**Potassium iodide**
Chlorine water			
Bromine			
Iodine			

Expectedly, the results will be as shown below.

Solutions	Potassium chloride	Potassium bromide	Potassium iodide
Chlorine water	X	√	√
Bromine	X	X	√
Iodine	X	X	X

Chlorine is displacing bromine and iodine in solution; bromine is displacing iodine only while iodine is not displacing any of the other halogens in solution. This means that chlorine is the most reactive seconded by bromine and iodine is the least reactive

i.e.



The results will be as shown above because halogens react by gaining an electron, and chlorine has the strongest pulling force due to its small radius. The bromine has a relatively bigger radius hence it has a relatively strong pulling force and this makes it to be relatively more reactive. Iodine is the least reactive because, amongst the three halogens being studied in this experiment, it has the biggest atomic radius hence it has the weakest pulling force.

DEHYDRATION OF COMMON SUGAR (SUCROSE) BY CONCENTRATED SULPHURIC ACID

Materials: beaker ($100cm^3$), tea spoon/spatula, sugar (sucrose), concentrated sulphuric acid and a glass rod

Procedure: a. put a teaspoon full of sucrose, $C_{12}H_{22}O_{11}$ (about 7.5g) into a dry beaker
b. pour a little sulphuric acid, H_2SO_4 over the sugar
c. mix the sugar and sulphuric acid using a rod

d. observe what happens

The process can be represented by means of an equation as shown below

$$\text{sucrose (sugar)} \xrightarrow{\text{conc. } H_2SO_4} \text{carbon} + \text{water}$$

i.e.

$$C_{12}H_{22}O_{11(s)} \xrightarrow{\text{conc. } H_2SO_4} 12C_{(s)} + 11H_2O_{(l)}$$

The process forms a black substance and according to the equation representing the process, the substance is carbon. Sulphuric acid is a powerful dehydrating agent. It can also be used to dehydrate other substances like hydrated copper (II) sulphate crystals to form anhydrous copper(II) sulphate according to the equation shown below.

$$\text{hydrated copper(II) sulphate} \xrightarrow{\text{conc. } H_2SO_4} \text{anhydrous copper(II) sulphate} + \text{water}$$

i.e.

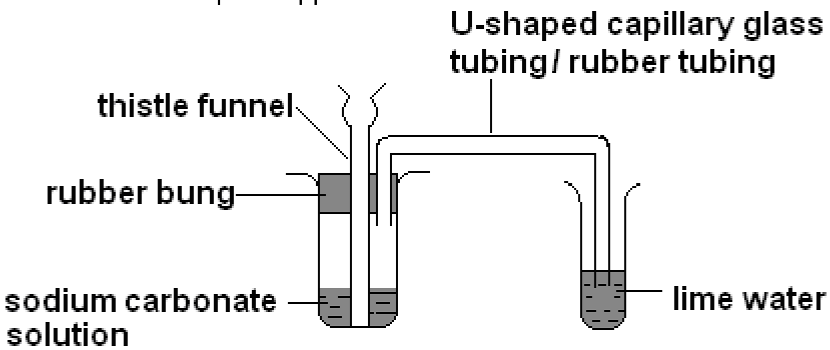
$$CuSO_4.5H_2O_{(s)} \xrightarrow{\text{conc. } H_2SO_4} CuSO_{4(s)} + 5H_2O_{(l)}$$

4 CHEMICAL REACTIONS I & II

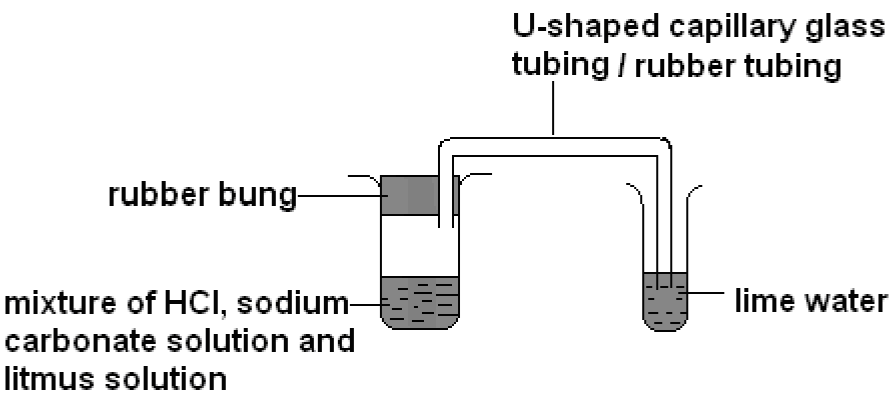
INVESTIGATING THE REACTION BETWEEN HYDROCHLORIC ACID AND SODIUM CARBONATE

Materials: U-shaped glass tubing / rubber tubing, test tubes (2), thistle funnel, lime water, saturated sodium carbonate solution, hydrochloric acid, rubber bung, litmus solution,

Procedure: a. put sodium carbonate solution in one test tube and lime water in the other
b. set up the apparatus as shown below



c. add hydrochloric acid (5ml) and 5 drops of litmus solution to the beaker containing sodium carbonate solution through the thistle funnel and carefully remove the thistle funnel. The set up will look as shown below



e. observe what happens in the test tubes and record in the table of results

TABLE OF RESULTS

TEST TUBE	OBSERVATION
With sodium carbonate solution ,HCl and litmus solution	
With lime water	

It is expected that the mixture of sodium carbonate, hydrochloric acid and litmus solution will turn from red to colourless and the lime water will turn milky.

If the mixture of sodium carbonate, hydrochloric acid and litmus solution turns from red to colourless, it means that the acid has all reacted (there is no more acid in the reaction vessel). On the other hand, if the lime water turns milky, it means one of the products of the reaction is carbon dioxide. The whole process can be represented in an equation form as follows:

$$2HCl_{(aq)} + Na_2CO_{3(aq)} \rightarrow 2NaCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$$

DETERMINING THE FORMULA OF A COMPOUND USING MASSES OF REACTIONS

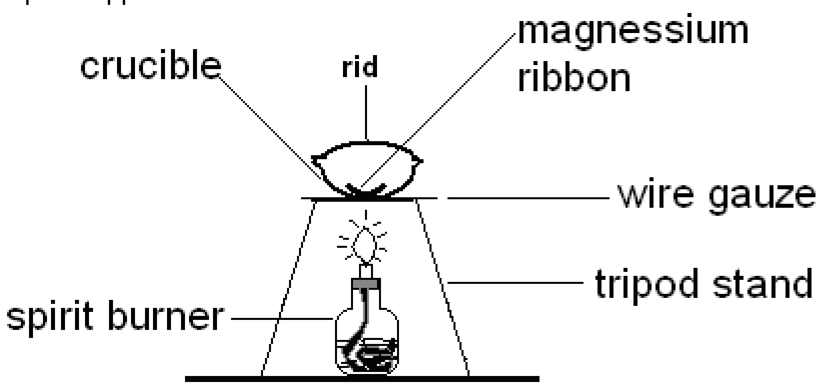
Materials: magnesium ribbon ($Mg_{(s)}$), crucible, wire gauze, tripod stand, source of heat (candle, hot plate, spirit burner, etc can do), triple beam balance.

Procedure: a. find the mass of the crucible using the triple beam balance and record in the table of results.

b. put the magnesium ribbon in the crucible and find the mass of the crucible + magnesium ribbon.

c. record in the table of results

d. set up the apparatus as shown below



e. heat the magnesium ribbon in the crucible until a white powder (magnesium oxide) forms.

f. weigh crucible + white powder (magnesium oxide) using the triple beam balance and record in the table of results.

TABLE OF RESULTS

Mass of crucible (g)	
Mass of crucible + magnesium ribbon (g)	
Mass of crucible + magnesium oxide (g)	
Mass of magnesium (g)	
Mass of oxygen which has reacted with magnesium	

What is needed first is to find the number of moles of magnesium and oxygen formed using their masses using the formula below:

Finding the number of moles:

$^{n}Mg = {}^{m}Mg / {}^{M}Mg$ and $^{n}O = {}^{m}O / {}^{M}O$ where n, m and M stand for number of moles, mass and molar mass respectively. The mass is taken from the table and the molar mass is calculated from the periodic table i.e. 24g/mol for magnesium and 16g/mol for oxygen.

The formula of the compound produced, magnesium oxide, can be found by finding the ratio of the moles and use the numbers in the ratio as subscripts.

SAMPLE RESULTS

Mass of crucible (g)	14.63
Mass of crucible + magnesium ribbon (g)	14.87
Mass of crucible + magnesium oxide (g)	15.03
Mass of magnesium (g)	0.24
Mass of oxygen which has reacted with magnesium	0.16

Assuming that the results are as shown in the table above, the formula can be found as follows:

Finding the number of moles:

${}^{n}Mg = {}^{m}Mg / {}^{M}Mg = 0.24g / 24gmol^{-1} = 0.01mol$

${}^{n}O = {}^{m}O / {}^{M}O = 0.16g / 16gmol^{-1} = 0.01mol$

${}^{n}Mg : {}^{n}O = 0.01mol : 0.01mol = 1:1$

The numbers making up the ratio are then used as subscripts of the formula as shown below

$\mathbf{Mg_1O_1}$

If the subscript is one, it is invisible; hence the formula of Magnesium oxide is **MgO**

DETERMINING THE PERCENTAGE COMPOSITION OF CARBON IN SUCROSE (COMMON SUGAR)

Materials: sugar, a tin, tripod stand, wire gauze, a gas or ethanol burner, matches and balance.

Procedure: a. weigh the empty tin and record the mass in the table below.
b. with the tin still on the balance, add sugar until the mass increases by approximately 10g.
c. record the mass of sugar in the table below.
d. heat the sugar in the tin until a dry, black solid (carbon) is formed.
e. weigh the tin + the black substance.
f. heat and reweigh several times until the mass is constant.
g. record the mass of tin + carbon in the table of results.
h. calculate the mass of carbon [(mass of tin + carbon) – mass of empty tin].
i. record mass of carbon in the table.

TABLE OF RESULTS

Item	Mass (g)
Empty tin	
Tin + Sugar	
Sugar	
Tin + Carbon	
Carbon	

To calculate the percentage composition by mass of carbon in the sugar, the formula below is used:

$$\text{\% composition of carbon} = \frac{\text{mass of carbon from the table}}{\text{mass of sugar (10g)}} \times 100\%$$

The number of moles of the carbon produced can be calculated using the formula below

$${}^{n}C = {}^{m}C / {}^{M}C$$

where n means number of moles, m means mass and M means molar mass. The mass of the carbon is taken from the table of results and molar of carbon is 12g/mol.

SAMPLE RESULTS

Item	Mass (g)
Empty tin	30

Tin + Sugar	40
Sugar	10
Tin + Carbon	34.1
Carbon	4.1

$$\text{\% composition of carbon} = \frac{\text{mass of carbon from the table}}{\text{mass of sugar (10g)}} \times 100\%$$

= (4.1g /10g) x 100%

= 42.1 %

PREPARING A SOLUTION FROM A STANDARD SOLUTION (250ml 2M NaOH solution from a 3M NaOH solution)

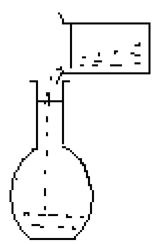
Materials: measuring cylinder (100ml), volumetric flask (250ml) with a stopper, distilled water, standard solution (3M NaOH solution), balance.

Procedure: a. find the volume of the standard solution to be diluted to give the molarity required.
i.e. use the dilution formula,

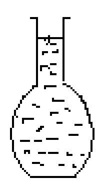
$$C_1 V_1 = C_2V_2$$
$$V_1 = C_2V_2/C_1$$
$$= (2M \times 250ml) / 3M$$
$$= 167ml$$

b. measure the volume of the standard solution found from the calculation (167ml) using the measuring cylinder.

c. transfer the 167ml solution from the cylinder into the volumetric flask.
i.e.



d. add distilled water up to the mark
i.e.



PREPARATION OF 500 CM^3 OF 0.2M SODIUM CHLORIDE SOLUTION FROM SODIUM CHLORIDE CRYSTALS

Materials: balance, sodium chloride crystals, beaker (20 cm^3), volumetric flask(250 cm^3), distilled water.

Procedure: a. calculate the mass of the sodium chloride which is going to be contained in 500 cm^3 of 0.2M sodium chloride solution by following the steps below:

- finding number of moles

$${}^{n}NaCl = {}^{c}NaCl \times {}^{v}NaCl$$

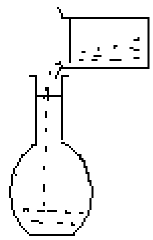
$= 0.2M \times 0.5dm^3$
$= 0.1mol$

- finding mass

$^{m}NaCl = {^{n}NaCl} \times {^{M}NaCl}$
$= 0.1mol \times 58.5gmol^{-1}$
$= 5.85g$

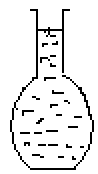
b. Weigh 5.85 g of NaCl using the balance
c. Dissolve it using a little distilled water in a small beaker
d. Transfer the solution into a 500 cm^3 volumetric flask

i.e.



e. add distilled water into the volumetric flask up to the mark

i.e.



PREPARATION OF 250 CM^3 OF 1 M COPPER SULPHATE SOLUTION FROM HYDRATED COPPER SULPHATE CRYSTALS

Materialss: balance, hydrated copper sulphate crystals, beaker (20 cm^3), volumetric flask (250 cm^3), distilled water.

Procedure: a. calculate the number of moles which is going to be contained in 250 cm^3 of 1M copper sulphate solution by following the steps below:

- find the percentage mass of $CuSO_4$ in the compound:

160/250 x 100% = 64%

- then find the mass of $CuSO_4$ needed to prepare 250 cm^3, 1M solution:

$^{n}CuSO_4 = 1\ mol/l \times 0.25 l = 0.25\ mol$

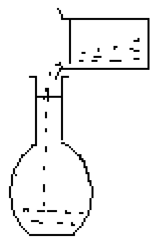
$^{m}CuSO_4 = Mn = 160g\ /mol \times 0.25\ mol = 40\ g$

- if 40g is 64% of the mass of the compound, the mass of the whole compound will be found as follows:

$$^{m}CuSO_4.5H_2O = 100/64 \times 40 \text{ g} = 62.5 \text{ g}$$

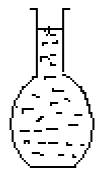
b. Weigh 62.5 g of $CuSO_4.5H_2O$ using the balance
c. Dissolve it using a little distilled water in a small beaker
d. Transfer the solution into a 250 cm^3 volumetric flask

i.e.



e. add distilled water into the volumetric flask up to the mark

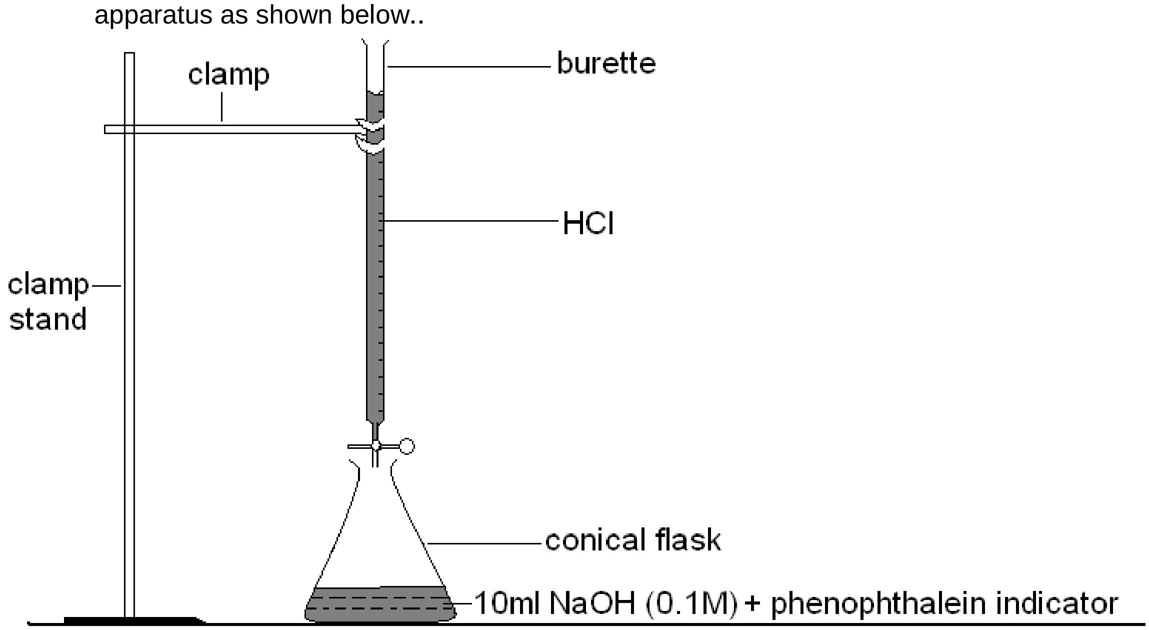
i.e.



DETERMINING THE CONCENTRATION OF HYDROCHLORIC ACID ($HCl_{(aq)}$) USING TITRATION

Materials: a burette, clamp and clamp stand, measuring cylinder, conical flask, phenolphthalein indicator, 0.1M sodium hydroxide solution (NaOH) and hydrochloric acid (HCl) of unknown concentration.

Procedure: a. Fill the burette to the mark with the hydrochloric acid (HCl)
b. Record the volume of HCl.
c. Measure 10 ml of the 0.1 M NaOH using the measuring cylinder and transfer it into the conical flask.
d. Add two drops of phenolphthalein indicator into the conical flask and set up the apparatus as shown below..



e. Add the HCl gradually, in small amounts, from the burette into the conical flask.
f. Shake the conical flask as the HCl is being added gradually
g. Stop adding the HCl when a colour change is observed in the flask (note that only one drop of the acid is responsible for the colour change).
h. determine the volume of the HCl used (titre) by subtracting the final volume of the HCl from the initial volume and record in the spaces below.

Initial volume of HCl = ________
Final volume of HCl = ________
Volume of HCl used (titre) = ________

The whole process can be represented in form of an equation as shown below:

$$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$$

The concentration of HCl can be found using the formula below:

$$\frac{C_a V_a}{n_a} = \frac{C_b V_b}{n_b}$$

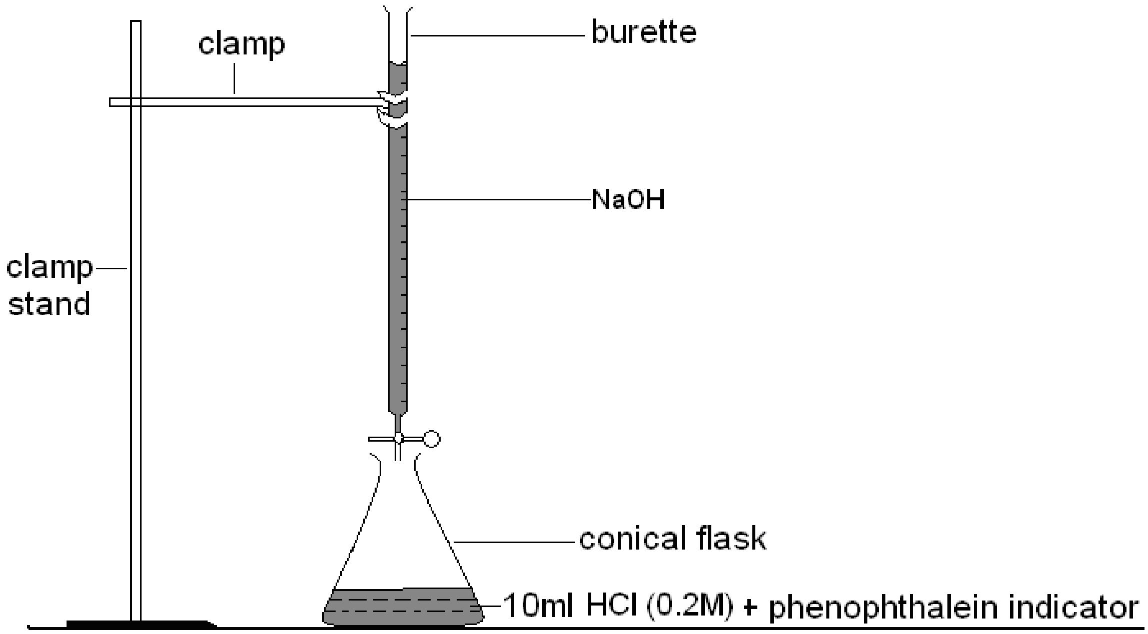
$$\longrightarrow \quad C_a = \frac{n_a C_b V_b}{n_b V_a}$$

Where (**a**) means acid and (**b**) means base and V_a is the volume of HCl used (titre), V_b is the volume of the base used, which is 10ml, C_b is the concentration of the base, which is 0.1M, and C_a is the concentration of HCl. n_a = 1and n_b =1(coeffients of HCl and NaOH in the balanced equation above respectively)

DETERMINING THE CONCENTRATION OF SODIUM HYDROXIDE ($NaOH_{(aq)}$) USING TITRATION

Materials: a burette, clamp and clamp stand, measuring cylinder, conical flask, phenolphthalein indicator, sodium hydroxide solution (NaOH) of unknown concentration and 0.2M hydrochloric acid (HCl).

Procedure: a. Fill the burette to the mark with the sodium hydroxide (NaOH)
b. Record the volume of the NaOH in the table of results.
c. Measure 10 ml of the 0.2 HCl using the measuring cylinder and transfer it into the conical flask.
d. Add two drops of phenolphthalein indicator into the conical flask and set up the apparatus as shown below..



e. Add the NaOH gradually, in small amounts, from the burette into the conical flask.
f. Shake the conical flask as the NaOH is being added gradually
g. Stop adding the NaOH when a colour change is observed in the flask (note that only one drop of the base is responsible for the colour change).
h. determine the volume of the NaOH used (titre) by subtracting the final volume of the NaOH from the initial volume and record in the spaces below.

Initial volume of NaOH = ________
Final volume of NaOH = ________
Volume of NaOH used (titre) = ________

The whole process can be represented in form of an equation as shown below:

$$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$$

The concentration of NaOH can be found using the formula below:

$$\frac{C_b V_b}{n_b} = \frac{C_a V_a}{n_a}$$

$$\longrightarrow C_b = \frac{n_b C_a V_a}{n_a V_b}$$

Where (**a**) means acid and (**b**) means base and V_a is the volume of HCl = 10ml, V_b is the volume of the base used (titre), C_a is the concentration of HCl and C_b is the concentration of the base.
n_a = 1 and n_b =1(coefficients of HCl and NaOH in the balanced equation above respectively)

INVESTIGATING ENDOTHERMIC AND EXOTHERMIC REACTIONS (I)

Materials: test tubes (2) in a rack, a measuring cylinder, stirring rod, thermometer, spatula, tap water and substances A and B.

Procedure: a. Pour 5 cm^3 of tap water into one test tube.
b. Measure the temperature of the water in the test tube and record in the table of results.

c. Add half a spatula of substance A into the test tube and stir gently using the stirring rod.
d. Measure the temperature of the solution and record it in the table of results.
e. Remove the thermometer from the test tube and rinse it with water.
f. Repeat steps (a) to (d) with substance B.
h. Rinse the thermometer with distilled water, dry and return it into its case.

TABLE OF RESULTS

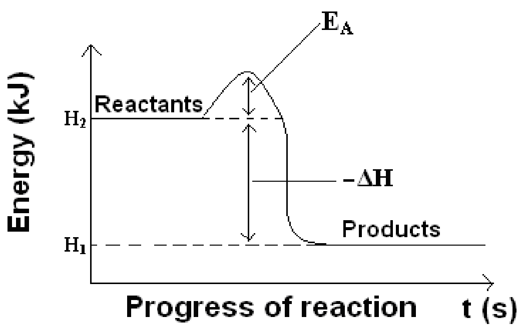
SOLUTION	INITIAL TEMPERATURE (^oC)	FINAL TEMPERATURE (^oC)	CHANGE IN TEMPERATURE (^oC) (Final – Initial)
A			
B			

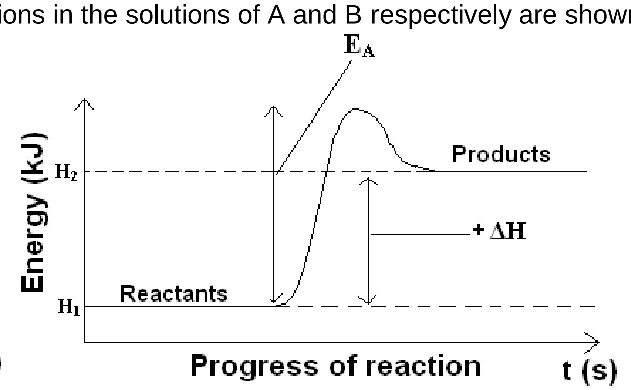
If the final temperature reached exceeds the initial temperature i.e. if the change in temperature is positive, then the reaction is exothermic (this means heat is released into the surroundings). On the other hand, if the final temperature reached is less than the initial temperature i.e. if the change in temperature is negative, then the reaction is endothermic (this means heat is absorbed from the surroundings).

For the exothermic reaction, the change in heat energy is said to be negative because there is loss of heat energy to the surroundings ($-\Delta H$). For the endothermic reaction, the change in heat energy is said to be positive because there is gain of heat energy from the surroundings ($+\Delta H$).

Note: Be careful when interpreting change in temperature and change in heat energy. Positive change in temperature($+\Delta T$) means negative change in heat energy ($-\Delta H$) and negative change in temperature ($-\Delta T$) means positive change in heat energy ($+\Delta H$).

Energy level diagrams to illustrate the reactions in the solutions of A and B respectively are shown overbleaf





When using energy profile diagrams like the ones shown above, the energy change is found by the formula: $\boldsymbol{\Delta H = H_2 - H_1}$

INVESTIGATING ENDOTHERMIC AND EXOTHERMIC REACTIONS (II)

Materials: thermometer, test tubes (2) in a rack, a piece of magnesium ribbon, potassium hydrogen carbonate or sodium hydrogen carbonate, dilute hydrochloric acid solution, spatula or tea spoon and a measuring cylinder.

Procedure: a. Pour 2 cm^3 (or 2cm column) of hydrochloric acid into a test tube.
b. Measure the temperature of the acid and record it as initial temperature in the table of results.
c. Drop the magnesium ribbon in the acid and record the changes taking place as the reaction occurs.
d. Record the final temperature reached in the table of results.
e. In the second test tube, pour 2 cm^3 (or 2cm column) of hydrochloric acid and record

its temperature as its initial temperature in the table of results.

f. Add ¼ spatula full of potassium hydrogen carbonate or sodium hydrogen carbonate to the acid and record the changes taking place as the reaction occurs.
g. record the final temperature reached in the table of results.

TABLE OF RESULTS

Liquid in the tube	Initial temperature (^{o}c)	Substance added	Final temperature reached during reaction (^{o}c)	Temperature change (^{o}c)	Other changes observed during reaction
Hydrochloric acid		Magnesium ribbon			
Hydrochloric acid		Potassium hydrogen carbonate or sodium hydrogen carbonate			

If the final temperature reached exceeds the initial temperature i.e. if the change in temperature is positive, then the reaction is exothermic (this means heat is released into the surroundings). On the other hand, if the final temperature reached is less than the initial temperature i.e. if the change in temperature is negative, then the reaction is endothermic (this means heat is absorbed from the surroundings).

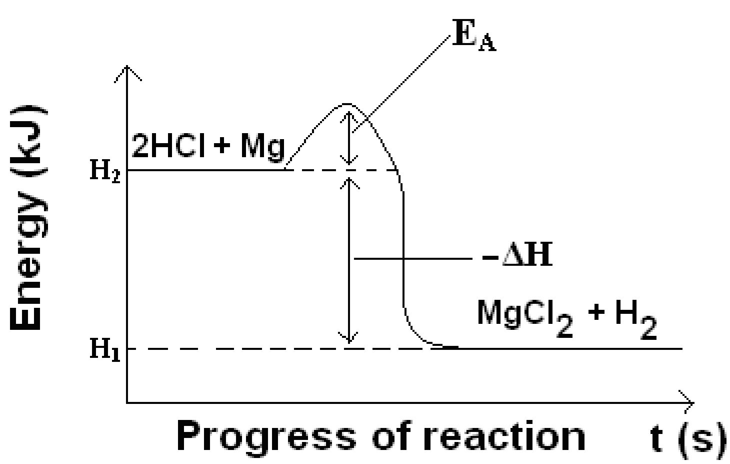
For the exothermic reaction, the change in heat energy is said to be negative because there is loss of heat energy to the surroundings ($-\Delta H$). For the endothermic reaction, the change in heat energy is said to be positive because there is gain of heat energy from the surroundings ($+\Delta H$).

Note: Be careful when interpreting change in temperature and change in heat energy. Positive change in temperature($+\Delta T$) means negative change in heat energy ($-\Delta H$) and negative change in temperature ($-\Delta T$) means positive change in heat energy ($+\Delta H$).

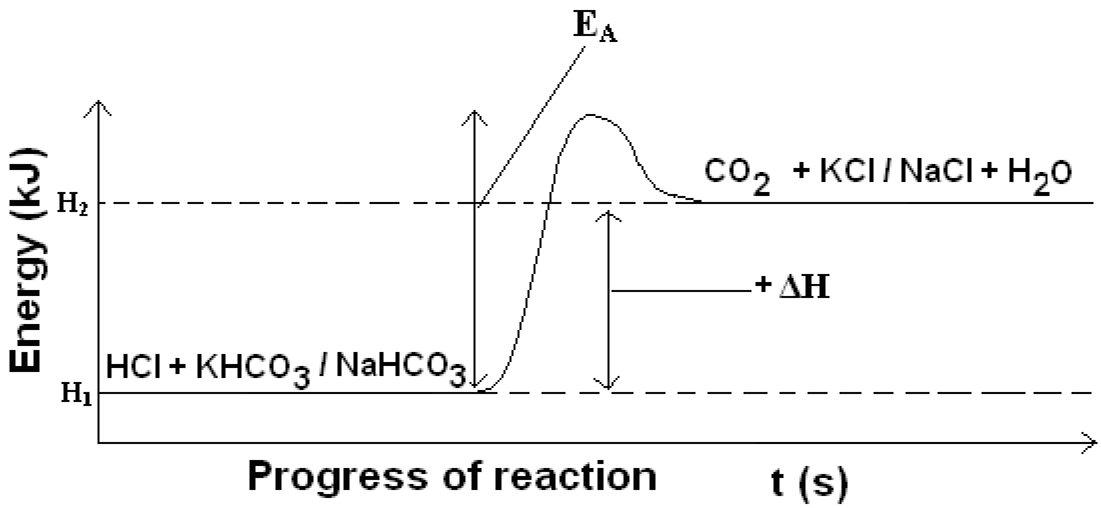
Expectedly, the reaction between hydrochloric acid and magnesium will be exothermic; and the reaction between hydrochloric acid and potassium hydrogen carbonate / sodium hydrogen carbonate will be endothermic.

Energy level diagrams to illustrate the two reactions are shown below

Reaction between hydrochloric acid and magnesium



Reaction between hydrochloric acid and potassium hydrogen carbonate / sodium hydrogen carbonate



Note: $\Delta H = H_2 - H_1$

INVESTIGATING EXOTHERMIC AND ENDOTHERMIC REACTIONS (III)

Materials: test tubes in a rack (2), measuring cylinder ($5cm^3$), thermometer, spatula/ tea spoon, sodium hydroxide pellets ($NaOH_{(s)}$), hydrochloric acid ($HCl_{(aq)}$, 1M), ammonium nitrate crystals ($NH_4NO_{3(s)}$), distilled water.

Procedure:
a. pour 5 cm^3 of distilled water into one test tube.
b. measure the temperature of the water in the test tube and record in the table of results
c. add half spatula full/quarter teaspoon (about 1g) of ammonium nitrate , NH_4NO_3, crystals and stir gently using the thermometer.
d. measure the temperature of the solution and record in the table of results
e. remove the thermometer from the test tube and rinse it with distilled water.
f. pour $5cm^3$ of the hydrochloric acid into the second test tube.
g. measure the temperature of the hydrochloric acid in the test tube and record in the table of results.
h. add one sodium hydroxide pellet into the test tube with HCl and stir gently with the thermometer.
i. measure and record the temperature of the solution and record it in the table of results.

TABLE OF RESULTS

Solution	**Initial temperature (^oc)**	**Final temperature (^oc)**	**Change in temperature (^oc)**
Ammonium nitrate + water			
Sodium hydroxide + hydrochloric acid			

If the final temperature reached exceeds the initial temperature i.e. if the change in temperature is positive, then the reaction is exothermic (this means heat is released into the surroundings). On the other hand, if the final temperature reached is less than the initial temperature i.e. if the change in temperature is negative, then the reaction is endothermic (this means heat is absorbed from the surroundings).

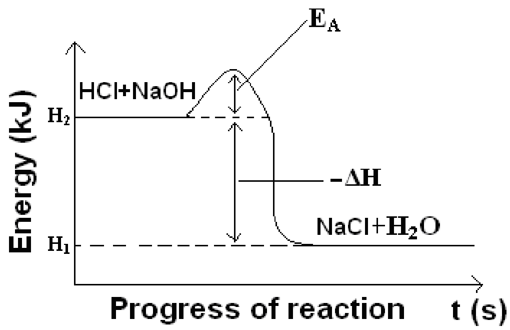
For the exothermic reaction, the change in heat energy is said to be negative because there is loss of heat energy to the surroundings (-ΔH). For the endothermic reaction, the change in heat energy is said to be positive because there is gain of heat energy from the surroundings (+ΔH).

Note: Be careful when interpreting change in temperature and change in heat energy. Positive change in temperature(+ΔT) means negative change in heat energy (-ΔH) and negative change in temperature (-ΔT) means positive change in heat energy (+ΔH).

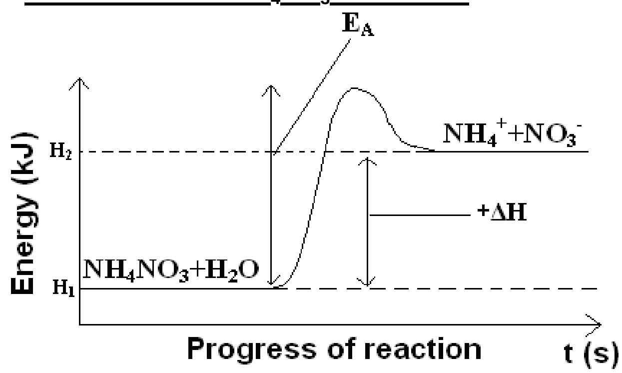
The process that takes place when ammonium nitrate and water are mixed is ionization i.e. $NH_4NO_3 + H_2O \rightarrow NH_4^+{}_{(aq)} + NO_3^-{}_{(aq)}$ and it is an endothermic process. On the other hand, the reaction between hydrochloric acid and sodium hydroxide will be exothermic.

Energy level diagrams to illustrate the two reactions are shown below

REACTION BETWEEN HCl AND NaOH



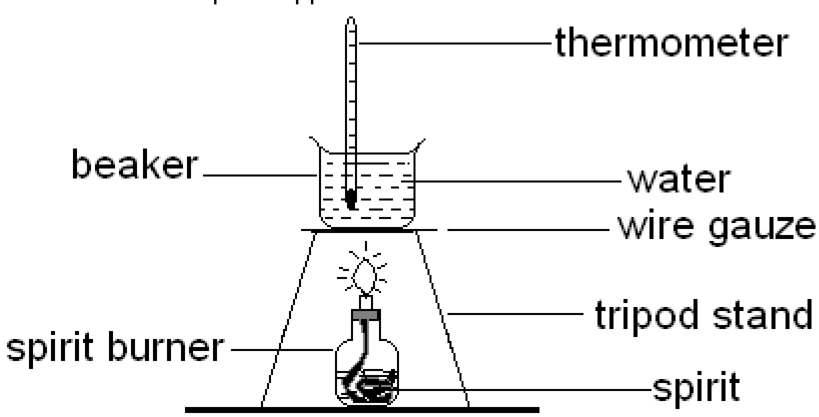
IONISATION OF NH_4NO_3 IN WATER



DETERMINING HOW MUCH HEAT A SPIRIT BURNER CAN SUPPLY

Materials: water in a pyrex beaker, tripod stand, a spirit burner, a measuring cylinder, clamp stand, thermometer, scale balance, a pyrex beaker and matches.

Procedure: a. Set up the apparatus as shown below.



b. Measure 150cm^3 of water using a measuring cylinder and put it in the pyrex beaker.
c. Measure the mass of the spirit burner and record in the space below.
d. Record the temperature of water before heating.
e. Light the lamp and heat the water for 10 minutes
f. Record the temperature of water after heating.
g. Measure and record the mass of the spirit burner

TABLE OF RESULTS

Mass of spirit burner (g)			Temperature of the water (^oC)		
Initial	Final	Change	Initial	Final	Change

d. find the amount of heat gained by the water using the formula below

Heat = specific heat capacity of water, C (J/kg^{o}c) x mass of water (kg) x change in temp. (ΔT)
= 4200 J/kg^{o}C X 0.15kg x (ΔT)

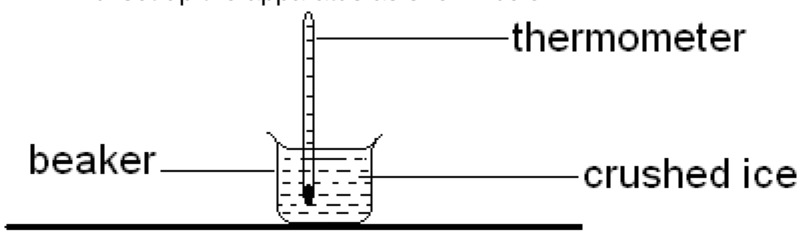
The amount of heat lost by the spirit is the same heat gained by the water i.e. the energy has just been transferred from spirit to water.

Since some of the heat energy from the spirit burner is lost into the surrounding in heating the air around and the pyrex beaker, this can be considered as a source of error. This means that not all the energy lost by the spirit is gained by the water.

INVESTIGATING HOW TEMPERATURE CHANGES WHEN ICE IS HEATED

Materials: ice blocks, beaker, thermometer, source of heat (burner or candle), glass stirrer, tripod stand.

Procedure: a. crush some ice and put it into a beaker.
b. set up the apparatus as shown below



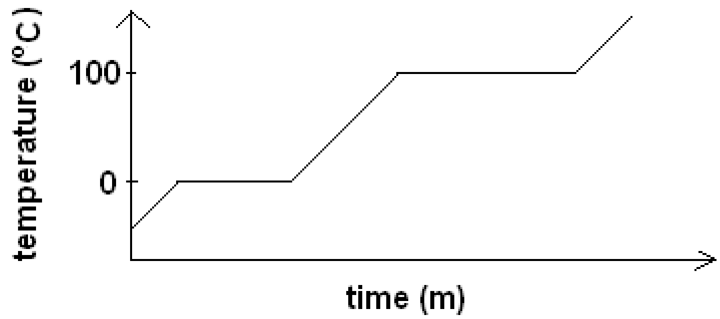
c. measure the temperature of the ice every 3 minutes for 10 times.
d. record the thermometer readings in the table of results.

TABLE OF RESULTS

TIME (MINUTES)	TEMPERATURE (^{o}C)
0	
1	
3	
6	
9	
12	
15	
18	
21	
24	
27	

e. draw a graph of temperature against time

Expected shape of the graph



The graph can help in analyzing what happens to the temperature as time goes.

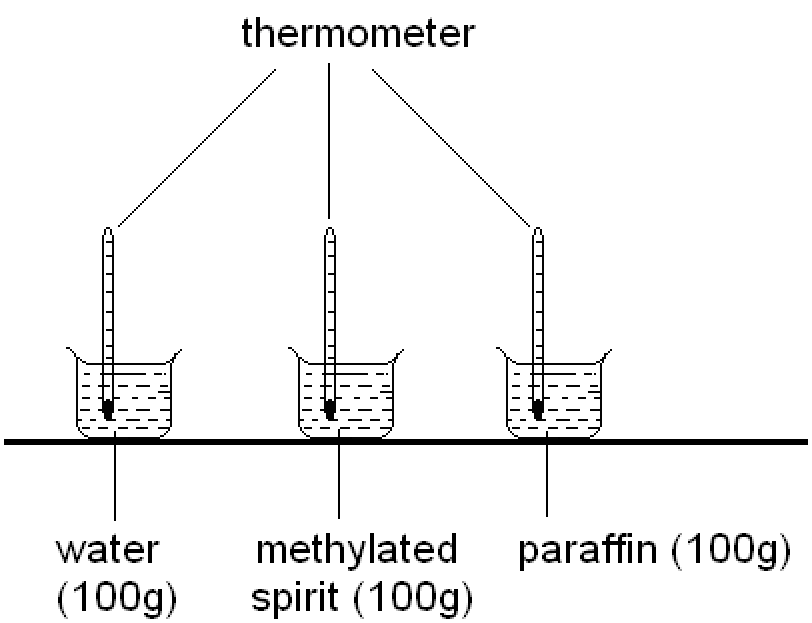
As the time goes, temperature increases. But there are some points on the graph where temperature is constant. This is so because instead of the heat raising the temperature of the substance, it is used to overcome the intermolecular forces when the phases change from solid to liquid and from liquid to gas, hence the temperature does not change.

FINDING OUT WHETHER DIFFERENT LIQUIDS HAVE DIFFERENT HEAT CAPACITIES

Materials: water, paraffin, methylated spirit, source of heat, large container, identical empty tins / identical beakers (3), matches, thermometer (3), beam balance, 2 litre tin, a large trough, stop watch, glass stirrers.

Procedure: a. weigh 100g of water, paraffin and methylated spirit in respective identical tins / beakers.

b. set up the apparatus as shown below

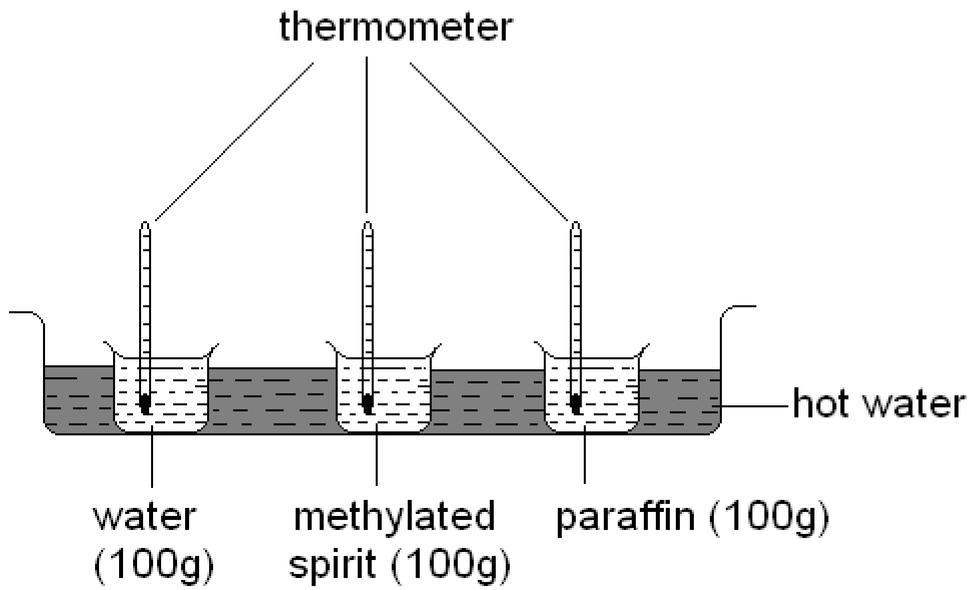


c. note the temperature readings i.e. initial temperatures (Ti) for all the liquids and record in the table of results .

d. pour 2 litres of water in a tin and heat it until it boils.

e. transfer the boiling water into a large trough.

f. place the three identical tins/beakers with their contents and the thermometers still in them in the boiling water at the same time.



g. stir the contents continuously and note the thermometer readings after 3 minutes (T_f) and record in the table of results.

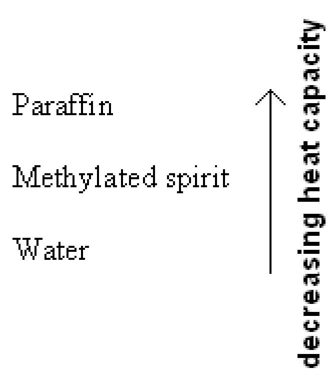
TABLE OF RESULTS

TYPE OF LIQUID	MASS OF LIQUID (g)	INITIAL TEMPERATURE(^OC)	FINAL TEMPERATURE(^OC)	TEMPERATURE CHANGE (ΔT) (^OC)
Water				
Paraffin				
Methylated spirit				

h. compare the temperature rises

Expectedly, the temperature rises for the different liquids will be different. The one which has the highest rise in temperature requires less heat for its temperature to rise i.e. it has low heat capacity, and the one which has the least rise in temperature requires more heat for its temperature to rise the same way as the other one has i.e. it has high heat capacity.

In the experiment, temperature for paraffin will rise more than that of methylated spirit, and temperature for methylated spirit will rise more than that of water. Therefore, the order of heat capacity is as shown below:



Therefore, different liquids have different heat capacities.

DETERMINING THE REACTIVITY SERIES OF METALS USING DISPACEMENT REACTIONS

Materials: beakers (4), distilled water , a measuring cylinder, sand paper, solutions of copper sulphate, zinc sulphate, iron sulphate and magnesium sulphate, pieces of copper , zinc, iron and magnesium metal.

Procedure:
a. Pour about 2 cm^3 of copper sulphate solution into each of the four beakers.
b. Clean the copper, zinc, iron and magnesium metals using sand paper.
c. Put a piece of each metal into each of the four beakers containing copper sulphate solution.
d. Observe the contents of the beakers for 2 to 3 minutes.
e. Record the results in the table below by indicating "Reaction" or "No reaction".
f. Rinse the beakers with distilled water.
g. Repeat steps (a) to (f) using solutions of zinc sulphate, iron sulphate and magnesium sulphate, respectively.

TABLE OF RESULTS

metal / solutions	copper	zinc	iron	magnessium
copper sulphate				
zinc sulphate				
iron sulphate				
magnessium sulphate				

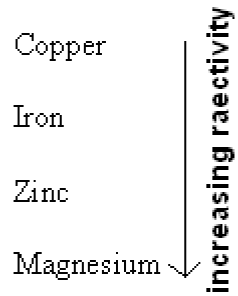
Expectedly, the results will be as follows

metal / solutions	copper	zinc	iron	magnessium
copper sulphate		reaction	reaction	reaction
zinc sulphate	no reaction		no reaction	reaction
iron sulphate	no reaction	reaction		reaction
magnessium sulphate	no reaction	no reaction	no reaction	

Where it is marked reaction, it means the metal has been displaced from solution and is less reactive than the metal which has displaced it. In this case, copper has been displaced by 3 metals, iron has been displaced by 2 metals, zinc has been displaced by 1 metal only and magnesium has not been displaced by any of the metals. It follows, therefore, that copper is the least reactive and magnesium is the most reactive. The metals can be arranged in the order of increasing reactivity as shown over leaf.

Copper, Iron, Zinc, Magnesium

i.e.



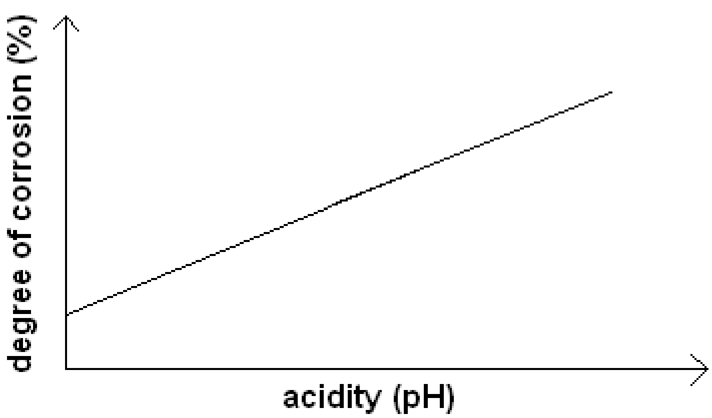
INVESTIGATING THE EFFECT OF ACIDITY ON PERCENTAGE CORROSION OF IRON

Materials: test tubes (7), $HCl_{(aq)}$ of pH from 1 to 7, iron nails (7).

Procedure: a. label the test tubes 1 to 7
b. put the $HCl_{(aq)}$ of different pHs in respective test tubes.
c. put the iron nails in all the test tubes
d. leave the test tubes at a safe place for a week.
e. observe the degree of corrosion / rusting of the iron nails and arrange the test tubes in order of decreasing corrosion of the iron nail.

Expectedly, the degree of corrosion will decrease as the pH increases from 1 to 7. But the increase in pH is a decrease in acidity; hence the degree of corrosion is directly proportional to acidity i.e. the iron nail will corrode / rust more if the solution in which it is put is more acidic.

The relationship can be clearly illustrated if a graph as shown below is used



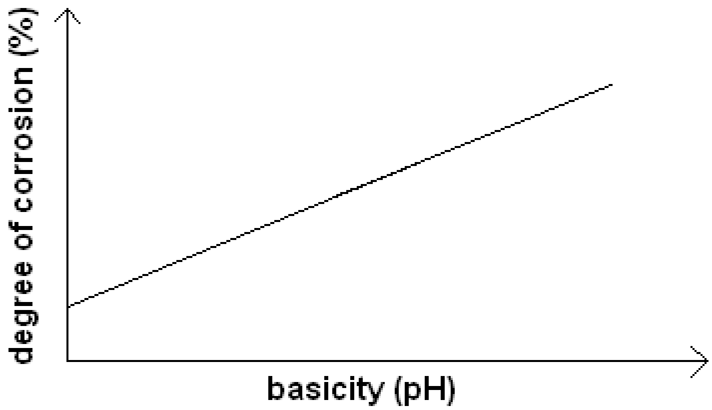
INVESTIGATING THE EFFECT OF BASICITY ON PERCENTAGE CORROSION OF IRON

Materials: test tubes (7), $NaOH_{(aq)}$ of pH from 8 to 14, iron nails (7).

Procedure: a. label the test tubes 8 to 14
b. put the $NaOH_{(aq)}$ of different pHs in respective test tubes.
c. put the iron nails in all the test tubes
d. leave the test tubes at a safe place for a week.
e. observe the degree of corrosion / rusting of the iron nails and arrange the test tubes in order of decreasing corrosion of the iron nail.

Expectedly, the degree of corrosion will increase as the pH increases from 8 to 14. But the increase in pH is also an increase in basicity; hence the degree of corrosion is directly proportional to basicity i.e. the iron nail will corrode / rust more if the solution in which it is put is more basic.

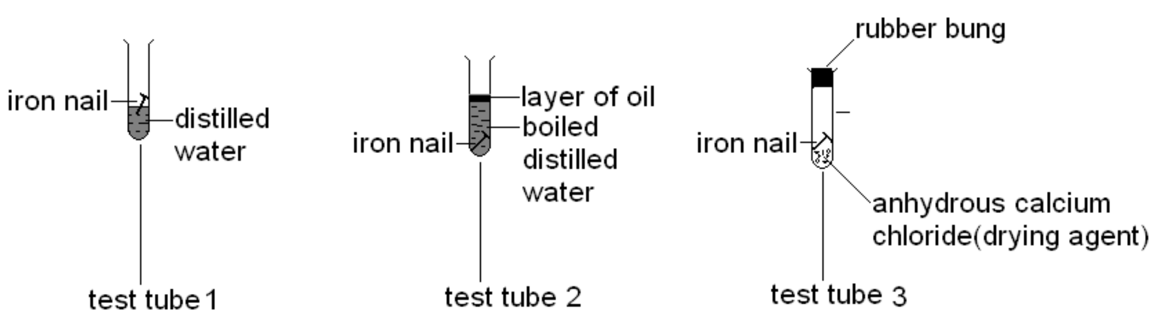
The relationship can be clearly illustrated if a graph as shown below is used



INVESTIGATING THE CONDITIONS OF RUSTING

Materials: iron nails (3), test tubes (3), distilled water, boiled but cooled water, distilled water, anhydrous calcium chloride, cotton wool, oil, glass wool, rubber bung

Procedure: a. set up the apparatus as shown below



b. leave the set up for 2 weeks
c. observe what happens to the iron nail after the 2 weeks
d. record your observations by writing ‘rusting’ or ‘no rusting’ in the appropriate space in the table of results.

TABLE OF RESULTS

Test tube	Observation
1	
2	
3	

The test tube in which there is rusting consists of the necessary conditions of rusting.

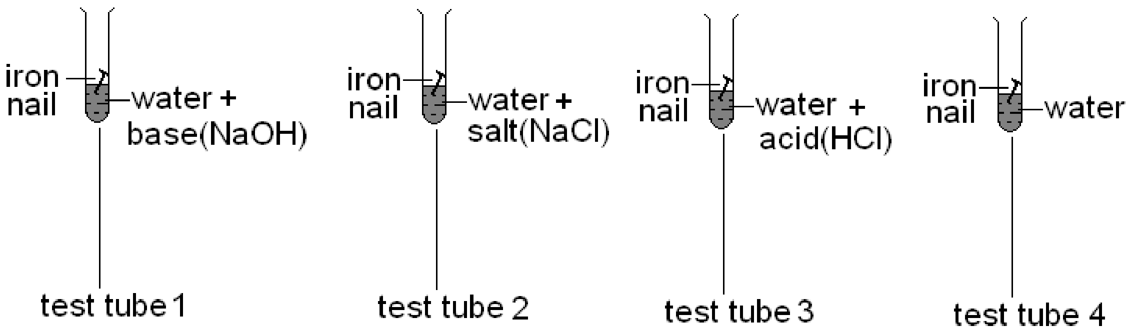
Expectedly, there will be rusting in test tube 1 and no rusting in test tubes 2 and 3. In test tube 1, there is both oxygen (from the air) and water but in test tube 2, there is no oxygen and in test tube 3, there is no water.

Hence the necessary conditions for rusting are oxygen and water.

INVESTIGATING THE FACTORS THAT AFFECT RUSTING

Materials: test tubes (4), iron nails (4), dilute sodium hydroxide, dilute hydrochloric acid, dilute sodium chloride solution and water.

Procedure: a. set up the apparatus as shown below



b. leave the set ups for 2 weeks
c. observe what happens to the iron nails
d. record your observations in the table of results by writing 'more rusting' if the degree of rusting exceeds that of test tube 4 and 'less rusting' if the degree of rusting is less than that of test tube 4.

TABLE OF RESULTS

Test tube	Contents	Observation
1	Water + air + base (sodium hydroxide)	
2	Water + air + salt (sodium chloride)	
3	Water + air + acid (hydrochloric acid)	

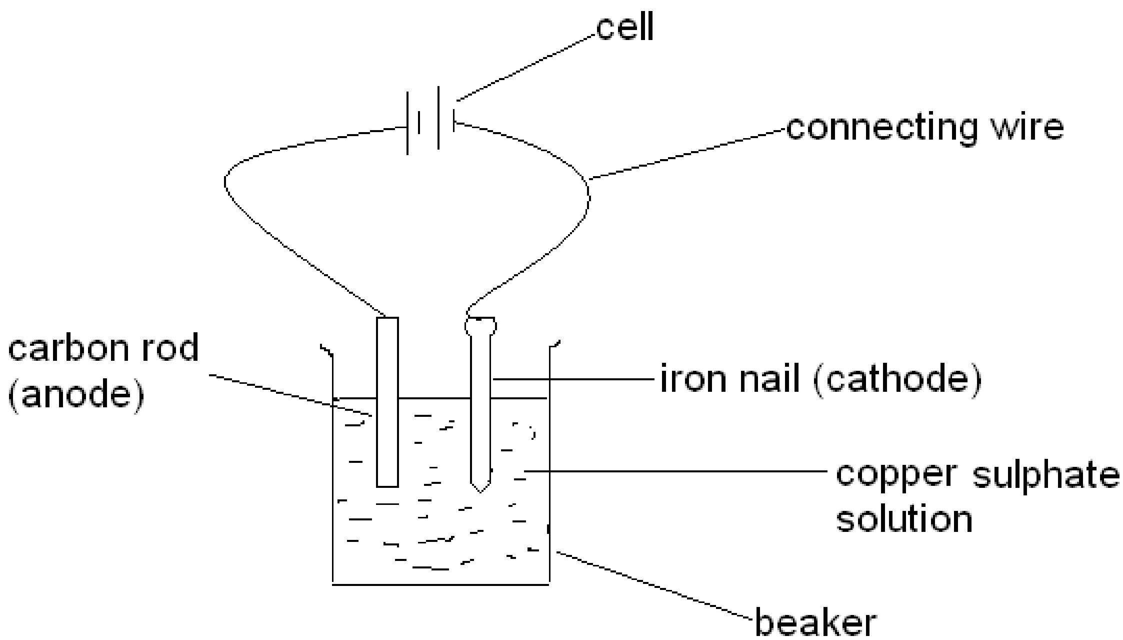
In test tube 1, there will be normal rusting. If there is more or less rusting in the other test tubes, it means the additional substances in the test tubes i.e. acid, base and salt affect rusting.

Expectedly, there will be more rusting in the other test tubes; hence acids, bases and salts affect rusting.

ELECTROPLATING A NAIL WITH COPPER

Materials: nail, beaker (150ml), copper electrode, cells (4), switch, torch bulb in a holder, support for electrodes, copper sulphate solution

Procedure: a. set up the apparatus as shown below:



b. close the switch; allow the current to flow for about 10 minutes.
c. open the switch and remove the nail.
d. observe the colour of the nail. Is it similar to copper?

The colour of the nail will change to that of copper (reddish-brown) showing that copper has been deposited on it. Therefore the iron nail has been electroplated with iron and the process can be represented as shown below

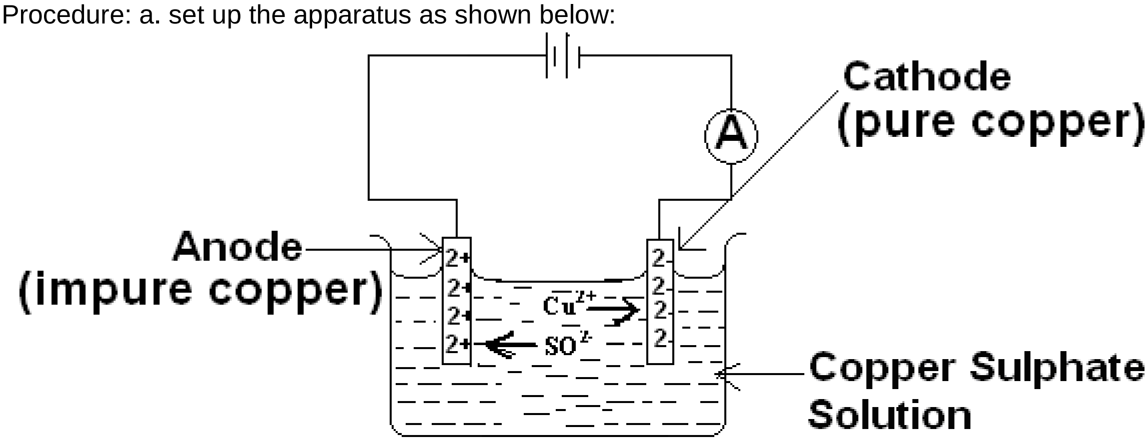
At the cathode: $2Cu^{2+}_{(aq)} + 4e^- \rightarrow 2Cu_{(s)}$ (reduction)

At the anode : $2H_2O_{(l)} \rightarrow O_{2(g)} + 4H^+_{(aq)} + 4e^-$ (the electrons are given off the anode into the wire)

PURIFYING COPPER USING ELECTROLYSIS

Materials: impure copper electrode, pure copper electrode, support for electrodes, cells (2), switch, an ammeter, copper sulphate solution

Procedure: a. set up the apparatus as shown below:



b. close the switch; allow the current to flow for about 10 minutes.

c. open the switch and remove the electrodes
d. observe the colour of the deposit on the pure copper electrode and what has happened to the impure copper electrode

During the process, the impure copper electrode loses mass because the copper atoms lose electrons and become copper ions, $Cu^{2+}_{(aq)}$, which go into the solution.

The electrons lost by the impure copper electrode travel around the external circuit to the cathode. At the cathode, the electrons attract the positively charged copper ions, $Cu^{2+}_{(aq)}$ from the copper sulphate solution and copper metal, $Cu_{(s)}$ atoms are formed. This copper solid is then deposited or copper plated on to the cathode (the pure copper). The process is known as purification of copper because the cathode is now all copper.

The processes happening at the anode and cathode can be summarized and represented in form of half equations as shown below

At the anode : $2Cu_{(s)} \rightarrow Cu^{2+}_{(aq)} + 4e^{-}$ (oxidation)

At the cathode: $2Cu^{2+}_{(aq)} + 4e^{-} \rightarrow 2Cu_{(s)}$ (reduction)

IDENTIFYING ACIDS AND BASES USING UNIVERSAL INDICATOR

Materials: universal indicator, test tubes (3), solutions A, B and C

Procedure: a. put 2ml of liquid X in one test tube
b. add 4 drops of universal indicator in the test tube in which liquid X has been put
c. obverse the colour change and record in the table of results
d. repeat steps (a) to (c) for the solutions Y and Z

TABLE OF RESULTS

SOLUTION	OBSERVATION (COLOUR)	ACID / BASE
X		
Y		
Z		

The solution is acidic if the colour changes to either red, orange or yellow; the solution is basic if the colour changes to either blue, violet or purple and the solution is neutral if the colour changes to green.

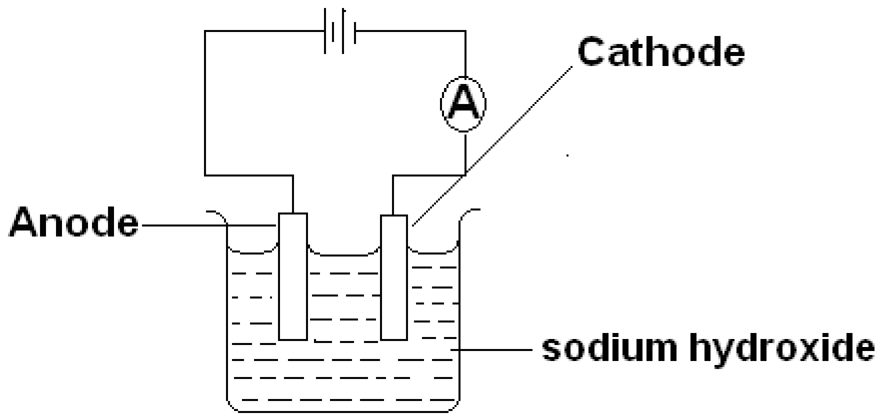
To determine the strength of the acid or base, a pH scale is used. The colour of the solution is matched against the colour on the scale. The scale is shown below

Colour of universal indicator	Red	orange	Light orange	yellow	green	Green blue	Light blue	Dark blue	Violet	Purple
Ph	0- 2	3-4	5	6	7	8	9	10	11-12	13-14

INVESTIGATING THE STRENGTH OF BASES USING CONDUCTIVITY

Materials: ammeter, beaker (100ml), carbon electrodes and support, connecting wires (4), switch, distilled water in a separate beaker, cells(4) in a holder, sodium hydroxide solution(1M), sodium carbonate solution, (1M), ammonium hydroxide solution(1M), potassium hydroxide solution(), calcium hydroxide solution(1M), barium hydroxide(1M)

Procedure: a. fill the beaker with sodium hydroxide acid and set up the apparatus as shown below:



b. close the switch and note the ammeter reading. Record the observation/results in the appropriate space in the table of results
c. pour out the sodium hydroxide and rinse the beaker and the electrodes with distilled water.
d. repeat steps (a) and (b) with each of the other bases to complete the table below.

Remember to rinse the beaker and electrodes with distilled water every time you change the test solution.

TABLE OF RESULTS

Name of base	Ammeter reading (A)
Sodium hydroxide	
Sodium carbonate	
Ammonium hydroxide	
Calcium hydroxide	
Barium hydroxide	
Potassium hydroxide	

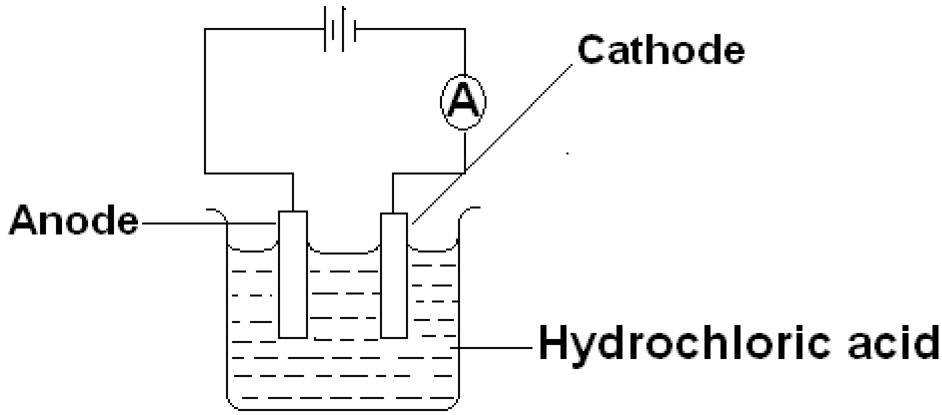
e. compare the ammeter readings for the bases and draw up a list of strength of the bases starting with the strongest.

The base with the highest ammeter reading is the strongest base and the one with the lowest ammeter reading is the weakest base. An arrangement in order of increasing strength of basicity can then be produced.

INVESTIGATING THE STRENGTH OF ACIDS USING CONDUCTIVITY

Materials: ammeter, beaker (100ml), carbon electrodes and support, connecting wires (4), switch, distilled water in a separate beaker, cells(4) in a holder, hydrochloric acid (1M), sulphuric acid(1M), acetic acid(1M), citric acid(1M), nitric acid(1M), potassium hydrogen sulphate (1M)

Procedure: a. fill the beaker with hydrochloric acid and set up the apparatus as shown below:



b. close the switch and note the ammeter reading. Record the observation/results in the appropriate space in the table of results

c. pour out the hydrochloric acid and rinse the beaker and the electrodes with distilled water.

d. repeat steps (a) and (b) with each of the other acids to complete the table below.

Remember to rinse the beaker and electrodes with distilled water every time you change the test solution.

TABLE OF RESULTS

Name of acid	Ammeter reading (A)
Hydrochloric acid	
Sulphuric acid	
Acetic acid	
Nitric acid	
Potassium hydrogen sulphate	
Citric acid	

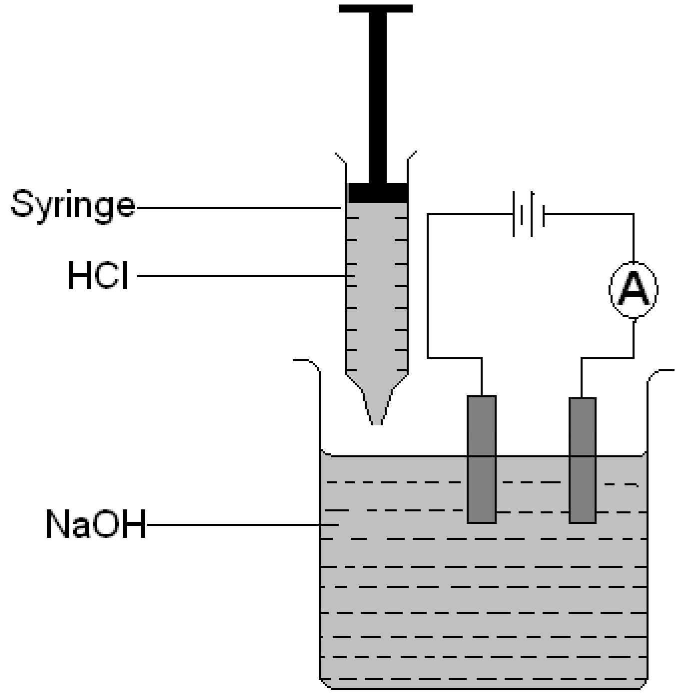
e. compare the ammeter readings for the acids and draw up a list of acid strength, starting with the strongest.

The acid with the highest ammeter reading is the strongest acid and the one with the lowest ammeter reading is the weakest acid. An arrangement in order of increasing strength of acidity can then be produced.

INVESTIGATING THE EFFECT OF ACIDITY AND BASICITY ON ELECTRIC CURRENT

Materials: $HCl_{(aq)}$, $NaOH_{(aq)}$(10ml), connecting wires (3), beaker, power source, carbon, electrodes (2), syringe, phenolphthalein indicator and ammeter.

Prcedure: a. connect the circuit as shown in the figure below:

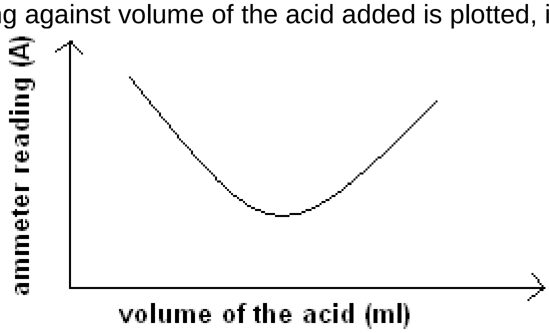


b. read and record the ammeter reading in the appropriate space in the table of results
c. add $HCl_{(aq)}$ (2ml) in the beaker using the syringe
d. read and record the ammeter reading in the appropriate space in the table of results
e. repeat steps (c) and (d) for 3 times

TABLE OF RESULTS

Volume of $HCl_{(aq)}$ added (ml)	Ammeter Reading (mA)
0	
2	
4	
6	
8	

When the volume of the acid is at 0ml, it means there are only sodium hydroxide ions in the beaker, hence there will be high conductivity (there will be high concentration of the ions responsible for conductivity). As the acid is added little by little, the base (sodium hydroxide) is neutralized hence the ions will be decreasing in concentration and this makes the conductivity to decrease until a point is reached when all the base has been neutralized, This is the point where there will be minimum conductivity. If the acid is still being added, there will be an excess of the ions from the acid and conductivity will start increasing again. If a graph of the ammeter reading against volume of the acid added is plotted, it will have the shape as shown below

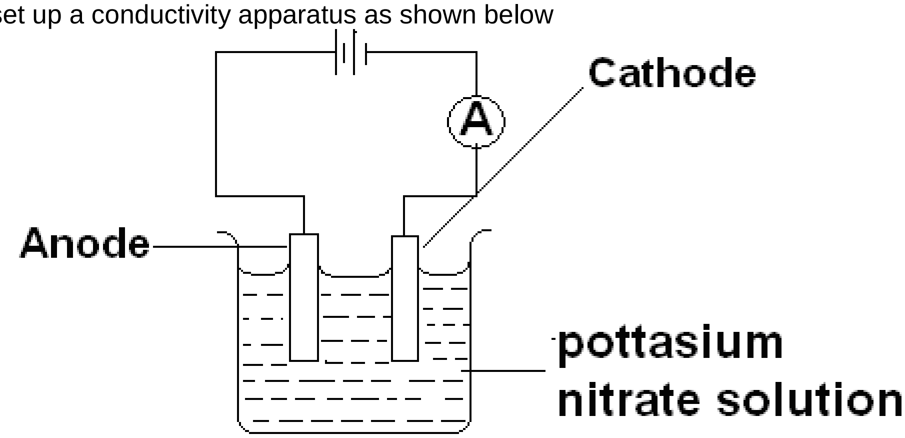


The minimum point of this graph (where there is minimum conduction) is the neutralization point. According to the graph, there is still conduction of electric current. Do you have any idea why this is happening? This is so because one of the products of neutralization, salt (NaCl) is in ionic form, so it is the sodium chloride ions which conduct at this point.

COMPARING THE CONDUCTIVITY OF POTASSIUM NITRATE AND POTASSIUM CHLORIDE

Materials: measuring cylinder (50ml), stirrer, beakers (2) (100ml), carbon rods (2), potassium nitrate crystals, potassium chloride crystals, cells (2) in a holder, connection wires (3), ammeter.

Procedure: a. measure 20g of potassium nitrate crystals in a beaker using a beam balance
b. dissolve the solid using 50ml of distilled water.
c. set up a conductivity apparatus as shown below



d. record the reading of the ammeter in the table of results.
e. rinse the beaker and the electrodes with distilled water followed by potassium chloride solution.
e. repeat steps (a) to (d) with potassium chloride.

TABLE OF RESULTS

Solution	Ammeter
Potassium nitrate solution	
Potassium chloride solution	

The solution whose ammeter reading is higher has higher conductivity than the other.

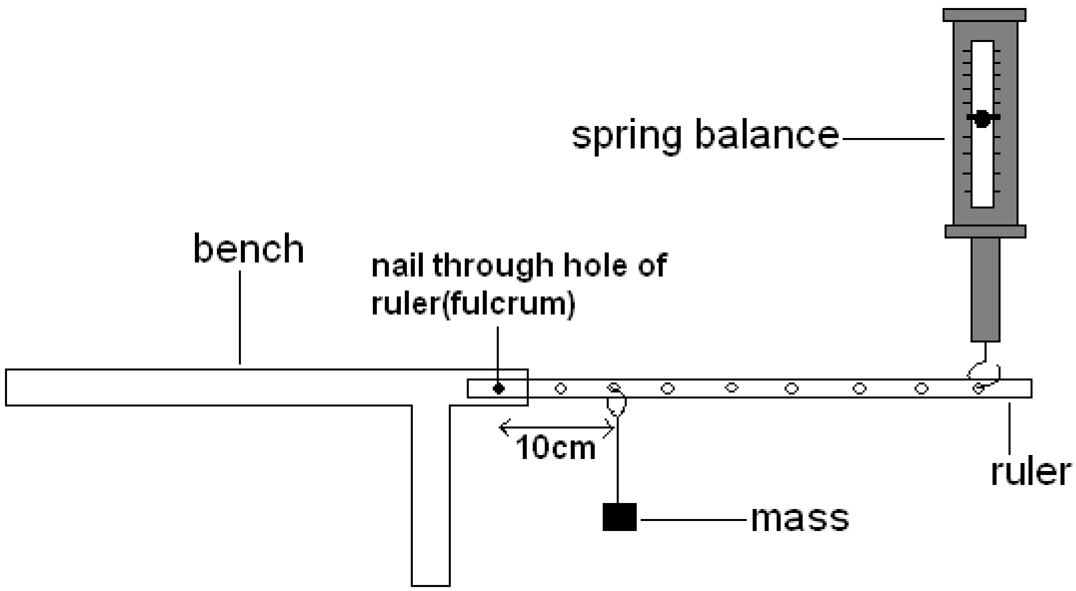
In this experiment, potassium chloride solution will register a higher reading than potassium nitrate solution. This is so because there will be more ionization in potassium chloride solution than in potassium nitrate solution. Chlorides are weaker Lowry-Bronsted bases hence they adhere less strongly to the potassium cation hence more ionization. On the other hand, nitrates are relatively stronger Lowry-Bronsted bases hence they adhere relatively more strongly to the potassium cation than does the chlorides hence less ionization.

5 FORCES AND MOTION

INVESTIGATING THE EFFECT OF THE DISTANCE OF LOAD FROM FULCRUM (LOAD ARM) ON EFFORT APPLIED.

Materials: a spring balance, 500g mass, a metre rule, a nail and a G-clamp.

Procedure : a. set up the apparatus as shown below.



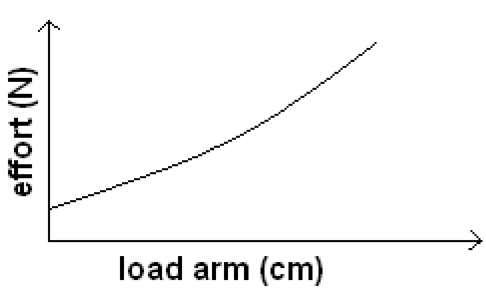
b. hook the mass 10 cm away from the fulcrum and note the reading on the spring balance.
c. record the mass and the spring balance reading in the table of results
d. change the positions of the mass as indicated in the table results and record the readings on the spring balance in the spaces in the table.

TABLE OF RESULTS

Distance of the load from the fulcrum (cm)	Effort (the reading of the spring balance (N))
10	
20	
30	
40	

If the effort changes as the distance of the load from the fulcrum (load arm) is changed, it means distance of load from fulcrum has an effect on the effort applied. In fact, the effort increases as the load arm increases. To visualize the relationship clearly, a graph of load arm against effort can be drawn.

The graph will have the shape as shown below

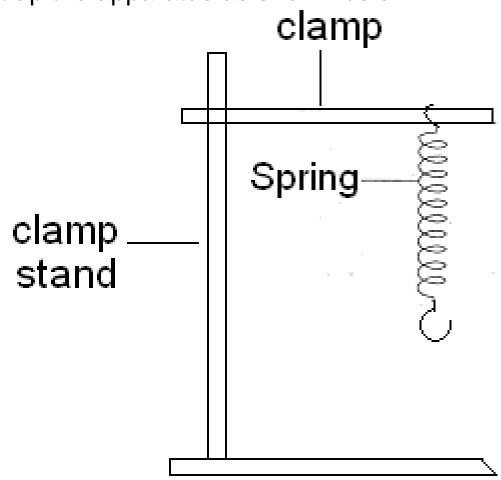


The graph is shaped the way it is because the effort increases more than load arm does.

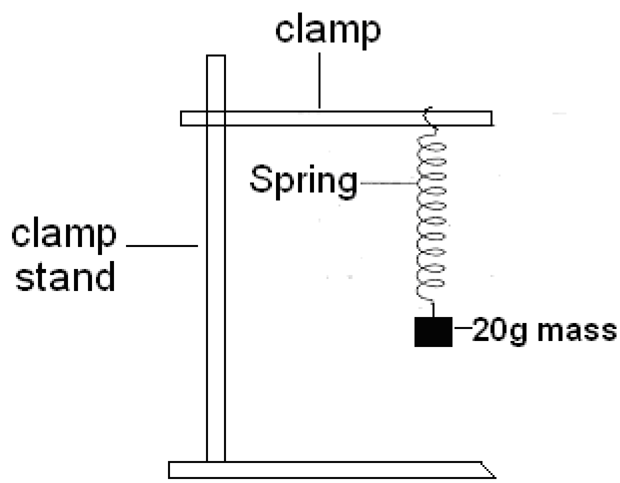
INVESTIGATING HOOK'S LAW

Materials :spiral spring, clamp, clamp stand, ruler (30cm), masses (20g, 40g, 60g,80g and 100g)

Procedure: a. set up the apparatus as shown below



b. measure the length of the spring in cm and record the measurement in the table of results
c. hang a 20g mass at the end of the spiral spring as shown below



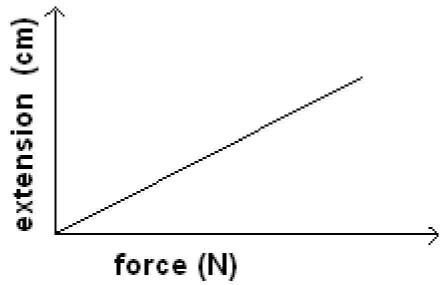
d. measure the length of the spiral spring again and record in the table of results
e. find the extension of the spring by subtracting the length of the spring in (d) and the length of the spring in (b)
f. repeat steps (c) to (e) with masses 40g, 60g, 80g and 100g

TABLE OF RESULTS

MASS (g)	EXTENSION (cm)
20	
40	
60	
80	
100	

If the extension changes as the mass is changed, it means mass has an effect on extension.

Expectedly, the extension will increase as the mass is increased. Since as mass increases, force (weight) also increases, it can be concluded that extension increases as force (weight) is increased i.e. extension is directly proportional to force. This is known as Hook's Law. A graph of extension against force can be drawn as shown below to clearly illustrate the relationship



The graph can also help in determining the spring constant of the spring i.e. the spring constant of the spring is the reciprocal of the slope of the graph.

Slope of the graph = extension(cm or m) / force(N)

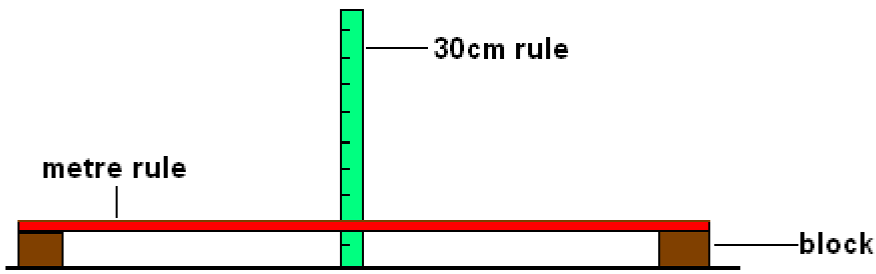
Spring constant = force(N) / extension(cm or m)

The graph can also help in finding the force, and hence the mass, which can be used to bring about a certain extension of the spring by finding the point on the graph which is the desired extension and tracing the equivalent point on the force axis.

INVESTIGATING THE EFFECT OF MASS ON DEPRESSION

Materials: metre rule (1), blocks (2), 30cm rule (1), masses (100g, 150g, 200g and 250g)

Procedure: a. set up the apparatus as shown below

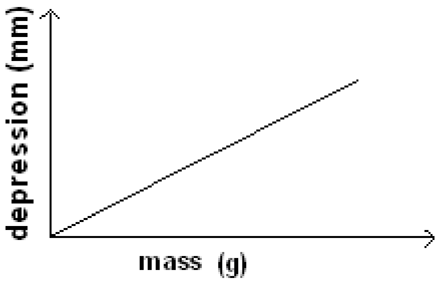


b. put a 250g mass on the 50 cm mark of the metre rule
c. read and record the reading on the 30cm rule in the table of results
d. repeat steps (b) and (c) for masses, 200g, 150g and 100g
e. calculate the depressions for each mass and complete the table of results

TABLE OF RESULTS

Mass (g)	Reading on the 30cm rule (mm)	Depression Final reading - initial reading
250		
200		
150		
100		

It is expected that the depression will be decreasing as the mass is being decreased i.e. depression is directly proportional to the mass. To visualize the relationship clearly, a graph of depression against mass can be drawn and it will look as the one below



DETERMINING THE AVERAGE SPEED OF AN ATHLETE

Materials: Tape measure, whistle, stopwatch, the athlete

Procedure: a. determine the distance to be covered by the athlete using the tape measure.
b. blow the whistle for the athlete to start running and at the same time start the stopwatch
c. blow the whistle and stop the stopwatch when the athlete reaches the end of the distance
d. find the speed of the athlete by dividing the distance (m) covered and the time(s) taken for the athlete to cover the distance.

6 ORGANIC CHEMISTRY

DISTINGUISHING AN ALKANE FROM AN ALKENE USING BROMINE TEST

Materials: liquids A and B in separate beakers (one is octane and the other one is octene but not necessarily in that order) and bromine in a dropper bottle.

Procedure: a. add a few drops of bromine in the beaker containing liquid A, observe what happens and record in the table of results.
b. add a few drops of bromine in the beaker containing liquid B, observe what happens and record in the table of results.

TABLE OF RESULTS

MIXTURE	COLOUR
Liquid A + bromine	
Liquid B + bromine	

The mixture that remains brown (the colour of bromine) contains octane and the one which turns colourless contains octene. This is so because octene reacts with bromine to form dibromooctane which is colourless while octane does not react with bromine so the bromine (brown in colour) remains in solution.

DISTINGUISHING ALKANE FROM ALKANOL USING SODIUM TEST

Materials: liquids A and B (one is pentane and the other one is ethanol), small pieces of sodium metal (2), glass dish

Procedure: a. pour a little of liquid A in a glass dish
b. drop a piece of sodium metal into the glass dish
c. observe what happens and record in the table of results by writing ‘reaction’ or ‘no reaction’ where appropriate in the table.
d. repeat steps (a) to (c) for liquid B.

TABLE OF RESULTS

LIQUID	SODIUM (Na)
A	
B	

If the liquid reacts with sodium, it means the substance is ethanol, and if it does not react with sodium, the substance is pentane. This is so because alkanols react with metals
i.e. $C_2H_5OH + Na \rightarrow C_2H_5ONa + H_2$, while alkanes do not react with metals.

DISTINGUISHING ALKANE FROM ALKANOL USING SOLUBILITY TEST

Materials: distilled water, liquids A and B (one is ethanol and the other one is pentane but not necessarily in that order), test tubes (2)

Procedure: a. pour 5ml of liquid A in one test tube
b. add 5ml of distilled water to the test tube, shake and let the mixture settle
c. observe what happens and record in the table of results by writing the number of layers formed.
d. repeat steps (a) to (c) for liquid B

TABLE OF RESULTS

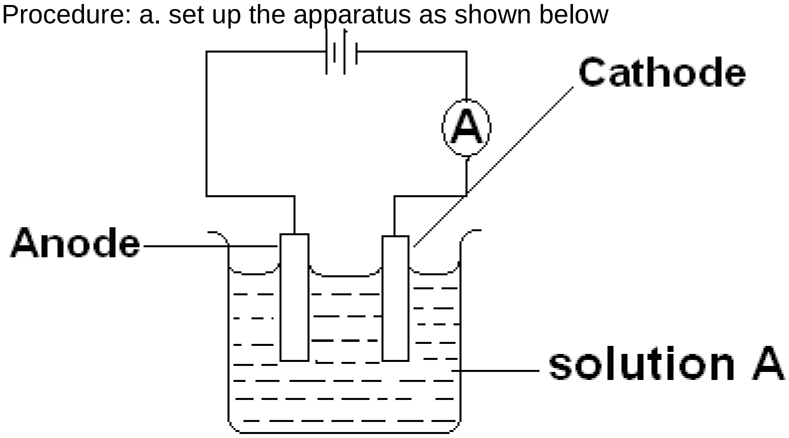
MIXTURE	LAYERS
Water + liquid A	
Water + liquid B	

If the liquid is soluble in water i.e. one layer forms after mixing the liquid with water, it means the liquid is ethanol, and if the liquid is insoluble in water, it means the liquid is pentane. This is so because alkanols are soluble in water since they are polar like water, while alkanes are insoluble in water since they are not polar unlike water.

DISTINGUISHING ALKANE FROM CARBOXYLIC ACID USING CONDUCTIVITY

Materials: connecting wires (3), carbon rods (2), beaker, liquids A and B (one is ethane and the other one is ethanoic acid but not necessarily in that order), cells (2) in a cell holder, ammeter

Procedure: a. set up the apparatus as shown below



b. note the ammeter reading and record in the table of results.
c. repeat steps (a) and (b) with liquid B

note: remember to clean up the carbon rods and the beaker with distilled water followed by liquid B after you are through with liquid A to avoid conduction errors due to contamination.

TABLE OF RESULTS

LIQUID	AMMETER READING (A)
Liquid A	
Liquid B	

If the liquid conducts i.e. the ammeter registers a reading, then it is ethanoic acid. If it does not conduct , it is ethane. The results are expected to be so because conduction in liquids is accomplished through ions only and in this case, it is the acid which can ionize to release the ions which can conduct. The ethane does not ionize to release ions for conduction.

DISTINGUISHING ALKANE FROM CARBOXYLIC ACID USING SOLUBILITY TEST

Materials: distilled water, liquids A and B (one is ethanoic acid and the other one is pentane but not necessarily in that order), test tubes (2)

Procedure: a. pour 5ml of liquid A in one test tube
b. add 5ml of distilled water to the test tube, shake and let the mixture settle
c. observe what happens and record in the table of results by writing the number of layers formed.
d. repeat steps (a) to (c) for liquid B

TABLE OF RESULTS

MIXTURE	LAYERS
Water + liquid A	
Water + liquid B	

If the liquid is soluble in water i.e. one layer forms after mixing the liquid with water, it means the liquid is ethanoic acid, and if the liquid is insoluble in water, it means the liquid is pentane. This is so because carboxylic acid are soluble in water since they are polar like water, while alkanes are insoluble in water since they are not polar unlike water.

DISTINGUISHING ALKANE FROM CARBOXYLIC ACID USING SODIUM TEST

Materials: liquids A and B (one is pentane and the other one is ethanoic), small pieces of sodium metal (2), glass dish

Procedure: a. pour a little of liquid A in a glass dish
b. drop a piece of sodium metal into the glass dish
c. observe what happens and record in the table of results by writing 'reaction' or 'no reaction'.
d. repeat steps (a) to (c) for liquid B.

TABLE OF RESULTS

LIQUID	SODIUM (Na)
A	
B	

If the liquid reacts with sodium, it means the substance is ethanoic acid, and if it does not react with sodium, the substance is ethane. This is so because carboxylic acids react with metals i.e. $CH_3COOH_{(aq)} + Na_{(s)} \rightarrow CH_3COONa_{(aq)} + H_{2(g)}$, while alkanes do not react with metals.

DISTINGUISHING ALKANE FROM CARBOXYLIC ACID USING LITMUS TEST

Materials: test tubes (2), liquids A and B (one is ethane and the other is ethanoic acid but not necessarily in that order), litmus papers (2).

Procedure: a. place liquid A in one test tube and liquid B in another test tube
b. dip litmus paper in liquid A
c. observe the colour of the litmus paper when it is taken out and record in the table of results
d. repeat steps (a) to (c) for liquid B

TABLE OF RESULTS

Liquid in which litmus paper is dipped	Colour of litmus paper
Liquid A	
Liquid B	

The liquid is ethanoic acid if the litmus paper turns red when dipped into it, and it is ethane if the litmus paper does not turn red. This is so because litmus paper turns red in acidic solutions only.

DISTINGUISHING ALKANE FROM CARBOXYLIC ACID USING PHENOLPHTHALEIN INDICATOR ACID TEST

Materials: liquids A and B (one is ethane and the other is ethanoic acid but not necessarily in that order), phenolphthalein indicator, sodium hydroxide, test tube.

Procedure: a. pour a little sodium hydroxide (about 5ml) in a test tube.
b. add two drops of phenolphthalein indicator (the colour will turn pink)
c. drop-wisely add liquid A to the test tube
d. observe what happens to the colour and record in the table of results
e. repeat steps (a) to (d) for liquid B

TABLE OF RESULTS

MIXTURE	OBSERVATION
NaOH + Phenolphthalein indicator + liquid A	
NaOH + Phenolphthalein indicator + liquid B	

If the liquid under test decolourises the mixture of NaOH and phenolphthalein indicator, it means the liquid is ethanoic acid. If it does not decolourise the mixture, it means the liquid is ethane. This is so because an acid will neutralize the base but ethanol can not neutralize the base (phenolphthalein indicator is pink in a base only, and after neutralization, the base will no longer be there).

DISTINGUISHING A SMALLER ALKENE FROM A BIGGER ALKENE USING RATE OF REACTION

Materials: bromine, beakers (2)(100ml), liquids A and B (one is ethane and the other one is pentene but not necessarily in that order).

Procedure: a. pour liquid A (10ml) in a beaker
b. add 2ml of bromine to the beaker
c. note the time taken for the brown colour to disappear
d. repeat steps (a) to (c) with liquid B.

LIQUID	TIME TAKEN (S)
A	
B	

The liquid in which it takes a long time for the brown colour of the bromine to disappear is pentene and the one in which the time taken for the brown colour of bromine to disappear is ethane. This is so because the rate of reaction is dependent on the proportion of the functional group, C=C. In ethene, there is a large proportion of the C=C double bond than in pentene, hence the reaction is faster in ethene than in pentene.

DISTINGUISHING AN ALKENE FROM AN ALKANOL USING BROMINE TEST

Materials: liquids A and B in separate beakers (one is octene and the other one is octanol but not necessarily in that order) and bromine in a dropper bottle.

Procedure: a. add a few drops of bromine in the beaker containing liquid A, observe what happens and record in the table of results.
b. add a few drops of bromine in the beaker containing liquid B, observe what happens and record in the table of results.

TABLE OF RESULTS

MIXTURE	COLOUR
Liquid A + bromine	
Liquid B + bromine	

The mixture that remains brown (the colour of bromine) contains octanol and the one which turns colourless contains octene. This is so because octene reacts with bromine to form dibromooctane which is colourless while octanol does not react with bromine so the bromine (brown in colour) remains in solution.

DISTINGUISHING ALKENE FROM ALKANOL USING SOLUBILITY TEST

Materials: distilled water, liquids A and B (one is ethene and the other one is ethanol but not necessarily in that order), test tubes (2)

Procedure: a. pour 5ml of liquid A into one test tube
b. add 5ml of distilled water to the test tube, shake and let the mixture settle
c. observe what happens and record in the table of results by writing the number of layers.
d. repeat steps (a) to (c) for liquid B

TABLE OF RESULTS

MIXTURE	LAYERS
Water + liquid A	
Water + liquid B	

If the liquid is soluble in water i.e. one layer forms after mixing the liquid with water, it means the liquid is ethanol. If the liquid is insoluble in water i.e. 2 layers form after mixing the liquid with water, it means the liquid is ethene. This is so because alkanols are soluble in water since they are polar like water, while alkenes are insoluble in water since they are not polar unlike water.

DISTINGUISHING ALKENE FROM ALKANOL USING SODIUM TEST

Materials: liquids A and B (one is ethene and the other one is ethanol), small pieces of sodium metal (2), glass dish

Procedure: a. pour a little of liquid A in a glass dish
b. drop a piece of sodium metal into the glass dish
c. observe what happens and record in the table of results by writing 'reaction' or 'no reaction'
d. repeat steps (a) to (c) for liquid B.

TABLE OF RESULTS

LIQUID	SODIUM (Na)
A	
B	

If the liquid reacts with sodium, it means the substance is ethanol, and if it does not react with sodium, the substance is ethene. This is so because alkanols react with metals i.e. $C_2H_5OH + Na \rightarrow C_2H_5ONa + H_2$, while alkenes do not react with metals.

DISTINGUISHING ALKENE FROM CARBOXYLIC ACID USING SOLUBILITY TEST

Materials: distilled water, liquids A and B (one is ethene and the other one is ethanoic acid but not necessarily in that order), test tubes (2)

Procedure: a. pour 5ml of liquid A into one test tube
b. add 5ml of distilled water to the test tube, shake and let the mixture settle
c. observe what happens and record in the table of results by writing the number of layers.
d. repeat steps (a) to (c) for liquid B

TABLE OF RESULTS

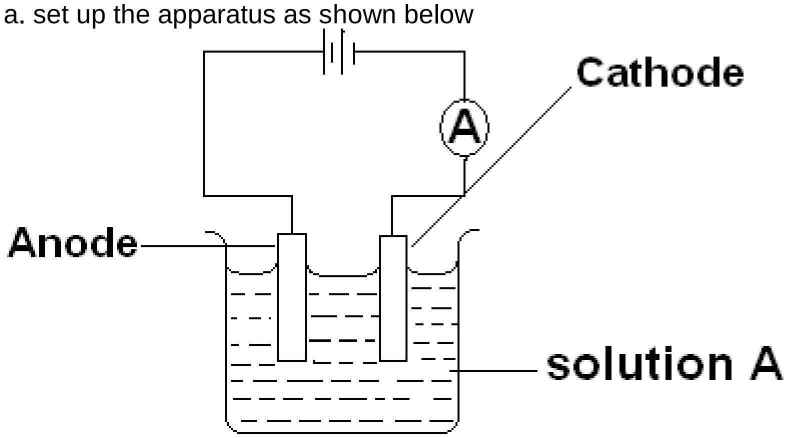
MIXTURE	LAYERS
Water + liquid A	
Water + liquid B	

If the liquid is soluble in water i.e. one layer forms after mixing the liquid with water, it means the liquid is ethanoic acid. If the liquid is insoluble in water i.e. 2 layers form after mixing the liquid with water, it means the liquid is ethene. This is so because carboxylic acids are soluble in water since they are polar like water, while alkenes are insoluble in water since they are not polar unlike water.

DISTINGUISHING ALKENE FROM CARBOXYLIC ACID USING CONDUCTIVITY TEST

Materials: connecting wires (3), carbon rods (2), beaker, liquids A and B (one is ethene and the other one is ethanoic acid but not necessarily in that order), cells (2) in a cell holder, ammeter

Procedure: a. set up the apparatus as shown below



b. note the ammeter reading and record in the table of results.
c. repeat steps (a) and (b) with liquid B

note: remember to clean up the carbon rods and the beaker with distilled water followed by liquid B after you are through with liquid A to avoid conduction errors due to contamination.

TABLE OF RESULTS

LIQUID	AMMETER READING (A)
Liquid A	
Liquid B	

If the solution conducts i.e. the ammeter registers a reading, then it is ethanoic acid. If it does not conduct, it is ethene. The results are expected to be so because conduction in liquids
is accomplished through ions only and in this case, it is the acid which can ionize to release the ions which can conduct. The ethene does not ionize to release ions for conduction.

DISTINGUISHING ALKENE FROM CARBOXYLIC ACID USING SODIUM TEST

Materials: liquids A and B (one is ethene and the other one is ethanoic acid), small pieces of sodium metal (2), glass dish

Procedure: a. pour a little of liquid A in a glass dish
b. drop a piece of sodium metal into the glass dish
c. observe what happens and record in the table of results by writing ‘reaction’ or ‘no reaction’
d. repeat steps (a) to (c) for liquid B.

TABLE OF RESULTS

LIQUID	SODIUM (Na)
A	
B	

If the liquid reacts with sodium, it means the substance is ethanoic acid, and if it does not react with sodium, the substance is ethene. This is so because carboxylic acids react with metals
$CH_3COOH_{(aq)} + Na_{(s)} \rightarrow CH_3COONa_{(aq)} + H_{2(g}$, while alkenes do not react with metals.

DISTINGUISHING ALKENE FROM CARBOXYLIC ACID USING LITMUS TEST

Materials: test tubes (2), liquids A and B (one is ethene and the other is ethanoic acid but not necessarily in that order), litmus papers (2).

Procedure: a. put liquid A (5ml) in one test tube and liquid B (5ml) in another test tube
b. dip litmus paper in liquid A
c. observe the colour of the litmus paper when it is taken out and record in the table of results
d. repeat steps (a) to (c) for liquid B

TABLE OF RESULTS

Liquid in which litmus paper is dipped	Colour
Liquid A	
Liquid B	

The liquid is ethanoic acid if the litmus paper turns red when dipped into it, and it is ethene if the litmus paper does not turn red. This is so because litmus paper turns red in acidic solutions only.

DISTINGUISHING ALKENE FROM CARBOXYLIC ACID USING PHENOLPHTHALEIN INDICATOR ACID TEST

Materials: liquids A and B (one is ethene and the other is ethanoic acid but not necessarily in that order), phenolphthalein indicator, sodium hydroxide, test tube.

Procedure: a. pour sodium hydroxide (5ml) in a test tube.
b. add two drops of phenolphthalein indicator (the colour will turn pink)
c. drop-wisely add liquid A to the test tube
d. observe what happens and record in the table of results
e. repeat steps (a) to (d) for liquid B

TABLE OF RESULTS

MIXTURE	OBSERVATION
NaOH + Phenolphthalein indicator + liquid A	
NaOH + Phenolphthalein indicator + liquid B	

If the liquid under test decolourises the mixture of NaOH and phenolphthalein indicator, it means the liquid is ethanoic acid. If it does not decolourise the mixture, it means the liquid is ethene. This is so because an acid will neutralize the base but ethene can not neutralize the base (phenolphthalein indicator is pink in a base only, and after neutralization, the base will no longer be there).

DISTINGUISHING AN ALKENE FROM CARBOXYLIC ACID USING BROMINE TEST

Materials: liquids A and B in separate beakers (one is octene and the other one is ethanoic acid but not necessarily in that order) and bromine in a dropper bottle.

Procedure: a. add a few drops of bromine in the beaker containing liquid A, observe what

happens and record in the table of results.
b. add a few drops of bromine in the beaker containing liquid B, observe what happens and record in the table of results.

TABLE OF RESULTS

MIXTURE	COLOUR
Liquid A + bromine	
Liquid B + bromine	

The mixture that remains brown (the colour of bromine) contains ethanoic acid and the one which turns colourless contains octene. This is so because octene reacts with bromine to form dibromooctane which is colourless while ethanoic acid does not react with bromine so the bromine (brown in colour) remains in solution.

DISTINGUISHING A SMALLER ALKANOL FROM A BIGGER ALKANOL USING SOLUBILITY TEST

Materials: distilled water, liquids A and B (one is ethanol and the other one is octanol but not necessarily in that order), test tubes (2)

Procedure: a. pour 5ml of liquid A in one test tube
b. add 5ml of distilled water to the test tube, shake and let the mixture settle
c. observe what happens and record in the table of results by writing the number of layers.
d. repeat steps (a) to (c) for liquid B

TABLE OF RESULTS

MIXTURE	LAYERS
Water + liquid A	
Water + liquid B	

If the liquid is soluble in water i.e. one layer forms after mixing the liquid with water, it means the liquid is ethanol, and if the liquid is insoluble in water, it means the liquid is octanol. The expected results are like that because ethanol has a large proportion of the –OH group which is responsible for solubility in water while as the octanol has a very small proportion of the –OH group which is responsible for solubility in water i.e. the octanol behaves like a hydrocarbon which has no –OH group and is insoluble.

DISTINGUISHING ALKANOL FROM CARBOXYLIC ACID USING PHENOLPHTHALEIN INDICATOR ACID TEST

Materials: liquids A and B (one is ethanol and the other one is ethanoic acid but not necessarily in that order), phenolphthalein indicator, sodium hydroxide, test tube.

Procedure: a. pour sodium hydroxide (5ml) in a test tube.
b. add two drops of phenolphthalein indicator (the colour will turn pink)
c. drop-wisely add liquid A to the test tube
d. observe what happens and record in the table of results
e. repeat steps (a) to (d) for liquid B

TABLE OF RESULTS

MIXTURE	OBSERVATION
NaOH + Phenolphthalein indicator + liquid A	
NaOH + Phenolphthalein indicator + liquid B	

If the liquid under test decolourises the mixture of NaOH and phenolphthalein indicator, it means the liquid is ethanoic acid. If it does not decolourise the mixture, it means the liquid is ethanol. This is so because an acid will neutralize the base but ethanol can not neutralize the base (phenolphthalein indicator is pink in a base, and after neutralization, the base will no longer be there).

DISTINGUISHING ALKANOL FROM CARBOXYLIC ACID USING LITMUS TEST

Materials: test tubes (2), liquids A and B (one is ethanol and the other one is ethanoic acid but not necessarily in that order), litmus papers (2).

Procedure: a. put liquid A (5ml) in one test tube and liquid B (5ml) in another test tube
b. dip litmus paper in liquid A
c. observe the colour of the litmus paper when it is taken out and record in the table of results
d. repeat steps (a) to (c) for liquid B

TABLE OF RESULTS

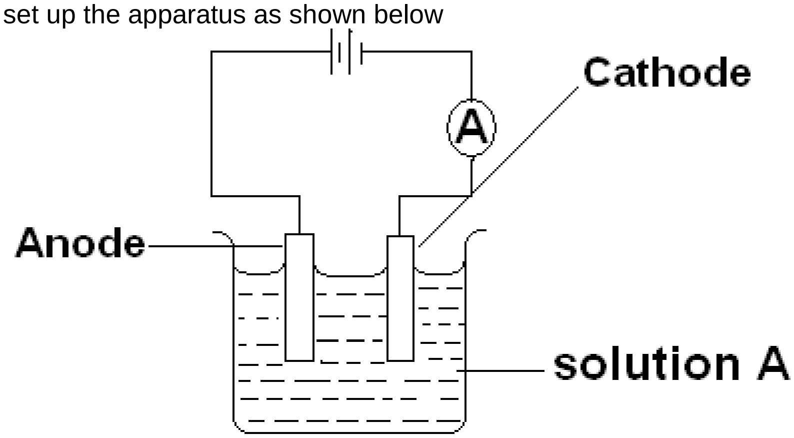
Liquid in which litmus paper is dipped	Colour
Liquid A	
Liquid B	

The liquid is ethanoic acid if it turns the litmus paper red, and it is ethanol if the litmus paper does not turn red. This is so because litmus paper turns red in acidic solutions only.

DISTINGUISHING ALKANOL FROM CARBOXYLIC ACID USING CONDUCTIVITY TEST

Materials: connecting wires (3), carbon rods (2), beaker, liquids A and B (one is ethanol and the other one is ethanoic acid but not necessarily in that order), cells (2) in a cell holder, ammeter

Procedure: a. set up the apparatus as shown below



b. note the ammeter reading and record in the table of results.
c. repeat steps (a) and (b) with liquid B

note: remember to clean up the carbon rods and the beaker with distilled water followed by liquid B after you are through with liquid A to avoid conduction errors

TABLE OF RESULTS

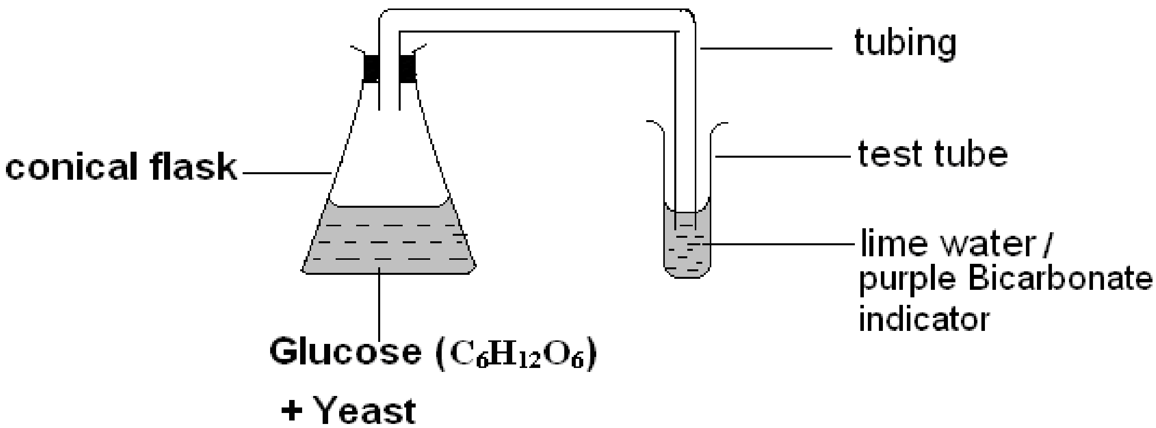
LIQUID	AMMETER READING (A)
Liquid A	
Liquid B	

If the liquid conducts i.e. the ammeter registers a reading, then it is ethanoic acid. If it does not conduct, it is ethanol. The results are expected to be so because conduction in liquids
is accomplished through ions only and in this case, it is the acid which can ionize to release the ions which can conduct. The ethanol does not ionize to release ions for conduction.

INVESTIGATING FERMENTATION OF SUGAR BY YEAST

Materials: conical flask (250ml), rubber bang with one hole, test tube, U-shaped glass tube, sugar sucrose, $C_6H_{12}O_6$), dry yeast (active), teaspoon/spatula, lime water / purple bicarbonate indicator and water.

Procedure: a. dissolve 3 teaspoonfuls of sugar into a little water in the flask.
b. add one teaspoonful of yeast to the solution.
c. put a little lime water into a test tube and set up your apparatus as shown below



d. leave the apparatus to stand for some time; observe what happens in the flask. Note any change in the colour of the lime water.(note: the best temperature for this process is 37^oc)

The process taking place in the conical flask can be represented in form of an equation as shown below:

$$\text{Glucose} \xrightarrow{\text{Yeast}} \text{Ethanol} + \text{Carbon dioxide}$$

i.e.

$$C_6H_{12}O_6 \xrightarrow{\text{Yeast}} 2C_2H_5OH + 2CO_2$$

It is expected that the carbon dioxide, which is a gas, escapes into the test tube with lime water / purple bicarbonate indicator. If lime water is used, it will turn milky and if the purple bicarbonate indicator is used, it will turn yellow.

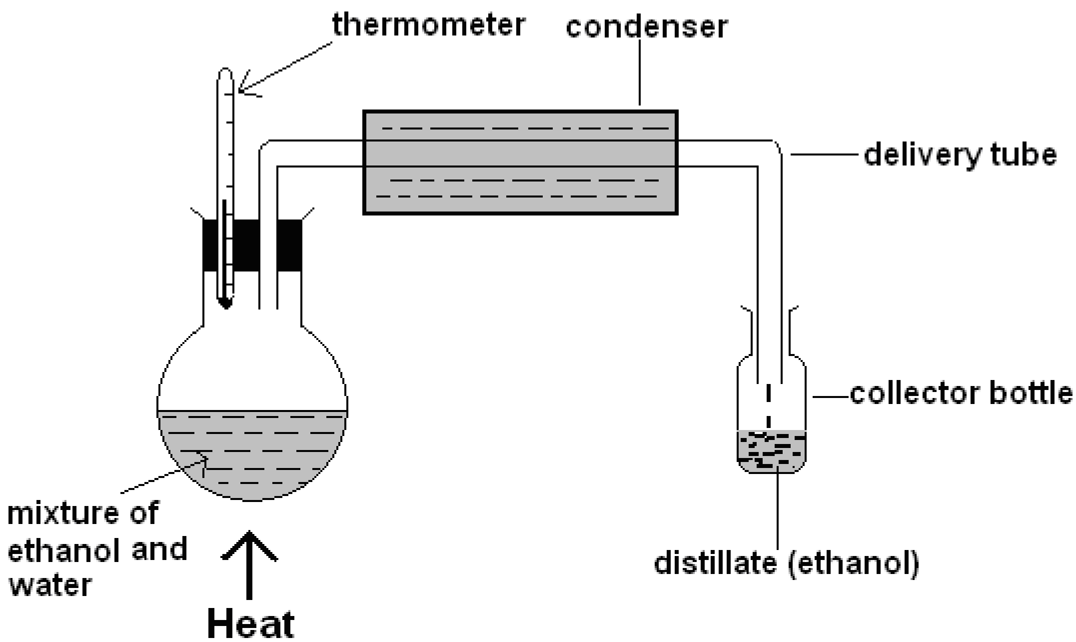
If the ethanol produced is to remain pure, no air should be allowed to get in since it will oxidize the ethanol produced into ethanoic acid i.e. $C_2H_5OH + 2[O] \rightarrow CH_3COOH + H_2O$

SEPARATING A MIXTURE OF ETHANOL AND WATER

Materials: source of heat, wire gauze on a stand, conical flask, the mixture of ethanol and water, 2-holed stopper, thermometer, delivery tube, condenser, collector bottle.

Procedure: a. put the mixture in the conical flask and rest it on the wire gauze.
b. stopper the flask and fix the thermometer and the delivery tube in the holes of the stopper.
c. direct the delivery tube into the collector bottle through the condenser. The flask contains glass beads around which condenses water vapour which goes up along with ethanol vapour. The condensed water vapour (liquid) gets back into the mixture because it is heavy.
d. apply heat onto the flask until all the alcohol is vaporized, condensed and collected in the collector bottle. When the thermometer reads just above 78^0C, all the alcohol is gone and what is remaining is the water.

The apparatus should be set as below:



OXIDATION OF ETHANOL TO ETHANOIC ACID BY ACIDIFIED POTASSIUM DICHROMATE(VI)

Materials: Ethanol, Potassium dichromate, Dilute sulphuric acid (0.1M), A test tube in a rack, Droppers (2), Syringe (5ml), Test tube holder, Burner and matches, Thermometer (optional)

Procedure:
a. put 10 drops (approximately 0.6ml) of potassium dichromate solution into the test tube using one dropper
b. add 5 drops (approximately 0.3ml) of dilute sulphuric acid using the other dropper
c. warm the mixture to about 50^0C by putting the tube onto a lit burner
d. add 1 ml ethanol to the tube using the syringe
e. leave the tube standing for some time (about 5 minutes) and observe any changes
f. dip a litmus paper into the solution and observe its colour change (this is to verify if an acid has really been formed)

TABLE OF RESULTS

O B S E R V A T I O N S	
The colour change of the litmus paper	

The process can be represented in form of an equation as shown below

$$C_2H_5OH + 2[O] \longrightarrow CH_3COOH + H_2O$$

Instead of using the pure oxygen, an oxidizing agent, potassium dichromate, is used in this experiment. The process is summarized in an equation form as shown below.

$$C_2H_5OH + \underset{\text{(acidified)}}{K_2Cr_2O_7} \longrightarrow CH_3COOH + H_2O$$

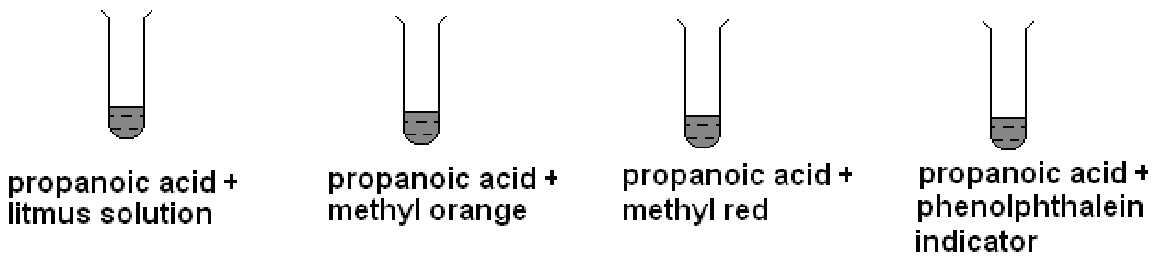
Apart from the potassium dichromate used in this experiment, potassium permanganate can also be used as an oxidizing agent.

As shown in the process, the ethanoic acid produced is not pure i.e. it contains water. It can, however , be purified by using distillation. Distillation is ideal because the two liquids, ethanoic acid and water, have different boiling points i.e. the boiling point of water is 100^oC and that of ethanoic acid is 118 ^oC.

INVESTIGATING THE EFFECT OF CARBOXYLIC ACIDS ON ACID-BASE INDICATORS

Materials: propanoic acid, sulphuric acid, test tubes (4) in a rack, acid-base indicators (litmus solution, methyl orange solution, methyl red solution, phenolphthalein indicator)

Procedure: a. put 5ml propanoic acid into each of the 4 test tubes.
b. add 2 drops of each indicator to the test tubes as shown below.



c. note the colours in each tube and record in the table of results
d. repeat steps (a) to (c) with sulphuric acid

TABLE OF RESULTS

Acid	Litmus solution	Methyl orange	Methyl red	Phenolphthalein indicator
Propanoic acid				
Sulphuric acid				

If the colour changes for propanoic acid when the indicator is added are the same as for those of sulphuric acid when the indicator is added, then propanoic acid has the true properties of an acid. Since propanoic acid is in the family of carboxylic acids, it follows, therefore, that carboxylic acids have the true properties of acids i.e. carboxylic acids have the same effect on acid-base indicators as any other acid.

The expected colours will be as follows:

Acid	Litmus solution	Methyl orange	Methyl red	Phenolphthalein indicator
Propanoic acid	Red	Pink	Red	Colourless
Sulphuric acid	Red	Pink	Red	Colourless

For bases, the colours are as follows:

Litmus solution	Methyl orange	Methyl red	Phenolphthalein indicator
Blue	Yellow	Yellow	Pink

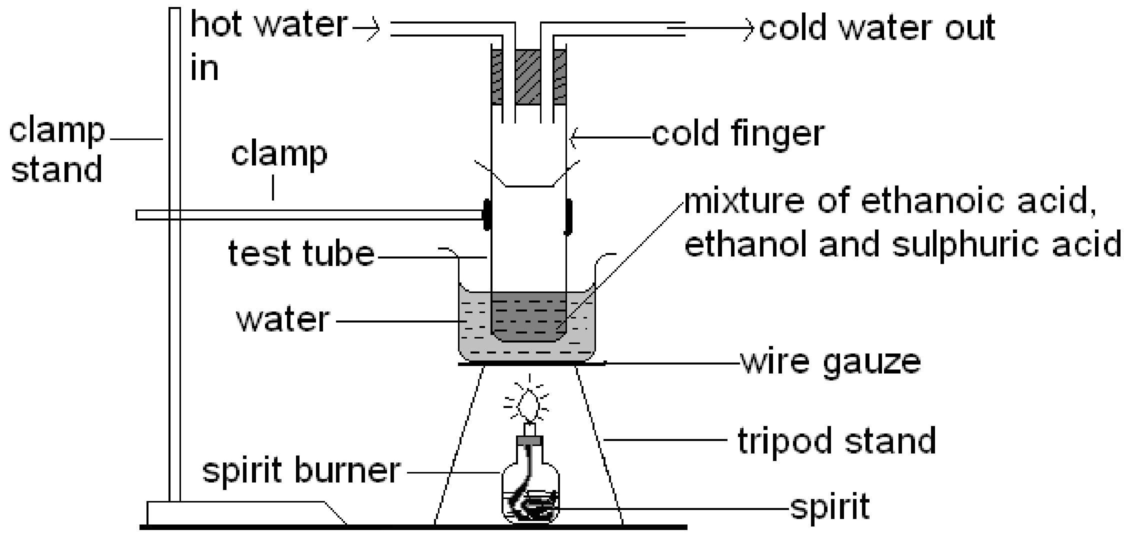
For universal indicator, the colours vary depending on how strong the acid or base is. The colours are shown on a pH scale. The pH scale is shown below

Colour of universal indicator	Red	orange	Light orange	yellow	green	Green blue	Light blue	Dark blue	Violet	Purple
pH	0- 2	3-4	5	6	7	8	9	10	11-12	13-14

FORMATION OF ESTERS (REACTION OF ETHANOL AND ETHANOIC ACID)

Materials: Test tube (Pyrex), Beaker (Pyrex, 400ml), Cold finger, Retort stand and clamp, Tripod stand and gauze, Bunsen burner and matches, Measuring cylinder ($20cm^3$), Ethanoic acid, Ethanol, Concentrated sulphuric acid, Tap water, Anhydrous Sodium Carbonate

Procedure: a. put $10cm^3$ of ethanoic acid (CH_3COOH) into a dry test tube
b. add $10cm^3$ of ethanol (C_2H_5OH) and 5 cm^3 of concentrated sulphuric acid
c. half-fill the beaker with water and set up the apparatus as shown below:



e. boil the mixture under reflux for 30 minutes then extinguish the fire.
f. remove the cold finger and leave the test tube in the beaker of boiling water for further 15 minutes to evaporate the excess alcohol. Impure ethyl ethanoate remains
g. add to the impure ethyl ethanoate, about an equal volume of water; then add anhydrous sodium carbonate gradually until effervescence ceases. This neutralizes any remaining acid.

The esterification process can be represented in form of an equation as shown below

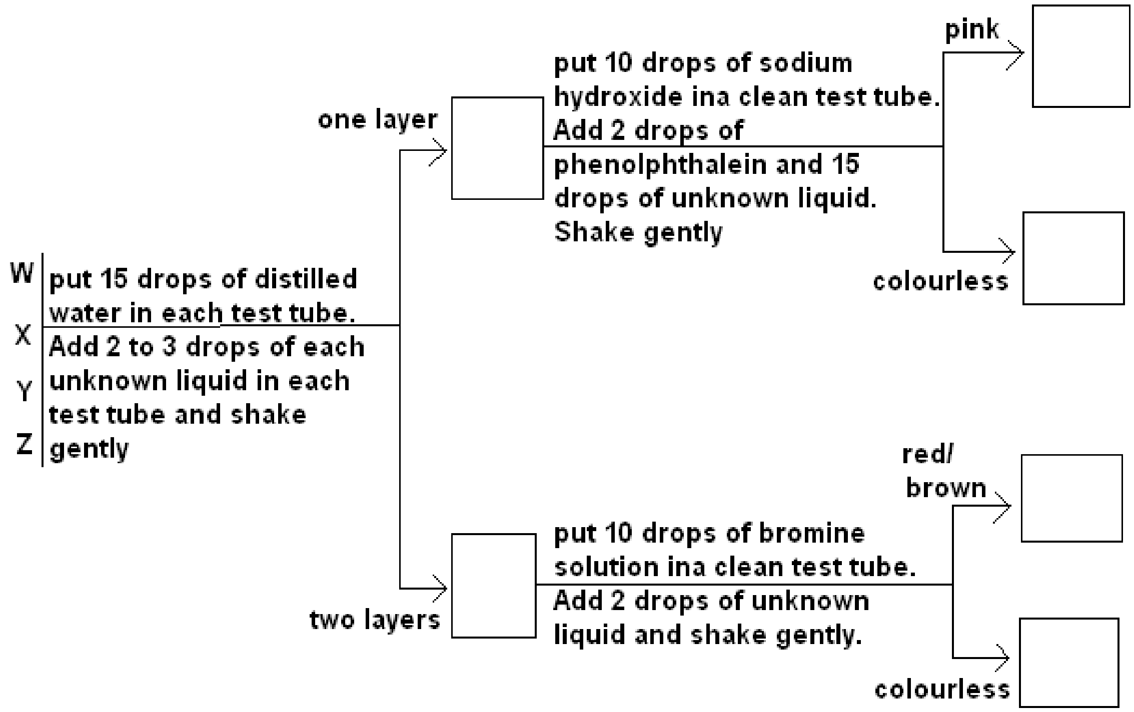
$$C_2H_5OH + CH_3COOH \xrightleftharpoons{\text{conc. } H_2SO_4} CH_3COOC_2H_5 + H_2O$$

The ester (ethylethanoate) produced is not pure since some ethanol may remain unreacted, the acid is just a catalyst so it remains mixed with the product and there is also water produced as a by-product. All these impurities have to be removed if the ester is to be pure. The steps (f) and (g) will make the ester pure.

IDENTIFYING ORGANIC SUBSTANCES USING FLOW DIAGRAM

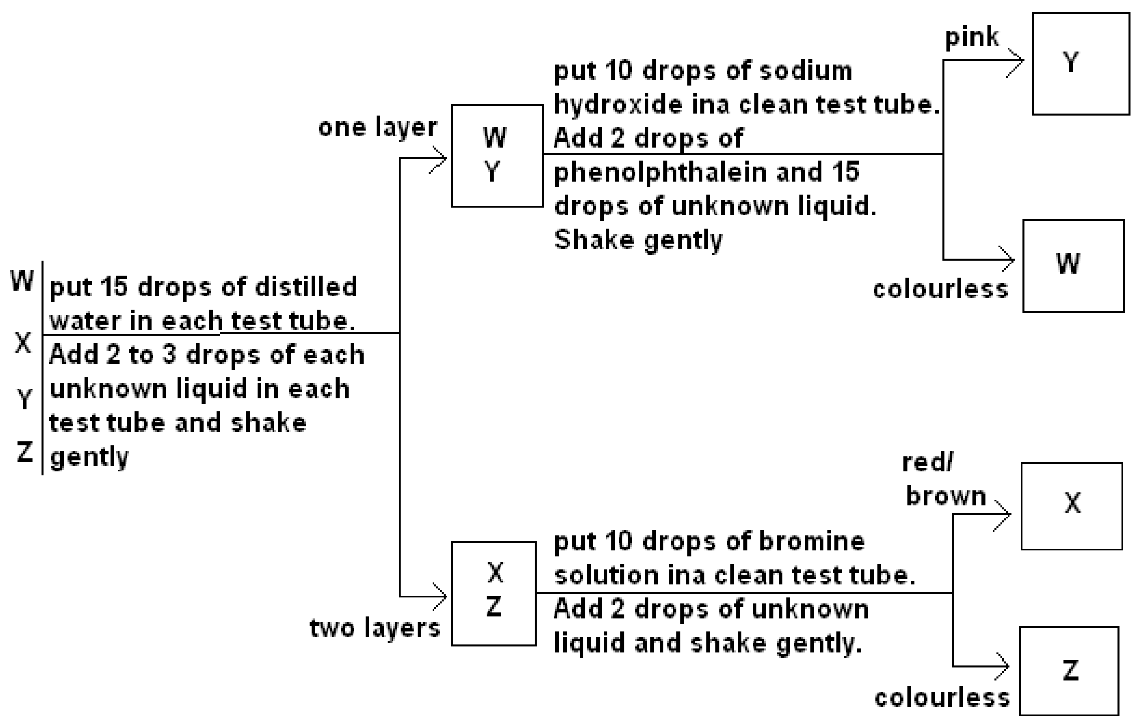
Materials: test tubes (4), distilled water, bromine solution, sodium hydroxide solution and phenolphthalein indicator, unknown liquids labeled W, X, Y and Z which are hexane, ethanol, cyclohexene and ethanoic acid but not necessarily in that order.

Procedure: a. perform the tests given in the flow diagram in the figure below and complete the diagram by filling in the letters W, X, Y and Z in the appropriate boxes.



b. identify liquids W, X, Y and Z

Assuming the results are as shown below



Then W is ethanoic acid
X is hexane
Y is ethanol
Z is cyclohexene

IDENTIFYING FAMILIES OF ORGANIC COMPOUNDS

Materials: dilute sodium hydroxide, phenolphthalein indicator and bromine solution in dropper bottles, four test tubes (in a rack) containing substances P, Q, R and S and distilled water in a wash bottle.

Procedure: a. On each substance, perform the tests shown in the table below and record the observations in the appropriate space. Wash the test tubes after use.

Test / Substance	add 1-2 drops of substance to 15 drops of distilled water	add 1drop of phenolphthalein to 15 drops NaOH then add 1 drop of substance	add 1-2 drops of substance to 15 drops bromine
Substance	RESULTS	RESULTS	RESULTS
P			
Q			
R			
S			

b. Identify the families to which the compounds belong.

P__________________________

Q__________________________

R__________________________

S __________________________

The substance belongs to alkene family if

- It is insoluble in water i.e. two layers form when water is added to it
- It does not decolourise the solution of NaOH + phenolphthalein
- It makes the brown colour of bromine disappear i.e. if it reacts with bromine

The substance belongs to alkane family if

- It is insoluble in water i.e. two layers form when water is added to it
- It does not decolourise the solution of NaOH + phenolphthalein
- It does not make the brown colour of bromine disappear i.e. if it does not react with bromine

The substance belongs to alkanol family if

- It is soluble in water i.e. one layer forms when water is added to it
- It does not decolourise the solution of NaOH + phenolphthalein
- It does not make the brown colour of bromine disappear i.e. if it does not react with bromine

The substance belongs to carboxylic family if

- It is soluble in water i.e. one layer forms when water is added to it
- It decolourises the solution of NaOH + phenolphthalein
- It does not make the brown colour of bromine disappear i.e. if it

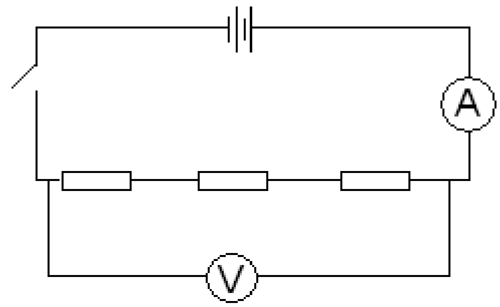
does not react with bromine

7 ELECTRICITY, MAGNETISM AND ELECTROMAGNETIC INDUCTION I & II

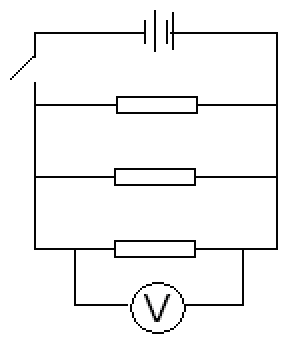
INVESTIGATING TOTAL RESISTANCE IN PARALLEL AND SERIES

Materials: carbon resistors having the same value (3), cells (2) in a holder, switch, connecting wires (7), ammeter and voltmeter.

Procedure: a. connect the resistors in a circuit in series as illustrated below:



b. close the circuit
c. note the reading of the voltmeter and the ammeter; record in the table of results
d. change the arrangement of the resistors. Arrange them in parallel as shown in the figure below:



e. close the switch
f. note the reading of the voltmeter and the ammeter and record in the table below.

TABLE OF RESULTS

Arrangement of resistors	Voltmeter reading (v)	Ammeter reading (A)	Resistance, $R_T = V/A$
Series			
Parallel			

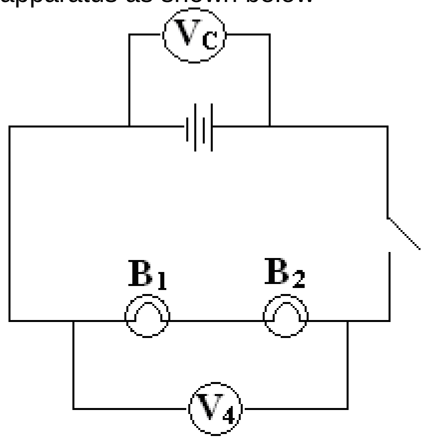
g. complete the table by calculating the resistance

Expectedly, the voltage in the series and parallel circuits above will be the same. This is so because voltage in series is shared i.e. the voltage across the three voltmeters in the series circuit above is the total voltage and is equal to the voltage that the battery is supplying. On the other hand, the voltage across the one resistor in the parallel circuit is the total resistance since voltage in parallel is the same at each and every point. Hence it is equal to the total voltage that the battery is supplying.

INVESTIGATING VOLTAGE IN SERIES CIRCUIT

Materials: cells (2) in a holder, bulbs (2) in bulb holders, switch, voltmeter, connecting wires (7).

Procedure: a. set up the apparatus as shown below



b. close the switch and note the readings of the voltmeters V_c and V_4 and record in the table of results.
c. disconnect V_4
d. connect it across bulb, B_1
e. note the voltmeter reading and record in the table of results
f. disconnect the voltmeter across bulb, B_1 and connect it across bulb, B_2
g. note the voltmeter reading and record in the table of results

TABLE OF RESULTS

Component	Voltmeter reading (V)
Cells	V_C =
B_1	V_1 =
B_2	V_2 =
B_1 and B_2	V_4 =

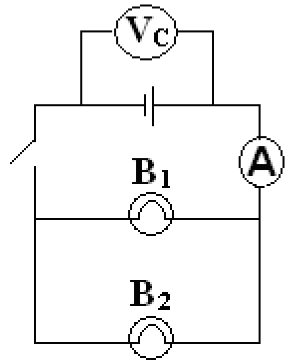
h. describe the relationship that exists between V_C and V_4
i. describe the relationship that exists between V_1, V_2 and V_4
j. describe the relationship that exists between V_1, V_2 and V_c
k. from the relationships in (h) to (j), make a conclusion on the voltage in series circuit.

Expectedly, $V_C = V_4$, $V_4 = V_1 + V_2$, $V_C = V_1 + V_2$ and this shows that voltage in series is shared i.e. the total voltage, V_C or V_4 is shared between B_1 and B_2

INVESTIGATING VOLTAGE IN PARALLEL

Materials: cell in a cell holder, voltmeter, bulbs (2) in holders, switch, connecting wires.

Procedure: a. set up the apparatus as shown below



b. close the switch and note the reading of voltmeter V_C
c. repeat steps (a) and (b) with the voltmeter across B_1 and B_2.

TABLE OF RESULTS

COMPONENT	VOLTMETER READING (V)
Cell	V_C =
B_1	V_1 =
B_2	V_2 =

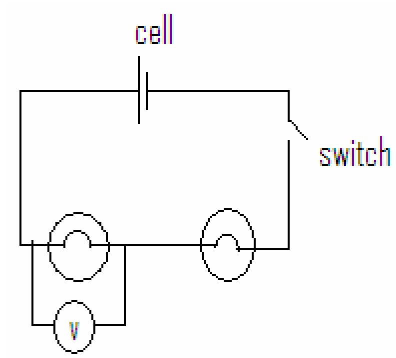
d. describe the relationship between V_C, V_1 and V_2.
e. from the relationship in (d), make a conclusion on the voltage in parallel

Expectedly, $V_C = V_1 = V_2$ and this shows that voltage in parallel is the same i.e. it is not shared.

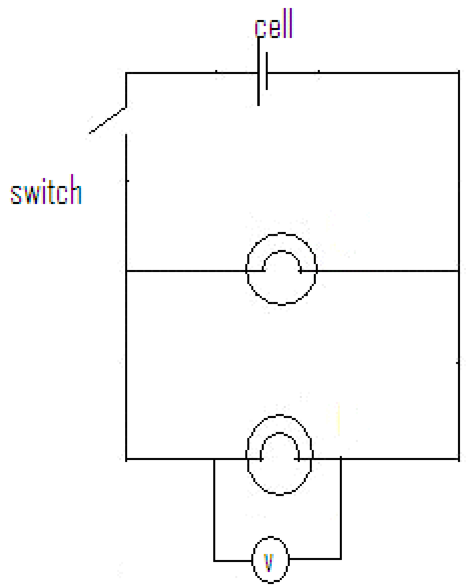
INVESTIGATING THE DEPENDENCE OF BRIGHTNESS OF BULBS ON VOLTAGE USING SERIES AND PARALLEL CIRCUITS

Materials: cell (1), identical bulbs (2), voltmeter, switch and connecting wires (9)

Procedure: a. set up the apparatus with the bulbs in series as shown below.



b. read the voltmeter and record in the table of results.
c. note the brightness of the bulbs and record in the table of results by writing 'less bright' or 'brighter'.
d. set up the apparatus again, this time with the bulbs in parallel as shown below.



e. read the voltmeter and record the reading in the table of results.
f. note the brightness of the bulbs and record in the table of results by writing 'less bright' or 'brighter'.

TABLE OF RESULTS

Circuit	Voltmeter reading	Brightness
Series		
Parallel		

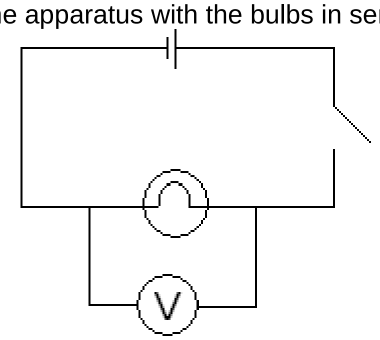
Since the voltage in series is shared, the voltage across the bulb in series is lower than the voltage in the parallel circuit (the voltage in parallel is the same). Comparing the brightness of the bulbs in the series (lower voltage) and the brightness of the bulb in the parallel circuit (higher voltage), it is expected that the bulb in the parallel circuit will be brighter than that in the series. This is so because when there is high voltage, there is strong push of electrons which results in more current passing through the bulb hence more brightness.

Therefore, the higher the voltage the brighter the bulbs

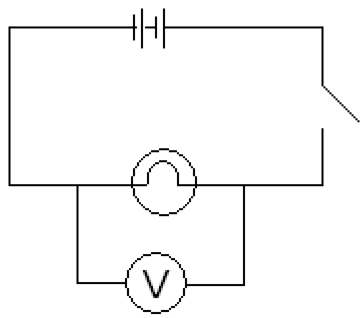
INVESTIGATING THE DEPENDENCE OF BRIGHTNESS OF BULBS ON VOLTAGE USING DIFFERENT NUMBER OF CELLS

Materials: cells (2), a bulb, voltmeter, connecting wires and a switch.

Procedure: a. set up the apparatus with the bulbs in series as shown below.



b. read the voltmeter and record in the table of results.
c. note the brightness of the bulbs and record in the table of results by writing 'less bright' or 'brighter'.
d. set up the apparatus again; this time with 2 cells as shown below



e. read the voltmeter and record in the table of results.
f. note the brightness of the bulbs and record in the table of results by writing ‘less bright’ or ‘brighter’.

TABLE OF RESULTS

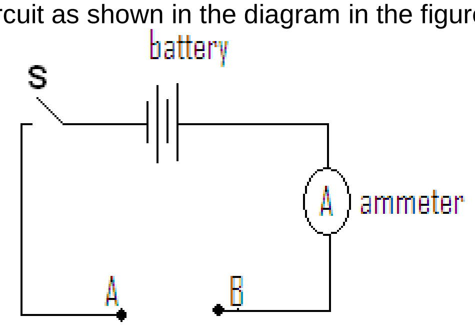
Number of cells	Voltmeter reading	Brightness
1		
2		

It is expected that the bulb connected in the circuit with 2 cells will be brighter than the one which is connected in the circuit with one cell. This is so because the 2 cells will provide a strong push of electrons and hence more current than 1 cell.

INVESTIGATING THE RELATIONSHIP BETWEEN THE LENGTH OF A WIRE AND THE CURRENT PASSING THROUGH IT

Materials: cells (2) in a cell holder, a nichrome wire(100 cm), an ammeter, a switch, connecting wires (4) and a ruler.

Procedure: a. Connect a circuit as shown in the diagram in the figure below.

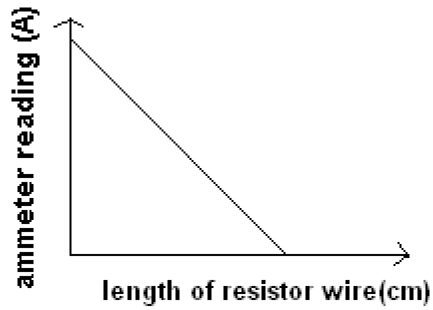


b. measure 80cm of the nichrome wire and connect it on the gap AB
c. Record the reading of the ammeter in the table of results.
d. Disconnect the wire from the circuit.
e. Repeat steps (b) and (c) for 60 cm, 40 cm and 20 cm lengths of the wire.

TABLE OF RESULTS

LENGTH (cm)	AMMETER READING (A)
80	
60	
40	
20	

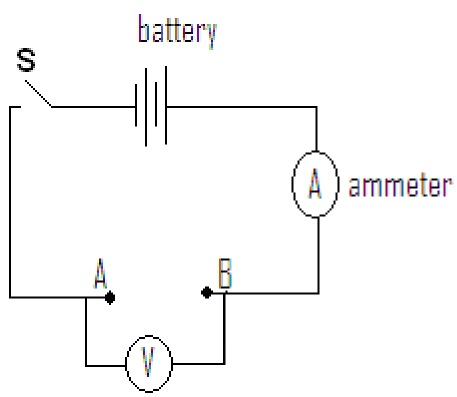
If the ammeter reading changes as the length is changed, it means that length of the wire has an effect on current. Expectedly, the ammeter reading will be increasing as the length is decreased. This is so because as the length decreases, the resistance of the wire also decreases and as the resistance decreases, the amount of current passing also decreases. Hence length of a wire is inversely proportional to the current passing through it. To visualize the relationship clearly, a graph of ammeter reading against length can be drawn and it should look as the one below



INVESTIGATING THE RELATIONSHIP BETWEEN LENGTH OF A WIRE AND ITS RESISTANCE

Materials: nichrome wire (100 cm), Ammeter, Voltmeter, Connecting wires (6) and Cells (2) / battery

Procedure: a. set up the apparatus as shown below



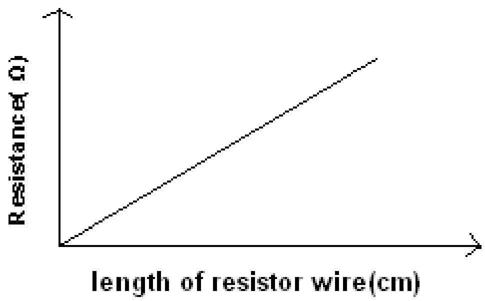
b. measure 80Cm of the nichrome wire and connect it on the gap AB
c. read the voltmeter and the ammeter and record in the table of results
d. find the resistance using the formula, R = V / I and fill in the table.
e. repeat steps (b) to (d) for lengths 60cm, 40cm, and 20cm

TABLE OF RESULTS

Length of nichrome wire	Voltmeter reading (v)	Ammeter reading (A)	Resistance
80			
60			
40			
20			

If the resistance changes as the length of the resistor wire is changed, it means that length has an effect on the resistance of a resistor wire. Expectedly, the resistance will decrease as the length is decreased i.e. resistance is directly proportional to the length of the resistor wire. To visualize the relationship, a graph of the resistance against length of the wire can be drawn.

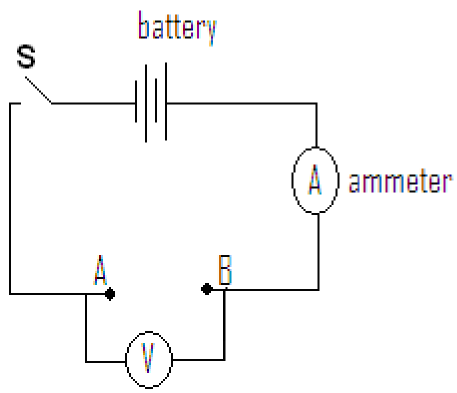
The graph will look as the one below



DETERMINING THE LENGTH OF THE NICHROME WIRE EQUIVALENT TO RESISTANCE OF 1.7Ω

Materials: nichrome wire (100 cm), Ammeter, Voltmeter, Connecting wires (6) and Cells (2) / battery

Procedure: a. set up the apparatus as shown below

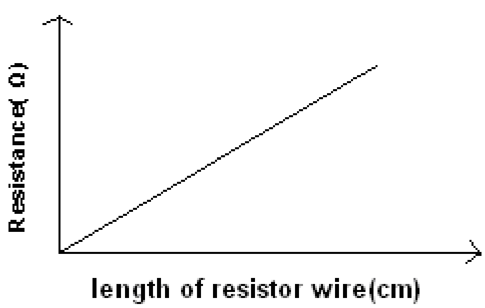


b. measure 80Cm of the nichrome wire and connect it on the gap AB
c. read the voltmeter and the ammeter and record in the table of results
d. find the resistance using the formula, R = V / I and fill in the table.
e. repeat steps (b) to (d) for lengths 60cm, 40cm, and 20cm

TABLE OF RESULTS

Length of nichrome wire	Voltmeter reading (v)	Ammeter reading (A)	Resistance
80			
60			
40			
20			

Draw a graph like the one shown below

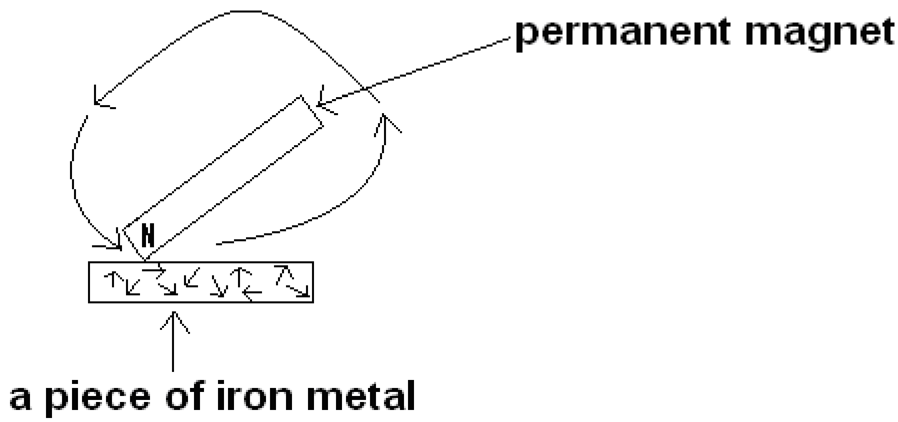


Mark the point where it reads 1.7Ω on the resistance axis and find the equivalent length on the length axis.

INVESTIGATING HOW A MAGNET CAN BE MADE USING STROKING METHOD (SINGLE TOUCH)

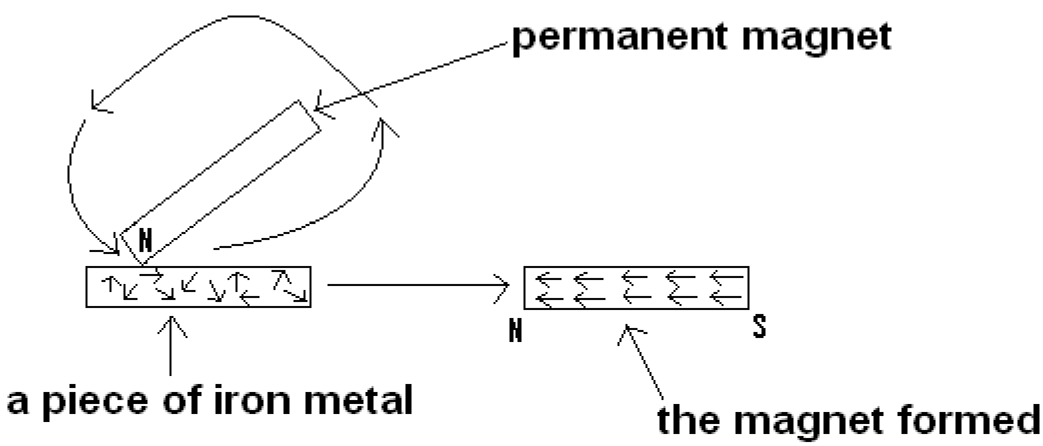
Materials: strong bar magnet, steel nail, iron fillings, plotting compass

Procedure: a. put the steel nail flat on a bench and then stroke it with one end of the magnet in one direction only by lifting the magnet before having another stroke as shown below:



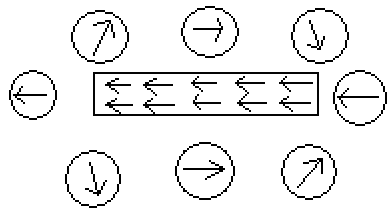
b. stroke the iron bar 10-20 times.
c. take the bar close to paper clips and observe what happens.
d. stroke the bar again 20 times and repeat step(c).
e. compare the degree of attraction in (c) and in (d).
e. test the polarity of each end of the bar by bringing it closer to an accurate plotting compass.

The first stroking magnetizes the iron bar and it will pick up the paper clips. The second stroking increases the magnetism by perfecting the alignment of the magnetic particles (domains) and the attraction of the paper clips is more than that of the first stroking. Using the diagram above, the polarity of the magnet formed will be as shown below



The tips of the magnetic particles are north poles and are attracted by the south pole of the permanent magnet. The tails are the south poles and are repelled by the north pole of the magnet, hence the magnetic particles (regarded as tiny magnets) point left according to the diagram above. Where the magnetic particles point, that is the North Pole and the other end is South Pole.

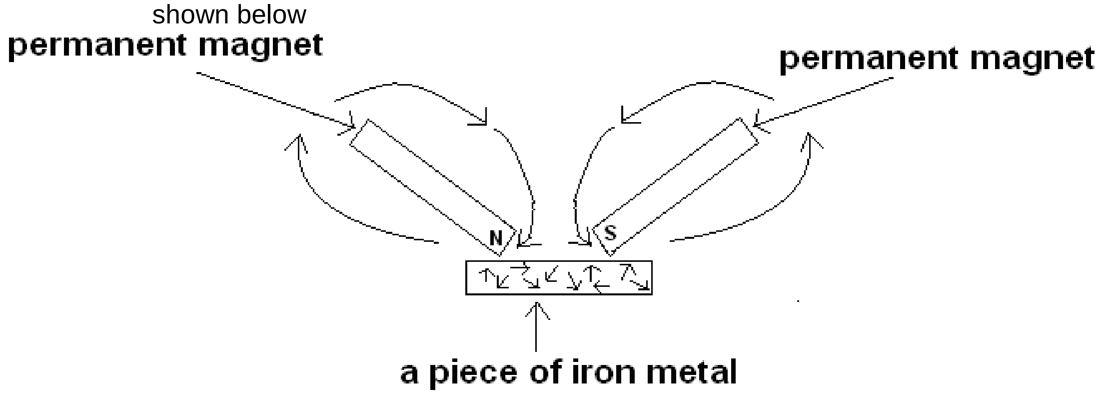
The plotting compass will behave as shown below



INVESTIGATING HOW A MAGNET CAN BE MADE BY STROKING METHOD (DOUBLE /DIVIDED TOUCH)

Materials: strong bar magnets (2), steel nail, iron fillings, plotting compass (accurate), plasticine/ soft wax

Procedure: a. put the iron nail on a table and stroke it 15 times with opposite ends of the 2 magnets starting from the middle of the bar in opposite directions as shown below

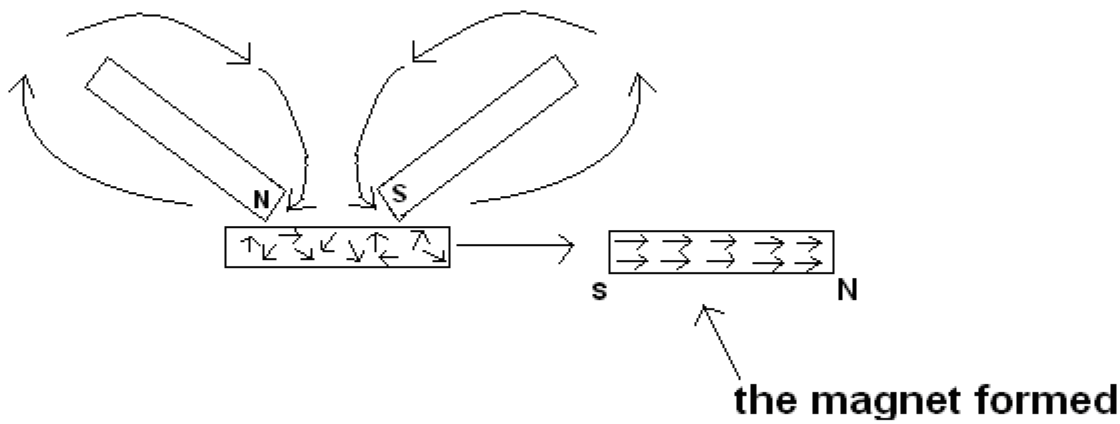


b. take the bar close to paper clips and observe what happens.
c. stroke the bar again 20 times and repeat step(c).
d. compare the degree of attraction in (c) and in (d).
e. test the polarity of each end of the nail by bringing it closer to an accurate compass.
h. record the observations in the table of results.

TABLE OF RESULTS

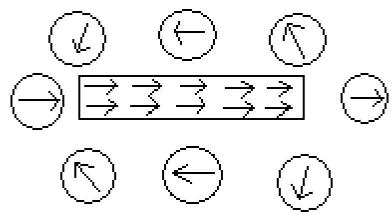
OBSERVATIONS	
First stroking	
Second stroking	

The first stroking magnetizes the iron bar and it will pick up the paper clips. The second stroking increases the magnetism by perfecting the alignment of the magnetic particles (domains) and the attraction of the paper clips is more than that of the first stroking. Using the diagram above, the polarity of the magnet formed will be as shown below



The tips of the magnetic particles are north poles and are attracted by the south pole of the permanent magnet, and the tails are the south poles and are attracted by the north pole of the other magnet, hence the magnetic particles (regarded as tiny magnets) point to the right as shown in the diagram above. Where the magnetic particles point, that is the North Pole and the other end is South Pole.

The plotting compass will behave as shown below



INVESTIGATING DEMAGNETISATION OF MAGNETS BY HAMMERING

Materials: magnet (1), hammer, paper clips

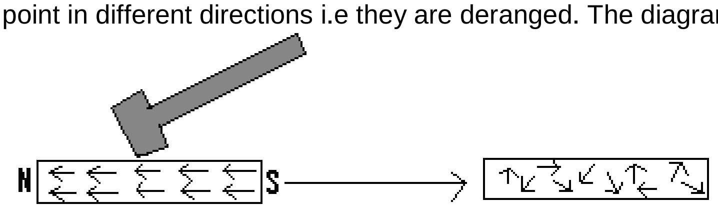
Procedure: a. take the magnet close to the paper clips. Record the observation in the table of results.
b. hit the magnet with a hammer 15 times
c. take the magnet close to the paper clips. Record the observation in the table of results.
d. compare the observations of the two tests

TABLE OF RESULTS

OBSERVATIONS	
Before hitting with a hammer	
After hitting with a hammer	

Expectedly, there will be more attraction of the paper clips before hammering and after hammering, the magnet will be less strong i.e. weak attraction of the paper clips.

This is so because the magnetic particles (domains) in the magnet are made to vibrate with higher frequency hence they point in different directions i.e they are deranged. The diagram below shows what happens



INVESTIGATING DEMAGNETISATION OF MAGNETS BY HEATING

Materials: magnet (1), source of heat, a pair of tongs, paper clips, container of cold water

Procedure: a. take the magnet close to the paper clips. Record the observation in the table of results.
b. heat the magnet very gently for one minute
c. dip the hot magnet in cold water to cool
d. take it close to the paper clips. Observe what happens and record in the table of results.
d. compare the observations of the two tests

TABLE OF RESULTS

OBSERVATIONS	
Before heating	
After heating	

Expectedly, there will be more attraction of the paper clips before heating. After heating, the magnet will be less strong; hence weak attraction of the paper clips.

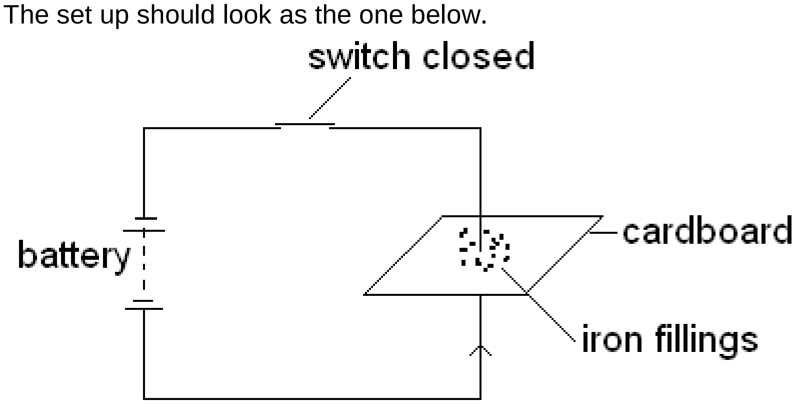
This is so because the magnetic particles (domains) in the magnet are made to vibrate with higher frequency after gaining the kinetic energy from the heat; hence they will point in different directions i.e they will be deranged. The diagram below shows what happens

INVESTIGATING THE MAGNETIC EFFECT OF ELECTRIC CURRENT

Materials: cardboard, thick copper wire (connector wire),
switch, cells (4) in a holder, iron fillings

Procedure: a. pass a thick piece of copper wire through the hole in the piece of cardboard supported horizontally.
b. sprinkle iron fillings over the board and close the switch to allow current to pass for 5 seconds.

The set up should look as the one below.



.

c. tap the paper and observe happens
d. note the flux pattern as taken by the iron fillings and record in the table of results.

TABLE OF RESULTS

OBSERVATIONS	
Before passing current	
When current is passing	

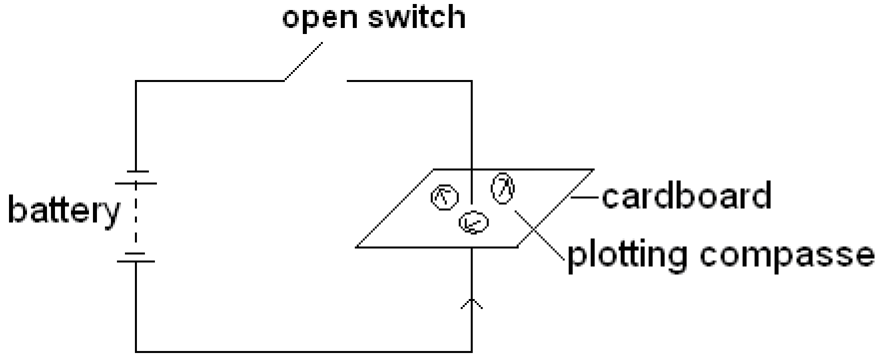
Expectedly, before passing the current, the iron fillings will be arranged randomly. However, when current is passing, the iron fillings will align themselves around the current carrying wire in a definite manner.

INVESTIGATING THE DIRECTION OF ELECTRIC FIELD LINES AROUND A CURRENT CARRYING CONDUCTOR

Materials: cardboard, thick copper wire (connector wire), switch, cells (4) in a holder, and a plotting compass

Procedure: a. pass a thick piece of copper wire through the hole in the piece of cardboard supported horizontally.

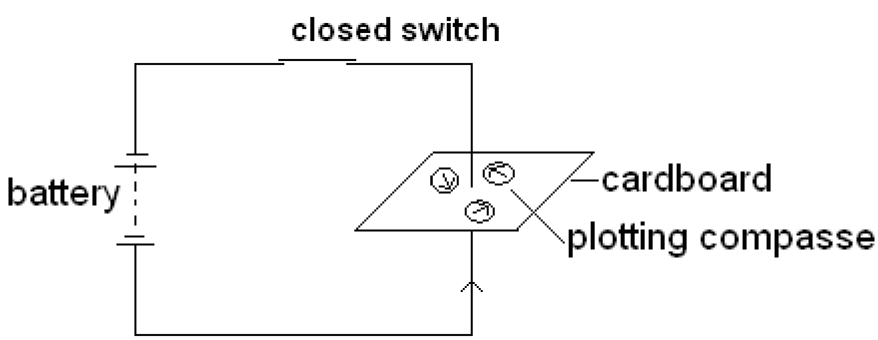
b. place the compasses round the wire as shown below



c. close the switch and observe what happens to the needles of the plotting compass.

d. deduce the flux pattern and direction of the electric field lines.

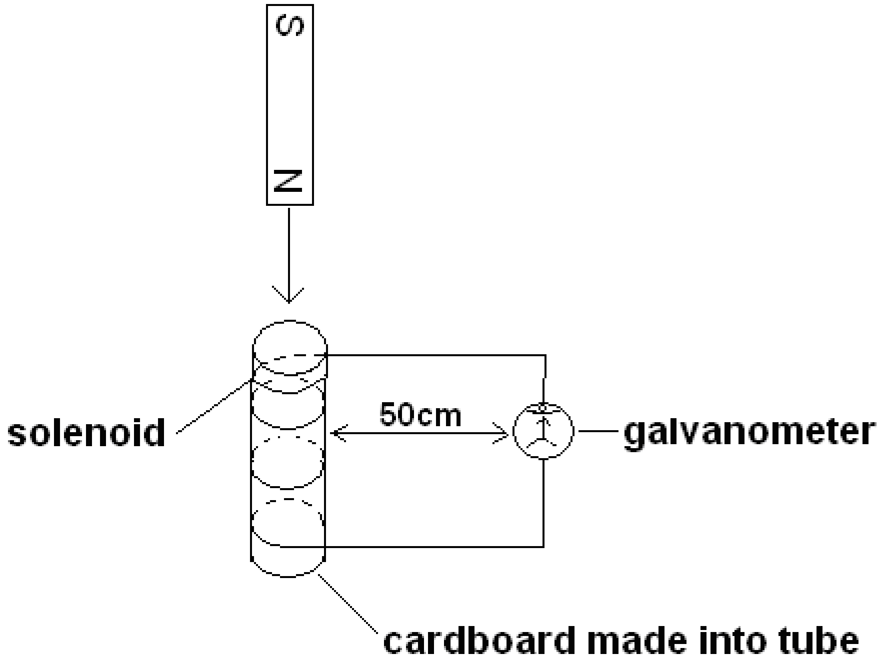
It is expected that the needles of the plotting compass will be aligned in the way as shown below



INVESTIGATING ELECTROMAGNETIC INDUCTION /LENZ'S LAW

Materials: strong bar magnet, galvanometer/sensitive centre zero ammeter, long solenoid (100 turns of plastic/silk-covered copper wire on a cardboard tube. The magnet should move freely through the card board tube), 2 connecting wires/ crocodile leads (6cm long).

Procedure. a. connect the solenoid and the galvanometer as shown below such that the galvanometer is 50cm away from the coil.



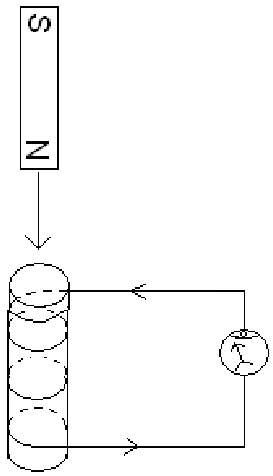
b. push the north pole of the magnet rapidly into the coil and observe what happens to the arrow of the galvanometer. Record the observation in the table of results.
c. when the magnet is fully inside the coil (solenoid), hold it steadily abd observe what happens to the arrow of the galvanometer. Record the observation in the table of results.

d. withdraw the magnet quickly and observe what happens to the arrow of the galvanometer. Record the observation in the table of results.
e. repeat steps (b) to (d) with the south pole of the magnet getting into the coil first.

TABLE OF RESULTS

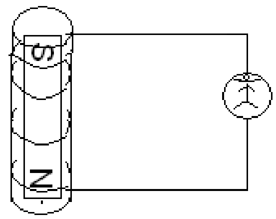
	OBSERVATION
Magnet pushed into the coil, north pole first	
Magnet held steadily in the coil	
Magnet withdrawn from the coil	
Magnet pushed into the coil, south pole first	
Magnet held steadily in the coil	
Magnet withdrawn from the coil	

The expected results will be as shown below



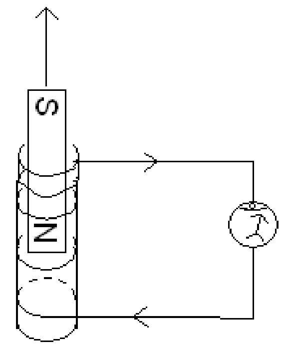
magnet pushed into the coil, north pole first

arrow deflects to the left



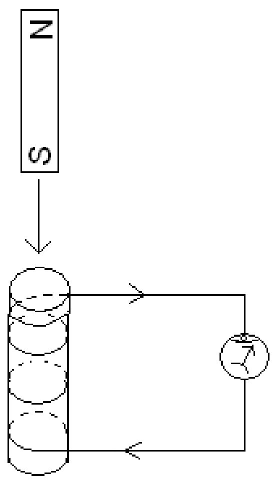
magnet held steadily inside the coil

arrow at zero



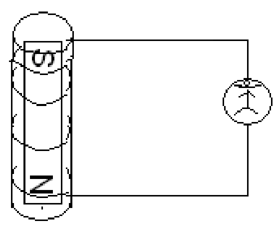
magnet withdrawn

arrow deflects to the right



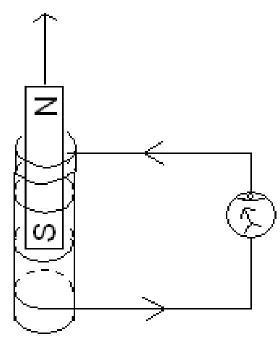
magnet pushed into the coil, south pole first

arrow deflects to the right



magnet held steadily inside the coil

arrow at zero

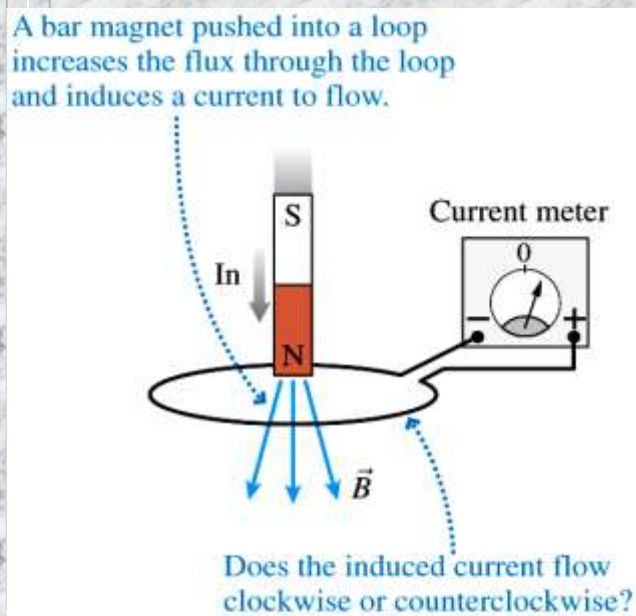


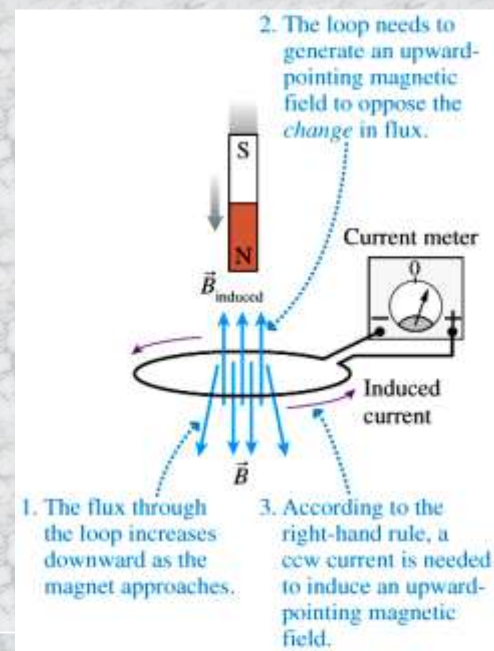
magnet withdrawn from the coil

arrow deflects to the left

NOTES ON LENZ'S LAW

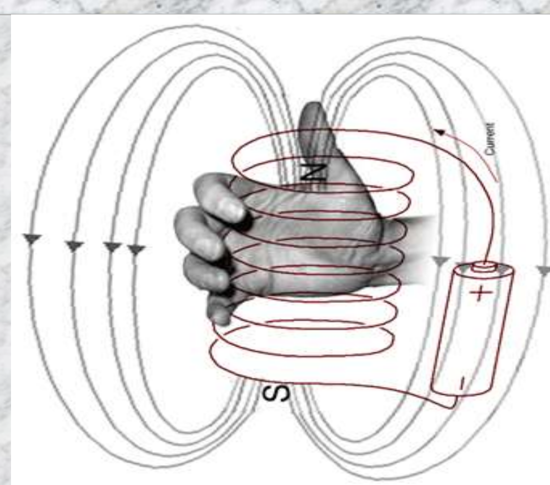
There is an induced current in a closed conducting loop if and only if the magnetic flux through the loop is changing. The direction of the induced current is such that the induced magnetic field always opposes the change in the flux.



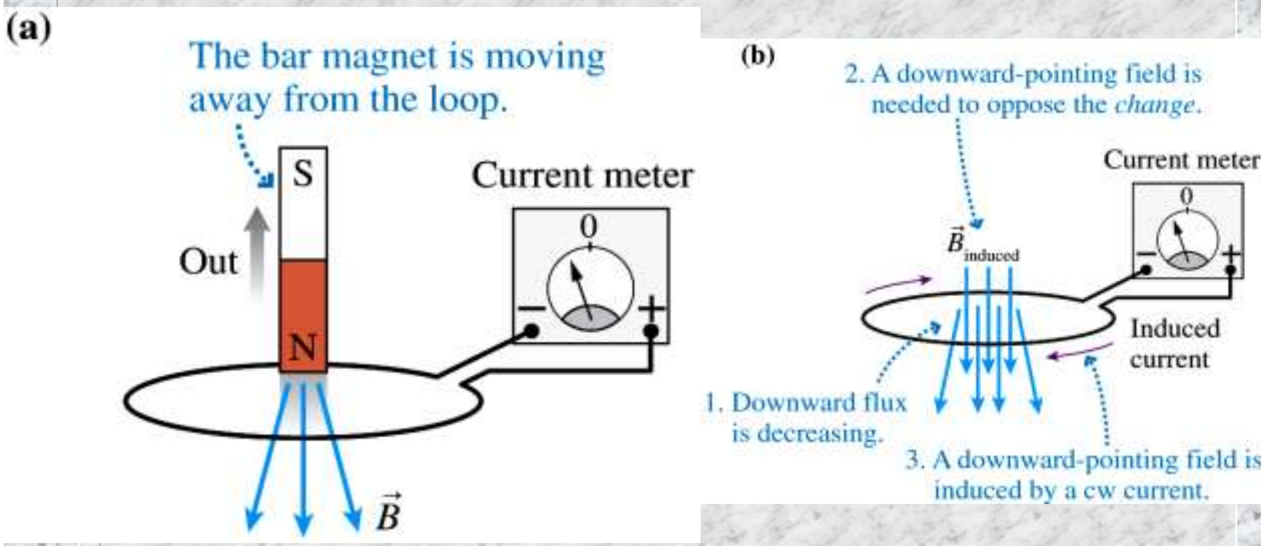


Right Hand Rule

- If you wrap your fingers around the coil in the direction of the current, your thumb points north.

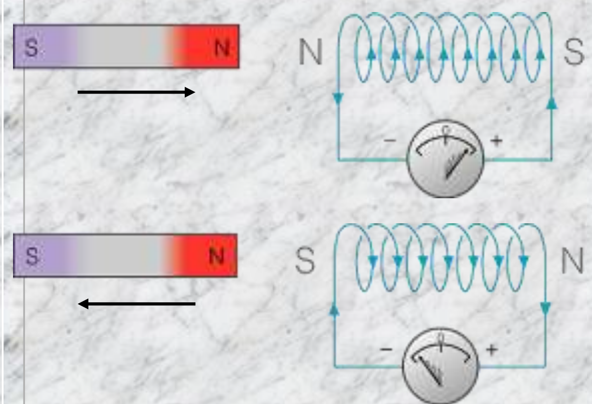


If the field of the bar magnet is already in the loop and the magnet is removed, the induced current is in the direction that tries to keep the field constant



2 Direction of induced current

b Lenz's law



In both cases, magnet moves **against a force**.

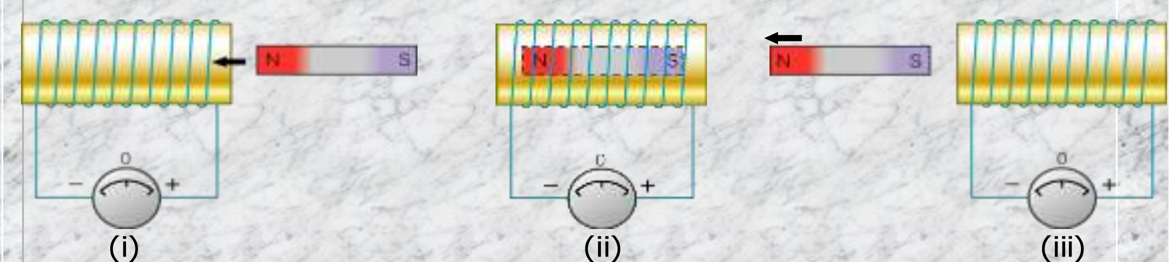
Work is done during the motion & it is transferred as electrical energy.

Induced *I* always flows to oppose the movement which started it.

Example 1

Current induced along a coil

A bar magnet passes through a coil:

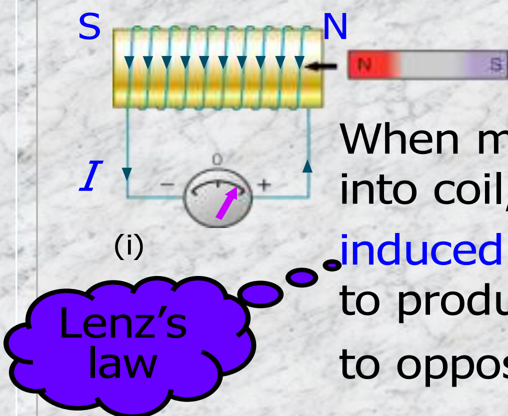


(a) Indicate the direction of the induced *I* in each case. Explain briefly.

Example 1

Current induced along a coil

(a) Indicate the direction of the induced I. Explain.



(i)

When magnet's N-pole is moving into coil,

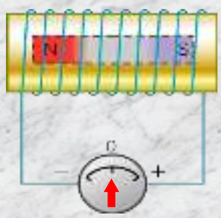
induced I flows in such a direction as to produce a N-pole

to oppose the approaching of magnet.

Example 1

Current induced along a coil

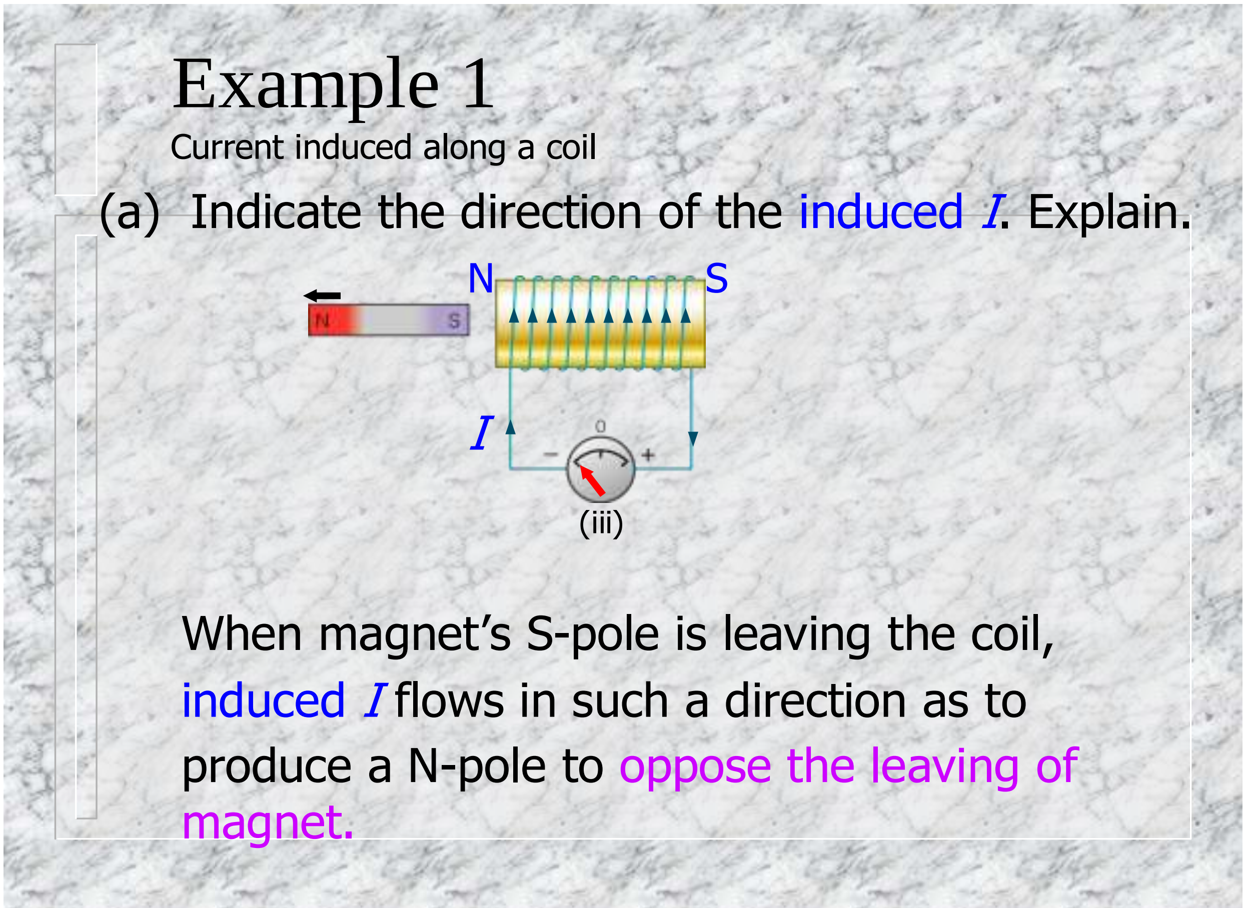
(a) Indicate the direction of the induced I. Explain.



(ii)

The induced I become zero

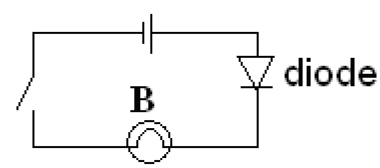
∵ I is about to change direction.



HOW A DIODE FUNCTIONS IN A CIRCUIT

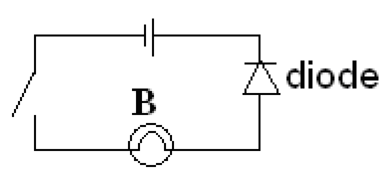
Materials: cells in a holder (2), switch, bulb (3 volts), connecting wires (4) and diode

Procedure: a. connect a circuit as shown below:



b. close the switch and note whether the bulb gives light or not and record the results in the table of results

c. open the switch and connect the diode with its terminals reversed as shown below.



d. repeat step (b)

TABLE OF RESULTS

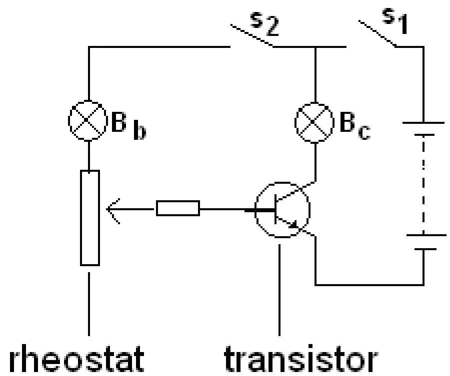
Connection	effect on bulb
Diode connected band facing the cathode	
Diode connected band facing the anode reverse way	

If the bulb gives light, it means the diode is connected in a forward bias way, and if it does not give light, the diode is connected in a reverse bias way. Hence the forward bias way is the way to connect a diode.

HOW A TRANSISTOR FUCTIONS IN A CIRCUIT (I)

Materials: transistor, cells (3) in a holder, bulb (3V), Rheostat, 10kΩ or slightly lower, ammeter, connecting wires (9) or connecting wires, switch.

Procedure: a. connect the transistor, cells, bulb, rheostat and ammeter in the circuit as illustrated below:



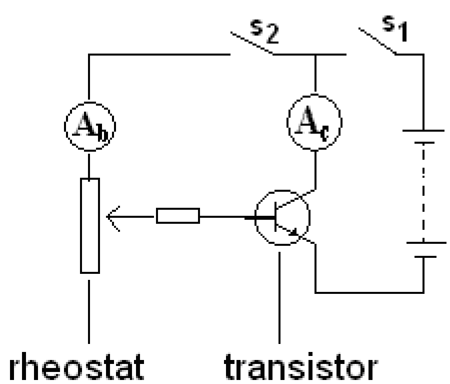
b. close S_1 and observe if bulb Bc gives light. Record the observation in the table of results
c. close S_2 and observe if Bb and Bc give light. Record the observation in the table of results
d. adjust the rheostat (decrease the length of the resistor) to decrease the resistance until something happens to Bc. Record the observation in the table of results.

- When S_1 is closed, both Bb and Bc will not give light
- When both S_1 and S_2 are closed, again both Bb and Bc will not give light
- When the rheostat is adjusted, Bc will give light but Bc will not. This is so because there is need of a small base current to ignite the collector current. The base current is so small that it is unable to light Bb.

HOW A TRANSISTOR FUCTIONS IN A CIRCUIT(II)

Materials: transistor, cells (3) in a holder, bulb (3V), Rheostat, 10kΩ or slightly lower, ammeter, connecting wires (9) or connecting wires, switch.

Procedure: a. connect the transistor, cells, bulb, rheostat and ammeter in the circuit as illustrated below:



b. close S_1 and note the readings on both A_b and A_c. Record the readings in the table of results
c. close S_2 and again note the readings on both A_b and A_c. Record the readings in the

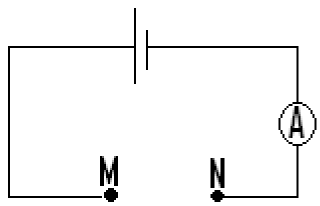
table of results.
d. adjust the rheostat until the reading on A_b is slightly beyond zero. Note the reading on A_c and record in the table of results.
e. repeat step (d) for the following readings on A_b. Record the corresponding readings on A_c: readings of 0.01A, 0.05A, 0.10A.
f. conclude on the relationship between the readings on A_b and A_c.

The expected observation is that the base current ignites the collector current e.g. the collector current can be x10 the base current i.e. a small current input results in a large current output . This is why a transistor is said to be a current amplifier

IDENTIFYING A DIODE, INSULATOR AND A RESISTOR

Materials: Unknown components labelled W, X and Y; connecting wires (4), DC power supply (2 cells in a holder are ideal), ammeter.

Procedure: a. set up the apparatus as shown below



b. connect a normal connecting wire on the gap MN
c. record the ammeter reading.
ammeter reading_________________
d. remove the wire and replace it with component W
e. record the ammeter reading in the space below.
ammeter reading ________________
f. exchange the terminals of W and record the ammeter reading in the space below
ammeter reading _________________
g. repeat steps (d) to (e) with components X and Y
h. according to the ammeter readings, put a tick or a cross where applicable in the table below:

TABLE OF RESULTS

COMPONENT	OBSERVATIONS		
	Allows current to pass in one direction	Reduces current	Does not allow current to pass
W			
X			
Y			

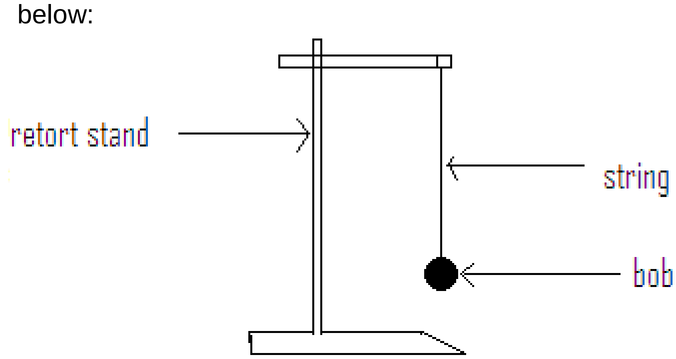
- if it allows current to pass through in one direction only, it is a diode
- if it reduces current, it is a resistor
- if it does not allow current to pass through, it is an insulator

8 OSCILLATIONS AND WAVES

INVESTIGATING THE EFFECT OF LENGTH ON FREQUENCY OF A VIBRATING PENDULUM

Materials: Stop watch, a string, bob, clamp and clamp stand, ruler

Procedure: a. set up a pendulum such that the string is 50cm long as illustrated in the diagram below:



b. pull the bob sidewards by a small amount (about 15cm) and release it to oscillate; start the stop watch at once.

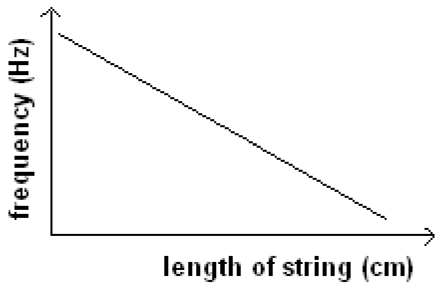
c. note the time taken for 10 oscillations (cycles) and record in the table of results
d. calculate the period (T) and frequency (f) of the oscillations and record it in the table
e. maintaining the amplitude and the mass of the bob, repeat steps (b) to (d) with the following lengths of the string 40cm, 30cm, 20cm, 10cm

TABLES OF RESULTS

Length of string (cm)	Time for 20 oscillations (s)	Period (T), (s)	Freq. (f)
50			
40			
30			
20			
10			

If the frequency changes as the length of the string is changed, it means that there is an effect of the length on the frequency of an oscillating pendulum. In fact, as the length of the string increases, the frequency decreases. To visualize the relationship clearly, a graph of frequency against length of the string (cm) can be drawn

The graph will look like the one below



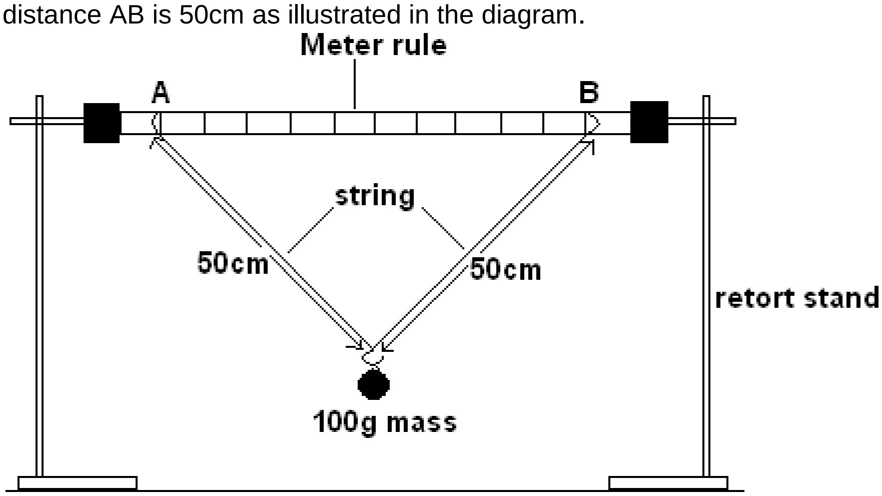
A graph showing the indirect relationship between the length of the string and the frequency of the oscillating pendulum

INVESTGATING THE EFFECT OF THE ANGLE BETWEEN STRING ARMS ON FREQUENCY OF AN OSCILLATING PENDULUM

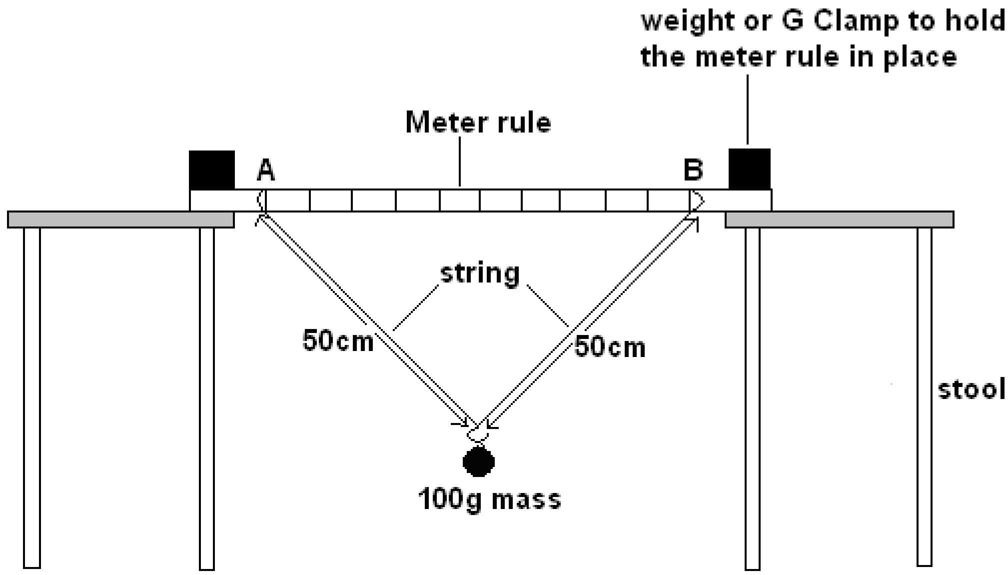
Materials: meter rule (1), mass (100g), a string, stop watch and means of mounting a ruler.

Procedure: a. Mount the ruler between two retort stands as shown in figure 1. If you do not have retort stands then fix the ruler with a G-clamp or weights between two stools as shown in figure 2.

b. Suspend the 100g mass using a string such that the string arms are 50cm long and distance AB is 50cm as illustrated in the diagram.



If there are no clamp stands, stools and weights can be used as shown below



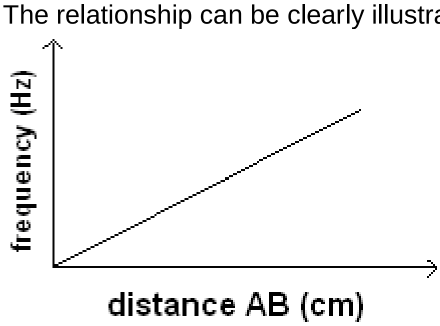
c. Pull the mass outward by a small amount and release it to oscillate.
d. Measure the time for 10 complete oscillations and write it down in the appropriate space in the table of results below.
e. Calculate the period (T) of oscillation and record it in the table.
f. maintaining the length of the string arms and the amplitude, repeat steps (c) to (e) when distance AB is 40 cm, 30 cm, 20 cm and 10cm.

TABLE OF RESULTS

Distance AB	Time for 10 oscillations (s)	Period (T) = Time/10 (s)
50		
40		
30		
20		
10		

g. Plot a graph of period against distance AB.
h. From the graph find the distance AB which gives a period of 1.0 s.
i. From the graph again, determine the effect of length of string arms on the frequency of the oscillating pendulum

If the frequency changes as the distance AB is changed, it means that the distance in question has an effect on frequency. In fact, when the distance is decreased, the frequency will also decrease i.e. the distance is directly proportional to frequency. The relationship can be clearly illustrated using a graph as shown below

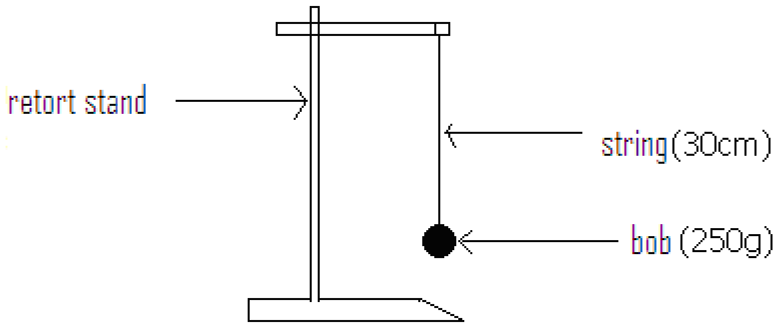


It also stands to reason that as distance AB decreases, the angle between the string arms also decreases; hence as the angle between the string arms decreases, the frequency also decreases i.e. the angle between the string arms is directly proportional to frequency.

INVESTIGATING THE EFFECT OF MASS ON FREQUENCY OF AN OSCILLATING PENDULUM

Materials: Stop watch, Masses (250g, 200g, 150g, 100g, 50g,), clamp, Clamp stand, string

Procedure: a. clamp the ruler to the bench as illustrated in the diagram below:



b. pull the mass sidewards by a small amount (about 15cm) and release it to oscillate; start the stop watch at once.

c. note the time taken for 10 oscillations (cycles) and write it down in the space in the table below.

d. calculate the period (T) and frequency (f) of the oscillations and record it in the table

e. maintaining the amplitude and the length of the string, repeat steps (b) to (d) with the following lengths of the masses; 200g, 150g, 100g, 50g.

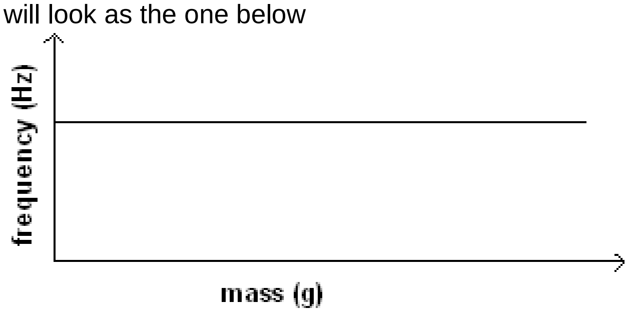
TABLES OF RESULTS

Mass of the bob (g)	Time for 10 oscillations (s)	Period (T), (s)	Freq. (f)
250			
200			
150			
100			
50			

If the frequency changes as the mass is changed, it means that there is an effect of the mass on the frequency of an oscillating pendulum.

Expectedly. as the mass is increased, the frequency will not change. This is so because as the mass increases, weight also increases. Weight is gravitational pull and gravity does not affect the frequency of an oscillating pendulum. To visualize the relationship clearly, a graph of frequency against mass (g) can be drawn

The graph will look as the one below

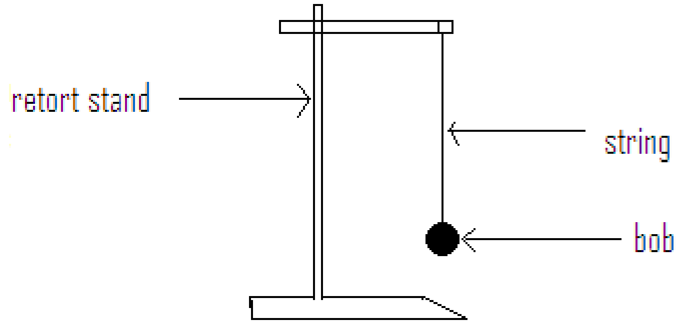


It will be a graph of constant frequency

INVESTIGATING THE EFFECT OF TYPE OF MATERIAL OF STRING ON FREQUENCY OF AN OSCILLATING PENDULUM

Materials: stop watch, strings (heavy and light), clamp, clamp stand, mass (20g).

Procedure: a. clamp the ruler to the bench as illustrated in the diagram below:



b. pull the mass sidewards by a small amount (about 15cm) and release it to oscillate; start the stop watch at once.
c. note the time taken for 10 oscillations (cycles) and write it down in the space in the table below.
d. calculate the period (T) and frequency (f) of the oscillations and record it in the table
e. maintaining the length of the string and the amplitude, repeat steps (b) to (d) with the heavier string.

TABLES OF RESULTS

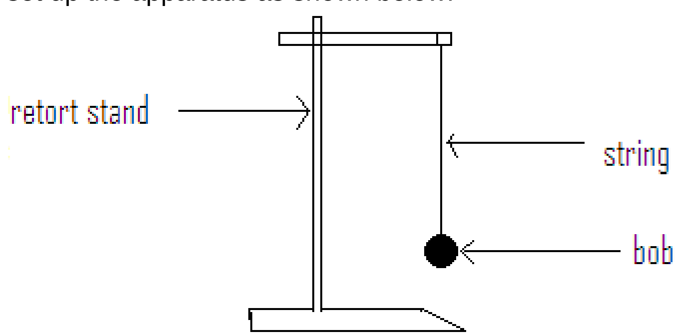
Type of string	Time for 10 oscillations (s)	Period (T), (s)	Freq. (f)
Lighter			
Heavier			

If the frequency changes as the type of string is changed, it means that there is an effect of material on the frequency of an oscillating pendulum. The relationship is 'the lighter the string, the higher the frequency and the heavier the string, the lower the frequency'. This is so because the heavier string is subjected to more air friction, which tends to lower the speed of the oscillating pendulum, than the lighter string.

INVESTIGATING THE EFFECT OF AMPLITUDE ON FREQUENCY OF AN OSCILLATING PENDULUM

Materials: stop watch, mass / bob (20g), clamp, clamp stand, string

Procedure: a. set up the apparatus as shown below:



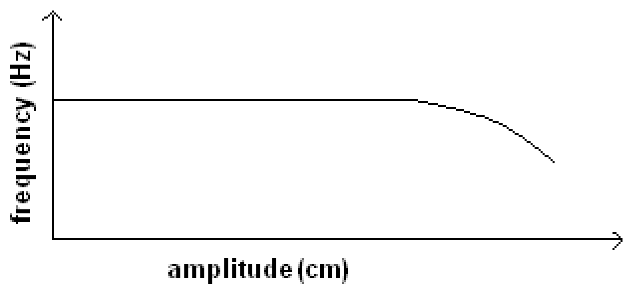
b. pull the mass sidewards by 15cm and release it to oscillate; start the stop watch at once.
c. note the time taken for 10 oscillations (cycles) and write it down in the space in the table below.
d. calculate the period (T) and frequency (f) of the oscillations and record it in the table
e. maintaining the length of the string and the mass at the end of the string, repeat steps (b) to (d) with the following amplitudes 20cm, 25cm, 30cm, 35cm.

TABLES OF RESULTS

Amplitude (cm)	Time for 20 oscillations (s)	Period (T), (s)	Freq. (f)
15			
20			
25			
30			
35			

If the frequency changes as the amplitude is changed, it means that there is an effect of the amplitude on the frequency of an oscillating pendulum. In fact, there will be no change of frequency if there are small changes in amplitude. But if there are appreciable changes in the amplitude, the frequency tends to change too. Therefore the relationship is that frequency decreases with big changes in amplitude.

The graph will look like the one below

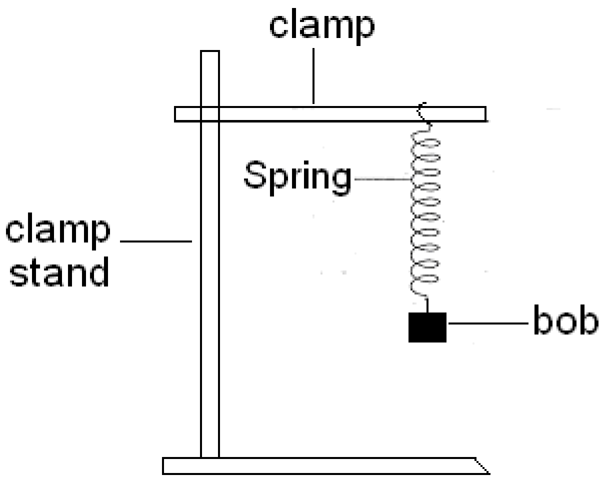


A graph of constant frequency for smaller changes in amplitude and the frequency decreases as the changes become bigger.

INVESTIGATING THE EFFECT OF LENGTH ON FREQUENCY OF AN OSCILLATING SPIRAL SPRING

Materials: Stop watch, spiral springs (20cm, 25cm, 30cm, 35cm), bob, clamp and clamp stand.

Procedure: a. set up the apparatus as shown below



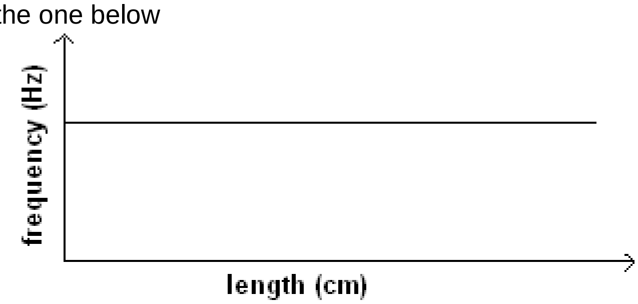
b. pull the bob downwards by 10cm and release it to oscillate; start the stop watch at once.
c. note the time taken for 10 oscillations (cycles) and write it down in the space in the table below.
d. calculate the period (T) and frequency (f) of the oscillations and record in the table.
e. maintaining the amplitude, type of spring and the mass at the end of the spring, repeat steps (b) to (d) with the spiral springs of lengths 25cm, 30cm, 35cm.

TABLES OF RESULTS

Length of spring (cm)	Time for 10 oscillations (s)	Period (T), (s)	Freq. (f)
20			
25			
30			
35			

If the frequency changes as the length of the spring is changed, it means that there is an effect of the length on the frequency of an oscillating spring. Expectedly, there will be no change in the frequency of the oscillating spiral spring as the length is changed. To visualize the relationship clearly, a graph of frequency against length of the spring (cm) can be drawn

The graph will look as the one below

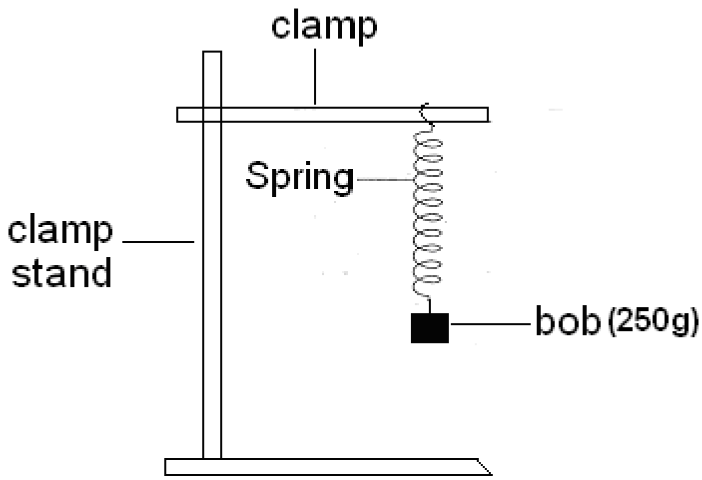


It will be a graph of constant frequency

INVESTIGATING THE EFFECT OF MASS ON FREQUENCY OF AN OSCILLATING SPIRAL SPRING

Materials: stop watch, masses (250g, 200g, 150g, 100g, 50g,), clamp, clamp stand, spiral spring.

Procedure: a. set up the apparatus as shown below:



b. pull the mass downwards by 10cm and release it to oscillate; start the stop watch at once.
c. note the time taken for 10 oscillations (cycles) and write it down in the space in the table below.
d. calculate the period (T) and frequency (f) of the oscillations and record in the table
e. maintaining the amplitude, the type of material and the length of the spring, repeat steps (b) to (d) with the following masses, 200g, 150g, 100g and 50g.

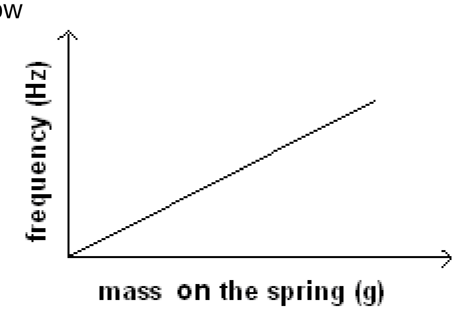
TABLES OF RESULTS

Mass (g)	Time for 10 oscillations (s)	Period (T), (s)	Freq. (f)
250			
200			
150			
100			
50			

If the frequency changes as the mass of the spring is changed, it means that there is an effect of the mass on the frequency of an oscillating pendulum. The relationship is that as mass of the spring increases, the frequency will also increase.

To visualize the relationship clearly, a graph of frequency against mass of the spring can be drawn

The graph will look like the one below

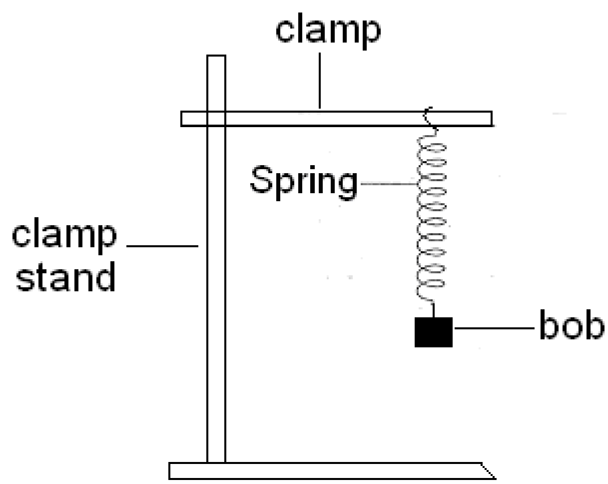


A graph showing the direct relationship between mass and the frequency of the oscillating spiral spring.

INVESTIGATING THE EFFECT OF TYPE OF MATERIAL OF SPRING ON FREQUENCY OF AN OSCILLATING SPIRAL SPRING

Materials: Stop watch, spiral springs (spring constant 0.5N/cm, spring constant 1.0N/cm, spring constant 1.5N/cm , spring constant 2.0N/cm), clamp, clamp stand and bob / mass (50g).

Procedure: a. Set up the apparatus as shown below:



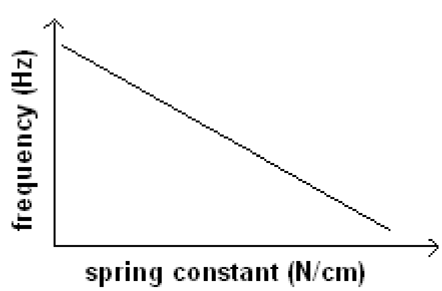
b. Pull the mass downwards by 10cm and release it to oscillate; start the stop watch at once.
c. Note the time taken for 20 oscillations (cycles) and write it down in the space in the table below.
d. Calculate the period (T) and frequency (f) of the oscillations and record it in the table
e. Maintaining the length of the spring, the mass at the end of the spring and the amplitude, repeat steps (b) to (d) with the heavier string.

TABLES OF RESULTS

Spring constant (N/cm)	Time for 20 oscillations (s)	Period (T), (s)	Freq. (f)
0.5			
1.0			
1.5			
2.0			

If the frequency changes as the type of spring is changed, it means that there is an effect of the type of material on the frequency of an oscillating spring. The relationship is that as the spring constant of the spring increases, the frequency of the oscillating spring decreases. This is so because as the spring constant of the spring increases the spring becomes stiffer (not flexible to stretch appreciably). To visualize the relationship clearly, a graph of frequency against length of the spring (cm) can be drawn

The graph will look like the one below

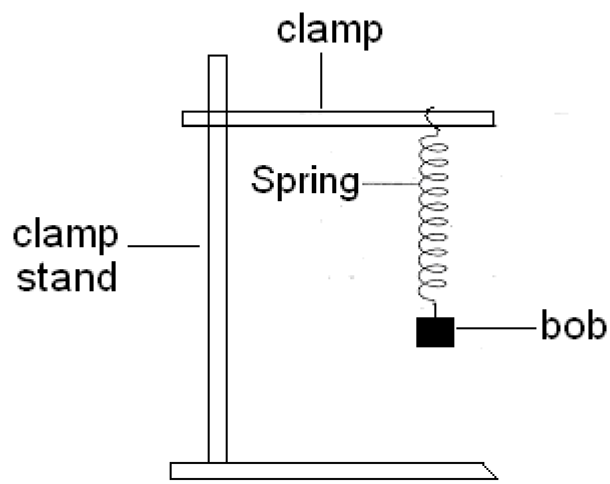


A graph showing the indirect relationship between the type of material of the spring (spring constant) and the frequency of the oscillating spiral spring.

INVESTIGATING THE EFFECT OF AMPLITUDE ON FREQUENCY OF AN OSCILLATING SPIRAL SPRING

Materials: stop watch, mass (bob), clamp, clamp stand, spiral spring

Procedure: a. set up the apparatus as shown below:



b. pull the mass downwards by 5cm and release it to oscillate; start the stop watch at once.
c. note the time taken for 10 oscillations (cycles) and write it down in the space in the table below.
d. calculate the period (T) and frequency (f) of the oscillations and record in the table
e. maintaining the length of the spring, the type of material of the spring and the mass at the end of the spring, repeat steps (b) to (d) with the following amplitudes 10cm, 15cm, 20cm.

TABLES OF RESULTS

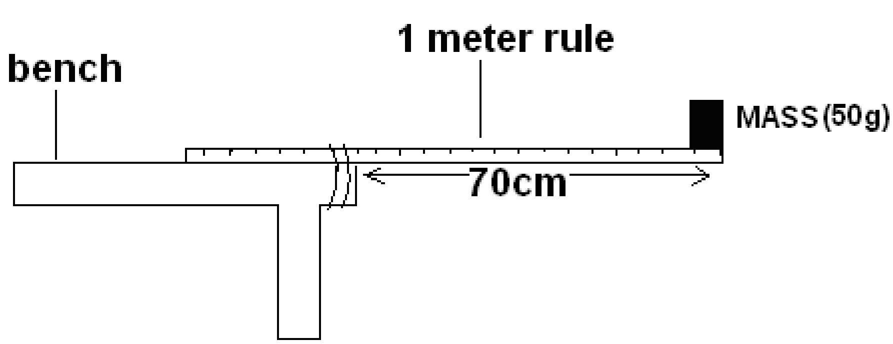
Amplitude (cm)	Time for 10 oscillations (s)	Period (T), (s)	Freq. (f)
5			
10			
15			
20			

If the frequency changes as the amplitude is changed, it means that there is an effect of the amplitude on the frequency of an oscillating spiral spring. Expectedly, the amplitude will not affect the frequency of the oscillating spiral spring.

INVESTIGATING THE EFFECT OF LENGTH ON FREQUENCY OF AN OSCILLATING CANTILEVER

Materials: stop watch, piece of string (for fixing the mass at the end of the cantilever), bob / mass, G-clamp, meter rule and a bench.

Procedure: a. Clamp the ruler to the bench such that the mass is 70cm away from the bench as illustrated in the diagram below:



b. Pull the bob downwards by 10cm and release it to oscillate; start the stop watch at once.
c. Note the time taken for 10 oscillations (cycles) and write it down in the space in the table below.
d. Calculate the period (T) and frequency (f) of the oscillations and record it in the table
e. maintaining the mass at the end of the cantilever, the type of material of the

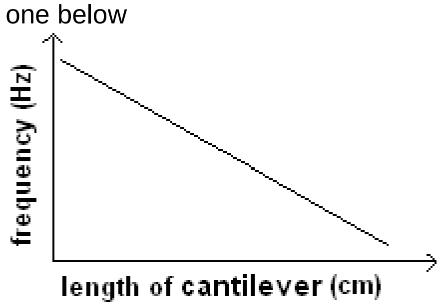
cantilever and the amplitude, repeat steps (b) to (d) with the following lengths of the ruler (distance of the mass from the bench); 60cm, 50cm, 40cm, 30cm.

TABLES OF RESULTS

Length of ruler (cm)	Time for 10 oscillations (s)	Period (T), (s)	Freq. (f)
70			
60			
50			
40			
30			

If the frequency changes as the length of the cantilever is changed, it means that there is an effect of the length on the frequency of an oscillating cantilever. In fact, the relationship is that as the length of the cantilever is decreased, the frequency increases i.e. the length of the cantilever is inversely / indirectly proportional to the frequency of the oscillating cantilever. This is so because the longer cantilever is exposed to more air resistance, which tends to slow down the movement of the cantilever. To visualize the relationship clearly, a graph of frequency against length of the cantilever (cm) can be drawn

The graph will look like the one below

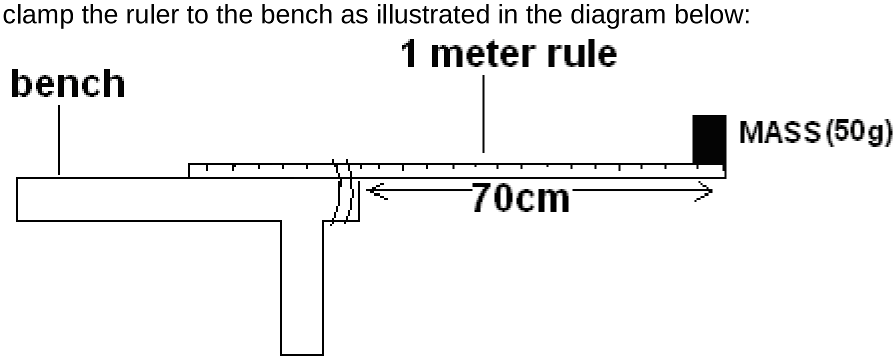


A graph showing the indirect relationship between length of the cantilever and the frequency of the oscillating cantilever.

INVESTIGATING THE EFFECT OF MASS ON FREQUENCY OF AN OSCILLATING CANTILEVER

Materials: stop watch, masses (250g, 200g, 150g, 100g, 50g), bench, G-clamp, meter rule and a piece of string (for fixing the mass at the end of the cantilever)

Procedure: a. clamp the ruler to the bench as illustrated in the diagram below:

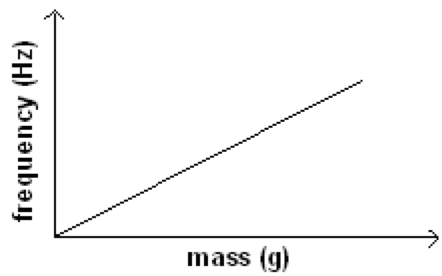


b. pull the mass downwards by 10cm and release it to oscillate; start the stop watch at once.
c. note the time taken for 10 oscillations (cycles) and write it down in the space in the table below.
d. calculate the period (T) and frequency (f) of the oscillations and record in the table
e. maintaining the length of the cantilever, the type of material of the cantilever and the amplitude, repeat steps (b) to (d) with the following masses 40g, 30g, 20g, 10g.

TABLES OF RESULTS

Mass (g)	Time for 10 oscillations (s)	Period (T), (s)	Freq. (f)
50			
40			
30			
20			
10			

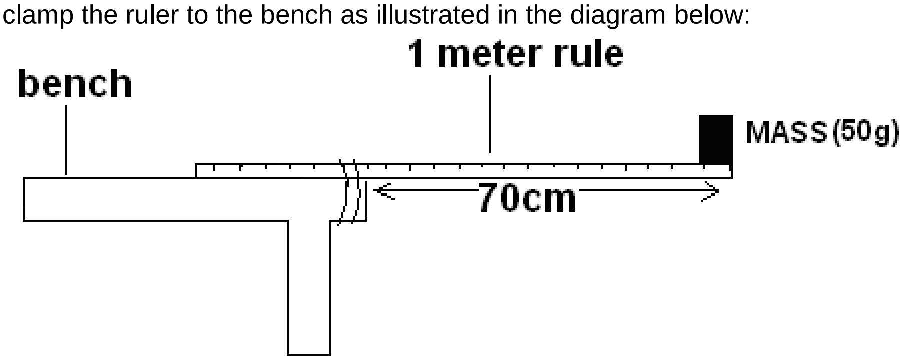
If the frequency changes as the mass at the end of the cantilever is changed, it means that there is an effect of the mass on the frequency of an oscillating cantilever. Expectedly, as the mass is decreased, the frequency also decreases i.e. frequency is directly proportional to the mass at the end of the cantilever. To visualize the relationship clearly, a graph of frequency against the mass at the end of the cantilever can be drawn as shown below



INVESTIGATING THE EFFECT OF TYPE OF MATERIAL OF A CANTILEVER ON ITS FREQUENCY

Materials: stop watch, 2 meter rules (one made of wood and the other made of plastic), G-clamp, a piece of string (for fixing the mass at the end of the cantilever).

Procedure: a. clamp the ruler to the bench as illustrated in the diagram below:



b. pull the mass downwards by 5cm and release it to oscillate; start the stop watch at once.
c. note the time taken for 10 oscillations (cycles) and write it down in the space in the table below.
d. calculate the period (T) and frequency (f) of the oscillations and record in the table
e. maintaining the length of the cantilever, the mass at the end of the cantilever and the amplitude, repeat steps (b) to (d) with the ruler made of wood.

TABLES OF RESULTS

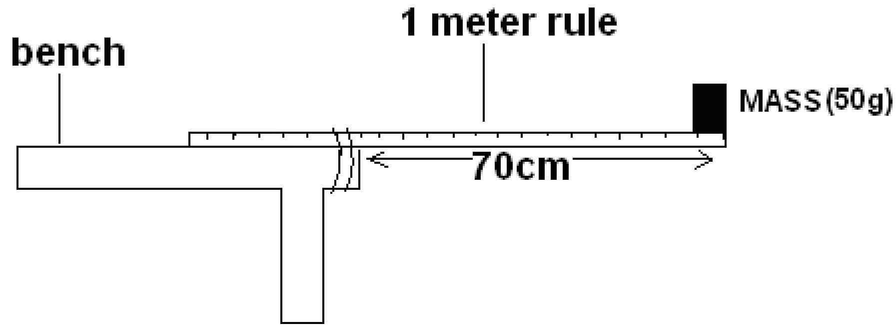
Type of ruler	Time for 10 oscillations (s)	Period (T), (s)	Freq. (f)
Made of plastic			
Made of wood			

If the frequency changes as the type of ruler is changed, it means that the type of material of the cantilever affects its frequency. Expectedly, as the type of ruler is changed, the frequency also changes. Therefore, type of material affects the frequency of an oscillating cantilever.

INVESTIGATING THE EFFECT OF AMPLITUDE ON FREQUENCY OF AN OSCILLATING CANTILEVER

Materials: stop watch, mass / bob, G-clamp, bench, string (for fixing the mass at the end of the cantilever) and a meter rule

Procedure: a. clamp the ruler to the bench as illustrated in the diagram below:



b. pull the mass downwards by 5cm and release it to oscillate; start the stop watch at once.
c. note the time taken for 10 oscillations (cycles) and write it down in the space in the table below.
d. calculate the period (T) and frequency (f) of the oscillations and record it in the table
e. maintaining the length of the cantilever, the type of material of the cantilever and the mass at the end of the cantilever, repeat steps (b) to (d) with the following amplitudes 10cm, 15cm, 20cm.

TABLES OF RESULTS

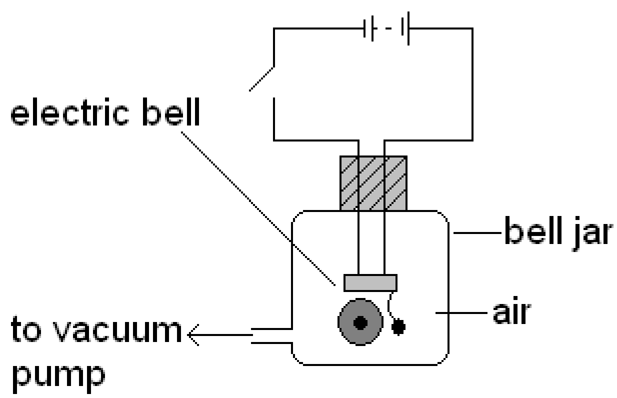
Amplitude (cm)	Time for 10 oscillations (s)	Period (T), (s)	Freq. (f)
5			
10			
15			
20			

If the frequency changes as the amplitude is changed, it means that there is an effect of the amplitude on the frequency of an oscillating cantilever. Expectedly, there will be no effect of the amplitude on the frequency of the cantilever.

WHETHER SOUND WAVES REQUIRE A MEDIUM FOR THEIR PROPAGATION

Materials: an electric bell, bell jar

Procedure: a. set up the apparatus as shown below



b. switch on the electric bell and observe what happens (if the sound is heard or not) and record the results in the table of results
c. pump the air out of the bell jar gradually, observe what happens (what is happening to intensity of the sound)
d. observe what happens when all the air has been pumped out of the bell jar and record in the table of results.

TABLE OF RESULTS

CONDITION	OBSERVATION (WHETHER SOUND IS HEARD OR NOT)
When there is air inside the bell jar	
When all the air has been pumped out of the bell jar	

If sound is heard when there is air in the bell jar and is not heard when there is no air in the bell jar, it means that sound can not travel in a vacuum. This means that sound needs a medium for its propagation.

INVESTIGATING THE DIFFERENCES BETWEEN THE SPEEDS OF TWO SOUNDS TRAVELING THROUGH DIFFERENT MEDIA (METAL AND AIR)

Materials: meter rule and stop watch

Procedure: a. measure the length of the pipe using the ruler provided
b. let the student at A bang the pipe and start the stop watch at once.
c. stop the stop watch when the first sound is heard and record the time taken for the sound to travel.
d. repeat steps (b) and (c) for the second sound.

TABLE OF RESULTS

	Time taken (s)
First sound	
Second sound	

e. calculate the speed of the first sound using the formula:

speed = length of pipe (m) / time taken(s)

f. calculate the speed of the second sound using the same formula used in (e).
g. compare the time taken for the two sounds to travel

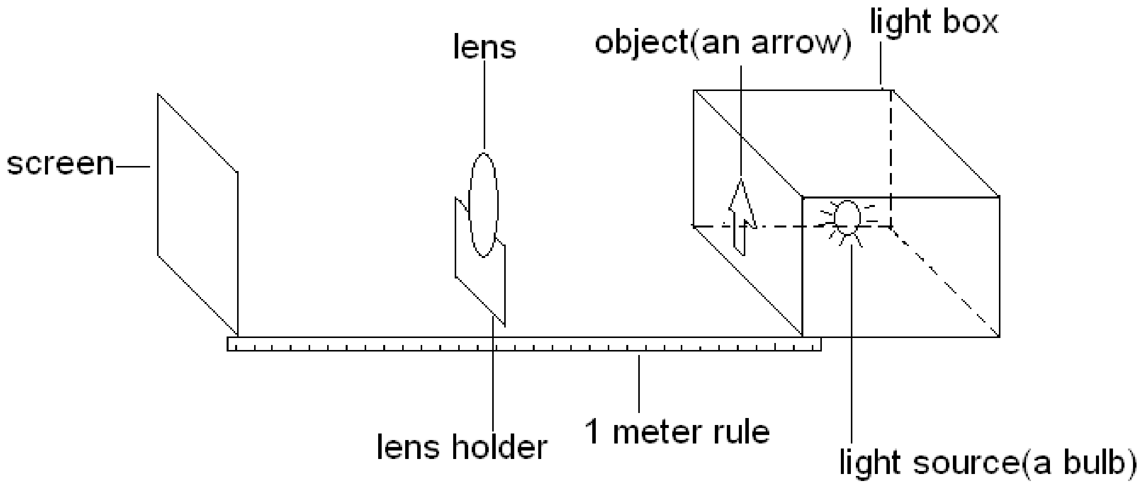
One sound will travel through the metal (pipe) and the other will travel through the spaces around the pipe i.e. air.

It is expected that the speed of the sound traveling through the metal will be higher than the speed of the sound traveling through the air. This is so because the particles responsible for the transmitting of the sound are tightly packed in metals than in air

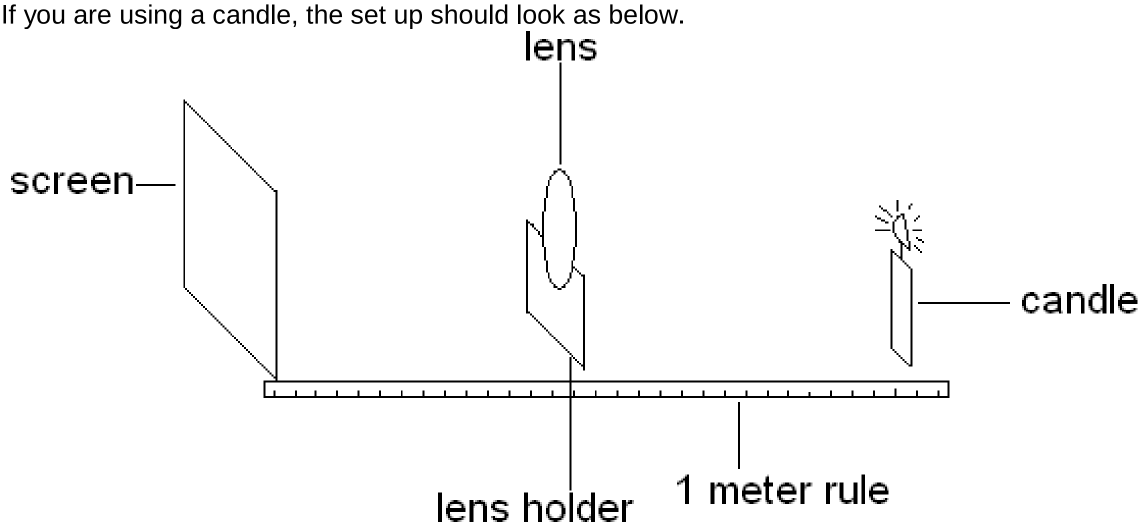
DETERMINING THE FOCAL LENGTH OF CONVERGING LENS USING GRAPH METHOD (1)

Materials: convex lens in a holder, meter rule, white screen, candle and matches/ light box.

Procedure: a. arrange the apparatus as shown below:



If you are using a candle, the set up should look as below.



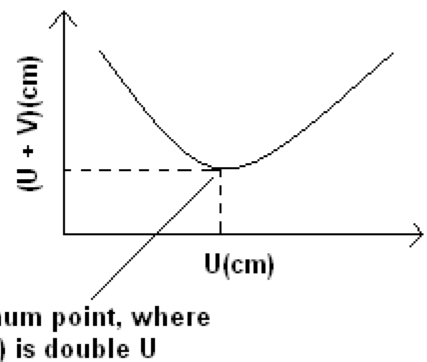
b. light the candle/switch on the light box
c. adjust the lens such that the object distance is 30cm.
d. move the screen until a sharp image is formed.
e. measure and record the image distance in the table of results.
f. repeat steps (c) to (e) for object distances shown in the table of results.
g. find the values of (U + V), and complete the table.

TABLE OF RESULTS

Object distance (cm)	Image distance (cm)	U + V (cm)
30		
40		
50		
60		

To find the focal length of the converging lens

- a graph of (U + V) against U should be drawn and is normally shaped like the one shown below

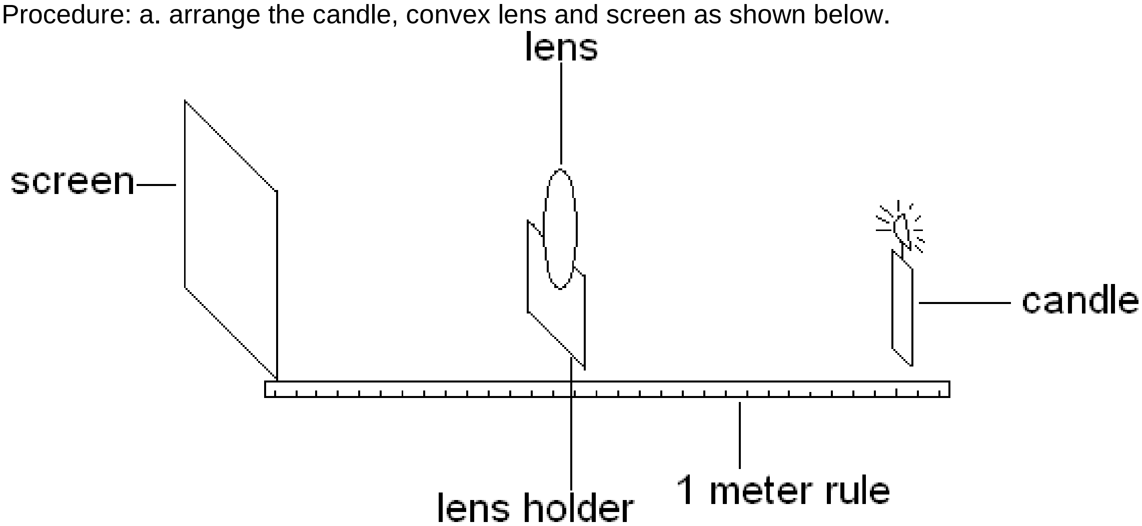


- at the minimum point of the graph, (U + V) is double U and this means that at that point, U = V and this happens when the object is at 2F i.e U = 2F and the image is also at 2F i.e. V = 2F
- to find the focal length, the U or V at that minimum point is divided by 2 or (U + V) is divided by 4 i.e. F= U / 2 or V / 2 or (V + U) / 4

DETERMINING FOCAL LENGTH OF A CONVERGING LENS USING GRAPH METHOD (2)

Materials: a candle, matches, a lens holder, convex lens, a white screen and a meter rule.

Procedure: a. arrange the candle, convex lens and screen as shown below.



b. light the candle
c. with the candle at 22.5 cm from the lens, produce a well focussed image of the flame on the screen.
d. measure and record the image distance in the table of results.
e. repeat steps (c) and (d) for the object distances shown in the table.

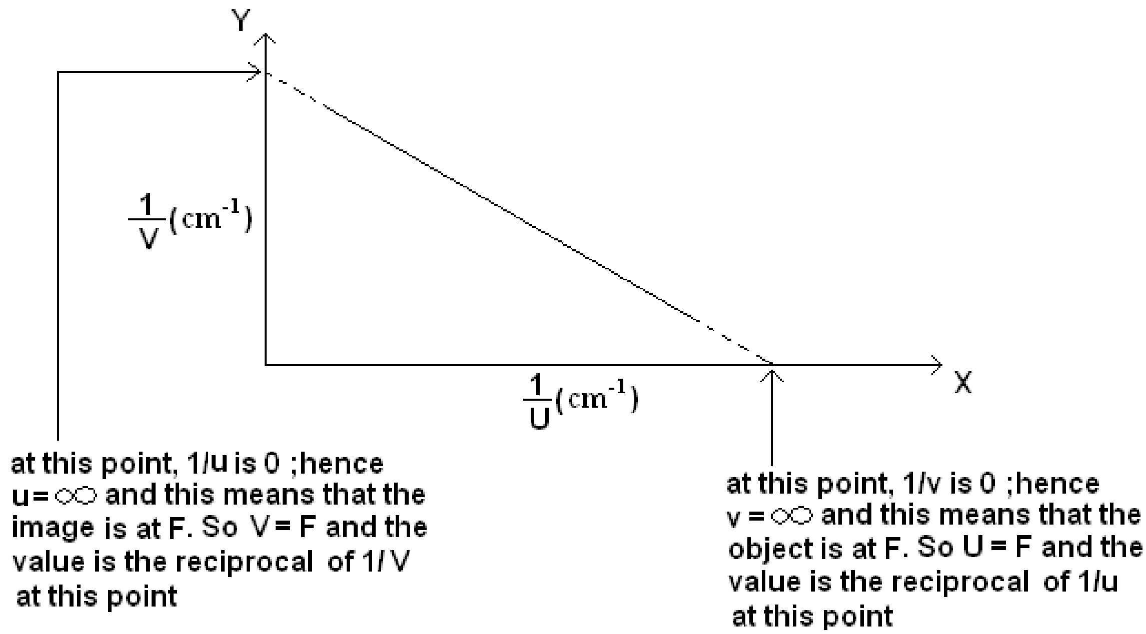
TABLE OF RESULTS

Object distance (cm),U	Image distance (cm), V	1/U	1/V
22.5			
28.0			
37.5			
45.0			
52.5			

b. draw a graph of 1/V against 1/U.

c. extrapolate the graph to X and Y axes
d. Using the coordinates on the axes, find the focal length of the converging lens.

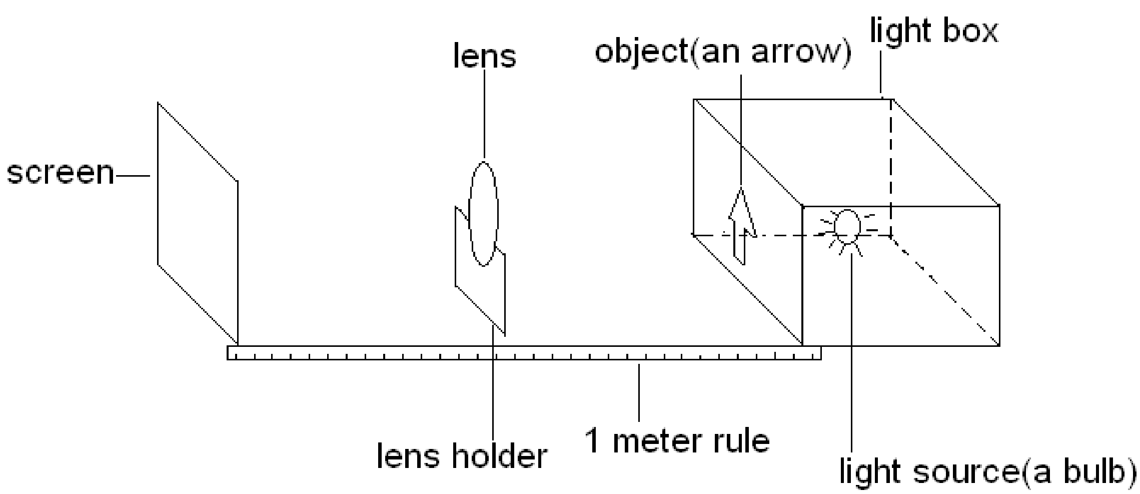
The graph will look like the one shown below



DETERMING FOCAL LENGTH OF CONVERGING LENS USING GRAPH METHOD (3)

Materials: a candle, matches, a lens holder, convex lens, a white screen and a meter rule.

Procedure: a. arrange the candle, convex lens and screen as shown below.



b. measure the height of the object (arrow)
c. light the bulb
d. with the object at 35cm from the lens, produce a well focussed image of the arrow on the screen.
e. measure and record the image distance in the table of results.
f . measure and record the image height in the table of results
g. repeat steps (d) to (f) for the object distances shown in the table.

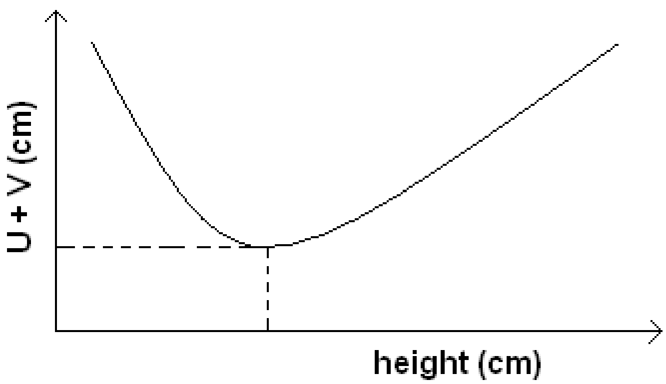
TABLE OF RESULTS

Object distance, U	Image distance, V	Distance between the object	Height of the

(cm)	(cm)	and the screen (U + V)	image, h_i
40			
35			
30			
25			
20			

f. draw a graph of image distance + object distance (V + U) against image height (h_i).
g. using the graph, find the focal length of the converging lens.

Expectedly, the graph will look like the one shown below

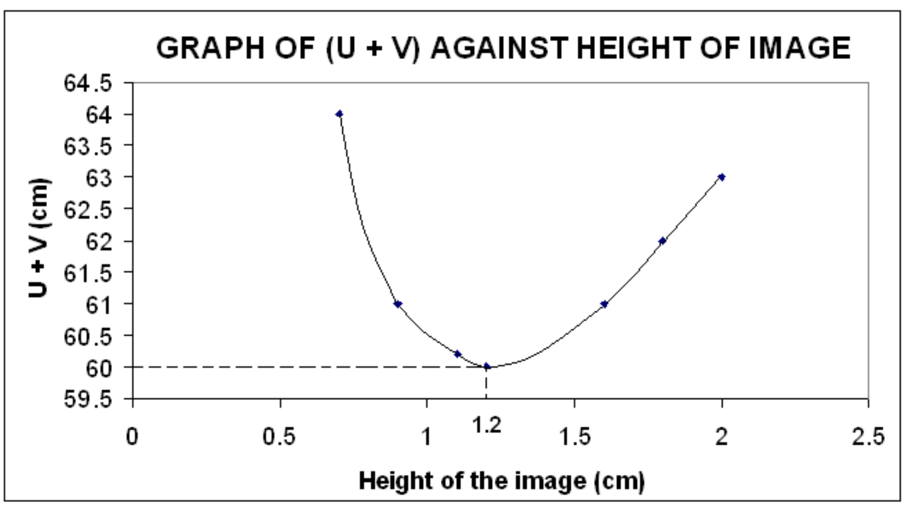


- At the minimum point of the graph, $h_i = h_o$
- This occurs when the object is at 2F
- V will, therefore, be equal to U
- When V and U are equal, V = 2F and U = 2F; hence U + V = 4F
- Therefore, the focal length, F = (V + U) / 4

An example is given below:

Given that ho = 1.2cm

hi	U + V
2	63
1.8	62
1.6	61
1.2	60
1.1	60.2
0.9	61
0.7	64

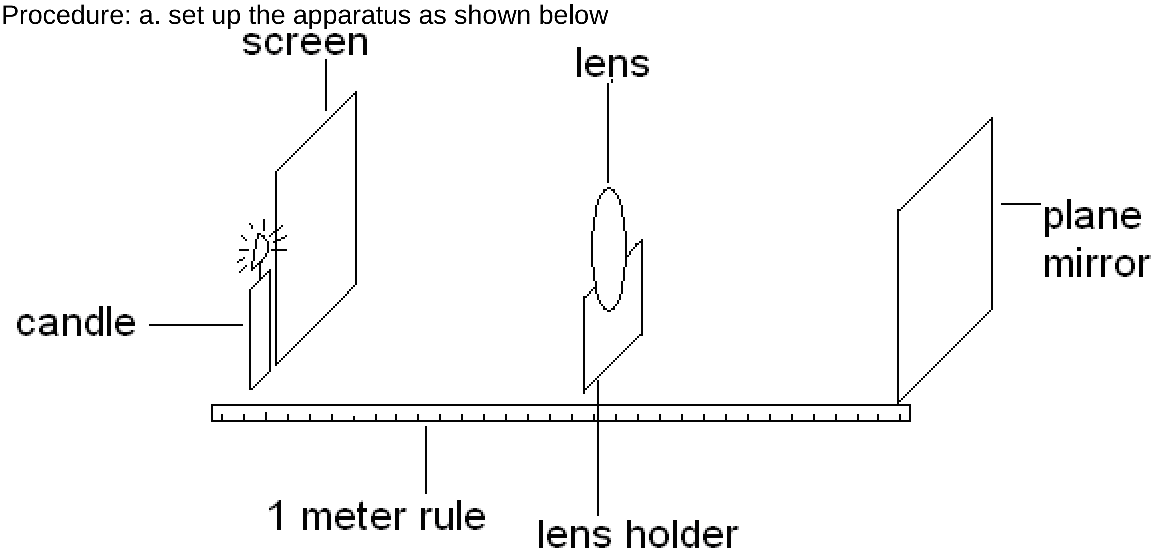


- h_o is 1.2cm; hence at the minimum point, h_i is also 1.2cm as shown in the table above
- this occurs when the object is at 2F
- therefore V = U, V = 2F and U = 2F; hence U + V = 4F = 60cm
- therefore, the focal length, F = (U + V) / 4 = 60cm / 4 = 15cm

DETERMINING FOCAL LENGTH OF A CONVERGING LENS USING MIRROR METHOD

Materials: plane mirror, a converging lens, ruler, light source, object, screen.

Procedure: a. set up the apparatus as shown below



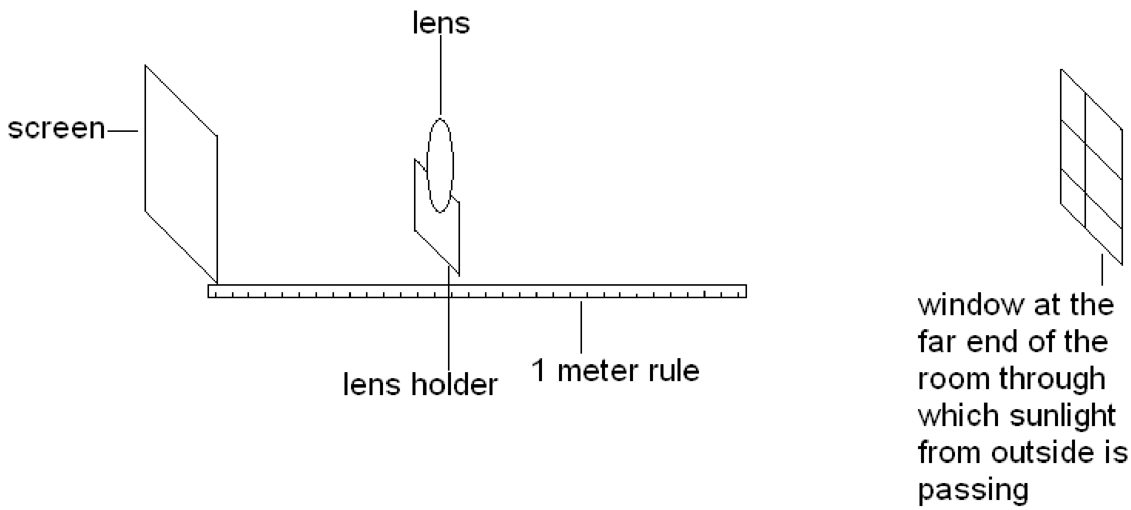
b. adjust the lens until an inverted, sharp image is formed on the screen next to the object.
c. measure the distance between the object/image and the lens.

Note that the distance measured is the focal length.

DETERMINING FOCAL LENGTH OF A CONVERGING LENS USING ROUGH METHOD

Materials: screen, a converging lens, a far object (a window at the far end of a room through which light from the sun is passing can do)

Procedure: a. set up the apparatus as shown below



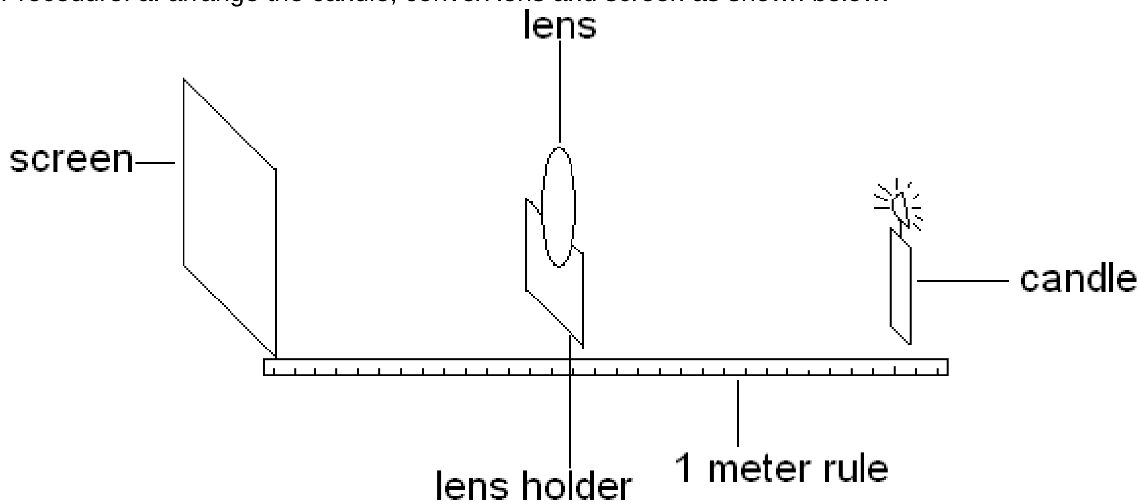
b. adjust the screen until a sharp inverted image of the window is formed.
c. measure the distance between the lens and the screen

Note that the distance measured is the focal length of the converging lens.

INVESTIGATING THE EFFECT OF OBJECT DISTANCE (U) ON IMAGE DISTANCE (V)

Materials: a candle, matches, a lens holder, convex lens, a white screen and a meter rule.

Procedure: a. arrange the candle, convex lens and screen as shown below.



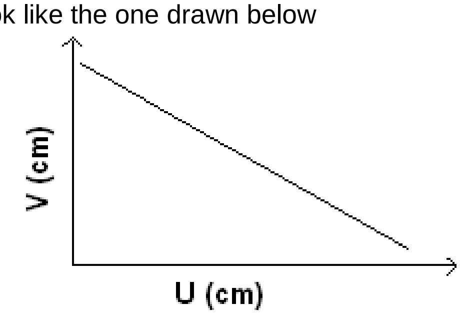
e. light the candle
f. with the candle at 22.5 cm from the lens, produce a well focussed image of the flame on the screen.
g. measure and record the image distance in the table of results.
h. repeat steps (c) and (d) for the object distances shown in the table.

TABLE OF RESULTS

Object distance (cm)	Image distance (cm)
22.5	
28.0	
37.5	
45.0	
52.5	

If the image distance changes as the object distance is changed, it means the object distance has an effect on the image distance. Expectedly, the image distance will be decreasing as the object distance is being increased i.e. the image distance is indirectly/inversely proportional to object distance. To visualize the relationship clearly, a graph of image distance against object distance can be drawn.

The graph will look like the one drawn below



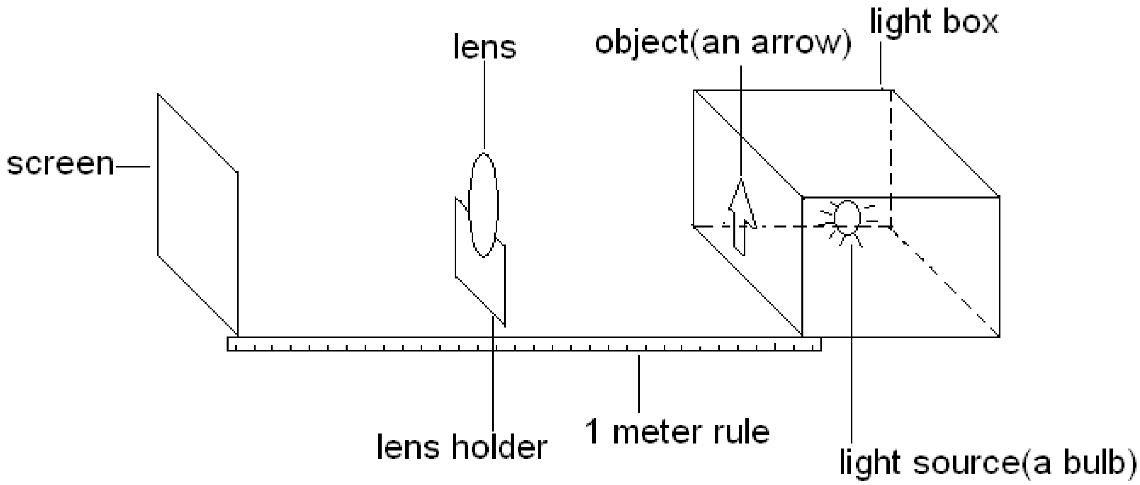
A graph of image distance against object distance.

Using the graph, it is possible to find the distance where the object should be placed (U) to give the image at any distance (V)of interest.

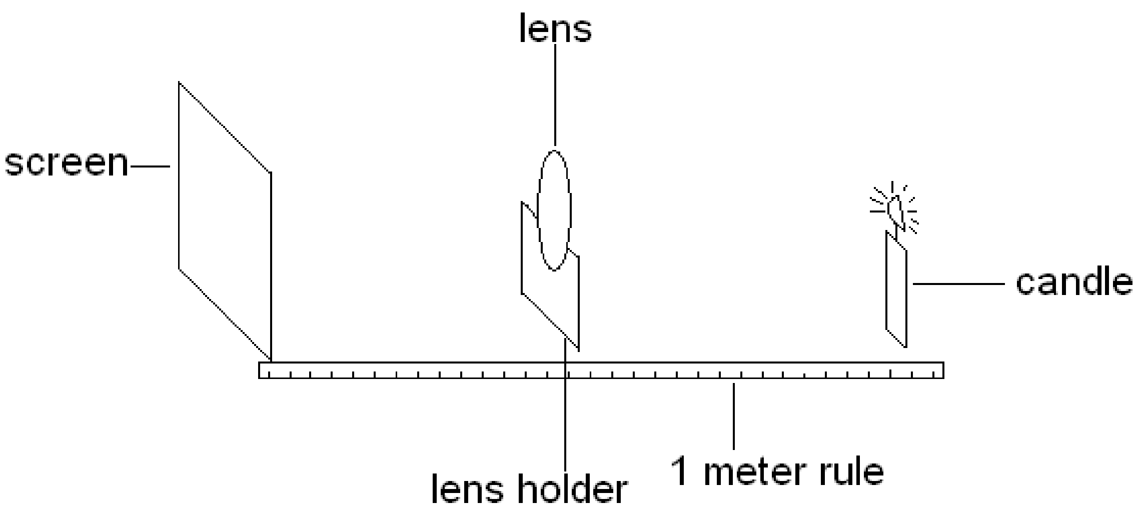
INVESTIGATING THE EFFECT OF OBJECT DISTANCE (U) ON MAGNIFICATION (M)

Materials: a converging lens, a lens holder, an object (candle or an illuminated object), a screen, a meter rule and a matches

Procedure: a. Arrange object (candle or an illuminated object), lens and screen as shown in the diagram below.



If you are using a candle, the set up should look as below.



b. Light the candle or switch on the bulb if you are using an illuminated object.
c. Move the object until it is 20 cm away from the lens.
d. Move the screen until you focus the image of the object.
e. Measure the image distance v from the lens to the screen and record the reading in the table below.
f. Divide image distance (v) by object distance (u) to find the magnification and record your answer in the table of results.
g. Repeat steps (c) to (f) for object distances of 25 cm, 30 cm, 40 cm and 45 cm to complete the table of results.

TABLE OF RESULTS

Object distance u (cm)	Image distance v (cm)	Magnification m = v/u
20		
25		
30		

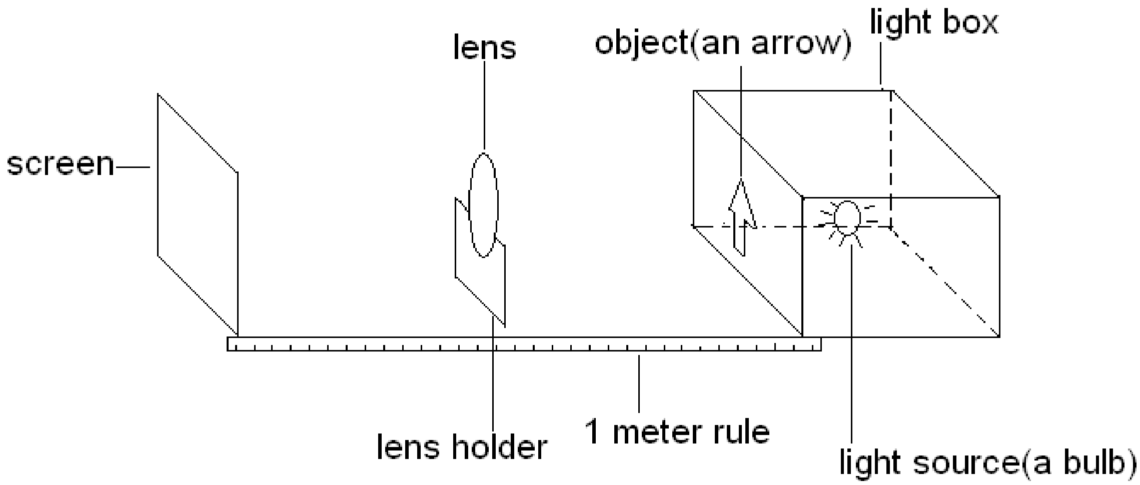
40		
45		

If the magnification changes as the object distance is changed, it means the object distance affects magnification. Expectedly, as the object distance increases, magnification also increases.

INVESTIGATING THE EFFECT OF OBJECT DISTANCE ON POSITION AND CHARACTERISTICS OF THE IMAGE FORMED BY A CONVERGING LENS

Materials: lens of focal length 15cm in a lens holder, white screen, candle / light box, marker / piece of chalk, meter rule, plane white paper.

Procedure: a. set up the apparatus as shown in the figure below.



b. using a ruler, measure 15cm from the centre lens (focal length) on both sides of the lens and mark the 2 points f.
c. measure 30cm from the centre of lens on both sides of the lens and mark the points 2f
d. place the object behind 2f (about 35cm away from the lens)
e. adjust the screen until a sharp image is formed
f. measure the image distance, V, and record in the table of results.
g. repeat steps (d) to (f) with object distances, 2f , between f and 2f, f and between lens and f

TABLE OF RESULTS

OBJECT	IMAGE			
Position	Position	Real or Virtual	Magnified or diminished	Erect/upright or inverted
Behind 2F (35cm from lens)				
2F				
Between f and 2f				
F				
Between lens and F				

Expectedly, the observations will be as follows

OBJECT	IMAGE			
Position	Position	Real or Virtual	Magnified or diminished	Erect/upright or inverted
Behind 2F (35cm from lens)	Between f and 2f	Real	Diminished	Inverted
2F	2f	Real	The same size	Inverted
Between f and 2f	Beyond 2f	Real	Magnified	Inverted

F	Infinity	Virtual	Magnified	Erect
Between lens and F	Behind object	Virtual	Magnified	Erect

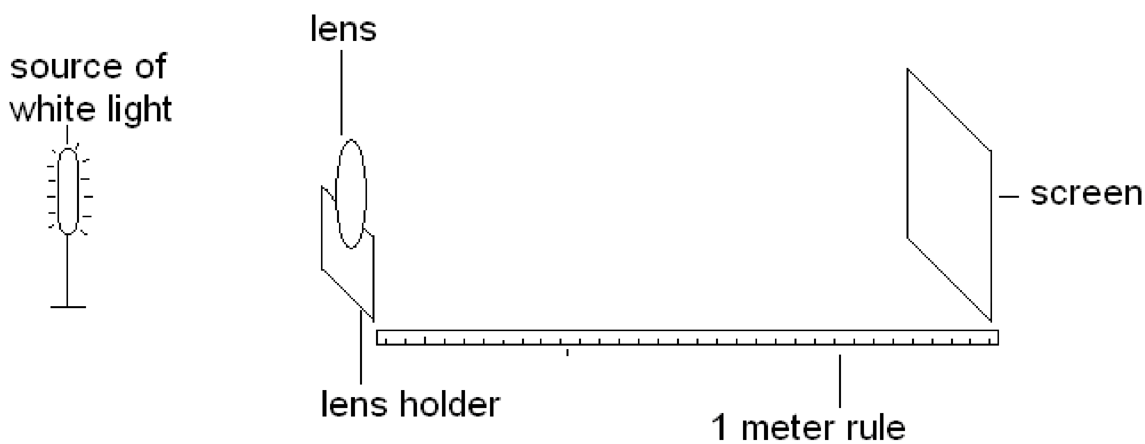
The expected results show that as the object distance, U, increases

- image distance, V, also increases
- magnification, m, also increases
- the image is real and when it goes to infinity, it becomes virtual

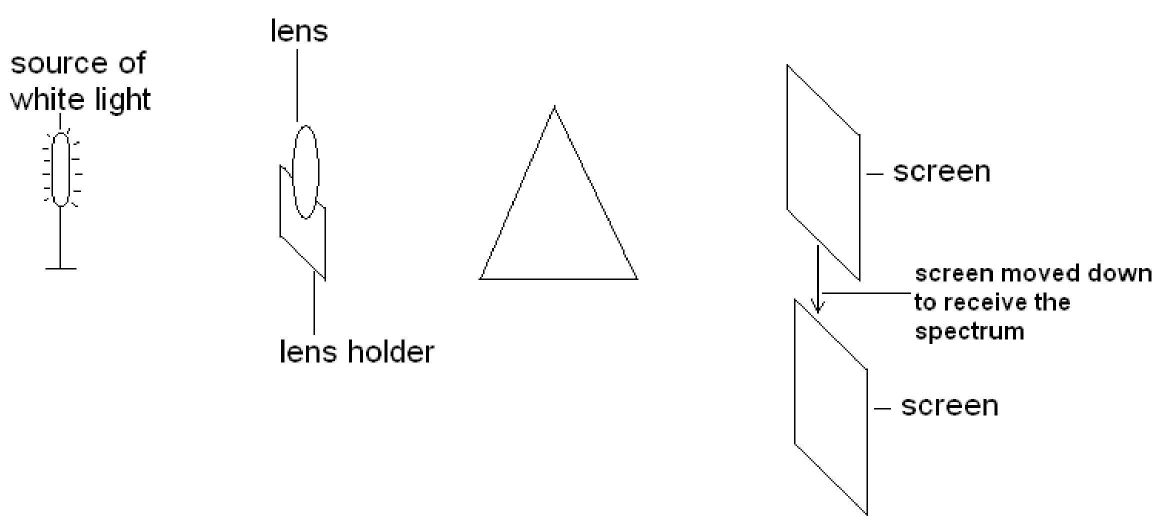
INVESTIGATING HOW A PURE SPECTRUM CAN BE FORMED FROM WHITE LIGHT

Materials: white light source (lamp with vertical filament), converging lens, 60^o prism, white screen and meter rule.

Procedure: a. arrange the lens L, so that it forms an image of the vertical filament of the lamp on the screen at S_1 1 meter away as shown below:



b. insert the prism P, in between the lens and the screen and move the screen keeping the same distance from the lens to receive the spectrum. The set up should be as shown below:



c. rotate the prism until the colours do not overlap. (when the colours do not overlap, the spectrum is said to be pure)

9 NUCLEAR PHYSICS

INVESTIGATING HOW THICKNESS OF SHEET OF PLASTIC CAN BE CONTROLLED DURING MANUFACTURE USING RADIATION

Materials: sources of gamma-rays, beta particles; material used make plastic sheet.

Procedure: a. determine how much each radiation penetrates a sheet of plastic
b. during the manufacture of the sheet of plastic, subject the sheet to the respective radiations depending on how thick you want you want your sheet to be.

The table below can help in choosing the type of radiation to use.

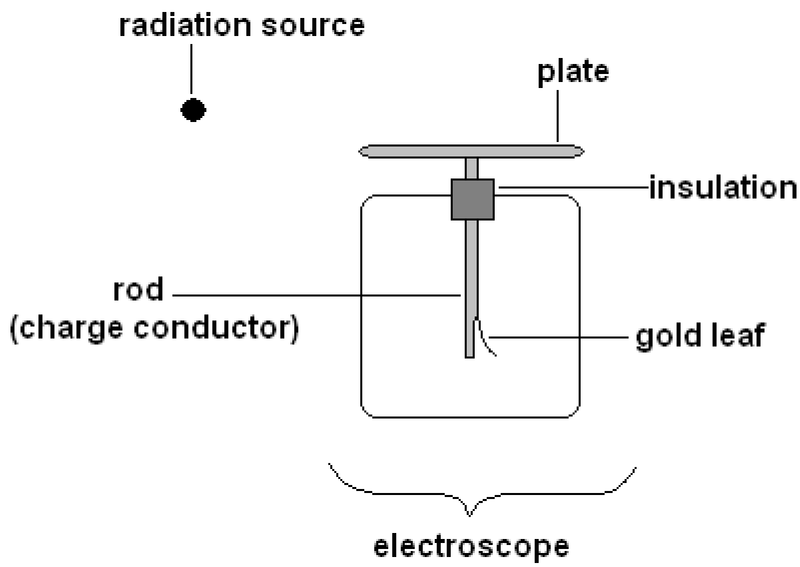
Radiation the sheet is subjected to	**Thickness of plastic sheet**
Gamma radiation	
Beta radiation	

Gamma radiation can pass through a relatively thick sheet but can be stopped by a very thick sheet, hence it can be used to gauge if the sheet is thick enough. On the other hand, beta radiation can pass through a thin sheet of plastic but can be stopped by a relatively thick sheet, hence it can be used to gauge if the sheet is relatively thicker.

IDENTIFYING ALPHA, BETA AND GAMMA RADIATION USING AN ELECTROSCOPE

Materials: 3 different sources of radiation labeled A, B and C (one is alpha radiation source, and the others are beta and gamma radiation sources but not necessarily in that order), gold leaf electroscope

Procedure: a. set up the apparatus as shown below



b. bring radiation source A close to the plate of the electroscope.
c. observe what happens to the gold leaf
d. repeat steps (b) and (c) for the sources of radiation B and C.

TABLE OF RESULTS

Source of radiation	Observation
A	
B	
C	

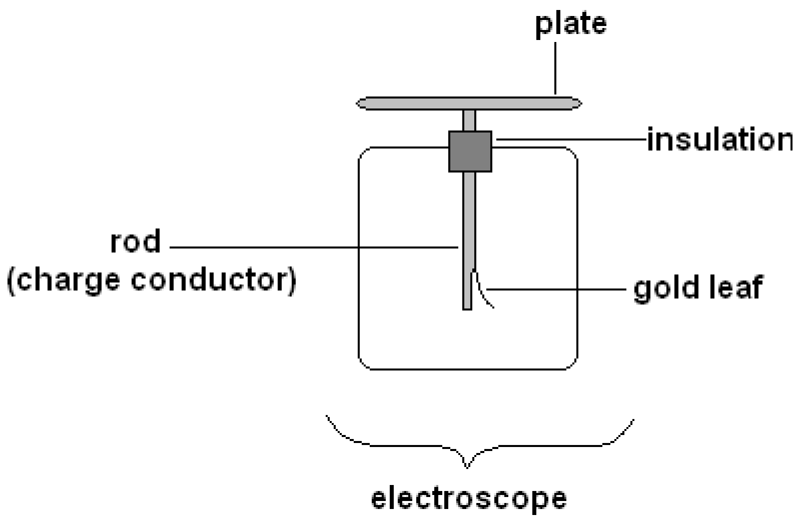
Expectedly, the source is for

- alpha radiation if the gold leaf rises most
- beta radiation if the gold leaf rises more
- gamma radiation if the gold leaf rises the least

The expected results are as shown because alpha particles have the largest charge hence most ionizing. The beta particles have a relatively larger charge hence relatively more ionizing. Gamma rays have no charge hence the least ionizing. The ionization by gamma rays is attributable to its speed hence the charging is by friction.

SHORT NOTES ON HOW A GOLD LEAF ELECTROSCPE WORKS

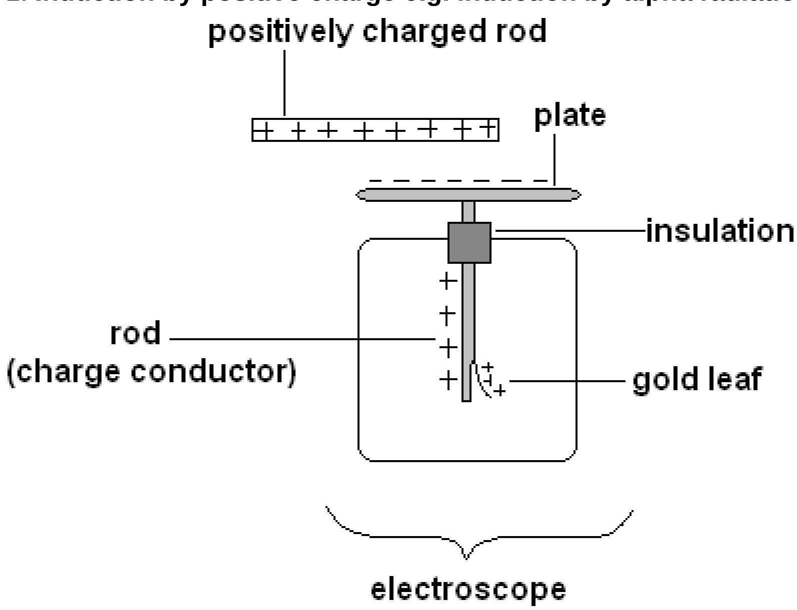
The instrument is used to detect charge. The gold electroscope measures the repulsion between a plate and a small piece of gold leaf that is fixed to it. The figure below shows a basic electroscope



Any charge placed on the plate will distribute itself over the leaf and rod as well, and so the leaf will be repelled. The greater the charge the greater the repulsion.

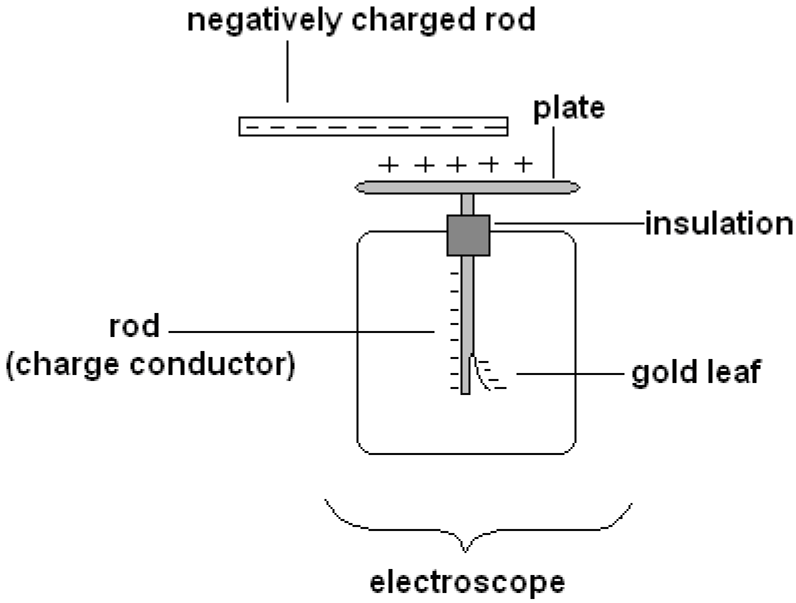
The electroscope is charged by induction. Two situations are shown below. The first one shows induction by positive charge and the second one shows induction by negative charge.

1. **Induction by positive charge e.g. induction by alpha radiation**



The positively charged rod induces a negative charge on the plate, and the leaf as well as the rod therefore become positive. Positive rod and positive leaf will then repel.

2. **Induction by negative charge e.g. induction by beta radiation**



The negatively charged rod induces a positive charge on the plate, and the leaf as well as the rod (charge conductor) therefore become negative. Negative rod and negative leaf will then repel.

10 DENSITY

DETERMINING THE DENSITY OF A LIQUID (WATER AND PARAFFIN)

Materials: water, paraffin, 2 beakers (100ml) and triple beam balance.

Procedure: a. measure the volume of water (50ml) and record in the table of results.
b. determine the mass of the water and record in the table of results
c. calculate the density of water and record in the table of results
d. measure the volume of paraffin (50ml) and record in the table of results
e. determine the mass of the paraffin and record in the table of results
f. calculate the density of paraffin and record in the table of results

TABLE OF RESULTS

Liquid	Volume (cm^3)	Mass (g)	Density (g/cm^3)
Water			
Paraffin			

g. mix the 2 liquids and observe what happens.
h. discuss the observation/s in (g) in terms of the densities in (f)

It is expected that the density of water will be higher than that of paraffin. To verify this, the liquids can be mixed and the observation will that paraffin will float on water.

DETERMINING DENSITY OF A LIQUID USING ANOTHER LIQUID OF KNOWN DENSITY

Materials: triple beam balance, water of density 1g/cm^3, cooking oil, clear, empty bottle

Procedure: a. determine the mass of the bottle using the triple beam balance
b. while the bottle is still on the triple beam balance, add water gradually into the bottle until the mass increases by 1g
c. mark the level of the water on the bottle (this will be 1cm^3 mark. Do you know why? think about it)
d. pour out the water from the bottle
e. add the cooking oil up to the mark (the 1cm^3 mark)
f. measure the mass of the cooking oil + bottle using the triple beam balance
g. find the mass of the cooking oil
h. determine the density of the cooking oil since its volume and corresponding mass are known

i.e. density = mass (g) / volume (cm^3)

IDENTIFYING A METAL USING DENSITY

Materials : a shiny metal, a well calibrated beaker (100ml), water and a chart showing densities of three metals (aluminium: 2.7g/cm^3, tin: 7.3g/cm^3 and nickel: 8.7g/cm^3)

Procedure: a. measure the mass of the metal using a triple beam balance / digital balance
b. record the mass in the table of results
c. put water into the beaker up to a 50ml mark
d. immerse the shiny metal into the water
e. note the water rise and record in the table of results

TABLE OF RESULTS

Mass (g)	Volume (cm^3) Final reading –initial reading

Density is found by dividing mass (g) by volume (cm^3)

The metal can be identified as aluminium, tin or nickel by comparing the actual density of the metal found by experiment with the densities of the three metals. The metal will be identified as the one which has density which matches the density found by experiment.

11 SEPARATING MIXTURES

SEPARATING A MIXTURE, W, OF SOLIDS X (SOLUBLE IN CARBON TETRACHLORIDE ONLY), Y (SOLUBLE IN WATER ONLY) AND Z (INSOLUBLE IN BOTH CARBON TETRACHLORIDE AND WATER)

Materials: mixture W, distilled water, carbon tetrachloride, oven, filter funnel, filter paper, beaker, evaporating dishes (3)

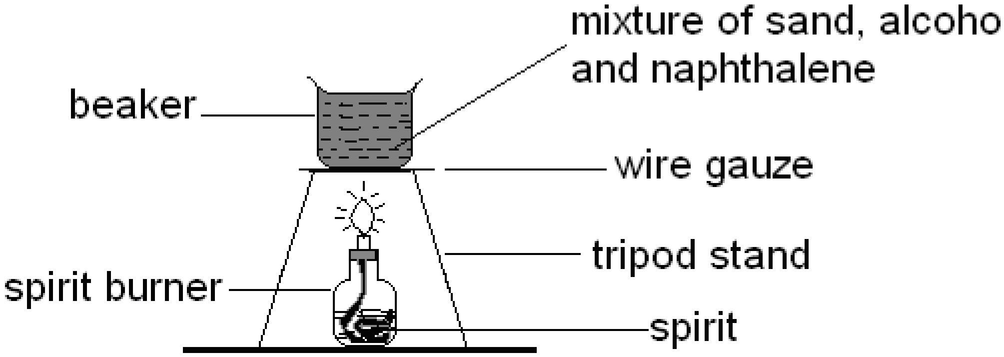
Procedure: a. dissolve W in distilled water
b. filter the mixture
c. wash the residue using distilled water
d. dry the filtrate by evaporation followed by drying in an oven
e. dry the residue by evaporation followed by drying in an oven
f. dissolve the well dried residue in carbon tetrachloride
g. filter the mixture
h. wash the residue using CCl_4
i. dry the filtrate by evaporation followed by drying in an oven
j. dry the residue by evaporation followed by drying in an oven

Pure solid Y is realized in step (d) since it is the one which dissolved in water.
Pure solid X is realized in step (i) since it is the one which dissolved in carbon tetrachloride.
Pure solid Z is realized in step (j) since it is the one which did not dissolve in any of the solvents

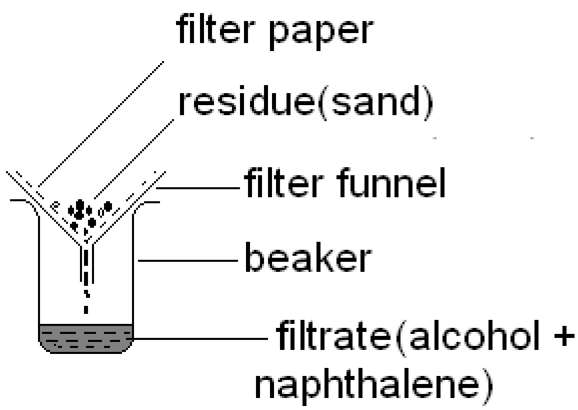
SEPARATING A MIXTURE OF SAND, NAPHTHALENE AND ALCOHOL

Materials: filter funnel, filter paper, beakers (2), the mixture of sand, naphthalene and alcohol.

Procedure: a. heat the mixture to 77^{o}C to melt the naphthalene as shown below.



b. filter the mixture as shown below



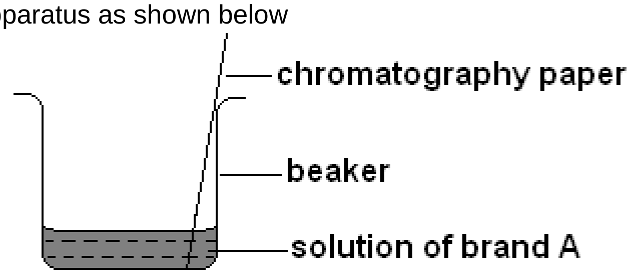
Note that the filtrate collected is a mixture of naphthalene and ethanol, hence sand has been separated from the mixture.

c. let the filtrate cool for about10 to 15 minutes. Note that 2 layers are formed since naphthalene is a solid and ethanol is a liquid at room temperature.
d. pour off the liquid into another beaker. This separates the 2 substances, naphthalene and ethanol.

ISOLATING COMPONENTS OF DYES OF TWO BRANDS OF SOAP

Materials: chromatography papers (2), small beakers (2), distilled water, brand of soap A and brand of soap B.

Procedure: a. dissolve brand of soap A in a small beaker using distilled water.
b. set up the apparatus as shown below



c. wait for the soap solution to rise by capillary action up the chromatography paper.
d. after 20 minutes, observe the chromatography paper and describe your observation
e. repeat steps (a) to (d) for brand of soap B.
f. compare and contrast the dyes that go up the chromatography papers for brand of soap A and brand of soap B

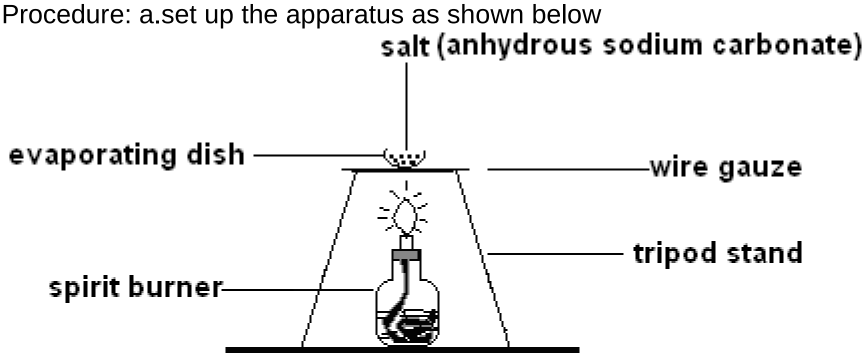
If there is equal number of dyes and they rise similarly, then they are the same dyes. On the other hand, if the components rise differently i.e. the colours rising are different and there are differences in the way they rise, then the dyes are different.

Then the dyes can be isolated for testing.

INVESTIGATING THE REMOVAL OF WATER OF CRYSTALLISATION FROM SALTS

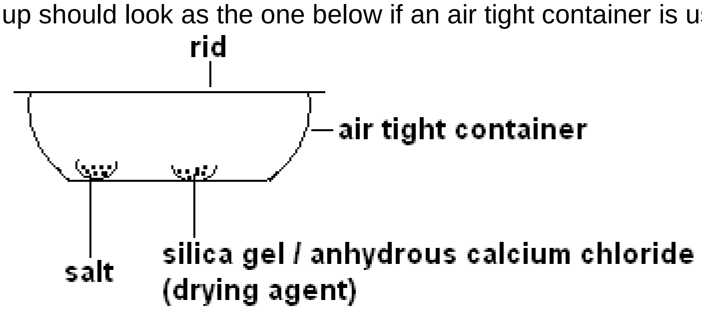
Materials: evaporating dish, drying agent (anhydrous calcium chloride/silica gel), Bunsen burner, wire gauze, metallic spatula, a pair of tweezers, salt (anhydrous sodium carbonate, air tight container or desiccator.

Procedure: a.set up the apparatus as shown below



b. stir the solid continually while heating (remember that overheating decomposes the salt)
d. remove the dish using the pair of tweezers and leave it in a closed air tight container to cool. If a desiccator containing drying agent is used, its lips must be greased thinly.

The set up should look as the one below if an air tight container is used



e. wait for 20 minutes

At the end of the 20 minutes the salt will be free of water of crystallization. To verify the removal of the water of crystallization, measure the mass of the salt at the end of the experiment and compare with the mass at the beginning of the experiment.

DETERMINING HOW MUCH WATER IS FOUND IN A SAMPLE OF HYDRATED COPPER SULPHATE

Materials: hydrated copper sulphate, an evaporating basin, a gas burner, a triple beam balance and a wire gauze.

Procedure: a. weigh the evaporating basin on the triple beam balance and record the mass

b. add crystals of hydrated copper sulphate until the reading increases by approximately 5g.

c. record the mass of the evaporating basin plus hydrated copper sulphate in the table of results.

d. record the mass of hydrated copper sulphate in the table of results.

e. heat the evaporating basin gently until the hydrated copper sulphate turns into a white powder.

f. weigh the evaporating basin plus white powder and record the results in the table

g. subtract mass of empty evaporating basin from the mass of evaporating basin and white powder and record the results

h. calculate and record the mass of white powder.

TABLE OF RESULTS

Material measured	**Mass (g)**
Basin	
Basin + hydrated copper sulphate	
Hydrated copper sulphate	
Basin + white powder	
White powder	
water	

I. calculate the percentage of water in the hydrated copper sulphate

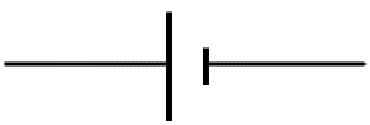
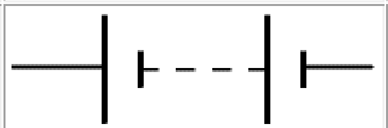
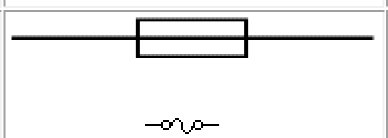
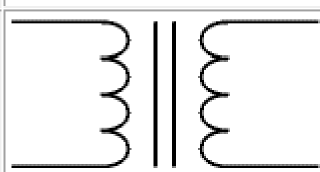
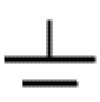
j. what name is given to the water found in the crystals?

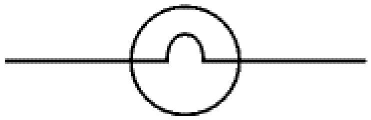
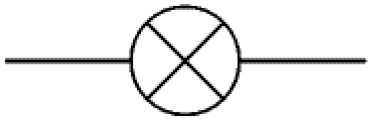
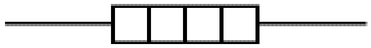
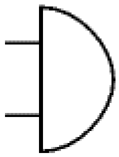
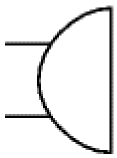
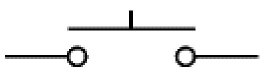
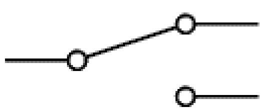
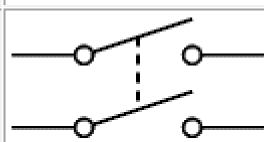
----

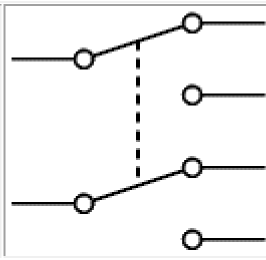
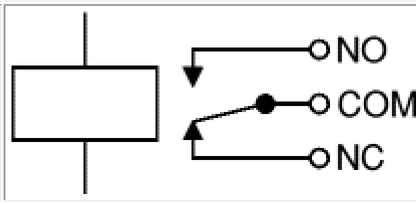
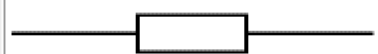
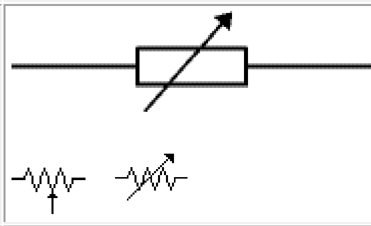
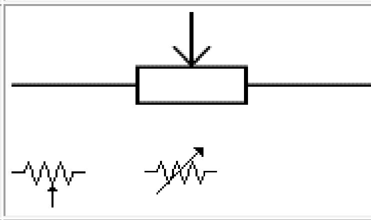
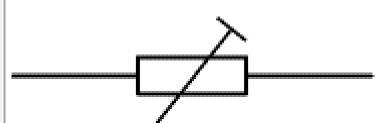
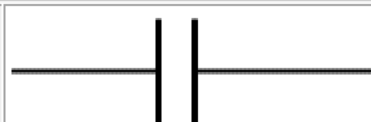
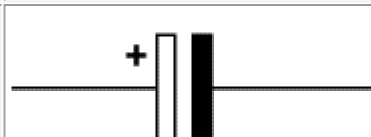
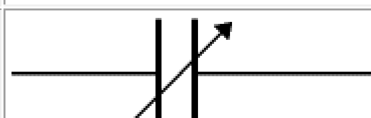
k. mention any two sources of error in this experiment.

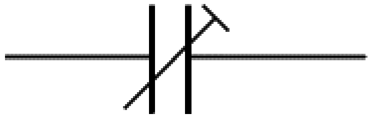
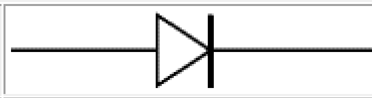
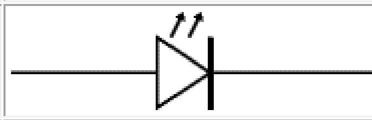
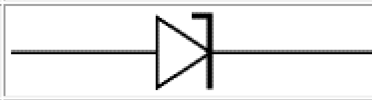
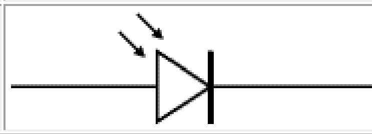
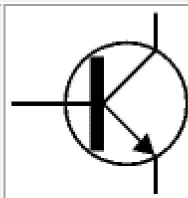
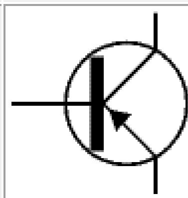
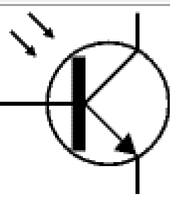
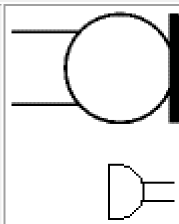
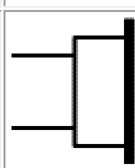
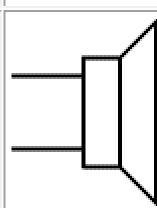
APPENDIX A

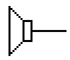
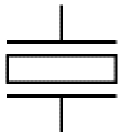
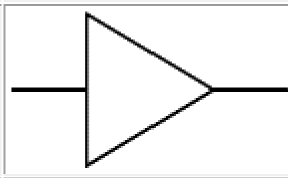
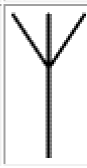
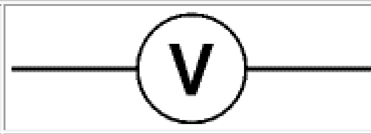
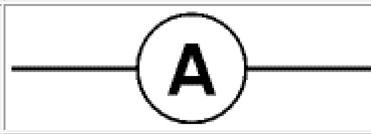
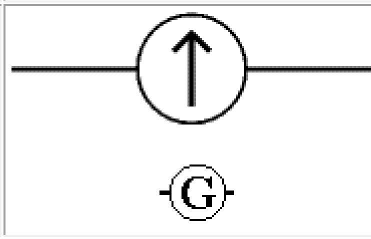
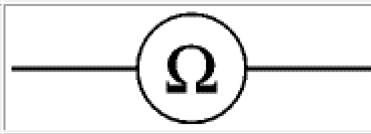
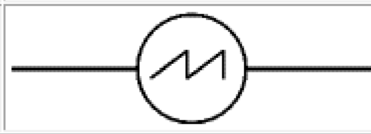
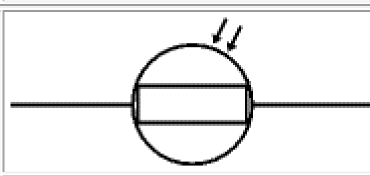
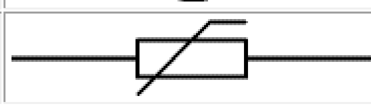
Electricity symbols and their meanings

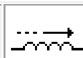
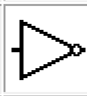
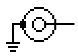
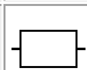
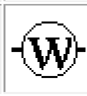
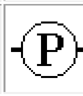
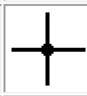
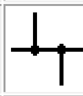
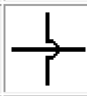
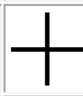
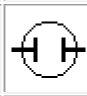
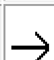
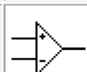
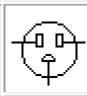
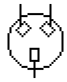
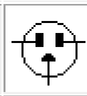
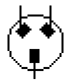
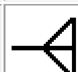
Component	Circuit Symbol	Function of Component
Cell		Supplies electrical energy. The larger terminal (on the left) is positive (+). A single cell is often called a battery, but strictly a battery is two or more cells joined together.
Battery/accumulator		Supplies electrical energy. A battery is more than one cell. The larger terminal (on the left) is positive (+).
DC supply		Supplies electrical energy. DC = Direct Current, always flowing in one direction.
AC supply		Supplies electrical energy. AC = Alternating Current, continually changing direction.
Fuse		A safety device which will 'blow' (melt) if the current flowing through it exceeds a specified value.
<u>Transformer</u>		Two coils of wire linked by an iron core. Transformers are used to step up (increase) and step down (decrease) AC voltages. Energy is transferred between the coils by the magnetic field in the core. There is no electrical connection between the coils.
Earth (Ground)		A connection to earth. For many electronic circuits this is the 0V (zero volts) of the power supply, but for mains electricity and some radio circuits it really means the earth. It is also known as ground.

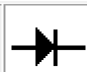
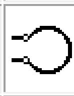
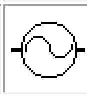
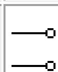
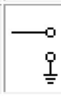
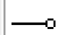
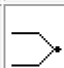
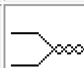
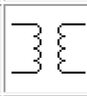
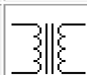
Lamp (lighting)		A transducer which converts electrical energy to light. This symbol is used for a lamp providing illumination, for example a car headlamp or torch bulb.
Lamp (indicator)		A transducer which converts electrical energy to light. This symbol is used for a lamp which is an indicator, for example a warning light on a car dashboard.
Heater		A transducer which converts electrical energy to heat.
Motor		A transducer which converts electrical energy to kinetic energy (motion).
Bell		A transducer which converts electrical energy to sound.
Buzzer		A transducer which converts electrical energy to sound.
Inductor (Coil, Solenoid)		A coil of wire which creates a magnetic field when current passes through it. It may have an iron core inside the coil. It can be used as a transducer converting electrical energy to mechanical energy by pulling on something.
Push Switch (push-to-make)		A push switch allows current to flow only when the button is pressed. This is the switch used to operate a doorbell.
Push-to-Break Switch		This type of push switch is normally closed (on), it is open (off) only when the button is pressed.
On-Off Switch (SPST)		SPST = Single Pole, Single Throw. An on-off switch allows current to flow only when it is in the closed (on) position.
2-way Switch (SPDT)		SPDT = Single Pole, Double Throw. A 2-way changeover switch directs the flow of current to one of two routes according to its position. Some SPDT switches have a central off position and are described as 'on-off-on'.
Dual On-Off Switch (DPST)		DPST = Double Pole, Single Throw. A dual on-off switch which is often used to switch mains electricity because it can isolate both the live and neutral connections.

Reversing Switch (DPDT)		DPDT = Double Pole, Double Throw. This switch can be wired up as a reversing switch for a motor. Some DPDT switches have a central off position.
Relay		An electrically operated switch, for example a 9V battery circuit connected to the coil can switch a 230V AC mains circuit. NO = Normally Open, COM = Common, NC = Normally Closed.
Resistor		A resistor restricts the flow of current, for example to limit the current passing through an LED. A resistor is used with a capacitor in a timing circuit. Some publications still use the old resistor symbol: 
Variable Resistor (Rheostat)		This type of variable resistor with 2 contacts (a rheostat) is usually used to control current. Examples include: adjusting lamp brightness, adjusting motor speed, and adjusting the rate of flow of charge into a capacitor in a timing circuit.
Variable Resistor (Potentiometer)		This type of variable resistor with 3 contacts (a potentiometer) is usually used to control voltage. It can be used like this as a transducer converting position (angle of the control spindle) to an electrical signal.
Variable Resistor (Preset)		This type of variable resistor (a preset) is operated with a small screwdriver or similar tool. It is designed to be set when the circuit is made and then left without further adjustment. Presets are cheaper than normal variable resistors so they are often used in projects to reduce the cost.
Capacitor		A capacitor stores electric charge. A capacitor is used with a resistor in a timing circuit. It can also be used as a filter, to block DC signals but pass AC signals.
Capacitor, polarised		A capacitor stores electric charge. This type must be connected the correct way round. A capacitor is used with a resistor in a timing circuit. It can also be used as a filter, to block DC signals but pass AC signals.
Variable Capacitor		A variable capacitor is used in a radio tuner.

Trimmer Capacitor		This type of variable capacitor (a trimmer) is operated with a small screwdriver or similar tool. It is designed to be set when the circuit is made and then left without further adjustment.
Diode		A device which only allows current to flow in one direction.
LED Light Emitting Diode		A transducer which converts electrical energy to light.
Zener Diode		A special diode which is used to maintain a fixed voltage across its terminals.
Photodiode		A light-sensitive diode.
Transistor NPN		A transistor amplifies current. It can be used with other components to make an amplifier or switching circuit.
Transistor PNP		A transistor amplifies current. It can be used with other components to make an amplifier or switching circuit.
Phototransistor		A light-sensitive transistor.
Microphone		A transducer which converts sound to electrical energy.
Earphone		A transducer which converts electrical energy to sound.
Loudspeaker		A transducer which converts electrical energy to sound.

		
Piezo Transducer		A transducer which converts electrical energy to sound.
Amplifier (general symbol)		An amplifier circuit with one input. Really it is a block diagram symbol because it represents a circuit rather than just one component.
Aerial (Antenna)		A device which is designed to receive or transmit radio signals. It is also known as an antenna.
Voltmeter		A voltmeter is used to measure voltage. The proper name for voltage is 'potential difference', but most people prefer to say voltage!
Ammeter		An ammeter is used to measure current.
Galvanometer		A galvanometer is a very sensitive meter which is used to measure tiny currents, usually 1mA or less.
Ohmmeter		An ohmmeter is used to measure resistance. Most multimeters have an ohmmeter setting.
Oscilloscope		An oscilloscope is used to display the shape of electrical signals and it can be used to measure their voltage and time period.
LDR		A transducer which converts brightness (light) to resistance (an electrical property). LDR = Light Dependent Resistor
Thermistor		A transducer which converts temperature (heat) to resistance (an electrical property).
Circuit Breaker		
Inductor, Iron-Core		

Inductor, Variable		
Integrated Circuit		
Inverter		
Jack, Coaxial		
Unspecified Component		
Wattmeter		
Wires		
Wires, Connected, Crossing		
Wires, Not Connected, Crossing		
Lamp, Neon		
Male Contact, General		
Negative Voltage Connection		
Operational Amplifier		
Outlet, Utility, 117-V		
Outlet, Utility, 234-V		
Plug, Utility, 117-V		
Plug, Utility, 234-V		
Positive Voltage Connection		
Probe, Radio-Frequency		

Rectifier, Semiconductor		
Resonator		
Signal Generator		
Switch, Momentary-Contact		
Terminals, General, Balanced		
Terminals, General, Unbalanced		
Test Point		
Thermocouple		
Transformer, Air-Core		
Transformer, Iron-Core		

APPENDIX B

Some Safety and Hazard symbols and their meanings

corrosive

a substance that may cause damage to skin on contact

flammable

a substance that can catch fire easily

oxidising

a substance that gives off a large ammount of heat when in contact with other substances

explosive

a substance that may explode if it comes into contact with a flame or heat. It may also explode due to friction or shock

harmful

a substance that may cause harm in some way

irritant

a substance that may cause irritation to the skin, eyes or inside your body

	disposal Alert	this symbol appears when care must be taken to dispose of materials properly
	open flame alert	this symbol appears when use of an open flame could cause a
	thermal safety	this symbol appears as a reminder to use caution when handling hot objects
	sharp oject safety	this symbol appears when a danger of cuts or punctures caused by the use of sharp objects exists

	disposal Alert	this symbol appears when care must be taken to dispose of materials properly
	open flame alert	this symbol appears when use of an open flame could cause a
	thermal safety	this symbol appears as a reminder to use caution when handling hot objects
	sharp oject safety	this symbol appears when a danger of cuts or punctures caused by the use of sharp objects exists
	animal safety	this symbol appears whenever live animals are studied and the safety of the animals and the students must be ensured
	clothing protection safety	this symbol appears when substances used could stain or burn clothing
	eye safety	this symbol appears when a danger to the eyes exists. Safety goggles should be worn when this symbol appears
	chemical safety	this symbol appears when chemicals used can cause burns or are poisonous if absorbed through the skin
	fire safety	this symbol appears when care must be taken around open fires

APPENDIX C

Laboratory safety rules

Some rules are NOT made to be broken. That is true of the rules used in a chemistry lab. They are really, truly for your safety and not your humiliation.

- Wear goggles and an apron anytime you are working with dangerous chemicals, hot liquids or solids, and other potential sources of splashes, splattering or spills.
- Goggles must be worn anytime a Bunsen burner is used.
- Make use of any safety equipment such as beaker tongs, test tube clamps, thermal gloves, etc. when handling hot beakers, test tubes or other containers.
- Do not wear a coat or jacket during a lab. Necklaces and bulky jewelry should be removed. These items tend to get in the way when reaching for objects and can get caught in moving parts such as motors.
- Do not perform any experiment that is unauthorized.
- Study your lab assignment/experiment before you come to class. If you have any questions, Do not touch or taste any chemical unless specifically instructed to do so.
- Read chemical labels more than once before using the contents - it is easy to confuse chemicals.
- When working with chemicals or dissections, keep your hands away from your face. The skin on your face is much more sensitive to irritation than your hands.
- To smell something, hold it away from your nose and wave your hand over it towards your nose. You may pass out or inhale dangerous gases is you just stick your nose over the container and breath in.
- Flush any chemical spill on your skin with plenty of water. The rule of thumb is 15 minutes.
- When heating anything in a test tube, point the mouth of the test tube towards a wall, away from people.
- Do not lay the glass stopper from a reagent bottle on the lab table. Hold the handle of the stopper between two fingers while you pour from the bottle.
- When mixing acids and water, pour the *acid into the water and not water into the acid*.
- Wash your hands when you are finished with the lab.
- Never use chipped or broken glass. If you notice chipped or cracked glassware during a lab please report it to the instructor to be replaced.
- Broken glass should never be handled with your hands. Use a dustpan and broom to sweep up broken glass. Small pieces can be wiped up using a wet paper towel.
- Broken glass should be placed in the proper container - either a can for broken glass or a sharps container.
- Always have the instructor clean up a broken *mercury* thermometer. Mercury is a poisonous substance and should not be handled. VHHS no longer has any mercury thermometers.
- Broken glass that has contacted blood must be disposed of in a sharps container.
- The plastic cylinder guard on a graduated cylinder is to protect the cylinder from breaking if it should tip over. The cylinder guard is not made to slide up and down for measuring.
- A graduated cylinder should be laid down when it is empty - if it is laying down it can't be tipped over.
- Remove glass tubing and funnels from stoppers as soon as your lab is finished. If you do not they will become stuck in the stopper.
- Wear latex gloves anytime you assist someone who is or has been bleeding or vomiting.
- Clean the entire area (desktop, floor, etc.) with a disinfectant when you are finished caring for the person.
- Remove your latex gloves by pulling them off inside out. Avoid contact with the outside of the gloves.
- All paper towels, tissues, latex gloves and other materials used to clean up blood and other possible infectious materials should be disposed of in the proper biohazardous waste bag.
- Standard Biohazardous waste bags are red with the biohazardous waste symbol on them. If one is not available, use a regular plastic garbage bag and attach a biohazardous waste sticker to the bag.
- ask the instructor for help.
- A Bunsen burner flame is very hot. The center of the flame will be over 1000 degrees Celsius. Treat burner flames with respect.
- Always use the main gas shut off valve on the desk to shut off a Bunsen burner. The valve at the base of the burner is only used to control the flame.

- If your hair or clothing catches on fire *stop drop and roll*.
- If someone else's hair or clothing catches on fire, wrap them with a fire blanket to smother the fire. *Do not let them run.*

SOME OF THE REASONS WHY SAFETY RULES MUST BE FOLLOWED

- **Do Not Pipette By Mouth - Ever**
  You say, "But it's only water." Even if it is, how clean do you think that glassware *really* is? Using disposable pipettes? I know lots of people who rinse them and put them back! Learn to use the pipette bulb or automated pipetter. Don't pipette by mouth at home either. Gasoline and kerosene should be obvious, but people get hospitalized or die every year, right? I know someone who used his mouth to start the suction on a waterbed to drain it. Do you know what they put in some waterbed additives? Carbon-14. Mmmm...radiation. He couldn't retch fast enough! The lesson is that even seemingly harmless substances may be dangerous!
- **Read the Chemical Safety Information**
  A Material Safety Data Sheet (MSDS) should be available for every chemical you use in lab. Read these and follow the recommendations for safe use and disposal of the material.
- **Dress Appropriately (for chemistry lab, not fashion or the weather)**
  No sandals, no clothes you love more than life, no contact lenses, and long pants are preferable to shorts or short skirts. Tie long hair back. Wear safety goggles and a lab coat. Even if you aren't clumsy, someone else in the lab probably is. If you take even a few chemistry courses you will probably see people set themselves on fire, spill acid on themselves, others, or notes, splash themselves in the eye, etc. Don't be the bad example to others, remembered for all time for something stupid!
- **Identify the Safety Equipment**
  And know how to use it! Given that some people (possibly you) will need them, know the locations of the fire blanket, extinguishers, eyewash, and shower. Ask for demonstrations! If the eyewash hasn't been used in a while the discoloration of the water is usually sufficient to inspire use of safety glasses.
- **Don't Taste or Sniff Chemicals**
  For many chemicals, if you can smell them then you are exposing yourself to a dose that can harm you! If the safety information says that a chemical should only be used inside a fume hood, then don't use it anywhere else. This isn't cooking class - don't taste your experiments!
- **Don't Casually Dispose of Chemicals Down the Drain**
  Some chemicals can be washed down the drain, while others require a different method of disposal. If a chemical can go in the sink, be sure to wash it away rather than risk an unexpected reaction between chemical 'leftovers' later.
- **Don't Eat or Drink in Lab**
  It's tempting, but oh so dangerous... just don't do it!
- **Don't Play Mad Scientist**
  Don't haphazardly mix chemicals! Pay attention to the order in which chemicals are to be added to each other and do not deviate from the instructions. Even chemicals that mix to produce seemingly safe products should be handled carefully. For example, hydrochloric acid and sodium hydroxide will give you salt water, but the reaction could break your glassware or splash the reactants onto you if you aren't careful!
- **Take Data *During* Lab**
  Not after lab, on the assumption that it will be neater. Put data directly in your lab book rather than transcribing from another source (e.g., notebook or lab partner). There are lots of reasons for this, but the practical one is that it is much harder for the data to get lost in your lab book. For some experiments, it may be helpful to take data *before* lab. No, I'm not telling you to dry-lab or cheat, but being able to project likely data will help you catch bad lab procedure before you are three hours or so into a project. Know what to expect. You should always read the
- Wash your hands thoroughly with a disinfectant when you are finished.

APPENDIX D

Insight to the periodic table

GROUP / PERIOD	I	II	III	IV	V	VI	VII	VIII
1	$^{1}_{1}\mathrm{H}$							$^{4}_{2}\mathrm{He}$
2	$^{7}_{3}\mathrm{Li}$	$^{9}_{4}\mathrm{Be}$	$^{11}_{5}\mathrm{B}$	$^{12}_{6}\mathrm{C}$	$^{14}_{7}\mathrm{N}$	$^{16}_{8}\mathrm{O}$	$^{19}_{9}\mathrm{F}$	$^{20}_{10}\mathrm{Ne}$
3	$^{23}_{11}\mathrm{Na}$	$^{24}_{12}\mathrm{Al}$	$^{27}_{13}\mathrm{Mg}$	$^{28}_{14}\mathrm{Si}$	$^{31}_{15}\mathrm{P}$	$^{32}_{16}\mathrm{S}$	$^{35.5}_{17}\mathrm{Cl}$	$^{40}_{18}\mathrm{Ar}$
4	$^{39}_{19}\mathrm{K}$	$^{40}_{20}\mathrm{Ca}$						

The first twenty elements of the periodic table in order of increasing atomic number

Z	SYMBOL	NAME OF ELEMENT	ELECTRON CONFIGURATION
1	H	Hydrogen	1
2	He	Helium	2
3	Li	Lithium	2,1
4	Be	Beryllium	2,2
5	B	Boron	2,3
6	C	Carbon	2,4
7	N	Nitrogen	2,5
8	O	Oxygen	2,6
9	F	Fluorine	2,7
10	Ne	Neon	2,8
11	Na	Sodium	2,8,1
12	Mg	Magnesium	2,8,2
13	Al	Aluminium	2,8,3
14	Si	Silicon	2,8,4
15	P	Phosphorous	2,8,5
16	S	Sulphur	2,8,6
17	Cl	Chlorine	2,8,7
18	Ar	Argon	2,8,8
19	K	Potassium	2,8,8,1
20	Ca	Calcium	2,8,8,2

SOME OTHER IMPORTANT ELEMENTS

Sc	Scandium	Ge	Germanium	Ni	Nickel	Ag	Silver
Ti	Titanium	As	Arsenic	Cu	Copper	Sn	Tin
V	Vanadium	Se	Selenium	Zn	Zinc	Au	Gold
Cr	Chromium	Br	Bromine	Ga	Gallium	Hg	Mercury
Mn	Manganese	Kr	Krypton	Fe	Iron	Pb	Lead
Fe	Iron	Cu	Copper	Co	Cobalt	Zn	Zinc

INSIGHT TO TRENDS IN THE PERIODIC TABLE

The properties of the elements exhibit trends. These trends can be predicted using the periodic table and can be explained and understood by analyzing the electron configurations of the elements. Elements tend to gain or lose valence electrons to achieve stable octet formation. Stable octets are seen in the inert gases, or noble gases, of Group VIII of the periodic table. In addition to this activity, there are two other important trends. First, electrons are added one at a time moving from left to right across a period. As this happens, the electrons of the outermost shell experience increasingly strong nuclear attraction, so the electrons become closer to the nucleus and more tightly bound to it. Second, moving down a column in the periodic table, the outermost electrons become less tightly bound to the nucleus. This happens because the number of filled principal energy levels (which shield the outermost electrons from attraction to the nucleus) increases downward within each group. These trends explain the periodicity observed in the elemental properties of atomic radius, ionization energy, electron affinity, and electronegativity.

Atomic Radius

The atomic radius of an element is half of the distance between the centers of two atoms of that element that are just touching each other. Generally, the atomic radius decreases across a period from left to right and increases down a given group. The atoms with the largest atomic radii are located in Group I and at the bottom of groups.

Moving from left to right across a period, electrons are added one at a time to the outer energy shell. Electrons within a shell cannot shield each other from the attraction to protons. Since the number of protons is also increasing, the effective nuclear charge increases across a period. This causes the atomic radius to decrease.

Moving down a group in the periodic table, the number of electrons and filled electron shells increases, but the number of valence electrons remains the same. The outermost electrons in a group are exposed to the same effective nuclear charge, but electrons are found farther from the nucleus as the number of filled energy shells increases. Therefore, the atomic radii increase.

Atomic Volume

The atomic volume is like the volume of any spherical object. To calculate the volume the following formula can be applied: $V = 4/3\ \pi\ r^3$. This shows that as the radius is decreasing, the volume also decreases and as the radius is increasing, the volume also increases.

From the above analogy, it follows that moving along the periods, volume decreases and moving down the groups, the volume increases.

Ionization Energy

The ionization energy, or ionization potential, is the energy required to completely remove an electron from a gaseous atom or ion. The closer and more tightly bound an electron is to the nucleus, the more difficult it will be to remove, and the higher its ionization energy will be. The first ionization energy is the energy required to remove one electron from the parent atom. The second ionization energy is the energy required to remove a second valence electron from the univalent ion to form the divalent ion, and so on. Successive ionization energies increase. The second ionization energy is always greater than the first ionization energy. Ionization energies increase moving from left to right across a period (decreasing atomic radius). Ionization energy decreases moving down a group (increasing atomic radius). Group I elements have low ionization energies because the loss of an electron forms a stable octet.

Electron Affinity

Electron affinity reflects the ability of an atom to accept an electron. It is the energy change that occurs when an electron is added to a gaseous atom. Atoms with stronger effective nuclear charge have greater electron affinity. Some generalizations can be made about the electron affinities of certain groups in the periodic table. The Group IIA elements, the alkaline earths, have low electron affinity values. These elements are relatively stable because they have filled *s* subshells. Group VIIA elements, the halogens, have high electron affinities because the addition of an electron to an atom results in a completely filled shell. Group VIII elements, noble gases, have electron affinities near zero, since each atom possesses a stable octet and will not accept an electron readily. Elements of other groups have low electron affinities.

Electronegativity

Electronegativity is a measure of the attraction of an atom for the electrons in a chemical bond. The higher the electronegativity of an atom, the greater its attraction for bonding electrons. Electronegativity is related to ionization energy. Electrons with low ionization energies have low electronegativities because their nuclei do not exert a strong attractive force on electrons. Elements with high ionization energies have high electronegativities due to the strong pull exerted on electrons by the nucleus. In a group, the electronegativity decreases as atomic number increases, as a result of increased distance between the valence electron and nucleus (greater atomic radius). An example of an electropositive (i.e., low electronegativity) element is cesium; an example of a highly electronegative element is fluorine.

Summary of Periodic Table Trends

Moving Left --> Right

- Atomic Radius Decreases
- Atomic Volume Decreases
- Ionization Energy Increases
- Electronegativity Increases

Moving Top --> Bottom

- Atomic Radius Increases
- Atomic Volume Increases
- Ionization Energy Decreases
- Electronegativity Decreases