Hydrolysis of Halogenoalkanes

(Planning Section)

The aim of this experiment is to show how the rate of reaction of the halogenoalkanes changes in respect to the C-X bond, where the C is the carbon and the X is the halogen. This will occur through a nucleophilic attack. The halogenoalkanes undergo hydrolysis according to the following equation

$$C_nH_{n+1}X + OH^- \rightarrow C_nH_{n+1}OH + X^-$$

Nucleophilic attacks are a predominant type of chemical attack. It is a type of substitution reaction where a nucleophile breaks the bond between the carbon and in this case the halogen and removes the halogen to get a halide ion. There are 3 main types of nucleophilic reaction; one involves hydrolysis, which is the one being used in this experiment and involves an OH molecule, cyanide ions, which is not being used due to cyanide being extremely dangerous and the final nucleophilic reaction involves ammonia ions. This one is not used because it will just keep substituting the chemicals and you will end up with a huge range of compounds, most, if not all of which will not be needed. These products are called amines and an example of one would be $CH_3CH_2NH_2$, which is ethylamine.

The bond enthalpies of the 4 most reactive halogens is as follows

Bond	Bond enthalpy (kj mol^{-1})
C-F	467
C-Cl	340
C-Br	280
C-I	240

From this table you can see that bond enthalpy decreases going down the group. This means that the weaker bonds will be more reactive with a nucleophile and the C-Cl bond will be the hardest to break out of the bonds being tested.

My prediction for which bond will react most vigorously with the nucleophile is C-I. This is because it has the lowest bond enthalpy and is also very polar because of the large difference of sizes between the carbon and iodine thus allowing the nucleophile to attack the bond much easier. C-Br will not be as easy to break as C-I because the molecule is not as polar and also has a higher bond enthalpy. C-Cl will therefore be the hardest bond to break because it is the least polar and has the highest bond enthalpy of all the bonds being tested.

Equipment

The equipment that will be used is the following;

- 3x Test tubes
- Test tube rack
- 250ml beaker
- Thermometer
- Stop Watch
- Ethanol
- Halogenoalkanes (C-Cl, C-Br, C-I)
- Silver Nitrate

Method

1. Set up equipment as shown in diagram
2. Add 1cm^3 of ethanol to each test tube
3. Add in 2-3 drops of a different halogenoalkane in to each test tube
4. Fill up the beaker with hot water at about 50˚C (check with thermometer)
5. Add 5cm^3 of silver nitrate solution to each test tube and quickly put in the water and start the timer on the stop watch
6. Record how quickly it takes for the halogenoalkane to react and form a silver halide

(Evaluation Section)

Results:

Halogenoalkane Reacted	Time taken for change (Seconds)	Colour change
C-I	0.73	Clear to Yellow
C-Br	0.97	Clear to Cream
C-Cl	1.22	Clear to Hazy

The level of accuracy of these results was fairly high. It was possible to gain a high level of accuracy for these results due to the equipment we were using and the fact that the experiment was fairly simple to set up and carry out. Also when recording the results there was very little information to collect so there was very little chance of any date getting mixed up.

The only problems that did occur which may have affected the results in some way is having drops of the halogenoalkane hitting the side of the test tube and not running all the way down and therefore meant that the reaction with the silver nitrate was much faster than it should have been.

The main sources of error in the procedure of the experiment were in actual adding chemicals to the test tube where drops of the chemicals may have hit the side of the test tube. Other errors within the experiment came from the actual measuring and recording the resu lts. There may have been spillages when transferring the chemicals into the test tubes which would result in a lower amount of halogenoalkanes being reacted. All these errors would have been caused by human error as the equipment used was reliable.

To minimise errors and increase reliability I would have to revise the method and improve it to minimise the errors. The changes I would make to the method would be to make what I say more specific so it is very definite about what I am doing. Although th is will make the method appear more complex it should only hopefully make the experiment much more efficient and have much less errors.