Planning (a)

Aim: To investigate the factors which affect the rate of heat loss from a body.

Theory: In this experiment we will study how several factors affect the rate of heat loss by carrying out investigations to test different hypotheses made concerning size, insulating layers, speed of evaporation of water, surrounding medium, etc.
Several observations and claims can be explained using theoretical knowledge about the nature of a body and the rate of heat lost from it.

1. Short and fat people tend to lose heat more slowly than tall and thin people of the same body weight because their surface area to volume ratio is much smaller. As the rate of heat loss is directly proportional to the surface area volume ratio this means that even though the body weight is constant, this rate is higher in tall thin people than in short fat ones.

2. Several thin layers of clothing (insulating layer) keep you warmer than one thick layer as they contain a lot of air spaces in between which help to trap heat and hence reduce heat loss. As these tiny pockets containing air are absent in a single layer, it has poorer insulating action. Hence it can be concluded that several thin layers of clothing are more efficient at reducing heat loss than one thick layer.

3. Evaporation of water (for instance in perspiration) from the body surface speeds up the rate of cooling. This is because evaporating particles need energy to overcome the intermolecular forces to escape from the surface. They gain this energy by absorbing it from the body surface, making it lose heat. Therefore the loss of water in the form of sweating increases the rate of heat loss from the body surface.

4. Huddling together in groups keeps bodies (frequently animals) warmer than isolated and single bodies. Heat being lost from individual bodies becomes trapped in between them by huddling together in groups, unlike the way in which it is easily lost to the surroundings by isolated bodies. Huddling together retains heat by trapping it within the group. This reduces the loss of heat and thus helps to keep the animals warm.

5. A body in water loses heat at a more rapid rate than a body of the same temperature kept in air because water is a better conductor of heat than air. This means that it quickly conducts heat away from a body. Not only does this facilitate the heat loss due to faster conduction, but also it helps to maintain a steeper temperature gradient in between the body and its surroundings. This process increases not only the amount of heat lost but also the rate at which it is lost.

Hypothesis: Various hypotheses are made on the factors affecting the rate of heat loss from a body and the nature of their relationship with the rate. The hypotheses that this investigation studies are:

1. Short and fat people lose heat more slowly than tall thin people of the same body weight.
2. Several thin layers of clothing keep you warmer than one thick layer.
3. Evaporation of water (for example in sweat) from the body surface speeds up the rate of cooling.
4. Huddling together in groups can help animals to keep warm.
5. A person in water loses heat more quickly than a person in air of the same temperature.

Variables: The constant in this experiment is the surrounding temperature of the test tubes or beakers that are used to represent bodies, because the rate of heat loss is directly proportional to the difference between the temperature of the body and its surroundings. The controlled variables are the different conditions in which the representative bodies are kept.

Planning (b):

Apparatus:

- Test tubes
- Beakers
- Tissue paper (insulating material)
- Hot water
- Water at room temperature
- Stopwatch
- Thermometer

Procedure:

Investigation 1:

- A beaker was taken and a test tube full of hot water was poured into it.
- A thermometer was placed inside it and allowed to reach the highest stable temperature. This temperature reading was recorded.
- The stopwatch was started and the readings of the temperature of the water were taken and recorded at regular intervals of 1 minute.
- A test tube was taken and filled with the same amount of water as that in the beaker.
- A thermometer was placed into the test tube. It was allowed to reach the highest stable temperature. Record this reading.
- Start the stopwatch and record the temperature of the water in the test tube at regular intervals of 1 minute.

Investigating hypothesis 2:

- A test tube was taken and covered with a single thick layer of tissue paper.
- This test tube was carefully filled with hot water.
- A thermometer was placed inside the test tube and allowed to reach the highest stable temperature.
- The stopwatch was started and the temperature was recorded at regular intervals of 1 minute.
- Then another test tube was taken and tissue paper was wrapped one by one around it, to cover it with several thin layers.
- This test tube was filled with the same amount of hot water as in the first test tube.
- A thermometer, which was initially at room temperature, was placed into it and allowed to reach the highest stable temperature.
- The stopwatch was stared and the temperature was recorded at regular intervals of 1 minute.

Investigating hypothesis 3:

- 2 test tubes were taken and covered with identically thick and arranged layers of tissue paper.
- The layer of tissue paper around one the test tubes was moistened using water that was at room temperature.
- Each test tube was filled with the equal amounts of hot water.
- A thermometer was placed into each test tube.
- Once the temperature shown by the thermometer reached the highest point, the stopwatch was started and readings were taken for the temperature of water in each of the test tubes at regular intervals of a minute.

Investigating hypothesis 4:

- Around 5-6 test tubes were individually covered with a layer of tissue paper.
- A rubber band was used to tie the test tubes together in a group.
- All of the test tubes were filled with hot water.
- A thermometer, which was initially at room temperature, was placed into the test tube at the centre of the bundled group and allowed to reach the highest temperature.
- The stopwatch was started and the temperature was recorded at regular intervals of 1 minute.
- A single test tube was covered with a layer of tissue paper similar to that around each of the test tubes in the group.
- A thermometer, which was initially at room temperature, was placed and allowed to reach the highest temperature.
- The stopwatch was started and the temperature was recorded at regular intervals of 1 minute.

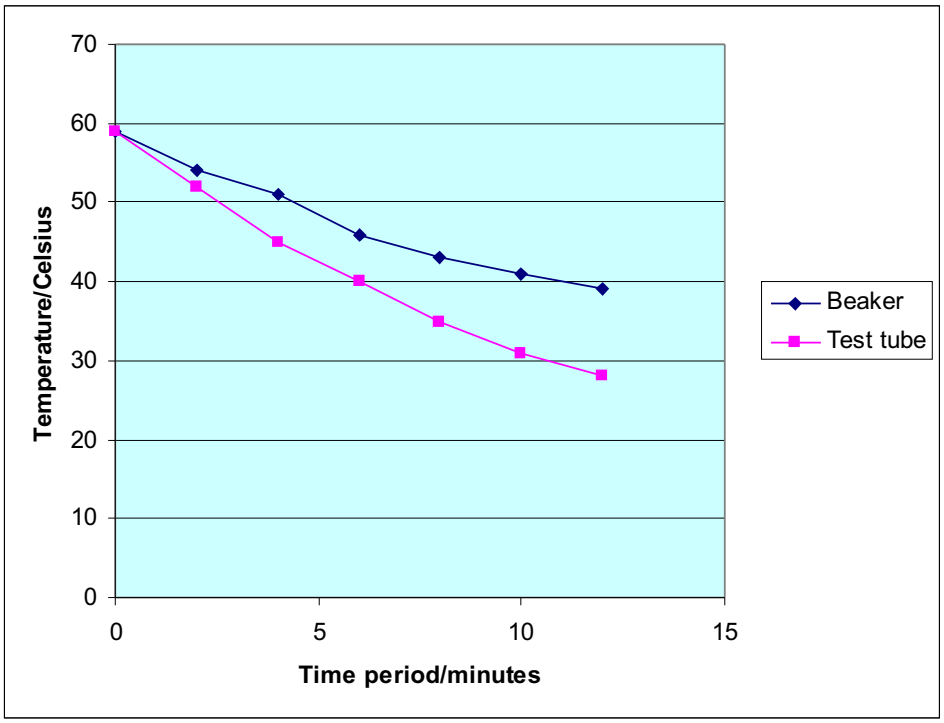
Investigating hypothesis 5:

- A beaker, which was large enough to fully contain a test tube, was filled with water at room temperature.
- Then a test tube was taken and filled with hot water.
- A thermometer, which was initially at room temperature, was placed inside the test tube and it was allowed to reach the highest temperature.
- The stopwatch was started and then the temperature was recorded at regular intervals of 1 minute.
- Another test tube was filed with hot water and placed on a test-tube stand.
- A thermometer into it, which was initially at room temperature, was placed into it and allowed to reach the highest temperature.
- The stopwatch was started and the temperature was recorded at regular intervals of 1 minute.

Data Collection

Investigation 1

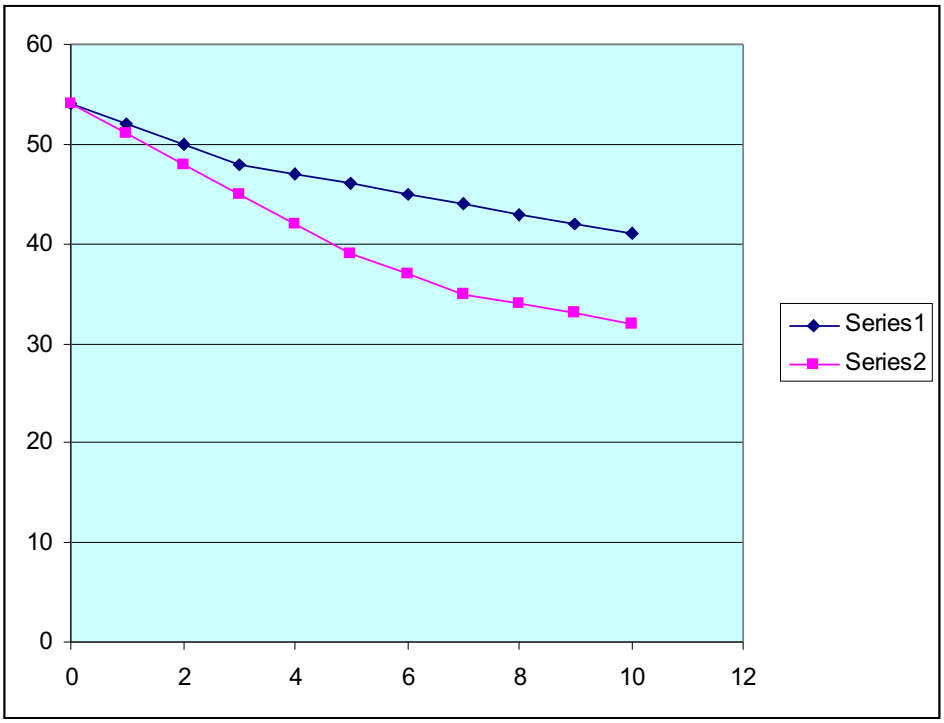
S.N.	Time (minutes)	Temperature of Small Beaker (± 1°C)	Temperature of Long test tube (± 1°C)
1.	0	59	59
2.	2	54	52
3.	4	51	45
4.	6	46	40
5.	8	43	35
6.	10	41	31
7.	12	39	28



Graph 1.

Experiment 2.

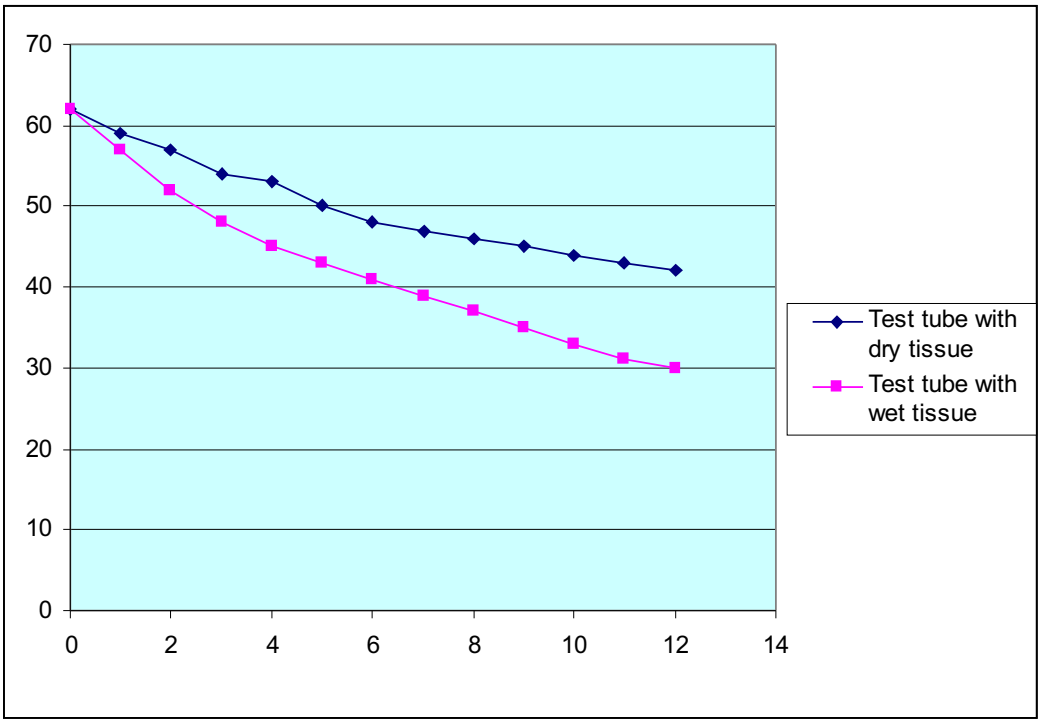
S.N.	Time (minutes)	Temperature of test tube with many thin layers of tissue (± 1°C)	Temperature of test tube with one thick layer of tissue (± 1°C)
1.	0	54	54
2.	1	52	51
3.	2	50	48
4.	3	48	45
5.	4	47	42
6.	5	46	39
7.	6	45	37
	7	44	35
	8	43	34
	9	42	33
	10	41	32



Graph 2.

Experiment 3.

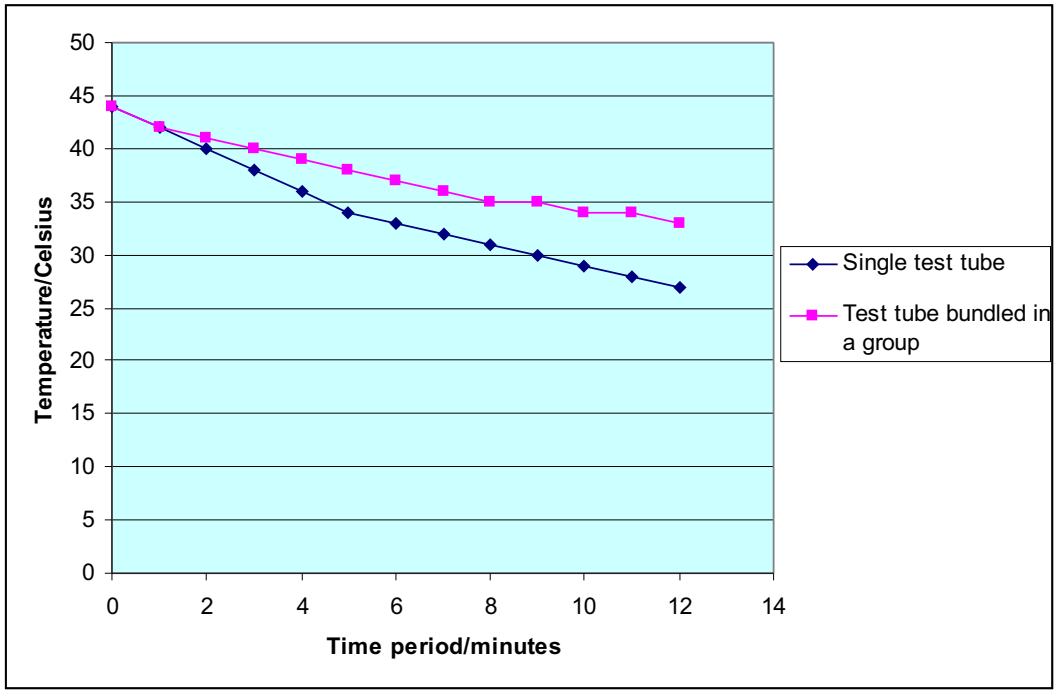
S.N.	Time (minutes)	Temperature of test tube with dry tissue(± 1°C)	Temperature of test tube with wet tissue (± 1°C)
	0	62	62
	1	59	57
	2	57	52
	3	54	48
	4	53	45
	5	50	43
	6	48	41
	7	47	39
	8	46	37
	9	45	35
	10	44	33
	11	43	31
	12	42	30



Graph 3.

Experiment 4

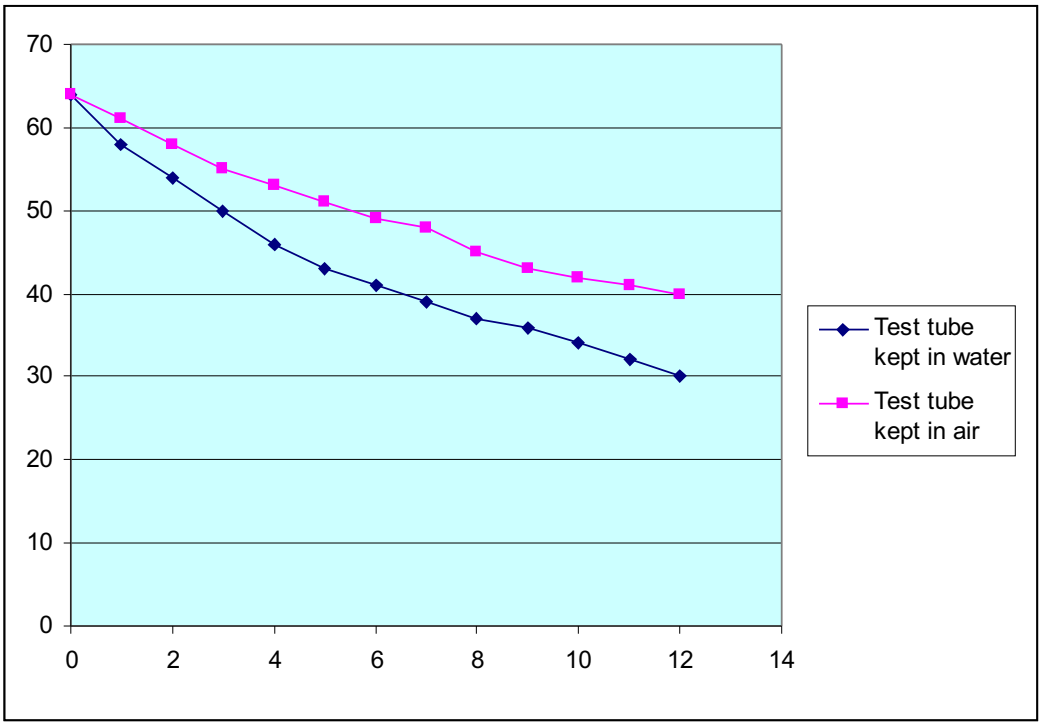
S.N.	Time (minutes)	Temperature of test tube surrounded by six other test tubes (± 1°C)	Temperature of single test tube (± 1°C)
	0	44	44
	1	42	42
	2	40	41
	3	38	40
	4	36	39
	5	34	38
	6	33	37
	7	32	36
	8	31	35
	9	30	35
	10	29	34
	11	28	34
	12	27	33



Graph 4

Experiment 5

S.N.	Time (minutes)	Temperature of test tube in water (± 1°C)	Temperature of test tube in air (± 1°C)
	1	58	61
	2	54	58
	3	50	55
	4	46	53
	5	43	51
	6	41	49
	7	39	48
	8	37	45
	9	36	43
	10	34	42
	11	32	41
	12	30	40



Graph 5.

Evaluation:

The investigation provides a reasonable method to study the factors affecting the rate of heat loss from a body. Based on the observations the following can be deduced:

- As a test tube rather than a beaker has a larger surface area in contact with its surroundings, the rate of heat loss is higher. Therefore tall thin people lose heat more quickly than short fat people.
- A test tube wrapped in several thin layers of tissue paper (insulating layer) lost heat at a quicker rate than one wrapped in a single layer due to air trapped in between the layers. Therefore a person wearing several layers of clothes during winter stays warmer than a person who wears only a single thick layer of clothing.
- Test tube that was covered with wet tissue paper lost heat quicker than the one covered with dry ones. As water from the wet tissue paper evaporated from the surface of the test tube, it absorbed heat from it, and making it lose heat.
- Test tubes huddled together in a group lost heat at a slower rate than those left alone because heat was trapped within the group. Also in a single test tube there is a lager area in direct contact with the surroundings and therefore the rate at which heat is lost by the body to its surroundings is greater.

- Test tubes that were placed in water lost heat faster than those of the same temperature left in air. This is due to the better conduction properties of water compared to air. Therefore a person in water loses heat more quickly than a person in air of the same temperature.

Precaution:

Some precautionary methods which must be adopted are:

1. Care should be taken while handling the hot water.
2. The reading on the thermometer should be allowed to reach the highest level before the reading for temperature is taken.
3. An equal volume of water should be taken in both test tubes to obtain accurate results, as different volumes of water will have different heat capacities.

Limitation:

The method of investigation has various limitations to the scope of studying the factors affecting heat loss and the way in which they affect it, which are:

1. There may be variations in the surrounding temperature when performing the experiment due to factors like wind and cooling from the air conditioner.
2. As the least count of the thermometer is $1^{o}C$, the temperature readings recorded may have some slight errors of - 0.5 to + 0.5 ^{o}C.
3. The test tubes aren't exact representatives of people and animals due to differences in shape and size ratio. Due to these variations, the way in which heat is lost from the test tubes will definitely be different to the actual heat loss of humans and animals.

Modification:

The experiment can be modified to obtain more accurate results by the following:

- Carrying out each of the above experiments more number of times to order greater accuracy.
- These factors could be studied together to deduce which factor has a larger affect on the rate of heat loss. For instance a beaker, which represents a short fat person, could be covered with wet tissue paper whereas a test tube representing thin tall people could be covered with dry tissue paper.

Conclusion

The investigation verifies our hypotheses as:

- The tall thin body lost heat more quickly than the short fat body
- The body wrapped in several thin layers of material lost heat more slowly than the one which was wrapped in one think layer of the material
- The body with a wet surface lost heat more quickly than the one with a wet surface
- The huddled together bodies did not lose heat as quickly as a single body
- The body in water lost heat more quickly than the body in air