Homoeopathy — an alternative kind of medicine

Contents: Data analysis and discussion concerning the nature and effectiveness of homoeopathy.

Time: 1 to 2 periods, depending on amount of discussion.

Intended use: GCSE Biology, Human Biology and Integrated Science. Links with work on treatment of disease.

Aims:

- To complement work on the treatment of disease
- To develop awareness of an important form of alternative medicine
- To develop awareness of the methods used in medical research, and the frequently uncertain nature of its findings, and to show that science does not necessarily have all the answers
- To provide opportunities to practise skills in data analysis, and to encourage willingness to enter discussion.

Requirements: Students' worksheets No. 509

This unit needs to be used carefully, and it is important to avoid condemning out of hand what is an important therapeutic regime for millions of people around the world. In this country homoeopathic treatment is available under the National Health Service and there are five National Health homoeopathic hospitals. (See 'Notes on discussion points' below.)

The data is taken from an article by Shipley et al. (1983) *Lancet*, I,97.

Notes on some of the questions

Q.1 Orthodox medicines are usually designed to have the opposite effects to those of the illness (allopathy). Some homoeopathic-type remedies do exist, for example, vaccinations and the use of X-rays to treat cancer. Orthodox medicines are usually given in regular doses and in relatively large amounts. With suitable classes the question of dilution could be taken further and put on a quantitative basis, using for example the question below.

How many molecules are left?

Suppose a few grams of a medicine are dissolved in water. This might contain around 0.01 mole of the medicine. Let us consider the situation when 0.01 mole is dissolved in 1 litre of water.

(a) Suppose this solution is diluted a million times.

(i) How many moles are there now per litre?

(ii) How many molecules are there now per litre?
(1 mole contains 6×10^{23} molecules)

(iii) Suppose a dose of the medicine is $5cm^3$.
How many molecules are there per dose?

(b) Suppose the original solution was diluted a million million million million million times. How many molecules are there now per dose?

Answers:

(a) (i) $0.01 \times 10^{-6} = 10^{-8}$ mol/litre

(ii) $10^{-8} \times 6 \times 10^{23} = 6 \times 10^{15}$ molecules/litre

(iii) $6 \times 10^{15} \times 5/1000 = 3 \times 10^{13}$ molecules

(b) $0.01 \times 10^{-30} \times 6 \times 10^{23} \times 5/1000 = 3 \times 10^{-11}$ molecules, i.e. no molecules left at all.

Dilutions of 1 in 10^{30} (as in part (b) of the question) are common in homoeopathy, and 1 in 10^{200} is not uncommon. In neither case can there be a molecule of the original drug left. 'Dynamization' cannot be explained on current scientific lines and the extent to which this is stressed tends to separate 'scientific' homoeopaths using lower dilutions, for example 1 in 10^6, from the more 'metaphysical' ones who would say that 1 in 10^{200} is not only very potent but potentially dangerous.

Qs 2 to 4 It appears that fenoprofen has an effect while placebo and Rhus tox. do not, but there is too much overlap to tell by eye. Statistical tests are needed. t-tests show that the effect of fenoprofen is significant while Rhus tox. is the same as placebo.

A t-test is used to tell whether or not the distribution of results using one treatment is significantly different from the distribution of results using another treatment. In particular it can be used to show that the mean of one set of results is significantly different from the mean of another set when, as in this experiment, it is not clear by eye. In this study, most of the differences between fenoprofen and Rhus tox. were significant at the 0.001 level, meaning that there is less than a 1 per cent chance in each case that the difference is due to chance variation. Differences between placebo and Rhus tox. were not significant.

Notes on the discussion points

In fact these results do not disprove the validity of homoeopathy at all. Since homoeopathic remedies are meant to be tailored to an individual and are sometimes given in single doses (regular doses were given in this experiment because it was a blind study) it can be argued that they would not be expected to work anyway. It can also be argued that blind studies are inappropriate for homoeopathy. Stress the difficulty of drawing firm conclusions from research, particularly in an area like this.

In any case, in these tests homoeopathy was used in the general context of conventional medicine. In the homoeopathic context of treating the whole person, patients may be encouraged to be more involved in their treatment, to consider their disease in relation perhaps to their personality and attitudes, in a way which may aid recovery. It is worth noting that this 'holistic' approach to treatment is gaining ground in some areas of conventional medicine. Examples are to be found in the treatment of diseases thought to be stress related (for example, heart disease) and diseases which are also social problems (for example, drug dependence and alcoholism).

It seems likely that there is more to homoeopathy than a simple placebo effect or the fact that most people tend to get better anyway. Those using the medicines claim that they are highly specific. An explanation in terms of current molecular pharmacology is not possible.

Further reading

A good reference for further details on this subject is *The Two Faces of Homoeopathy* by A. Campbell (Robert Hale, 1984).

Acknowledgements Figure 1 supplied by Weleda (UK); Figure 2 supplied by the Department of Medical Illustration, St. Bartholomew's Hospital.

HOMOEOPATHY — AN ALTERNATIVE KIND OF MEDICINE

What do you do if you are suddenly taken ill with stomach pains or bruise yourself badly? The chances are that you go to your ordinary doctor and take one of the modern medicines available to you. But you might go to a homoeopath — someone who practises homoeopathy.

What is homoeopathy?

Homoeopathy is a form of 'alternative' medicine used by millions of people around the world. In this country, homoeopathic treatment is available under the National Health Service.

Homoeopathy was started nearly 200 years ago by a German doctor called Samuel Hahnemann.

Like cures like

The basic principle of homoeopathy is in treating like with like.

The idea is that symptoms are the body's way of fighting disease, not the disease's way of fighting the body. The homoeopathic doctor gives the patient a medicine which would produce the same symptoms in a healthy person. The idea is to help the body's defence system.

Vaccination uses much the same idea of treating like with like. But most ordinary medicines are designed to have the *opposite* effects to those of the disease. Many ordinary doctors see no reason why like should cure like every time.

Figure 1 A field of Arnica Montana. *Arnica is a common homoeopathic medicine. Arnica ointment is used to treat bruising.*

The micro dose

Homoeopathic medicines are given in very small doses and sometimes in a single dose. They are prepared by diluting the original substance many times over. Between each dilution the mixture is shaken violently. This shaking is done to 'dynamize' the substance and make it more powerful. A common dilution is one in a million. This is one part of the substance per million parts of water. The more it is diluted, the more powerful it is considered to be. Dilutions of one in a million million million million million or even more may sometimes be used.

Many ordinary doctors cannot understand why diluting the substance millions and millions of times makes it more, not less, powerful. They would say that in some dilutions no trace of the medicine can remain. In ordinary medicine relatively large doses are given. The dose may be *increased* for greater effect.

Treating the person not the disease

In homoeopathic treatment the whole person is considered. The nature of the patient, physical and mental, influence the choice of medicine. Two patients with the same symptoms may need different prescriptions. And the prescription may also vary according to the mental state of the patient.

Answer Question 1.

Question

1 What are the main differences between homoeopathy and ordinary medicine?

Testing medicines

Scientists test all new medicines to see if they work. The basic method is to give the medicine to a group of patients and to see if, on average, they get better.

In practice it is not quite that simple. In countless experiments it has been found that just pretending to give a medicine will do some good. Sometimes patients are given something which *looks* just like the real medicine, but is really harmless and inactive. These 'dummy medicines' are called **placebos**. Patients given placebos usually feel some improvement even though the placebo is inactive. To carry out a full test of a medicine, two groups of patients are used. One group is given the placebo and the other is given the real medicine. The patients must not know which group they are in.

Testing a homoeopathic medicine for arthritis

Arthritis is a disease of elderly people. It can cause severe pain in the joints. An experiment was carried out to compare a homoeopathic medicine with an ordinary medicine for the treatment of a form of arthritis. The homoeopathic medicine was prepared from the poison ivy Rhus tox. The ordinary medicine was called fenoprofen.

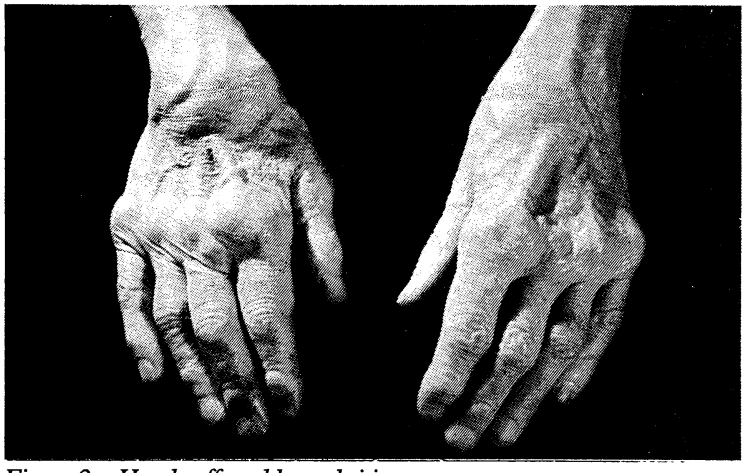


Figure 2 Hands affected by arthritis

In each case the patients were asked how much pain they felt. They were asked this before the treatment, and after a two-week course of treatment. The patients were asked to rate the pain they felt on a 0 to 5 scale. A higher pain score means more pain.

The pain scores for all the patients in a group were added up and averaged. The averages are shown in Table 1. The table also shows the amount of variation from the average. For example, a pain score of 2.30 ± 0.88 means that the average score was 2.3 and that about 70 per cent of the scores ranged up to 0.88 more or 0.88 less than the average. Obviously the pain that people feel differs from one person to the next.

There were three groups of patients:

Group 1 were given the inactive placebo
Group 2 were given the homoeopathic medicine Rhus tox
Group 3 were given the medicine fenoprofen.

All the patients were also allowed to take paracetamol tablets for pain relief if they wanted. At the end of the experiment they returned the paracetamol tablets they had not used.

The results of the experiment are shown in Table 1. Study the table carefully, then answer questions 2 to 4.

Questions

2 *What does the experiment suggest about the usefulness of Rhus tox. and fenoprofen in treating arthritis?*

3 *What difficulties did you have trying to draw conclusions from the figures?*

4 *What in particular does the number of returned paracetamol tablets tell you?*

Table 1 Results of the experiment to compare a homoeopathic medicine and an ordinary medicine

	Pain before treatment — all groups	*Pain after treatment*		
		Group 1 Placebo	*Group 2 Rhus tox.*	*Group 3 Fenoprofen*
Pain on movement	2.09 ± 0.72	2.30 ± 0.88	2.27 ± 0.63	1.70 ± 0.85
Pain at rest	1.45 ± 0.90	1.64 ± 0.96	1.58 ± 0.87	1.18 ± 0.82
Night pain	1.55 ± 1.0	1.91 ± 0.95	1.91 ± 0.80	1.27 ± 1.04
Paracetamol — number of tablets returned		61.8 ± 30.1	59.0 ± 33.0	70.1 ± 30.6

More points for discussion

- From the evidence of this experiment can you draw a general conclusion about whether homoeopathic medicines work?
- Did the experiment provide a normal situation for homoeopathic treatment?
- Do you have to believe in homoeopathy for it to work? Do you think 'believing in' any medical treatment helps in recovery?
- How could you set up an experiment to test your answer to the last point? What would be the problems?
- Many people use homoeopathic medicines and find that they do work. How might they work?
- Do you think that homoeopathic medicines would work on animals?

Perkin's Mauve

Contents: Practical work, reading and questions concerning the discovery of the first synthetic dye.

Time: 2 periods for practical work. Reading and questions need a further 1 to 2 periods, though homework time could be used. There are many opportunities for extension.

Intended use: GCSE Chemistry and Integrated Science. Links with work on chemistry of carbon compounds.

Aims:

- To show an important application of carbon chemistry: the production of synthetic dyes
- To illustrate the human side of scientific discovery through the story of William Perkin
- To show the historical and social impact of the development of the dye industry
- To provide opportunities to practise certain practical skills, and skills in reading and comprehension.

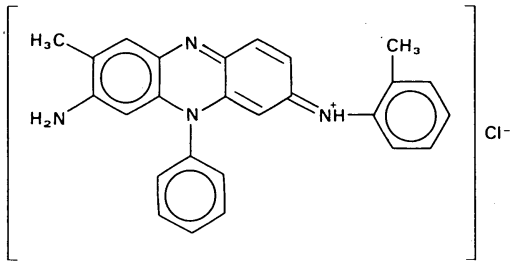
Requirements: Students' worksheets No. 510. For practical requirements, see below.

Dyeing experiments are fun and are enjoyed by girls and boys of all abilities. It is recommended that all students do the experimental work, since this will make the reading more interesting.

Notes on the reading and associated questions

The molecular formula of quinine was thought in Perkin's time to be $C_{20}H_{22}O_2N_2$. This is two hydrogen atoms short, and in any case the structural formula was unknown. The artificial synthesis of quinine was in fact not achieved until 1944.

The structural formula of mauve is:



Q.2 The development of synthetic dyes marked the beginning of the modern organic chemical industry. Britain was so committed to Industrial Revolution industries such as steel and textiles, and to colonial enterprise, that it was left to Germany to develop the British initiative, leading to the founding of such giants as BASF (Badische Anilin und Soda Fabrik) and Agfa. This led to the situation where, by the time of the First World War, Britain was importing most of its dyes from Germany, including those used to dye military uniforms.

Q.3 The first two 'coal tar' dyes, mauveine and magenta, were made from aniline, itself made from benzene extracted from coal tar. Today, petroleum is the source of benzene, though coal tar may again become important as oil supplies run out.

Q.6 Other examples of chance discoveries include Fleming's discovery of penicillin and Plunkett's discovery of p.t.f.e.

Notes on the experimental work

Each group of students will need:

beaker, 400 cm^3
conical flask, 250 cm^3
filter funnel
small piece of silk
boiling tube and glass rod
hot water bath

access to:
aniline sulphate (phenylammonium sulphate)
potassium dichromate
ethanol (with measuring cylinder to measure 25 cm^3)
paper towels or blotting paper
filter papers

Note that cotton, silk and other fabrics can be obtained cheaply at the remnant counters of large department stores. These fabrics have often been treated with surface dressings to improve the finish. Untreated fabric is best for dyeing experiments.

The Investigations provide an opportunity for students to design and carry out comparative tests. Fastness testing could be done at home. Small samples can be stitched or stapled to a larger piece of white cloth for testing fastness to washing. For light fastness it is convenient to cover the samples with a piece of card with small holes cut in it and then to expose them to light on a window ledge. After a few weeks some dyes will show marked fading and it is easy to compare the exposed portions with the areas hidden under the card.

Further experimental work

There is plenty of scope for further experimental work. See, for example:

Revised Nuffield Chemistry, Option 10, *Historical Topics*
Science at Work, Dyes and Dyeing (Longman)

Further resources

Revised Nuffield Chemistry, Option 10, includes further background to Perkin's discovery.

Revised Nuffield Advanced Chemistry, Book II, Topic 17, gives details of the chemistry of dyes which may be useful background for the teacher, as well as further experimental work.

The Colour Chemists, by A S Travis (ASE) has a detailed account of the historical development of the synthetic dye industry.

Acknowledgements Figure 1 supplied by the Mansell Collection; Figure 2 supplied by the Science Museum; Figures 3 and 4 reproduced by permission from *Punch.*

PERKIN'S MAUVE

William Perkin (1838–1907) is famous because he discovered the first synthetic dye. He made the dye by mistake when trying to find a way to make quinine.

Figure 1 William Perkin, aged 14, in a photograph he took himself

Before Perkin's discovery, all dyes came from natural sources. Some examples are given in Table 1. Many people like the colours of natural dyes, including the indigo used to dye blue jeans. But the colours of these dyes are dull and limited in range. Also, natural dyes are not **fast**. This means that they fade when repeatedly washed or when exposed to sunlight.

Table 1 Some natural dyes

Dye	*Source*	*Notes*
Indigotin	The indigo plant in India or the woad plant in Europe	In 1897, German dye manufacturers first marketed synthetic indigo. All the indigo used to dye blue jeans is now made synthetically.
Alizarin	The roots of the madder plant	The traditional source of good red dyes. It can also be used to dye cloth orange, brown, or purple depending on the conditions.
Cochineal	A Mexican insect	A scarlet or crimson dye which was used to colour the red coats of the British army. It is still used as a food colour.
Logwood	A South American tree	One of the few natural dyes which still has commercial importance. It can be used as a black dye for nylon and cotton.

How Perkin discovered mauve

Perkin's interest in chemistry started at school. At the age of 15 he entered the Royal College of Chemistry as a student. He was assistant to the famous chemist, August Hofmann. Perkin was so keen that he set up a laboratory at home so that he could carry out experiments in his spare time. It was in his own rough laboratory that he discovered his new dye in 1856.

At that time Perkin was excited by the idea of finding artificial ways of making natural substances. Quinine had been used for two hundred years to treat malaria. It was obtained from the bark of a tree, but had only been separated in a pure state in 1817. Perkin failed to make quinine. This is not surprising, because no one knew its exact formula at that time. But it was during investigations that he discovered mauve — by accident.

Perkin was heating a mixture of aniline sulphate and potassium dichromate. He got a black precipitate. Instead of just throwing this away he decided to investigate it. He added some alcohol and found that he could extract a beautiful purple coloured material from the black mess. He then found that the material could be used as a dye. What is more, it was fast to light.

Perkin sent samples of dyed silk to a commercial firm of dyers. They were very interested because there were then no lilac or purple dyes for cotton or silk. This encouraged Perkin. He and his brother scaled up the process so they could make more of the dye. They patented the discovery.

At this point Perkin decided to leave the Royal College of Chemistry. His father, a builder, was willing to risk money to help establish a new firm to manufacture the dye. Perkin and his brother bought a site near Harrow and began building a factory in 1856 (Figure 2).

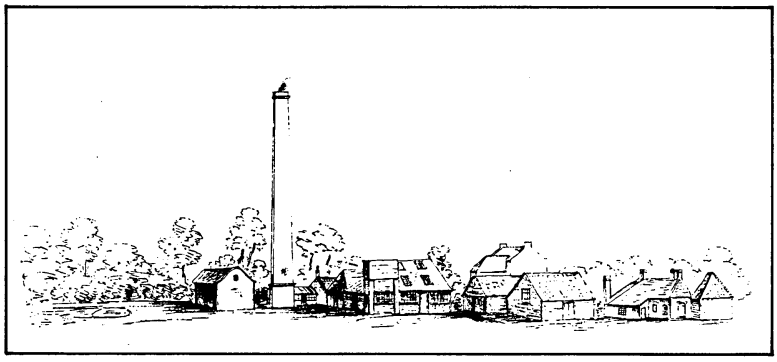
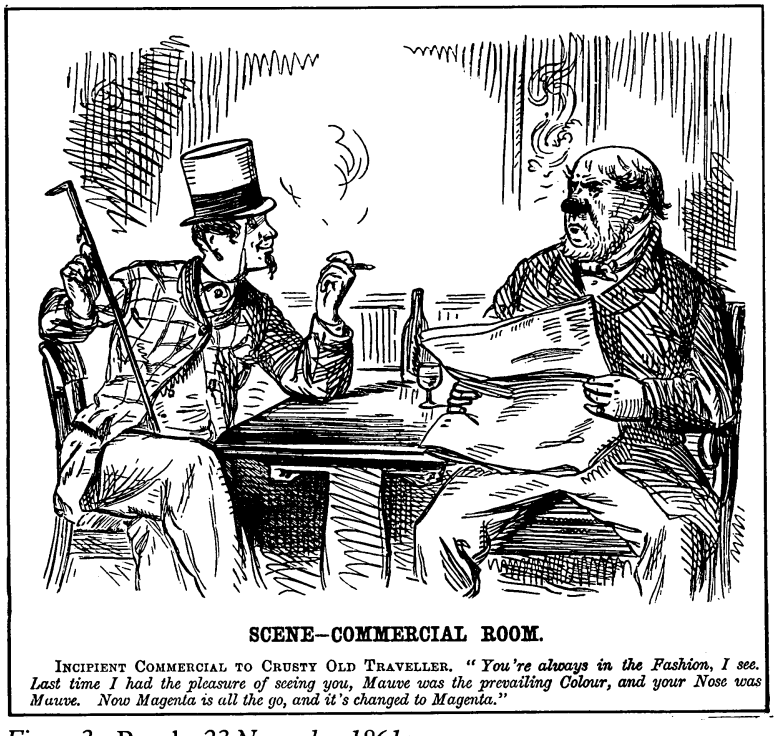


Figure 2 A sketch by W. H. Perkin of his first artificial dye factory in 1858

Mauve becomes famous

Perkin's new dye was called **mauveine** and it became very fashionable. Queen Victoria wore a mauve dress at the International Exhibition of 1862. The penny mauve stamp was printed in 1881. The new colour had a big impact on society. There were many references to it in *Punch* and other periodicals (Figures 3 and 4).



SCENE—COMMERCIAL ROOM.

INCIPIENT COMMERCIAL TO CRUSTY OLD TRAVELLER. *"You're always in the Fashion, I see. Last time I had the pleasure of seeing you, Mauve was the prevailing Colour, and your Nose was Mauve. Now Magenta is all the go, and it's changed to Magenta."*

Figure 3 Punch, *23 November 1861*

Perkin's discovery soon led to many others. In 1859 a French chemist called Verguin discovered a dyestuff which he called **magenta**. Hofmann was able to produce a series of new dyes by altering the structure of magenta.

GREEN GO THE LASSES, O!

FTEN have we heard of countless accidents by Crinoline, but Crinoline is not the only cause of danger in a lady's dress. At least a correspondent who writes to a contemporary, and appends his name with the affix of "M.D.," gives some rather startling reasons for believing so. After stating that the fashionable *mauve* tint, and *Magenta*, "will not stand the test of artificial light," he proceeds next to remark that—

"The only colour, perhaps, which remains fixed under all kinds of light is what is known as 'SCHEELE'S green.' This colour, which is pleasingly bright in the day, is made of arsenic, and preserves its freshness and beauty under all trials of artificial light. Now, as Paterfamilias probably knows, if he looks into his wife's account with her milliner, there is a new light stuff called tarlatane, which has recently come very much into vogue. A lady in proper fashion, with a good green tarlatane dress, is surrounded by 92 square feet of tarlatane, and this 92 square feet of tarlatane contains, as a chemical fact, about 13 ounces of arsenic! Fancy a bevy of a dozen or two of such young ladies 'in verdure clad' of this kind, and that at every crush of their dress, every toss of it in a quadrille, this arsenic is given off in poisonous dust, and that this dust is the fruitful source of headache, redness of skin, inflammation of the stomach, consumptive cough, &c."

With this knowledge in his mind, we think a man would be as green as the dress of his fair partner, if he either waltzed or polked with a lady in SCHEELE'S green. In fact, girls in these green dresses ought to be marked "DANGEROUS!"

Figure 4 Punch, *5 October 1861*

Perkin's factory was a commercial success and he was soon rich. However, he had a lot of competition from other companies, particularly German ones. The Germans were much quicker to develop the dye industry than the British. There was not much interest in the dye industry in Britain. This was because iron, steel, textiles, shipbuilding and colonial industries were so profitable. Perkin sold the business after a few years and continued research in his private laboratory.

At this time chemists were getting a better understanding of the structure of substances. They were soon able to plan their approach to making new molecules, so that new dyes could be made by design rather than by accident.

Questions

1 *Why was the discovery of synthetic dyes so important?*

2 *Why did Germany develop the synthetic dye industry quicker than Britain?*

3 *Mauve was made from aniline and in 1856 aniline was produced from coal tar. So mauve was the first of the 'coal tar' dyes. What is the main source of chemicals for the synthesis of dyes, drugs and plastics nowadays?*

4 *How old was Perkin when he discovered mauve?*

5 *In what ways can young people of school or college age make a lot of money from science or technology today?*

6 *Perkin seems to have discovered mauve by chance. Give another example of a chance discovery in science.*

7 *How many colours of cloth have been used to make the clothes you are wearing? What are the colours? Are the dyes likely to be synthetic or natural?*

Making Perkin's mauve

In this experiment you will use roughly the same method as William Perkin used when he discovered his mauve dye in 1856.

What you do

Follow the instructions shown in Figure 5.

Caution: Safety. Aniline sulphate and potassium dichromate are harmful. Avoid skin contact with these chemicals. Ethanol is highly flammable and must only be heated with a hot water bath. Make sure no burners are alight when the ethanol is being heated.

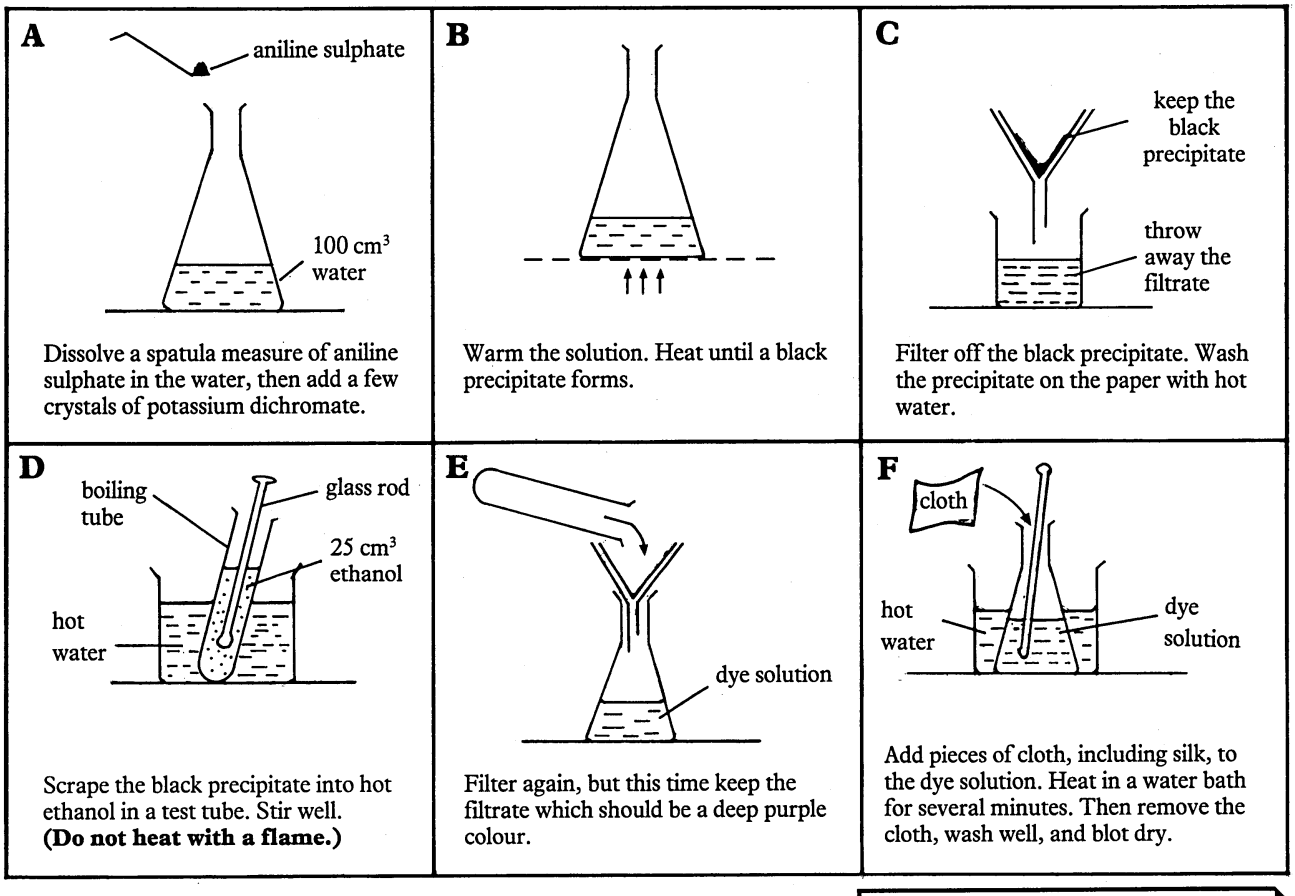


Figure 5 Making Perkin's mauve

Investigations

1 Dye different types of material (for example cotton, silk, nylon, wool, polyester) with Perkin's mauve. Which type of material takes the colour best? (Which of these fabrics would have been available in Perkin's time?)

2 Perkin's discovery was valuable because the dye was fast — it did not fade. Design tests to see how fast your dyed samples are when (a) washed; (b) exposed to light.

Questions

8 *At the end of stage B could you see any signs of a purple colour in the black precipitate? If you had been Perkin would you have had the idea of looking for a dye in the black mess?*

9 *What would be the difficulties of 'scaling-up' this procedure for large-scale manufacture? How is filtering carried out on an industrial scale? How could the ethanol be recovered for re-use?*

SATIS 5

List of units in this book.

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