A black solid

Introduction
Teachers who have not used the problems before should read the section Using the problems before starting.

Prior knowledge
Properties of dilute acids, the reduction of metal oxides and the reactivity series. A detailed knowledge is unnecessary as students are encouraged to consult textbooks and data books during the exercise.

Equipment
Data books and inorganic textbooks should be available for reference.

- A mixture of roughly equal amounts of powdered carbon and copper(II) oxide should be provided at the start of the exercise.

Students can request apparatus and chemicals during the practical session, and these should be issued if they are safe to use eg flame test equipment will probably be required but it should not be on view.

Risk assessment
A risk assessment must be carried out for this problem.

Group size
3–4.

Possible methods
The students' starting point is to find out what solids are black. They might recall this; otherwise they should look at chemicals on the shelves and refer to textbooks. They should identify carbon and metal oxides such as CuO and NiO as possibilities, but are unlikely to consider that the unknown could be a mixture. They may try experiments such as those listed below, however, they will find anomalies in their results if they assume that the mixture is a pure solid. Success will depend upon how the group deals with these anomalies.

1. A flame test gives blue/green colour, showing that copper ions are present.
2. Warming with dilute acid gives a blue solution showing that copper(II) ions are present. The reaction between CuO and warm dilute acid is slow, and filtration is necessary to separate the unreacted CuO as well as the carbon.
3. On heating in air, the mixture should give copper metal.1
4. On reduction, for example with natural gas, there will be two reductants – natural gas and carbon. Copper will be produced but the carbon may mask its colour.
5. Solid phase displacement with a more reactive metal such as magnesium, iron or zinc, will produce copper. These reactions can be unpredictable and are not recommended

Suggested approach
During trialling the following instructions were given to students and proved to be extremely effective:

1. Working as a group, decide how you are going to set about identifying the solid. You should be able to devise several different methods. Discussion can play a vital part in

working out solutions to problems like this, and you should spend sufficient time on it – about 10 minutes initially with further discussion as required.
2. Each group should select and write up their chosen method in note form.
3. Get your method checked for safety and then carry out the practical work to find out how well it works.
4. Write a brief account of what you did.
5. Once all the methods have been tried, come together as a group, discuss what you have all done and try to decide what the black solid is. If you can't, more discussion and more practical work is needed!
6. Working as a group, prepare a short (ca 5-minute maximum) presentation to give to the rest of the class. If possible all group members should take part: any method of presentation (such as a blackboard, overhead projector, etc) can be used.

Outline the problem, describe what you did and explain your conclusion.

After the presentation, be prepared to accept and answer questions and to discuss what you did with the rest of the class.

Notes

1. Heating the solid mixture will give copper metal. For this to work, students will have to heat the solid, but not for too long because this will burn off all the carbon and the copper produced will re-oxidise. It is sometimes necessary to cool the hot mixture quickly under a slowly running water tap to prevent this re-oxidation.
2. Zinc powder can be a particular problem – some samples react well, others explosively, perhaps because the different samples are oxidised to different extents.

By using chemicals and apparatus in the laboratory, devise experiments to identify the black solid sample.
You should refer to any sources of information that you think might help such as your notebooks, textbooks and data books. Ask for assistance if you get stuck.

Health, safety and technical notes

There are no special safety requirements. Normal safety procedures when handling chemicals should be adhered to and eye protection worn.

You must get your method checked for safety before starting on the practical work.