Amount of CO_2

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

Prior knowledge
pH of solutions of ionic compounds, tests for ions and solubility rules. 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 solid barium sulphate1 and potassium carbonate should be prepared. The mixture could be anywhere from 10 g of barium sulphate to 5 g of potassium carbonate to 5 g of barium sulphate and 10 g of potassium carbonate. Weighing on a two decimal place balance is sufficient; the teacher should keep a note of the masses used.

Students can request apparatus and chemicals during the practical session and these should be issued if they are safe to use. The following are likely to be needed:

- Volumetric glassware;
- standard strong acid and an indicator such as methyl orange;
- a 2-decimal place top-pan balance; and
- filtration equipment.

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

Group size
3.

Possible methods
1. Stir the mixture with water and filter the ensuing suspension. Wash the residue, barium sulphate, with a little more water before drying it to a constant mass in an oven. It is recommended to use a two decimal place top-pan balance.
2. Stir the mixture with water and titrate the solution against standard strong acid.
3. Measure the loss of mass on reacting the mixture with excess strong acid. This is best done in a conical flask with a glass wool plug to prevent any liquid spraying out. A two decimal place top-pan balance is again recommended.
4. Measure the volume of gas evolved when the mixture is reacted with excess strong acid.
5. As number 4, but absorb the gas evolved in an alkali such as aqueous sodium hydroxide or aqueous calcium hydroxide, and measure the increase in mass of the alkali.
6. As for method 1, but add aqueous barium chloride or calcium nitrate to the filtrate to precipitate out the carbonate ions.

With methods 3, 4 and 5 some of the carbon dioxide remains dissolved in the water.

Suggested approach

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

1. Working as a group, devise as many different methods as you can. Ask for help if you can't think of at least three. Some methods will seem to be better than others – discuss the advantages and disadvantages of each of the methods that you have devised.
   This discussion plays an important part in devising suitable methods, and can save time and effort. Several minds focusing on a problem together can achieve more than the same minds working independently. About 10 minutes should be spent on this initially, with further discussion as required.
2. Select a method each and write up your 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. You should mention any problems that were found.
5. When you have finished testing your chosen method, choose another method and see how it compares with the last one. If all the other methods are being tried, join and help one of the other groups.
6. Once all of the methods have been tested the group should discuss each method and decide which one was best.
7. Again 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 choice of best method. After the presentation, be prepared to accept and answer questions and to discuss what you did with the rest of the class.

Notes

1. Another insoluble salt (not a carbonate or sulphite) can be used.
2. Information about generating and collecting the gas will probably be needed for methods 4 and 5.

Amount of CO_2

A mixture of two solids, barium sulphate and potassium carbonate, is provided. By using chemicals and apparatus in the laboratory, devise experiments to determine the amount of carbon dioxide that can be obtained from the mixture.
You should try to devise three or, if possible, four different methods; test each one and decide which is best.
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.

Safety

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.