Storyline: answers to assignments.

- 1 Responses will vary over a wide range, but there should be very few items left which have not been dependent on a contribution from the chemical industry.
- 2 The chemical industry involves teams of people who play different roles in taking an idea for a product from concept to marketing. *Cash and chemicals*, published by the Chemical Industry Education Centre (CIEC) at the University of York, is a decision-making exercise which describes the nature and interdependence of these roles.
- **3** The answers given to this question will depend upon the student's familiarity with COSHH regulations and their awareness of other British Standard codes. (This could be a good point in the course to discuss Risk Assessments.)
- 4 The siting of Grangemouth near to the coast and to major road and rail networks ensures good transport links. The pipelines from the North Sea and from the deep water terminal on the west coast of Scotland

(Finnart) ensure the supply of feedstocks. Other raw materials come by road and rail. There is easy access to an unlimited supply of water. The ethene pipeline from the site allows 'excess' ethene to be 'exported' to other sites in the UK. Proximity to a major city provided reasonable certainty of skilled labour, added to which there had been many other similar companies in the area in recent years.

- 5 The answers will depend on the site visited.
- 6 a To produce 1 tonne of phenol needs
 - i 0.83 tonne benzene
 - ii 0.98 tonne methylbenzene
 - **b** Methylbenzene may be a cheaper feedstock, but this is more than balanced out by the fact that the overall process is much more expensive.
- 7 Ethane and propane feedstocks produce large percentages of ethene.

Activities: notes and answers to questions _

VCI 1 A visit to the chemical industry

Why visit the chemical industry?

The way industry uses chemistry is one of the central themes throughout the course, for it is a major contributor to our well being.

The key feature of the unit is a visit to a chemical company to give students an opportunity to:

- have contact with industry and the external working world
- understand the relationship between industry and society
- illustrate relevant aspects of their study.

Further it provides another opportunity to revisit various principles of chemistry met in the course for they are all applied in one way or another in industry.

From the company's point of view there are also benefits from such links because visits

- enhance public understanding of the chemical industry
- give students an awareness of the process of wealth creation and its importance in society
- help companies to gain valuable insight into current educational practice
- may interest students in moving towards a career in the industry.

Thus, overall, the unit gives students an opportunity to experience industrial chemistry at first hand and brings together and defines some of the principles of industrial chemistry.

The **Storyline** and **Chemical Ideas** provide a background to the UK chemical industry while **Activity VCI 1** is concerned with the students' preparation work and organisation for the visit and the follow-up. **Activity VCI 7** is a case study which illustrates some of the general principles in the unit.

A2 LEVEL

Time allocation

Including planning and reporting-back time, you should allocate the equivalent of at least one week of lesson time for the students to tackle the unit. Planning will have to be done well in advance, and if you have a large number of students going on different visits, or on the same visit but in separate groups, you may have to deal with this unit over a longer period of time.

When should the visit happen?

You will need to plan a long time ahead as some companies like to fit such visits into an annual schedule.

The visit is part of the A2 course. However, experience shows that some students may be substantially influenced in their career or degree choice by visits to industry. It might be appropriate to arrange for the visit to take place before your students make such decisions. Many teachers find that doing the visit at the end of the first year is the most beneficial for students. Alternatively, you may consider linking the visit to a work experience programme.

To get maximum benefit from the unit, the students will need to have met the following chemical principles:

- exothermic and endothermic reactions
- equilibrium
- · electrolytic processes
- rates of reactions
- catalysis.

However, it is unlikely that you will have covered all of these topics to completion by the time of the visit.

Links with other visits

You may wish the visit to coincide with or reinforce a particular unit. Possible topics are shown in Table 1.

During your visit you might consider reinforcing other aspects of the course which are not directly related to the VCI objectives; the most likely example of this would be to see i.r., n.m.r and mass spectrometry in action.

Table 1 Units with particular relevance to chemical industry				
DF	Petrochemicals			
	Fuel additives			
	Catalyst manufacturers			
Μ	Bromine production			
	Chlorine production			
	Uses of halogens			
	Copper recycling			
	Electro-refining			
А	HFC production and uses			
PR and DP	Polymer production			
	Polymer processing			
WM	The pharmaceutical industry			
	Infrared spectroscopy and mass spectrometry			
EP	Nuclear magnetic resonance spectroscopy			
	Genetic engineering			
	Applications of genetically engineered enzymes			
SS	Steel manufacture			
	Corrosion prevention			
	Recycling of steel			
AA	Fertiliser production			
	Haber process			
	lon exchange			
	Pesticide production			
CD	Ultraviolet and visible spectroscopy			
	Paints			
	Pigments			
-	Dyes			
0	Water treatment and analysis			
MD	The pharmaceutical industry			

Deciding where to visit

Often the first hurdle to overcome is knowing which company to visit or whom to contact in the company to set up a visit.

You may already have close relations with a local company, in which case things may be easy.

Table 2 Choosing a site

- Ask close to home first for a personal contact, eg colleagues, students and governors, to see if they have a suggestion from personal experience, or by knowing a relative or friend in a suitable company.
- Try the local Education Business Partnership, Science and Technology Regional Organisation (SATRO) or Technical Enterprise Council. Addresses will be available from your Local Education Authority.
- Partners in Science Education is a directory produced by CIEC (address on page 128) which lists organisations and chemical companies willing to support science education.
- For further help, consult the Salters Advanced Chemistry Web Site.

If you are in an area where there is little obvious chemical industry, remember that chemical processes go on in all sorts of places (Table 3).

If it should prove impossible to visit a manufacturing or process plant, many university chemistry departments are willing to demonstrate analytical techniques, and chemical engineering departments may be able to show students an operating, pilot plant.

Table 3 Industries which use chemical processes					
Heavy chemical					
Students will probably be familiar with some of the chemicals manufactured at these sites: they include chlorine and sodium hydroxide, sulphuric acid, ammonia, nitrozen, calcium oxide and petrochemicals.					
• Fine chemicals					
These chemicals will be less familiar as they are made in relatively small amounts for special purposes. The chemicals are often described as 'building blocks' for more advanced chemicals.					
Pharmaceuticals					
 Other process industries such as 					
cement production					
brick making					
other building materials production					
 Food processing 					
breweries					
Cosmetics					
 Glass industry 					
Metal foundries					
anodising					
electroplating					
Polymer processing					
Quarrying and mining					
Environmental monitoring and analysis					
water treatment sewage treatment					
waste uisposai public rieaitri					

Opening the company gate

When you have an idea of which company you would like to visit, approach the company's school liaison officer directly. This is often someone in the public affairs, human resources or training department. If the name of this person is not known or it is not clear that such a person exists, then approaching someone in a senior position is the most effective way forward. Usually, the company telephone exchange operator will give the name of the most appropriate contact.

Provide your company contact with relevant aspects of the OCR AS/A specifications and copies of student material which demonstrate the SAC context-led approach. Industrialists are very much drawn to this and it is important that they know why the visit is taking place, what learning outcomes are required and what to expect.

The visit may help companies meet their *Responsible Care* programme targets in which they declare publicly that they operate responsibly by signing up to a code known as *Responsible Care*. The company needs to meet a strict Code of Practice covering safety, health and environmental protection before they are able to use the *Responsible Care* logo.

The preliminary visit

A preliminary visit is virtually essential even if the company has already been visited by a Salters school or college. It provides an opportunity to establish personal contacts, and ensures that both teacher and industrialist are well briefed. You will then be in a stronger position to provide guidance to students to ensure that they can make the most of their visit.

A2 LEVEL

Even before you go on the preliminary visit, it would be helpful to find out what goes on at the site and the background to the company (which can be found in company literature and often on the web).

During the preliminary visit, it is important to tell your industrial contact

- the level of the students' background knowledge
- about the Salters Advanced Chemistry course
- the context of the visit within the course and within the VCI unit.

During the preliminary visit you need to agree

- when the visit will take place
- how long it will take (say, from 2–4 hours)
- a detailed outline of what goes on in the chemical processes you will see (examples can be found in Table 4)
- whether you will see production or experimental research and development
- how to ensure the party's safety and what the students need to wear on site
- how many students are allowed on site at any one time
- contact names and telephone numbers (including your home number in case a last minute problem arises), and who will be involved with your students on the visit
- whether a visit from the host company to meet the students before or after the visit is desirable
- what the students need to know about the company in advance of the visit.

There are of course other details, which sound trivial, but can be important, so be sure to find out

- where the party is to be met
- whether handouts are available, especially if they contain flow diagrams or pictorial representations. (These are very helpful in assisting students to interpret unfamiliar plant.)
- the availability of other resources. eg toilets; a place to leave coats and bags; a lecture room; refreshments
- if there is any assistance with transportation.

Finally, during the preliminary visit, make sure that your hosts know that your students will have questions to ask or tasks to do during their visit. The company may have a standard tour or professional guides and it is important for you and the company to agree that what they are offering really does suit your objectives. Ask for modifications if necessary.

After the preliminary visit

Follow your school/college policy on such matters as notification of the Headteacher, Governors or Local Education Authority, sending a letter to parents and checking the insurance cover during the visit. Table 5 is a checklist to help you plan and organise the visit.

Table 5 Checklist					
Contacted company (by phone/letter) and preliminary visit arranged					
Preliminary visit made; company literature obtained					
Date and time of main visit confirmed					
Number of students confirmed					
Names of visitors sent in advance to company if required					
Transport arranged					
Arrangements/venue to meet school party confirmed					
Students briefed on required clothing					
Informed company of any special dietary requirements if food is being provided					
Structure of visit agreed					
Company briefed on the kind of questions that will be asked					
Suggestions for follow-up work arising from visit explored					
Method of feedback to company agreed					
Headteacher/Governors/Education Authority notified					
Insurance cover confirmed					
Letter to parents					
Any handouts for students distributed					
Student preparation done					
Company and main contact(s) thanked					
Company representatives invited to the report back session					

Student preparation

A key element in the success of the visit for your students is their preparation beforehand. It is possible that they have been on other trips during which they were passive participants in a guided tour. The main point of this preparation work is to ensure that they are actively involved during this visit. The students themselves might have some constructive suggestions for making a visit even more worthwhile as a result of their previous experiences, or you may have your own strategy for achieving this objective; alternatively, the approach suggested here might be applicable to your situation.

You will need to decide, in the light of what the students already know about industrial chemistry, whether to do the background to the Chemical Industry, before or after the visit.

So that your students get the most from their visit, brief them, ensuring they cover

- the chemical concepts they would need to understand the manufacturing process being seen
- background information about the company, taken from company literature and/or video
- discussion of relevant issues, which are raised in the Salters publications, including, for example, why it is valuable to visit a site.

The students will need to find out a lot of things during their visit. A list of suggestions for questions is given in **Activity VCI 1**. The questions may not all be relevant to your proposed visit, so students should be encouraged to select and adapt those questions which they will use as a guide to their research of the site. They may want to add more of their own.



A suggested model

This model results in each student having their individual reason for taking an active role during the visit; it also provides them with a substantial basis for their contribution to the follow-up exercise.

- Select specific problems or issues which have to be addressed by the company which you are going to visit. If possible, select a different issue for each student.
- Provide each student with some information or a suitable reference about their problem.
- Set them the task of producing a solution by a specified lesson to occur before the visit.
- In a lesson devoted to the visit, ask each student to outline the problem they were assigned and their solution. Do not tell them if their solution is the one used by the company.
- Go on the visit and ensure that each student discovers the company's actual solution to their assigned problem. (See **The visit** below.)

Asking questions

In **Activity VCI 1** there are some generalised questions which could be used to allocate problems to the students. You, or your students, may be able to re-write these questions in a style which better suits the company you are to visit. This will be more obvious after your preliminary visit.

Encourage students to ask additional questions about chemistry, industry and careers, not only of the guides but of other personnel around the plant. All this will help build up a fuller picture. If the students are likely to want to interrupt people at work, they will need first to obtain permission to do so.

The careers video *Your Future?* follows a day in the life of a young production manager. In 15 minutes, the manager interacts with 15 colleagues at various places on site, to give students not only a comprehensive picture of career opportunities but a good introduction to the industry itself. It is supported by notes. *Your Future?* is available from the Chemical Industry Education Centre at the University of York.

The visit

Your group of students will probably tour around the plant in parties of four, with eight being the usual maximum; the common limiting factors are the ambient noise level on the site, and the size of the rooms being visited.

There are several approaches if you have a large set of students divided into small groups, for example:

- each group can visit the whole plant
- each group can visit a different part of the plant, and report back to one another after the visit.

The way you choose to divide the party should be related to the students' preparation work, their prepared tasks, the time available, planned follow-up arrangements and the nature of the company being visited.

Table 6 shows some of the activities in which SAC students have been engaged during a site tour.

Most of all encourage your students to enjoy the visit and make the most of it!

Follow-up

You will need to set aside time for 'debriefing' and allow students to share answers to the questions.

Table 6 Activities of students on a site tour				
Hearing about	Seeing	Participating in		
 site history the chemical processes at the heart of their visit health, safety and the environment on site career opportunities the future of the industry 	 production areas R&D and analysis (eg n.m.r., m.s., etc.) control of automated processes pilot plants training areas 	discussion with company staff (eg managers, chemists) on: -problem solving exercises -presentations -making a profit		

Students who have experienced a SAC visit have used the experience and the data gathered for one or more of the following activities:

- briefing other chemistry students who were not on that visit
- pooling data into a report, for their own use and to send back to the company as feedback with their thank-you letter
- making presentations to the school governors, parents and local press
- producing an information booklet or display
- stimulating an individual investigation (when sometimes they could borrow equipment from the company visited)
- relating the chemical concepts witnessed to other units studied.

Remember that the company hosting your visit will be interested to have some kind of feedback. Decide with the students the best way to report back and present your findings to the company. You could try

- oral reports at school or the site
- articles for the company in-house journal or local newspaper
- formal reports
- a frieze of other visual display material companies often like to display material from school visits in their library, foyer or on open days.

It is also a good idea to invite the company to join you in evaluating and improving the exercise for following years.

It is *important* that the company involved receives acknowledgement of their commitment in terms of time and effort; you could encourage your students to express their appreciation as part of their follow-up work.

Reports on the VCI unit

Many teachers have reported that despite the effort involved in setting up the site visit it had become an essential part of the course because of the perceived benefits to the students. Their students have gained from the visit

• increased motivation and confidence

- improved problem solving skills
- better understanding of relevance of chemistry learnt at school to real life situations



- increased understanding of large-scale production or small-scale research
- an insight into career opportunities
- an opportunity to do real investigations.

In a detailed study of the course, entitled 'Student perceptions of chemical industry', Mary Beth Key writes

When students reflected on impressions from their visit at the end of the course, several key areas emerged: learning from firsthand experience centred on the attainment of greater insight into the chemical industry, including an increased appreciation of the relevance of school chemistry and/or of the industry itself and a greater understanding of industrial processes.

Firsthand experience may be the single most important factor in determining that students have a clear balanced view of the chemical industry, but the experience must be properly orchestrated.

The Chemical Industry Education Centre, based at the University of York, can provide other assistance for the VCI unit. For further information contact: **The Manager**, **Chemical Industry Education Centre, Department of Chemistry, University of York, Heslington, York, YO10 5DD** (Tel: 01904 432523; Fax: 01904 434078; email address: ciec@york.ac.uk).

Guidance and up-to-date information is also available on the **Salters Advanced Chemistry Web Site**.

VCI 7 Setting up a new chemical plant

This activity provides the background information for a case study of a complete chemical process which illustrates general principles of industrial production and site selection. It would be suitable for students who are not able to go on a visit, though, of course, it can never replace the 'real thing'.

- **a** The Solvay process produces a single product which is required consistently in large quantities. It is possible to run the process continuously with reactants being fed continuously into each stage of the interlinked processes. The co-products of some stages are used in later stages.
- **b** A raw material is a naturally occurring resource. A feedstock is one of the chemicals required for a chemical process. In the Solvay process, limestone, a raw material, is heated with coke to produce carbon dioxide which is a feedstock for the reaction occurring in the carbon dioxide absorber.

Calcium oxide is a co-product of the process which converts limestone to carbon dioxide.

One of the reactants, ammonia, is recovered from a coproduct, ammonium chloride, and then recycled so that it can be used again.

- **c** Limestone and salt.
- **d** The ammonia ends up as ammonium chloride. Ammonia can be extracted from this by heating with calcium oxide so theoretically it is not used up and in that sense it is not a raw material. In practice 100% of the ammonia will not be recovered so, from time to time, it will need to be topped up.

The Winnington site was close to river and rail transport, Liverpool docks and sources of raw materials. Salt in the form of brine was available next to the site. Limestone could be transported from nearby quarries and coal from nearby mines. Ammonia stocks could be replenished from nearby gas works.

All of the above factors still apply even though road transport has become more important.