STS 課程的研究

—英、日、美三國在ＳＴＳ課程表現之比較

102－118

【內容大綱】

為什麼需要ＳＴＳ的課程？

什麼是ＳＴＳ課程？

ＳＴＳ在各先進國家施行的情形如何？成效如何？

如何引入ＳＴＳ課程？

結語

參考資料

指導教授：方泰山教授

彭旭明教授

研究教師：曹淇峰教師

STS 課程的研究

—英、日、美三國在ＳＴＳ課程表現之比較

台北市立明倫高中　曹淇峰

為什麼需要ＳＴＳ的課程？

時空環境的改變：科學的進步及科技的發展固然改善了人類的生活，增進了全球的福祉，然而也由於人們的不當使用（譬如核武、化學藥劑等），給人們造成莫大的劫難，有鑑於此，科學家、教育學者們紛紛呼籲，該從社會的內涵層面重新定位科學、科技的研究發展，並審慎思考科學、科技對社會造成的衝擊及他們三者之間交互作用的關係，因而大力倡導科學、技學、社會教育（ＳＴＳ）。（蘇宏仁，民 86）。

未來社會的需要：在民主時代中，社會上許多事物都取決於公投民意，像最近頗受爭議的台中拜耳投資案、貢寮核四建廠案，因而教育目標也特別強調要培養出具有「具有科學素養的現代公民」。美國科學教師協會(NSTA,1991)把ＳＴＳ定義為在人類經驗範疇內的科學教學。而中小學ＳＴＳ的總目標，乃在培養未來公民當面對ＳＴＳ議題時，便具備此問題的知識、技能及情意三方面的素養，以負責任的態度，做出明智的抉擇，並採取適切行動。因此，現在及將來的ＳＴＳ教育，都將強調這些能力的培養。

改進傳統科學教學缺失：傳統的科學教育引發許多問題，如學生不喜歡科學、學生無法應用所學的概念於新的情境中、學校教學未能考慮學生的想法、教學內容與生活脫節...等，是不是正發生在我們的教育中呢？傳統科學教學著重知識的獲得，使用的是與覺知有關的教學活動，而ＳＴＳ教育著重在指導學生面對ＳＴＳ議題時，能做出明智的抉擇，以達到科學概念、科學方法、與科學態度三位一體的科學教育。

通識教育的新大道：為了使學生能處理身邊的問題，多年來，課程專家試過將各學科統整成為合科，但其效果不彰。ＳＴＳ教學與傳統教學有明顯不同（表一）。經由ＳＴＳ互動產生的問題一定連結於環境、文化及其他學科。透過解決這些問題，各學科的智能及技能自然會在學習者的心智結構中統整為網狀組織，達到合科學習的目標，（王澄霞，民 84），為我國通識教育開一條新大道。

表一：　ＳＴＳ與傳統教學之比較

ＳＴＳ的教學	一般標準化的教學
● 以個人生活或當時當地事物，爲人所關切的問題入手來學習	● 探討教科書中所陳述的主要概念及問題
● 以當時當地資源協助處理問題	● 依教科書所陳列之設備及設計，運用實驗室內設備完成之
● 學生蒐集資訊以解決問題	● 學生被動地吸收由教科書及教師提供的資訊
● 以學生個人好奇及關切之事物爲學習重點	● 以教師所提示要學生學習的內容爲重點
● 不會把科學內容當成紙上記載且要學生精熟的材料	● 認爲科學是教科書及教師講演的資訊
● 不刻意強調過程技能，而是在實作中自然學會	● 刻意強調一步步過程技能，但實際解決問題時卻用不出來
● 把科學自然地運用於一般行業，不僅限於科學研究、工程、醫學等自然科學	● 很少把科學與一般行業關連，常認爲科學是已故科學家累積的貢獻
● 當學生從事於解決他們關切的問題時，無形中體認到他們對社會的一個責任	● 學生關切教師與教科書所提示的問題與科學內容
● 學生能體認到在各種場合中，科學扮演的角色	● 學生認爲科學是學校所安排的課程之一部份
● 科學是一種經驗，學生受到鼓勵去享用	● 科學是一種資訊的實體，學生被期望去認知
● 學習著重在「未來可能…」	● 學習在於知道「過去知道的…」

本表摘自（陳文典，民 86）

什麼是ＳＴＳ課程？

以英國的牛津大學出版部 (Oxford University Press) 於 1994 年出版的行動科學 (action science) 系列中的化學變化模組爲例。參見附錄。

此系列每一個ＳＴＳ模組教材都有四種不同頁型，可以有不同的使用方式。

第一頁(本文第 9、10 頁)爲視覺刺激，主要爲引起興趣、促進思考、並引發學生對周圍環境的注意。在這部分，有許多在我們周遭環境的精美相片或漫畫，讓學生發現圖片中的變化爲何？能量變化如何？變化是不是可逆的？是物理變化還是化學變化呢？腦力激盪一下，還有那些反應是發生在我們每天的生活之中呢？

第二頁(本文第 11、12 頁)爲化學知識之資料庫，並將本模組的活動所需的基本知識加以介紹，並將其摘要在右上方的方框中。 學生必須精熟這些化學知識，才能解決後續活動中的問題。

第三頁(本文第 13、14 頁)爲閱讀資料，多半是些引人入勝的短文，討論與本單元最相關的議題，學生可以從閱讀中了解所學的科學如何應用在生活中，並學習做價值判斷，且在最後的活動中，可以測試學生的學習情況。

第四頁(本文第 15、16 頁)爲問題與活動，形式非常多元，如(A)蒐集有關化學反應的資料、(B)繪製重要化學物質的蘊藏圖、(C)化學反應的分類、(D)酒類飲料麵包的製造研究、(I)建立自己的化學反應資料庫、用卡紙自製一微觀的反應動畫等。

另外於模組之後，還有化合物的資料庫，詳列出常見化合物的性質供學生查詢，作爲活動所需之價值判斷依據，不再強調片段化學知識的記憶。

此類ＳＴＳ教材含有較多的學科知識，屬於將學科知識生活化的教材，著重學科知識的深度，但也要求學生重視社會議題。另有一類的ＳＴＳ教材著重於全球社會議題的討論，常需要其他學科知識的配合，社會議題影響層面的多，因而著重知識的廣度，國內開發的模組如溫室效應（王澄霞、林梅芬，民 83)、臭氧層破洞（王澄霞、劉奕昇，民 83）即是。

ＳＴＳ在各先進國家施行的情形如何？成效如何？

表二將英國（魏明通，民 83a、民 83b）、日本（魏明通，民 83c）、美國（佘曉清，民 83；邱美虹，民 83）的ＳＴＳ發展與成效作一比較。

表二、 先進國家實施 STS 課程的比較

國家	英國	日本	美國
主要單位	英國科學教育協會(ASE)	文部省	NSF、NSTA、NSB
發展	● 1975 開始研究 ● 1981 社會中的科學(SIS) ● 1983 社會脈絡中的科學(SISCON) ● 1984 社會中的科學與技術(SATIS)	● 1989 頒佈小學校、中學校、高等學校學習指導要領 ● 1992 分階段實施	● 1977 Project Synthesis(NSF) ● 1982 STS (NSTA) ● 1983 STS(NSB) ● 1985ChemCON
適用對象	● SIS…高三、大一 ● SISCON…高三、大一 ● SATIS 8～14…8～14 歲 SATIS 14～16…14～16 歲 SATIS 16～19…16～19 歲	初中 高中	九年級、十年級 另一年ＳＴＳ課程上大學爲選修，不上大學者必修(NSB)
現行方式	SIS 有五十多所學校以通識課程方式使用；SISCON(ASE 版)每週 2 小時，一年課程；SATIS 每一階段均有一百多個模組，每個模組大約 2 小時	學習指導要領中雖未標榜ＳＴＳ，但所列之教材內容中有多處ＳＴＳ教育有關的敘述	各州不一，最初多配合原課程插入ＳＴＳ專題方式，1993 以後的教材漸多以ＳＴＳ爲主幹
特色	● 重視科學與生活的相關關係 ● 導入引起爭議性的議題 ● 多樣而彈性的教學方法	● 主要有能源、科技與生活、及環境保護三類 ● 融入現行課程中	● 考慮社會議題 ● 重視科學與生活環境相關 ● 培養學生價值判斷力及解決問題與做決策的能力
成效	初步結果令人滿意 進一步評鑑進行中	多數教師認爲有推行價值，但須在將ＳＴＳ列入考試科目及教材資料齊全時方可行	至 1990 年爲止，已有 2000 個學院的 STS 課程，100 個內部訓練計畫，數千個高中採用 STS 教學
借鏡	● 彈性的模組教材值得效法 ● 強調科學概念、科學方法、科學態度三位一體的科學教育爲通識教育開一條新大道	● 妨礙教學的因素如：教學時間不足、缺少資料及計畫、忙於其他任務…等值得注意	● STS 課程隨社會議題而改變，師資的培訓是成功的重要關鍵因素

茲說明如下：

ＳＴＳ運動始於英國，而在美國將其列爲教育基本方針後，成爲教育的主流後，引起各國跟進的熱潮。至於主要的推動單位，在歐美，多爲教育團體，日本與我相近，爲中央的文部省。

開發ＳＴＳ課程的過程，英國先推出的是高三至大一程度的教材，如「社會中的科學」（Science in Society 簡稱 SIS）與「社會脈絡中的科學」（Science in a Social Context 簡稱 SISCON），再出版更年輕學生適用的「社會中的科學與技術」（Science and Technology in Society 簡稱 SATIS）。美國則因各州和各學區而有不同的版本，此外，其民間出版社書商的激烈競爭，也是改革效率提高的重要因素之一。而日本則沒有ＳＴＳ教育的學科名稱，而是將有關ＳＴＳ的教材分散在學習指導要領中。

ＳＴＳ課程在各國多年的倡導、推展、施行及演進，成效有優點，也有缺點。研究報告顯示，ＳＴＳ課程訓練下的學生，在應用能力、創造力、態度、科學過程技能、科學概念及世界觀等六方面的表現，都要比傳統課程的學生佳。老師與學生有機會選擇符合興趣或認爲重要的問題加以研究，學生各成爲議題的組織者，使學校的科學課程更具有關切性，也更有意義。

ＳＴＳ課程也遭受許多的批評，如沒有明確的定義可使人易於理解其內涵。課程缺乏固定的架構，使教師憂心其內容不易掌控，有些又有時間的限制性，很快會淪爲過時。評量方式與教師所應扮演的角色，令教師感到迷惑。且許多科學教師缺乏哲學及社會層面的知識，許多社會科教師缺乏科學知識，目前多數教師研究僅止於自己所學的領域上，各科間少有共同工作，共同研究之機會，將使其教學不易推動。

日本的調查研究顯示，ＳＴＳ教育在學校實施的妨害因素主要有：教學時間不足(45%)、缺少資料及計畫(42%)、忙於其他任務(39%)、沒有在課程標準裡(30%)、教師能力的不足(29%)、沒有教師進修的機會(29%)、無用於入學考試(21%)、難以評量學生的成就(14%)、缺少行政與公眾的支持(13%)、經費不足(10%)等困難點，我國教育制度與日本相近，值得我們注意。

如何引入ＳＴＳ課程？

將ＳＴＳ課程引入現行的學校課程中，以下列三種形式較可行，但各有其優缺點。表三列出這三種策略的比較。（蘇宏仁，民 85）

表三、 引入ＳＴＳ課程較可行的三種方式之比較

方式	優點	缺點
選擇些小單元或小主題插入一般課程中	● 強化現行課程的整體性及凝聚性，容易被視爲既定課程而接受之	● 難以抉擇該捨棄那些已有的單元，以容納ＳＴＳ課程 ● 無法對一些重要的議題做深入的探討，而只能做膚淺的、片段的介紹
延伸現有的課程單元，開發新的模組，以供數星期或數月的教學使用	● 有機會對ＳＴＳ進行深入的研究 ● 對ＳＴＳ課程的呈現較有彈性空間	● 當教學時間不敷使用時，ＳＴＳ可能只觸及皮毛，甚至棄而不談
創立一學期或一學年的全新課程，常標榜科際整合、合科課程等	● 有機會發展一套有深度、內涵且完整的ＳＴＳ課程，可充分探討科學、技學、與社會三者間的複雜關係 ● 使此方面的研究更具適法性	● 課程須小心設計，否則學生在傳統課程中學習科學概念、技能、價值觀的時間與機會將會被剝奪。 ● 跨科目抽取一些內容，而共同建構一新課程，經濟因素亦須考量

就目前的教育環境，如欲引入ＳＴＳ課程，在我國初步宜先以前二種方式，或以專題方式試行一段時間，以了解ＳＴＳ課程在我國施行可能面臨之問題與困難，加以改進後，在於新課程綱要或標準施行時，以第三種方式大量採行ＳＴＳ教材，並期望能未我國科學教育注入新的活力。

結語

近年來，我國的科學課程在的變化不大，而世界趨勢卻是瞬息萬變，過去傳統科學教育確實為我國培養不少的人才，但也有不少為人詬病的缺失，現在正是我們邁開步伐，迎向新挑戰的契機，ＳＴＳ正提供我們一種新的角度來看科學，來教科學，在先進諸國施行多年後，仍大力推行ＳＴＳ課程之際，我們是否也該加快改革的腳步，讓我們新的一代成為具有科學素養的現代公民。

施行ＳＴＳ課程之初期，必定會遭遇許多的困難，如日本的調查中所顯示的，教師可能是最大的障礙，成功的關鍵可能就在人的問題上。如何培養具有ＳＴＳ教學能力的科學教師，或如何將現行科學教師之人力資源予以整合，或提供教師進修的機會，以利進行ＳＴＳ的課程活動等與人相關的問題，將會比如何編輯ＳＴＳ資料或評量等教材問題來的困難。

推行雖不易，但有了先進國家的經驗與成效良好，加上ＳＴＳ能使學生統整所學的科學知識與概念，加上自己的分析判斷，將其應用於社會之上，活用於生活之中，相當值得推廣。但值得注意的是，ＳＴＳ也是建立在各科學學科之上，因此，不是說有了ＳＴＳ就不用科學課程了，而是在此基礎之上，在面對社會議題或生活問題時，予以融會貫通加以活用。

參考資料

王澄霞（民 83）開發溫室效應ＳＴＳ單元，中華民國第十屆科學教育研討會論文彙編. 37-68。

王澄霞（民 83）臭氧層破洞ＳＴＳ單元：大二學生，中華民國第十屆科學教育研討會論文彙編. 1-35。

王澄霞（民 84）ＳＴＳ活動中的學與教，科學教育學刊. 第三卷第一期,115-137。

邱美虹（民 83）科學課程革新─評介 Project 2061,SS&C,和 STS 理念，科學教育月刊. 174, 2-14。

余曉清（民 83a）各國ＳＴＳ課程教材評介(四)—美國的科學—技術—社會（ＳＴＳ）教育，科學教育月刊. 171, 12-17。

陳文典（民 86）ＳＴＳ教師所需之專業準備，科學教育學刊. 第五卷第二期, 167-189。

魏明通（民 83a）各國ＳＴＳ課程教材評介(一)—英國ＳＩＳ及ＳＩＳＣＯＮ計畫，科學教育月刊. 168, 2-9。

魏明通（民 83b）各國ＳＴＳ課程教材評介(二)—英國ＳＡＴＩＳ計畫，科學教育月刊. 169, 12-19。

魏明通（民 83c）各國ＳＴＳ課程教材評介(三)—日本的科學—技術—社會（ＳＴＳ）教育，科學教育月刊. 170, 11-22。

蘇宏仁（民 86）美國科學教育的改革—回顧、前瞻與借鏡，科學教育月刊. 200,2-11。

蘇宏仁（民 85）科教課程模式—科學、技學、社會（ＳＴＳ）之研究探討，科學教育月刊. 190, 2-12。

Alan Jarvis(1994)Action Science : chemical change, Oxford University Press, Oxford.

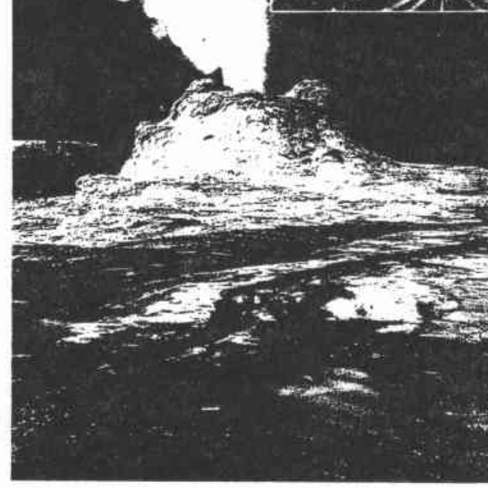
National Science Teachers Association (1991) Science/Technology/Society :A new effort for providing appropriate science for all. A position statement.

附錄：

What's new?

Some substances seem to stay the same forever – others change. Melting, boiling and dissolving are all examples of **physical** changes. In these, adding or taking away energy simply rearranges the particles of a substance.

Chemical changes always produce new substances. The starting materials disappear and are replaced by entirely new substances with their own properties. Unlike physical changes, chemical changes are hard to reverse.



A Divide the photographs into two groups. Decide which show physical changes and which show chemical changes. Make an accurate record of what changes you think are happening in each photograph. Draw up a table to show where:

- new substances are being formed;
- energy changes are taking place;
- the changes can easily be reversed;
- chemical changes are taking place; or
- physical changes are occurring.

B Imagine you could see particles with the naked eye. Discuss with a friend what is happening in two of the physical changes. Draw accurate particle diagrams of what you think is going on.

C Talk about two of the chemical changes. For one of them identify and write down:

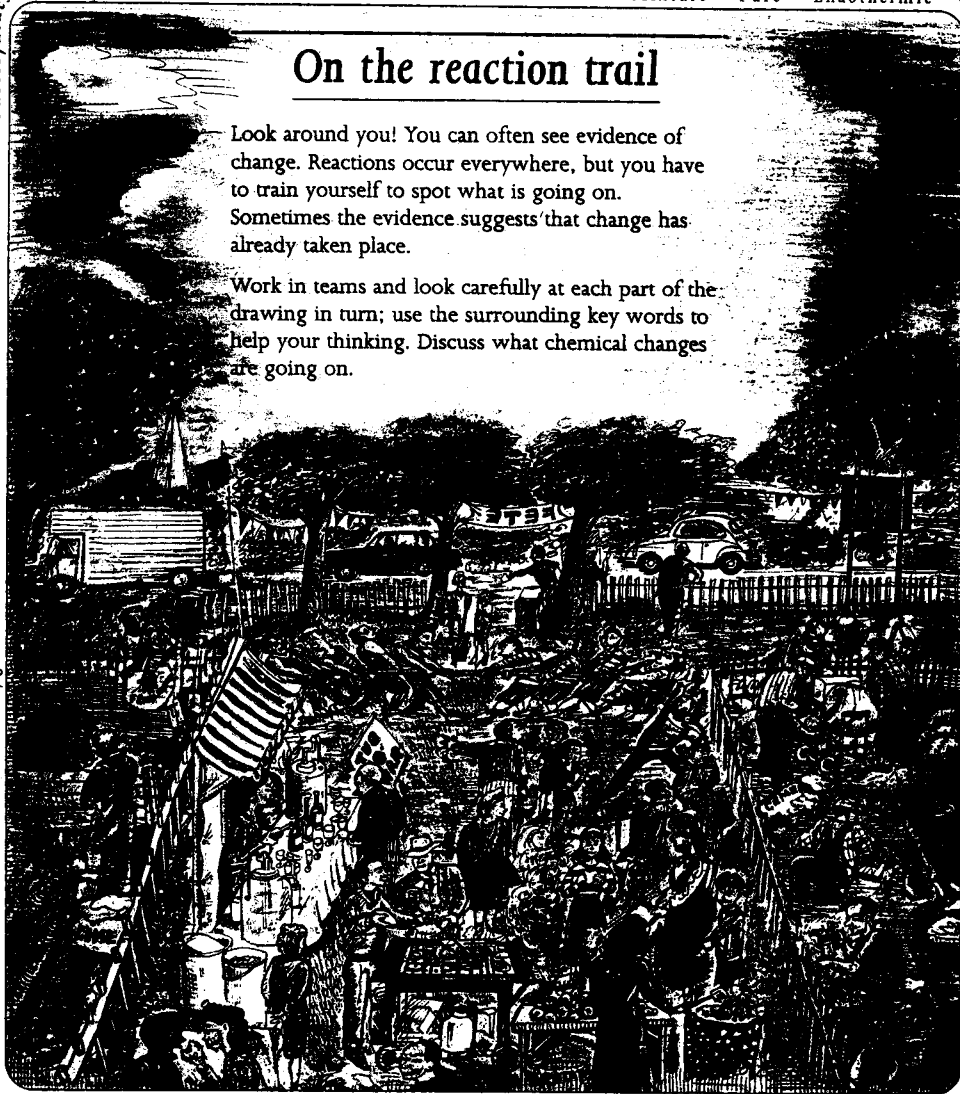
- the reactants and products;
- the formulae of each substance;
- a word or symbol equation which describes the change.

Visual stimulus

On the reaction trail

Look around you! You can often see evidence of change. Reactions occur everywhere, but you have to train yourself to spot what is going on. Sometimes the evidence suggests that change has already taken place.

Work in teams and look carefully at each part of the drawing in turn; use the surrounding key words to help your thinking. Discuss what chemical changes are going on.



A What chemical changes can you spot happening in the picture? Make a list of these. Brainstorm some other chemical changes that occur in everyday life and add these to your list.

B Share out the key words which surround the illustration among the class. Make *Factfile* boxes around the words. Then organize them to make a wall display.

C Discuss each chemical change in more detail. Draw up a table of facts about the changes. Use some of these headings to get you started.

- Reaction
- Products
- Energy changes
- Reactants
- Reaction conditions
- Speed of reaction

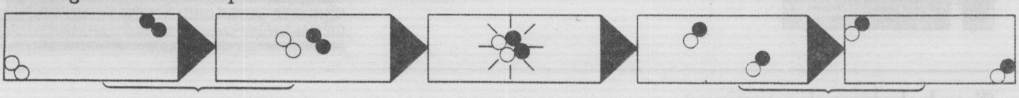
D What evidence is there in the illustration that some chemical changes have already taken place? Make a list of your observations.

Key facts: simple chemical reactions

- People use chemical changes to convert raw materials into new substances.
- Chemical changes always involve either the input or release of energy.
- Substances which are present at the start of a reaction are called reactants.
- Substances which are left at the end of a reaction are called products.
- Some reactions occur by themselves; others need an input of energy to make them start.
- Chemical changes are usually difficult to reverse.
- Rocks, plants, sea water, air and living things are all rich sources of raw materials.
- The different sorts of chemical change can be classified according to what happens in them.

Chemical changes

Chemical changes (**reactions**) produce new chemical substances. During a reaction an input of energy helps to break apart the particles in the reactants. Energy is released when the particles are re-combined and rearranged to make the products of the reaction.



Reactants move closer together. *Old bonds are broken — new bonds are made.* *New substances (products) are formed*

Raw materials

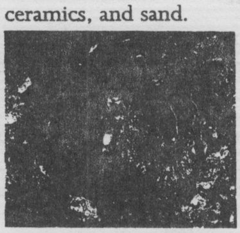
Many useful substances occur in nature. Raw materials from a variety of sources can be converted into new and useful products by chemical changes.

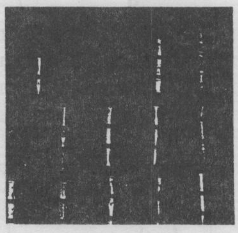
Coal can be burnt to make heat. It also contains a variety of useful raw materials. Chemical changes convert these into soap, dyes, perfumes, paint, and a range of other chemical products.

Rocks and **minerals** from the Earth are a rich source of raw materials. Many metals can be extracted from ores found in rock. Rocks and minerals also provide other useful materials such as lime, ceramics, and sand.

Air might not seem very useful. However, it provides oxygen for you to breathe. Oxygen, argon, nitrogen and carbon dioxide can also be separated from air by cooling it down.

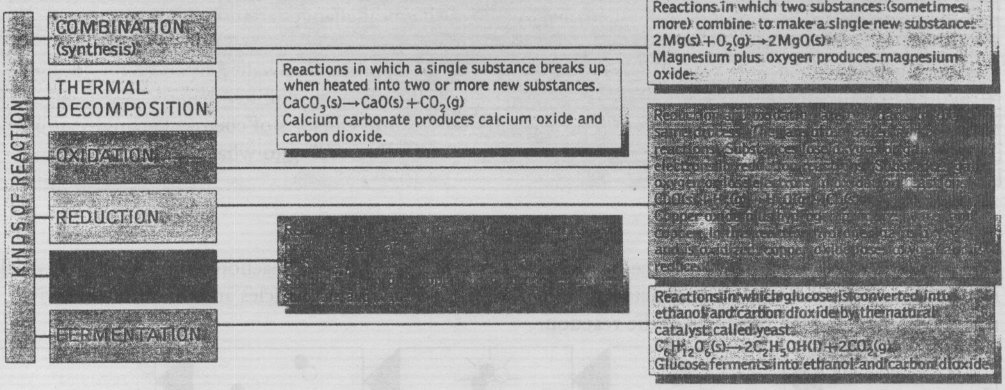
Crude oil is a mixture of very useful chemicals. These are separated in an oil refinery. Some can be used as they are. Others are chemically changed into new products such as plastics, paints, and drugs.





Patterns in chemical reactions

There are millions of different chemical reactions. Chemists like to group together (classify) reactions which have similar changes taking place within them.



Simple balanced equations

- A chemical equation tells you more about the substances which take part in the reaction. Equations may be written in words or symbols.

Word equation

Sulphur plus oxygen produces sulphur dioxide.

Symbol equation

$S + O_2 \rightarrow SO_2$

- A balanced equation is written in symbols and always has the same number of atoms of each element on both sides of the equation.

Unbalanced equation

$C_5H_8 + O_2 \rightarrow CO_2 + H_2O$

Balanced equation

$C_5H_8 + 7O_2 \rightarrow 5CO_2 + 4H_2O$

- State symbols show whether a substance is

solid (s)	liquid (l)
gas (g)	dissolved in water (aq)

State symbols are used in equations.

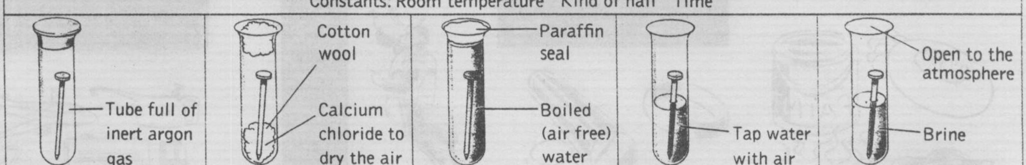
$S(s) + O_2(g) \rightarrow SO_2(g)$

Rusting – a simple but unwanted reaction!

Most metals corrode when left in the atmosphere. Rusting is the special name given to the corrosion of iron. This occurs when iron is left in moist air. The presence in the air of dissolved ions such as those in salt seem to speed up rusting.

$4Fe(s) + 3O_2(g) + 6H_2O(l) \rightarrow 4Fe(OH)_3(s)$ Iron rusts more quickly in some conditions than in others.

Constants: Room temperature Kind of nail Time



Air × Water × Salt ×	Air ✓ Water × Salt ×	Air × Water ✓ Salt ×	Air ✓ Water ✓ Salt ×	Air ✓ Water ✓ Salt ✓
No rust	No rust	No rust	Rust	Rust

Testing, testing!

Rajinda and Paul work for BAL (Bedton Analytical Laboratories). They have worked there since they left school. They applied for the job because they liked chemistry at school. They really put their knowledge of science to good use.

Many firms and organizations send substances to BAL for testing, so that they can find out what the substances are. BAL answers each query quickly and sends a written report.

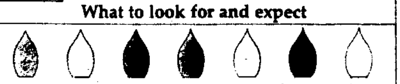
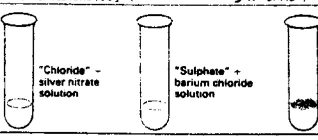
When a substance comes in for identification it is given a number of chemical tests. Each one gives a clue to its identity. A single test is usually not good enough as it does not provide enough facts to identify the substance. A number of tests give more information and help pinpoint its correct identity.

Most, but not all substances Rajinda and Paul test are compounds. Sometimes they use special machines to help them identify chemicals quickly and accurately. But often the substances that come in can be identified using simple chemical tests.

Tests that can be carried out

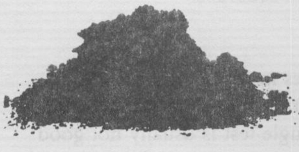
- **Appearance** Looking at a compound will often give clues about the element(s) it contains. For example, blue compounds often contain copper.
- **Analysis of physical properties** This provides information about a substance's possible structure, e.g. covalent compounds do not conduct electricity.
- **Melting point** Every substance has a unique melting point. The melting points of unknown compounds can be compared with those of compounds that have already been identified.
- **Flame test** This identifies metal (positive) ions. Compounds which contain a metal ion burn in a hot bunsen flame with characteristic colours, e.g. sodium compounds burn yellow.
- **Chemical tests for negative ions** Simple chemical reactions can test to see if a compound contains chloride (Cl^-), sulphate (SO_4^{2-}), or carbonate (CO_3^{2-}) ions.
- **Solubility in water** Some compounds are soluble in water, others are not. A compound's solubility can give information as to the ions it might contain.
- Other tests are used when required to provide extra information.

Bedton Analytical Laboratories

Test	How to test/What to look for	What to look for and expect
Flame tests	Clean a nichrome wire in a hot bunsen burner flame. Dip the wire in some dilute hydrochloric acid to clean it, then add a small amount of the substance to be treated. Put the wire in the hot bunsen flame and look for any colour straight away.	
Solubility tests	Put 100g of water into a clean beaker. Add a few grams of the substance. Decide whether it dissolves (soluble), only dissolves when heated (slightly soluble) or does not dissolve at all (insoluble)	**A compound will be soluble if it contains:** • sodium ions (Na^+) • potassium ions (K^+) • nitrate ions (NO_3^{2-}) • chloride ions – except if it is silver or lead chloride • sulphate ion – except if it is calcium, barium or lead sulphate **A compound will be insoluble if it contains:** • oxide ions (O^{2-}) • hydroxide ions (OH^-) } (unless it contains • carbonate ions (CO_3^{2-}) } K^+ or Na^+)
Tests for negative ions (anions)	Test for **chloride** ions (Cl^-): Dissolve a little substance in water. If water will not work use dilute nitric acid instead. Add one or two drops of dilute silver nitrate solution. Test for **sulphate** ions (SO_4^{2-}): Dissolve a little substance in water. If water will not work use dilute hydrochloric acid instead. Add one or two drops of barium chloride solution. Test for **carbonate** ions (CO_3^{2-}): Add one or two drops of dilute hydrochloric acid to the substance. If a gas is produced, bubble it through lime water and look to see what happens.	

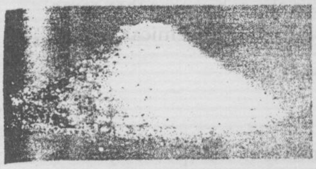
All in a day's work!

One day Rajinda and Paul were asked to test a number of unlabelled bottles which had come in from Bedton school. They had to be identified before they could be safely disposed of.



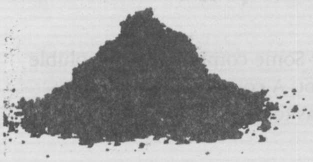
1 Rajinda looked at the first compound. She knew only three substances which were black. Tests showed that it did not conduct electricity and had a very high melting point. When she did the flame test it gave a blue colour. Rajinda tried a test of her own: when hydrogen was passed over the heated compound a pink powder was formed.

2 Paul's first substance looked trickier. He tested its melting point: 419 K (146 °C). When he heated the substance strongly it liquified and turned brown. It was very soluble in water. Paul thought it contained covalent molecules. One of his testing machines told him it contained carbon, hydrogen and oxygen.



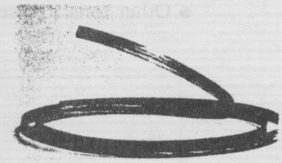
3 These crystals easily dissolved in water forming an alkaline solution (pH 10+). Rajinda found that the flame test gave a yellow colour. The crystals gave off water when heated but the white solid which formed seemed stable to further heating. This basic compound reacted with hydrochloric acid to produce carbon dioxide gas.

4 Yet another white compound. Paul quickly found out that it was insoluble and had a very high melting point. He deduced that it must be ionic and probably contained a group II metal. Its flame colour was a bright crimson. The compound dissolved in dilute hydrochloric acid. Adding barium chloride solution to this gave a white precipitate.



5 Rajinda looked forward to testing these beautiful crystals. She knew that brightly-coloured compounds usually contain a transition metal. The crystals were very soluble in water and decomposed on heating, producing water and a blue powder. A white precipitate formed when dilute silver nitrate was added to a solution of the compound.

6 The last substance was obviously very different. Its appearance indicated that it was a metal. But which one? Paul tested it and found that it was not magnetic. He took a small piece and it burnt fiercely in air. It seemed to combine with oxygen. He did another test and found that 2.4 g of this material burnt to give 4.0 g of a white ash.



Use the information on these pages, the *Factfile*, the *Chemical Database* (pages 52 and 53) and your knowledge of science to answer the following questions.

A Analyse the information provided by each of the six tests that Paul and Rajinda carried out. Write a report which correctly identifies each substance and includes good reasons for this choice. In each case suggest one more test that Rajinda or Paul could do to provide more good evidence.

B Give examples from Rajinda and Paul's work of a:
- combination or synthesis reaction;
- thermal decomposition reaction;
- REDOX (reduction and oxidation) reaction;
- neutralization reaction.

C Write balanced word or symbol equations for the tests and reactions that Rajinda and Paul carried out.

D What tests could you carry out on the following substances to confirm their identity?
- Potassium chloride
- Naphthalene (moth balls)
- Lead carbonate
- Sulphuric acid
- Copper sulphate
- Rust (iron oxide)

Questions and activities

A Collect the labels from a range of household products and/or cuttings from magazines which show everyday chemicals being used. For each chemical decide on

- the raw materials which are used to make it;
- the kind of chemical change used to produce it.

Put your answers together in a table with these headings:

Substance	Raw materials	Chemical change needed

B Use an atlas to help you draw a map of the world showing the major sources of these valuable raw materials. Use different colours for the different materials on your map.

- Oil
- Coal
- Wood
- Sulphur
- Natural gas
- Bauxite
- Wheat
- Malachite
- Haematite

Brainstorm all the useful new chemicals that can be made from these raw materials.

C Study the following reactions.

$C_6H_{12}O_6(s) \rightarrow 2C_2H_5OH(l) + 2CO_2(g)$

$2FeO(s) + C(s) \rightarrow 2Fe(s) + CO_2(g)$

$2AgCl(s) \rightarrow 2Ag(s) + Cl_2(g)$

$CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l)$

$2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$

$S(s) + O_2(g) \rightarrow SO_2(g)$

a Classify (sort) each reaction into one of the following groups:

- Combination
- Decomposition
- Oxidation
- Reduction
- Fermentation
- Neutralization

b Explain why each reaction fits into the group it does.

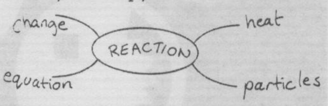
D Research how fermentation reactions are used to make beer, wine, spirits and bread. Make an interesting poster out of your findings.

E What kind of chemical change might happen when:

a petrol (C_8H_{18}) burns in a car;
b milk of magnesia (MgO) neutralizes stomach acid;
c iron rusts;
d yeast and sugar makes bread rise;
e lead ore (PbS) is heated strongly?

Write down a balanced word or symbol equation to explain what is going on.

F Put together words which go with the one in the centre and you have a word burr! This one has been started for you. Copy it out and add some more words.



Choose some other words from this section and make some word burrs of your own. Try to connect them to make a spider diagram.

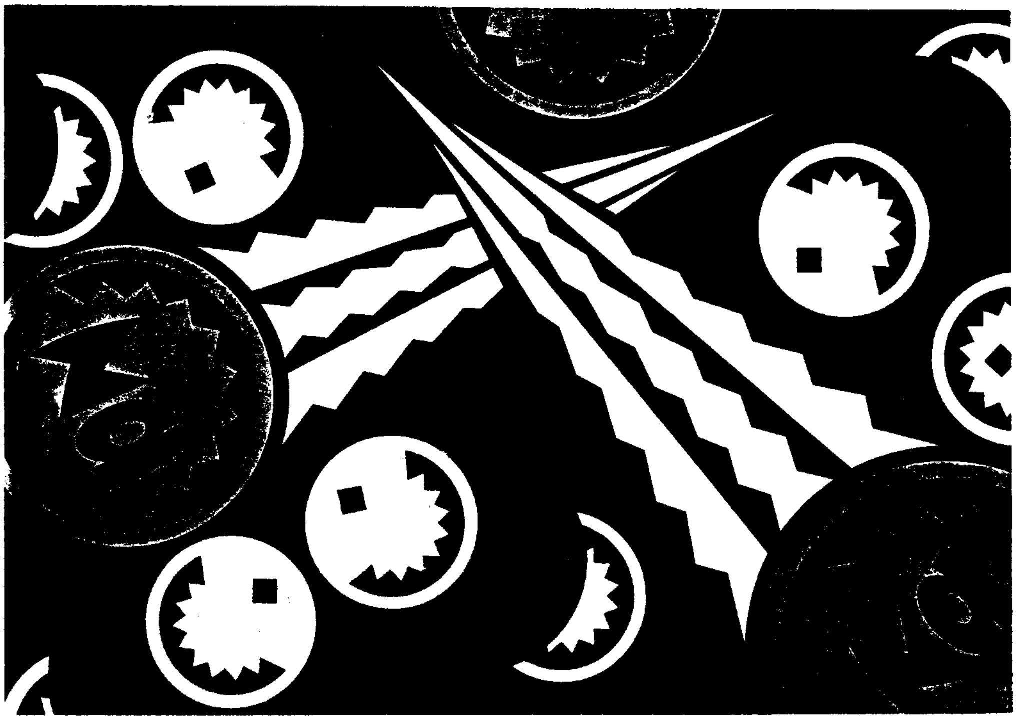
G Bert owns a small garage. He tells his customers that in the old days the best way to protect cars from rusting was to cover all the exposed parts with grease. Some people do not believe him. They think that paint, rust inhibitor, chromium plating or something else must be better. Plan an investigation to prove Bert right or wrong.

Remember to think about:

- what you will keep the same;
- what you will change;
- what you expect to see changing.

I Design and make a database for the different kinds of chemical reaction you will come across in this book. You could follow the design of the one below or make one of your own. Add to your database as you go through each section of this book.

Symbol equation	Reaction type
Word equation	Information

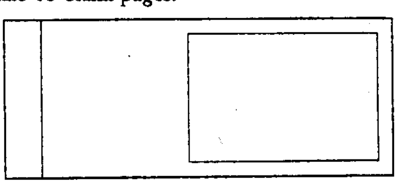


At the flicks

Miss Flavell, a science teacher at Bedton school, likes to get her class involved in practical activity. Some of her class were having difficulty in coming to grips with how reactants change to products in chemical reactions. What really does happen to the particles? Watching a TV cartoon gave Miss Flavell an idea. She knew that the moving cartoon was made up of lots of individual images, flashed on the screen for just a fraction of a second. Then she remembered making flick book cartoons when she was at school. Why not make 'reaction' flick books, to show chemical changes in action? Try some out for yourself.

Rules for making your flick book
Read these carefully before you start.

1 Make 15 blank pages.



2 On pages 1 to 5 draw particle pictures of the reactants coming closer until they touch.
3 On pages 6 to 10 draw the particles in the reactants rearranging to form the products.
4 On pages 11 to 15 draw the particles in the products gradually moving further apart.
5 Arrange the pages of the flick book in order with number 1 on top. Then staple the book together.
6 Test your flick book to see if it works! Think about ways in which you could improve it. What happens if you add more pages?

Here are some ideas to get you started. Later you can think of some of your own.

- Hydrogen (H_2) and oxygen (O_2) molecules reacting to make water (H_2O) molecules.
- Nitrogen (N_2) and hydrogen (H_2) molecules reacting to make ammonia (NH_3) molecules.
- Carbon (C) reacting with iron oxide (Fe_2O_3) to form iron and carbon dioxide molecules (CO_2).
- Methane molecules (CH_4) reacting with oxygen molecules (O_2) to form water and carbon dioxide.