Cosmetics Chemistry Module

Chemistry in the Modern World

Foreword

Chemistry is both a creative, an analytical and a logical science. We all have the pleasure on a daily basis in our lives to enjoy the fruits of chemical inventions, from the delicious food we eat to the clothes we wear. Chemists around the world work on a daily basis to manufacture, to the highest standards, metallic paint for cars, coatings for compact discs as well as the latest fragrance of perfume. Research and development is one of the first steps to bring a product to the market place. Research is done in the chemistry departments of universities and in the research units of large companies.

In this module, we will consider the chemistry involved in the cosmetics business, the manufacture of skin, nail and hair care and other beauty products. The beauty business worldwide is worth a small fortune and here in Ireland, young people are enjoying the products that help with their personal grooming, help to develop their self-esteem and enhance their attractiveness. We will explore the chemistry involved in the manufacture of a few of these products, you will have a few experiments you can try out taking the safety guidelines of your teacher into account and if you want to explore this topic further you can connect with the industry, browse some web-sites and maybe enter the ESAT Young Scientist Competition with a project (www.esatys.com). Other chemistry modules that might be of interest to you include the *Forensic Science* module and *Medicines and You* to be found in: www.pharmachemicalireland.ie.

Enjoy the module and learn some chemistry into the bargain!

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Introduction

Cosmetics in general are classified as substances that are used to groom and beautify the body, to contribute to a person's sense of well-being and to enhance their feelings of attractiveness. Since ancient times mankind has explored ways of beautifying the body, including face painting and wearing ornate headress and jewellery. In this module, we will focus on the cosmetics that help us clean and beautify the skin, hair, nails and teeth. Cosmetics are manufactured in a chemical process, either on a small scale or large scale, and the production has to be carefully monitored.

The manufacture of skin cream, moisturisers and other skin treatments, particularly face creams, are often carried out in *clean-room* conditions so that no bacteria enter the cream and there is little or no risk of an adverse skin reaction. Staff entering the *clean room* wear protective clothing and a face mask at all times and the air conditions are controlled in the room. This may explain why some womens' face creams are so expensive. Skincare involves an entire range of washing products, including soaps, perfumed soaps, shower gels and lotions.

Haircare has a tremendous store of treatments, including shampoos and conditioners and then branching out to including a multitude of dye products from full colour treatments to highlights. Nailcare has become a big business in Ireland in the last few years, with nail extensions of many types replacing the more traditional manicures and nail varnishes. Teethcare has entered the realm of cosmetic surgery, besides toothpaste there is mouth washes, tooth polishes and whitening pastes. The end result

is that young people are more aware of the need to present themselves clean and well groomed.

New markets have been created, for example, the *BodyShop* has entered a new market, producing smaller quantities and a more environmentally friendly product (www.the-body-shop.com). This new consciousness about the origin of the cosmetics, whether or not they are tested on animals and where they are originating from has led to a new debate. While this unit will not seek to cover all the possible debates it suggests that you get the scientific knowledge first and foremost so that your debate is based on facts. You will be aware of the black and white attitude taken by many people with regard to chemicals, the thinking that chemicals are either all bad or all good for you, when in fact neither statement is in fact correct. You can search for the chemistry underlying the products by looking closely at the labels and doing a web-site search for more information.

Aims of the Module

The aims of the cosmetic chemistry module include to:

- present basic fundamental aspects of chemistry, in terms of knowledge, skills and scientific method.

- introduce an aspect of science that has mass appeal to all teenagers nowadays.

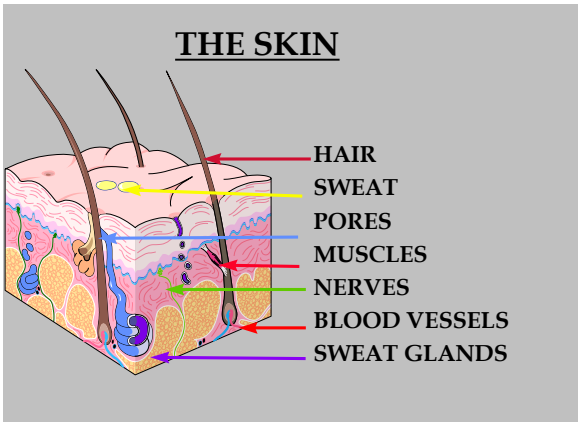
- provide students with opportunities through experiments to develop a range of foundation laboratory skills suitable for progression to senior cycle.

- give opportunities to students to develop their skills of independent scientific inquiry and research.

Teaching has moved away from the "filling empty vessels" approach of thirty years ago to one in which the emphasis is on teaching students "how to learn". Researchers, such as Dewey, Piaget and more recently Bruner, Kolb and Vygotsky all see the value of students learning from reflecting on experience. This is the scientific method in action, and has always been what good experimental science has stood for. Assessment can be built into the module, by inviting the students to keep a scrapbook with their research, their experiments and their notes and inviting them to speak about what they learned about chemistry during the course of their work, what they liked

Unit 1 SKIN

1.1 Core Knowledge



The skin is made of two layers, the lower layer the dermis and the upper layer the epidermis. The dermis contains blood vessels, nerve endings, sweat glands and the root of the hair follicle. The epidermis has several layers of cells, as dead ones are shed new ones push to the surface. At the surface the skin cells have died and become the protein keratin, which is the same protein that hair is made of. A water content of about 10% keeps the upper layer of skin in good condition, not too dry and not too wet. The sebaceous glands of the hair follicles produce sebum, an oil which protects the skin.

The skin is the largest organ of the body. Skin functions in regulating our temperature, as a form of protection, it is an organ of excretion and it has receptors for touch, pressure, and pain keeping us in close contact with our environment. The skin becomes dirty when natural oils from the sebaceous glands trap dirt and hold it on the skin. Using shower gels and soaps is a way of removing this oily dirt from the skin.

Soap

Soap is a product when used with water decreases surface tension, loosens unwanted particles and absorbs dirt and grease into a foam which can be washed away. Soap bars are a 19th century invention, with soaps used in the textile industry been around for the last 5000 years. Bathing was popular in Roman times and a soap factory was found in the ruins of Pompeii, a city destroyed by the eruption of Mount Vesuvius in 79 A.D. People who made soaps for personal use tended also to make candles since the same raw materials are used in both products. In the 19th century a new process, using sodium hydroxide, was found making a hard product and making soap bars that were affordable. Soap results from a chemical reaction between an acid and a base, that causes "saponification" to occur. The acid part of the soap comes from a fat, either an animal or vegetable fat. The soap molecule is made up of a fat-loving tail and a water-loving head. It removes dirt by emulsifying the oil on the skin making it miscible with water.

Animal fats have to be rendered and purified before been used in soap making. Soaps, made from vegetable oils, like Castile soap in Spain, are regarded as superior to those made from lard. The vegetable fats includes olive oil, coconut oil and other oils such as jojoba, almond and avocado. The base or alkali part, is either made from ashes (lye water from potash) or sodium hydroxide. Sodium hydroxide is corrosive and requires careful handling, including safety goggles and gloves. It was introduced into the soap-making industry by the French chemist Nicolas Leblanc (1742 – 1806) and improved

by the Belgian chemist, Ernest Solvay (1836-1922). The soap bars produced from sodium hydroxide were hard and easy to ship and to store.

During the chemical reaction the base reacts with the fat or oil, fatty acids get separated from the glycerin part and they bond with the sodium or potassium part of the alkali. The product formed, is the sodium or potassium salt, so that technically soap is a salt, for example, sodium hexadecanoate. The sodium salts of long chain carboxylic acids are soaps. A carboxylic acid has a –COOH grouping. The sodium displases the hydrogen in the process and a typical soap molecule is formed.

The long chain part of the hydrocarbon molecule, tends to dissolve in non-polar solvents while the other end of the molecule, the COONa part is hydrophobic and dissolves in water. The end product has a neutral pH and will not burn the skin. Additives get added to soaps including fragrances and additives that will extend the shelf life and enhance colour and odour. The effectiveness of soap is reduced in areas with hard water i.e. water rich in calcium or magnesium salts.

1.2 Suggestions for Further Investigations

- Additives: investigate the use of proply alcohol and essential oils to extend the shelf life of soaps.

- Check out the Irish Soap company manufacturing, Breeze www.irishbreeze.com

- Find out about the chemicals involved in hard water and the methods used to remove water hardness.

- Investigate a range of sun block products, find out their ingredients and establish how they work.

Cosmetic Surgery

Having Botox injections to clear up wrinkles has become a fashion statement in the last few years. Botox is short for "botulinum toxin A", a diluted form of a food poison produced by the bacterium Clostridium Botulinum, which works by blocking the nerve signals and paralysing the muscles. The bacterium causes botulism, a severe form of food poisoning. It has to be topped up regularly otherwise the wrinkles will return. Investigate the botox fad and other fashion fads down through history, where women were prepared to suffer for the sake of their appearance: (http://bbc.co.uk/science/hottopics/extremecosmetics/botox.shtml).

1.3 Experiment

If you want to try making soap, under the guidance of your teacher at school or your parent/guardian at home try the recipe on:

http://msms.essortment.com/recipessoapsma_rljw.htm

Or follow a similar experiment in the Transition Year text-book (Analyse This! Experiments Workbook for Transition Year, Thomas McCloughlin and Geraldine Kenny, Gill & Macmillan, 2001, page106 or any Leaving Certificate Chemistry text-book, for example, Leaving Certificate Rapid Revision Chemistry, Declan Kennedy and Pat Walsh, Folens, 2002, page 185-186.

1.4 Science Project Suggestion

Investigate the difference in chemical composition and effectiveness between a local cottage industry soap and one of the big commercial companies. Compare and contrast these on the basis of price, appearance, chemical composition and availability.

Unit 2 HAIR

2.1 Core Knowledge

Hair has a variety of functions, it serves to control our body temperature, it is a secondary sexual characteristic, it serves as a form of protection and it has a social function. Hair styles are used to make a statement or to identify the person from a certain faction of society. If, as we are led to believe, first impressions are formed very quickly then well looked after hair will create a positive impression. Hair benefits from a healthy, well balanced diet with plenty of vitamins, exercise and adequate rest.

Hair itself is a dead substance made of a protein called keratin. Proteins are made of amino acids all joined together in rows, called polymers. Each monomer is an amino acid. There are twenty different amino acids by formula, so that there are over 10 000 ways to make proteins in the body. The simplest amino acid is called glycine. One end of the molecule is made of the acidic carboxylic acid group –COOH while the other end has the basic amine group –NH . So when the amino acids join together they lose water between each pair and they join up in long strands to form proteins.

Each hair strand grows from a follicle under the skin. Each strand has a central core, the cortex and this is surrounded by a sheath called the cuticle. Sebum from the sebaceous glands keeps the strand from drying out. The detergent action of hair shampoo, removes dirt from the hair and scalp, as well as enough sebum to keep the

hair looking clean, but not so much as to remove all the oil. The action of the detergent lauryl sulphates accomplishes this tightrope act very well. Other shampoo ingredients are added to give the shampoo a pleasant viscosity, to adjust the pH and to act as preservatives. The acidity of the shampoo plays a part in the production of a good shine, a slightly acidic cuticle reflects light better, thus giving the hair a better shine.

Hair has two natural pigments, melanin, the dark brown pigment of the skin and phaeomelanin, a red-brown or yellow-brown pigment similar to melanin. The colour of hair depends on the amount of these two pigments within the hair strand. Their absence produces white or grey hair. Changing the colour of hair nowadays occurs through the action of complex synthetic organic chemicals. Dyes without bleach darken the hair, while hair is lightened in colour with bleaches. Hair is the protein keratin, and the protein molecules are held together by disulphide linkages -S-S- . If hair is to be made either wavy, or straight the disulphide linkages have first to be broken and their positions changed. This happens when hair is washed, and heated rollers and other methods are used to change the shape of the hair as it dries.

2.2 Further Investigation

- If you want to trial a shampoo evaluation kit, look up the web-site for details: http://sciencekit.com/caregory.asp?c=434167
- Find the chemical formula for lauryl sulphate, a detergent commonly used in many shampoos.

2.3 Experiment

"How strong is your hair"

What you will need

You will need to get a retort stand and weights, a weighing scale, some strands of your hair. You will need to set up a number of tests, that allow you to hold one end of the hair firmly, attach an increasing load to the other end of the hair, ensure the tests are done safely and record your results in the tables below (www.selah.wednet.edu).

Method *Experiment 1*

Increase the load on the hair until it breaks. Do this several times and record the mean value. Record you results in the table below:

Weight (g)	Hair 1 Breaking point	Hair 2 Breaking point	Hair 3 Breaking point	Hair 4 Breaking point

Experiment 2

Increase the load as before, but this time measure how much the hair stretches with each additional load.

Weight (g)	Initial length of hair (cm)	Hair 1 Stretch (cm)	Hair 2 Stretch (cm)	Hair 3 Stretch (cm)	Hair 4 Stretch (cm)

Experiment 3

Use hair that has been soaked in warm water for 30 minutes. What difference to the strength will the water content make? Make a prediction then do the experiment.

Weight (g)	Initial length of hair (cm)	Hair 1 Stretch (cm)	Hair 2 Stretch (cm)	Hair 3 Stretch (cm)	Hair 4 Stretch (cm)

What do you conclude from your results. Will this make a difference to the way you care for your hair in future? www.tlhs.org

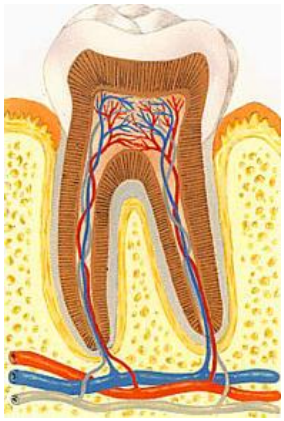
2.4 Science Project Suggestion

- Do a detailed analysis of several shampoos and conditioners and find out the main differences between each of the brands.

- Investigate the various dyes used on hair down through the last fifty years, and the difference each product has in terms of chemical composition and possible damage to the hair.

Unit 3 TEETH

3.1 Core Knowledge



A typical tooth has an exposed crown and a buried root. The crown is partly covered by a bone-like substance called enamel. Beneath the enamel is dentine and this surrounds the inner pulp cavity filled with pulp, which is living tissue. There are four basic types of teeth, the incisors, canines, premolars and molars. See the university of Michigan Museum of Zoology web-site for more information: www.animaldiversity.ummz.edu

Bacteria in our mouth attack our teeth and damage the enamel. The diagram shows a typical bacterium, with cell nucleus, cell membrane and cell wall. Our bodies are covered with millions of bacteria. If it were not for our bacteria we would not be able to fully digest our food. Our mouths are full of bacteria, both good and bad; the bad ones need to be kept in check to avoid tooth decay and bad breadth.

There is a lot of evidence nowadays to suggest that there is a direct link between the decay of teeth and the frequency of sugar in the diet. Bacteria in the mouth act on the sugars and turn them to acids which in turn attack the tooth enamel. Saliva is made up of 99% water, and it also contains engymes, urea, minerals and antibodies. Saliva is alkaline, it neutralises plaque acids and can repair acid attack damage to the teeth. This neutralisation process takes about twenty minutes.

If sugary foods are only eaten at meal times then the acid produced, can be neutralised. However, if sugary foods are eaten throughout the day, plaque acid will build up and tooth decay will result. Toothpastes have antibacterial agents as well as cleaning agents. Fluoride is added to toothpaste to help strengthen the enamel.

Fluorides in toothpaste are found in the form of:

stannous fluouride (SnF)

sodium monofluorophosphate (Na PO F) and

sodium fluoride (NaF).

Toothpaste typically contains water, glycerol (retains water), calcium phosphate (abrasive), sodium-N-lauryl sarcoinate (surfactant), carrageenan (thinkening agent) and fluorides (enamel hardener). Good dental hygiene is essential for our health and well being. It is recommended that you change your toothbrush every three months, you brush your teeth regularly twice a day and you use a mouth wash.

3.2 Further Investigations

- Find out about tooth whitening agents, what products are in them and how do they work.
- Cosmetic surgery on teeth has recently become more popular in Ireland, find out about the most popular treatments been taken.

3.3 Experiment

To investigate how effective are toothpastes at stopping the growth of bacteria.

What you will need

- Sticky tape
- Petri dish, with three wells, inoculated with bacteria
- Three tubes of different toothpastes
- Three spatulas
- A chinagraph pencil
- Three glass rods

Method

1. Using the chinagraph pencil, number the wells on the base of a petri dish, 1-3.

2. Label the tubes of toothpaste 1-3.

3. Using a clean spatula each time, half fill each well with toothpaste 1-3.

4. Seal the petri dish with sticky tape. Store the petri dish for two days at room temperature. DO NOT OPEN THE PETRI DISH ONCE IT HAS BEEN CLOSED.

5. After two days, examine the dish but do not take off the lid.

6. Measure in millimetres the distance across the clear areas around the wells.

7. Record your results in the table provided:

Well Number	Type of Toothpaste in well	Distance across the clear area around well (mm)	Tick the type of toothpaste which was best at stopping bacterial growth

The agar had bacteria in it. Where these grow the agar is cloudy. If the agar is clear, the bacteria are not growing. Look on the list of ingredients in each of the toothpastes to identify the antibacterial agents (www.catie.org.uk/ for further details).

3.4 Science Project Suggestion

- Carry out a full scientific analysis of the effectiveness of a range of toothpastes, including tooth polishes and mouthwashes. Comment on your findings.

Unit 4 NAILS, LIPSTICKS and PERFUMES

4.1 Core Knowledge

NAILS

Nail polish has been used since 3000 B.C., when the Egyptians used henna for its red colour. Nowadays, nail polish is made of lacquer, and is made of polymers (nylon), solvents, plasticisers, colourants and perfumes. The plasticisers are used to make the nail polish more flexible and they help to prevent chipping. The main solvent in nail-varnish is acetone, a non-polar solvent.

LIPSTICKS

Lipsticks prevent moisture loss, and contain castor oil, sesame oil, mineral oils, lanolin, beeswax and perfume. Other chemicals are also found in lipsticks, for example, the whitening agent titanium oxide and polyethylene glycol. The dyes in lipstick all need to be insoluble in water so that the colour lasts. Most lipsticks are waxy solid materials combines with a non-volatile oil which spread easily but remains stiff in the tube.

PERFUMES

The word perfume comes from the Latin “per” meaning “through” and “fumus” meaning “smoke”. Today’s perfumes are made from synthetic chemicals, fragrant plants and animal oils all dissolved in 10% to 25% solutions in alcohol. Cologne is much less expensive and is about one tenth the concentration of perfume. There has to be a match between the perfume, the bottle and the image it conveys. The distillation process that is involved in the manufacture of perfume is interesting in that the length of time can sometimes be the distinguishing difference between the two, for a man’s

fragrance and a woman's perfume the cocktail of chemicals might be the same, yet the period of distillation different (www.france.diplomatie.fr).

Flowers and a few animal essences such as musk and amber are the basic ingredients in all perfumes. To create a perfume you need to blend several essences and choose what specialists call the "key note" (the fragrance that is instantly noticed), the "core note" (which gives the perfume its character) and the "basic note" (which gives the perfume structure). The "key note" comes from substances that vapourises easily and come quickly to the nose, for example phenylacetaldehyde, which has the odour of lilac. The "core note" is produced by substances such as 2-phenylethanol which has the aroma of roses. Finally, the "basic note" is a longer lasting scent carried by substances such as civetone, a cyclic organic compund with a musk like odour. Civetone was once obtained from the secretions of the Ethopian civet cat and was originally obtained by prodding the gland of the caged animals.

4.2 Further Investigation

Investigate the following chemicals found in nail polish, lipsticks and perfumes: 2-phenylethanol, acetone and titanium oxide. Write down their chemical formula, their chemical and physical properties and find out how they are manufactured.

4.3 Experiment

How to extract clove oil perfume from cloves by steam distillation

(BASF MINILAB MANUAL): www.basf.de/uk/ireland/

Leaving Certificate Rapid Revision Chemistry, Declan Kennedy and Pat Walsh, page 182, Folens.

4.4 Science Project Suggestion

- Find out how to grow fingernails by looking up the web-site

http://www.cheminst.ca/ncw/experiments/2001_growing_fingernails_e.htm

Fingernails grow about 3.8 centimetres per year while toenails grow about half as fast. Fingernails are made of the protein keratin, which has long molecular chains of carbon atoms and nitrogen linked together like NCCNCC etc. Keratin molecules are twisted together like strands in a rope, held together by bridges made from sulphur atom side chains. When the keratin is heated or shocked, the S-S bonds break, and the unpaired electrons in each of the sulphur atoms behave like tiny magnets, which can be measures by electron spin resonance spectrometer (ESR). Doug Hayward, of the University of British Columbia tells us that chemists working with archaelogists have used ESR to prove that proteins in charred bones in a cave near Bejing were cooked in a fire 230,000 years ago.

- Make some bath bombs: The Salters Chemistry Club, Handbook Volume 2, page 21 www.salters.co.uk

Web-sites to browse

Pharmachemical Ireland

http://www.pharmachemicalireland.ie

European Cosmetic Trade Asociation

http://www.colipa.com

All you ever wanted to know about cosmetics

http://www.catie.org.uk/

soap manufacture down through the ages

http://www.kitchendoctor.com/articles/soap.html

Is animal testing morally right? Find out more in:

http://www.bbc.co.uk/science/hottopics/animalexperiments/index.shtml

Is botox dangerous?

http://www.bbc.co.uk/science/hottopics/extremecosmetics/

making molecules stand on their head

http://www.cheminst.ca/ncw/experiments/

science teachers across the world

http://www.scienceacross.org

the web-site for the International Union of Pure and Applied Chemistry

www.iupac.org

Text-books for your school library

Medicinal Chemistry

Publisher: Educational Division, the Royal Society of Chemistry (1996).

isbn number 1-870343425, http://www.rsc.org/

This book shows some of the areas where medicinal chemistry is helping to provide the pharmaceuticals to fight major diseases.

Chemistry and the Good Life

The science behind the products you love to buy Vanity, Vitality and Virility

John Emsley

Oxford University Press £18.99 isbn 0-192805096

http://www.rsc.org/

This book seeks to show that although chemicals are not entirely benign, they nevertheless surround us all every day and can be of positive benefit if handled properly.

The Chemistry of Fragrances

D.H. Pybus and C.S. Sell Series: Royal Society of Chemistry Series

http://www.rsc.org/

£19.95

Moderm perfumery is a blend of art, science and technology, with chemistry being the central science involved. The book aims to educate and entertain, and inform the audience of the latest chemistry, techniques and tools applied to fragrance chemistry.

The Cosmetics Industry

The Christain Dior plant, south of Paris is one example of a cosmetics plant. The company employs over two thousand people, and manufactures lipsticks, perfumes and face creams among other products. The perfumes are all manufactured in large distillation apparatus with the cocktail of flowers left to ferment for various stages. The mixture of ingredients is a trade secret and the period the still is left to ferment gives it its special bouquet. While the perfume is being manufactured downstairs the marketing department upstairs is busy getting the right shape and colour of the bottle, the packaging and name for the perfume. This will have a considerable bearing on the sale of the product so a considerable amount of market research is done to get this right.

The lipsticks are manufactured in large blocks of waxes which are cut for each lipstick, the colours and ingredients change each season to suit the ever-changing palette of the fashion industry. The face creams are all manufactured in *clean-room* conditions, with great care been taken to ensure a high quality control for each of the products. So in this plant alone, we see engineers, chemists, marketing graduates and business graduates all working alongside one another to keep the industry at the cutting edge of fashion and to bring customer satisfaction to every season of the year (www.france.diplomatie.fr).

Investigate the Irish cosmetics industries, including the well established SeaVite Galway company (www.seavite.ie) and an emerging company in the Gaeltacht, Ri na Mara, Spiddal, Co. Galway (www.rinamara.ie).

The Legends

The cosmetics industry has been built by a number of significant people who had a particular style to offer at a time when it was most needed:

Christian Dior (1905-1957)

http://www.ba-education.demon.co.uk/for/fashion/dior.html

Christian Dior swept Europe off its feet with his bright fashions, offering light and hope to the drab world after the end of the second world war, in 1947. He was born in the Loire valley in 1905, the second of five children. He was different from his brothers and sisters and liked to help his mother both in the house and garden. His father owned a fertiliser factory but lost everything he owned in the stock market crash of 1929. His mother died at the age of fifty one in 1931.

Christian was a great socialiser and an active member of the arts world. He decided to become a couturier and his sketches were used by the best, particularly his hat designs. By the end of the war he had his own fashion house in Paris, he launched ninety outfits, called the "New Look" as well as a new perfume called "Miss Dior". He was an overnight success. Over his lifetime he dressed royalty and opened shops in London and New York.

Find out about the lives and achievements of two other icons of the cosmetics industry:

(i) Helena Rubenstein and (ii) Anita Ruddick.

TEST YOUR KNOWLEDGE

This is an open book test, a test used to refresh your knowledge of Junior Certificate Chemistry. To find the answers to the questions, you can use a Junior Certificate science text-book. Compare your answers in class with your teachers'guidance.

1. Name the three states of matter.
2. State two differences between a physical and a chemical change.
3. What is a chemical compound? Give three examples of compounds.
4. Give an example of a solution, a solute and a solvent.
5. Explain, with a labelled diagram in each case, the following processes of separation: filtration, evaporation, distillation and chromatography.
6. Write down the composition of air.
7. How is oxygen prepared in the laboratory. Give a labelled diagram of the apparatus used.
8. State two physical and two chemical properties of oxygen.
9. Write down the definition of a catalyst.
10. How is carbon dioxide prepared in the laboratory. Give a labelled diagram of the apparatus used.
11. State two physical and two chemical properties of carbon dioxide.
12. Name the three conditions necessary in order to light a fire.

13. Describe what happens in each of the following stages in the treatment of water to produce clean, drinking water: screening, sedimentation, filtration, chlorination and fluoridation.
14. Name the three particles that make up the atom.
15. What is the atomic number of an element. What is the atomic number of chlorine.
16. The electronic configuration of an atom of an element is 2,8,3. Name the element.
17. Draw a simple atomic diagram (Bohr diagram) of an atom of lithium and an atom of magnesium.
18. Give two physical and two chemical properties of the elements in group I. What is the name given to this group of chemicals.
19. Give two physical and two chemical properties of the elements in group II. What is the name given to this group of chemicals.
20. Give two physical and two chemical properties of the elements in group VII. What is the name given to this group of chemicals.
21. What information does the mass number of the element give?
22. What is the main difference between covalent and ionic bonds.
23. State two examples of covalent and ionic compounds and give one main difference between them.
24. Define the valency of an element.
25. What is the main difference between an exothermic reaction and an endothermic reaction. Give one example of each.
26. Define an indicator, give two examples of indicators and write down their colour in acid and in base solutions.

27. Give three examples of acids.
28. Give three examples of bases.
29. What is the difference between a base and alkali. Name one chemical which is both.
30. What makes water hard?
31. What chemicals cause temporary hardness?
32. What chemicals cause permanent hardness?
33. How are temporary and permanent hardness removed from a sample of water?
34. What is corrosion? What conditions are necessary for corrosion to occur?
35. Give three properties and three examples of metals.
36. Write down the balanced chemical equation for the reaction of a metal of your choice with (i) water (ii) hydrochloric acid and with (iii) oxygen.
37. What is an electrolyte?
38. Draw the labelled diagram of a simple cell.
39. Define oxidation and reduction. Give one example of an oxidation-reduction chemical reaction and state which element is oxidised and which element is reduced.
40. State what you would expect to happen when a piece of copper is placed in a solution of silver nitrate. Which substance is oxidised and which is reduced in the reaction.

COMPOUND FORMULAS

The following compounds have been mentioned in this module. Write down their formulae and state whether they are elements, covalent compounds or ionic compounds. Check your findings with other members of your class and with your teacher.

Helium	Silver
Mercury	Lead
Einsteinium	Hydrogen
Beryllium	Carbon
Sodium chloride	Keratin
Sodium hydroxide	Sodium hexadecanoate
Carboxylic acid	Proply alcohol
Glycine	Lauryl sulphate
Melanin	Phaeomelanin
Stannous fluoride	Sodium monofluorophosphate
Sodium fluoride	Glycerol
Calcium phosphate	Sodium-N-lauryl sarcoinate
Acetone	Titanium oxide
Polyethylene glycol	Phenylacetaldehyde
2-phenylethanol	Silver nitrate

Geraldine Mooney Simmie, a chemistry graduate of NUI, Galway has published several books and articles related to science education including Integrated Chemistry by Folens, Science by School and College Publishers, and several educational videos including Organic Chemistry I and II produced by the Science Teaching Centre, NUI, Galway. Geraldine is well known to science teachers in Ireland, worked as a researcher on the Teaching and Learning for the 21st century project (TL21) in NUI, Maynooth and is currently employed as Academic Coordinator for Teaching Practice and Mentoring in the Department of Education and Professional Studies at the University of Limerick.