Chapter 1 lifestyle chemistry

Take a walk through your kitchen, bathroom and laundry and note the wide range of commercial products that clean and protect all kinds of surfaces from the porcelain bathtub to the skin of your face. Each cleaning or protective agent is specifically designed to suit a particular surface material or fabric.

The variety of consumer products we use in our everyday lives is a result of the explosion in knowledge over the past 50 years of many chemical substances and their interactions. Development of the petroleum industry was accelerated during the Second World War due to the need to develop substitutes for raw materials such as cotton and rubber. The need to control disease and ease pain among wounded soldiers and civilians stimulated new branches of medicine and the pharmaceutical industry.

Our understanding of chemicals and their interactions has led to the development of chemical technology. Accurate control of chemical processes allows industry to produce cosmetics and pharmaceuticals under precisely controlled conditions so that chemicals are produced that serve a specific purpose and have few side effects.

The challenge for the chemical industry is to leave as few unwanted effects on the environment as the cosmetics and pharmaceutical industries have managed for the human body. Part of that challenge is fulfilled by the production of biodegradable detergents and cleaners that release minimal phosphates into our waterways.

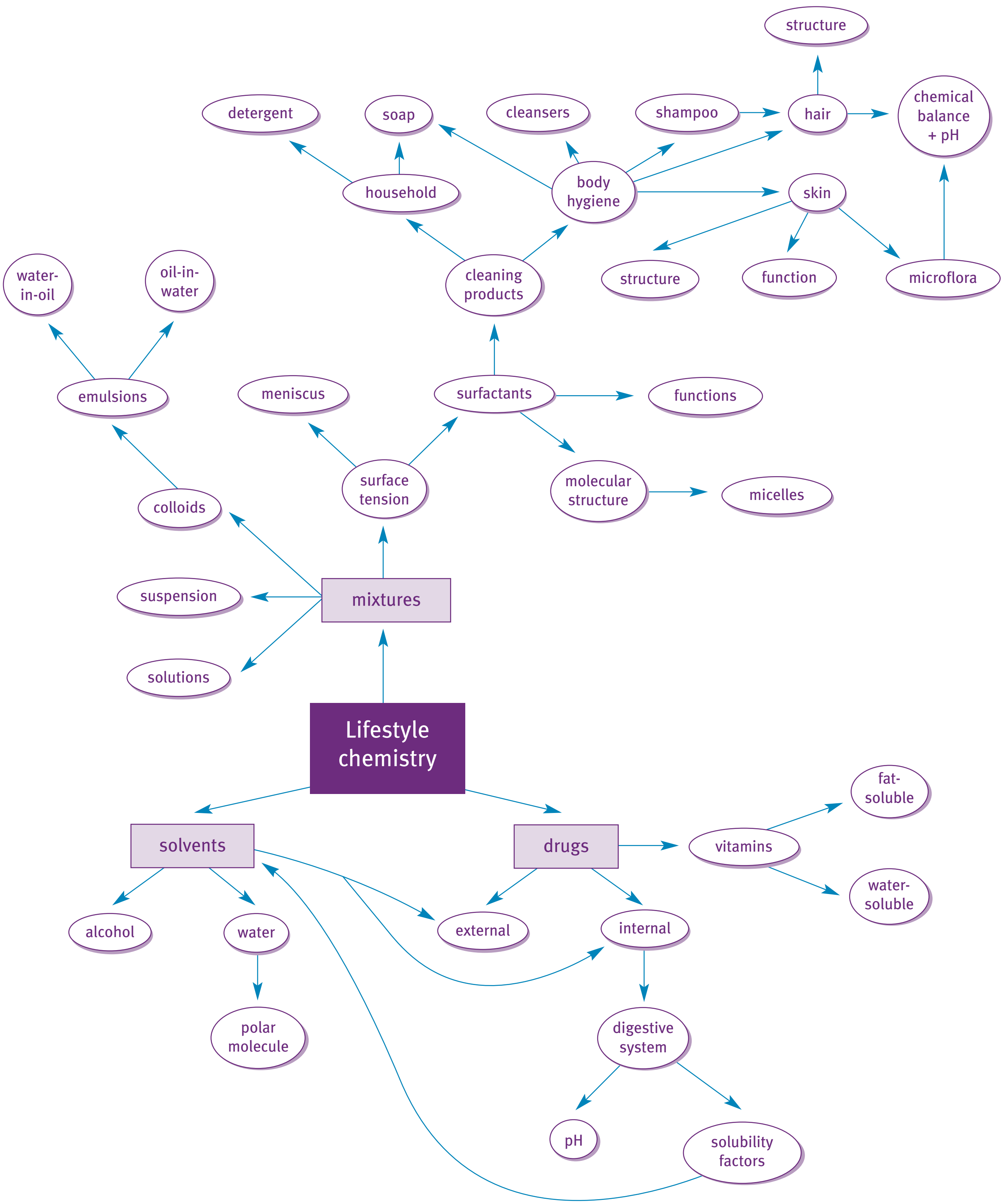
This chapter will examine the variety of chemical substances in common use in households, the way they work and their effects on humans and the environment.

Outcomes

This chapter contributes to the following HSC course outcomes:

- **H2** applies the processes that are used to test and validate models, theories and laws, to investigations
- **H4** assesses the impacts of applications of science on society and the environment
- **H6** describes uses of the Earth's resources
- **H7** identifies effects of internal and external environmental changes on the human body
- **H8** relates the properties of chemicals to their use
- **H9** relates the structure of body organs and systems to their function
- **H11** justifies the appropriateness of a particular investigation plan
- **H12** evaluates ways in which accuracy and reliability could be improved in investigations.
- **H13** uses terminology and reporting styles appropriately and successfully to communicate information and understanding
- **H14** assesses the validity of conclusions from gathered data and information
- **H15** explains why an investigation is best undertaken individually or by a team.
- **H16** justifies positive value about the attitudes towards both the living and non-living components of the environment, eithical behaviour and a desire for a critical evaluation of the consequences of the applications of science.

Mind map—Lifestyle chemistry



1.1 Chemicals in everyday life

SECTION OUTCOMES

Successful completion of this section will allow you to:

- recognise that a wide range of substances are used as part of food, hygiene, entertainment and health maintenance
- analyse information to identify the chemicals used in everyday living and outline any precautions needed in the use and handling of these chemicals
- recall that most consumer products are mixtures in the form of either solutions, suspensions or colloids and distinguish the properties of each
- identify examples of suspensions and colloids and outline the advantages of using mixtures in that form for each case
- produce a range of suspensions and colloids commonly used by consumers
- demonstrate different properties of solutions, suspensions and emulsions
- explain surface tension in terms of the forces experienced by particles at the surface of a liquid and describe the effect of surfactants on surface tension
- demonstrate the effect of surface tension through investigations of natural phenomena.

FIGURE 1.1

Daily chemicals

Chemicals contribute to our enjoyment of life. Imagine life without soap! Every day we use a vast array of chemicals in our food, for our hygiene, to maintain our health, to protect and enhance our bodies, as well as to clean and preserve our homes and possessions. Each substance we use has its own purpose. What is it about 'creaming cleansers' that makes them useful for cleaning the bath and basin but a disaster on the bathroom mirror? Why don't we just use dishwashing liquid to clean our faces? What would happen to our cars without the right combination of oils and lubricants to keep the engine parts running smoothly?

The chemical properties of any substance must suit its purpose and should cause no other side effects. It is especially important that the chemical behaviours of materials we apply to our skin or take orally are compatible with our own body chemistry.

The chemical properties of household products suit the purposes they are designed for.

FIGURE 1.2
Chemicals from around the home.

TABLE 1.1 The properties and uses of a number of chemicals used in everyday life.

Possible ingredients	Major function	Examples
Cleaners		
solvents	dissolve and disperse soils	water, alcohols, hydrocarbons (petroleum fractions)
alkalis	remove oils and fats	sodium carbonate, caustic soda
surfactants	wet surfaces and emulsify fats and oils	detergents
builders	reduce hardness, especially in heavy soils	phosphate, carbonate silicate and citrate salts
abrasives	remove soil by friction	Feldspar, clays, silicates
Degreasers		
strong alkalis	clean machinery of oil, grease, metal fragments	caustic soda
chlorinated hydrocarbons		trichloroethylene, chloroform
detergent/emulsifiers		heavy duty detergents
citrus-based solvents		proprietary brands
Lubricants		
liquid hydrocarbons (usually with additives)	prevent contact between two moving solid surfaces to reduce friction, wear, overheating and rust	greases and oils
graphite (finely powdered carbon)		used in locks
air or gas		hovercraft

TABLE 1.1 The properties and uses of a number of chemicals used in everyday life (*continued*).

Possible ingredients	Major function	Examples
Pesticides		
heavy metal compounds	kill a variety of animal pests, especially insects, spiders, rats and mice	copper and arsenic compounds
chlorinated hydrocarbons		dieldrin, chlordane lindane
organophosphates		'malathiol'
plant-based natural insecticides		pyrrethrins
Solvents		
water	clean materials or surfaces or remove impurities from other solvents, dissolve stains	
alcohols		methylated spirits
chlorinated hydrocarbons		dry-cleaning fluid
aromatic hydrocarbons		floor sealants
oils		oil-based paint
Metal cleaners		
strong alkalis	remove corrosion from metals	ammonia
acids		lemon juice
Body hygiene chemicals		
Body soaps and cleansers		
soap	clean the skin without drying or damaging it	
oil/water emulsions		cleansing cream
Toothpaste		
suspension of solid polishing agent in aqueous polyalcohols	polish tooth enamel	alcohols can be glycerol, sorbitol or propylene glycol
fluorides	kill bacteria that cause tooth decay	sodium fluoride or amine fluoride
other bactericides	kill bacteria	'triclosan' in Colgate
abrasives	clean teeth by friction	silica, gypsum
Deodorant		
aqueous aluminium compounds	prevent perspiration by forming a hydroxide gel that blocks sweat glands	most are aluminium-based
tea tree oil, other plant oils	kill most bacteria and fungi in armpits	alternative to aluminium-based
Antiseptics		
bactericides	kill bacteria	most antiseptics contain both
fungicides	kill fungi	
solvent and suspending agents	alcohols and sodium carboxy methyl cellulose	antiseptic creams or ointments
Cosmetics		
Moisturiser		
oil/water or water/oil emulsions	slow water loss; replenish water lost from skin	
Lipstick		
castor oil, waxes	keep lipstick solid in tube	beeswax, carnauba wax
ester	reduce stickiness	
colours	colour lips evenly	

Everyday chemicals

ACTIVITY 1.1

Look at Table 1.1 and answer the following questions.

1 What is the purpose of a degreaser?

2 What types of substance are used as metal cleaners? Why?

3 What are pesticides used for? List the types of substances that may be used as pesticides.

4 Some chloro-aluminium compounds form a water-repellent gel when applied to the skin. In what body hygiene product is this property useful?

5 Visit a supermarket, hardware store or plant nursery and obtain samples of cleaning products for different uses in the home, or copy down the product ingredients from the labels. Draw up a table that lists the ingredients and their uses. Compare the major ingredients found in household cleaners, laundry and dishwashing cleaners and body cleaning products.

6 While using safer substitute chemicals for most purposes around the home has eliminated many health and safety hazards, there are still a number of products that require special handling when used. Find out the correct handling procedures and any precautions that need to be taken when using the following:

- weed sprays
- polyurethane coating for floors
- insecticide spray for plants
- epoxy resins
- cockroach baits
- dry-cleaning fluid
- oil-based paints
- dishwasher powders
- maldison or 'malathion' (used for 'nits' in hair and scalp).

Chemicals come in mixtures

Mixtures can be solutions, suspensions or colloids.

Most household chemical substances are not in the form of pure substances, but are mixtures. These mixtures can be solutions, suspensions or colloids.

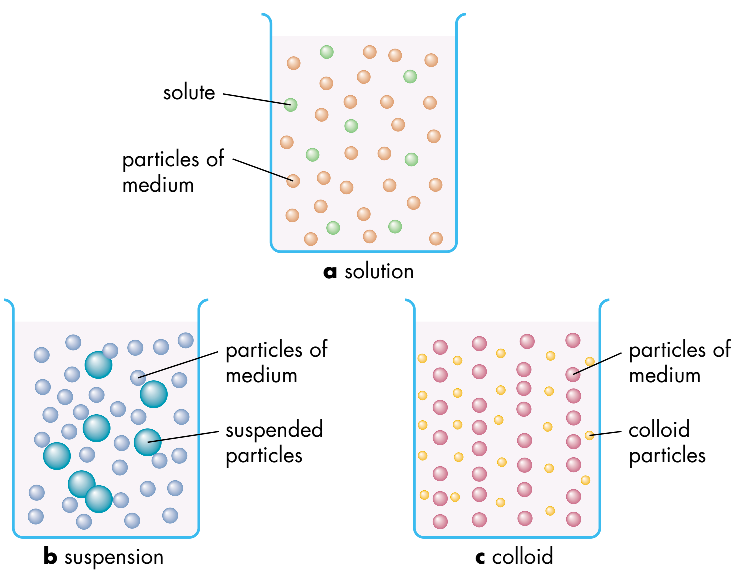


FIGURE 1.3
(a) Particles in solution. (b) In a suspension, particles are larger than those in a colloid and are unevenly spread through the liquid medium. (c) In a colloid, particles are smaller and more evenly distributed throughout the liquid medium.

Solutions

A **solution** occurs when two substances completely mix with each other so that one part of the mixture is the same as any other part of the mixture—that is, the mixture is uniform or **homogeneous**. A solution consists of a **solute** completely dissolved in a **solvent**. The three most common types of solutions are solid in liquid, liquid in liquid, and gas in liquid. Seawater, tea (without milk) and soft drinks are three common examples of solutions. The particles of solute in a solution are tiny and cannot be filtered out. Solutions are clear—they allow light to pass through without scattering, and you cannot see the dissolved particles.

Solutions contain dissolved particles that are uniformly distributed.

Suspensions

A **suspension** is a mixture of fine particles suspended in a liquid. After a time these particles settle out of the medium in which they are suspended to form two distinct layers or 'phases'. Flavoured milks, many medicines and paints are examples of suspensions. The particles within a suspension are large in comparison with those in a solution. These particles may be filtered out using normal laboratory-grade filter paper. Since the particles within a suspension are not distributed evenly throughout the medium, it is a **heterogeneous** mixture.

Suspensions contain particles that separate into phases after a time.

Colloids

A **colloid** is a mixture in which the particles of one part of the mixture remain suspended among the particles of the other for a long period of time. Colloids are a very useful means of storing and delivering a substance to its target surface—such as using a sunscreen lotion to spread the protective UV filters evenly over the skin. Colloids may also be used to deliver drugs to a targeted site in the human body.

The particles in a colloid remain suspended for extended periods of long time.

The particle size of a colloid is in between that of a solution and a suspension. One way in which a suspension of solid in liquid may be distinguished from a colloid of solid in liquid is to attempt filtration using fine filtration paper. The dispersed particles in a colloid cannot be filtered out, whereas the particles in a suspension can. In this respect, a colloid is like a solution. Yet the particles in a colloid are much larger than those in a solution. In fact, when a light beam shines through a colloidal liquid, the beam's path can be clearly seen because colloid particles are large enough to cause light to scatter. The effect of light scattering by a colloid is called the **Tyndall effect**.

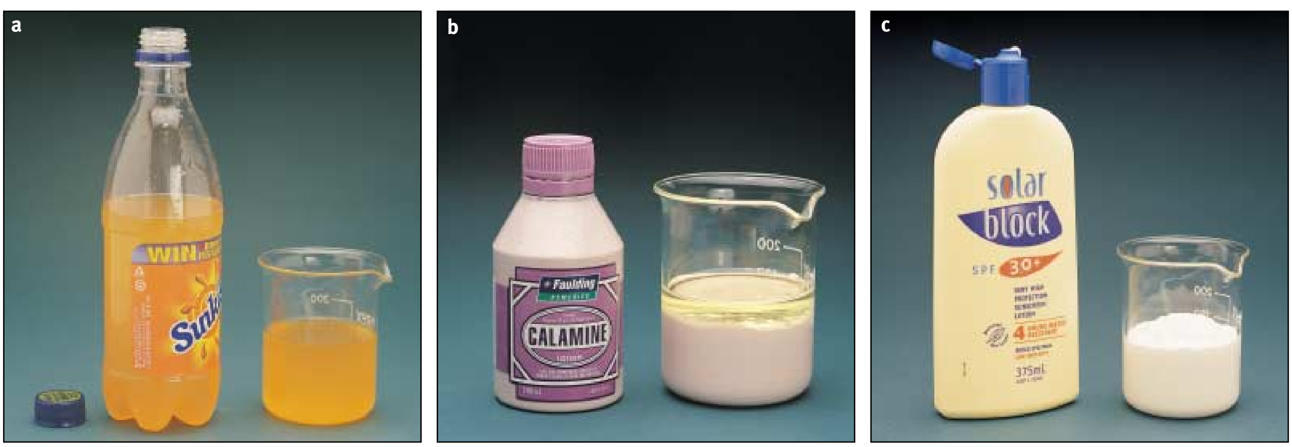


FIGURE 1.4
Examples of (a) a solution, (b) a suspension and (c) a colloid

INVESTIGATION 1.1 Solutions, suspensions and colloids

Aim
To compare the properties of solutions, suspensions and colloids.

Materials
- 3×250 mL clear jars with lids labelled A, B and C and containing the following:
  A: 200 mL nickel chloride solution (0.5 M) or another green salt solution
  B: 180 mL water, 15mL clear vegetable oil, 5 mL green dishwashing detergent
  C: 200 mL water mixed with finely powdered green chalk
- slide projector
- filtration apparatus
- fine filter paper
- safety glasses

Method
1. Prepare the mixtures A, B and C. Ensure that each is thoroughly mixed before using at each stage in the experimental procedure.
2. Shake each mixture thoroughly and place in a row in front of the slide projector.
3. Turn on the projector and note whether you can observe the beam of light passing through each mixture.
4. Fold a fine filter paper and place it in a filter funnel attached to a retort stand over a beaker.
5. Pour each mixture in turn through a fresh filter paper.
6. Observe any residue in the filter paper and the colour of the filtrate (the liquid dripping into the beaker).
7. Record your observations in an appropriate form.

Discussion
1. Identify each of the mixtures A, B and C as a solution, colloid or suspension and state your reasons for each identification.
2. Explain why you can observe a beam of light in suspensions and colloids but not in solutions.
3. Why is it not possible to obtain a residue when you filter a colloidal suspension?

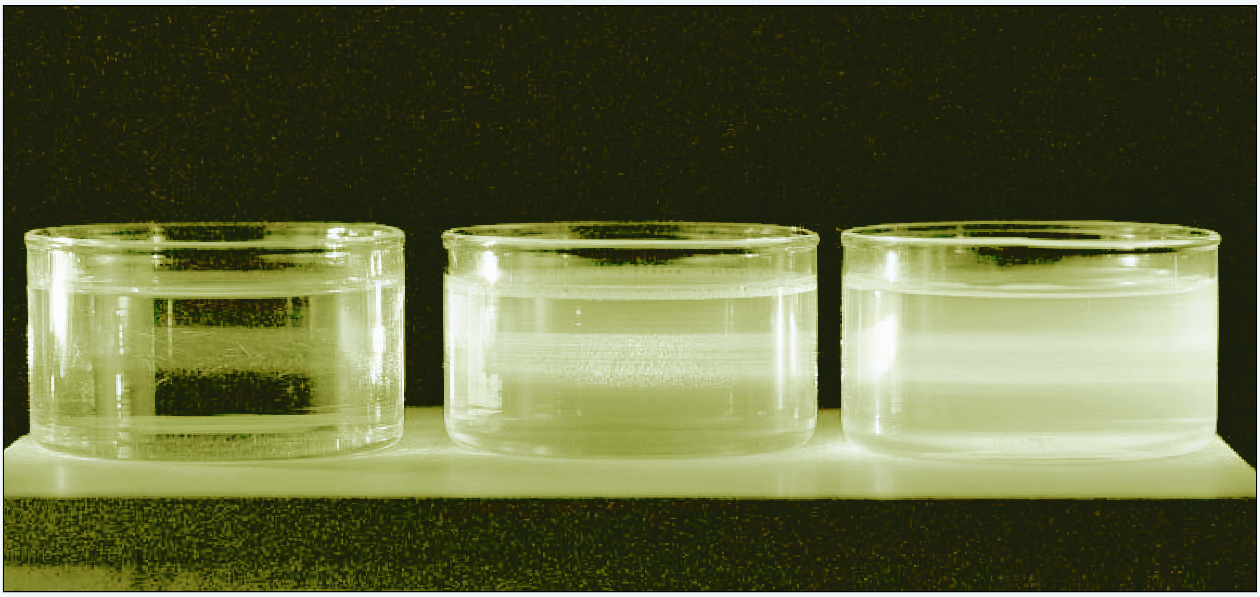


FIGURE 1.5
The Tyndall effect. Light is scattered by suspensions and colloids, but not by solutions. Can you identify which is which in this photo?

Types of colloid

There are many types of colloids, depending on the type of particle and the medium in which the particles are suspended. The suspended particles and the medium may be solid, liquid or gas. An **emulsion** is a type of colloid that is used in everyday products—it is a colloid of tiny liquid droplets suspended in another liquid. An oil-in-water (O/W) emulsion, like cream or mayonnaise, contains droplets of oils dispersed in a water medium. A water-in-oil (W/O) emulsion, like butter, contains water droplets dispersed in an oil medium. In foam fire extinguishers, gaseous carbon dioxide is trapped in bubbles of water and protein polymer film forming a gas-in-liquid colloid.

Table 1.2 shows some further examples of colloid types.

An emulsion is a liquid-in-liquid colloid.

TABLE 1.2 Colloids.

Colloid type		Dispersed particle	Medium	Examples
emulsions: liquid-in-liquid	**oil-in-water**	oil (liquid)	water (liquid)	milk, antiseptic ointment, cream
	water-in-oil	water	oil	butter, oil-based ointments
foam: gas-in-liquid		gas	liquid	shaving foam, hair mousse
sol or gel		solid	liquid	paints, toothpaste, jelly
aerosol		liquid or solid	gas	smog, fly spray, aerosol deodorants

Solution, suspension or colloid?

ACTIVITY 1.2

Find out why certain household products are in the form of a solution, suspension or colloid.

1 Collect ten commonly used preparations from around your home.
2 Identify whether each product is in the form of a solution, suspension or colloid.
3 Use the information provided on the label or use the library and Internet to find out why each product is a solution, suspension or colloid.
4 Present your information in a way that clearly outlines the advantages of each mixture being in this form.

Emulsifiers

A suspension of two liquids can be converted into an emulsion with the aid of an **emulsifier**—a substance that improves the ability of a liquid to disperse within another liquid. For example, bile—an emulsifier made in the gall bladder—reduces the size of fat droplets in the human intestine so that they can mix thoroughly in the watery environment. When the fat droplets are small, enzymes can break down the fat into fatty acids. These fatty acids can then pass easily through the walls of the intestine into the lymphatic system.

Detergents contain emulsifying agents that help disperse oil and grease from soiled items into a water medium. The oil and grease are then removed from the surface along with the water. The yolk of an egg also contains emulsifiers, so eggs are used in many sauces to disperse oils within a watery or vinegar medium. This principle is used in the making of mayonnaise, hollandaise sauce and béarnaise sauce.

An emulsifier mixes two immiscible liquids.

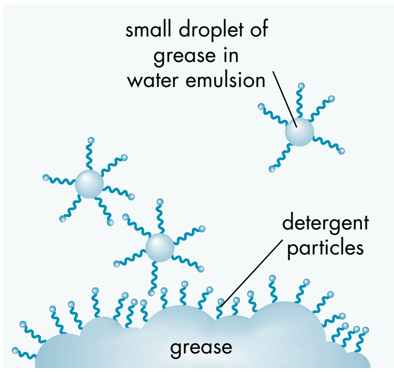


FIGURE 1.6
Particles of grease are removed from a surface and held in a water emulsion by detergent particles.

INVESTIGATION 1.2 Making sauce

Aim

- To investigate and compare the effect of egg yolk in forming the emulsions of mayonnaise and hollandaise sauce.
- To compare the properties of vinegar, salad dressing, mayonnaise and hollandaise sauce

Safety warning

This experiment should be carried out in a kitchen if you wish to taste the results.

Materials

- metal bowl
- measuring spoons
- measuring cups
- 2 × 250 mL jars with lids
- wire whisk
- saucepan
- stove top

Salad dressing

- 1/3 cup vinegar
- 2/3 cup oil

Mayonnaise (Part A)

- 1 g (1/4 teaspoon) sugar
- 110 g (1/2 cup) vegetable oil
- 1 g (1/4 teaspoon) salt
- 2 g (1/2 teaspoon) prepared mustard
- 2 egg yolks
- 50 g (1/4 cup) vinegar

Mayonnaise (Part B)

- as for Part A, but omit egg yolks

Hollandaise sauce (Part A)

- 1/4 teaspoon salt
- 15 mL lemon juice
- 3 egg yolks
- 30 g (2 tablespoons) cold butter

Hollandaise sauce (Part B)

- as for Part A, but omit egg yolks

Method

Salad dressing

1 Pour the vinegar and oil into separate jars. Observe and note the appearance and consistency of each.

2 Pour the vinegar into the oil and allow to settle. Note what happens.

3 Put the lid on the jar and shake the oil and vinegar mixture vigorously for 30 seconds.

4 Observe the mixture for 1 minute and note what happens.

Mayonnaise (Part A)

1 Mix the dry ingredients and mustard.

2 Beat the egg yolks.

3 Add the dry ingredients to the egg yolk and mix well.

4 Add half the vinegar gradually and beat well.

5 Add about 1 tablespoon of oil, a few drops at a time, beating vigorously after each addition.

6 Add about 2 tablespoons of oil, a teaspoon at a time, beating vigorously after each addition.

7 Beat in the remaining vinegar.

8 Add the remaining oil, a tablespoon at a time, beating vigorously after each addition.

Mayonnaise (Part B)

1 Repeat all steps in Part A, excluding the egg yolks.

Hollandaise sauce (Part A)

1 Beat the egg yolks with a wire whisk in a saucepan for a minute or two until they thicken slightly and turn lemon-coloured.

2 Whisk in the salt, lemon juice, and half of the butter.

3 Set over moderately low heat and whisk continuously, removing pan from the heat now and then to make sure the yolks aren't cooking too fast.

4 When the mixture clings to the wires of the whisk and you can see the bottom of the pan between the strokes, remove from heat.

5 Stir in the rest of the butter.

Hollandaise sauce (Part B)

1 Whisk the salt, lemon juice, and half of the butter in a saucepan.

2 Set over moderately low heat and whisk continuously for 5 minutes.

3 Remove from heat and stir in the rest of the butter.

Discussion

1 Compare the consistency of the sauces you prepared—with egg yolks and without egg yolks. What effect does the egg yolk have on the consistency of each sauce?

2 What substance in egg yolk allows an oil-in-water emulsion to form? What substance helps form a water-in-oil emulsion?

3 Salad dressing is a simple mixture of oil and vinegar with herbs and other added flavours. Why must it be shaken immediately before adding to a salad?

4 Compare vinegar, salad dressing and your two sauces for the following properties: appearance, consistency, texture and flavour. What difference does the presence of the oil medium make to the flavour? How does the presence of beaten egg yolk affect the texture, consistency and flavour?

FIGURE 1.7
(a) Vinegar and olive oil (top), salad dressing (containing oil and vinegar) before and after shaking (bottom). (b) Mayonnaise requires the addition of an emulsifier.

Surface tension

The image of a falling raindrop is familiar to you. Have you ever wondered why a drop of water forms a rounded shape? Have you noticed insects such as pond skaters or water striders that can walk on the surface of a pond? **Surface tension** is responsible for these two observations.

Within a liquid there are forces of attraction holding the molecules together. The strength of these forces varies from liquid to liquid. They act over short distances in all directions and hold molecules close together, drawing the liquid into a spherical shape.

At the surface of a liquid—the **interface** between liquid and air—the forces don't act equally in all directions. Molecules at the surface are held strongly by the molecules below and beside them, but not by the molecules of the air above them. So at the surface of the liquid there is an unbalanced force pulling molecules inwards to the liquid. This produces surface tension. The surface tension of water is greater than the surface tension of most other liquids because of the strong bonds that exist between water molecules.

Surface tension is the result of strong forces between molecules in a liquid, pulling them inward.

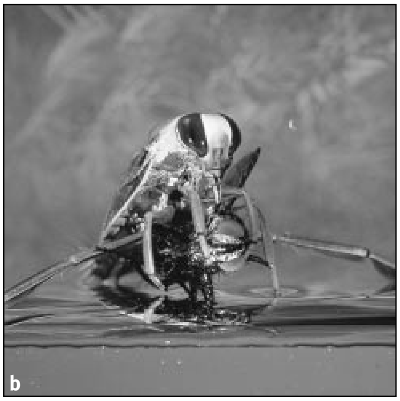


FIGURE 1.8
(a) Surface tension gives a raindrop its shape. (b) A pond skater can walk on the skin-like surface of water.

Did you know?

In a space vehicle where there is no gravity, water drops are perfectly spherical.

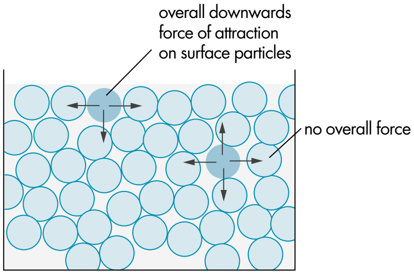


FIGURE 1.9
The forces of attraction on particles at the surface and in the body of a liquid.

A drop of liquid tends to form the shape that requires the least energy to maintain. A sphere has the smallest surface area for any given volume of liquid. In a sphere, the minimum number of molecules are exposed at the surface and the unbalanced force at the interface is minimised. This is why water drops form spheres.

The inward force at the surface of water causes the uppermost layer of water molecules to form a type of 'skin'. Water striders and other insects can walk on this skin without sinking. They have pads on their feet that repel water, forming a dimple on the surface. They are able to move forward by pushing back on the water's surface, but without breaking the surface.

FIGURE 1.10
Surface tension causes water to form bubbles as the water molecules draw together over a volume of air.

INVESTIGATION 1.3 — Drops and surfaces

The shape a liquid takes when a small amount is dropped onto a material gives us an indication of the surface tension of the liquid and the surface tension of the material.

Aim

To examine the differences in the shape of liquid drops on a variety of materials.

Materials

- sheet of glass
- sheet of Perspex
- sheet of plastic (e.g. overhead projector slide)
- sheet of copper
- 5 wax-coated microscope slides
- dropper
- alcohol (methylated spirits)
- oil
- water
- detergent
- milk

Method

1. Lay the five sheets of surface material (glass, Perspex, plastic, copper, one of the waxed slides) side by side.
2. Place five drops of water onto each material. Observe and note the shape of each drop.
3. Rotate each material until the drops join.
4. Pour the liquid off the surface.
5. Lay the five waxed slides side by side.
6. Draw up an appropriate table of results to record the differences in the shape of each drop, the behaviour of the water when each sheet is rotated, and the behaviour of water when poured.
7. Place a different drop of each liquid (alcohol, oil, water, detergent, milk) on each slide. Observe the shape of each drop. Draw up a table of results.

Discussion

1. On which surface did water form the most spherical drop?
2. Explain why a water drop assumes this shape.
3. The water drop on glass is much flatter than the drop on plastic. Is water more attracted to glass than to plastic?
4. List the five materials you tested in order of their attraction to water.
5. Suggest what shape a drop of water may take on a Teflon surface.
6. Which liquid formed the most spherical (rounded) drop on the waxed slides?
7. Which liquid has the highest surface tension?
8. List the liquids in order of increasing surface tension.

The meniscus

A **meniscus** (plural: menisci) is the shape that the surface of a liquid takes in a tube. The shape of a meniscus depends on two things—the type of liquid and the material the tube is made of. When water is poured into a glass tube, the meniscus at the surface of the water is concave—it curves upwards where it meets the sides of the glass. Glass contains electrically charged particles on its surface, to which water is highly attracted. We call the forces of attraction of water for glass **adhesive** forces. The adhesive forces between water and glass are greater than the **cohesive** forces that hold water molecules together. So water 'sticks' to glass better than water sticks to itself.

A liquid such as mercury, which has very high internal cohesive forces, forms a convex meniscus—it curves downwards at the edges. The forces of cohesion within mercury are much greater than the forces of adhesion between mercury and glass.

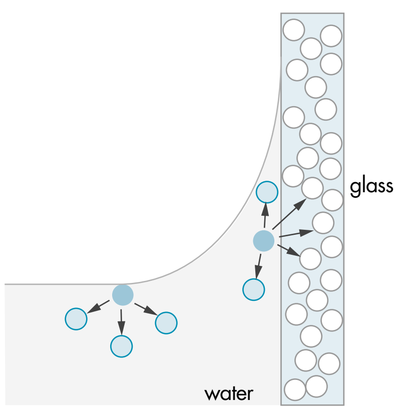


FIGURE 1.11
A meniscus: water rises up the sides of a glass container due to the attraction between water particles and glass.

When adhesive forces between the container and liquid are strong, a concave meniscus forms.

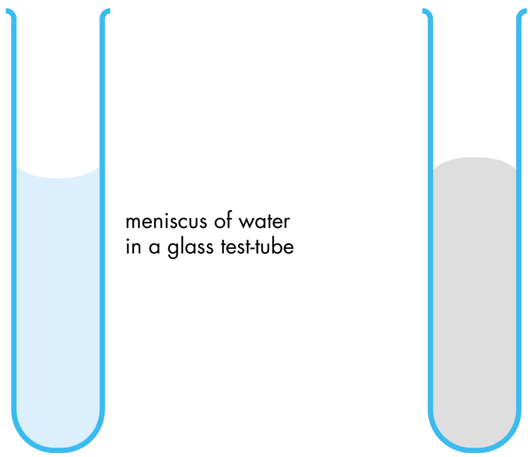


FIGURE 1.12
Comparison of menisci. When the adhesive forces are less than the cohesive forces in a liquid, a convex meniscus forms.

INVESTIGATION 1.4 Comparing menisci

Aim
To compare the menisci produced by different liquids.

Materials
- 5 medium test-tubes in a test-tube rack
- 5 mL alcohol (methylated spirits)
- 5 mL water
- 5 mL oil
- 5 mL detergent
- 5 mL milk
- hand lens (optional)

Method
1 Pour 5 mL of each liquid into the test-tubes.
2 Compare the shapes of the meniscus formed by each liquid.
3 Record your results in a table or as a diagram.
4 Your teacher may be able to demonstrate the shape of the meniscus formed by mercury.

Discussion
1 Using your results from the previous experiment on shapes of drops, explain the differences in the meniscus shape of each liquid.
2 Explain the 'reverse' shape of the meniscus formed by mercury.

Surfactants

Surfactants reduce surface tension, allowing a surface to be wet.

Surface tension influences the ability of a liquid to be absorbed by, or to 'wet', a porous surface. A surface is wet when the molecules of the liquid are attracted to the molecules of the surface material.

If you add a few drops of water to a finely woven cotton fabric, the drops will remain on the surface without spreading or wetting the fabric. Add a little detergent to the water and it spreads into the fabric, wetting it. Detergent is a **surfactant**. A surfactant ('*surf*ace *act*ive *agent*') is a substance that can reduce the surface tension of a liquid.

When added to water, detergent reduces the surface tension of the water and therefore increases its wetting power.

If a suspension of oil and water is allowed to settle, the oil and water separate and an interface forms between them. At the interface there is a large difference in the surface tension of each liquid because of the different types of forces holding together the molecules of water and the molecules of oil. The two liquids cannot be thoroughly mixed unless this difference in surface tension is overcome. A surfactant contains molecules that are able to attract the molecules of both liquids. This reduces the surface tension and the oil and water will mix.

FIGURE 1.13
A drop of water 'sits' on a piece of fabric (top), but detergent solution wets the fabric. The ability of detergent solutions to wet fabric is crucial when clothes are washed.

INVESTIGATION 1.5 Surfactant effects of detergent

Aim

To observe the effect of detergent on the surface tension of water.

Materials

- 250 mL beaker
- talcum powder in dispenser
- dishwashing detergent in dropper bottle

Method

1. Half-fill the beaker with tap water.
2. Sprinkle talcum powder over the surface of the water.
3. Record your observations.
4. Add detergent to the water in the beaker a drop at a time until you observe a change at the surface of the water.

Discussion

1. Why did the talcum powder remain on the surface of the water at first?
2. What happened to the talcum powder when the detergent was added?
3. What was the effect of the detergent on the surface tension of water?

The properties of surfactants

Water by itself is useful for cleaning away only a few substances—those that are easily dissolved in water. Most stains contain oils and fats, which are insoluble in water, or other substances that are not easily wet by water. In order for water to become a useful cleaning agent, it must be able mix with and remove all types of dirt.

Why won't oil and water mix?

Oil and water do not mix because they consist of very different types of molecules. Water molecules are **polar**. This means they have positively and negatively charged ends. Water can dissolve substances that are either polar or **ionic** (consisting of positive and negative ions). Oil molecules are **non-polar** and do not dissolve in water.

Did you know?

The lungs of adults and most newborns are coated with a surfactant that allows the wettable surface area inside the lungs to increase when air enters. In many premature babies the lung is not sufficiently developed to produce enough of this surfactant. These babies have problems breathing. Part of neonatal intensive care involves delivering surfactant to the undeveloped lungs.

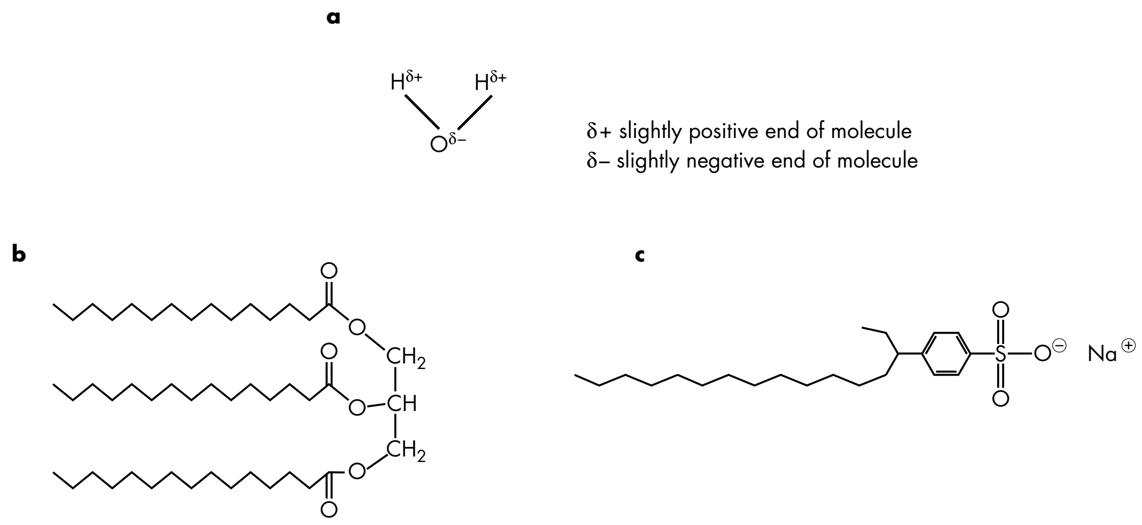


FIGURE 1.14
(a) A water molecule is polar because the hydrogen end of the molecule carries a small positive charge while the oxygen end carries a small negative charge. The negative ends of one water molecule attract the positive ends of surrounding water molecules. (b) A lipid molecule has long chains of carbon and hydrogen atoms (called hydrocarbon chains) and a few oxygen atoms. (c) A detergent molecule has the combined properties of water and lipids in one molecule. The polar head dissolves in water and the long, non-polar hydrocarbon chain tail dissolves in lipids.

A surfactant has two different parts: the hydrophilic head dissolves in water, and the lipophilic tail dissolves in fats and oils.

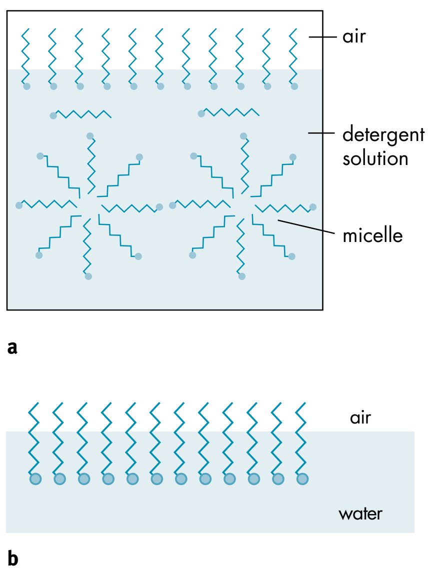


FIGURE 1.15
(a) Micelles form in detergent solution.
(b) Surfactant molecules at the surface of water.

How surfactants work

Cleaning products make use of surfactants to mix oil with water. In a sink full of dirty, greasy dishes, water cannot reach the surface of the dishes to clean them because of the oil coating them. When a surfactant such as detergent is added to the water, it causes the oil to emulsify in the water. Surfactants have this property because they consist of molecules with two different parts, which behave in different ways:

- The small polar, usually ionic, 'head' of the molecule is attracted to water. It is called **hydrophilic** ('water-loving').
- The non-polar hydrocarbon chains of the molecule, which form its 'tail', are repelled by water but are attracted to oils because they have a similar structure. This end of the molecule is called **hydrophobic** ('water-fearing').

We can also call the non-polar part of the surfactant molecules **lipophilic** (oil-loving), and the polar end **lipophobic** (oil-fearing) as it repels fats and oils.

A surfactant will dissolve its hydrocarbon chain in a droplet of oil so that the hydrophilic head sticks out into the surrounding water. This arrangement is called a **micelle** and forms a 'bridge' between the oil and water, lowering the surface tension and allowing the water to wet a previously non-wettable surface.

While surfactants play a major role in the action of cleaning, they are also widely used to bring any two materials together so that one may act effectively on the other. For example, surfactants in insecticide suspensions allow the waxy outer layer of leaves on plants to be wet. The insecticide is then able to pass through the outer layer into the plant's system. Surfactants in fabric conditioners attach themselves to the surfaces of the fabric's fibres to give each fibre a smooth coating. This gives the fabric more bulk and a soft texture.

Questions

1 Why should a cosmetic substance applied to the skin have chemical properties similar to the skin?

2 What type of colloid is:
  a butter
  b milk
  c toothpaste?

3 How does adding detergent allow water to wet a piece of cloth more thoroughly than it does without detergent?

4 Briefly explain the structure of a surfactant molecule.

5 Explain why it is often more useful to use a colloid rather than a suspension in skin products.

6 Complete the table below to summarise the properties of solutions, suspensions and colloids.

TABLE 1.3 Properties of solutions, suspensions and colloids.

Property	Solution	Colloid	Suspension
Particle size		smallest	
Distribution of particles in medium	homogeneous		
Particle settling			particles settle over time
Effect of filtering		particles not filtered	
Effect on light beam			scatters light

Further questions

1 Choose five of the following products from a typical household:

deodorant	calamine lotion
soluble aspirin	toothpaste
acrylic paint	floor wax
skin toner	laundry powder
mayonnaise	sunscreen lotion

liquid dishwashing detergent

  a State whether each is a solution, suspension or mixture.
  b Describe the major use of each product.
  c Explain how the mode of delivery (whether it is a solution, suspension or colloid) affects the usefulness of each product.

2 A cotton cloth is made waterproof by spraying it with a fine coating of waterproofing agent. Draw a diagram to show the appearance of water drops on the surface of this cotton after it has been treated in this way.

3 List two commercial products that contain surfactants and explain how the surfactant enables each product to work.

4 Use your library or the Internet to find out how water striders are able to walk on the surface of water.

5 Why do mercury and water form menisci with opposite shapes in a glass container?