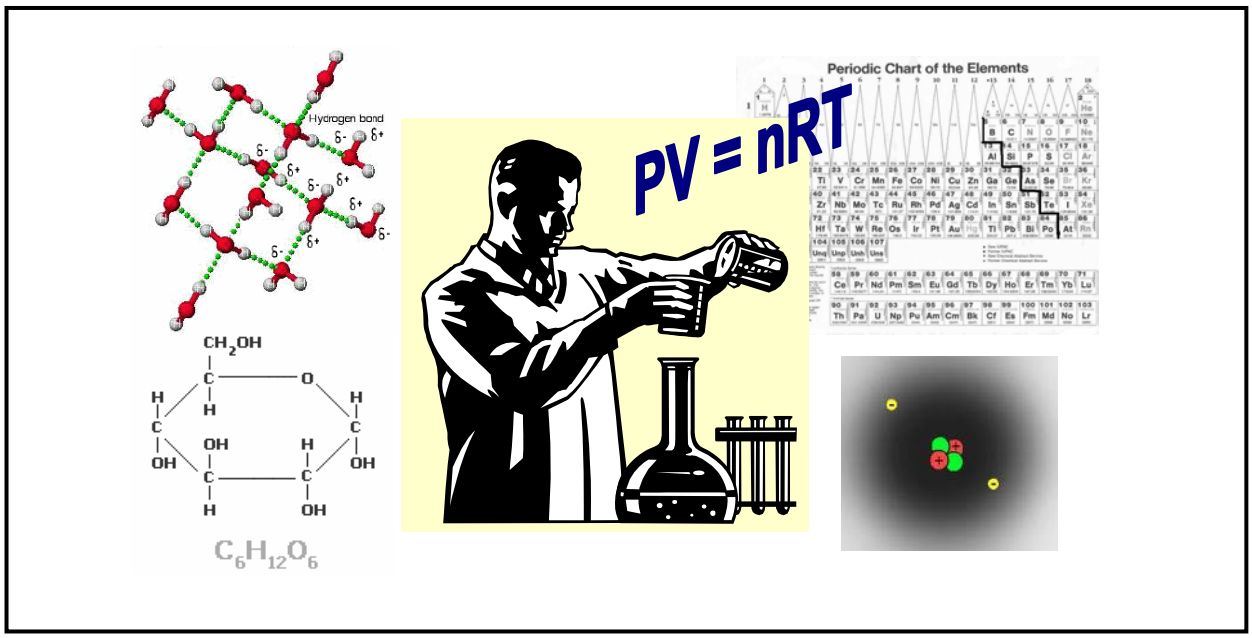
Project EASE

(Effective Alternative Secondary Education)

CHEMISTRY



MODULE 5

Colloids

BUREAU OF SECONDARY EDUCATION
Department of Education
DepEd Complex, Meralco Avenue
Pasig City

Module 5
Colloids

What this module is about

What do milk, paints, cooked starch, ceramics, glue, ink, rubber, jelly, butter and cheese have in common? All of them are basic examples of colloids. A colloid is another type of mixture. It is distinguished from solutions and suspensions in that its particle size is bigger than those of solutions but smaller than those of suspensions. Colloids may appear homogenous to the naked eye but are actually ***heterogenous*** when carefully viewed in a microscope. This means that more than one distinct phase can be distinguished.

This module is all about colloids, their properties and behavior. Knowledge of colloid chemistry can help you answer questions like *How are fogs formed? Why are the sky and sea blue? What makes glue, adhesive, paint, and ink stick to surfaces? What is the principle behind the preparation of your all-time favorite mayonnaise spread?*

To make the discussion easy for you, the module is divided into four lessons:

- **Lesson 1 – How Do You Classify Colloids?**
- **Lesson 2 – What are the Properties of a Colloid?**
- **Lesson 3 – How are Colloids Prepared?**
- **Lesson 4 – How are Colloids Utilized in Technology, Human Body and Environment?**

What you are expected to learn

After going through this module, you should be able to:

1. classify colloids;
2. relate the properties of colloids to their behavior;
3. discuss the methods and principles applied in purifying colloids;
4. prepare colloids; and
5. explain how the properties of colloids are utilized in technology, human body and environment

How to learn from this module

Here are some pointers to remember as you go over this module.

1. Read and follow the instructions carefully.
2. Answer the pre-test first before reading the content of the module.
3. Take down notes and record points for clarification.
4. Always aim to get at least 70% of the total number of items given.
5. Be sure to answer the posttest at the end of the module.

What to do before (Pretest)

Take the pretest before proceeding in the lessons. Check your answers against the answer key at the end of the module.

I. Multiple Choice. Choose the letter of the best answer. Write the chosen letter on a separate sheet of paper.

1. The *Tyndall effect* can be used to distinguish between
   a. oil and water
   b. solvents and solutes
   c. solutions and colloids
   d. colloids and heterogenous mixtures

2. Which of the following is a colloid?
   a. oil and water
   b. salt and water
   c. sand and water
   d. alcohol and water

3. Which is **NOT** an emulsion?
   a. milk
   b. mayonnaise
   c. shaving cream
   d. crude petroleum

4. Metal alloys belong to which type of colloid?
   a. sol
   b. gel
   c. foam
   d. emulsion

5. What is the phenomenon characterized by random, zigzag movement of colloidal particles which prevents them from settling?
   a. adsorption
   b. Tyndall effect
   c. Brownian motion
   d. electrical charge effect

6. What phenomenon is observed when vapors are held on the surface of activated carbon powder?
   a. adsorption
   b. Tyndall effect
   c. Brownian motion
   d. electrical charge effect

7. Which is the process of separating ions and molecules from colloidal particles by passing through a semi-permeable membrane?
   a. dialysis
   b. adsorption
   c. activation
   d. coagulation

8. Which chemical aids in the clumping together of colloidal particles?
   a. ion
   b. solvent
   c. coagulant
   d. dispersed phase

9. What is the phase of a dispersed material in Styrofoam?
   a. solid
   b. liquid
   c. gas
   d. cannot be determined

10. Which of the following colloid is considered harmful?
   a. cheese
   b. hair spray
   c. whipped cream
   d. black diamond

II. Matching Type. Match the description in column A with the type of colloid in column B.

Column A	Column B
_____ 1. solid dispersed in liquid	a. gel
_____ 2. liquid dispersed in gas	b. emulsion
_____ 3. liquid dispersed in liquid	c. liquid sol
_____ 4. liquid dispersed in solid	d. solid foam
_____ 5. gas dispersed in solid	e. liquid foam
	f. liquid aerosol

Key to answers on page 17.

Lesson 1. How Do You Classify Colloids?

Mixtures are classified as suspensions, colloids and solutions. By now, you should clearly distinguish between suspensions and solutions (Module 15). The only new term to you is just colloid. Let us check how well you can differentiate these three types of mixtures by doing Activity 1.1.

What you will do

Activity 1.1 Types of mixtures

Materials:

sand	oil
sugar	three glasses of water
flashlight	filter paper (if not available use bond paper)

Procedure:

1. Mix the following:
    a. sand and water
    b. sugar and water
    c. oil and water
2. Stir the contents of each mixture. Do the contents settle at the bottom?
3. Observe the three mixtures for homogeneity or heterogeneity. Are the components evenly distributed to one another in all proportions? If yes, it is homogenous. If no, it is heterogenous.
4. Allow the flashlight to pass through the contents of each mixture. Do the contents scatter light?
5. Fold your bond paper into two parts crosswise and cut it. Make a cone out of your cut-out bond paper. This will serve as improvised filter paper. Let the three mixtures pass through the improvised filter paper. Can the contents of each mixture be filtered?

Analysis:

1. Tabulate your data as follows:

Behavior of Particles	Sugar + Water	Oil + Water	Sand + Water
Settle at the bottom			
Scatter light			
Can be filtered			
Homogeneity/ Heterogeneity			

2. Based from the behavior of the particles, identify the type of mixture in each set-up. State whether the mixture is a solution, colloid or suspension.

A ***colloid*** is a dispersion of particles of one substance (*the dispersed phase*) throughout a *dispersing medium* made of another substance. Thus colloids are classified based on the phases of both the dispersed material and the dispersing medium. For example, when you beat an egg, you introduce air into the egg. Here, the egg is the dispersing medium and the air is the dispersed material. In Activity 1.1, which mixture is a colloid?

Table 1.1 below shows the different types of colloid and examples of each type:

Table 1.1 Different Types of Colloid and Examples

Dispersed Material	Dispersing Medium	Name	Example
Liquid	Gas	Liquid aerosol	Fog
Solid	Gas	Solid aerosol	Smoke
Gas	Liquid	Liquid foam	Meringue
Gas	Solid	Solid foam	Styrofoam
Solid	Liquid	Liquid sol	Paint, glue
Solid	Solid	Solid sol	Certain alloys such as steel
Liquid	Solid	Gel	Gelatin
Liquid	Liquid	Liquid emulsion	Mayonnaise
Liquid	Solid	Solid emulsion	Cheese

Let us test how well you understand classifying colloids. Can you classify what type of colloid each of these substances are?

1. cheese
2. marshmallow
3. ink
4. whipped cream
5. cork
6. mist

Did you know?

Milk is a colloid. The solid particles in milk are evenly spread throughout a liquid. Vinegar causes the small dissolved particles in milk to clump together, making a solid called curd. The liquid part is called whey. Still remember the nursery rhyme "Little Miss Muffet?" This would be a great time to review it.

What you will do

Self-Test 1.1

Now that you are through with the first lesson, try to answer the following and see for yourself how much you learned.

Matching Type. Match the items in column A with the type of colloid in column B. Note: Items in Column B may be used twice.

Column A	Column B
_____ 1. clouds	a. liquid emulsion
_____ 2. soap in water	b. gel
_____ 3. jellies	c. liquid sol
_____ 4. soap suds	d. solid sol
_____ 5. plastics	e. solid foam
_____ 6. milk	f. liquid foam
_____ 7. salad dressing	g. liquid aerosol
_____ 8. butter	h. solid aerosol
_____ 9. gemstones	i. solid emulsion
_____ 10. dust in air	

Did you encounter any problem? Well, compare your answers with the answer key and see for yourself the items you missed. Good luck!

Key to answers on page 17.

Lesson 2. What are the Properties of a Colloid?

Colloids are a special type of mixture because they exhibit unique properties. That is why many kinds of food products and raw materials are in the form of colloids. These unique properties of colloids include the Tyndall effect, Brownian motion, adsorption and electrical charge effect.

Tyndall Effect

When a beam of light is made to pass through a colloid, it is scattered by the colloidal particles which appear as tiny specks of light. This light scattering is called the ***Tyndall effect***. No such scattering is observed with ordinary solutions because the solute molecules are too small to interact with visible light. Colloidal particles can scatter light because they are large enough to catch light and reflect it back. This is the reason why oil and water mixture in Activity 1.1 has the ability to scatter light because it is a colloid. The ability of a mixture to scatter light is one way of distinguishing colloids from solutions. Manifestations of

Tyndall effect are observed everyday in nature. For instance, when we wake up on a sunny morning, our senses are awakened by sunlight scattered by dust or smoke in the air.

Did you know?

Have you ever wondered why the sea and sky are blue? It is because of the scattering of the blue or shorter wavelength of light by the thick layer of small particles in the atmosphere and in the deep waters. The brilliant colors of sunset are also due to light scattering by colloidal water droplets in the atmosphere.

Light scattering is often used in determining particle size. The different colors that we see are not due to pigments but rather to the scattering of light by colloidal substances in the iris. Green, brown, and black are due to a combination of light scattering and the presence of yellowish-brown pigment in front of the iris, causing selective absorption of light.

Brownian Movement

Observe the movement of dust particles floating in air one sunny day. Could you describe their movement? Do they settle on standing?

The motion of particles floating in air is random and almost in a zigzag fashion. This interesting property of colloids, called ***Brownian motion***, is due to the constant and continuous collision of colloidal particles against each other. This is also the reason why colloidal particles do not settle on standing. The rate of settling of particles is dependent on the following:

a. size of the colloidal particles
b. gravitational force acting on the colloidal particles
c. viscosity of the medium (ability to resist flow)
   Water and gasoline mixture has low viscosity as compared to syrup and oil mixture which has high viscosity.

The above factors are also useful in identifying viruses, proteins, plastics and other macromolecules.

Adsorption

How is adsorption different from absorption? If you place a few drops of water onto a cotton ball, the water droplets are immediately soaked up by the cotton. This is absorption.

On the other hand, adsorption is when you use the cotton ball against the

chalkboard. Observe closely what happens to the cotton. Chalk particles and dust adhered to the surface. This phenomenon is called ***adsorption.*** Physical and/or chemical forces may be involved in adsorption. One property of colloidal particles is that they exhibit adsorption. This is due to the large surface areas of colloidal particles. This interesting property makes colloids very useful in everyday life. For example, charcoal is used to remove the bad odor produced by vapors of food in the refrigerator. The network of pores in the charcoal provides extensive surface area that adsorbs the vapors.

The adsorptive ability of colloids is used in dyeing fabrics, in the use of aluminum hydroxide in purifying water, in the use of activated carbon in refining sugar and electroplating solutions, and in the use of bone black in gas masks to remove toxic gases in the air.

Electrical Charge Effect

A colloid may allow ions to be adsorbed on its surface, thereby acquiring an electrical charge. The electrical charge may either be positive or negative. This electrical charge will prevent the particles from clumping together or coagulating.

To understand more about the electrical charge effect of colloids, it will be interesting to do Activity 2.1 which is similar to the "Joy Dishwashing Challenge" you have seen in TV commercials.

What you will do

Activity 2.1 Electrical Charge Effect of Colloids

Materials: plastic jar with lid
powdered laundry detergent
cooking grease or shortening
water

Procedure:

1. Fill the jar with water about half full.
2. Add some laundry detergent and shake the jar until the solution is soapy and bubbly.
3. Drop a small glob of grease and put it in the soapy solution.
4. Observe what will happen to the grease when the detergent solution is added.

Analysis:

1. What happens when the detergent comes in contact with the grease?
2. Why is the grease removed when it comes in contact with the detergent?
3. How is the electric nature of colloids exemplified in this activity?

What causes the colloidal particles to carry a charge? Colloidal particles have high adsorptive capacity. Thus, particles are adsorbed on their surface ions from water or from solutions of electrolytes. Such molecules are called ***surfactants***, because they tend to adsorb at the surface of a substance that is in contact with the solution that contains them. Classic examples of surfactants are soap and detergents. They have both ***hydrophobic*** ("*water fearing*" which refers to nonpolar part of molecule not attracted to water) and ***hydrophilic*** ("*water loving*" which refers to polar part of molecule attracted to water) groups in their molecular structure.

Figure 2.1
Cleansing action of detergents

The nonpolar part of the soap molecule dissolves grease, while the polar ends dissolve in water. The net result is that the grease/soap complex is water soluble and gets washed away. This process is called ***emulsification***. You can see it working if you add soap to some oil-and-vinegar salad dressing. The vinegar layer of the dressing gets cloudy because the soap has surrounded little droplets of oil and prevents them from rejoining the oil layer.

What you will do

Self-Test 2.1

Again, try to check how much you have learned from the lesson by answering the following questions.

Identification. Give the principle behind the following.

1. A colored solution poured through a layer of charcoal becomes colorless.
2. Colloidal gold does not sink noticeably in water.
3. Colored glasses are made by using dispersed particles of metals in glass.
4. Beautiful blue beam of light is produced from the glass roof as you enter a building.
5. Soaps can remove oil and grease.

Did you encounter any problem? Well, compare your answers with the answer key and see for yourself the items you missed. Good luck!

Key to answers on page 18.

Lesson 3. How are Colloids Prepared?

There are actually two ways of making a given substance disperse to colloidal size – by means of dispersion or condensation. ***Dispersion*** is the breaking of large pieces into colloidal particle size. On the other hand, ***condensation*** involves tiny particles (molecules, ions, or atoms) clumping together to form clusters.

Several processes make use of the principle of dispersion in making colloids. For example, grinding using a colloid mill is used in the preparation of paint pigments or face powder. Also, the process of beating, stirring and whipping in preparing mayonnaise or creams is a form of dispersion. You may also use chemicals to break down big particles. For example, sodium hydroxide (NaOH) is used to break up clay, glue, starch and gelatin peptized in water. The process is known as *peptization*.

On the other hand, condensation is involved in the preparation of carbon black by burning methane in limited air and collecting the soot or carbon atoms on cool surfaces. Carbon black is used as filler for rubber tires and in dispersions such as printer's ink and Indian ink. Condensation is also involved in formation of clouds, fog and mist.

What you will do

Activity 3.1 Making Mayonnaise

Materials:

- two egg yolks
- measuring cups
- ¼ cup oil
- one small clear jar with lid
- food coloring (optional)
- ¼ tsp prepared mustard
- ¼ cup vinegar
- water
- one small cup or bowl
- ¼ tsp table salt

Procedure:

1. Measure out 2-3 cups of water and pour into the jar. Add about 4-6 drops of food coloring to the water and mix (optional). Next, measure out 2-3 cups of salad oil. Pour into the jar and mix again. Observe what happens. Let the contents of the jar sit for 3 - 5 minutes.
2. Get some oil and water to mix. What should we add to mix oil and water together?
3. Pour the vinegar into your jar.
4. Pour the salad oil into the jar and put on the lid. Shake the contents very hard for 3 - 4 minutes, then let the mixture sit for three to four minutes. Compare the vinegar and oil mixture with the oil and water mixture previously done. What do you observe?
5. Put the egg yolks into the small cup or bowl. Beat the yolks until they are liquid.

6. Pour the beaten yolks into the jar with the oil and vinegar and close the lid. Shake the contents very hard for 3 - 4 minutes. Observe what happens.
7. Add the mustard and the salt to the mixture. Again, shake very hard for three to four minutes. Taste it. You now have your home-made mayonnaise.

Analysis:

1. What happens to the oil? _____
2. Why is the oil in the top layer? _____
3. What is the vinegar for? _____
4. What happens to the mixture when egg yolk is mixed? _____
   _____
5. How does this mayonnaise differ from the one bought from the store?
   _____

The oil and the vinegar (water) mixed much better when the egg yolk was added. The lecithin, which is a protein in the egg yolk, acts as an ***emulsifying agent***. Emulsifying agents have regions that associate with the oil and regions that associate with the vinegar (water). Thus the ***emulsifier*** (the egg yolk) acts as a bridge between the oil and water. The mayonnaise created is an ***emulsion*** of oil droplets in water.

If colloids are made, they can also be broken for certain purposes. There are several ways of breaking colloids. These include applying heat, adding a reactant or chemical, or passing an electric current through it.

1. Applying heat

Have you tried cooking egg for breakfast? An egg white is a colloidal protein. The particles of an egg clump together because of the heat applied while the egg is being cooked. This is one way of breaking colloids. Another application of heat in breaking colloids is by ***digestion***. This involves slow application of heat causing the colloidal particles to get bigger which is used to prepare precipitates for filtration in the laboratory.

2. Adding a reactant or chemical

Have you heard of "**cloud seeding**"? Rain is made by seeding the clouds with solid carbon dioxide (dry ice) or with silver iodide crystals. These "seeds" provide nuclei on which water vapor condenses.

For a clearer visibility of the runways during rainy season, airport fog is removed by using salt or dry ice.

3. Passing through an electric current

Smoke and other types of harmful aerosols are destroyed by Cottrell method of ***electric coagulation***. This precipitator removes smoke particles by attracting them to the charged plates. In this way, the charge on the smoke particles are neutralized, causing them to coagulate and settle down.

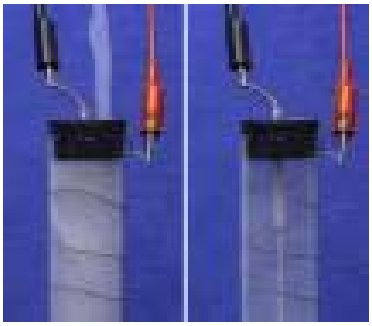


Figure 3.1
Cottrell electric precipitator

What you will do

Self-Test 3.1

Let us try to check how much you have learned from this lesson by answering the following questions.

Identification. Identify the following.

_____1. It is the method that involves the breaking down of big particles to smaller ones.
_____2. It is the agent which brings about the formation of an emulsion.
_____3. It is a method of allowing electric current to pass through the particle so that it will be attracted to the plates and be neutralized causing the particles to coagulate and settle down.
_____4. It is the method where colloidal particles are built from the accumulation of smaller particles.
_____5. It is the method utilized in “rain making”.

Did you encounter any problem? Well, compare your answers with the answer key and see for yourself the items you missed. Good luck!

Key to answers on page 18.

Lesson 4. How are Colloids Utilized in Technology, Human Body and Environment?

Colloids in Body Processes

Colloid substances are involved in many biological processes. For example, the human blood is a colloid. Protein molecules in the blood can be very long and their size falls within colloidal size range. Soluble waste products of metabolic processes will be carried by the blood to the kidneys for elimination.

Sometimes, toxic substances build up in the blood because the kidneys are not working efficiently specially in the case of patients suffering from *Uremia*. In order to clean the blood, it is made to flow across a large cellophane in an artificial kidney or dialyzing machine. This process is known as dialysis. ***Dialysis*** is the process of separating the contaminated ions and other smaller molecules from the colloidal particles of the blood by letting the true solutes to pass through a semi-permeable membrane. Dialysis of the blood is known as *hemodialysis*.

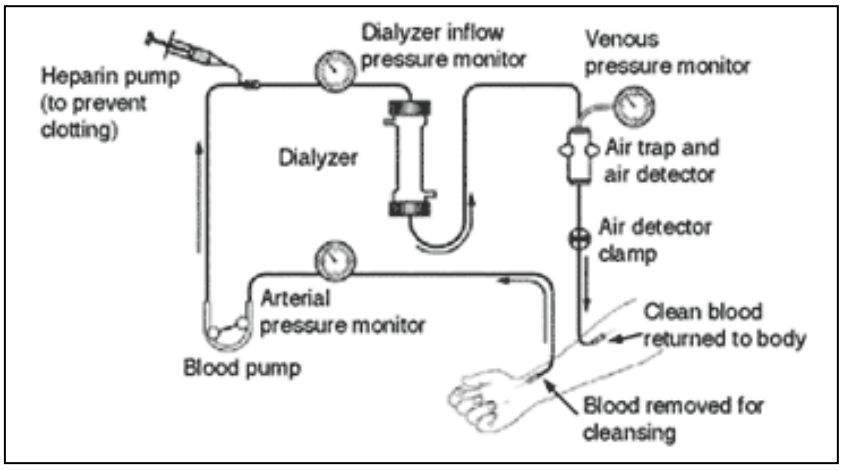


Figure 4.1

In the process of hemodialysis, contaminated ions in the blood is allowed to pass in the dialyzing tube, letting the true solutes to pass through a semi-permeable membrane

In ***hemodialysis***, the bloodstream is diverted from its normal course in the body and pumped through a dialyzing tube with the semi-permeable membrane. An aqueous solution containing ions, such as Na^+, K^+, and Cl^- are of the same concentration as that of the blood on the other side of the dialyzing membrane (*isotonic*). To prevent blood clotting, an anti-clotting agent is added to the dialyzing solution. It is however important that the dialyzing solution is isotonic because that ensures that the solute particles pass in and out of the blood at equal rates, resulting in no net removal of essential components of the blood. In this regard, only the contaminated ions are removed faster than they are returned to the blood. Within a certain time, the procedure reduces the level of toxic substances in the blood.

Colloids in Environment

The use of colloids in the environment can be both harmful and beneficial. Some may be natural while others are caused by human activities. Harmful ones can be made beneficial if we just learn how to manipulate colloids.

Aerosols are one of the unwanted colloids in the environment. These consist of solid or liquid particles that are dispersed in air smaller than 100μm in diameter. These very small particles include carbon black, silver iodide, and sea salt. These suspended particles in air are commonly called **particulates** or simply **particulate matter (PM)**. Larger particulates include cement dusts and soil dust. Even larger particulates are raindrops, fog and sulfuric acid mist. In some of these particulates, viruses, bacteria and fungal spores may also be present. The presence of these bacteria causing diseases can be a threat to health in the community as what happened in the meningococcemia epidemic in Baguio City on December 2004. Some toxic air pollutants such as unburned hydrocarbons from motor vehicles can cause respiratory irritations when inhaled.

Aside from posing a threat to human health, these particulates can also affect the transport industry when road visibility is reduced by during fog or mist.

In our waterways, the disposal of detergents and other pollutants can act as protective colloids that stabilize foam formation. When these foams accumulate on the surface of water, they can seriously reduce the amount of sunlight that can penetrate the water surface. In this regard, the photosynthetic activity of aquatic plants is drastically reduced.

Figure 4.2
Foams collected on surface of bodies of water

Did you know?

Colloid science has evolved in technology and invaded the field of photography. Photographic films and paper have a light-sensitive emulsion coating. This emulsion consists of gelatin and one or more silver halides. In color films, several emulsion layers are separated by filter layers enabling the processing of brilliant colors. The gelatin keeps the silver halide crystals suspended when the emulsion is spread on the plastic film or photographic paper.

What you will do

Self-Test 4.1

Let us check how much you have learned from the lesson by answering the following questions.

Fill in the blanks. Supply the missing word in each statement.

1. In our waterways, the disposal of detergents and other pollutants can act as protective colloids that stabilize _____ formation.
2. _____ is the process of separating the contaminated ions and other smaller molecules from the colloidal particles of the blood by letting the true solutes to pass through a semi-permeable membrane.
3. _____ is a condition where toxic substances build up in the blood because the kidneys are not working efficiently.
4. Suspended particles in air are commonly called _____.
5. It is important that the dialyzing solution is _____ to ensure that solute particles pass in and out of the blood at equal rates, resulting in no net removal of essential components of the blood.

Did you encounter any problem? Well, compare your answers with the answer key and see for yourself the items you missed. Good luck!

Key to answers on page 18.

Let's Summarize

1. A colloid is a dispersion of particles of one substance, the dispersed phase, throughout a dispersing medium made of another substance.
2. Colloids are classified according to the phases of the dispersed material and dispersing medium. The types of colloids are sol, gel, emulsion, foam and aerosol.
3. A colloid is distinguished from a regular solution by the Tyndall effect, which is the scattering of visible light by colloidal particles.
4. Colloids exhibit special properties like Tyndall effect, Brownian motion, adsorption and electrical charge effect.
5. Brownian motion is the movement of colloidal particles in a random and zigzag fashion.
6. Since colloids have a large surface area, they exhibit high adsorbing capacity.
7. The ions adsorbed on the surface of a colloid produce an electrical charge. This, along with Brownian motion, prevents colloids from coagulating.

8. Dispersion and condensation are two ways of making a given substance disperse to colloidal size. When larger pieces are broken into colloidal size, the process is dispersion. But when tiny particles clump together to form clusters the process is condensation.

Posttest

I. Multiple Choice. Choose the letter of the best answer. Write the chosen letter on a separate sheet of paper.

1. Which of the following is a colloid?
   a. oil and water
   b. salt and water
   c. sand and water
   d. alcohol and water

2. Pond water appears clear on standing. Thus, pond water is _____.
   a. a colloid
   b. a solution
   c. an emulsion
   d. a suspension

3. A metal alloy belongs to what type of colloid?
   a. sol
   b. gel
   c. foam
   d. emulsion

4. As you enter the building, you observe a beautiful beam of light from the glass roof. What best explains this phenomenon?
   a. adsorption
   b. Tyndall effect
   c. Brownian motion
   d. electrical charge effect

5. “Merengue” is prepared by beating the egg white vigorously. What method is used in making this colloid?
   a. deposition
   b. dispersion
   c. adsorption
   d. condensation

6. Which of the following involves adsorption?
   a. plating of copper on a steel object
   b. brown color of the eyes of Filipinos
   c. adherence of paint to wood surfaces
   d. removal of odor inside a refrigerator using charcoal

7. When egg yolk is added to oil and water with vinegar to make mayonnaise, the egg yolk serves as:
   a. solvent
   b. coagulant
   c. surfactant
   d. emulsifiying agent

8. What is the phase of a dispersed material in emulsion?
   a. gas
   b. solid
   c. liquid
   d. cannot be determined

9. Which of the following colloids is considered harmful?
   a. cheese
   b. hair spray
   c. whipped cream
   d. black diamond

10. What phenomenon clearly distinguishes a colloid from a solution?
   a. adsorption
   b. Tyndall effect
   c. Brownian motion
   d. electrical charge effect

II. Analogy. Fill in the blanks with the correct answer based on the relationship provided.

1. clouds : liquid aerosol :: mayonnaise : _____
2. solutions : homogenous :: colloids : _____
3. rain : cloud seeding :: smoke : _____
4. _____ : egg yolk :: soap : surfactants
5. _____ : non-polar :: hydrophilic : polar

Key to answers on page 18.

Key to Answers

Pretest

Multiple Choice		Matching Type
1. c	6. a	1. c
2. a	7. a	2. f
3. d	8. c	3. b
4. a	9. c	4. a
5. c	10. b	5. d

Lesson 1

Self-Test 1.1

1. g	6. a
2. d	7. a
3. d	8. i
4. f	9. d
5. e	10. h

Lesson 2

Self-Test 2.1

1. adsorption
2. Brownian motion
3. Tyndall effect
4. Tyndall effect
5. Emulsification

Lesson 3

Self-Test 3.1

1. dispersion
2. emulsifying agent
3. electric coagulation
4. condensation
5. cloud seeding

Lesson 4

Self-Test 4.1

1. foam
2. dialysis
3. uremia
4. particulate or particulate matter
5. isotonic

Posttest

Multiple Choice

1. a
2. b
3. a
4. b
5. b
6. d
7. d
8. c
9. b
10. b

Analogy

1. liquid emulsion
2. heterogenous
3. electric coagulation
4. emulsifying agent
5. hydrophobic

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