Thermometer

Question

Why the common laboratory mercury thermometer is not used to measure the temperature of the Bunsen flame?

Answer

Mercury boils at 356.58 ^{o}C. Liquid mercury would boil and turn into vapour at the temperature of the Bunsen flame. The thin wall of the glass bulb may crack and leak out mercury vapour, which is extremely poisonous.

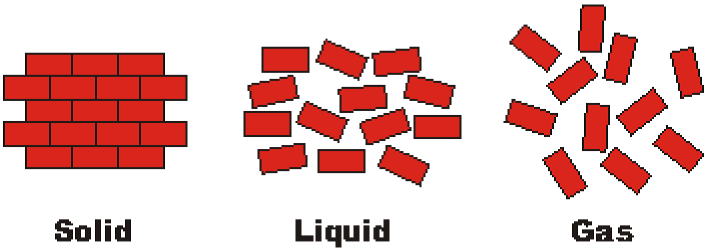
Glass

Question

What makes glass transparent?

Answer

Water, cooking oil, rubbing alcohol, air, natural gas, etc. are all clear, most liquids and gases are transparent. This is because of a fundamental difference between **solids**, **liquids** and **gases**. When a substance is in its solid state, normally its molecules are highly organized, strengthening the bond between them and giving the substance rigidity. As the substance changes from a solid to a liquid, however, the strength of the bond lessens and the molecules begin to align themselves randomly. The molecular bond is greatly weakened in gas and the relationship of the molecules to one another is almost completely random.



The primary reason that light can pass through liquids and gases is the progression from ordered to random organization. The ordered molecules of most solids are virtually impenetrable to light waves, just like bricks stacked neatly on top of one another. Depending on the substance, the light waves will be reflected, scattered, absorbed or, more likely, some combination of the three. But as the substance changes to liquid or gas and the molecules are not stacked neatly anymore, gaps and holes occur that allow portions of the light waves to pass through. The greater the randomness of the molecular organization of the substance, the easier it is for the light to pass through.

Another factor happens at the **sub-atomic level**. When light strikes on an object, photons come in contact with the electrons of its atoms, the following can occur:

- **Transform into heat**: an electron absorbs the energy of the photon and transforms it into heat
- **Luminescence**: an electron absorbs the energy of the photon and stores it (fluorescence if the electron stores the energy for a short time, phosphorescence if it stores it for long time)

- **Reflection**: an electron absorbs the energy of the photon and sends it back out the way it came in
- **Transmitted through the object**: an electron cannot absorb the energy of the photon, the photon continues on its path

Most of the time, it is a combination of the above that happens to the light that hits an object.

Electrons in different materials vary in the range of energy that they can absorb. A lot of glass, for example, blocks out **ultraviolet** (UV) light. The electrons in the glass absorb the energy of the photons in the UV range, while ignoring the weaker energy of photons in the visible light spectrum.

If the electrons absorb the energy of any portion of the visible spectrum, the light that transmits through will appeared colored according to the portion of the spectrum absorbed. In fact, the color of any object is a direct result of what levels of energy the electrons in the substance will absorb!

Glass is generally a manmade substance (although forms of glass, such as **obsidian** or **volcanic glass**, can occur naturally). Here is the basic way to make glass:

- Take the most common glass material, **silica**, which is just plain old sand like you could find on the beach.
- Heat it to an extreme temperature until it becomes liquid, then cool it.

The resulting substance has a molecular structure that is very random like a liquid, yet that retains the strong bond and rigidity of a solid. This is a simplification of the process. The temperature, heating time and cooling method must all be very exact.

The materials used for glass-making cool to form an amorphous mix of molecules (like a liquid) and have electrons that do not absorb the energy of photons in the visible spectrum. This is why you can see through glass, but not wood, metal or stone, which are all solids.

A similar method, called **quenching**, is used with plastics to make them transparent or translucent. Quenching causes the **polymers** (long-chain molecules) in the plastic to settle into a random pattern that allows light to pass through. You can even use this process with organic substances. A clear or translucent candy is created, by heating the ingredients of the recipe and then rapidly cooling them. Notice that clear glass, clear plastic and clear candy are all solids that are melted and then cooled.

Thousands of different substances are used to make various forms of glass. How much and what type of light is transmitted depends on the type and purity of the substance used. Silica, in its purest form, transmits light well. Very little of the light wave is absorbed, but some of it is usually reflected. Look at almost any window and you will see this is true.

Other materials used to make glass may transmit or block specific types of light, such as **ultraviolet light**, or even parts of the visible spectrum. Glass that was black or some other opaque colour, are often caused by microscopic particles suspended in the glass, like the impurities in some liquids and gases.

Another way to change the properties of the glass, such as filtering specific wavelengths of light, is to slow down the cooling process enough to allow the molecules to partially crystallize, or form pattern. And finally, some materials are chosen because they can be shaped and made to transmit and/or refract light in specific ways to use, for instance, as eyeglass lenses or as a magnifying glass.

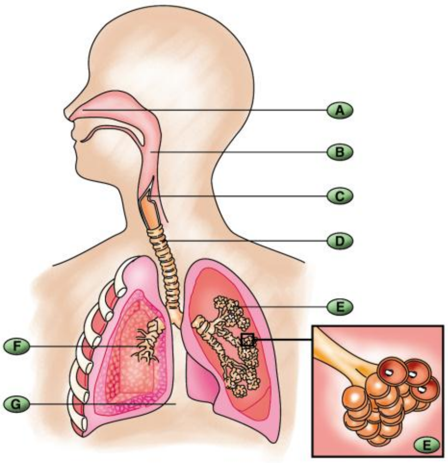
Breathing 100% oxygen

Question

Oxygen is vital to our lives. Is it a good idea to breathe 100-percent oxygen? What will happen?

Answer

We require oxygen for survival and normally we breathe in 21-percent oxygen. You might think that breathing 100-percent oxygen would be good for us, but actually it can be harmful. The harm it brings to you depends on the time of exposure and the pressure of the oxygen (the normal air pressure is 1 atmosphere). Before we discuss the effects of breathing 100-percent oxygen, let's look briefly at how your lungs work.



Your lungs are basically a long series of branching tubes from your nose and mouth (trachea to bronchi to bronchioles) that end in little thin-walled air sacs called **alveoli** (singular - alveolus). Surrounding each alveolus are blood vessels called **pulmonary capillaries**. Between the capillaries and the alveolus is a thin wall of about 0.5 microns thick, through which gases (oxygen, carbon dioxide, nitrogen) exchange can be carried out.

The air you breathe in contains high concentrations of nitrogen and oxygen, but low concentration of carbon dioxide. Since the concentration of oxygen is higher in the air than in the blood entering the pulmonary capillary, oxygen diffuses from the air into the blood. Likewise, it is because the concentration of carbon dioxide is higher in the blood entering the capillary than it is in the alveolar air, carbon dioxide diffuses from the blood to the alveolus. The concentration of nitrogen in the blood and the alveolar air are about the same. The gases exchange across the alveolar wall and so the air inside the alveolus becomes depleted of oxygen and rich in carbon dioxide. When you breathe out, the carbon-dioxide enriched, oxygen-poor air is expelled.

Now let's look at the effects of breathing 100-percent oxygen. In guinea pigs exposed to 100-percent oxygen at normal air pressure for 48 hours, fluid accumulated in the lungs and the epithelial cells lining the pulmonary capillaries and alveolus were damaged. This was probably due to a highly reactive form of the oxygen molecules called the **oxygen free radical**, which destroyed proteins and membranes in the epithelial cells. If human breathe in 100-percent oxygen at normal pressure for over 24 hours, the following effects would be observed:

- **Decrease** in the total volume of exchangeable air in the lung (**vital capacity**) by 17 percent
- **Decreases** in the rate of gas exchange across the alveoli
- **Pulmonary edema**
- **Chest pains** that were worse during deep breathing
- **Local areas of collapsed alveoli**
- **Blindness**

Besides the effect of time exposure, the pressure of oxygen is also a factor to determine the effects of breathing 100% oxygen. Some astronauts breathed 100-percent oxygen at reduced pressure for up to two weeks without any problems. In contrast, when 100-percent oxygen is breathed under high pressure, **acute oxygen poisoning** can occur with the following symptoms:

- Nausea
- Dizziness
- Seizures/convulsions
- Blurred vision

Oxygen consumption

Question

How much oxygen does a person consume in a day?

Answer

Adult at rest inhales and exhales about 7 or 8 liters of air per minute. That totals something like 11,000 liters of air in a day.

The air we breathed in is about 20-percent oxygen, and the air that we breathed out is about 15-percent oxygen, so about 5-percent of the volume of air is consumed in each breath and converted to carbon dioxide. Therefore, a human being uses about **550 litres of pure oxygen** per day. A person who is exercising definitely consumes more oxygen than that.

Vacuum

Question

Air rushes into a vacuum container immediately if the container is punctured. Then why doesn't the vacuum of space suck away all of the Earth's atmosphere?

Answer

From our daily experience, it seems like nature abhors a vacuum. If you create a vacuum inside a container here on Earth, nature will fill the container with air very quickly if you give it the chance (for example, by puncturing the container).

On the other hand, we know that outer space is a giant vacuum. Outer space is infinitely larger than Earth, so 99.9999999...% of our universe is a vacuum. Based on this estimation, it might be better to say that "nature loves a vacuum!" So why doesn't the vacuum of outer space suck away our atmosphere?

Imagine you are standing on Earth and holding a glass bottle. If you attach the bottle to a vacuum pump, pump out all the air and then seal the bottle, the bottle contains a vacuum. If you put a hole in the bottle, air rushes in.

The reason air rushes in the vacuum container when you put a hole in the bottle is because of the **air pressure** around the bottle. In fact, the air molecules stack up on one another (just like 'layers' of air molecules) and create a pressure of 14.7 pounds per square inch at sea level. The higher you rise in the atmosphere, the shorter the layers of air molecules it is, and so results in a lower pressure.

Air Pressure at Various Altitudes (*1 psi = 1 atm.)

- Sea level - 14.7 psi*
- 10,000 feet - 10.2 psi
- 20,000 feet - 6.4 psi
- 30,000 feet - 4.3 psi
- 40,000 feet - 2.7 psi
- 50,000 feet - 1.6 psi

At sea level, it is the weight of all of the molecules stacked above the bottle (14.7 pounds of them in every square inch) that forces the molecules into a punctured vacuum container.

There is no air pressure in the space. Instead, individual air molecules are moving around in the vacuum of space. The molecules can move anywhere they like, but they tend to move toward the Earth because the Earth's gravity acts on them. The reason the vacuum of space does not attract the molecules is because there is no suction to the vacuum of space (i.e. there is no air pressure forcing things into the vacuum.)

You can see that the vacuum of space does not suck our atmosphere away. But it turns out there is another force that *could* strip away our atmosphere. That force is called the **solar wind**. Luckily, the atmosphere is protected from the solar wind by the Earth's magnetic field.

Meteors

Question

The atmosphere protects us from meteors because it burns them up when they hit the atmosphere. Why doesn't the space shuttle burn up?

Answer

When a small meteor enters the Earth's atmosphere, it goes from travelling through a vacuum to travelling through air. Travelling through air is another story.

A meteor travels at speeds reaching tens of thousands of miles per hour through the vacuum. Travelling through a vacuum is effortless so that it takes no energy. When the meteor from vacuum space hits the atmosphere, however, the air in front of it **compresses** extremely quickly. Temperature rises when a gas is compressed. This produced a large amount of heat that causes the meteor to glow. Then the air burns the meteor until there is nothing left. This temperature can reach as high as 1,650 ^{o}C!

Obviously, it would not be good for a spacecraft to burn up when it re-enters the atmosphere. Two technologies are used to allow spacecraft to re-enter:

(1) (1) In **ablative technology**, the surface of the heat shield melts and vaporizes, and it carries away heat in the process, Apollo spacecraft uses this technology to prevent from burning up.

(2) (2) The space shuttles are protected by special **silica tiles**. Silica (SiO2) is an excellent **insulator**. The tiles are produced from amorphous silica fibers which are pressed and sintered. The resulting tile is very lightweight and has low thermal expansion and conductivity, as well as good thermal shock properties. It is possible to hold a space shuttle tile by the edge even when the center is red-hot. The tile insulates so well that no heat makes it out to the edges. These tiles keep the heat of re-entry from ever reaching the body of the shuttle.

Steam and water vapour

Question

What is the difference between steam and water vapour?

Answer

Steam is merely water vapour at a temperature equal to or greater than the boiling point. We cannot see water vapour; for the same reason, we cannot see steam.

When water is heated in a vessel with a nozzle, cloud forms as the hot water vapour issuing from the nozzle mixes with the colder surrounding air. Such a cloud is popularly, although incorrectly, called "steam". We cannot see steam, so what we can see is not rightly called steam.

Call the cloud what you like, but just remember that it is composed of water droplets not water vapour. Like mixing cloud in meteorology, it is the mixing of moist air masses with different characteristics that yields such a cloud. If you heat the nozzle with a gas torch the cloud will soon disappear. Yet, water vapour is still issuing from the nozzle.

Amount of water on Earth

Question

How much water is there on Earth?

Answer

Roughly 1,260,000,000,000,000,000,000 litres can be found on our planet. This water evaporates from the ocean, travels through the air, rains down on the land and then flows back to the ocean, which forms a constant cycle

The oceans are huge. About 70 percent of the planet is covered in ocean, and the average depth of the ocean is several thousand feet (about 1,000 meters). 98 percent of the water on the planet is in the oceans, and therefore is unusable for drinking. About 2 percent of the planet's water is fresh, but 1.6 percent of the planet’s water is locked up in the polar ice caps and glaciers. Another 0.36 percent is found underground in aquifers and wells. Only about 0.036 percent of the planet's total water supply (about thousands of trillions of gallons) is found in lakes and rivers, a very small amount compared to all the water available.

The rest of the water on the planet is either floating in the air as clouds and water vapor, or locked up in plants and animals (65 percent of our body is water, for one weighs 100 pounds will contain 65 pounds of water). Also, there are drinks and beverages at the stores and in your refrigerator. Probably several billion gallons of water sitting on a shelf at anytime!

The Mohs Scale

Question

How to determine the hardness of minerals?

Answer

To determine the hardness of solids, especially minerals, we can use the **Mohs Scale**. It is named after the German mineralogist **Friedrich Mohs**. The scale reads as follows, from softest to hardest:

1. **Talc** - easily scratched by the fingernail
2. **Gypsum** - just scratched by the fingernail
3. **Calcite** - scratches and is scratched by a copper coin
4. **Fluorite** - not scratched by a copper coin and does not scratch glass
5. **Apatite** - just scratches glass and is easily scratched by a knife
6. **Orthoclase** - easily scratches glass and is just scratched by a file
7. **Quartz** (amethyst, citrine, tiger's-eye, aventurine) - not scratched by a file
8. **Topaz** - scratched only by corundum and diamond
9. **Corundum** (sapphires and rubies) - scratched only by diamond
10. **Diamond** - scratched only by another diamond

Source: Kingzett's Chemical Encyc.

Atomic theory

Question

What is the atomic theory?

Answer

Concept of the Atom

The idea of the atom was first devised by Democritus in 530 B.C. In 1808, an English school teacher and scientist named

The atomic theory

John Dalton proposed the atomic theory as follows:

1) All matter is made of atoms. Atoms are indivisible and indestructible.

2) All atoms of a given element are identical in mass and properties

3) Compounds are formed by a combination of two or more different kinds of atoms.

4) A chemical reaction is a rearrangement of atoms.

Modern atomic theory is, of course, a little more involved than Dalton's theory but the essence of Dalton's theory remains valid. Today we know that atoms can be destroyed via nuclear reactions but not by chemical reactions. Also, there are isotopes within an element (same atomic number, differing by their masses), which have the same chemical properties.

Halogen lamps

Question

How are halogen lamps different from normal light bulbs? Why are they sometimes called "quartz halogen"?

Answer

A normal light bulb is made up of a fairly large, thin, frosted glass envelope, filled with gas(es) such as argon and/or nitrogen. At the center of the lamp is a tungsten filament. Electricity The filament heats up to about 2,500 ^{o}C when conducting electricity, and gets "white hot" and emits a great deal of visible light in a process called **incandescence**.

A normal light bulb is not very efficient because, it radiates far more heat than light in the process. Since the purpose of a light bulb is to generate light, the heat is wasted energy. It doesn't last very long because the tungsten in the filament evaporates and deposits on the glass. Eventually, a thin spot in the filament causes the filament to break, and the bulb "burns out."

A **halogen lamp** also uses a tungsten filament, but it is encased inside a much smaller **quartz envelope**. Because the envelope is so close to the filament, it would melt if it were made from glass. The gas inside the envelope is also different -- it consists of a **halogen** gas. If the temperature is high enough, the halogen gas will combine with tungsten atoms as they evaporate and redeposit them on the filament. This **recycling** process lets the filament last a lot longer. In addition, it is now possible to run the filament hotter, more light per unit of energy can be obtained. Also the quartz envelope is so close to the filament, it is extremely hot compared to a normal light bulb.

Formation of ion

Question

How does an atom lose or gain an electron/electrons to form an ion?

Answer

The electron was the first subatomic particle discovered. It was identified in 1897 by the British physicist J.J. Thomson during investigations of cathode rays.

Under ordinary conditions, electrons are bound to the positively charged nuclei of atoms by the attraction between opposite electric charges. In a neutral atom the number of electrons is identical to the number of positive charges on the nucleus. Any atom, however, may have more or fewer electrons than positive charges and thus be negatively or positively charged as a whole; these charged atoms are known as ions. Not all electrons are associated with atoms. Some occur in a free state with ions in the form of matter known as plasma.

Although an atom is normally electrically neutral, it can lose or gain a few electrons in some chemical reactions or in a collision with an electron or another atom. This gain or loss of electrons produces an electrically charged atom called an ion. An atom that loses electrons becomes a positive ion, and an atom that gains electrons becomes a negative ion. The gain or loss of electrons is called ionisation. Any process that can add or remove electrons from an atom or a molecule can produce ions. Radiation and chemical reactions are such processes.

Radiation can increase the energy of the electrons in an atom or a group of atoms. If this energy is increased enough, one or more electrons can overcome the attraction of the nucleus and escape from the atom. The loss of negative charge results in the atom becoming a positive ion. Radiation that can produce ions includes light, X rays, gamma rays, atomic nuclei, subnuclear particles, and electrons. Ionisation, in general, occurs whenever sufficiently energetic charged particles or radiant energy travel through gases, liquids, or solids. Charged particles, such as alpha particles and electrons from radioactive materials, cause extensive ionisation along their paths.

In chemistry, ionization often occurs in a liquid solution. For example, neutral molecules of hydrogen chloride gas, HCl, react with polar water molecules, H_2O, to produce positive hydronium ions, H_3O^+. Negative chloride ions, Cl^-; at the surface of a piece of metallic zinc in contact with an acidic solution, zinc atoms, Zn, lose electrons to hydrogen ions and become colourless zinc ions, Zn^{2+}.

Ionization by collision occurs in gases at low pressures when an electric current is passed through them. If the electrons constituting the current have sufficient energy (the ionization energy is different for each substance), they force other electrons out of the neutral gas molecules, producing ion pairs that individually consist of the resultant positive ion and detached negative electron. Negative ions are also formed as some of the electrons attach themselves to neutral gas molecules. Gases may also be ionised by intermolecular collisions at high temperatures.

Silicon in semiconductors

Question

What makes silicon suitable to used in semiconductors?

Answer

Today, most semiconductor chips and transistors are created with **silicon**. Silicon is a very common element, it is the main element in sand and quartz.

Structure of silicon

Silicon is an element in group IV of the periodic table, below carbon and above germanium. It has four outermost shell electrons. This allows them to form nice crystals. The four electrons form a giant covalent network with the neighboring atoms, creating a **lattice**. In carbon, the crystalline form is diamond. In silicon, the crystalline form is a silvery, metallic-looking substance.

Metals are good conductors of electricity, as they have delocalized electrons that can move easily between atoms, and electricity involves the flow of electrons. While silicon crystals look metallic, they are not, in fact, metals. All of the outer electrons in a silicon crystal are participated in **giant covalent bonds**, so there is no free electrons to conduct electricity. A pure silicon crystal is nearly an **insulator**.

Doping Silicon

Silicon can be turned into a conductor by means of **doping**. In doping, a small amount of an **impurity** is mixed with the silicon crystal. There are two types of impurities:

- **N-type** - In N-type doping, phosphorus or arsenic is added to the silicon in small quantities. Phosphorus and arsenic each have five outer electrons, so they're out of place when they get into the silicon lattice. The non-bonding fifth electron is free to move around. It takes only a very small quantity of the impurity to create enough free electrons to allow an electric current to flow through the silicon.
- **P-type** - In P-type doping, boron or gallium is the dopant. Boron and gallium each have only three outer electrons. When mixed into the silicon lattice, they form "holes" in the lattice, where the silicon atom has a non-bonding electron. The absence of an electron creates the effect of a positive charge, hence the name P-type. Holes can conduct current. A hole happily accepts

an electron from a neighbor, moving the hole over a space.

A minute amount of either N-type or P-type doping turns silicon crystals from a good insulator into a viable (but not great) conductor, that is the reason why it is so called "semiconductor."

Silica gel

Question

Why packets of "Silica Gel" are commonly found in the packages of electronics products or food stuffs? Is it poisonous?

Answer

The little packets of silica gel are found in all sorts of products are **desiccants**. Silica gel adsorbs and holds water vapor. In leather products or foods, silica gel can remove the moisture, so to limit the growth of mold and reduce spoilage. In electronics products it prevents condensation, which might damage the electronics. You will find little silica gel packets in anything that would be affected by excess moisture or condensation.

Silica gel is nearly harmless, so it is used as a desiccant in food products. Silica, or **silicon dioxide** (SiO2), is the same material found in quartz. The gel form contains millions of tiny pores that can adsorb and hold moisture. Silica gel is essentially porous sand.

Silica gel can adsorb about 40 percent of its weight in moisture, and can take the relative humidity in a closed container down to about 40 percent. Once saturated, the moisture can be driven off by heating it above 150 ^{o}C. The silica gel can be reused afterwards.

Platinum

Question

What are the physical and chemical features of platinum? How was it discovered and who discovered it? What is it used for?

Answer

Platinum is durable, heavy, silver-white metal that is malleable, ductile, and extremely resistant to corrosion. It does not react with the oxygen in the air and is therefore usually found in nature as pure metal. Strong acids that dissolve most metals do not attack platinum. Platinum can be best dissolved in aqua regia, a mixture of nitric and hydrochloric acid.

An Englishman named Charles Wood discovered platinum in 1741. There is evidence, however, that it was used by the pre-Columbian Indians of America. It takes its name from the Spanish word platina, which means "silver."

Platinum is used in petroleum refining, dentistry, the chemical industry, the ceramics industry, and the electrical and electronics industries. In recent years, the automobile industry has found a major use for the metal. A platinum-coated ceramic grid serves as the catalyst in the catalytic converter attached to the exhaust system. The platinum assists chemical reactions that "clean up" the exhaust gases coming from the engine of the car, converting carbon monoxide and unburned fuel into water and carbon dioxide. The glass industry uses platinum to make dies for fibreglass. Platinum is also used on the best surgical instruments.

Sodium reacts with water

Question

Why sodium + water = sodium hydroxide + hydrogen, instead of sodium + water = sodium hydroxide + oxygen?

Answer

Sodium (atomic number 11) belongs to group I of the periodic table, and has one more electron than the noble gas neon (atomic number 10). The sodium tends to lose one electron to form sodium ion Na^+ (10 electrons, the same electronic configuration as neon).

Sodium is an extremely reactive metal. When sodium reacts with other substances, it tends to loss one electron to become Na^+, in order to achieve noble gas electronic arrangement for stability (low reactivity).

In pure water or in any aqueous solution, the ionisation of water may be represented as follows:

$H_2O = H^+ + OH^-$

When sodium reacts with water, H^+ would be more ready to accept the electron from sodium than OH- would. Two resulting hydrogen atoms would then combine to form hydrogen gas. For the same argument, when metals react with acids in aqueous solution, hydrogen is given out.

Chemical formula for rust

Question

How rusting occurs? What is the correct formula for rust? Why is it that some books say it is Fe_2O_3 while others say it is Fe_3O_4?

Answer

When a piece of metal or alloy exposed to air under the natural environment, if the metal is not inert, it will have some degree of reactivity towards oxygen in the air, and eventually forms metallic oxide at the surface. Rust is a brownish-red substance that forms on the surface of iron or steel when it is exposed to damp air. It is formed by the union of the oxygen of the air with the iron (oxidation).

Rust has a variable composition. Iron rust consists mainly of hydrated iron oxide ($Fe_2O_3 \cdot H_2O$), which has a corundum structure where the oxide ions form a hexagonal close-packed array with the Fe(III) ions occupying the octahedral interstices.

Fe_3O_4 is the magnetic iron oxide, which is the product of steam with iron at high temperature (say $600^{o}C$ or higher). It appears as metallic bluish black on steel, and is a protective film to the steel. Unlike the Fe_2O_3 it doesn't peel off from the steel. Fe_3O_4 occurs as mineral magnetite, which is a mixed oxide of $Fe_2O_3 \cdot FeO$, with the oxide ions forming the cubic close-pack array, and the Fe(II) and Fe(III) ions in the octa- and tetrahedral holes.

Fe_2O_3 is hematite. Loosely used rusts are oxides of iron (hydrous ferric oxide), which may go on to form Fe_3O_4 or Fe_2O_3 under appropriate conditions:

Physical conditions

Temperature: higher temperature will speed up the formation of metallic oxide.

Chemical conditions

Presence of:

a. water,

b. acidic substances, e.g. carbon dioxide,

c. oxygen or an oxidizing agent, &

d. inorganic salts e.g. NaCl.

When iron rust, the following overall reaction have taken place:

$4Fe + 3O_2 \rightarrow 2Fe_2O_3$

In fact, the rust often contain some water molecules: $Fe_2O_3 \cdot xH_2O$ (x is an integral it values can range from 1 to 5 or 6). There are a number of ways to express the formula of rust, depends on the conditions during formation. However, Fe_2O_3 is basically correct and convenient to use.

WD - 40

Question

What does the name WD-40 stand for?

Answer

WD – 40 is a car lubricant, which protects metal from rust and corrosion, penetrates stuck parts, displaces moisture, and lubricates. It can also be used in cleaning grease, grime, and other marks from most surfaces.

The formula of WD-40 was worked out in 1953, when the company set out to create a line of rust-prevention solvent and degreaser for use in the aerospace industry. WD-40 literally stands for Water Displacement, 40th attempt. That's the name straight out of the lab book used by the chemist who developed WD-40 back in 1953. The chemist, Norm Larsen, was attempting to concoct a formula to prevent corrosion -- a task which is done by displacing water. Norm's persistence paid off when he perfected the formula on his 40th try.

Tartaric acid

Question

What is tartaric acid and where can I found it?

Answer

Tartaric acid is an organic acid that occurs naturally in grapes and several other fruits, its IUPAC name is dihydroxybutanedioic acid. The various tartaric acids and the common tartrate salts are all colourless, crystalline solids that are readily soluble in water.

Most commercial tartaric acid is obtained as a by-product of the wine industry. Along with several of its salts, cream of tartar (potassium hydrogen tartrate) and Rochelle salt (potassium sodium tartrate), it is obtained from by-products of wine fermentation.

Uses

Tartaric acid is widely used to acidulate carbonated drinks, effervescent tablets, gelatin desserts, and fruit jellies. Its industrial applications are cleaning and polishing metals, calico printing, wool dyeing and certain photographic printing and development processes.

Rochelle salt is used in silvering mirrors, in processing cheese, and in compounding mild cathartics. Crystals of Rochelle salt, which are piezoelectric, are also an important part of some microphones.

Cream of tartar is incorporated into baking powders, hard candies, and taffies; and it is employed in the cleaning of brass, the electrolytic tinning of iron and steel, and the coating of other metals with gold and silver. Tartar emetic is used as an insecticide and a dyeing mordant.

Century eggs

Question

What is the role of alkali in the process of making century egg?

Answer

Century eggs are made by coating duck eggs with wood ash (mixed with lime and clay) traditionally. The eggs are then left to ripen for about a month. Chemical analyses of the coating shows that alkali and alkali earth oxides are the main ingredients in making the century eggs.

Production of the century egg involves chemical reactions such as denaturation of proteins, hydrolysis, deamination, decarboxylation and racemisation. In denaturation, the strong alkali disrupts the hydrogen bonds and salt bridges, causing an unfolding of the coiled structure of the protein. Although the peptide bonds are still intact, the biological nature and activity of the protein are destroyed. After denaturation, coagulation takes place, resulting in the hardened egg white and egg yolk. The colour darkens during the ripening period.

Hydrogen sulphide and ammonia gases are often evolved during the production of century eggs. This is due to the decomposition of the macromolecules into smaller protein units by the alkali (hydrolysis and deamination reactions).

pH of blood

Question

Is it true that certain food or diet can adjust the pH of blood in our body? What is the ideal pH of blood?

Answer

Intake of food or diet does not cause changes in the pH of blood. In fact, only a narrow pH range is compatible with life, even small changes on hydrogen-ion concentration will have dramatic effects on normal cell function.

Fluctuations in hydrogen-ion concentration have profound effects on our body chemistry. The pH of pure water is 7.0, which is considered to be chemically neutral. The pH of arterial blood is normally 7.45 and the pH of venous blood is 7.35, for an average blood pH of 7.4.

The pH of venous blood is slightly lower (more acidic) than that of arterial blood, as the formation of H_2CO_3 from CO_2 picked up at the tissue capillaries generates H^+ ions. Acidosis exists whenever the blood pH falls below 7.35, whereas alkalosis occurs when the blood pH is above 7.45.

Note that the neutral acid-base status in our bodies is not the chemical neutral pH of 7.0, but the normal plasma pH of 7.4. Thus a plasma pH of 7.2 is considered acidic, even though in chemistry a pH of 7.2 is considered basic.

Arterial pH falls outside the range of 6.8 to 8.0 for more than a few seconds is fatal, for the blood pH is not compatible with life. Therefore, hydrogen-ion concentration in the body fluids is carefully regulated.

Home-made indicators

Question

Are there any other indicators that one can make at home besides that from cabbage juice?

Answer

Acid-base indicators are used to indicate the strength of an acidic or alkaline solution. They show a range of colour changes according to the pH of a solution.

Most plants contain many pigments that occur most prevalently as glycosides. The anthocyanins are the most important and widespread group of colouring matters in plants. These water-soluble pigments account for many of the red, pink, purple, and blue colours found in higher plants.

Plant pigments can be extracted with the right solvents at appropriate temperatures. Their colours are normally pH dependent and most plant pigments change colours with pH. Hence they can be used as acid-base indicators.

Many indicators can be easily extracted from vegetables, flowers and fruits. Other than red cabbage, you may like to try out various plant materials such as dark red rose petals, hibiscus petals, clitoria flowers, grape juice, radish skin, onion skin, beetroot, or cherrie.

Universal indicator

Question

What are the components of a universal indicator?

Answer

A chemical indicator is a substance that indicates the presence, absence, or concentration of other substances, or the degree of reaction between two or more other substances by a colour change. The most common example is the use of acid-base indicators such as litmus, phenolphthalein, and methyl orange to indicate the presence or absence of acids or bases, or the approximate concentration of hydrogen ion in a solution.

Universal indicator is a mixture of acid-base indicators that changes colour (e.g. red-yellow-orange-green-blue) over a range of pH. Different manufacturers use different components for their products. The pH ranges of several typical indicators are as follows:

Indicator	**pH range**	**Colour change**
Alpha naphtholbenzein	0- 0.8	Colourless to yellow
Methyl violet	0.2- 1.9	Yellow to blue-violet
Para methyl red	1.0-3.0	Red to yellow
Thymol blue	1.2- 2.8	Red to yellow
Congo red	3.0- 5.2	Blue to red
Methyl orange	3.3- 4.5	Red to yellow
Methyl red	4.2- 6.2	Red to yellow
Litmus	4.4- 8.3	Red to blue
Chlorophenol red	5.2- 6.8	Yellow to red
Bromthymol blue	6.0- 7.6	Yellow to blue
Aurin	6.2- 7.2	Amber to pink
Phenol red	6.8- 8.5	Yellow to red
Cresol purple	7.4- 9.0	Yellow to purple
Thymol blue	8.0- 9.6	Yellow to blue
Phenolphthalein	8.3-10.2	Colourless to red
Thymolphthlein	9.4-10.7	Colourless to blue
Alizarin yellow R	10.1-12.0	Yellow to red
Malachite green	11.4-13.0	Blue-green to colourless
1,3,5-Trinitrobenzene	12.0-14.0	Colourless to orange

Baking powder

Question

How baking powder works?

Answer

Baking powder is a leavening agent, which releases carbon dioxide when wet and makes the dough to rise and increase in volume. Muffins, biscuits, cakes and cookies usually use baking powder.

Baking powder is normally made of three different parts:

- An acid
- A base
- A filler of some sort

All three need to be dry powders that can be mixed together. For example, baking soda (a base), cream of tartar (an acid) and corn starch (the filler) are three common ingredients. When water is added to baking powder, the dry acid and base go into solution and start reacting to produce carbon dioxide bubbles.

Baking soda, also known as sodium bicarbonate, has the chemical formula $NaHCO_3$. Cream of tartar, also known as tartrate salt, has the formula $KHC_4H_4O_6$. The reaction is:

$$NaHCO_3 + KHC_4H_4O_6 \rightarrow KNaC_4H_4O_6 + H_2O + CO_2$$

Some baking powders contain sodium aluminum sulfate: $NaAl(SO_4)_2$. The reaction there is:

$$NaAl(SO_4)_2 + 3\ NaHCO_3 \rightarrow Al(OH)_3 + 2\ Na_2SO_4 + 3\ CO_2$$

Many recipes call simply for baking soda rather than baking powder. Usually these recipes use some kind of liquid acid like buttermilk or yogurt to react with the baking soda to produce the bubbles.

People often prefer baking powder to yeast, because yeast takes a long time (usually two to three hours) to produce its bubbles. The reaction of baking powder is instant.

Gripe water

Question

How does the sodium bicarbonate in gripe water help to cure an infant's colic symptoms? Does it react with hydrochloric acid in the infant’s stomach?

Answer

Natural remedies for colic symptoms are called 'gripe water'. It has been used in old European and East Indian countries for over a century, to relieve babies from the discomforts of hiccups, colic, stomach cramps, gas and teething.

Nowadays, "gripe water" is free of alcohol, sucrose, artificial sweeteners, artificial flavours or colours and petroleum based products. Some of them contain essential oils, extracts or flavours from plants. Not all brands of "gripe water" contain bicarbonate.

Sodium bicarbonate (sodium hydrogen carbonate) is a common household chemical. Its commercial term is baking soda, which can be used as an antacid. Adults, relief from the discomforts of excess stomach acid, which can include the pain of ulcers, can often be obtained from antacids such as Alka-Seltzer, Milk of Magnesia, or simply some baking soda in water. In the process, excess hydrochloric acid in our stomach is neutralised. Carbon dioxide will be produced if sodium bicarbonate is used.

Antacid would not bring the stomach's fluids to complete acid-base neutrality of pH 7. Such action would shut down digestion completely and could shock the walls into flooding the stomach with fresh acid in what is called "acid rebound". Instead, a good antacid neutralises enough of the HCl in the gastric juices to alleviate the pain and discomfort, yet allows normal stomach action to proceed.

Colour of pH indicator

Question

Why do pH indicators change colour when they come into contact with acids or base?

Answer

Acid-base indicators are a special class of weak acids and bases, in which the ionised form and the un-ionised(as a salt) form have different colours. These substances change colour over a short pH range even in small concentrations. As the pH changes they go from one colour form to the other, which is useful for the determination of pH of solutions, or as indicators to show the end-point of an acid base neutralisation.

Indicators may be either organic or inorganic, by far the most useful and abundant are the organic ones. The colour changes of organic indicators are distinctive and observable at low concentrations. Some of them are bases (e.g. methyl violet, which is violet as the free base and yellow as the salt), while some are acid (e.g. trinitrobenzene, which is colourless as the free acid but red-orange as the salt).

Subject to the equilibrium, the reactions of the indicators are as follows:

$\mathrm{Ind} + \mathrm{H}^+ \rightarrow \mathrm{IndH}^+$ (Basic indicators)

$\mathrm{IndH} \rightarrow \mathrm{Ind}^- + \mathrm{H}^+$ (Acidic indicators)

Concentration of chlorine

Question

If chlorine has bleaching effect on clothes and it is present in the water in swimming pool, why doesn't our swimsuit or costume get bleached?

Answer

Ordinary swimming pools contains about 1.5 parts per million (ppm), i.e. 0.00015% of chlorine. This concentration is sufficient to keep the water free of microorganisms.

On the other hand, liquid household bleach usually has a concentration of 5% sodium hypochlorite (NaOCl). To prepare commercial bleach solutions, firstly add gaseous chlorine to 12-15% sodium hydroxide solution (until the alkalinity is just neutralised), followed by diluting the resulting solution to 5%. Percentage of available chlorine for commercial household bleach is normally 3-5%. Further dilution (usually more than 100 folds, i.e. 0.03-0.05% chlorine) is required for laundry use.

Since the concentration of chlorine in swimming pool is much lower than that of the diluted household bleach, water in the swimming pool does not affect the colours of our swimsuit. Neither does it irritate our skin nor our eyes.

Phenolphthalein

Question

What is the colour of phenolphthalein at the end point of titration? Should it be pink or deep red?

Answer

Phenolphthalein is used as the acid-base indicator in titration for which the end point lies clearly on the basic side (pH>7), e.g. oxalic acid or potassium hydrogen tartrate against caustic soda (weak acid titrate against strong alkali).

It is colourless for pH < 8.8 and becomes pink to deep-red if the pH rises above the transition range 8-9.6. Therefore it should give a pink colour when the end point of titration is just reached.

Melting ice experiment

Question

There are two cups containing the same amount of warm water. One cup of water has dissolved table salt, while the other is pure water only. If two identical ice cubes are put into each cup, which ice cube will melt faster? Why?

Answer

The rate of melting ice depends on the molecular forces holding the molecules of water together, and the temperature of the surroundings (temperature gradient).

In the two cases cited, it appears that neither case have distinguishable effects on the rate of melting, so the rate should therefore remain the same. The colligative effect of salt does not take part in the melting of ice and is not significant.

Deep cycle battery

Question

What is the difference between a normal lead-acid car battery and a "deep cycle" battery?

Answer

Deep cycle batteries are usually used in recreational vehicles (RVs), boats, golf carts and large solar power systems (the sun produces power during the day and the batteries store some of the power for use at night).

Both car batteries and deep cycle batteries are **lead-acid** batteries that use exactly the same chemistry for their operation. The difference is in the way that the batteries **optimize** their design:

- **A car's battery is designed to provide a very large amount of current for a short period of time.** This surge of current is needed to turn the engine over during starting. Once the engine starts, the alternator provides all the power that the car needs, so a car battery may go through its entire life without ever being drained more than 20 percent of its total capacity. Used in this way, a car battery can last a number of years. To achieve a large amount of current, a car battery uses thin plates in order to increase its surface area.
- **A deep cycle battery is designed to provide a steady amount of current over a long period of time.** A deep cycle battery can provide a surge when needed, but nothing like the surge a car battery can. A deep cycle battery, like car battery, can also be deeply discharged over and over again (something that would ruin a car battery very quickly). To accomplish this, a deep cycle battery uses thicker plates.

A car battery typically has two ratings:

- **CCA** (Cold Cranking Amps) - The number of amps that the battery can produce at 0 °C) for 30 seconds
- **RC** (Reserve Capacity) - The number of minutes that the battery can deliver 25 amps while keeping its voltage above 10.5 volts

A deep cycle battery will have two or three times the RC of a car battery, but will deliver one-half or three-quarters the CCAs. In addition, a deep cycle battery can withstand several hundred total discharge/recharge cycles, while a car battery is not designed to be totally discharged.

Modern Batteries

Question

What are the dry cells commonly used in daily life?

Answer

Modern batteries use a variety of chemicals to power their reactions. Typical battery chemistries include:

- **Zinc-carbon battery** - Also known as a **standard carbon** battery, zinc-carbon chemistry is used in all inexpensive AA, C and D dry-cell batteries. The electrodes are zinc and carbon, with an acidic paste between them that serves as the electrolyte.
- **Alkaline battery** - Used in common Duracell and Energizer batteries, the electrodes are zinc and manganese-oxide, with an alkaline electrolyte.
- **Lithium photo battery** - Lithium, lithium-iodide and lead-iodide are used in cameras because of their ability to supply power surges.
- **Lead-acid battery** - Used in automobiles, the electrodes are made of lead and lead-oxide with a strong acidic electrolyte (rechargeable).
- **Nickel-cadmium battery** - The electrodes are nickel-hydroxide and cadmium, with potassium-hydroxide as the electrolyte (rechargeable).
- **Nickel-metal hydride battery** - This battery is rapidly replacing nickel-cadmium because it does not suffer from the memory effect that nickel-cadmiums do (rechargeable).
- **Lithium-ion battery** - With a very good power-to-weight ratio, this is often found in high-end laptop computers and cell phones (rechargeable).
- **Zinc-air battery** - This battery is lightweight and rechargeable.
- **Zinc-mercury oxide battery** - This is often used in hearing-aids.
- **Silver-zinc battery** - This is used in aeronautical applications because the power-to-weight ratio is good.
- **Metal-chloride battery** - This is used in electric vehicles.

Biting on aluminium foil

Question

If you have metal dental work in your mouth, how would you feel when biting on aluminium foil? Why?

Answer

Biting on aluminum foil can be painful and is usually noticed if you have metal in your mouth from dental work (e.g. fillings, crowns). Basically, when you bite on foil, you set up a **battery** in your mouth and the electrical current stimulates nerve endings in your tooth. Here is what happens:

1. pressure from biting brings two different metals (aluminum foil, mercury in fillings or gold in crowns) in contact in a moist, salty environment (saliva).
2. the two metals have an electrochemical potential difference or voltage across them
3. electrons flow (as electrical current) from the foil into the tooth
4. the current gets conducted into the tooth's root, usually by the filling or crown
5. the current sets off a nerve impulse in the root's nerve
6. the nerve impulse is sent to the brain
7. 7. the brain interprets the impulse as pain

If you have no metal dental work in your mouth, you should not feel this effect.

“Self-recharging” features of batteries

Question

Why do batteries seem to "recharge themselves" if you let them sit for awhile?

Answer

To understand why this happens, we should investigate what’s going on inside the battery. Take the simplest zinc/carbon battery as an example. Electrons flow through the wire from the zinc anode to the carbon cathode. Hydrogen gas builds up on the carbon cathode, which coats the majority of the cathode's surface within a short period of time. The layer of hydrogen gas bubbles blocks the cell reaction, a drop of voltage and current is observed as a result. Stop using the battery rest for awhile can dissipate the hydrogen gas; the battery thus seems to “recharge” itself.

The same sort of thing can happen in any battery. Reaction products build up around the surface of the two poles, thus slow down the reaction of the battery. By using the battery intermittently, the reaction products can be dissipated. The higher the drain on the battery, the faster the products build up, so batteries under high drain appear to recover more.

Fuel Cell

Question

What is a fuel cell?

Answer

Power station burns fossil fuels to produce electricity. However, typically less than 40% of the heat energy is converted to electrical energy, which is not an efficient method. Combustion of fossil fuels are actually redox reactions: diatomic oxygen (oxidation number = 0) is reduced to carbon dioxide (oxidation number = -2) or water (oxidation number = -2).

Instead of combustion, direct production of electricity from redox chemistry, has a higher efficiency of production of electrical energy. Voltaic cells that perform this type of redox reaction for conventional fuels (such as hydrogen or methane) are called fuel cells

A common reaction being utilized in fuel cells is the reduction of oxygen by hydrogen

Cathode:

$O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$

Anode:

$2H_2(g) + 4OH^-(aq) \rightarrow 4H_2O(l) + 4e^-$

Overall reaction:

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

It is currently a very expensive, but extremely efficient and compact way to generate energy. Its applications nowadays are to provide electricity (and drinking water) for spacecraft.

Electrolysis of liquefied air

Question

Can electrolysis be applied at cryogenic temperatures? For example, can liquefied air be separated by electrolysis?

Answer

For electrolysis to be used as a method to recover substances, two criteria must be fulfilled:

a. The substance must exist in a different molecular form in the electrolyte, that is, the valency of the element(s) must be different in the two forms.

b. The electrolyte must be electrically conductive.

In liquefied air, for example, the oxygen, nitrogen and other gases exist in the same molecular form. In spite of the phase transformation, the electrolyte is also not conducting. The constituent components cannot thus be separated by electrolysis.

Chlorine in swimming pools

Question

How does chlorine in the swimming pool affect swimmers? How much is considered the safe amount of chlorine in the swimming pool?

Answer

Chlorination is the adding of chlorine to water in order to kill germs that might be present. Swimming pools, hot tubs, and the like are usually chlorinated with chlorine-containing substances like

calcium hypochlorite, $Ca(HClO)_2$

sodium hypochlorite, NaHClO (bleach)

trichloro-s-triazinetrione

elemental chlorine (Cl_2)

In every case, the effectiveness of chlorination as a germicide is a result of chlorine's powerful oxidizing action.

Swimming pools need to be chlorinated because the water must be kept free of micro-organisms even the water is not meant to be drunk. When the same water is used over and over again, it quickly becomes contaminated with bodily excretions and garden debris. Strong oxidising agents such as hypochlorites are used to sterilise the water.

In order to determine how much chlorine should be used, factors to be considered are:

- Chlorine demand of the pool (the amount of chlorine needed to destroy contaminants that are present).
- Capacity of the pool
- Water balance
- pH of the pool water

Most health departments will close down a public pool that does not have a minimum of 1.0 ppm of free chlorine available in the water during a health inspection.

For pools that experience strong sunlight, cyanuric acid should also be added. Cyanuric acid is a chlorine stabilizer, providing a chemical cloak around the chlorine molecule and protects it from the sun's UV radiation (the largest killer of chlorine).

The recommended level is in the range of 30 to 50 parts per million (ppm). Below 25 ppm, cyanuric acid has no stabilising effect on chlorine. Chlorine has a half-life of 35 minutes in strong sunlight. i.e. 1 ppm chlorine is reduced to 0.06ppm in just 140 minutes! Cyanuric acid can reduce this loss to 0.4ppm in 140 minutes.

Chlorine is a toxic gas, with some forms of it is dangerous for the handler and the environment. Chlorine in a solution of water at levels found in swimming pools pose no danger for swimmers. Allergic reactions to chlorine are rare, however some individuals may experience skin irritation.

It is a common misconception that red eyes and a strong chlorine smell of the water is the result of too much chlorine. Actually, the cause is not enough chlorine! When a free chlorine molecule combines with a nitrogen or ammonia molecule, a combined chlorine compound called chloramine is produced. These compounds have a bad smell, irritate eyes and skin, and consume the free chlorine available. Extremely high levels of chlorine in the water, however, could possibly release enough gas off of the surface in certain conditions, and render breathing difficulties.

Newspapers turn yellow

Question

Why do newspapers turn yellow over time?

Answer

Paper is made from wood, which is made up mainly of white cellulose. Wood also has a lot of dark substance in it called lignin, which ends up in the paper, too, along with the cellulose. The exposure of lignin to air and sunlight is what turns paper yellow.

Lignin makes wood stiff and trees stand upright. It acts as glue to bind the cellulose fibers together. Without lignin, a tree could only grow to be about 6 feet tall. Lignin also helps protect the wood from pests and other damage.

To make a fine white paper, the mill puts the wood through a chemical solvent process, which separates and discards the lignin. Pure cellulose is white, and the paper made from it will be white and will resist yellowing.

Some types of paper are not treated with bleaching chemicals, like the brown kraft paper (dark brown paper used in grocery store bags) and cardboard. They.are stiff and sturdy, because they have more lignin in them. It doesn't matter how dark they are because the printing on them is limited.

Newsprint, which must be produced as economically as possible, has more lignin in it than finer papers. At the mill, the wood that will be turned into newsprint is ground up, lignin and all. Lignin eventually turns paper yellow because of oxidation. The lignin molecules, when exposed to oxygen in the air, begin to change and become less stable. The lignin will absorb more light, giving off a darker color. If newsprint were kept completely out of sunlight and air, it would remain white. After only a few hours of sunlight and oxygen, however, it will start to change color.

Composition of crude oil

Question

What is the composition of crude oil?

Answer

On average, crude oils are made of the following elements or compounds:

Carbon - 84%

Hydrogen - 14%

Sulphur - 1 to 3% (hydrogen sulfide, sulfides, disulfides, elemental sulfur)

Nitrogen - less than 1% (basic compounds with amine groups)

Oxygen - less than 1% (found in organic compounds such as carbon dioxide, phenols, ketones, carboxylic acids)

Metals - less than 1% (nickel, iron, vanadium, copper, arsenic)

Salts - less than 1% (sodium chloride, magnesium chloride, calcium chloride)

Crude oil is a fossil fuel, it was formed naturally from decaying plants and animals living in ancient seas millions of years ago. Crude oil is also known as petroleum, which comes out of the ground and has not refined yet. Crude oils vary in color, from clear to tar-black, and in viscosity, from water to almost solid. Crude oils are useful, for they contain hydrocarbons that are the starting material of fuels, lubricants and chemicals.

Hydrocarbons are molecules that contain hydrogen and carbon and come in various lengths and structures, from straight chains to branching chains to rings. Hydrocarbons store a lot of energy. Fuels derived from crude oil, like gasoline, diesel fuel, paraffin wax and so on liberate such energy during combustion.

Hydrocarbons can take on many different forms. The smallest hydrocarbon is methane (CH4), which is a gas that is a lighter than air. Longer chains with 5 or more carbons are liquids. Very long chains are solids like wax or tar. By chemically cross-linking hydrocarbon chains you can get everything from synthetic rubber to nylon to the plastic. Hydrocarbon chains are very versatile!

The major classes of hydrocarbons in crude oils include:

Paraffins

General formula: C_nH_{2n+2} (n is a whole number, usually from 1 to 20)

Straight- or branched-chain molecules

Can be gasses or liquids at room temperature depending upon the molecule

Examples: methane, ethane, propane, butane, isobutane, pentane, hexane

Aromatics

General formula: C_6H_5 - Y (Y is a longer, straight molecule that connects to the benzene ring)

Ringed structures with one or more rings

Rings contain six carbon atoms, with alternating double and single bonds between the carbons

Typically liquids

Examples: benzene, napthalene

Napthenes or Cycloalkanes

General formula: C_nH_{2n} (n is a whole number usually from 1 to 20)

Ringed structures with one or more rings

Rings contain only single bonds between the carbon atoms

Typically liquids at room temperature

Examples: cyclohexane, methyl cyclopentane

Other hydrocarbons

Alkenes

General formula: C_nH_{2n} (n is a whole number, usually from 1 to 20)

Linear or branched chain molecules containing one carbon-carbon double-bond

Can be liquid or gas

Examples: ethylene, butene, isobutene

Dienes and Alkynes

General formula: CnH2n-2 (n is a whole number, usually from 1 to 20)

Linear or branched chain molecules containing two carbon-carbon double-bonds

Can be liquid or gas

Examples: acetylene, butadienes

Adding methane to the atmosphere

Question

How much and by what means methane is added to the atmosphere each year?

Answer

Each year 350 to 500 million tons of methane is added to the atmosphere. The sources of methane are:

Disposing of garbage in landfills

Burning forests and fields

Coal mining and drilling for oil and natural gas

Raising livestock

Because of rapidly growing world population and greater demand for meat and dairy products, the number of cattle has doubled in the past 40 years. There are now 1.3 billion cattle, each burps methane several times a minute.

Every time cattle burp, methane is released. Bacteria in the gut of cattle break down the food these animals eat, converting some of it to methane gas. A cow can belch up to a half-pound of methane a day. Sheep, goats, buffalo and camels also belch methane. More livestock means more methane to be released.

Rice cultivation

Rice, the most important grain crop, feeds one-third of the world's people. Farmland for rice has doubled in 45 years. Most types of rice grow in flooded fields. Bacteria in the waterlogged soil release methane.

Heading water

Question

Would the heating of water in an electric kettle by a coil of wire be considered an exothermic reaction?

Answer

Heating in this case is a physical process; it is not a chemical reaction.

If stove gas is used for heating, combustion itself is an exothermic reaction.

Catalytic converter

Question

What is a catalytic converter and how does it work?

Answer

A **catalytic converter** is a device that contains a catalyst. It is attached to the exhaust pipe, and converts the harmful compounds in car exhaust below:

- **Hydrocarbons** (in the form of unburned gasoline)
- **Carbon monoxide** (formed by the combustion of gasoline)
- **Nitrogen oxides** (created when the heat in the engine forces nitrogen in the air to combine with oxygen)

into the harmless ones.

In a catalytic converter, the **catalyst** (in the form of platinum and palladium) is coated onto a ceramic honeycomb or ceramic beads that are housed in a muffler-like package attached to the exhaust pipe.

The catalyst helps to convert carbon monoxide into carbon dioxide. It converts the hydrocarbons into carbon dioxide and water. It also converts the nitrogen oxides back into nitrogen and oxygen.

Domestic use of solar cells

Question

How many solar cells would I need in order to provide all of the electricity that my house needs?

Answer

To calculate how many square inches of solar panel you need for a house, you need to know:

- How much power the house consumes on average
- Where the house is located (so you can calculate mean solar days, average rainfall, etc.). This question is impossible to answer unless you have a specific location in mind. We'll assume that on an average day the solar panels generate their maximum power for 5 hours.

Generally we use either electricity or gas to provide heat, for example, the hot water, the stove/oven. If you were to power a house with solar electricity, you would certainly use gas appliances because solar electricity is so expensive. This means that you would powering things like the refrigerator, the lights, the computer, the TV, motors in things like fans… etc, with solar electricity. Let's say that all of those things consume 600 watts electricity on average. Over the course of 24 hours, you need 600 watts * 24 hours = 14,400 watt-hours per day.

For a solar panel that contains 4 cells, (each cell measures 2 inches by 0.5 inches) can produce 45 milliwatts electricity. For the sake of discussion, let's assume that a panel can generate 70 milliwatts per square inch. 70 milliwatts per square inch * 5 hours = 350 milliwatt hours per day. Therefore you need about 41,000 square inches of solar panel for the house. That's a solar panel that measures 17 feet by 17 feet, costs around US$16,000. For the sun only shines part of the time, you would need to purchase a battery bank, an inverter, etc., which often doubles the cost of the installation. Also, if you want to have a small room air conditioner in your bedroom, double everything.

Because solar electricity is so expensive, you would normally reduce your electricity consumption. Instead of a desktop computer and a monitor you would use a laptop computer. You would use fluorescent lights instead of incandescent. You would use a small B&W TV instead of a large color set. You would get a small, extremely efficient refrigerator. By doing these things you might be able to reduce your average power consumption to 100 watts. This would cut the size of your solar panel and its cost by a factor of 6, and this might bring it into the realm of possibility.

However, 100 watts per hour purchased from the power grid would only cost about 24 cents a day, or US$91 a year right now. That's why you don't see many solar houses unless they are in very remote locations. When it only costs about US$100 a year to purchase power from the grid, it is hard to justify spending thousands of dollars on a solar system.

Blood alcohol concentration

Question

Alcohol is a major cause of traffic accidents. How to measure the drivers' blood alcohol concentration?

Answer

Principle of Testing

Alcohol that a person drinks is not digested upon absorption, nor chemically changed in the bloodstream. As the blood goes through the lungs, some of the alcohol moves across the membranes of the **alveoli** (lung's air sacs) into the air, because alcohol is **volatile**.

The concentration of the alcohol in the **alveolar air** is related to the concentration of the alcohol in the blood. As the alcohol in the alveolar air is exhaled, it can be detected by the breath alcohol testing device. Instead of having to draw a driver's blood to test his alcohol level, an officer can test the driver's breath on the spot and instantly know if there is a reason to arrest the driver.

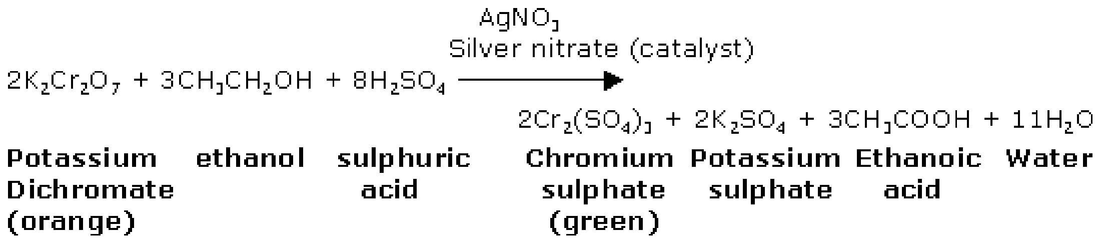
For the alcohol concentration in the breath is related to that in the blood, you can figure the BAC by measuring alcohol on the breath. The ratio of breath alcohol to blood alcohol is **2,100:1**. This means that 2,100 milliliters (ml) of alveolar air will contain the same amount of alcohol as 1 ml of blood.

The American Medical Association says that a person can become impaired when the blood alcohol level hits 0.05. The federal government of United States has pushed the states to lower the legal limit of drunkenness, from 0.10 to the **0.08 standard**. If a person's BAC measures 0.08, it means that there are 0.08 grams of alcohol per 100 ml of blood.

One of the devices to test for blood alcohol concentration (BAC) is the Breathalyzer. It has a **mouthpiece**, a tube through which the suspect blows air, and a **sample chamber** where the air goes. The **Breathalyzer** device contains:

- A system to sample the breath of the suspect
- Two glass vials containing the chemical reaction mixture
- A system of photocells connected to a meter to measure the color change associated with the chemical reaction

To measure alcohol, a suspect breathes into the device. The breath sample is bubbled in one vial through a mixture of sulphuric acid, potassium dichromate, silver nitrate and water. The principle of the measurement is based on the following chemical reaction:



$$2K_2Cr_2O_7 + 3CH_3CH_2OH + 8H_2SO_4 \xrightarrow[\text{Silver nitrate (catalyst)}]{AgNO_3} 2Cr_2(SO_4)_3 + 2K_2SO_4 + 3CH_3COOH + 11H_2O$$

In this reaction:

1. The **sulphuric acid removes ethanol from the air** into a liquid solution. It also provides the acidic conditon needed for this reaction.
2. The silver nitrate is a **catalyst**.
3. The **ethanol is oxidized by potassium dichromate** to form ethanoic acid.
4. The orange dichromate ion is reduced to the green chromium ion during the redox reaction with ethanol. The degree of colour change gives a measure of the concentration of alcohol in the expelled air.
5. To determine the amount of alcohol in the expelled air, the reacted mixture is compared to a vial of unreacted mixture in the **photocell system**. It produces an **electric current**, which causes the needle in the meter to move. The more the needle moves from its resting place, the greater the level of alcohol.

Bulletproof glass

Question

How does bulletproof glass work?

Answer

At first glance, bullet-resistant glass looks identical to an ordinary pane of glass, but that's where the similarities end. An ordinary piece of glass shatters when struck by a single bullet. Bullet resistant glass is designed to withstand one or several rounds of bullets depending on the thickness of the glass and the weapon being fired at it. So, what gives bullet-resistant glass the ability to stop bullets?

Bullet-resistant is basically made by a process called **lamination** (layering a polycarbonate material between pieces of ordinary glass). This process creates a glass-like material that is thicker than normal glass. Polycarbonate is a tough transparent plastic (often known by the brand name Lexan, Tuffak or Cyrolon).

Bullet-resistant glass is between 7 millimeters and 75 millimeters in thickness. A bullet fired at a sheet of bullet-resistant glass will pierce the outside layer of the glass, but the layered polycarbonate-glass material is able to absorb the bullet's energy and stop it before it exits the final layer.

The ability of bullet-resistant glass to stop a bullet is determined by the thickness of the glass. A rifle bullet will collide with the glass with a lot more force than a bullet from a handgun, so a thicker piece of bullet-resistant glass would be needed to stop a rifle bullet as opposed to a handgun bullet.

There is also one-way bullet-resistant glass available, which has one side able to stop bullets, while the other side allows bullets to pass through it unaffected. This gives a person being shot at the ability to shoot back. This type of bullet-resistant glass is made by laminating a brittle sheet of material with a flexible material.

Imagine a car equipped with this one-way bullet-resistant glass. If a person outside the car shoots a bullet into the window, the bullet would strike the brittle side first. This brittle material would shatter around the point of impact and absorb some of the energy over a large area. The flexible material then absorbs the remaining energy of the bullet, stopping the bullet. A bullet fired from inside the same car would easily pass through the glass because the bullet's force is concentrated on a small area, which causes the material to flex. This causes the brittle material to break outwards, allowing the bullet to pierce the flexible material and strike its target.

Washing powder

Question

What is a washing powder? Why we can feel heat when we are holding washing powder in our hands?

Answer

Washing powder is a detergent that cleans soiled surfaces. There are two types of detergents, soap and synthetic detergents, for which they have different chemical makeup. Synthetic detergents and soaps contain a basic cleaning agent called a surfactant or surface-active agent. Surfactants consist of molecules that attach themselves to dirt particles in soiled material. The molecules pull these particles out of the material and hold them in the wash water, until they are rinsed away.

Most detergents contain a surfactant plus other chemicals. These chemicals may improve a detergent's cleaning ability or make it easier to use. All soaps consist of basically the same kind of surfactant. Synthetic detergents and soaps may also contain ingredients like perfumes and colouring agents, bleaches, builders, fabric brighteners, stabilisers, and antiredeposition agents, which help prevent removed dirt from returning to cleaned material. The detergent mixture is then processed into granules, flakes, tablets, or a liquid.

When you are holding washing powder, its surfactant will take away the moisture in your hand. When the surfactant is hydrated, heat is given out. Your hand holding the detergent powder could feel the heat of this exothermic process.

Activated charcoal

Question

What is "activated charcoal" and what are its main uses?

Answer

Activated charcoal is carbon that has been treated with **oxygen** to open up millions of tiny pores between the carbon atoms. According to Encylopedia Britannica:

The use of special manufacturing techniques results in highly porous charcoals that have surface areas of 300-2,000 square metres per gram. These so-called active, or activated, charcoals are widely used to **adsorb** odorous or coloured substances from gases or liquids.

The huge surface area of activated charcoal gives it countless bonding sites. When certain chemicals pass next to the carbon surface, they attach to the surface and are trapped by chemical attraction.

Activated charcoal is used in tap water ‘purifiers’. It is good at trapping organic impurities, as well as other harmful substances like chlorine. Many other chemicals are not attracted to carbon at all, for example sodium, nitrates…etc., and they pass right through. This means that an activated charcoal filter l selectively remove certain impurities. Once all of the bonding sites are filled, an activated charcoal filter stops working and should be replaced.

Carbon-14 dating

Question

What is the carbon-14 dating?

Answer

Carbon-14 dating is a way of determining the age of certain archeological artifacts of a biological origin up to about 50,000 years old. It is used in dating things such as bone, cloth, wood and plant fibers that were created in the relatively recent past by human activities.

Principle of carbon-14 dating

As soon as a living organism dies, it stops taking in new carbon. The ratio of carbon-12 to carbon-14 at the moment of death is the same as every other living thing, but the carbon-14 decays and is not replaced. The carbon-14 decays with its half-life of 5,700 years, while the amount of carbon-12 remains constant in the sample. By looking at the ratio of carbon-12 to carbon-14 in the sample and comparing it to the ratio in a living organism, it is possible to determine the age of a formerly living thing fairly precisely.

A formula to calculate how old a sample is by carbon-14 dating is:

$$\mathbf{t = [\ \ln (N_f/N_o)\ /\ (-0.693)\ ]\ x\ t_{1/2}}$$

where ln is the natural logarithm, N_f/N_o is the percent of carbon-14 in the sample compared to the amount in living tissue, and $t_{1/2}$ is the half-life of carbon-14 (5,700 years).

So, if you had a fossil that had 10 percent carbon-14 compared to a living sample, then that fossil would be:

$t = [\ \ln (0.10) / (-0.693)\ ] \text{ x } 5{,}700$ years

$t = [\ (-2.303) / (-0.693)\ ] \text{ x } 5{,}700$ years

$t = [\ 3.323\ ] \text{ x } 5{,}700$ years

t = 18,940 years old

Because the half-life of carbon-14 is 5,700 years, it is only reliable for dating objects up to about 60,000 years old.

The principle of carbon-14 dating applies to other isotopes as well. Potassium-40 is another radioactive element naturally found in your body and has a half-life of 1.3 billion years. Other useful radioisotopes for radioactive dating include Uranium -235 (half-life = 704 million years), Uranium -238 (half-life = 4.5 billion years), Thorium-232 (half-life = 14 billion years) and Rubidium-87 (half-life = 49 billion years).

The use of various radioisotopes allows the dating of biological and geological samples with a high degree of accuracy. Anything that dies after the 1940s, however, will be harder to date precisely. Radioisotope dating may not work so well in the future, as Nuclear bombs, nuclear reactors and open-air nuclear tests started changing things.