SCIENCE AND TECHNOLOGY
SECONDARY 4

STUDY GUIDE
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EARTH AND SPACE

Lithosphere: Permafrost

*I can define **permafrost** as **'a layer of permanently frozen soil'**.*

Explanation of Concepts

Permafrost is a layer of permanently frozen soil (2 years or more), found in the polar regions and/or high altitudes.

In some areas, the top layer of the permafrost, called the **active layer**, thaws only in the summer. The lower layer remains frozen. Plants can grow during this short period of time.

Building homes in areas of permafrost can be challenging since they can become unstable during periods of thaw if they are built on the active layer. Placing the foundation on frozen soil, below the active layer, can prevent the problem

Questions

1. Which of the following statements correctly describes permafrost?
   A) All the frozen water on the Earth's surface.
   B) A layer of soil frozen for more than two years.
   C) The snow which accumulates on the surface of glaciers.
   D) The upper layer of water which freezes when in contact with cold air.

Answer:

1. B

Lithosphere: Permafrost

I can explain and interpret some of the consequences of a rise in temperature in the permafrost.

Explanation of Concepts

The rise in temperature associated with global warming affects the permafrost. With warmer temperatures, the depth of the active layer increases (more of the soil thaws during the summer) and the amount of time the active layer is thawed.

The consequences of melting permafrost include:

- The land above it sinks or changes shape. Sinking land can damage buildings and infrastructure such as roads, airports, and water and sewer pipes.
- Soil is more vulnerable to erosion. Sediments can accumulate in rivers; the rivers can become shallower, impacting the plant and animal life in the rivers.
- Landslides can occur because the melted soil slips off the frozen layer underneath.
- Carbon dioxide and methane are released to the atmosphere leading to the intensification of the greenhouse effect. (When the permafrost melts, the organic matter in it decomposes, releasing carbon dioxide and methane.)
- The type and number of plant species growing on the soil may change.
- Due to greater access to nutrients and a longer and warmer growing season, primary productivity will increase.

Questions

1. Which of the following is a consequence of melting permafrost?
   A) Increased primary productivity
   B) Decreased erosion
   C) Decreased levels of greenhouse gases
   D) Decreased decomposition of organic matter in soil

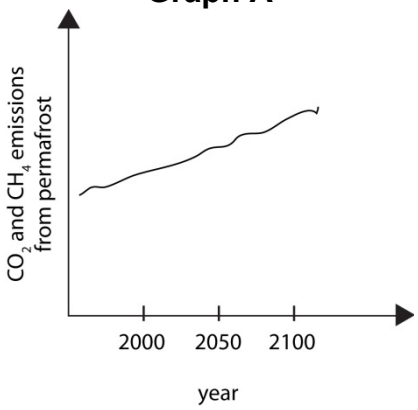
2. How does the melting of permafrost lead to higher average global temperatures?

3. What impact does the melting permafrost have on human settlements?

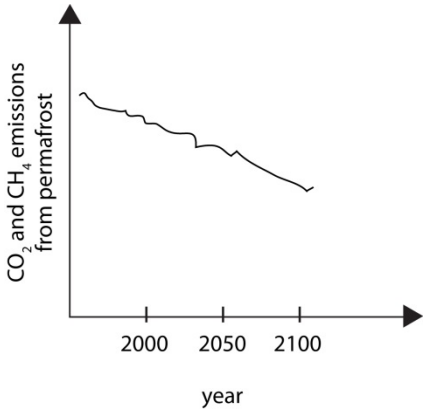
4. Global temperatures have been increasing at a steady rate. Ecologists have been hired to study the impact of increasing temperature s on a region in Northern Quebec.

   Which graph below correctly shows the consequence of a rise of temperature in the region? Explain your answer.

Graph A



Graph B



Answers

1. *A*
2. *The melting of permafrost releases additional methane which increases the greenhouse effect even more.*
3. *Buildings that are built on the permafrost become unstable and landslides occur.*
4. *Graph A. As temperatures rise, permafrost melts and releases CO_2 and CH_4 that is stored in the frozen ground.*

Biogeochemical Cycles

I can describe transformations related to the circulation of carbon in the environment.

I understand the role that photosynthesis and respiration play in the carbon cycle.

I understand the relationship between permafrost, the greenhouse effect, energy resources, combustion and the carbon cycle.

Explanation of Concepts

Carbon is an element found in the environment in many different forms.

Examples of Carbon in the Environment

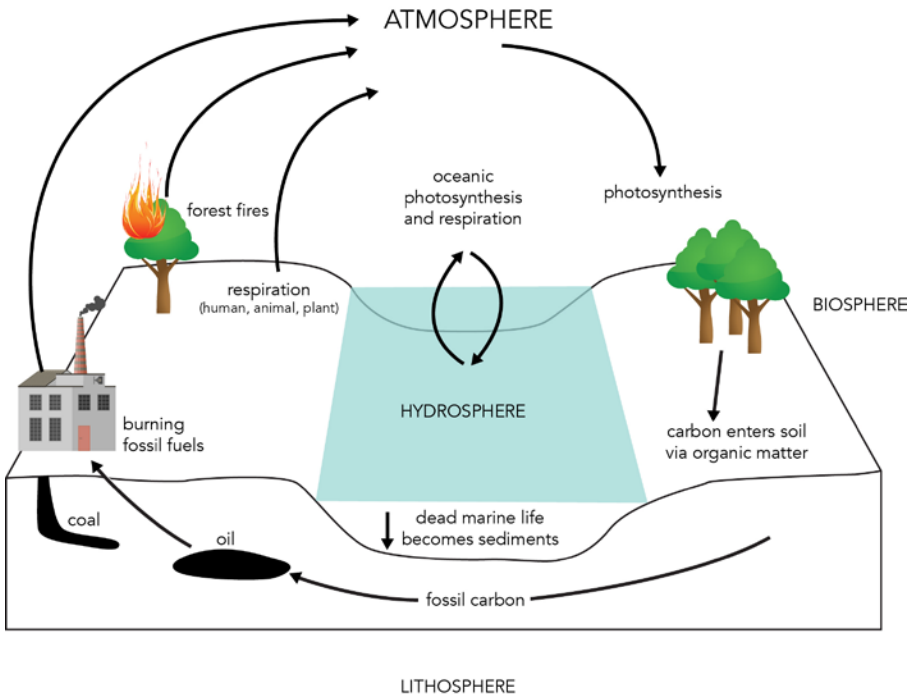
Sphere	Example
Biosphere	Part of the tissues of living organisms
Atmosphere	In the form of various gases (e.g. carbon dioxide:CO_2; methane:CH_4)
Hydrosphere	Dissolved in water (e.g. in oceans and lakes)
Lithosphere	Found in skeletons (calcium carbonate: $CaCO_3$), carbonate rocks, fossil fuels (oil, coal and gas)

Through various chemical reactions, **carbon cycles** through parts of the environment. It is transformed from simple to more complex forms, and vice-versa.

Examples of the Transformation of Carbon in our Environment

From	To	Action
Atmosphere	Biosphere	Photosynthesis: CO_2 is converted into glucose, $C_6H_{12}O_6$. Consumers eat producers and carbon thus circulates within the biosphere.
Atmosphere	Hydrosphere	CO_2 dissolves in water.
Biosphere	Atmosphere	CO_2 is returned to the atmosphere through cellular respiration of consumers, forest fires, etc. CO_2 and CH_4 are produced by the decomposition of plant and animal wastes.
Hydrosphere	Lithosphere	CO_2 dissolved in water in the form of $CaCO_3$ becomes part of shells and skeletons. It can then convert to carbonate rock or form fossil fuels.
Lithosphere	Atmosphere	Carbon rock can release CO_2 during volcanic eruptions. Burning of fossil fuels releases CO_2.

The Carbon Cycle



Questions

1. Which of the following processes <u>does not</u> cycle carbon dioxide (CO_2) back into the atmosphere?

   A) Photosynthesis

   B) Decomposition of waste

   C) Forest fires

   D) Volcanic eruptions

2. The carbon cycle describes the movement of carbon throughout the biosphere. Some human activities can have an impact on the carbon cycle through either the production of excess carbon dioxide gas, CO_2, or through decrease in the production of carbon dioxide.

   Which of the following human activities will increase the amount of CO_2 in the atmosphere? Explain your answer.

   a) A tree-planting initiative in the Boreal forest.

   b) Deforestation by a logging company

Answers

1. *A*

2. *Activity B: Deforestation will increase the amount of carbon dioxide in the atmosphere. Trees take in carbon dioxide through photosynthesis; deforestation will lead to an increase in CO_2 levels.*

Hydrosphere: Catchment Area

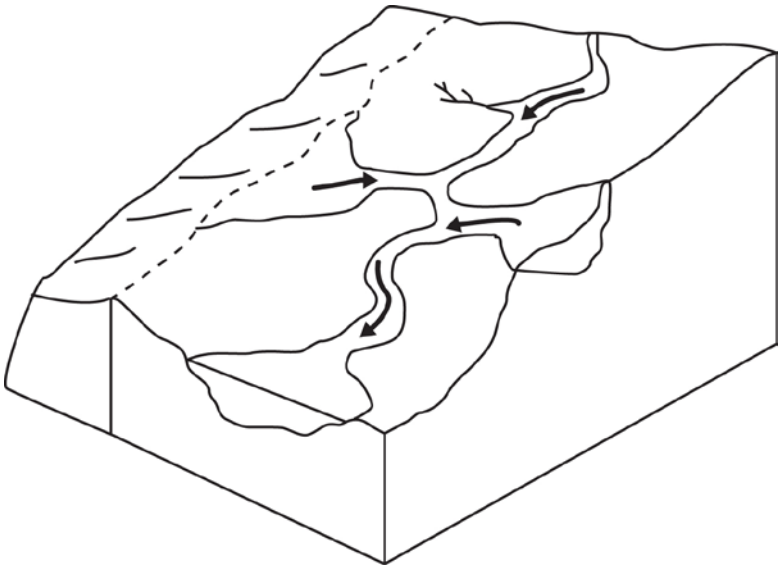
I can define a ***catchment area*** *as* **'a territory surrounding a waterway' (an area of land in which all the surface water drains into the same place)**

Explanation of Concepts

Precipitation falls on the surface of the Earth, produces surface runoff, accumulates in streams, rivers and infiltrates the ground (groundwater). The natural slope of the land causes water to flow into rivers and accumulate in larger reservoirs, such as a lake. All the area from which water empties into the same large body of water is called a **catchment area or watershed**.

The boundaries of a catchment area are usually defined by natural high ground, such as a hill or peak.

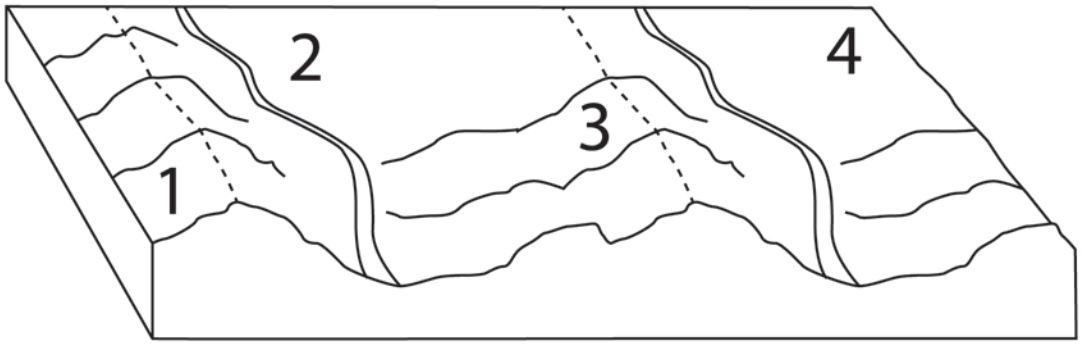
A Catchment Area



Questions

1. Which of the following <u>does not</u> affect the flow of water into a catchment area?
   A) Depth and latitude of the water reservoir
   B) Industrial and urban development
   C) Shape and slope of the terrain
   D) Density and diversity of the vegetation

2. Which location is in the same catchment area?



A) 1 and 2 only

B) 1 and 3 only

C) 2 and 3 only

D) 2 and 4 only

Answers

1. *A*
2. *C*

Hydrosphere: Catchment Area

I can describe and interpret some of the impacts of human activity on the waterways in a catchment area.

Explanation of Concepts

Human activity which impacts waters will not only affect the immediate area, but also the area downstream of the disturbance.

For example, excess fertilizer from a farm can seep into the soil and be washed into a river. The river is part of a catchment area and downstream of the farm will also be contaminated with the fertilizer. Locations upstream from the farm will not be affected. Water pollution can therefore spread hundreds of kilometers from its original source.

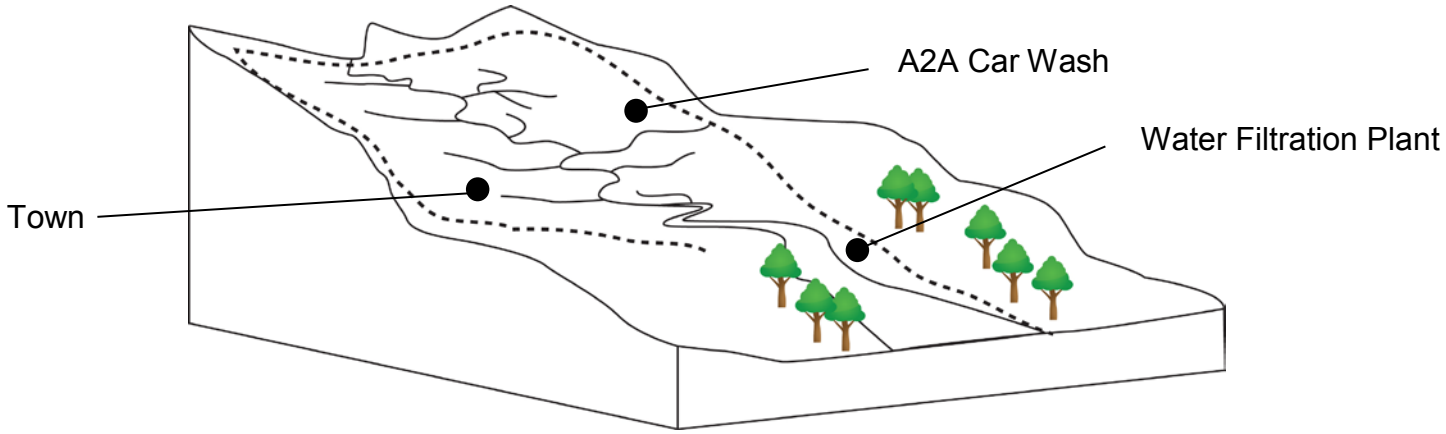
Other human activities that may disturb a watershed include creating a reservoir or navigation channel, irrigation projects and draining or filling wetlands.

Questions

1. Which of the following activities has the greatest impact on the flow of water in a catchment area?
   A) Filling up a child's swimming pool with 40 L of water.
   B) Treating drinking water for a city in a municipal water treatment plant.
   C) Rerouting rivers for the construction of a hydroelectric dam.
   D) Repairing a bridge connecting Montreal's South Shore to the Island of Montreal.

2. An inspector for a town of has noticed that the wastewater for the A2A carwash has been flowing into a nearby stream. The inspector informed the A2A carwash owners that they would be fined since they were polluting the town's water source.

   Use the map of the town's watershed below to explain whether the inspector was correct in fining the carwash. Explain your answer.



Answers

1. C

2. The inspector was correct. The A2A carwash and the town's filtration plant are in the same catchment area (watershed). Since the A2A car wash is above the filtration plant, any wastewater it produces will flow downstream and enter into the river used to supply the town with drinking water.

Hydrosphere: Salinity

*I can define **salinity** as **'a measure of the quantity of salt in a solution'**.*

Explanation of Concepts

The concentration of salt in a solution is defined as its **salinity**. Water in oceans is saline because salts from the lithosphere are dissolved in it.

Near the equator, ocean water has a higher salinity. Water evaporates at a greater rate due to high temperatures, creating a higher salt content.

Near the Polar Regions, ocean water has a lower salinity than near the equator. The fresh water (found in pack ice and glaciers) enters the oceans diluting the salt water, reducing its salinity.

Questions

1. From the statements below, choose two which will cause an increase in the salinity of ocean water.

    1. increased erosion
    2. ocean water redirected to a tidal energy plant
    3. ice floes and glaciers melt
    4. water evaporates at the equator

A) 1 and 3 B) 1 and 4 C) 2 and 3 D) 2 and 4

2. Samples of ocean water were collected from different depths and analyzed.

Sample	Mass of Salt	Volume of Sample
A	8.32 g	240 mL
B	7.65 g	0.225 L
C	4.20 g	115 mL

Rank these samples in order of increasing salinity. Show your work.

Answers

1. B

2. The higher the concentration of salt in the ocean water, the greater the salinity.

c= m/V

Solution A:

mass = 8.32 g volume= 240 mL = 0.240 L

c=8.32 g/0.240 L

c= 34.7 g/L

Solution B

mass = 7.65 g volume= 0.225 L

c=7.65 g/0.225 L

c= 34.0 g/L

Solution C:

mass =4.20 g volume= 115 mL = 0.115 L

c=4.20 g/0.115 L

c= 36.5 g/L

The samples in order of increasing salinity are: B, A, C.

Hydrosphere: Salinity

I can describe the influence of salinity on the density of a solution.

Explanation of Concepts

A solution with more salt dissolved in it will have a higher salinity and also a higher density.

A solution with less salt dissolved in it will have a lower salinity and also a lower density.

Therefore freshwater is less dense than ocean water

Questions

1. Which of the following will increase the density of a solution?
    1. Increasing the salinity
    2. Decreasing the salinity
    3. Adding water
    4. Allowing water to evaporate

    A) 1 only B) 1 and 2 C) 1 and 3 D) 1 and 4

2. Does the density of the ocean water increase or decrease as glaciers and pack ice melt? Explain your answer.

Answers

1. *D*
2. *The density of the ocean water decreases. Glaciers and pack ice are made of fresh water. When they melt, it decreases the salinity.*

Hydrosphere: Ocean Circulation

*I can describe the factors that affect the circulation of **surface** currents and **deep** currents.*

Explanation of Concepts

The water in oceans is in constant movement due to **ocean circulation**. This is the combination of water movement due to surface currents, subsurface current, and the rotation of the Earth.

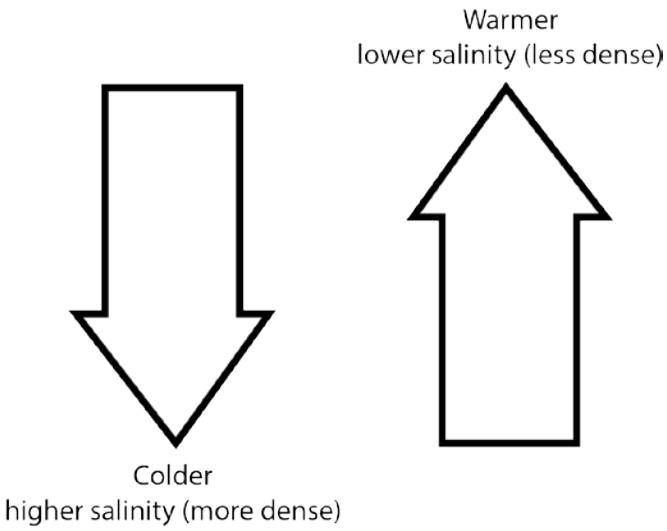
Surface currents carry water as deep as 400 m and are caused by wind. They generally move water across the Earth horizontally.

Subsurface currents are caused by the density of water.

The density is affected by two factors:

- the salinity of water
- the temperature of the water

Salty and cold water is denser, therefore has a tendency to sink. Less salty and warm water is less dense, and has a tendency to rise. These movements create subsurface currents.



Questions

1. Different factors can affect the circulation of surface currents and deep currents in the ocean.

    1. Temperature differences in the water
    2. Air pressure differences in the atmosphere
    3. Differences in the waters' salinity
    4. The rotation of the Earth
    5. The depth of the water

    Which of the factors above only effect surface currents?

    A) 1 and 3 only B) 2 and 4 only C) 1, 3 and 5 D) 2, 4 and 5

2. What are the characteristics of ocean water which has a tendency to sink?

    A) Low temperature and low density

    B) Low temperature and high density

    C) High temperature and low density

    D) High temperature and high density

3. On Monday, a high pressure system resides over the middle of the Atlantic Ocean; it is calm and sunny. On Thursday, several low pressure systems merge to create a powerful storm with strong winds and heavy rain.

    Describe the differences in oceanic circulation in this area on Monday and Thursday.

Answers

1. B

2. B

3.

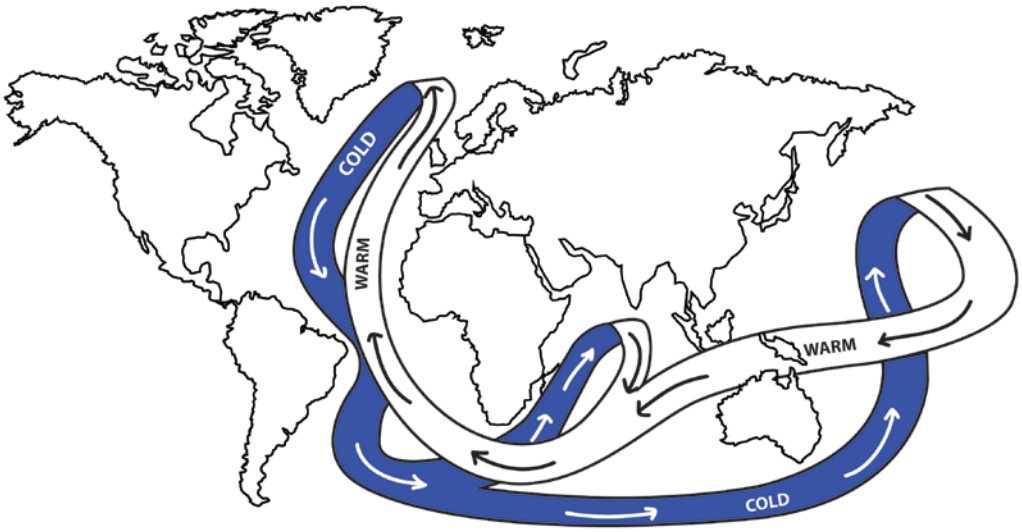
	Thursday
Surface Current	*Increase in wind causes more surface currents*
Subsurface Current	*The storm may mix up water, slightly alter, in that location, the temperature and salinity, which will eventually return to normal.*

Hydrosphere: Ocean Circulation

*I can describe the role of **thermohaline circulation** on **global climate regulation**.*

Explanation of Concepts

The combination of surface and subsurface currents results in **thermohaline circulation**. It functions like a conveyor belt which moves warm and cold water around the Earth.



- In the polar regions, cold surface water sinks to the bottom of the ocean floor and travels along the ocean floor
- When it gets to warmer regions (such as the equator) the water is heated and rises back up to the surface and then warm water travels along the surface towards
- When it gets to the Polar Regions, the warm water gets cooled once more and the process repeats itself.

Thermohaline circulation regulates temperatures, preventing extreme cold at the poles and extreme heat around the equator. For example, the Gulf Stream originates near the equator on the Atlantic Coast of Central America and carries warm water up the coast, releasing its heat into the atmosphere, past Quebec and Labrador.

Questions

1. Which of the following statements concerning thermohaline circulation is true?

   A) Thermohaline circulation allows for the heat accumulated in ocean water at the Polar Regions to circulate to the Equatorial Region.

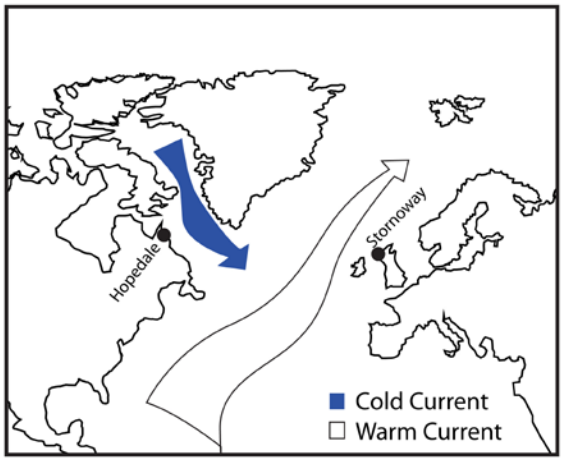
   B) Thermohaline circulation allows for the heat accumulated in ocean water at the Equatorial Region to circulate to the Polar Regions.

   C) Thermohaline circulation can be compared to a conveyor belt which moves warm and cold air masses around the Earth.

   D) Thermohaline circulation can be compared to a conveyor belt which moves warm and cold freshwater systems around the Earth.

2. The Labrador Current flows south along the coast of Newfoundland and Labrador. The water it carries is so cold that it keeps the most northern regions icebound in winter.

   The Labrador Current carries cold water towards the Atlantic Ocean where it will mix with the Gulf Stream. The Gulf Stream brings warm water up along the eastern coast of the U.S.A. and carries it towards Western



   Use your knowledge of thermohaline circulation to explain why Stornoway has milder winters than Hopedale although they are at similar latitudes.

Answers

1. *B*
2. *Thermohaline circulation is the movement of water around the Earth. As the warm water of the Gulf Stream current circulates upwards towards Stornoway, it releases its heat to the environment; creating a relatively mild winter. As the cold water of the Labrador current descends towards Hopedale, it does not have the same warming effect as the Gulf Stream current.*

Hydrosphere: Glacier and Pack Ice

*I can explain the differences between **glaciers** and **pack ice.***

Explanation of Concepts

	Glacier	Pack Ice
Formation	• Formed as a slow sliding mass of ice is formed on land due to the accumulation of snow on top of it. • As snow accumulates on top of the glacier, the layers below are compacted and form ice. • As the glacier slides, some of the ice gets pushed out its sides and breaks off. It falls into the ocean in large chunks and forms icebergs.	• Formed on the surface of the ocean due to cold temperatures which freeze the top layer of the water. • As pack ice is formed, the ocean water freezes and salt is eliminated. This increases the salinity and density of the ocean, affecting thermohaline circulation. • These large slabs of ice float together and are transported by the wind and accumulate throughout the winter months.
Content	• Fresh water	• Brackish water (mixture of fresh and salt water)
Location	• On land • Mountainous areas and polar regions • On every continent	• On ocean water • Only polar regions

Questions

1. Which of the following is true about glaciers and pack ice?
   A) Both glaciers and pack ice are formed on land.
   B) Both glaciers and pack ice are formed on the ocean's surface.
   C) Both glaciers and pack ice contain freshwater.
   D) Both glaciers and pack ice form icebergs.

2. Which of the following statements is true about pack ice?
   A) The melting of pack ice affects the salinity of the ocean water.
   B) The melting of pack ice does not affect the temperature of the ocean water.
   C) The melting of pack ice affects sea levels.
   D) The melting of pack ice does not affect oceans.

Answers

1. C

2. A

Hydrosphere: Glacier and Pack Ice

I can describe the impacts of the melting of glaciers and pack ice.

I understand how ocean circulation, glacier and pack ice, and salinity are interrelated.

Explanation of Concepts

Impact of Melting Glaciers

- Increase in sea level

  Due to global warming, the ice on the surface of glaciers melts, seeps to the bottom, and causes the glacier to slide more quickly. As more and more pieces of the glacier break off, icebergs fall into the ocean and raise the sea level. In addition, as glaciers melt, more fresh water is added to the ocean. Both these events can cause flooding.

- Slowing of thermohaline circulation

  As more glaciers melt, fresh water dilutes the salty water, causing a decrease in the density of the ocean water. The water has less of a tendency to sink, thus slowing thermohaline circulation. This can affect global climate.

- ‘Decrease in the albedo effect or reflectivity of the Earth surface (Less solar radiation is deflected back into space)

Impact of Melting Pack Ice

- Loss of habitat

  Animals living in the arctic rely on pack ice for their survival. Global warming, which has greatly reduced the area of pack ice on Earth, puts pressure on certain species, such as polar bears and seals, due to habitat loss.

- Slowing of thermohaline circulation

  As more pack ice melts, brackish water dilutes the salty water, causing a decrease in the density of the sea water. The water has less of a tendency to sink, thus slowing thermohaline circulation. This can affect global climate.

- Decrease in the albedo effect or reflectivity of the Earth surface (Less solar radiation is deflected back into space)

Note: Ocean levels do not increase when pack ice melts.

Questions

1. Which of the statements below correctly identifies the effect of the increase in the melting of pack ice due to climate change?
   A) Loss of habitat for arctic species
   B) Rise in the sea level
   C) Increase in the number of icebergs
   D) Flooding of low lying areas

2. Global warming has caused the melting of pack ice at the North and South poles.

   Explain how this affects the salinity and density of the water in those regions. How does this impact thermohaline circulation?

3. Explain how a population living at sea level near the equator can be affected by global warming at the Poles.

4. Why is flooding not a result of the increased melting of pack ice?

Answers

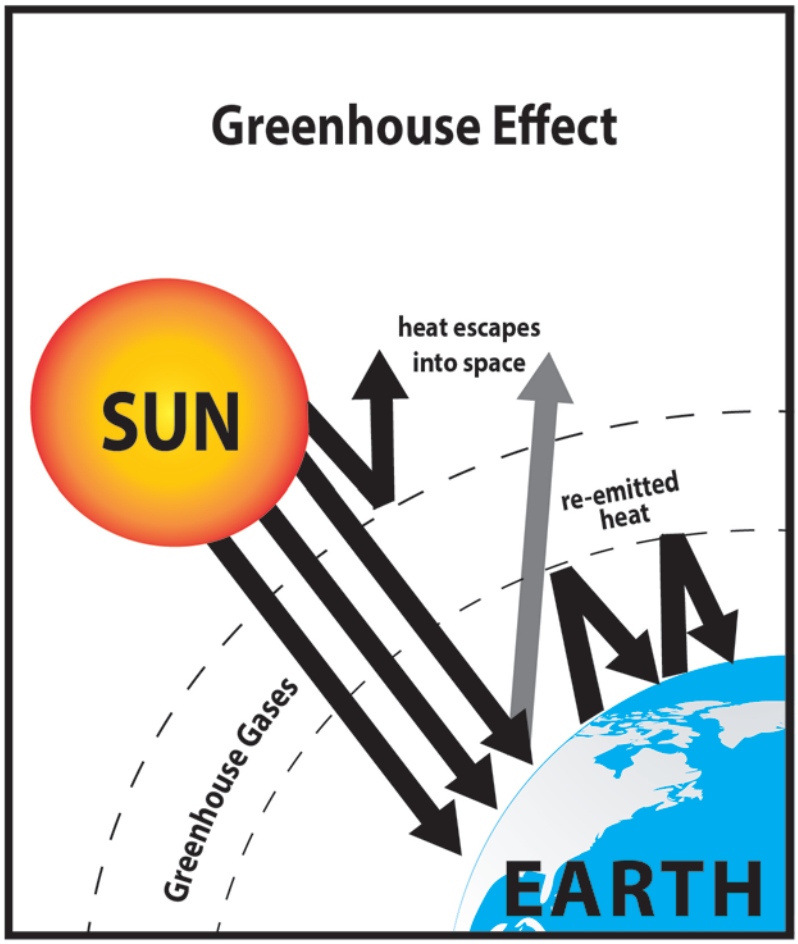
1. *A*
2. *As the pack ice melts, more fresh water is introduced into the ocean. This dilutes the salty water, decreasing its salinity. Lower salinity also means lower density. Since the water no longer sinks as easily, thermohaline circulation is slowed.*
3. *As glaciers melt ocean levels rise because water is added to the ocean as well as icebergs (which were not there before). The increased ocean level affects low lying areas around the world and can cause flooding even as far away as the equator.*
4. *Pack ice is formed from water already in the ocean. Ice has a higher volume for the same amount of water, but only 90% of it is below the surface*

Atmosphere: Greenhouse Effect

I can describe the greenhouse effect.

Explanation of Concepts

The **greenhouse effect** is a natural phenomenon which helps keep the air around us warm and stable. The Sun's rays hit the Earth and are absorbed by the ground. The heated ground then emits infrared rays. Some of these rays pass through the atmosphere, into space. Some are trapped in the Earth's atmosphere with the help of gases such as carbon dioxide (CO_2), methane (CH_4), and nitrogen oxides (NO_X). The greenhouse effect can be intensified by human activities that release greenhouse gases such as burning fossil fuels and large scale farming.



Questions

1. Which of the following gases do not contribute to the greenhouse effect?
   A) CO_2
   B) CH_4
   C) NO_2
   D) SO_2

2. Which of the following statements about the Greenhouse effect is true?
   A) An increase in greenhouse gases in the atmosphere leads to an increase in the amount of heat that escapes into space.
   B) A decrease in greenhouse gases in the atmosphere leads to an increase in the amount of heat that escapes into space.
   C) An increase in greenhouse gases in the atmosphere leads to an increase in the amount of solar radiation that will enter the atmosphere.
   D) A decrease in greenhouse gases in the atmosphere leads to an increase in the amount of solar radiation that will enter the atmosphere.

3. Explain how the greenhouse effect is essential for life on Earth.

Answers

1. *D*
2. *B*
3. *Greenhouse gases are necessary to keep the temperature and the climate around Earth stable. By trapping some of the sun's rays reflected of the surface of the Earth, the atmosphere around us remains warm and stable, necessary for sustaining life.*

Atmosphere: Greenhouse Effect

I can explain and interpret some of the consequences of a higher concentration of greenhouse gases.

Explanation of Concepts

The concentration of greenhouse gases in the atmosphere has been relatively constant for thousands of years, primarily through the balance created by the carbon cycle. Recently, human activity (especially the burning of fossil fuels and farming) has produced an unnatural increase in the concentration of greenhouse gases. This means that more heat is trapped in the atmosphere, causing global warming and climate change.

Global warming can lead to the melting of pack ice and glaciers. As the temperature of the ocean increases, species which are sensitive to even slight changes in temperature variations, for example corals, can die. An entire ecosystem of aquatic organisms depends on a thriving coral community and can be disturbed by a loss of habitat. Climate change also causes precipitation patterns and wind patterns to change.

Questions

1. Five human activities are listed below.

    1. Raising cattle
    2. Driving a gasoline powered car
    3. Using a natural gas fireplace
    4. Walking
    5. Swimming in a lake

    Which of the above activities could contribute to the greenhouse effect?

    A) 1 and 2 only B) 1, 2 and 3 C) 2 and 3 only D) 4 and 5 only

2. Which of the following does not contribute to the formation of greenhouse gases?
   A) Decomposition of waste in landfills
   B) Burning of fossil fuels
   C) Melting of the permafrost
   D) Photosynthesis in plants

3. The National Center for Policy Analysis released a newsletter in June 2009 highlighting "10 Cool Global Warming Policies". Two of the proposed policies for reducing the harm of global warming were:

   Policy 1: Reduce forest wildfires through Alternative Forest Management Institutions

   Policy 2: Subsidise the development of renewable energy resources

   Explain how each policy could reduce global warming.

Answers

1. *B*
2. *D*
3. *Policy 1: As the photosynthesis of plants consumes carbon dioxide, the destruction of forests by forest fires will reduce the amount of CO_2 that is consumed from the atmosphere.*

   The burning of the forests releases CO_2 to the atmosphere.

   So if forest fires are reduced, there will be less CO_2, a greenhouse gas, released to the atmosphere and more CO_2 consumed by the trees. With less greenhouse gas in the atmosphere, global warming could be reduced.

   Policy 2: Renewable energy resources such as wind and solar do not produce greenhouse gases whereas non-renewable such as fossil fuels, do.

Renewable and Non-Renewable Energy Resources

I can describe technologies used to produce electricity using the energy resources in the lithosphere, hydrosphere and atmosphere.

Explanation of Concepts

Lithosphere

Energy Source	Description
Fossil Fuels	• Produced when animal and plant residues accumulate on the sea floor and gradually get covered by layers of sand and rock. Over millions of years, they are transformed into oil and natural gas. • Humans mine fossil fuels and burn them to produce thermal energy, which can also be converted into mechanical and electrical energy in **thermal power plants.** • The burning of fossil fuels releases pollutants such as carbon dioxide (CO_2) and methane (CH_4). Other gases, such as sulfur dioxide (SO_2) and nitrogen oxides (NO_X) are also released.
Uranium (Nuclear)	• Uranium is a radioactive element and exists naturally in the lithosphere. • Nuclear power plants use mined uranium to transform thermal energy into mechanical and electrical energy. • A small amount of radioactive material produces a lot of energy • Nuclear waste is another by-product and needs to be buried since it continues to release radioactivity for hundreds of years
Geothermal	• Below the lithosphere lies hot magma which releases thermal energy. Harnessing this energy is called geothermics. • A fluid is circulated into the ground; it is heated naturally, then brought up to the surface. The hot liquid can be used to heat homes or its thermal energy can be transformed into electrical energy.

	• It can be difficult to access geothermal energy. It can also be very expensive.

Hydrosphere

Energy Source	Description
Hydroelectric	• Hydroelectric power plants use the movement of falling water to spin turbines which are located inside dams built across a river. • Water falling through a dam spins a turbine that converts mechanical energy into electrical energy. • Hydroelectricity is the main source of energy in Quebec.
Wave and Ocean Current	• Wave energy is produced when the energy contained in the movement of water is harnessed using buoys, which rise and fall with the waves. • Ocean currents are able to spin underwater turbines, which are similar to wind turbines. The mechanical energy produced by the movement of the buoys and blades can be converted into electrical energy. • Harnessing energy from waves and ocean currents is not yet widespread due to the fact that they are, at the moment, too expensive.
Tidal	• Electricity can be generated from tides when water from a high tide is collected (sometimes using a dam) and then falls through turbines converting mechanical energy into electrical energy. • A tidal range of 5 m is necessary to use this technology.

Atmosphere

Energy Source	Description
Wind	• The wind causes the **turbines** to rotate and a generator converts the mechanical energy into electrical energy. • Wind energy cannot be stored; therefore it needs to be used in conjunction with another source of energy. • Wind energy can be unreliable and unpredictable.

Other

Energy Source	Description
Solar	• As the rays of the sun hit panels containing photovoltaic cells, they cause electrons to flow, creating current electricity. • This technology is costly and is limited by the amount of sunlight present.

Questions

1. Which of the following technologies uses an energy source derived from the lithosphere?

   A) Tidal barrage

   B) Wind turbine

   C) Photovoltaic cell

   D) Coal-fired plant

2. The lithosphere and the hydrosphere provide us with many different resources that we can use to produce energy. Each resource has its advantages and disadvantages.

   Complete the following table regarding the advantages and disadvantages of uranium and tidal energy:

Resource	Advantages	Disadvantages
Uranium	1. 2.	1. 2.
Tidal Energy	1. 2.	1. 2.

3. Wind farms are growing in importance in Quebec. In partnership with Hydro-Quebec, these farms require many years of planning and construction. The Gros-Morne wind park in the Gaspésie region will have over 140 wind turbines at the end of its construction. In order to begin construction of Phase I in the spring of 2010, deforestation work was performed in the fall of 2009.

   What are the advantages and disadvantages of using wind energy?

Answers

1. D

2.

Resource	*Advantages*	*Disadvantages*
Uranium	*1. small quantity of uranium will produce much energy* *2. does not produce and greenhouse gases*	*1. non-renewable form of energy* *2. produces radioactive waste that is toxic to all organisms*
Tidal Energy	*1. renewable source of energy* *2. tides are predictable; there are 2 high tides and 2 low tides a day*	*1. turbines can only be used in certain regions where tide height reaches a minimum of 5 meters.* *2. turbines are placed in harsh salt water conditions, often far from city centers.*

3. ***Advantages*** *to using wind energy is that it is a renewable, clean (no greenhouse gases) form of energy.*

Disadvantages *to using wind energy are that the wind is not predictable and that the energy itself cannot be stored. Some would say that the wind turbines create both visual pollution, ruining the natural beauty of the environment and noise pollution. Deforestation also needs to take place before some wind parks are constructed.*

Renewable and Non-Renewable Energy Resources

I can describe the main impact of the use of energy resources in the lithosphere, hydrosphere and atmosphere.

Explanation of Concepts

There are advantages and disadvantages for using the different types of energy resources.

Note:

A **non-renewable** energy source is finite: It will eventually run-out or become so scarce that it is too expensive or environmentally damaging to retrieve.

A **renewable** energy source is constantly replenished and will never run out.

Impact of Energy Resources from the Lithosphere

Energy Source	Renewable or Non-Renewable	Environmental Impact
Fossil fuels	Non-Renewable	• The refining and burning of fossil fuels produces atmospheric pollutants, including the greenhouse gases carbon dioxide (CO_2, methane (CH_4), and nitrogen oxides (NO_x). • The burning and refining of fossil fuels can also contribute to the production of acid rain.
Uranium (Nuclear)	Non-Renewable	• No atmospheric pollutants are released. • Nuclear waste is highly toxic and must be stored safely for hundreds of years. • Leakage of nuclear materials could have a devastating effect.
Geothermal	Renewable	• Low atmospheric pollution compared to fossil fuels. • The hot ground water used in geothermal plants contains sulfur, mercury, hydrogen sulfide, arsenic and ammonia. These chemicals can be released in to the water supply, or the atmosphere through steam.

Impact of Energy Resources from the Hydrosphere

Energy Source	Renewable or Non-Renewable	Environmental Impact
Hydroelectric	Renewable	• Causes little pollution. • The building of dams often floods large areas of land, affecting the habitat of various plant and animal species.
Wave	Renewable	• May disturb aquatic ecosystems. • Does not release atmospheric pollutants.
Tidal	Renewable	• Does not release atmospheric pollutants • Tidal barrages (dams) can interfere with fish migration and can affect water flow and levels.

Impact of Energy Resources from the Atmosphere

Energy Source	Renewable or Non-Renewable	Environmental Impact
Wind	Renewable	• Does not release atmospheric pollutants. • Turbines can produce sound pollution. • Can disrupt the visual appeal of the landscape. • Birds can collide with the wind turbines.

Impact of Energy Resources from Other

Energy Source	Renewable or Non-Renewable	Environmental Impact
Solar	Renewable	• Does not release atmospheric pollutants. • Can disrupt the visual appeal of the landscape.

Note: All of these technologies produce electricity by converting mechanical energy into electrical energy except the technology associated with solar energy

Questions

1. A community in Gaspé is researching the environmental impacts of different energy sources.

   Below is a list of possible environmental impacts

   1. Tidal barrages can disrupt marine life.
   2. Tidal power plants and coal power plants release greenhouse gases.
   3. Nuclear power plants create no harmful waste products.
   4. Flooding is a concern in the building of hydroelectric dams.

   Which of the above statements are true?

   A) 1, 2 and 3 B) 1, 3 and 4 C) 1 and 4 D) 2 and 3

2. A community in Gaspé is researching the environmental impact of two different energy technologies: a tidal power plant and a coal power plant.

   For each of the energy resources the community is considering, state:

   - the energy source as renewable or non-renewable
   - the main environmental impact for each type of energy

Answers

1. C

2. Tidal Power Plant – renewable / tidal barrages can disrupt marine life

Coal Power Plant – non-renewable / releases greenhouse gases

MATERIAL WORLD

Properties of Solutions: Concentration

I can determine the concentration of an aqueous solution (g/L, % m/m, % m/V or ppm).

Explanation of Concepts

Concentration is a measurement of the amount of solute dissolved in a certain amount of solution. Various units can be used to express the concentration of a solution.

Units Used to Express Concentration

Units	Description
g / L	grams of solute per litre of solution
% (m/V)	grams of solute per 100 mL of solution
% (V/V)	mL of solute per 100 mL of solution
% (m/m)	grams of solute per 100 g of solution
ppm	mg of solute per 1 L of solution

Concentration in Parts per Million (ppm)

A concentration of 1 ppm means 1 mg of solute per 1 L of solution.

The concentration of a solution in ppm can be determined using the mass of the solute and the volume of the solution.

- The mass of the solute must be converted to mg
- The volume of the solution must be converted to L
- Divide the number of mg of solute by the number of litres of solution and the answer is the concentration in ppm

$$\text{Concentration (ppm)} = \frac{\text{mass of solute (mg)}}{\text{Volume of solution (ppm)}}$$

Some ppm conversions:

1 g/L = 1 000 ppm	1 % (m/V) = 10 000 ppm
g/L x 1 000 → ppm	% (m/V) x 10 000 → ppm
ppm ÷ 1 000 → g/L	ppm ÷ 10 000 → % (m/V)

Questions

1. 0.04 g of $CaCl_2$ is transferred to a 500 mL volumetric flask and water is added until the 500 mL line. Determine the concentration of the solution in ppm.
   A) 0.08 ppm
   B) 8 ppm
   C) 80 ppm
   D) 800 ppm

2. The chlorine ion (Cl^-) concentration in a swimming pool is recommended to be between 1.5 ppm and 3 ppm. Which of the following pools fall in the recommended range for chlorine concentration?
   A) Pool A: Concentration of chlorine is 0.0018 g/L
   B) Pool B: Concentration of chlorine is 0.0018 % (m/V)
   C) Pool C: Concentration of chlorine is 0.018 g/L
   D) Pool D: Concentration of chlorine is 0.018 % (m/V)

3. A laboratory technician needs to prepare 450 mL of a 15 % (m/V) NaCl solution. What amount of solute will be required?

4. Four solutions were on a shelf in the laboratory. The concentrations of the solutions are listed in the table below.

Solution	Concentration
1	5 g/L
2	4% (m/V)
3	200 ppm
4	2 g/100 mL

List the solutions in increasing order of concentration.

5. Calcium ions are found in bottled water. The concentration of Ca^{2+} ions given on the bottle label is 100 ppm. What is the concentration of the Ca^{2+} ions in g/ L?

6. A 20 L sample of water taken from a lake surrounded by farms is found to contain 0.1 g of phosphate (PO_4^{3-}) ions. What is the concentration of the phosphate ions in the lake water sample in ppm?

Answers

1. *C - 0.04 g *1000 = 40 mg 500ml / 1000 = 0.5 L 40 mg / 0.5 L = 80 mg / L = 80 ppm*
2. *A - 0.0018 g / L *1000 = 1.8 ppm*
3. $\frac{15\text{ g}}{100\text{ mL}} = \frac{x\text{ g}}{450\text{ mL}}$ $x = 67.5\text{ g of NaCl}$
4. *Solution 3 -200 ppm (0.2 g /L), Solution 1- 5 g/ L , Solution 4- 2 g/100 mL (20 g /L), Solution 2- 4 % (m/V) (40 g /L)*
5. *0.1 g /L*
6. *6. 0.1 g = 100 mg: so 100 mg/20 L=5ppm*

Properties of Solutions: pH Scale

I can describe the pH scale (acidity, alkalinity, neutrality, increasing and decreasing values, logarithmic nature of the scale).

Explanation of Concepts

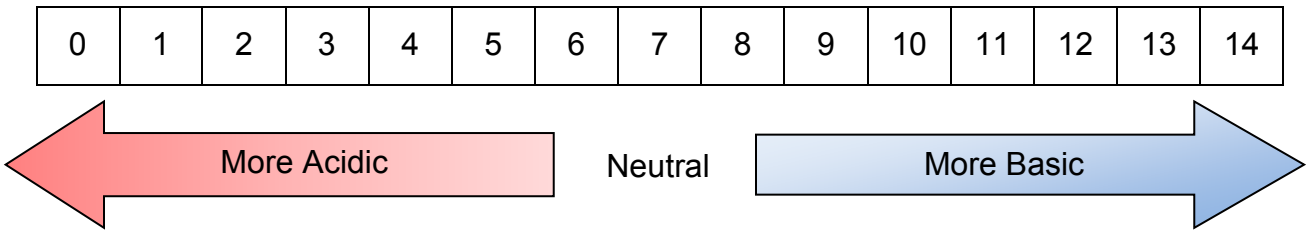
The pH scale is a measure of how acidic or basic a substance is. The pH scale ranges from 0 to 14, with 0 being the most acidic and 14 being the most basic.

A solution with a pH below 7 is acidic.

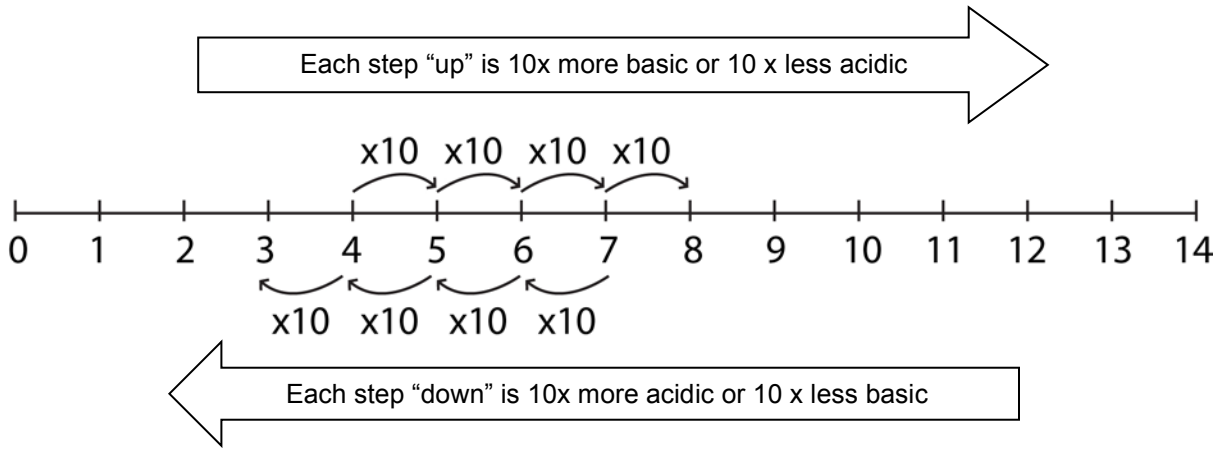
A solution with a pH above 7 is basic (alkaline).

A solution with a pH equal to 7 is neutral.

The pH Scale



The pH scale is a logarithmic scale. When the pH value increases by 1, there is a 10 fold decrease in acidity. When the pH value decreases by 1, there is a 10 fold increase in acidity.



Example: A solution with a pH of 2 is 10x more acidic than a solution with a pH of 3.

A solution with a pH of 2 is 100x more acidic than a solution with a pH of 4.

Questions

1. A solution has a pH that is greater than 7 and less than 14. What is the nature of the solution?

   A) Acidic

   B) Basic

   C) Neutral

   D) Salty

2. A lab technician needs a solution that is 1000 times more basic than solution with a pH of 8. Determine the pH of the solution that the lab technician needs.

Answers

1. *B*
2. *Every pH increment of one is a 10 fold increase in basicity therefore the pH = 11*

Properties of Solutions: pH Scale

I can determine the pH of a few common substances using indicators.

Explanation of Concepts

The pH scale ranges from 0 to 14.

The pH of substances can be determined by using indicators. Here are the pH values of a few common substances:

pH	Substance
1.0	battery acid
2.0	lemon juice
2.2	vinegar
3.0	apples , soft drinks
4.0 - 4.5	tomatoes, acid rain
5.6	rainwater
6.6	milk
7.0	distilled (pure) water
7.4	human blood
8.3	baking soda
10.0	soap
10.5	milk of magnesia
11.5	window cleaner
14.0	sodium hydroxide

Questions

1. Some common substances are listed below.

    1. vinegar
    2. distilled water
    3. seawater
    4. soft drinks
    5. tomato juice

    Which of the substances have a pH that is less than 7?

    A) 1, 2, and 3 B) 1, 3, and 4 C) 1, 4, and 5 D) 2, 3, and 5

2. Place the substances listed below in increasing order of pH.

    - Distilled water
    - Soap
    - Lemon Juice
    - Rainwater

Answers

1. *C*
2. *lemon juice(pH˜2), rainwater(pH˜5), distilled water(pH˜7), soap (pH˜10)*

Properties of Solutions: Ions

*I can describe the concept of **ion.***

I can relate the charge of a monatomic ion to its position in the periodic table.

Explanation of Concepts

An atom is neutral. It has an equal number of protons and electrons. The number of protons is the atomic number.

When an atom loses or gains electrons, it becomes charged and is known as an **ion**. An ion may be positively charged (electrons lost) or negatively charged (electrons gained).

Metals tend to lose electrons to become positively charged ions.

Metals in groups 1, 2 and 3 on the periodic table lose 1, 2, or 3 electrons respectively.

Non-metals tend to gain electrons to become negatively charged ions.

The non-metals in groups 5, 6 and 7 gain 3, 2, or 1 electrons respectively

Example: Sodium (Na) Forms a Positive Ion

Na	atom	11 protons (11^+)	11 electrons (11^-)
	⇩		⇩ loses 1 electron
Na^{+1}	ion	11 protons (11^+)	10 electrons (10^-)

Example: Sulphur (S) Forms a Negative Ion.

S	atom	16 protons (16^+)	16 electrons (16^-)
	⇩		⇩ gains 2 electrons
S^{2-}	ion	16 protons (16^+)	18 electrons (18^-)

Questions

1. Oxygen forms an O^{2-} ion. Which of the following statements is correct?
   A) The oxygen atom loses 2 protons to form its ion.
   B) The oxygen atom loses 2 electrons to form its ion.
   C) The oxygen atom gains 2 electrons to form its ion.
   D) Oxygen neither gains nor loses electrons when forming its ion.

Answers

1. *C*

Properties of Solutions: Electrical Conductivity

I can describe the mechanism that allows aqueous solutions to conduct electricity (electrolytic dissolution of a solute, formation of mobile ions).

I can predict if a solution will conduct electricity based on the molecular formula of the compounds involved

Explanation of Concepts

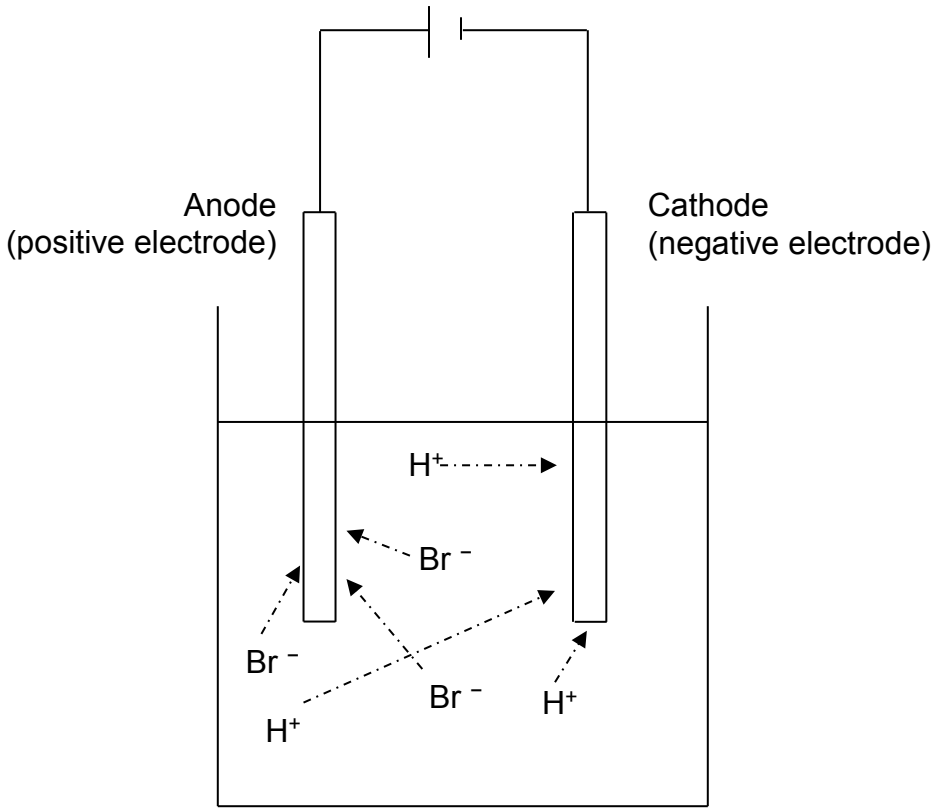
When an ionic substance dissolves in water, it dissociates into positive and negative ions.

$$HBr_{(s)} \rightarrow H^+_{(aq)} + Br^-_{(aq)}$$

These ions are **mobile** and will move in solution towards electrodes. This movement of charged particles produces an electrical current.

Example:

When hydrogen bromide dissolves, it forms an electrolytic solution as shown in the diagram below.



Questions

1. Which of the following substances will conduct electricity?
   A) Methanol
   B) Aqueous KCl
   C) NaCl in its solid form
   D) Sugar solution

2. You find a container in your school lab with KCl crystals and based on its molecular formula, you conclude that it is a salt. You test for its electrical conductivity, and surprisingly find that it does not conduct electricity.

   How can this be explained?

   What process must occur in order for the salt sodium chloride to conduct electricity?

Answers

1. *B*
2. *KCl must be dissolved in water in order for it to dissociate into its ions(K^+, Cl^-) and then conduct electricity.*

   NaCl must first be dissolved in water so that it can separate into its ions; sodium ions (Na^+) & chloride ions (Cl^-). The Na^+ ions can now travel to the negative electrode and the Cl^- ions are free to travel to the positive electrode so the current is able to flow

Chemical Changes: Combustion

I can describe the recognizable manifestations of rapid combustion.

Explanation of Concepts

Rapid combustion is a form of oxidation (a reaction that uses oxygen) that releases a large amount of energy over a short period of time. The energy is released mostly in the form of heat and light e.g., a candle burning.

Questions

1. Which of the following is NOT an example of rapid combustion?
   A) A log fire
   B) A candle burning
   C) Digestion
   D) A gas stove element burning

2. Why is rusting classified as an oxidation reaction and not a combustion reaction?

Answers

1. *C*
2. *During combustion, large amounts of heat and light are rapidly released. Rusting is an oxidation reaction that occurs at a rate too slow to be classified as combustion..*

Chemical Changes: Combustion

I can explain a combustion reaction using the fire triangle (oxidizing agent, fuel, and ignition temperature.

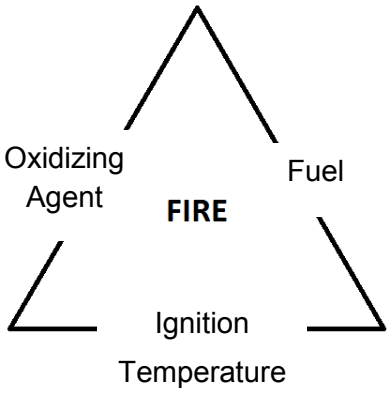
Explanation of Concepts

Combustion is a form of oxidation (a reaction that uses oxygen) that releases a large amount of energy. Three conditions must be met for combustion to occur:

1) The presence of an **oxidizing agent**, a substance that provides oxygen to react with a fuel
2) The **ignition temperature** has been reached.

   The ignition temperature is the minimum temperature at which there is enough energy to start the combustion. This varies from one type of fuel to another.
3) The presence of a **fuel.**

   A **fuel** is a substance that releases a large amount of energy by reacting with an oxidizing agent. (e.g. Wood)



Combustion will only occur if all three conditions are present. If any one of these conditions is removed, then combustion will stop.

Examples:

Water will extinguish a fire because the water significantly reduces the temperature of the system. (Ignition temperature not reached)

A candle will eventually stop burning when all of its wax is consumed. (Fuel no longer present)

A frying pan fire is extinguished when a lid is placed on the pan. (Oxidizing agent (oxygen in the air) is prevented from reaching the fuel)

Questions

1. Firefighters use the following methods to extinguish a forest fire.
    - Covering the ground fire with soil (shoveling)
    - Spraying the fire with water
    - Cutting down trees on the outside perimeter of the fire

    Explain each of these methods by using the fire triangle.

2. Each year, forest fires reduce a significant area of land in Quebec to cinders. Sometimes these fires are the results of human activity but most often, they are caused by lightning strikes.

    The environmental impact of this natural phenomenon, which is part of the life cycle of the Boreal Forests, is often widespread. In July 2005, the smoke produced by a gigantic forest fire in northern Quebec darkened the skies as far south as the Montreal region.

    Using the terms below, explain how forest fires affect the atmosphere.

Respiration	Photosynthesis	The Carbon Cycle
Oxygen	Carbon Dioxide	Combustion

Answers

1. *The soil prevents air (oxygen) from reaching the fire. This is an example of a decrease in the OXIDIZING AGENT.*

   The water absorbs heat from the fire. This is an example of preventing IGNITION TEMPERATURE.

   Cutting down trees ahead of the fire means that when the fire reaches this area (a firebreak) there is less FUEL to be burned.

2. *Fires are a large contributor to the carbon cycle. The carbon that is in the structure of the plants being burned are being combusted using oxygen and producing high quantities of carbon dioxide. This is how Carbon returns to the atmosphere. As a result this carbon dioxide is now available for plants to use as they undergo photosynthesis. They use the carbon dioxide, water and the sun's energy to make their own food. As a result plants will grow which provides a source of food for animals. Animals will consume these plants as part of their respiration process which involves breathing oxygen, eating plants for example and drinking water. As a result animals are consuming carbon through the plants they eat and are releasing carbon in the form of gas every time they exhale. It is remarkable how intertwined everything is in our ecosystem.*

Chemical Changes: Photosynthesis and Respiration

I can represent the photosynthesis reaction in a balanced equation.

I can represent the respiration reaction in a balanced equation.

Explanation of Concepts

Photosynthesis

Plants make their own food. They use carbon dioxide, water and solar energy during photosynthesis, a chemical change, which produces glucose and oxygen.

The photosynthesis reaction can be represented by the balanced chemical equation below.

$$6\ CO_{2(g)} + 6\ H_2O_{(l)} + \text{energy} \rightarrow C_6H_{12}O_{6(s)} + 6\ O_{2(g)}$$

Carbon Dioxide + Water + solar energy → Glucose + Oxygen

Respiration

Respiration is the process by which plants and animals release energy stored in glucose. Respiration involves the reaction of glucose with oxygen.

Cells will “burn” this fuel (glucose) for energy and give off waste in the form of carbon dioxide and water.

This respiration reaction can be represented by the balanced chemical equation below.

$$C_6H_{12}O_{6(s)} + 6\ O_{2(g)} \rightarrow 6\ CO_{2(g)} + 6\ H_2O_{(l)} + \text{energy}$$

Glucose + Oxygen → Carbon Dioxide + Water + energy

.

Questions

1. Which of the following combinations correctly represents the process of photosynthesis?
   a) Carbon Dioxide + Water + solar energy → Glucose + Oxygen
   b) Carbon Dioxide + Water → Glucose + Oxygen + solar energy
   c) Glucose + Oxygen → Carbon Dioxide + Water + energy
   d) Glucose + Oxygen + energy → Carbon Dioxide + Water

2. Which of the following combinations correctly represents the process of cellular respiration?
   A) Carbon Dioxide + Water + solar energy → Glucose + Oxygen
   B) Carbon Dioxide + Water → Glucose + Oxygen + solar energy
   C) Glucose + Oxygen → Carbon Dioxide + Water + energy
   D) Glucose + Oxygen + energy → Carbon Dioxide + Water

Answers

1. *A*
2. *C*

Chemical Changes: Acid-Base Neutralization Reaction

I can give examples of acid-base neutralization reactions.

Explanation of Concepts

Neutralization is a chemical reaction in which an acid combines with a base to form a salt and water.

Examples of neutralization reactions:

- Milk of magnesia can be used as an antacid to neutralize excess stomach acid. Different antacids contain different bases, but all act to neutralize stomach acid.
- Acid rain is causing the acidification of many of Quebec's lakes and soils. Lime, $Ca(OH)_2$, is a base that can be added to lake water or to soil whose pH has dropped too low. This process neutralizes some of the acid present and the pH will rise to be closer to 7.

Questions

1. Wasp stings are alkaline. Which substance would help relieve this injury?
   A) Vinegar
   B) Toothpaste
   C) Tap water
   D) Ammonia based window cleaner

2. Hydrangeas are flowers that have different colors depending on the pH of the soil in which they grow. Helen wants to change the color of her flowers. To do so, she must increase the pH of her soil from 5.2 to 6.6. She has compost made from vegetable and fruit peels, coffee grounds and tea bags. She also has a bag of lime. Which should she use? Describe the type of reaction that will occur.

Answers

1. *A*
2. *She should use the lime, which will increase the pH. The compost has coffee, fruit and vegetables in it, so it is probably acidic and would decrease the soil pH. The type of reaction is an acid-base neutralization*

Chemical Changes: Acid-Base Neutralization Reaction

I can name the products (salt and water) formed during acid-base neutralization reactions.

I can determine whether a solution is acidic, basic or neutral based on the molecular formula of the compound involved.

Explanation of Concepts

Neutralization Reaction:

ACID + BASE → SALT + WATER

Acids

- Generally have an "H" in the front of the formula (e.g. HCl but not H_2O = water)
- Can be used to neutralize bases

Bases

- Generally have a metal in the front of the formula and have "OH" at the end of the formula (e.g. NaOH, $Al(OH)_3$ NH_4OH)
- Can be used to neutralize acids

Salts

- A metal and a non-metal combine to form a salt (e.g. NaCl, CaF_2)
- Does not have a "H" in front or "OH" at the end of the formula

When an acid and a base combine, they neutralize each other forming a salt and water. Both salt and water have a neutral pH.

Example 1:

$$H_2SO_4 + 2\ NaOH \rightarrow Na_2SO_4 + 2\ H_2O.$$

acid + base → salt + water

- **H**$_2$SO$_4$ is an acid.
- Na**OH** is a base. Na is a metal, and it ends in "**OH**"
- Na_2SO_4 is a salt. Na is a metal and S and O are nonmetals. This is a salt.
- H_2O is water.

Example 2:

Milk of magnesia, $Mg(OH)_2$, can be used as an antacid to neutralize excess stomach acid, HCl.

$$2\ HCl_{(aq)} + Mg(OH)_{2\ (aq)} \rightarrow MgCl_{2\ (aq)} + 2\ H_2O_{(l)}$$

acid + base → salt + water

Questions

1. When an acid and a base react together, what are the products?
   A) Acid and Salt
   B) Salt and Base
   C) Base and Water
   D) Salt and Water

2. The chemical equation for an acid-base neutralization is shown below.

$$H_2CO_3 + Ca(OH)_2 \rightarrow CaCO_3 + 2\ H_2O$$

Classify each of the products and reactants as an acid, base or salt. Explain your answer.

Reactant and Product Identification		Explanation
H_2CO_3		
$Ca(OH)_2$		
$CaCO_3$		
H_2O		

Answers

1. *D*

2.

Reactant and Product Identification		*Justification*
H_2CO_3	*Acid*	*Begins with H which is an indication it is an acid.*
$Ca(OH)_2$	*Base*	*Has a metal at the start and OH at the end of the chemical formula which is indicative to a base.*
$CaCO_3$	*Salt*	*Is made of a metal (Ca) and two non-metals (C and O) which means this is an ionic bond and a salt.*
H_2O	*Water*	*Formula for water*

Chemical Changes: Acid-Base Neutralization Reaction

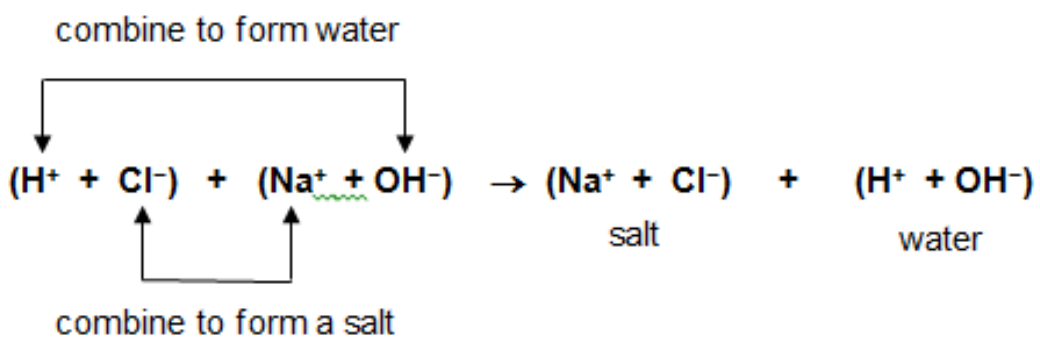
I can recognize an acid-base neutralization reaction from its equation.

Explanation of Concepts

The positive ion, H^+, from the acid combines with the negative ion, OH^-, from the base to form neutral water.

The positive ion of the base combines with the negative ion of the acid to form a salt.

$HCl_{(aq)}$	**+**	**$NaOH_{(aq)}$**	**→**	**$NaCl_{(aq)}$**	**+**	**$H_2O_{(l)}$**
Hydrochloric acid		Sodium Hydroxide		Sodium chloride		Water



Questions

1. Which equation below correctly represents the neutralization reaction of hydrochloric acid (HCl) and potassium hydroxide (KOH)?

   A) $HCl + KOH \rightarrow Cl + H_2O$

   B) $HCl + KOH \rightarrow KO + H_2Cl$

   C) $HCl + KOH \rightarrow KH + ClOH$

   D) $HCl + KOH \rightarrow KCl + H_2O$

2. From the chemical reactions below, select the one that is a neutralization reaction, then explain why it is a neutralization reaction:

   a) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

   b) $C_6H12O_6 + O_2 \rightarrow CO_2 + H_2O$ + energy

   c) $HF + LiOH \rightarrow H_2O + LiF$

3. Sodium hydroxide (NaOH), a very strong base, spilled in a laboratory. In order to safely clean the spill, hydrochloric acid (HCl) is used to neutralize it. Write the balanced neutralization equation for this reaction.

Answers

1. *D*
2. *C. $HF + LiOH \rightarrow H_2O + LiF$ is the neutralization reaction. The acid (HF) and the base (LiOH) react to produce the salt (LiF) and water (H_2O).*
3. *$HCl + NaOH \rightarrow NaCl + H_2O$*

Chemical Changes: Law of Conservation of Mass

I can describe the law of conservation of mass during a chemical reaction.

Explanation of Concepts

The **law of conservation of mass** states that in all chemical reactions the mass of reactants is equal to the mass of products.

Example:

The chemical equation for the combustion of methane, CH_4, is shown below.

$$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$$

When 8 grams of methane reacts completely with 32 grams of oxygen, 18 grams of water are produced. How many grams of carbon dioxide are produced in this reaction?

mass of reactants			=	mass of products	
mass CH_4	+	mass O_2	=	mass CO_2	+ mass H_2O
8g	+	32g	=	mass CO_2	+ 18g
		mass CO_2	**=**	**22 grams**	

Questions

1. What mass of ammonia (NH_3) is produced when 6 g of hydrogen gas (H_2) combines with 28 g of nitrogen gas (N_2)?

$$\mathbf{N_2 + 3\ H_2 \rightarrow 2\ NH_3}$$

A) 6 g

B) 23 g

C) 34 g

D) 46 g

2. The neutralization of 2.0 g of hydrochloric acid (HCl) with 3.1 g of potassium hydroxide (KOH) produces 4.1 g of potassium chloride salt (KCl) and water. The balanced equation for this reaction is shown below:

$$\mathbf{HCl + KOH \rightarrow KCl + H_2O}$$

What is the mass of the water produced during this neutralization reaction?

3. When fossil fuels such as coal and oil are burned, sulfur is released into the atmosphere, and, as a result acid rain is formed. The following reactions take place:

sulphur dioxide + oxygen → sulfur trioxide

sulphur trioxide + water → sulfuric acid (acid rain)

If 256 g of sulfur dioxide react with 64 g of oxygen and the sulfur trioxide produced is further reacted with 72 g of water, how much sulfuric acid would be produced?

Answers

1. *C*
2. *2.0 g + 3.1 g = 4.1 g + water*

   5.1 g = 4.1 g + water

   1.0 g = water
3. *256 g + 64 g = sulfur trioxide* *320 g + 72 g = sulfuric acid*

   320 g = sulfur trioxide ***392 g = sulfuric acid***

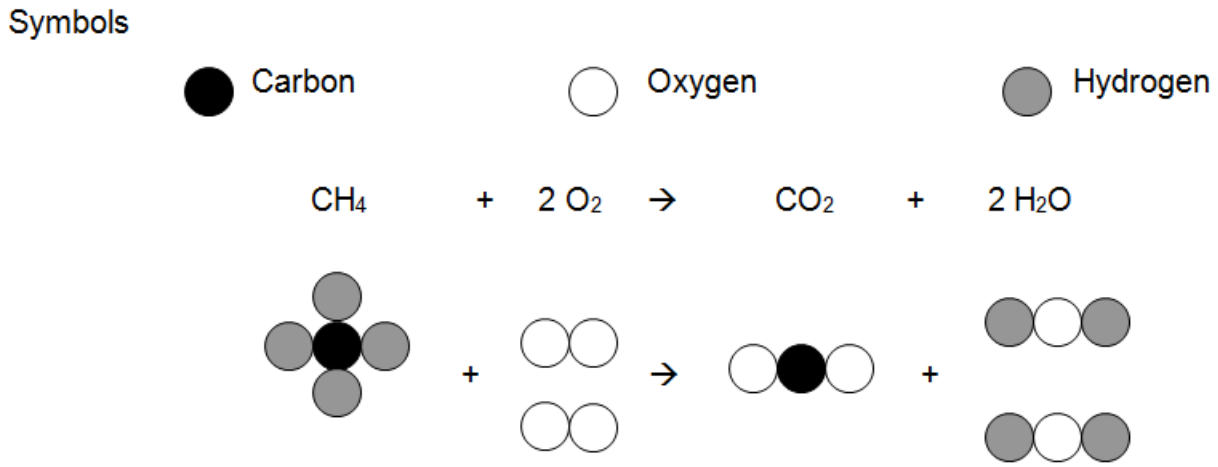
Chemical Changes: Law of Conservation of Mass

I can represent the conservation of mass using the particle model.

Explanation of Concepts

The particle model can be used to visually represent a chemical reaction. This can be applied to the law of conservation of mass to show an equal amount of reactants and an equal amount of products.

The reaction of the combustion of methane is represented below using the particle model.



Since mass in conserved, the number of particles of each type in the reactants is equal to the number of particles of each type in the products.

Particle		# of particles in reactants	# of particles in products
●	Carbon	1	1
○	Oxygen	4	4
●	Hydrogen	4	4

Questions

1. During a chemical reaction, one molecule of nitrogen gas (N_2) and three molecules of hydrogen gas (H_2) react to produce 2 molecules of ammonia (NH_3). The balanced equation for this reaction is:

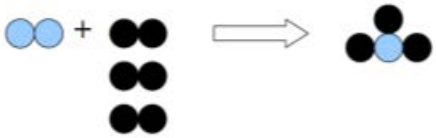
$$N_2 + 3\ H_2 \rightarrow 2\ NH_3$$

Which of the models below correctly represents the above reaction?

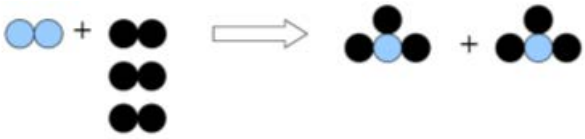
The following symbols are used:

Nitrogen Hydrogen

A)

B) 

C)

D) 

2. The following model represents a balanced equation for a reaction involving a piece of magnesium metal and hydrochloric acid.

Symbols:

Magnesium Hydrogen Chlorine

Which of the following equations correctly represents this reaction?

A) $Mg + HCl \rightarrow H_2 + MgCl_2$

B) $Mg + H_2Cl_2 \rightarrow H_2 + MgCl_2$

C) $Mg + 2\ HCl \rightarrow 2\ H_2 + MgCl_2$

D) $Mg + H_2Cl_2 \rightarrow 2\ H_2 + 2\ MgCl_2$

3. The reaction of copper oxide (CuO) with carbon (C) produces copper (Cu) and carbon dioxide (CO_2) as shown in the equation below.

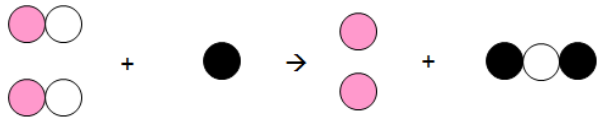
$$2\ CuO + C \rightarrow 2\ Cu + CO_2$$

Using the symbols below create a model representing this balanced reaction.

Symbols:

Copper Carbon Oxygen

Answers

1. *D*
2. *C*
3. 

Chemical Changes: Balancing Chemical Equations

I can balance chemical equations.

Explanation of Concepts

Balancing a chemical equation consists of placing a coefficient before each reactant and product so that the number of atoms of each element on the reactant side is equal to the number of atoms of each element on the product side.

- Coefficients must be whole numbers placed in front of a reactant or product
- Coefficients must be as small as possible (lowest common denominator)
- New substances must never be added, nor existing substances removed
- Subscripts in chemical formulas must never be changed
- The final equation should always be checked by counting the number of atoms of each element on both sides

An unbalanced chemical equation:

$$H_2SO_4 + KOH \rightarrow K_2SO_4 + H_2O$$

Atom	Reactants	Products
H	3	2
S	1	1
O	5	5
K	1	2

Atoms in reactants and products not equal

The balanced chemical equation:

$$H_2SO_4 + \mathbf{2}\ KOH \rightarrow K_2SO_4 + \mathbf{2}\ H_2O$$

Atom	Reactants	Products
H	2 + 2(1) = 4	2(2) = 4
S	1	1
O	4 + 2(1) = 6	4 + 2(1) = 6
K	2(1) = 2	2

An unbalanced chemical equation:

$$C_5H_{12} + O_2 \rightarrow CO_2 + H_2O$$

The balanced chemical equation:

$$C_5H_{12} + \mathbf{8}\ O_2 \rightarrow \mathbf{5}\ CO_2 + \mathbf{6}\ H_2O$$

	Reactants	Products
Check balancing	C: 5 H: 12 O: 8(2) = 16	C: 5(1) = 5 H: 6(2) = 12 O: 5(2) + 6(1) = 16

Questions

1. Which of the following equations is balanced?
   A) $2\ Fe_2O_3 + 3\ C \rightarrow 3\ CO_2 + 2\ Fe$
   B) $CH_4 + O_2 \rightarrow CO_2 + 2\ H_2O$
   C) $Cu + 4\ HNO_3 \rightarrow Cu(NO_3)_2 + 4\ NO_2 + 2\ H_2O$
   D) $4\ NH_3 + 3\ O_2 \rightarrow 2\ N_2 + 6\ H_2O$

2. Balance the following equations:
   A) $H_2SO_4 + KOH \rightarrow K_2SO_4 + H_2O$
   B) $CH_4 + O_2 \rightarrow CO_2 + H_2O$

Answers

1. *D*
2.
   a) $2\ KOH + H_2SO_4 \rightarrow K_2SO_4 + 2\ H_2O$
   b) $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$

Organization of Matter:
Groups and Periods in the Periodic Table

*I can locate the **groups** and **periods** in the periodic table.*

Explanation of Concepts

The periodic table of elements is an organization of the elements according to their physical and chemical properties.

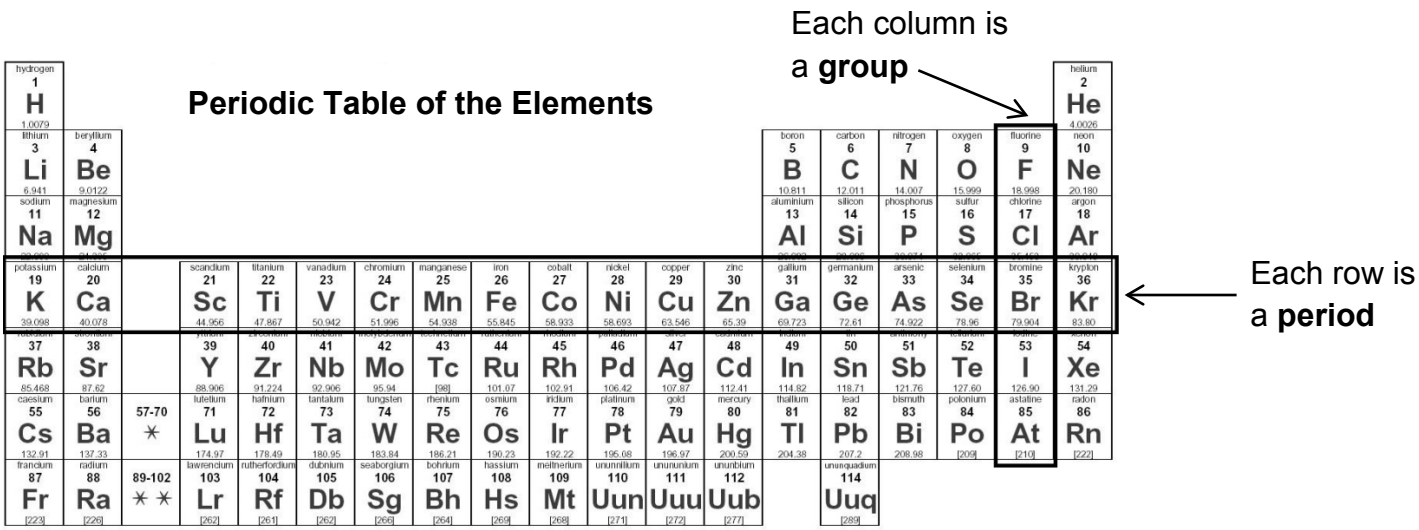


*Image modified from .http://commons.wikimedia.org/wiki/File:Periodic-table.jpg **Retrieved** March 12, 2014*

Groups

- Each column is called a **group**.
- The group number represents the number of valence electrons (electrons in the outermost shell).
- e.g. Halogens (F, Cl, Br, I, At) are in group VIIA and they all have 7 electrons in the outermost shell

Periods

- Each row is called a **period**.
- The period number represents the number of *electron shells* or *orbitals*
- eg: Period 3 elements (Na, Mg, Al, Si, P, S, Cl, Ar) have electrons in 3 electron shells.

Organization of Matter:
Groups and Periods in the Periodic Table

I can describe the common characteristics of a group.

Explanation of Concepts

Group IA: Alkali Metals	
General Description	• Li, Na, K, Rb, Cs, Fr • Hydrogen (H) is not an Alkali Metal! • Have one valence electron
Properties	• Soft, light metals that melt at low temperatures • Found combined with other elements (never found as free elements) • Excellent conductors • Highly reactive with water and air

Group IIA: Alkaline Earth Metals	
General Description	• Be, Mg, Ca, Sr, Ba, Ra • Have two valence electrons
Properties	• Grey, metallic solids that are excellent conductors • Also reactive with air and water, but less vigorously than alkali metals • Melting points are higher than alkali metals

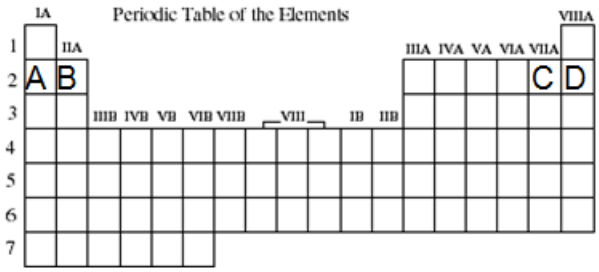
Group VIIA: Halogens	
General Description	• F, Cl, Br, I, At • Have seven valence electrons
Properties	• Very reactive (in nature they exist only in combined states) • Toxic and corrosive • Form salts when combined with alkali metals • Form strong acids in combination with Hydrogen

Group VIII: Noble Gases or Inert Gases	
General Description	• He, Ne, Ar, Kr, Xe, Rn • All have eight valence electrons except Helium, which has two
Properties	• Lack of chemical reactivity as they have full outer shell of electrons • Do not form compounds with other elements under normal conditions ordinary conditions

Questions

1. An element is examined in the laboratory. Despite several attempts it doesn't seem to react with any other substance. It is a gas at room temperature.

   Which letter best represents where this element would be located in the periodic table?



2. The properties of four elements are listed below.

Element	Property
A	It has seven valence electrons.
B	Its outermost energy level (orbit) contains two electrons.
C	It exists in the gaseous state. It does not react with other elements.
D	It has 11 protons. It is highly reactive.

   To which chemical group does each of these elements belong?

3. While doing a research project, you noted the following information about three elements.

Element	Properties
A	Is a solid Conducts electricity Has 2 electrons in its outermost shell Has a low density
B	Has a very low density Does not conduct electricity Has 7 electrons in its outermost shell Is light green in colour
C	Is found in very small quantities in nature Does not form compounds with other elements Is in a gaseous state Has a very low boiling point

Identify the group for each element. Explain by giving at least two properties justifying your choice.

4. Two elements A and B have the following properties.

Element A	Element B
• two valence electrons • located in the 4th period	• six valence electrons • has electrons on two shells

Name the two elements.

Answers

1. *D*
2. *Element A – Halogen*

   Element B – Alkaline Earth Metal

   Element C – Noble Gas;

   Element D – Alkali Metal
3. *Element A – Alkaline Earth Metal (reason: 2 electrons in its outermost shell, low density)*

   Element B – Halogen (reason: 7 electrons in its outermost shell, does't conduct electricity.

   Element C – Noble Gas (reason: Does not form compounds with other elements, is in agaseous state
4. *Element A – Calcium*

   Element B - Oxygen

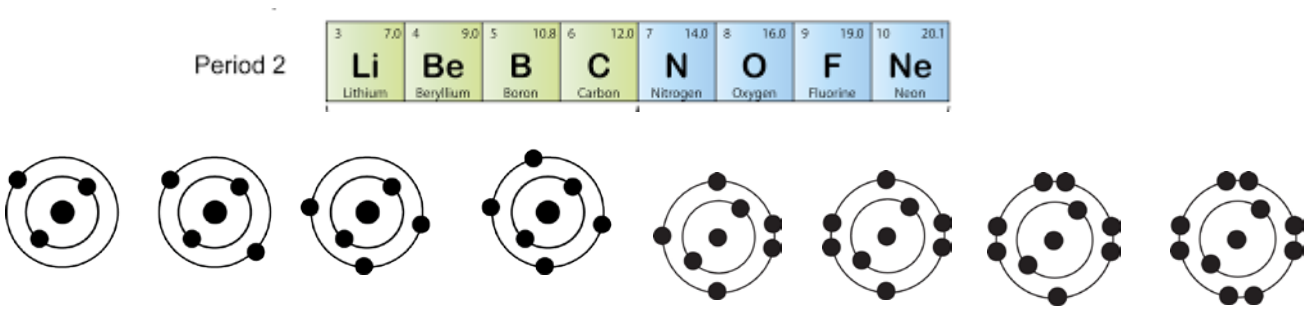
Organization of Matter:
Groups and Periods in the Periodic Table

I know that the number of electron shells in an element is the same as the number of its period.

Explanation of Concepts

A period corresponds to a row of the periodic table. All the elements in a period have the same number of electron shells.

Example:



Questions

1. Which element below has the following properties?
   - Has electrons in 2 electron shells
   - Is completely non-reactive or is inactive

   A) Li B) F C) He D)Ne

2. The periodic table is organized according to the properties of elements. The atomic structure of elements helps organize the elements in periods. Explain what Mg, Si, Cl have in common.

Answers

1. *D*
2. *All elements in the third period and thus have the same number of electron shells (orbitals).*

Organization of Matter: Rutherford-Bohr Atomic Model

I can describe the Rutherford-Bohr atomic model.

Explanation of Concepts

The **Rutherford-Bohr Atomic Model** represents the atom as

- Mostly empty space with a very dense, small, positively charged nucleus at the centre
- Negatively charged electrons moving in defined orbits around the nucleus
- Neutrally charged, so that the number of protons in the nucleus is equal to the number of electrons in the orbits

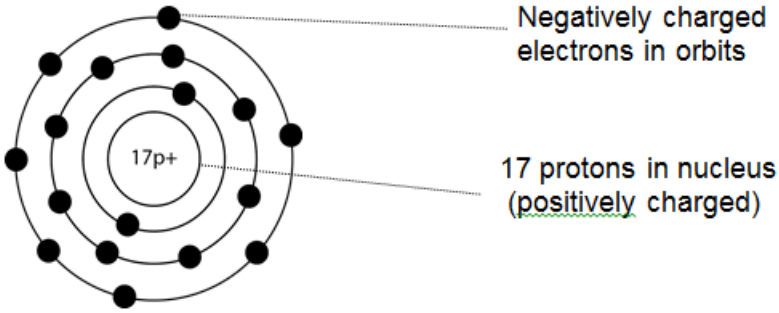
Nucleus

- Contains protons
- Is positively charged (because protons are positively charged)
- Contains nearly all of the mass of the atom
- The nucleus is much smaller than the atom and very dense
- The number of protons determines the type of element the atom makes up
- The number of protons in the nucleus is different for each element

Electron Orbitals (Shells)

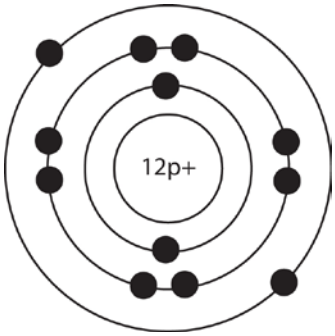
- Neils Bohr conducted experiments using light that allowed him to conclude that the electrons of an atom exist on specific orbitals which he called orbits.
- The orbitals hold the negatively charged electrons in their positions.
- Electron orbitals of an atom differ in the number of electrons that can be present at any one time. Each level has a maximum number of electrons that can be present.
- Electrons can move to other orbitals when stimulated by being heated or receiving an electrical discharge.

Example: Rutherford-Bohr Model of Chlorine



Questions

1. The diagram below shows the Rutherford-Bohr model of an atom.



Use the periodic table to answer the following questions

a) To what group does this element belong?

b) To what period does this element belong?

c) What is the name of this element?

Answers

1.

a) Group 2 or Alkaline Earth Metals

b) Period 3

c) Magnesium

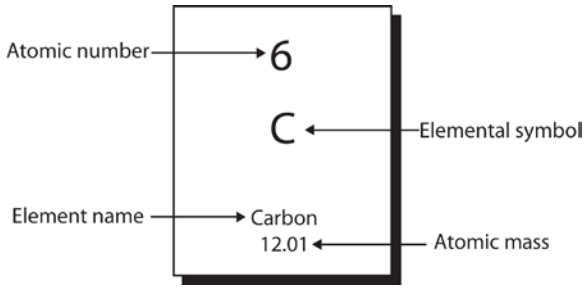
Organization of Matter: Rutherford-Bohr Atomic Model

I can represent atoms using the Rutherford-Bohr model (up until atomic number 20).

I can recognize Rutherford-Bohr diagrams of atoms that have an atomic number greater than 20 and that belong to one of the four major groups in the periodic table (IA, IIA, VIIA and VIIIA)

Explanation of Concepts

Step 1: Locate the element for that atom in the periodic table. The carbon atom will be used as an example.

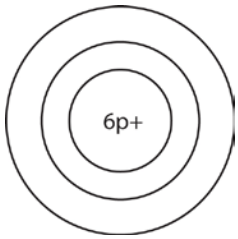


The **Atomic Number** represents the number of protons. The number of protons is equal to number of electrons. In this example, carbon has 6 protons and 6 neutrons.

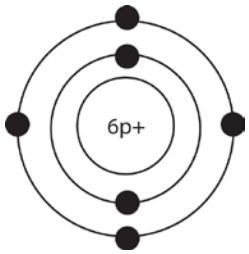
Step 2: Indicate the number of protons in the nucleus of the atom. Do not forget to include the charge symbol. (p^+ , +)

The **period** number indicates the number of orbitals.

Step 3: Draw the appropriate number of orbitals around the nucleus. Carbon is in period or row 2, so there are two orbitals in the carbon atom.



Step 4: Indicate the number of electrons by drawing them on their respective orbitals.



Remember: Each orbital has a maximum number of electrons allowed.

- a maximum of 2 e- on the first orbital
- a maximum of 8 e- on the second orbital
- a maximum of 8 e- on the third orbital
- A maximum of 2 e- on the fourth orbital

Fill up an energy level completely before placing electrons on the next level.

Carbon has 6 electrons, so there are 2 electrons in the first orbital and 4 electrons in the second orbital.

Questions

1. Which of the following statements correctly describes the fluorine atom using the Rutherford–Bohr model?

   A) An atom with 9 protons in the nucleus, with 2 electrons on the first shell and 7 on the second shell.

   B) An atom with 9 protons in the nucleus, with 8 electrons on the first shell and 11 electrons on the second shell and 9 electrons on the third shell.

   C) An atom with 19 protons in the nucleus, with 8 electrons on the first shell and 11 on the second shell.

   D) An atom with 2 protons, 1 electron on the first shell and 1 electron on the second shell.

2. The table below lists different elements. Choose two elements that are found in the same group in the periodic table and represent these atoms using the Rutherford-Bohr model.

Name of Element	Chemical Symbol
Calcium	Ca
Chlorine	Cl
Magnesium	Mg
Phosphorous	P
Potassium	K
Silicon	Si
Sodium	Na
Sulphur	S

Answers

2. *A*
3. *Possible Answers*

   Calcium has 20 protons, 2 electrons on the first energy level, 8 electrons on the second energy level, 8 electrons on the third energy level and 2 electrons on the fourth energy level.

   and

   Magnesium has 12 protons, 2 electrons on the first energy level, 8 electrons on the second energy level and 2 electrons on the third energy level.

   OR

   Sodium has 11 protons, 2 electrons on the first energy level, 8 electrons on the second energy level and 1 electron on the third energy level.

   and

   Potassium has 19 protons, 2 electrons on the first energy level, 8 electrons on the second energy level, 8 electrons on the third energy level and 1 electron on the fourth energy level.

Electricity and Electromagnetism: Electrical Charge

I understand that different particles have different charges i.e., that a proton has a positive charge, a neutron has neutral (no) charge and an electron has a negative charge.

Explanation of Concepts

An atom is composed of small particles of matter: *protons*, *neutrons* and *electrons.* The table below describes the charge and distribution of these elementary particles inside the atom:

Particle	Charge	Location in atom
Proton	Positive (+)	Nucleus
Electron	Negative (−)	Electron orbitals or shells
Neutron	Neutral (o)	Nucleus

Electrical charge is a property of protons and electrons.

- protons are positively charged (+);
- electrons are negatively charged(-);

Questions

1. What do protons and electrons have in common?
   A) They both carry an electrical charge.
   B) Neither of them carry an electrical charge.
   C) They are both situated outside the nucleus of an atom.
   D) They are both situated inside the nucleus of an atom.

2. Which of the following are positively charged?

    1. The proton
    2. The electron
    3. The atom
    4. The nucleus

A) 1 and 2 B) 2 and 3 C) 3 and 4 D) 1 and 4

3. Which of the following statements *correctly* describe a difference between electrons and protons?

A) Protons are found outside the nucleus; electrons are found inside the nucleus.

B) Protons are positively charged; electrons are negatively charged.

C) Protons have no electrical charge; electrons have a positive charge.

D) Protons are found inside the nucleus; electrons are found inside the neutrons

4. The concepts listed in the box below relate to the structure of an atom.

Draw arrows to represent the correct match between each particle, its location and its electrical charge:

a) proton	1) inside the nucleus
	2) outside the nucleus
	3) negative charge
	4) neutral
b) electron	5) positive charge

Answers

1. *A*
2. *D*
3. *B*
4. *a) proton 1) and 5)*

   b) electron 2) and 3)

Electricity and Electromagnetism: Electrical Charge

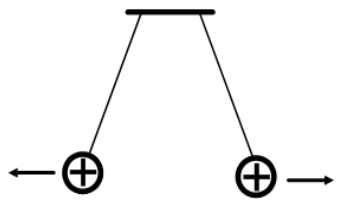
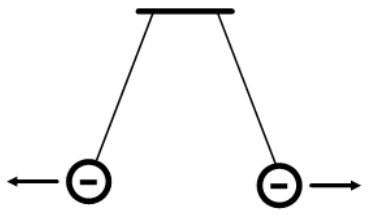
I understand that two objects with similar electrical charges will repel each other and that two objects with opposite electrical charges will attract each other.

Explanation of Concepts

Brought close together, two electrically charged objects interact.

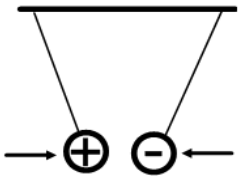
Possibility 1

When the charges are ***similar***, the objects ***repel*** each other

positive repels positive	
negative repels negative	

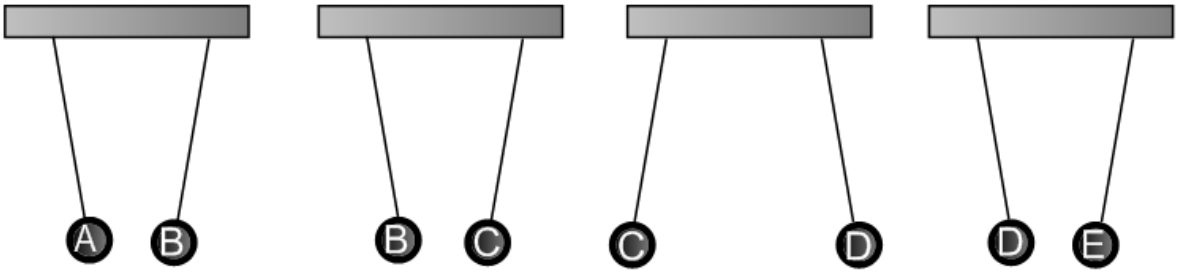
Possibility 2

When the charges are ***opposite***, the objects ***attract*** each other

positive and negative attract	

Questions

1. Five metallic spheres were electrically charged and then suspended as shown in the diagram below:



If sphere A is positively charged, which of the spheres are negatively charged?

A) B and C

B) C and D

C) D and E

D) B and E

Answer

1. *D*

Electricity and Electromagnetism: Static Electricity

I can describe static electricity as the transfer of electrons from one body to another.

I can predict how electrons will transfer based on a triboelectric series or a series of actions (conduction, friction)

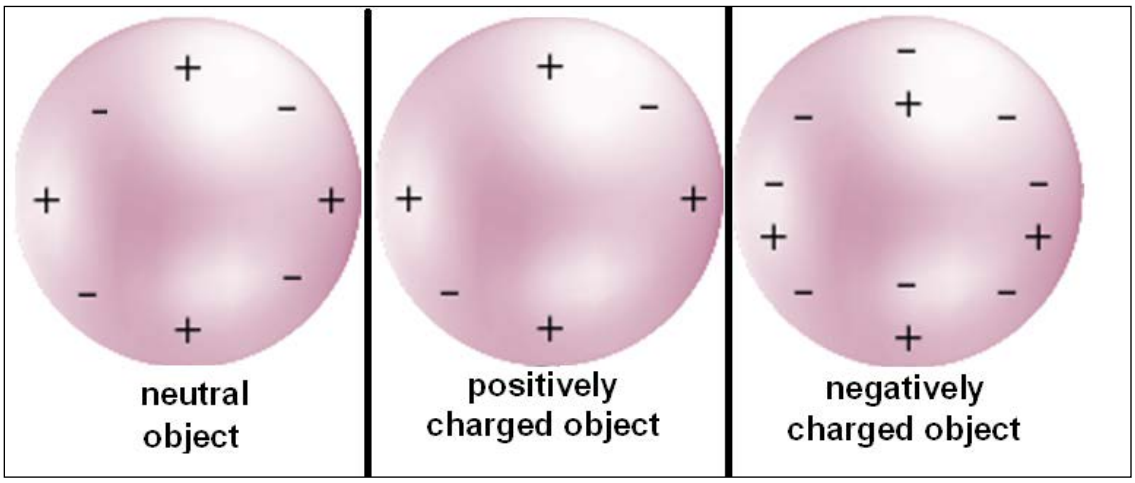
I understand induction as the displacement of negative charges within a neutral object when it is close to a charged object

Explanation of Concepts

An electrically neutral body contains the same number of protons (*positive charges*) as electrons (*negative charges*). Protons are very tightly bound to the nucleus and cannot be easily removed. Some electrons however, are not so tightly bound and can be transferred from one body to another. These transfers usually occur when two bodies are rubbed against each other.

- The atom that loses electrons becomes **positively charged.**
- The atom that gains electrons becomes **negatively charged**.

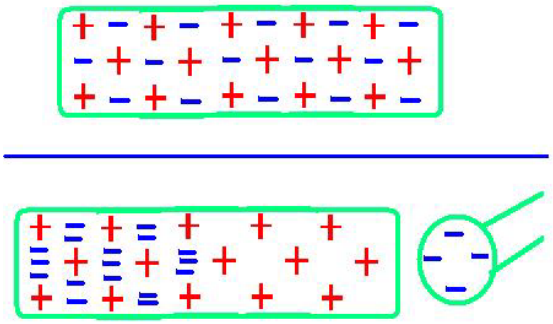
Electrically Charged Objects



Electrical charges can also be transferred from one body to another by direct contact.

Electrostatic Induction

When a charged object is brought close to a neutral object, the negative charges on the neutral object can be displaced.



Questions

1. The list below arranges different substances in increasing order of their tendency to acquire electrons. When two of these substances are rubbed together, the one situated lower on the list attracts electrons from the substance above and becomes negatively charged.

Electrostatic (Triboelectric) Series Chart

Acetate	*Weak hold on electrons*
Glass	
Wool	
Cotton	
Ebonite	
Plastic	
Rubber	*Strong hold on electrons*

In the laboratory, a student rubs a cotton cloth with each of the following materials: ebonite, plastic, acetate and glass.

He then brings the different materials together:

1. Ebonite and plastic
2. Plastic and acetate
3. Acetate and glass
4. Glass and ebonite

In which of the situations do the materials repel each other?

A) 1 and 2

B) 1 and 3

C) 2 and 4

D) 3 and 4

2. Tom wants to prepare a surprise party for his baby sister. Amongst other things, he wants to decorate the walls of their house with multi-coloured balloons. Once the balloons are inflated, Tom rubs them on his hair for a few seconds and then sticks them to the wall. He knows that this is possible due to friction, as the balloons become electrically charged and are attracted to the wall.

   Which of the following produced the static electricity?

   A) The transfer of protons between the hair and the balloons.

   B) The transfer of electrons between the hair and the balloons.

   C) The transfer of electrons between the balloons and the wall.

   D) The transfer of protons between the balloons and the wall.

3. Which of the statements below is TRUE?

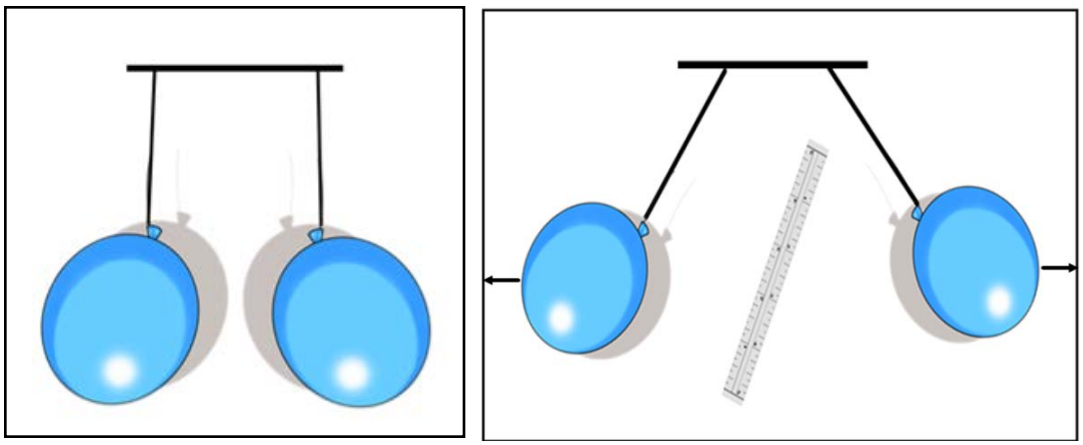
   A) Positively charged objects have a fewer protons than electrons.

   B) Positively charged objects have more electrons than protons.

   C) Negatively charged objects have more electrons than protons.

   D) Negatively charged objects have more protons than electrons.

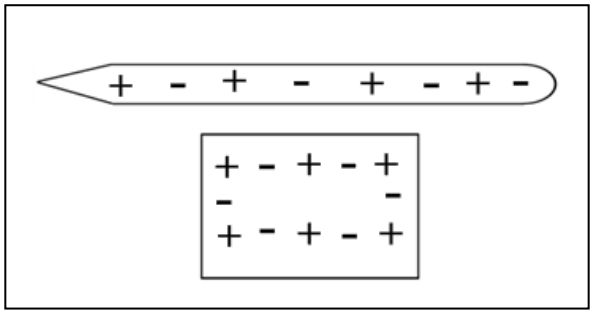
4. A student rubbed two identical inflated balloons on a piece of fur and suspended them from a high stand. He then rubbed a plastic ruler with a piece of wool and placed it between the two suspended balloons. The balloons quickly went high in the air as shown in the diagrams below.



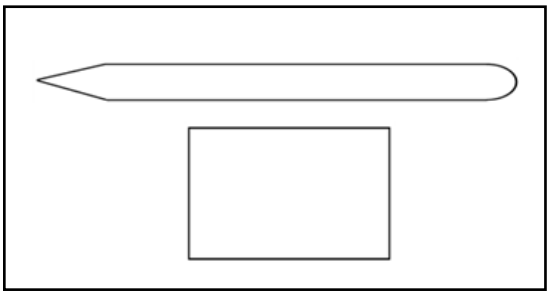
   Knowing that the wool cloth transferred electrical charges to the ruler, determine the overall charge of the balloons, fur, ruler and wool cloth. Explain your answer.

5. Demonstrations using ebonite rods and wool cloth are very common in static electricity activities. After being rubbed with wool, an ebonite rod attracts small objects. Ebonite is known to hold its electrons very tightly when rubbed against other substances. Wool on the other hand, exerts very weak attraction on its electrons.

   The diagram below shows the distribution of electrical charges before the two objects (ebonite rod and wool) are rubbed together:



   a) Show the distribution of electrical charges in the two substances after the two objects are rubbed together *(use + and -).* Explain your diagram.



   b) Explain why the ebonite rod attracts small objects after being rubbed with the wool cloth.

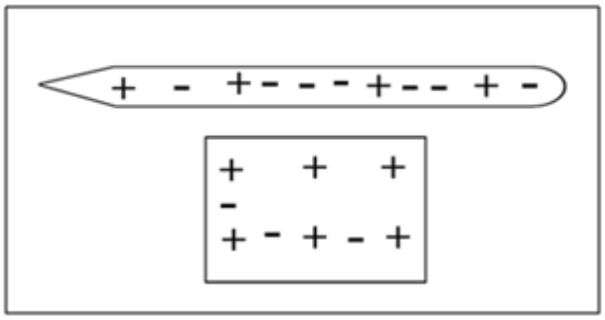
Answers

1. *B*
2. *B*
3. *C*
4.

	Electrical Charge (positive/negative)	*Explanation*
balloons	*negative*	*The charges transferred from the wool to the balloons were electrons, because only electrons can move from one atom to another. The balloons acquired electrons and became negatively charged.*
fur	*positive*	*By transferring electrons to the balloons, the fur lost electrons and became positively charged.*
ruler	*negative*	*Since the ruler repels the two balloons, it must be negatively charged. By rubbing the ruler with the wool cloth, the ruler gained electrons.*
wool cloth	*positive*	*The wool cloth has transferred electrons to the ruler. Then wool cloth lost electrons and became positively charged.*

5.

a)



b) The wool cloth does not hold its electrons tightly, like the ebonite rod. By rubbing these substances together some electrons are transferred from the wool cloth to the ebonite rod. Before being rubbed, both objects contain equal numbers of positive and negative charges. After rubbing, the ebonite rod has more electrons. The wool cloth has lost electrons.

NOTE: The number of negative charges that are added to the ebonite should equal the number negative charges that were removed from the wool cloth. The number of positive charges(protons) remains the same in both objects, because the positive charges cannot be transferred.

The ebonite rod gained electrons. When the ebonite rod is brought close to objects like small pieces of paper and styrofoam etc, the positive charges(protons) in these objects are attracted by the electrons in the ebonite rod. The objects will move towards ebonite rod.

Electricity and Electromagnetism: Ohm's Law

I can explain the relationship between voltage, resistance and current intensity in an electrical circuit.

Explanation of Concepts

Ohm's Law describes the relationship between current, potential difference and resistance in a circuit.

The **current intensity (I)** is the amount of charge that flows through a point of an electrical circuit in one second. (Imagine the number of the cars (electrons) passing a point on a racetrack in one second.)

The **potential difference (V)** is the amount of energy provided by the power supply (battery). It is the energy transferred by electrons <u>between two points</u> of an electrical circuit. (Imagine the amount of push needed to get a car on a racetrack from point A to point B.)

The **resistance (R)** of an element or a circuit is a property of materials. It is the ability of a material to resist the flow of electric charges. (Imagine speed bumps slowing down the cars on a racetrack.)

Relationship between Current, Potential Difference and Resistance in a Circuit

There is a proportional relationship between potential difference and current intensity for a circuit of a given resistance.

For a circuit where the resistance is held constant,

- If V $\uparrow$ then I $\uparrow$
- If V $\downarrow$ then I $\downarrow$

There is an inversely proportional relationship between current intensity and resistance in a circuit of a given potential difference.

For a circuit where the potential difference is held constant,

- If R $\uparrow$ then I $\downarrow$
- If R $\downarrow$ then I $\uparrow$

There is a proportional relationship between potential difference and current resistance for a circuit of a given current intensity.

For a circuit where the current intensity must be held constant,

- If V ↑ then R must ↑
- If V ↓ then R must ↓
- If R ↑ then V must ↑
- If R ↓ then V must ↓

Questions

1. In an electrical circuit, the current intensity doubles. The total resistance of the circuit stays the same.

   How does the potential difference change?

   A) The potential difference halves.

   B) The potential difference doubles.

   C) The potential difference quadruples.

   D) The potential difference stays the same.

2. What will happen to the current intensity in an electrical circuit if, for a given resistance, the potential difference is reduced by half?

   A) The current intensity will double.

   B) The current intensity will not change.

   C) The current intensity will reduce to half of the initial value.

   D) The current intensity will quadruple.

3. The resistance of a circuit is increased while the current intensity is maintained at the same value. How will the voltage change? Explain why.

Answers

1. *B*
2. *C*
3. *The voltage will increase. The resistance of an electrical circuit represents the capacity of a material to oppose the flow of electrical charges. As the current intensity and voltage are directly proportional, if the current is maintained constant and the resistance is increased, more energy will be needed for the current to flow through the resistor, so the voltage will increase.*

Electricity and Electromagnetism: Ohm's Law

I can use the equation (V = RI) or graph to determine voltage, resistance and current intensity in an electrical circuit.

Explanation of Concepts

The mathematical expression of Ohm's Law shows the direct proportionality between the potential difference and current intensity, for a given resistance:

$$\mathbf{V = R \cdot I}$$

The above formula can be also written as:

$$R = \frac{V}{I} \quad \text{or} \quad I = \frac{V}{R}$$

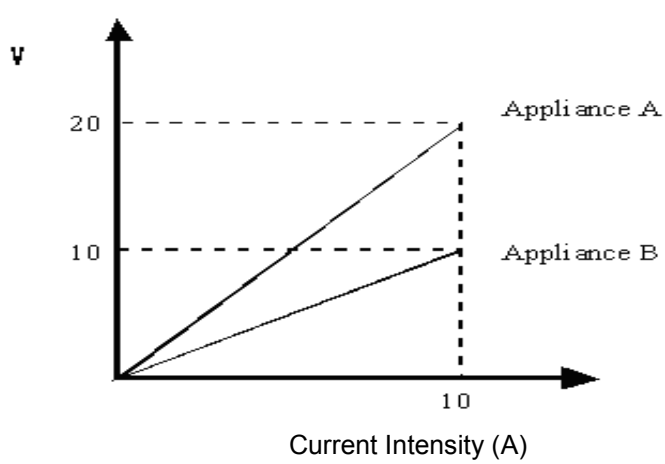
where:

- V is the potential difference (voltage) expressed in Volts (V)
- I is the current intensity expressed in Amperes (A)
- R is the resistance expressed in Ohms (Ω)

Using Ohm's Law to Calculate Resistance

The graph and table below show the relationship between the potential difference and the current intensity for the circuits of two different appliances. What is the resistance of the circuit for each appliance?

Relationship between Potential Difference and Current

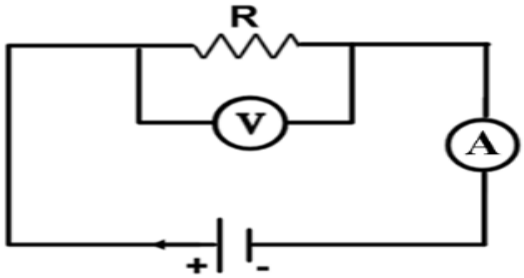


Appliance	Potential Difference (V)	Current Intensity (A)
A	20	10
B	10	10

• Rewrite the equation to solve for R	$R = \frac{V}{I}$	
• Substitute in known values. Remember the units.	Appliance A $R = \frac{20\ V}{10\ A}$	Appliance B $R = \frac{10\ V}{10\ A}$
• Solve for R	R = 2 Ω	R = 1 Ω

Questions

1. In the circuit diagram below the reading on voltmeter is 12 V and the reading on the ammeter is 0.6 A.



What is the resistance of element R?

A) 0.05 Ω

B) 7 Ω

C) 10 Ω

D) 20 Ω

2. What is the potential difference of a circuit if the resistance is 25 Ω and the current intensity is 10 A?

A) 250 Ω

B) 0.40 V

C) 2.5 V

D) 250 V

3. A large flashlight that requires a 1.5 V battery. If the resistance of the light bulb is 3Ω, what is the current flowing through the light bulb?

A) 0.50 A

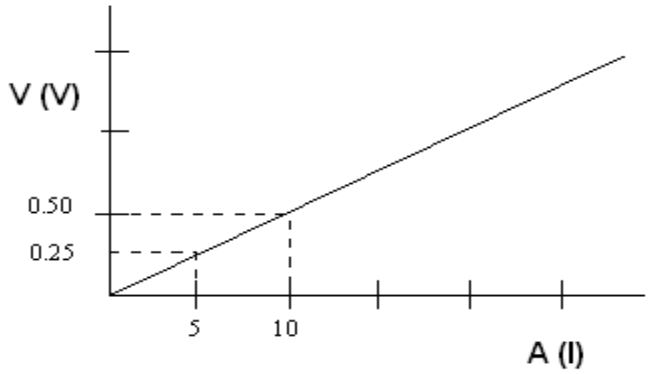
B) 1.5 A

C) 2.0 A

D) 4.5 A

4. The graph below shows the variation in the current intensity, *I*, as a function of the potential difference (voltage), *V*, across a resistor.

Relationship between Potential Difference and Current



What is the resistance, R, of the resistor?

A) 0.05 Ω

B) 1 Ω

C) 5 Ω

D) 20 Ω

5. In the laboratory, a student was asked to measure resistance and potential difference in an electrical circuit. The circuit requires 0.5 A of current to function optimally. He has experimented with four different resistors and recorded the data in the table below.

Resistance and Potential Difference Values

Resistor	Resistance (Ω)	Potential Difference (V)
1	60	12
2	24	12
3	48	12
4	36	12

Which resistors could be used for the optimal functioning of the circuit?

Answers

1. *D*
2. *D*
3. *A*
4. *A*
5. *Resistor 2. It provides the optimal amount of current for this circuit.*

   Resistor 1:

   $$I = \frac{V}{R} \quad I = \frac{12\ V}{60\ \Omega} \quad I = 0.2\ A$$

   Resistor 2

   $$I = \frac{V}{R} \quad I = \frac{12\ V}{24\ \Omega} \quad I = 0.5\ A$$

   Resistor 3:

   $$I = \frac{V}{R} \quad I = 0.25\ A$$

   Resistor 4:

   $$I = \frac{V}{R} \quad I = \frac{12\ V}{36\ \Omega} \quad I = 0.3\ A$$

Electricity and Electromagnetism: Electrical Circuits

I can describe the function of different components of an electrical circuit.

Explanation of Concepts

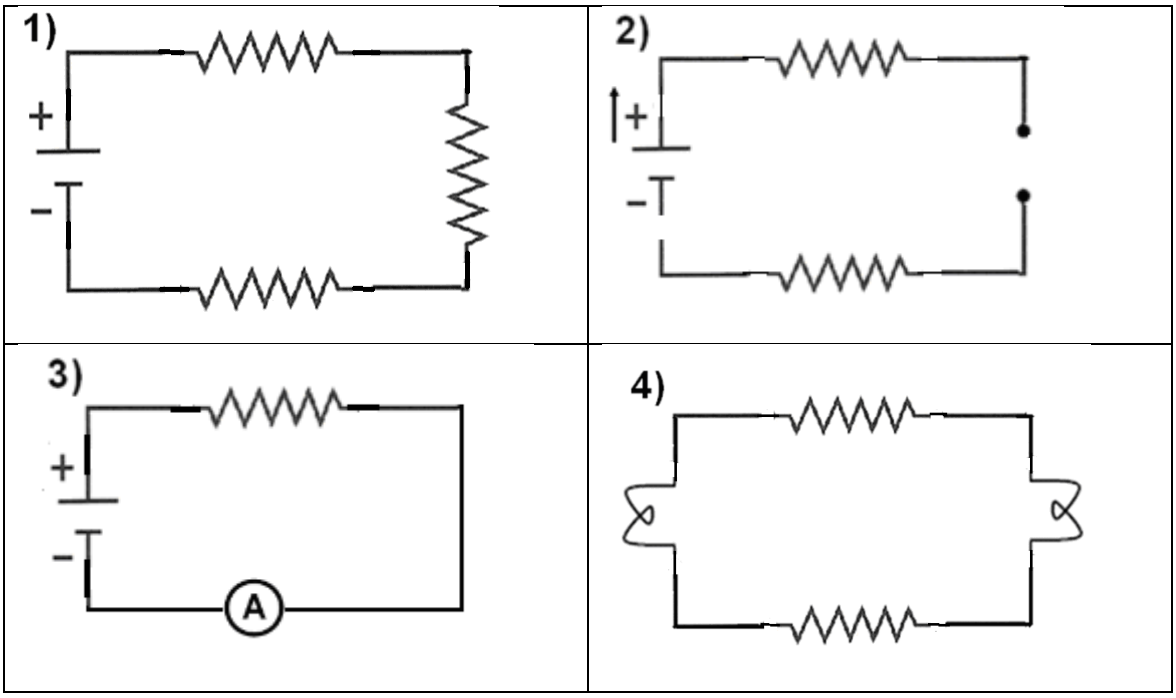
Electrical circuits transform electrical energy into other forms of usable energy (light, heat, sound, mechanical energy etc). The table below describes some components of electrical circuits and their specific role.

Basic Electrical Circuit Components and their Functions

Component(s) and Symbol	Electrical Function	Description
Power source, battery	Power Supply	Creates a potential difference; transfers energy to electrons
Wires	Conduction	Connect the circuit components and the power supply; carry electrons from the source to the components and back to the source
Resistor Light Motor	Electrical Resistance	Limit the flow of electrons; transform electrical energy into other forms of energy (light, heat, sound, motor etc)
Switch	Control	Allows the control of current by connecting or breaking the circuit; (when a switch is off, the electron flow is interrupted)
Ammeter	N/A	Measures the current flowing through a circuit (connected in series)
Voltmeter	N/A	Measures the potential difference (energy) that electrons have between two points of the circuit (connected in parallel)

Questions

1. In which of the following electrical circuits is electron flow *NOT* possible?



A) 1 and 2

B) 1 and 3

C) 2 and 3

D) 2 and 4

2. Which of the components depicted by the symbols below is used to STOP the electron flow in an electrical circuit?

A)

B)

C)

D)

3. Match the components below with the right function they carry in electrical circuits:

Functions		**Components**	
1.	converts electrical energy into other forms of energy	A	ammeter
2.	provides the energy to the circuit	B	resistor
3.	controls the current	C	light bulb
4.	measures the current intensity	D	voltmeter
5	measures the voltage	E	power supply
6.	carries the current	F	switch
7.	component that generates light	G	wires

Answers

1. *D*
2. *D*
3. *1.B, 2.E, 3.F, 4.A, 5. D, 6. G, 7 C.*

Electricity and Electromagnetism: Electrical Circuits

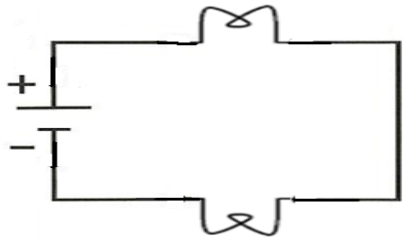
I can identify the two main types of electrical circuits (series, parallel).

Explanation of Concepts

In an ***electrical circuit*** electrical charges flow continuously. In order for charges to flow, all parts of the circuit must be connected together.

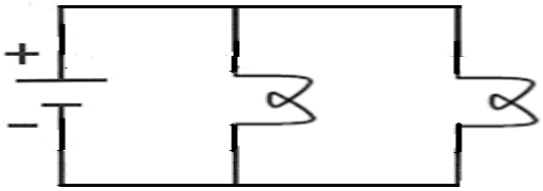
Series Circuits

In a series circuit, elements are linked directly together (connected end to end). All charges follow the same pathway. If a part of the circuit is open or an element is defective, the current stops flowing through the entire circuit.



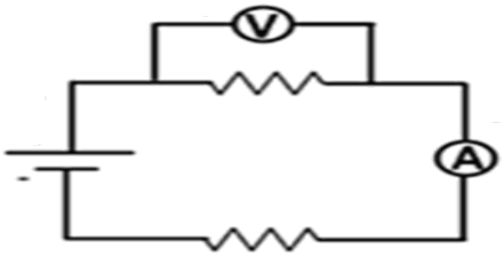
Parallel Circuits

A parallel circuit branches out at least at one point. The charges follow different pathways. If part of one pathway or branch in a parallel circuit is open or an element is defective, the current continues to flow through the other branches.



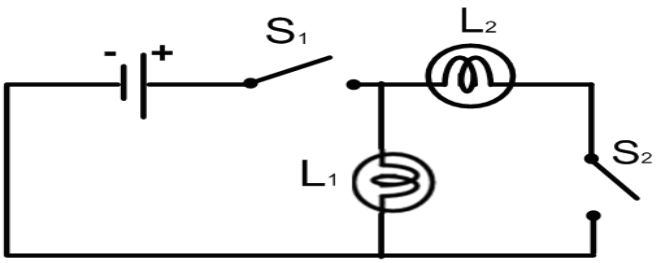
Measuring Instruments

- **Ammeters** are connected IN SERIES (the current passes through the ammeter).
- **Voltmeters** are connected IN PARALLEL (outside the element whose voltage is measured).



Questions

1. The diagram below shows a circuit made of two light bulbs, two switches and a power source.

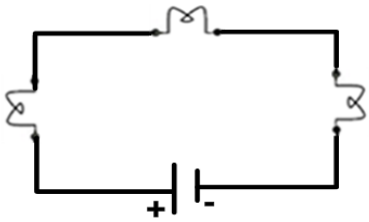


Which of the following statements about this circuit is TRUE?

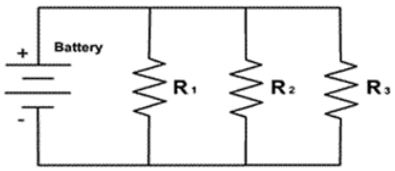
	S_1	S_2	L_1	L_2
A)	Opened	Closed	Off	On
B)	Closed	Opened	On	Off
C)	Opened	Closed	On	Off
D)	Closed	Opened	Off	On

2. Which of the circuits below are connected in parallel?

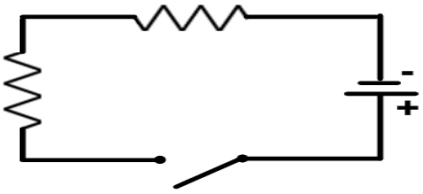
1)



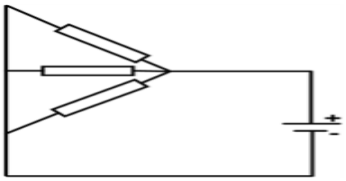
2)



3)



4)



A) 1 and 4

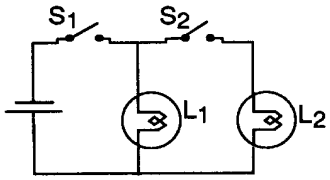
B) 2 and 4

C) 1 and 3

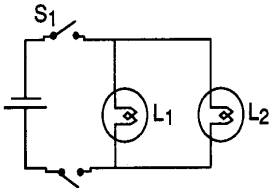
D) 2 and 3

3. In the three circuits below, if S_1 is closed and S_2 is open, which light bulb(s) will light up?

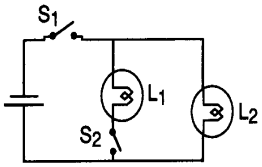
Circuit 1



Circuit 2



Circuit 3



Answers

1. *B*
2. *B*
3. *Circuit 1: light bulb 1 will light up*

   Circuit 2: neither light bulb will light up

   Circuit 3: light bulb 2 will light up

Electricity and Electromagnetism: Electrical Circuits

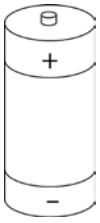
I can describe the differences between alternating and direct current.

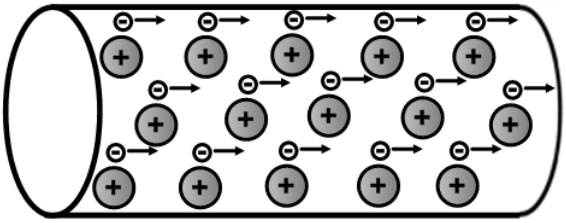
Explanation of Concepts

An **electric current** is an orderly flow of electrical charges. There are two types of electric current:

Direct Current (DC)

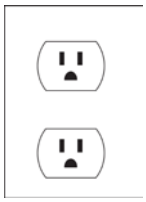
Electrons continuously move in the same direction. Batteries produce DC current.

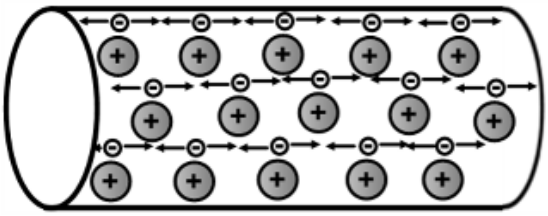




Alternating Current (AC)

Electrons change direction many times every second (they flow back and forth). AC current is provided by an electric outlet.

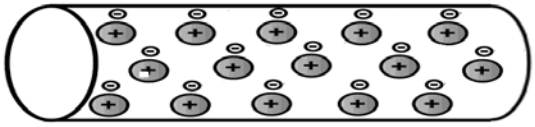




Questions

1. Which of the following statements describe an alternating current (AC)?
   A) It is produced by a battery
   B) Electrons change direction continuously.
   C) The electrons do not move.
   D) Electrons move in the same direction.

4. The diagram below shows the charges inside a wire.



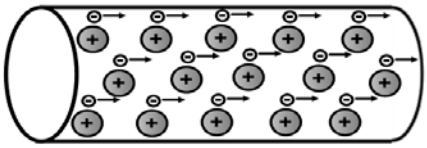
a) Use arrows to show the motion of the electrons if this wire was part of a circuit that had a battery as a power supply.

b) Draw a second wire with charges to show the motion of electrons if the wire was part of a circuit that is connected to an electrical outlet.

Answers

1. *B*

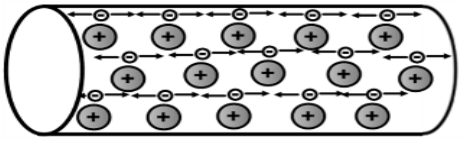
2.



a)

All arrows must point in the same direction

Originate ONLY with the electrons



b)

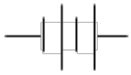
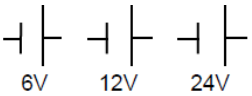
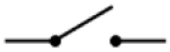
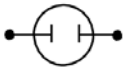
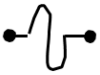
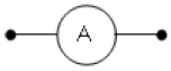
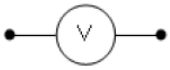
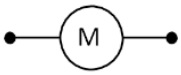
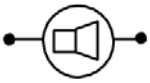
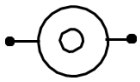
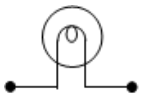
Arrows point in both directions

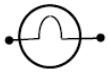
Originate ONLY with the electrons

Electricity and Electromagnetism: Electrical Circuits

I can recognize the symbols used in circuit diagrams.

Explanation of Concept:

Battery *A 1.5-volt battery*		Wire	
Two batteries *If there are two batteries, this provides 3 volts.*		Photoelectric Cell	
More than two batteries *If there are more than two batteries, the voltage is indicated in the diagram.*		Push-button switch	
Alternating current		Rocker switch	
Electrical outlet		Magnetic Switch	
Fuse		Ammeter	
Resistor		Voltmeter	
Motor		Speaker or Alarm	
Light bulb		Buzzer	
		Heating Element	

The symbol on the right is used to represent any type of indicator light in a technical object.			

Electricity and Electromagnetism: Electrical Circuits

I can represent a simple electrical circuit using a diagram and appropriate symbols.

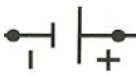
Explanation of Concepts

A simple electrical circuit contains at least the following components:

- a power source
- components (resistors, light bulbs, motors, heating elements)
- wires
- a switch

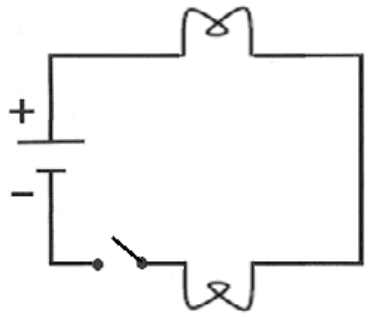
Circuits are represented by precise diagrams. Certain symbols are used to represent the elements of an electrical circuit:

Electrical Circuit Symbols

Wire	Power Supply	Resistor	Light Bulb	Switch	Ammeter	Voltmeter
						

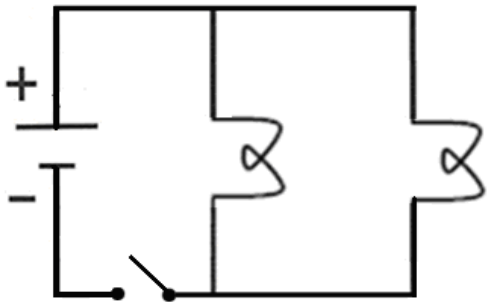
Series Circuit

The figure below represents a series circuit consisting of a power supply (electrical battery) and two resistors (light bulbs) along with its representation using symbols, in an electrical diagram:

Circuit	Circuit Diagram
	

Parallel Circuit

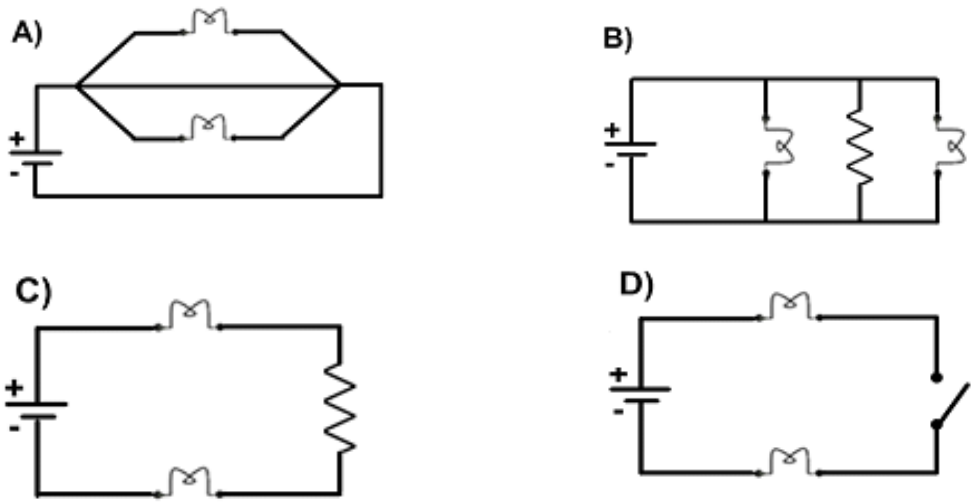
The figure below represents a parallel circuit consisting of a power supply (electrical battery) and two resistors (light bulbs) along with its representation using symbols, in an electrical diagram:

Circuit	Circuit Diagram
	

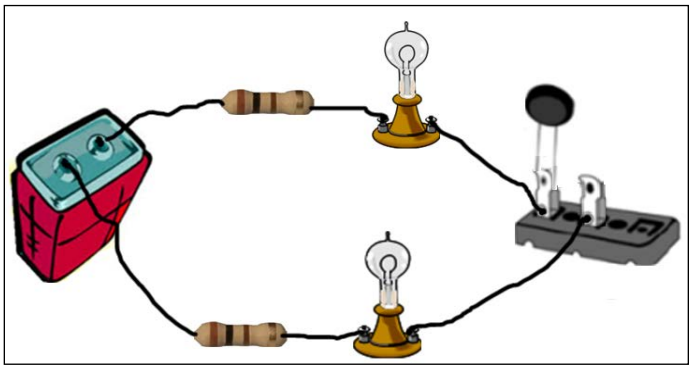
Questions

1. The figure below represents an electrical circuit containing a power source, two electrical bulbs and one resistor connected in parallel:

   Which of the circuit diagrams below best represents this circuit?



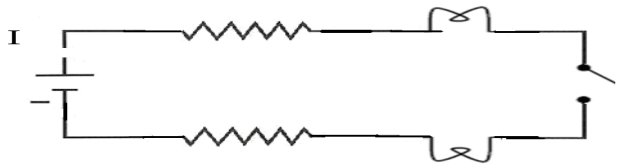
2. The electrical circuit below contains two resistors, two light bulbs, a power supply and a switch - all connected by copper wires as shown in the figure below.

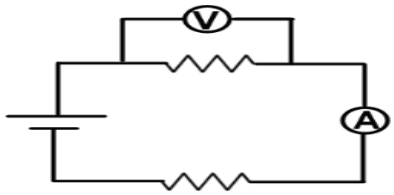


   Draw a diagram of this circuit using appropriate symbols used in electricity. Show the flow of charges on your diagram.

3. An electrical circuit is made of two resistors connected to a power supply, an ammeter and a voltmeter. All circuit components (resistors) are connected in parallel. The ammeter measures the current in both resistors. The voltmeter measures the potential difference of the first resistor only.
   Draw the circuit diagram, indicating also the measuring instruments.

Answers

1. *B*
2. 

3. 

Electricity and Electromagnetism:
Relationship between Power and Electrical Energy

I understand the relationship between power, voltage and current intensity.

I can use the equation (P = VI) or graph to determine power, voltage and current intensity in an electrical circuit.

Explanation of Concepts

Electrical power is the amount of work an electrical device can perform in one second.

The electrical power of a circuit is directly proportional to both voltage and current intensity and can be expressed in a formula as:

$$\boxed{P = V\,I}$$

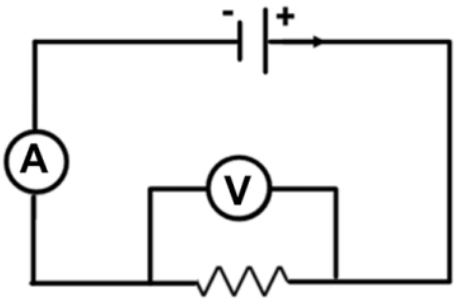
where:

- P is the electrical power expressed in watts (W)
- V is the voltage (potential difference) expressed in volts (V)
- I is the current intensity expressed in amperes (A)

Remember: 1000 W = 1 kW

Questions

1. A student was asked to assemble a simple electrical circuit made of a resistor and a battery, an ammeter and a voltmeter. The diagram below represents the circuit that he assembled:



The ammeter reads is 0.80 A and the voltmeter reads 20 V.

What is the electrical power of this circuit?

A) 0.040 W

B) 16 W

C) 6 W

D) 25 W

2. What is the current drawn when a kettle with a power of 1.65 kW is connected to a 110V power supply**?**

A) 0.0150 A

B) 1.50 A

C) 15.0 A

D) 66.7 A

3. What is the voltage required by an electric grill with a power of 2.2 kW and current 20 A?

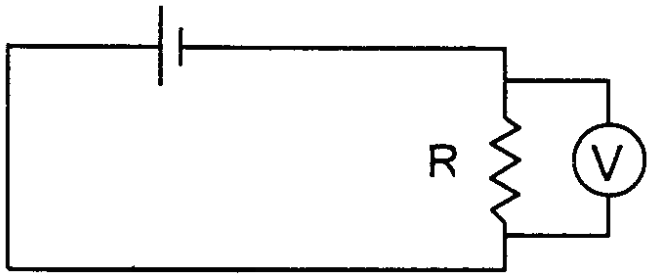
A) 0.11 V

B) 9.1 V

C) 26 V

D) 110 V

4. In the electrical circuit represented below, the voltage is 100 V and resistor R has a value of 50 Ω.



Calculate the electrical power of resistor R**.** Show all your work.

Answers

1. *B*
2. *C*
3. *D*
4. *Find current intensity:*

   $I = \frac{V}{R}$ $I = \frac{100\ V}{50\ \Omega}$ $I = 2\ A$

   Find electrical power:

   P= V·I P= 100 V ·2 A · P = 200 W

   Answer: The electrical power of the resistor is 200 W

Electricity and Electromagnetism:
Relationship between Power and Electrical Energy

I can explain the relationship between the power of an electrical appliance, the electrical energy it consumes and the amount of time it is in operation.

Explanation of Concepts

The **electrical energy** consumed by an electrical appliance is directly proportional to the **power** of the appliance and the amount of **time** it is in operation.

- The more powerful an electrical appliance is, the more energy it consumes for a period of time.
- The longer an appliance is in operation, the more energy it consumes.

Questions

1. Which of the following would reduce the cost of using an electrical appliance?

    1. Increase the operation time.
    2. Use an appliance with a lower power rating.
    3. Reduce the operation time.
    4. Use an appliance with a higher power rating.

    A) 1 and 3 B) 1 and 4 C) 2 and 3 D) 3 and 4

2. Lynn wants to buy a new hair dryer. The store sells two different models. The rating plates of the two appliances are shown below:

Model 1	**Model 2**
120 V 60 Hz 1200 W (1.2kW)	120 V 60 Hz 1400 W (1.2kW)

She usually dries her hair for about 15 minutes daily and she would like to use the least amount of energy possible.

Which of the two models should Lynn buy? Explain your answer.

Answers

1. *C*
2. *Lynn should buy* ***Model 1.***

   The power rating of Model 2 is lower. Since the amount of energy consumed by an appliance is directly proportional to its electrical power, for the same amount of operating time this model is going to use less energy.

Electricity and Electromagnetism:
Relationship between Power and Electrical Energy

I can use the equation $E = P\Delta t$ to calculate the electrical energy consumed, the power of an electrical appliance and the amount of time it is in operation.

Explanation of Concepts

The electrical energy of an electrical circuit can be calculated using the formula:

$$\boxed{E = P\,\Delta t}$$

where:

- E is the electrical energy expressed in joules (J) or kilowatt hour (kWh)
- P is the electrical power expressed in W (watt) or kilowatt (kW)
- Δt is the time interval expressed in seconds (s) or hours (h)

Remember:

- Since P is calculated as VI, energy can also be solved as: $E = VI\,\Delta t$
- 1000 J = 1 kJ
- In questions where the answer is in Joules, you will use time measured in seconds
- In questions where the answer is in kWh, you will use time measured in hours (and energy will be measured in kW)

Questions

1. How much energy does an electric heater with a power of 200 W consume in 2.0 minutes?

   A) 0.010 kJ

   B) 24 kJ

   C) 100 J

   D) 400 J

2. How much energy is consumed by an oven with an electrical power of 4000 W in use for 2.5 hours?

   A) 10 kWh

   B) 10 000 kWh

   C) 1600 kWh

   D) 1.6 kWh

3. How long does it take for a kettle with a power of 2 000 W to use 30 000 J of energy?

   A) 15 s

   B) 15000 s

   C) 15 min

   D) 15 h

4. What is the power of an electric bulb that gives off 3600 J of energy in 10 minutes?

   A) 6.0 kW

   B) 2.8 kW

   C) 6.0 W

   D) 360 W

5. A water heater has a resistor working with a potential difference of 220 V and a current of 50 A.

   Calculate the energy consumed by this water heater in 30 minutes. Show all your work.

Answers

1. *B*
2. *A*
3. *A*
4. *C*
5. *Calculate the power of the resistor:*

   P = VI *P = 220 V x 50 A* *P = 11 000 W = 1.1 kW*

   Express the time in hours:

   $$t = 30\,\text{min} \bullet \frac{1\ \text{h}}{60\,\text{min}} \quad t = 0.5\,\text{h}$$

   Calculate the energy consumed by the resistor:

   E= P Δt *E = 11 kW x 0.5 h* *E = 5.5 kWh*

   Answer: The resistor uses 5.5 kWh of energy in 30 minutes.

   *** Please note the equivalent answer in Ws is 20 700 000 Ws ***

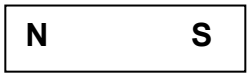
Electromagnetism: Forces of Attraction / Repulsion

I understand that for magnets, different poles attract, while similar poles repel.

I can describe and interpret the magnetic field of a magnet and the behaviour of a compass in the magnetic field of a magnet.

Explanation of Concepts

Every magnet has two poles: North (N) and South (S)



Like poles **repel**.

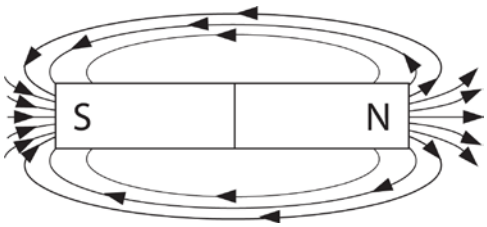
Opposite poles **attract**.

All magnets have a magnetic field. A magnetic field is the space around a magnet where magnetic forces are felt (both attraction and repulsion).

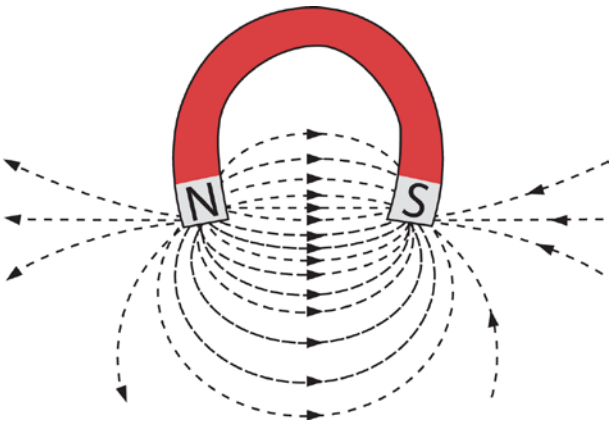
Lines of Force show you the shape, direction, and strength of the magnetic field around a magnet.

- **Shape** is shown by lines of force which can be straight, curved, circular, etc.
- **Direction** is shown by arrowheads. The direction is always from North to South.
- **Strength** is shown by how close the lines are to each other. The closer the lines of force are, the stronger the magnetic field.

Example: Magnetic Field of a Bar Magnet

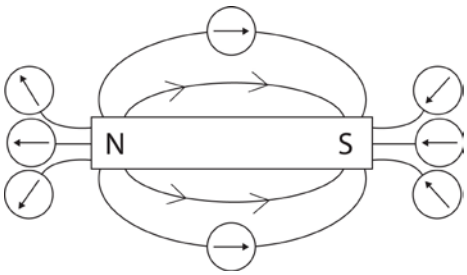


Example: Magnetic Field of a Horseshoe Magnet



A compass needle is a free moving magnet. The North pole of the compass needle is attracted to the South pole of a magnet. The compass needle will position itself parallel to the field lines that are beneath it.

The behaviour of a compass in the magnetic field of a bar magnet is shown below.



Geographic north attracts the north of a compass needle. This means that magnetically speaking, geographic north is really a magnetic south pole.

Earth's Magnetic Field

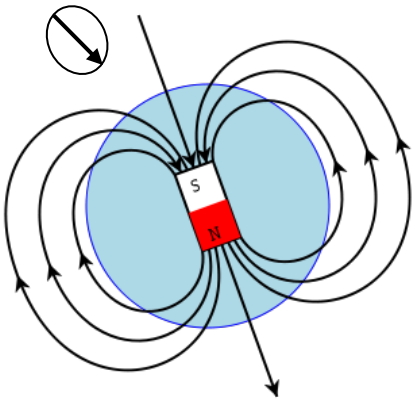
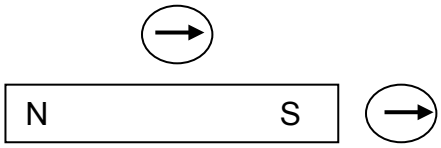
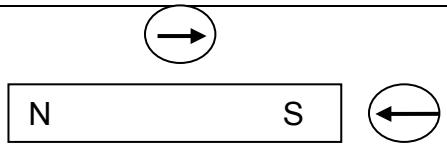
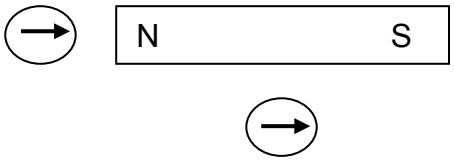
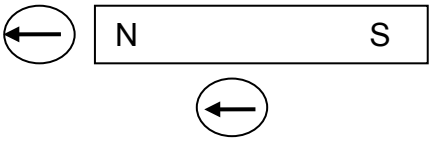


Image modified from http://commons.wikimedia.org/wiki/File:Earths_Magnetic_Field_Confusion.svg
Retrieved January 2014

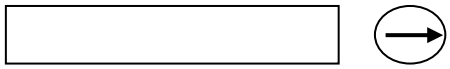
Questions

1. Which of the following correctly illustrates the behavior of a compass in the magnetic field of a bar magnet?

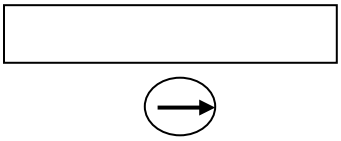
A)	
B)	
C)	
D)	

2. Indicate which pole is the North pole of the magnet. Draw the field lines.

a)



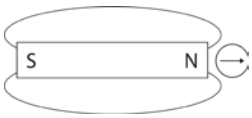
b)



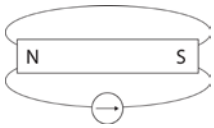
Answers

1. *B*
2.

a)



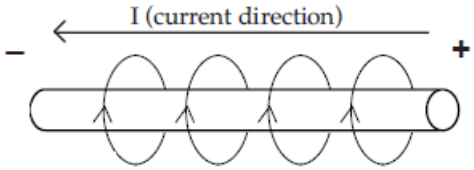
b)

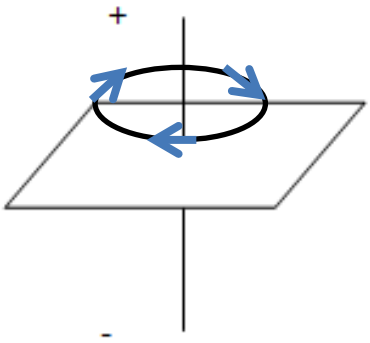


Electromagnetism: Forces of Attraction/Repulsion

I can describe and interpret the magnetic field produced by a current-carrying wire (right-hand rule or left-hand rule).

Explanation of Concepts

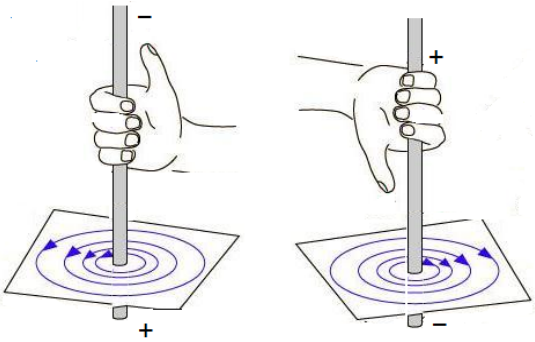




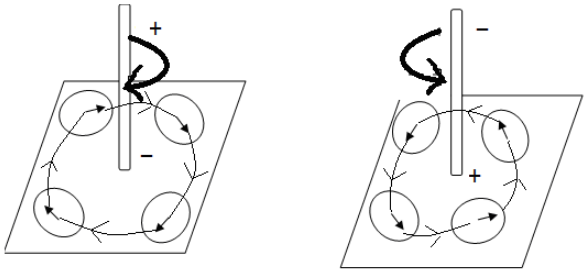
A straight wire with a current flowing through it has a circular magnetic field around it. The magnetic field is represented by circular lines around the wire.

The magnetic field of a straight conductor can be determined using the Right Hand Rule:

- Using your RIGHT hand, point your thumb towards the negative end of the wire (the direction of the current).
- Your fingers wrap around the wire and the curl of your fingers show the direction of the magnetic field.



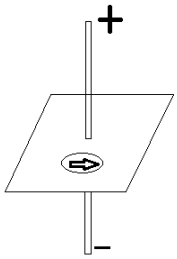
When a compass is placed in the magnetic field, the north end of the compass will point in the direction of the magnetic field.



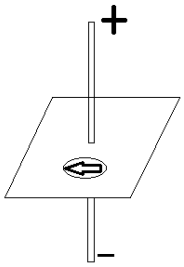
Questions

1. Which of the following diagrams correctly represents the behavior of a compass in the magnetic field of a live wire?

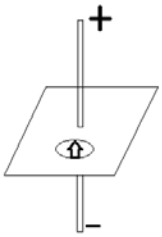
A)



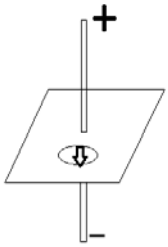
B)



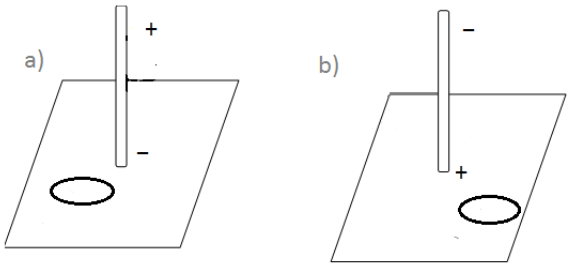
C)



D)



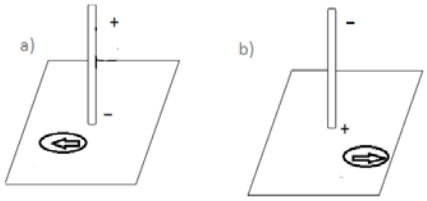
2. A compass (shown as a circle below) is placed on a paper which has a live wire going through it. Place an arrow on the compass showing the direction in which the compass will point.



Answers

1. B: When using the right hand rule, the thumb points in the direction of the conventional current. The thumb will therefore point towards the negative terminal and the fingers will wrap around the wire. The direction of the magnetic field is shown by the direction of the fingers.

2.



Electromagnetism: Forces of Attraction/Repulsion

I can identify ways of modifying the intensity of the magnetic field produced by a current-carrying wire (type of wire, current intensity).

Explanation of Concepts

To increase the intensity of the magnetic field of a live wire (wire with electric current running through it),

- Increase the current intensity.
- Use a better conductor.
- Remember: Metals are conductors. Some metals are better conductors than others
- Examples of good conductors: gold, silver, copper
- Examples of poor conductors: nichrome

Questions

1. An electrical engineer is trying to figure out how to maximize the intensity of a magnetic field generated from a live wire. Which scenario should she choose?

   A) A copper wire with 5 A.

   B) An aluminum wire with 5 A.

   C) A copper wire with 10 A.

   D) An aluminum wire with 10 A.

2. You are trying to increase the strength of the magnetic field around a current carrying wire. You have a choice between using a copper and a nichrome wire. Which one would you use? Explain your answer.

Answers

1. *C: A combination of copper and a strong intensity make for a good conductor*
2. *I would choose a copper wire, because copper is a better conductor than nichrome.*

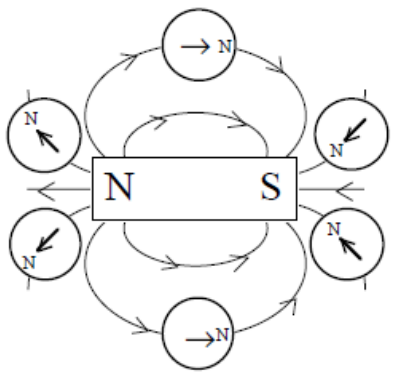
Electromagnetism: Forces of Attraction/Repulsion

I can compare the behavior of a compass in the magnetic field of a magnet with that of a current carrying wire.

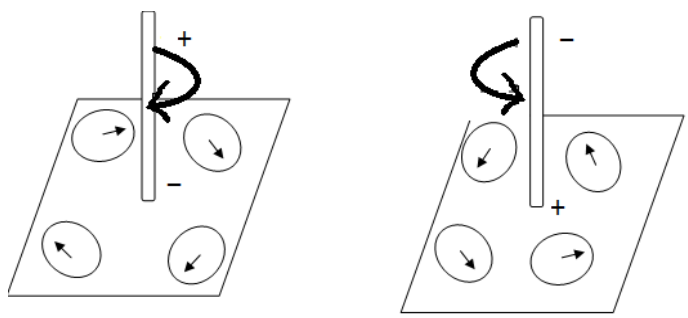
Explanation of Concepts

Recall: The magnetic field lines travel from the magnetic N pole to the S pole. The lines are drawn out of the North end and into the South end.

For a bar magnet, the behavior of the compass is shown below:



The behaviour of a compass in the magnetic field of a current-carrying wire is shown below:



Question:

1. Which of the statements below is TRUE?

   A) When a compass is placed in the magnetic field of a magnet, the North end of the compass always points to the North pole.

   B) When a compass is placed in the magnetic field of a magnet, the North end of the compass always points to the South pole.

   C) When placed in the magnetic field of a current carrying wire, the compass will point towards the positive end of the wire.

   D) When placed in the magnetic field of a current carrying wire, the compass will point towards the negative end of the wire.

.

Answers

1. B

Transformation of Energy: Law of Conservation of Energy

I can explain the law of conservation of energy.

I can apply the law of conservation of energy in different situations.

Explanation of Concepts

The law of conservation of energy states that energy can neither be created nor destroyed, but it can be transferred or transformed from one form to another.

In an isolated system, the total amount of energy remains constant.

Energy may have the appearance of being “lost” but in reality the energy is transformed to heat, light, or other forms of energy.

The transformed energy that is not considered “useful” in a system is known as the “dissipated” energy.

Questions

1. 30 Joules of energy enter a light bulb. 20 joules of energy are transformed into light, how much energy is dissipated as heat?

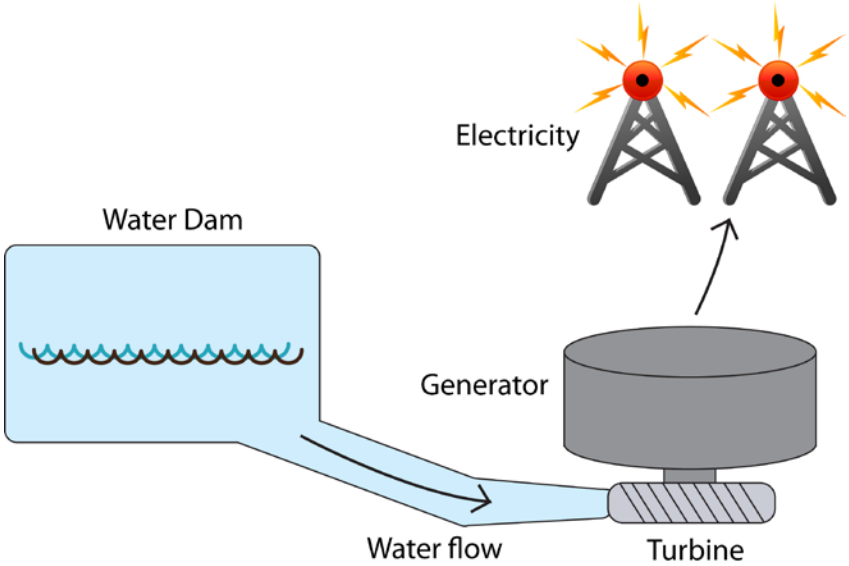
   A) 6.7 joules

   B) 10 joules

   C) 13 joules

   D) 100 joules

2. A simple diagram of a Hydro-Electric System is shown below.



Describe why all the energy from the water flowing into the turbine is not transformed into electrical energy.

Answers

1. *B*
2. *The water travels along the following path: It flows into the turbine which turns causing the generator to produce electricity which is then transferred along power lines. Due to this long process, not all the water's energy will be converted into electricity. Some will be lost in the process.*

Transformation of Energy: Energy Efficiency

*I can use the definition of **energy efficiency** of a device or system as **'the proportion of energy consumed that is transformed into effective work'**.*

I can determine the energy efficiency of a device by using the formula

$$\text{Energy Efficiency} = \frac{\text{amount of useful energy}}{\text{amount of energy consumed}} \times 100.$$

Explanation of Concepts

Machines cannot convert all of the energy they use into a useful form. Some is changed into another form or released as heat in the environment.

The energy efficiency of a machine is the percentage of energy consumed by the machine or device that is transformed into useful energy.

$$\text{Energy Efficiency (\%)} = \frac{\text{Amount of Useful Energy (J)}}{\text{Amount of Energy consumed (J)}} \times 100$$

The amount of useful energy is the energy that the machine actually uses to perform its intended task.

The transformed energy that is not considered "useful" in a system is known as the "dissipated" energy.

The amount of energy consumed is the total amount of energy that the machine uses.

Questions

1. A kettle consumes 15 500 J of energy to boil water. It is 85 % efficient. How much energy was used by the kettle to boil water?

   A) 182 J

   B) 13 175 J

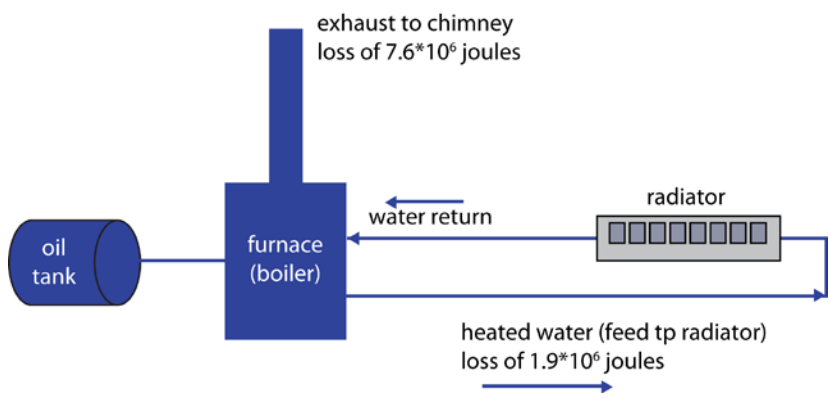
   C) 18 235 J

   D) 1 317 500 J

3. Some homes are still heated by hot water boiler furnaces. The components of the system are an oil tank, a furnace, water pipes and radiators.

   The furnace burns the oil from the storage tank. The heat released is used to heat water which is then pumped to radiators throughout the house. A diagram is shown below.

Furnace System



   If all the heat from the combustion was used to heat the water, the system would be 100% efficient. However, some heat is lost in the furnace exhaust and some is lost from the pipes delivering the water to the radiators.

   One litre of oil delivers 38 000 kJ of energy. 7 600 kJ are lost to the exhaust, and 1 900 kJ are lost in transporting the hot water to the radiators.

Determine the efficiency of this heating system.

Answers

1. *B*

2. $$\%\,\text{Energy Efficiency} = \frac{\text{Amount of Useful Energy (J)}}{\text{Amount of Energy consumed (J)}} \times 100$$

$$\frac{85}{100} = \frac{\text{Amount of Useful Energy (J)}}{15\,500\text{ J}}$$

$$\text{Amount of Useful Energy} = 13\,175\text{ J}$$

$$\%\,\text{Energy Efficiency} = \frac{\text{Amount of Useful Energy (J)}}{\text{Amount of Energy consumed (J)}} \times 100 \quad \%$$

Amount of useful energy = : 38 000 – 7 600 – 1 900 kJ = 28 500 kJ

(This is the energy used to heat the hot water. the total energy minus any energy that is "lost")

$$\%\,\text{Energy Efficiency} = \frac{28\,500\text{ kJ}}{38\,000\text{ kJ}} \times 100$$

% Energy Efficiency = 75%

Transformation of Energy: Energy Efficiency

I can explain how to improve the energy efficiency of an electrical appliance.

Explanation of Concepts

Measures can be taken to minimize the amount of energy "lost" in an electrical appliance. When the amount of energy that is "lost" as non useful forms of energy is reduced, then the energy efficiency is increased.

Examples:

- Replacing incandescent light bulbs with energy efficient light bulbs
- A cell phone's screen goes to "sleep" when not in use

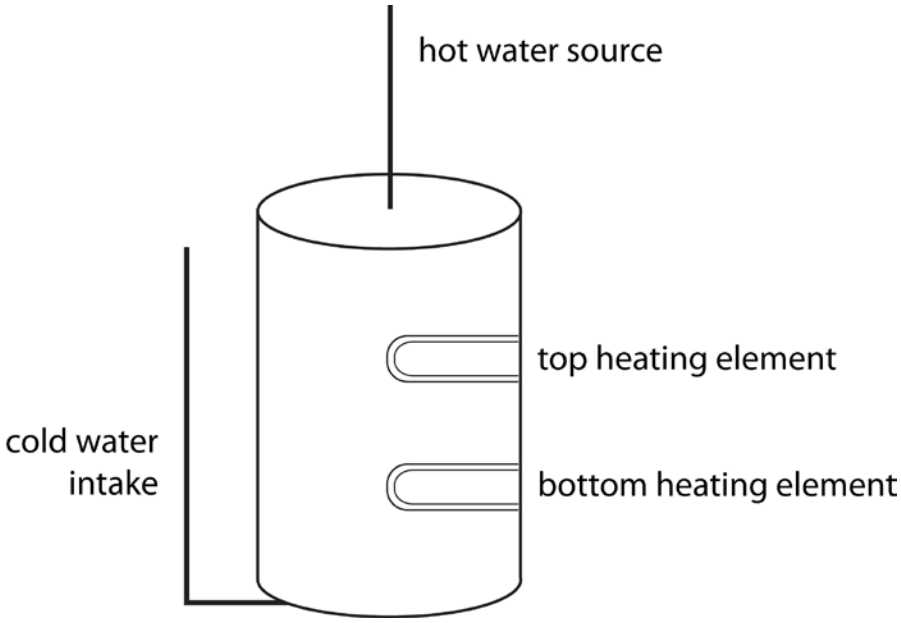
Questions

2. An electrician installs patio lights in a back yard. Which of the following will increase the efficiency of the wiring system to the back yard?

    1. Bury the extension cord deep underground.
    2. Use a shorter extension cord.
    3. Use a longer extension cord.
    4. Use compact fluorescent patio lights

    A) 1 and 2 B) 1 and 3 C) 2 and 4 D) 3 and 4

2. The following is a schematic of an electric hot water heater that we find in most of our homes. (cannot change diagram)



A cold water pipe intake fills the tank, the electrical elements heat the water and then the water leaves the tank from the top pipe whenever we turn on a hot water faucet.

How can we prevent the heat loss from the hot water tank?

Answers

1. *C*
2. *Insulation can be placed around the tank to prevent heat leakage from the tank. The water intake pipe can be insulated. The hot water pipe leaving the tank can be insulated.*

TECHNOLOGICAL WORLD

Mechanical Engineering: Linking of Mechanical Parts

I can recognize and describe the characteristics of the links in a technical object (direct or indirect, rigid or flexible, removable or permanent, partial or complete).

Explanation of Concepts

When two components are assembled, there is a link if and only if the assembled components perform a mechanical function that keeps the components together.

Every link displays four basic characteristics:

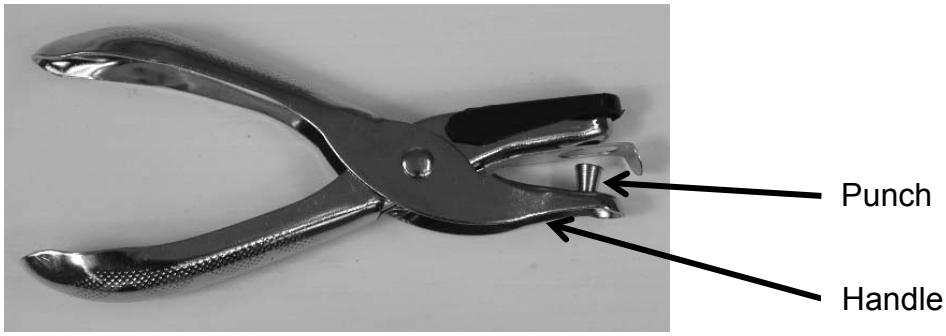
Direct two parts held together without a linking component	**OR**	**Indirect** a linking component is required to hold the two parts together
Rigid the linking component is not flexible	**OR**	**Flexible** the linking component can be deformed when used and has the ability to return to its initial position
Removable the linked parts can be separated without damaging either their surfaces or the linking component	**OR**	**Permanent** the linked parts cannot be separated without damaging either their surfaces or the linking component
Complete the linking component prevents the two parts from moving independently of one another	**OR**	**Partial** the linking component allows the two parts to move independently from one another

Questions to Help Identify the Characteristics of Links

Characteristic	Question
Direct or indirect?	*Do the parts require something else to hold them together?* Yes→ Indirect No → Direct
Rigid or flexible?	*Can the linking component be deformed when used and will it return to its initial position?* Yes→ Flexible No→ Rigid
Removable or permanent?	*Can the object be taken apart without causing damage to the object?* Yes→ Removable No → Permanent
Complete or partial?	*Is movement possible between the two parts?* Yes →Partial No → Complete

Example:

Characteristics of the link between the handle and the punch of a hole punch



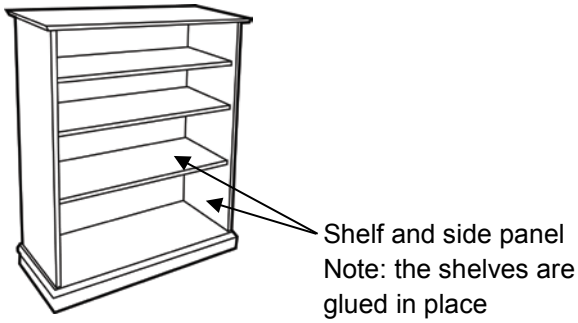
The characteristics of the link between the handle and the punch are:

Direct, rigid, permanent, and fixed

Questions

1. Select the four characteristics of the link between the components identified for each technical object shown below.

a) Bookshelf



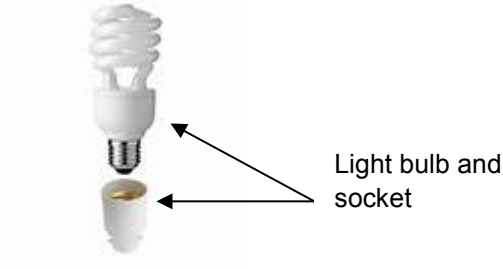
Direct or Indirect

Complete or Partial

Removable or Permanent

Rigid or Flexible

b)



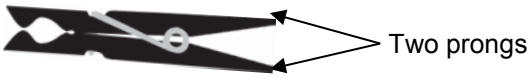
Direct or Indirect

Complete or Partial

Removable or Permanent

Rigid or Flexible

c) Clothespin



Direct or Indirect

Complete or Partial

Removable or Permanent

Rigid or Flexible

Answers

1.

a) *Indirect, complete, permanent, rigid*

b) *Direct, complete, removable, rigid*

c) *Indirect, partial, removable, flexible*

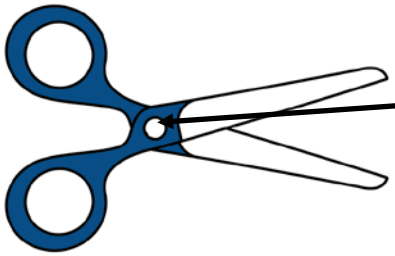
Mechanical Engineering: Linking of Mechanical Parts

I can determine the characteristics of links that are most suitable in the design of a technical object.

Explanation of Concepts

When objects contain two or more parts, engineers must determine how to connect these parts. When designing an object which will require links in its construction, how the object operates will determine the choice of link selected.

Example:



The two blades of the scissors must be linked in a way that allows the blades to slide over each other, but not to separate. In this case, a rivet was chosen as a linking component. The rivet provides a link which is moveable, indirect, rigid and non-

Questions

1. A washing machine contains many parts that may break down over time. What would be the best system to attach the back cover to the body of the washing machine to permit access for repairs.

   A) rivet

   B) glue (adhesive)

   C) screw

   D) nail

2. A small screw is usually used to link the arm of a pair of glasses to the frame. Explain why this is a good choice by referring to the characteristics of the link.

Answers

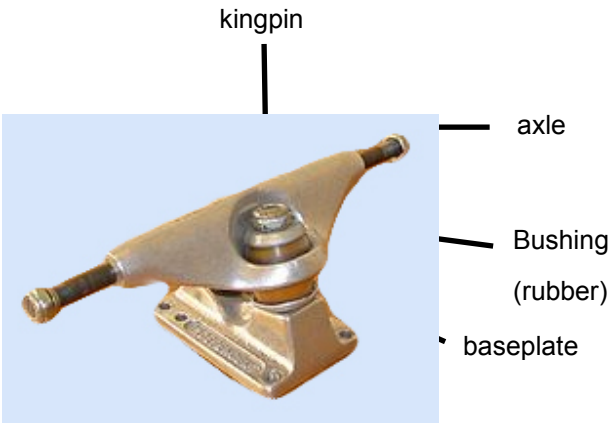
1. *C*
2. *The screw creates a link that is removable, indirect, so the arm can be replaced. The link is partial to permit movement.*

Mechanical Engineering: Linking of Mechanical Parts

I can judge the choice of assembly solutions in a technical object.

Explanation of Concepts

While engineers are designing technical objects, they must judge the appropriate choice for the materials used to initially construct the object and what to use to link the components together.

Example: Assembly Solutions for a Skateboard	
Skateboard-truck:  Image from: http://commons.wikimedia.org/wiki/File:Skateboard-truck.jpg, ***Retrieved*** November 2013	The baseplate of the truck is screwed to the deck of the skateboard. A rubber bushing provides the cushion mechanism for turning the skateboard. The kingpin runs through the axle piece, the bushing and the baseplate in order to keep these parts together. A loosely screwed kingpin allows for better manoeuvring (turning). A tightly screwed kingpin gives the skateboard more stability. The wheels are removable to fit the needs of the rider and to replace when worn.

Questions

1. Explain the choice to assemble an upright bookshelf with nails instead of screws.

Answers

1. *The choice to use nails to assemble an upright bookshelf could be for the following reasons:*

   The bookshelf is meant to be permanently assembled without the need to be taken apart, nails are faster to use.

Mechanical Engineering: Linking of Mechanical Parts

I can explain the choice of a type of link in a technical object.

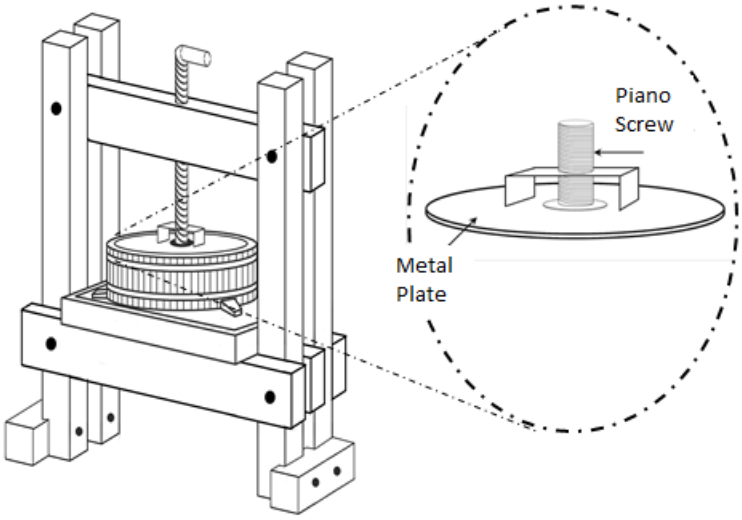
Explanation of Concepts

When analyzing a technical object, it is important to examine why a certain type of link has been used in its construction.

In order to do this, one must consider the characteristics of the link itself and how these characteristics play a role in the functioning of the object.

Example: A Cider Press

Function: A cider press is used to crush apples into an unfiltered, unsweetened juice.



A drawing of the squeeze plate system is shown in the circle above. In this system, a circular metal plate is welded to a piano screw.

The characteristics of the link between the metal plate and the piano screw are:

Direct, Rigid, Permanent, and Complete

In order for the cider press to function properly, it is important that the metal plate stays attached to the piano screw, and that all movement all of movement of the piano screw is transmitted to the metal. Therefore, the type of link used allows for the cider press to function properly.

Mechanical Engineering: Guiding Control

*I understand that **Guiding** is the function performed by a component that controls the motion of a moving component so that it follows a specific trajectory.*

I can identify components that guide in a technical object.

I can explain the choice of a type of guiding control in a technical object.

Explanation of Concepts

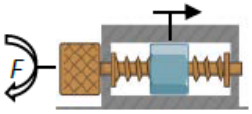
Guiding is the function performed by a component that controls the motion of a moving component so that it follows a specific trajectory. Since a guiding control involves movement between the components, there can be no guiding control in a complete link.

There are three main types of guiding: translational, rotational and helical.

1. **Translational** guidance ensures the straight translational motion of a moving part.

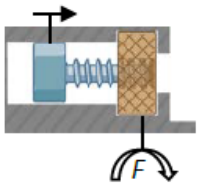
A track at the top and bottom of the window frame allows the translational guiding when the window is slid open.

Screw gear system, type III:



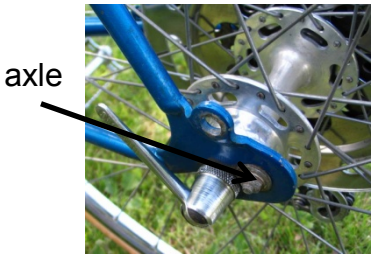
The screw (driver component) undergoes continuous rotational motion and the nut (driven component) undergoes continuous translational motion. This is an irreversible motion transformation system.

Screw gear system, type IV:



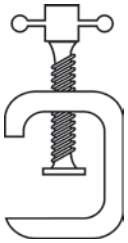
The nut (driver component) undergoes continuous rotational motion and the screw (driven component) undergoes continuous translational motion. This is an irreversible motion transformation system.

2. **Rotational** guidance ensures the rotational motion of a moving part.

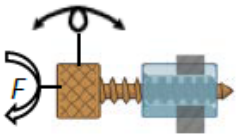


The axle attached to the bicycle frame guides the wheel in a rotational motion.

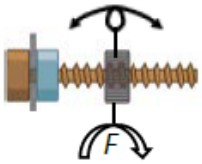
3. **Helical** guidance ensures the translational motion of a moving part while it rotates around the same axis.



Threads inside the frame of the C-clamp control the helical guiding of the threaded shank.



Screw gear system, type I:
The screw (driver component) moves inside a fixed nut.



Screw gear system, type II:
The nut (driver component) moves along a fixed screw.

Questions

1. View the video on this web page: bit.ly/QvCYAF

   Which type of guiding control was used in the vice?

   1. Rotational
   2. Translational
   3. Helical

   A) 1 and 2 B) 1, 2, and 3 C) 2 and 3 D) 1 and 3

   View the video on this web page bit.ly/1tys64c

   Which type of guiding control was used in the vice?

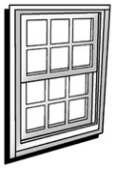
   1. Rotational
   2. Translational
   3. Helical

   A) 1 and 2 B) 1, 2, and 3 C) 2 and 3 D) 1 and 3

3. State the main type of guiding control for each item below.

a) Peanut Butter Jar

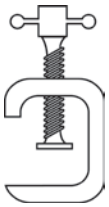
b) Window



c) File Cabinet Drawer

d) Door Handle

e) C-clamp



f) Laptop

Answers

1. *A: There is no helical guidance because the part in translation (vice jaw) does not rotate and the part that rotates (the screw) does not translate. See video:bit.ly/1hdEx01*
2. *C: The body of the vice provides helical guidance because the screw rotates and translates at the same time. The moving jaw of the vice translates. See video: bit.ly/RRZQvb (click on folder)*
3.
   a) helical
   b) translational
   c) translational
   d) rotational
   e) helical
   f) rotational

Mechanical Engineering:
Motion Transmission and Motion Transformation Systems

In Secondary 4, you are required to analyze certain motion transmission and motion transformation systems.

Here are some key points to consider:

1. **Identify the driver and driven components**
   - Kinematic chains have **driver** components, **intermediate** components, and **driven** (receptor) components.

     e.g. A bicycle has a front sprocket (driver) a chain (intermediary) and rear sprocket (driven component or "receptor")

2. **Identify whether the systems transmits or transforms motion.**
   - A **transmission of motion** occurs when the driven component has the same motion as the driver component (rotation to rotation, translation to translation).
   - A **transformation of motion** occurs when the driven component has a different motion from the driver component (rotation to translation, translation to rotation)

3. **Examine the system to see if a speed change is taking place.**
   - If necessary, refer to the section on speed changes.

4. **Determine whether the system is reversible.**
   - A system is considered to be **reversible** if the driver component and the driven component can be interchanged and the system still functions. i.e. The driver can become the driven component and the driven component can become the driver
   - A system is considered to be **irreversible** if the exchange of the driver and the driven component results in a mechanical dysfunction.

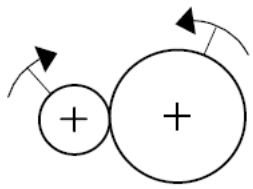
Mechanical Engineering: Motion Transmission Systems

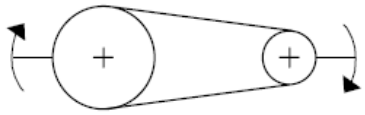
I understand the construction and characteristics of the following ***motion transmission systems.***

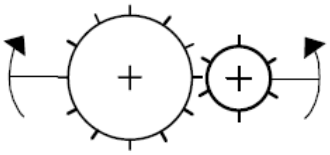
I can use the terms “driver component,” “intermediate component,” and “driven component” in the explanations of the mechanical systems.

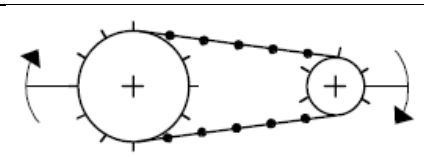
I can describe the reversibility of a motion transmission system.

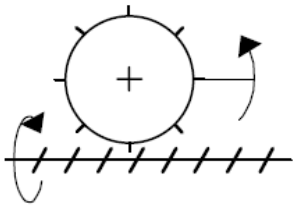
Explanation of Concepts

Friction Gears	
Symbol	
Description	• Rotational motion is transmitted from one wheel to the other • Transmission is done by friction between wheels • Rotation direction is opposite in each connecting wheel
Reversibility	Yes
Advantages	• Easy to assemble • Inexpensive to make • Will allow slippage, protecting it from damage • Gears can be positioned perpendicular or at any angle to each other
Disadvantages	• Wheels must always be together even as they wear away • Wheels can slip, causing interruption in transmission of motion • Must be kept clean(free of lubricants)

Pulley and Belt	
Symbol	
Description	• Rotational motion is transmitted from one pulley to the other by a belt • Rotation direction is opposite in each wheel • System can have more than two wheels
Reversibility	Yes
Advantages	• Easy to assemble • Will allow slippage, protecting it from damage • Allow for transmission of motion over long distances e.g. ski lift
Disadvantages	• Slippage will occur with wear and improper tension on the belt • Belt and Pulleys must be kept clean(free of lubricants) • Belt can be subject to premature wear

Gear Assembly	
Symbol	
Description	• Rotational motion is transmitted from one gear to the other • Rotation direction is opposite in each connecting gear • System can have more than two gear wheels • Used in machinery where mechanical advantage is needed • The torque(force) of a small motor can be increased considerably through a gear train • Requires fine machining of parts so that the teeth fit together precisely
Reversibility	Yes
Advantages	• Will not allow slippage • Can be connected at various angles • Allows for large forces to transmitted
Disadvantages	• Needs lubrication • Subject to severe damage if there is a failure in any one part of the system • Requires elaborate machining

Sprocket Wheels and Chain	
Symbol	
Description	• Rotational motion is transmitted from one sprocket to the other by a chain • Rotation direction is opposite in each connecting sprocket • System can have more than two sprockets • Used in machinery where mechanical advantage is needed • The teeth of the sprockets must be identical so that one chain securely fits all the sprockets • In a given system, the smaller the sprocket the faster it will rotate
Reversibility	Yes
Advantages	• Will not allow slippage • Allows for large forces to be transmitted
Disadvantages	• Needs lubrication

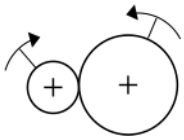
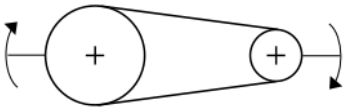
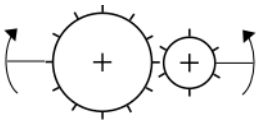
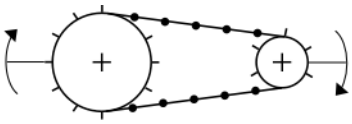
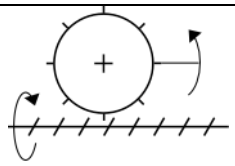
Wheel and Worm Gear	
Symbol	
Description	• Rotational motion is transmitted from the worm gear to one or more wheel gears(sprocket) • Used in machinery where fine adjustment is needed • One turn of the worm gear advances the wheel by one tooth. the above example requires eight turns of the worm gear for one complete revolution of the wheel • Requires fine machining of parts so that the wheel gear teeth fit precisely in the worm gear
Reversibility	No. If a force is applied to the wheel gear(sprocket) the worm gear will not turn
Advantages	• Will not allow slippage • Allows for fine adjustment eg tuning pegs on a guitar
Disadvantages	• Needs lubrication

Mechanical Engineering: Motion Transmission Systems

I am familiar with the symbols for the motion transmission systems.

Explanation of Concepts

Symbols for Motion Transmission Systems

Motion Transmission System	Symbol
Friction Gears	
Pulley and Belt	
Gear Assembly	
Sprocket Wheels and Chain	
Wheel and Worm Gear	

Symbols for mechanisms courtesy of Le Centre de Développement Pédagogique

Mechanical Engineering: Motion Transmission Systems

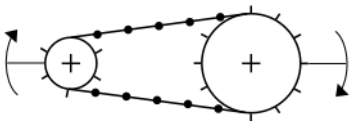
I can explain the choice of a motion transmission system in a technical object.

Explanation of Concepts

During the design of a technical object, one must consider which transmission systems are necessary and more advantageous than others. Being able to identify and explain these advantages involves the understanding of each of these systems.

For an explanation of these systems refer back to friction gears, pulley and belt, gear assembly, sprocket wheel and chain, and worm and worm gear systems in the previous sections.

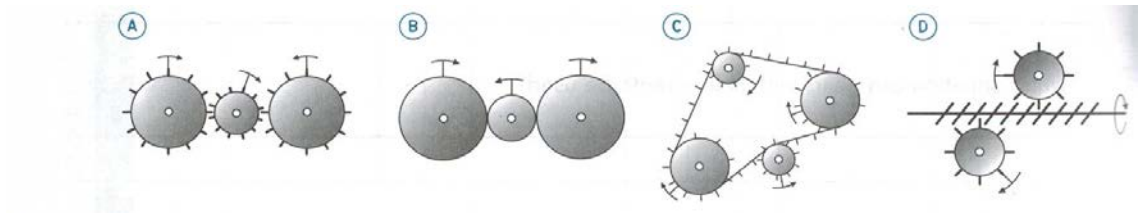
Example: Choice of Motion Transmission System for a Bicycle



A person riding a bicycle is regularly exerting a force on the pedals which drive the sprocket wheel and chain.. Engineers have chosen a sprocket wheel and chain system because of this force. The teeth of the gears fit perfectly into the chain, allowing the chain to stay on the sprockets as the force is exerted through the pedals. If a pulley and belt system was used, slipping would occur and the belt may not be able to withstand the force exerted by the bicycle rider.

Questions

1. Which of the following diagrams of a motion transmission system correctly illustrates the motion of the components?



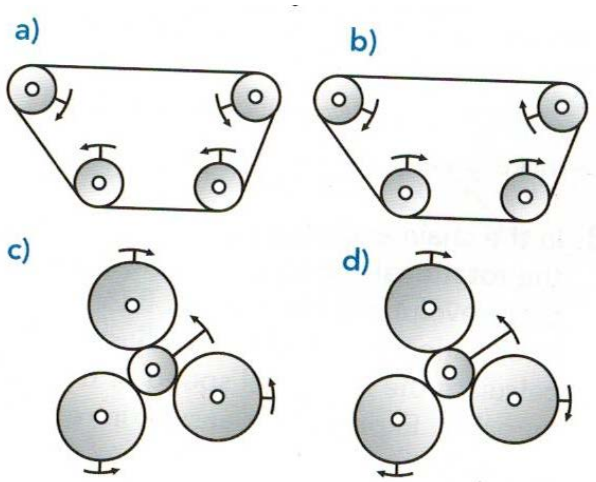
A) I and II only

B) II and III only

C) III and IV only

D) II, III and IV

2. Which of the following diagrams of a motion transmission system correctly illustrates the motion of the components?



A) I and II only

B) II and III only

C) II and IV only

D) I and III only

3. Explain why a sprocket wheel and chain system is used in a bicycle rather than a belt and pulley system

Answers

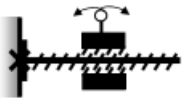
1. *B*
2. *C*
3. *The sprocket wheel and chain system does not permit slippage, therefore the forces applied to the pedals are transmitted to the back wheel*

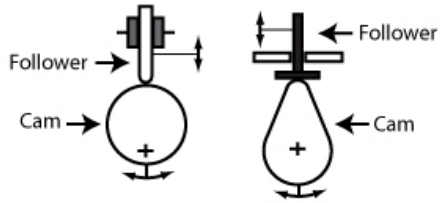
Mechanical Engineering: Motion Transformation Systems

I understand the construction and characteristics of the following ***motion transformation systems****.*

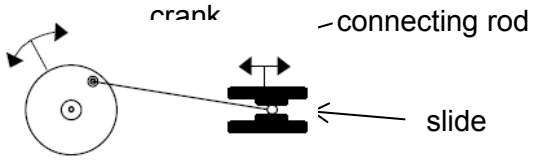
I can use the terms “driver component,” “intermediate component,” and “driven component” in the explanations of the mechanical systems.

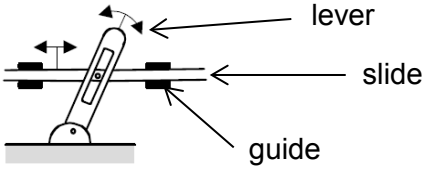
I can describe the reversibility of a motion transformation system.

Screw Gear System		
Symbol	**Type 1**  Nut is free component Screw is fixed component	**Type 2** Screw is free component Nut is fixed component
Description	• Rotational motion is applied to the free component to obtain translational motion in the other component • Transforms quick rotation to slower translation	
Reversibility	No, because you cannot transform translational to rotational motion in this system.	
Advantages	• Allows for precise adjustment in its use. Used in many types of tools and machinery	
Disadvantages	• Parts need to be lubricated	

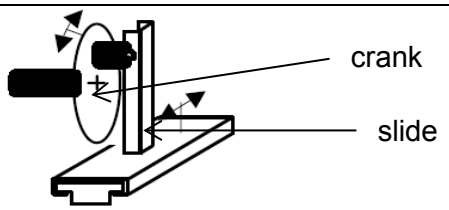
Cam and Follower	
Symbol	
Description	• Rotational motion can be applied to cam to create translational motion on the follower. The follower must have guidance of some sort to operate properly. • Size and shape of cam and placement of axle will determine the length and action of the stroke
Reversibility	No, because applying a force to the follower (moving it up and down) will not cause the cam to rotate.

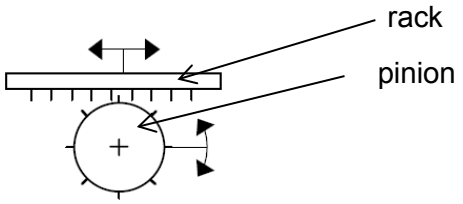
Advantages	• Allows for very precise and custom translational motion. Timing and distance of the follower can be determined by shape, size of cam and placement of axle on cam.
Disadvantages	• Parts need to be lubricated • A return mechanism (e.g. spring, gravityhas to be built into design

Connecting Rod and Crank	
Symbol	
Description	• Rotational motion can be applied to the crank to create translational motion in the slide. Connecting rod connects slide to crank. In order to achieve the change the slide must be guided. • Translational motion can be applied to slide to produce rotational motion in crank • Provides a mechanical advantage
Reversibility	Yes, because rotational motion can be applied to the crank to produce translational motion in the slide and translational motion can be applied to the slide to produce rotational motion in the pinion.
Advantages	• Allows force to be applied without slippage • Change motion from translational to rotational or vice versa • Allows force to be applied at a distance through the connecting rod
Disadvantages	• Parts need to be lubricated • Very precise fit needed between slider and guidance • Reversibility is only possible in a mechanism built to precise specifications

Lever and Slide	
Symbol	

Description	• Rotational motion can be applied to the lever to create translational motion in the slide and vice-versa. The slide must have guidance of some sort to operate properly. • The length of the lever will determine the distance that the slide will move. • Designed for short oscillatory movement
Reversibility	Yes
Advantages	• Simple mechanism
Disadvantages	• Parts need to be lubricated

Rotating Slider Crank Mechanism	
Symbol	
Description	• Rotational motion is transformed to translational motion in the slide • Translational motion of the slide is transformed into partial rotational motion in the crank • Provides a mechanical advantage which is determined by the size of the wheel • Produces oscillating motion
Reversibility	Yes, because rotational motion of the crank produces translational motion in the slide and translational motion of the slide produces partial rotational motion in the crank.
Advantages	• Change motion from translational to rotational or vice versa
Disadvantages	• Parts need to be lubricated • Reversibility is only partial

Rack and Pinion	
Symbol	
Description	• Rotational motion of pinion is transformed into translational motion of rack.

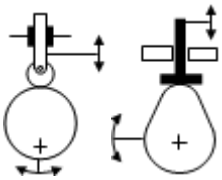
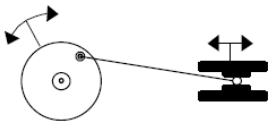
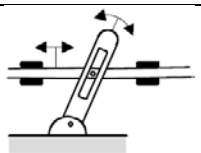
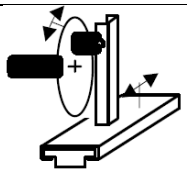
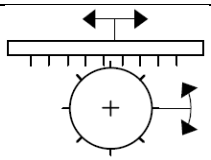
	• Translational motion can be applied to rack to produce rotational motion in the pinion • The rack is really a toothed gear wheel that has been straightened.
Reversibility	Yes, because rotational motion can be applied to the pinion to produce translational motion in the rack and vice versa.
Advantages	• Allows force to be applied without slippage
Disadvantages	• Parts need to be lubricated, • Very precise fit needed between teeth of rack and pinion

Mechanical Engineering: Motion Transformation Systems

I am familiar with the symbols for the motion transformation systems.

Explanation of Concepts

Symbols for Motion Transformation Systems

Motion Transformation System	Symbol
Screw Gear System	
Cam and Follower	
Connecting Rod and Crank	
Lever and Slide	
Rotating Slider Crank Mechanism	
Rack and Pinion	

Mechanical Engineering: Motion Transformation Systems

I can explain the choice of a motion transformation system in a technical object.

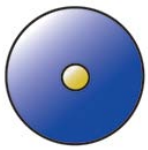
Explanation of Concepts

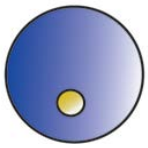
During the design of a technical object, one must consider which transformation systems are necessary and more advantageous than others. Being able to identify and explain these advantages involves the understanding of each of these systems.

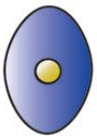
For an explanation of these systems refer back to screw gear system, cam and follower, connecting rod and crank, lever and slide, rotating slider crank mechanism and rack and pinion on the previous pages.

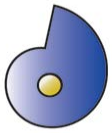
Questions

1. A cam and follower system transforms the rotational motion of a cam into the reciprocating translational motion of a follower. Which cam below would not allow for both clockwise and counter-clockwise motion?

A) 

B) 

C) 

D) 

2. A student wishes to build a pull toy of a clown sitting in a cart in which a mechanism will cause the hat of the clown to move up and down as the cart is pulled.

   Which one of the systems below would not be suitable for a mechanism in this toy?

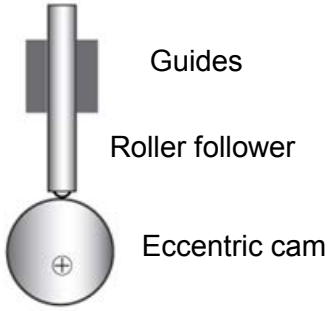
   A) Crank and slide

   B) Cam and follower

   C) Rack and pinion

   D) Crank, connecting rod, and slide

3. Examine the cam and follower system illustrated below.



Describe two ways the rise of the follower could be increased.

Answers

1. *D*
2. *C*
3. *Move the center of rotation closer to the outside of the cam. Increase the size of the cam.*

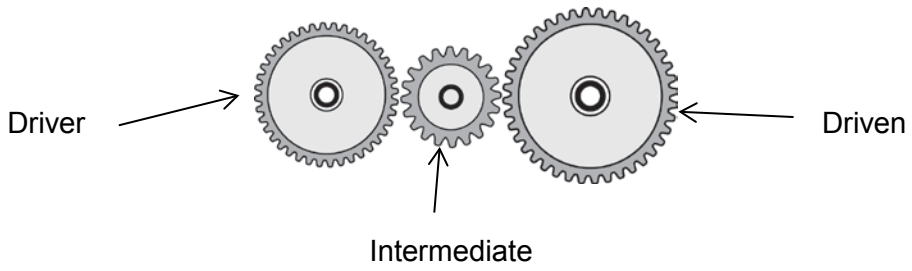
Mechanical Engineering: Speed Changes

I understand how systems can be used to allow for speed changes in the design of technical objects.

I can perform a simple calculation of the ratio between the driver and driven components

Explanation of Concepts

Speed Change occurs in a motion transmission system when the driven component rotates at a different speed than the driver.



Driver (Driving) Component: The component that receives the force needed for the system to start working and in most cases continue to work.

Driven Component: This component receives the motion from the driver component and transfers it to another part.

Intermediate Component: It is found between the driver and driven component. *Note that not all systems have an intermediate component.

The speed change in motion transmission systems depends on the relative diameters of the driver and driven components.

a) Speed Increase: Diameter of driver > diameter of driven

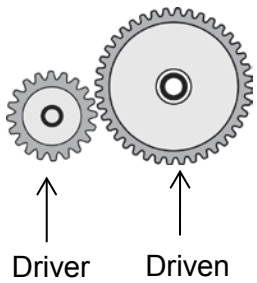
- When the diameter of the driver component is <u>greater</u> than the diameter of the driven component, there is a speed increase in the system.

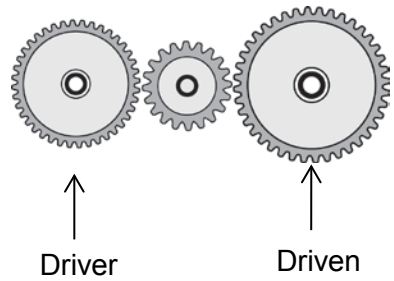
e.g.

b) Speed Decrease: Diameter of driver < diameter of driven

- When the diameter of the driver component is <u>less</u> than the diameter of the driven component, there is a speed decrease in the system.

e.g.

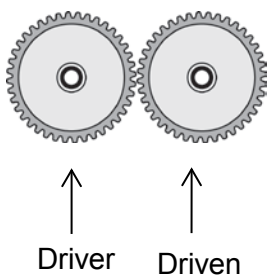


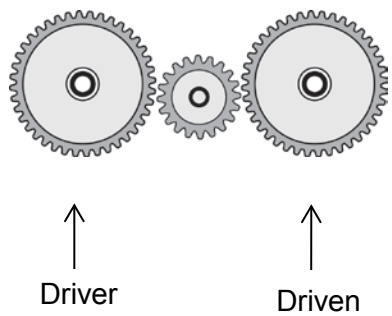


c) No Speed Change: Diameter of driver = diameter of driven

- When the diameter of the driver component is <u>equal to</u> the diameter of the driven component, there is no speed change in the system.

e.g.





Speed Ratio

The **speed ratio** can be used to describe the speed change for a system.

$$\text{Speed ratio} = \frac{\text{diameter (or number of teeth) of driver component}}{\text{diameter (or number of teeth) of driven component}}$$

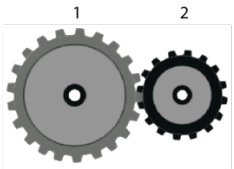
If the speed ratio = 1, then there is no change in speed.

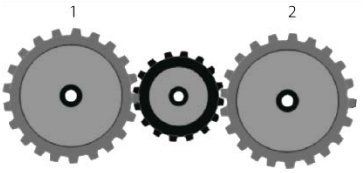
If the speed ratio >1, then there is an increase in speed

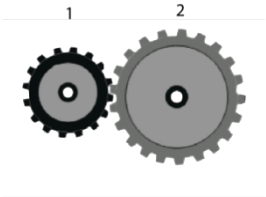
If the speed ratio is <1, then there is a decrease in speed.

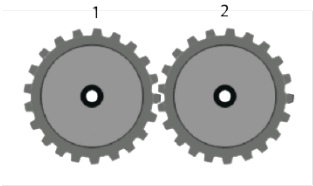
Questions

1. For which of the systems below will Gear 2 turn more quickly than the Gear 1?

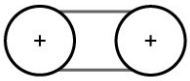
A) 

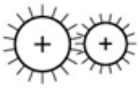
B) 

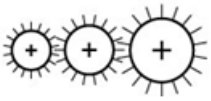
C) 

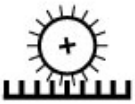
D) 

2. Which of the systems below could produce a change in speed similar to the one in a wheel and worm gear system?

   A) Two pulleys of equal size connected by a belt 

   B) A large driver gear turns a smaller driven (receptor) gear 

   C) A small driver gear turns a middle size intermediary gear which turns a large driven (receptor) gear 

   D) A rack and pinion system where the pinion is the driver and the rack is the driven (receptor). 

3. A wheel and worm gear system is shown below.

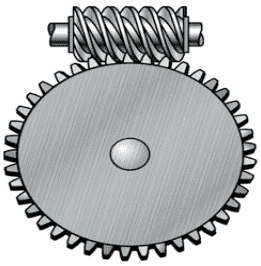
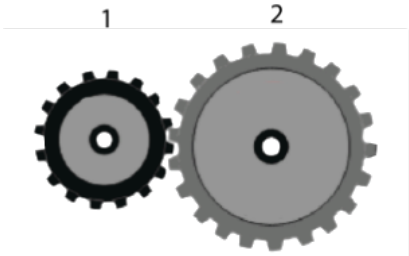


Image from: http://www.machinerylubrication.com/Read/1080/worm-gears
Retrieved: December 2013.

Given a constant speed of the driver (worm), what changes can be made to the components of the system to increase the speed of the driven gear?

4. A gear system is shown below.



Gear 1 is the driver gear and has a diameter of 8 cm. Gear 2 has a diameter of 10.5 cm.

Which gear turns faster and what is the speed ratio for the system?

Answers

1. *A*
2. *C*
3. *The best way to increase the speed in a worm and wheel transmission system is to have a gear that is smaller in diameter and/or a gear that has fewer teeth. A smaller diameter naturally takes less time to make one full rotation and few teeth means less time having each tooth mesh with this respective part on the worm component.*
4. *Gear 1 turns faster and the speed change ratio is 0.76.*

Electrical Engineering: Power Supply

I can define ***power supply*** *as* ***'the ability to provide an electrical current'****.*

Explanation of Concepts

A **power supply** has the ability to generate electrical current. A battery is an example of a power supply.

Questions

1. A circuit has many components. Which of the following components provides electrical current?
   A) Power supply
   B) Ammeter
   C) Voltmeter
   D) Switch

2. There are two types of electric drills. One has a battery while the other has to be plugged into an electrical outlet. Explain how a battery and an electrical outlet can be classified as power supplies in a circuit.

Answers

1. *A*
2. *The battery and electrical outlet both provide current and allow the electrons to flow through a circuit.*

Electrical Engineering: Power Supply

I can determine the source of current in technical objects with an electrical circuit.

Explanation of Concepts

Examples of the different power supplies (sources of current) in technical objects include:

Chemical battery: Chemical reactions inside the battery transform chemical energy into electrical energy.

Piezoelectric: Mechanical energy from vibrating crystals is transformed into electrical energy. Piezoelectric crystals are found in clocks, timers, lighters, ultra sound devices and speakers.

Solar cell (photovoltaic): Converts light energy to electrical energy.

Alternator: The mechanical energy of a rotating electromagnet is transformed into electrical energy.

Thermocouple: Thermal energy is transformed into electrical energy. A thermocouple is a sensor e.g. digital food thermometers, fridge thermometer, gas stoves and heaters.

Questions

1. A battery is a power source used in everyday objects. Which of the following objects does not use a chemical battery as a power supply?

   A) Flashlight

   B) Portable speakers

   C) Toaster

   D) Laptop

2. A piezoelectric quartz watch uses the vibration of crystals to keep track of time. Which type of energy transformation occurs in this system?

   A) Chemical energy into electrical energy

   B) Solar energy into electrical energy

   C) Magnetic energy into electrical energy

   D) Mechanical energy into electrical energy

3. Paul's calculator screen is dull when he sits in his living room where there is little light. When he walks into a well-lit room, the screen becomes brighter. What is the source of current in his calculator?

Answers

1. *C*
2. *D*
3. *Solar cell*

Electrical Engineering: Conduction, Insulation and Protection

*I can define **conduction** as the '**ability to conduct electricity**'.*

Explanation of Concepts

Conduction is the flow of electrons through a material.

Questions

1. Conduction plays an important part in an electrical circuit. Which of the following does NOT describe conduction?
   A) The flow of current through a switch
   B) The flow of current through a wire
   C) The flow of electrons through a wire
   D) The ability to prevent the current from flowing

2. The procedure for a lab on electricity states that the wires connecting the switch must touch the metal part and not the plastic part of the switch. Why is it important to connect the wire to the switch correctly?

Answers

1. *D*
2. *Conduction is the ability to allow the current to flow. The current can flow through the wire and the metal because they are conductors, but will not be able to flow through the plastic part of the switch because plastic is an insulator.*

Electrical Engineering: Conduction, Insulation and Protection

I can distinguish between electrical conductors and insulators in a technical object.

Explanation of Concepts

Conductor: A substance that allows electrical current to flow through it. Examples of good conductors are metals and electrolytic solutions.

Insulator: A substance that does not allow current to pass through it. Examples of good insulators are wood, plastics, paper, rubber, glass and ceramics.

Questions

1. Insulators are used in electronic toys. What material could a manufacturer use to insulate a part of a toy?

    1. Plastic
    2. Ceramic
    3. Metal
    4. Cardboard
    5. Glass

    A) 1, 2, and 4 B) 1, 2, and 5 C) 1, 2, 4, and 5 D) 1, 2, 3, 4, and 5

2. You are asked to build a circuit that will light up one light bulb with a switch. You have no wires available. The only materials in the classroom are listed below.

Chalk	Plastic fork
Cardboard	Nail
Wooden spoon	Ceramic coaster
Metal knife	Paperclip

    Which of the above materials could be used to complete the circuit? Explain your answer.

3. An ammeter is used to measure the current intensity; a voltmeter measures the potential difference in a circuit.

    Why do the terminals on an ammeter and a voltmeter have plastic casings over the metal components?

Answers

1. *C*
2. *The materials that could be used to replace the broken wire are the metal knife, nail and paperclip. They are all made out of metal and are good conductors. They all will allow the current to flow through them.*
3. *The plastic casing covers the metal component because it is an insulator. It does not allow the current to flow through it. Therefore, when you touch the knobs the current will not transfer to you and you will not get an electric shock.*

Electrical Engineering: Conduction, Insulation and Protection

I can describe the role of a protective device in a circuit (fuse, breaker).

Explanation of Concepts

Fuses and **breakers** are used to protect electrical circuits.

A high current intensity can result in a power surge which can damage electrical devices in a circuit and/or cause a fire. The protective components will then automatically cut off the flow of electrons (current) when there is too much of it passing through the circuit.

Fuses contain a thin wire that melts and breaks the circuit when there is too much current. The fuse needs to be replaced to restore the circuit.

Breakers contain a thin metal strip. When too much current passes through the breaker the metal becomes hot and bends. The metal is no longer in contact with the circuit and the current cannot pass through the breaker. Breakers can be used multiple times. By resetting the switch on a breaker the metal strip is returned to its original position and the current is restored.

Questions

1. Fuses and breakers are used in all buildings. What is the function of a fuse and breaker?
   A) Control the flow of the current
   B) Prevent the current from flowing
   C) Automatically cut the current
   D) Allow the current to flow in a circuit

2. While making toast, John turned on the coffee maker and almost immediately, both machines stopped functioning. Explain what happened.

Answers

1. *C*
2. *The electrical circuit was surcharged therefore; it couldn't handle operating both machines. The breaker was released disrupting the flow of electricity.*

Electrical Engineering: Conduction, Insulation and Protection

I can analyze the factors that affect electrical conductivity (section, length, nature, temperature of conductor).

Explanation of Concepts

The **conductivity** of a substance (how well it conducts) depends on the type of material, length, diameter and the temperature of the conductor.

The conductivity of a wire can be increased by:

- Increasing the diameter of the wire
- Decreasing the temperature of the wire
- Decreasing the length of the wire
- Changing the type of material (copper is one of the best and most affordable materials)

Questions

1. The conductivity of a wire in an electrical toy needs to be decreased. How should the electrical engineers change the wire?

    1. Increase the length
    2. Increase the diameter
    3. Decrease the length
    4. Decrease the diameter

    A) 1 and 2 B) 1 and 4 C) 2 and 3 D) 2 and 4

2. The properties of four copper wires are described in the table below.

Properties of Copper Wires

Wire	Length	Diameter	Temperature
A	10 m	2 mm	25 °C
B	10 m	3 mm	20 °C
C	20 m	2 mm	20 °C
D	20 m	3 mm	25 °C

Which of the copper wires has the best conductivity? Explain your answer.

Answers

1. *B*
2. *Wire B would have the highest conductivity. It has the shortest length, widest diameter and the lowest temperature, all of which are properties that increase conductivity.*

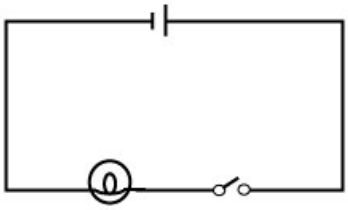
Electrical Engineering: Control

I can define ***control*** *as the* ***'ability to control the travel of electrical current'****.*

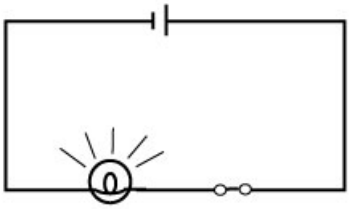
Explanation of Concepts

A **control** is a component placed in a circuit that helps regulate the flow of electricity.

A switch is the most common example of a control. When a switch is closed, current can flow through the circuit. When the switch is open, the current's pathway is broken and current cannot flow through the circuit.



Open Circuit



Closed Circuit

Questions

1. Controls play an important role in electrical engineering. Which of the following statements about control is false?

   A) A control is another word for switch

   B) A control regulates the electrical current in a circuit

   C) A control can be open or closed

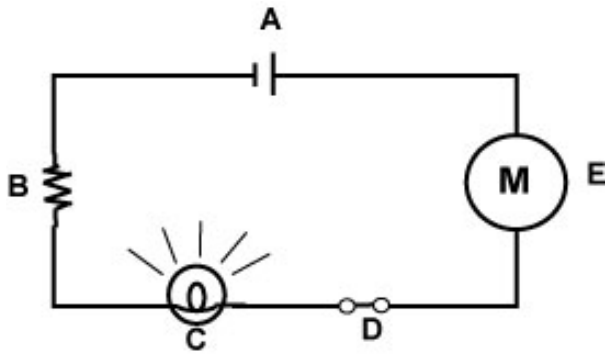
   D) A control regulates the speed of electrons in a circuit

2. In which of the situations below is current flowing through the circuit?

   1. The magnetic switch is closed in the presence of a magnetic field
   2. The magnetic switch is open in the presence of a magnetic field
   3. The flip-flop switch is closed in a circuit.
   4. The flip-flop switch is open in a circuit.

   A) 1 and 3 B) 1 and 4 C) 2 and 3 D) 2 and 4

3. Which of the following circuit components is a control?



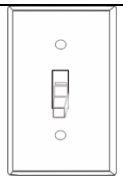
Answers

1. *D*
2. *A*
3. *D*

Electrical Engineering: Control

I can describe different types of switches (lever, pushbutton, flip-flop, magnetic control).

Explanation of Concepts

Type of Switch	Definition	Example
Lever	A **lever switch** is an electrical switch controlled by a mechanically moving arm through a small arc.	 1
Push Button	A **push button switch** completes an electric circuit when pressed. Push button switches can be found in computer keyboards (power button), doorbells, and calculators.	2
Flip-flop (rocker)	A **flip-flop switch** (**rocker switch**) is an on/off switch that rocks (back and forth) when pressed. One side of the switch is raised while the other side is lowered. A flip-flop switch can be found on a power bar.	3
Magnetic Control	A **magnetic control switch** has two pieces of metal that are separated by a gap. When the switch is near a magnetic field, the two pieces of metal come in contact with each other to close the circuit and allow the current to pass through it. A magnetic switch can be found home alarms on doors and windows.	4

Images from:

1: http://www.clker.com/clipart-light-switch-off.html **Retrieved** December 2013

2: http://upload.wikimedia.org/wikipedia/commons/a/a6/Knopka_8_ugolnik.jpg, **Retrieved** December 2013

3: http://openclipart.org/detail/46741/switch-black-on-built-in-by-palomaironique **Retrieved** December 2013

4: http://commons.wikimedia.org/wiki/File:Reed_switch_(aka).jpg.**Retrieved** December 2013

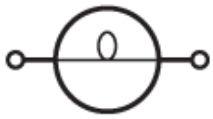
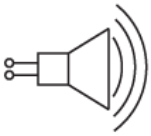
Electrical Engineering: Transformation of Energy

I can identify and explain the transformation of energy in different components of a circuit.

Explanation of Concepts

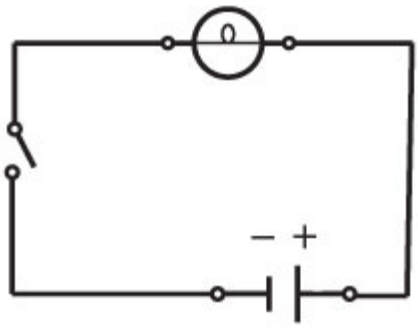
Electrical energy can be transformed into light energy, sound energy, mechanical energy or thermal energy.

Examples of Energy Transformations in Different Circuit Components

Component	Symbol	Transformation
Light Bulb		Electrical Energy →Light and Heat
Battery		<u>In Use:</u> Chemical Energy → Electrical Energy and Heat <u>Being Charged:</u> Electrical Energy → Chemical Energy and Heat
Motor		Electrical Energy →Mechanical Energy and Heat and Sound
Speaker		Electrical Energy → Sound and Mechanical Energy and Heat

Questions

1. Which of the following components of a circuit transforms energy?



1. light
2. switch
3. battery
4. wires

A) 2 and 4 B) 1 and 3 C) 1, 2, and 3 D) 1, 3, and 4

Answers

1. *B*

Electrical Engineering: Transformation of Energy

I can describe the energy transformations that take place in electrical or electronic appliances.

Explanation of Concepts

Electronics and electrical appliances *transform* **electrical energy** into **other forms** of energy depending on the device used in the system.

Electrical Energy can be transformed into:

- Light (luminous) Energy
- Sound Energy
- Mechanical (movement) Energy
- Thermal (heat) Energy.

Questions

1. A fan is designed to transform electrical energy to:

   A) Sound energy

   B) Mechanical energy

   C) Thermal energy

   D) Light energy

2. Identify the transformations that occur in each of the appliances listed below as electrical energy is transformed into other forms of energy.

Appliance	**Useful energy (purpose of appliance)**	**Other form(s) of energy**
T.V.	Light, sound	Thermal
Toaster		
Flashlight		
Blender		
Hairdryer		
Radio		

Answers

1. *B*
2. *A doorbell transforms electrical energy into sound energy. Electrical energy to light energy.*
3.

Appliance	***Useful energy (purpose of appliance)***	***Other form(s) of energy***
T.V.	*Light, sound*	*Thermal*
Toaster	*Thermal, Mechanical*	*Light*
Flashlight	*Light*	*Thermal*
Blender	*Mechanical*	*Sound, Thermal*
Hairdryer	*Thermal, Mechanical*	*Sound*
Radio	*Sound, Light*	*Thermal*

Materials: Constraints

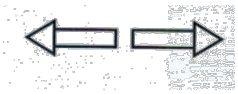
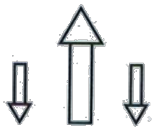
I can define ***constraint*** *as '****an external force (shearing, compression, deflection, torsion and tension) that is exerted on materials and that has a tendency to deform them'****.*

Explanation of Concepts

The parts of a technological object may be subjected to one or more external **constraints** or forces.

These forces can **deform** the parts.

Types of Constraints and Their Symbols

Constraint	Description	Symbol	Examples
Compression	Forces that tend to crush it.		Crushing a can. Squeezing a wet sponge.
Tension	Forces that tend to stretch it.		Copper being stretched into wire. Tug of war.
Torsion	Forces that tend to twist it.		Hands wringing a towel. Earthquake twisting a bridge.
Deflection	Forces that tend to bend it.		Fish bending a fishing rod. Clothes pushing down on a clothesline.
Shearing	Forces that tend to cut.		Scissors cutting paper.

Questions

1. The following image is an example of what type of constraint?

A) Compression

B) Torsion

C) Deflection

D) Tension

2. The following image is an example of what type of constraint?

A) Compression

B) Torsion

C) Deflection

D) Tension

3. A new bridge is being built for cars to cross the St. Lawrence River. What types of constraints must an engineer consider when he is designing the bridge?

Answers

1. *C*
2. *B*
3. *The top of the beams will be subjected to compression force by the traffic on the bridge, while at the same time the bottom of the beam is subjected to tension. Where the beams are supported on the pillars shearing forces must be taken into account. The pillars are subjected to compression forces from the weight of the bridge.*

Materials: Characteristics of Mechanical Properties

*I can define certain **mechanical properties** of materials: ductility, hardness, elasticity, fragility, malleability, resilience and stiffness.*

Explanation of Concepts

The **mechanical properties** of a material describe how it reacts when subjected to one or more constraints (forces).

Types of Mechanical Properties

Mechanical Property	Definition
Hardness	Capacity to resist indentation (nicks), abrasion (scratches), or deformation
Elasticity	Capacity to return to their original shapes after undergoing a constraint
Resilience	Capacity to resist shocks by undergoing deformation and then returning to its original shape.
Fragility	Capacity to break without undergoing deformation when subjected to various constraints
Stiffness	Capacity to retain their shapes when subjected to various constraints
Ductility	Shaping property usually associated with metals Capacity to be drawn into wires without breaking
Malleability	Shaping property usually associated with metals Capacity to be flattened or bent without breaking

Materials: Characteristics of Mechanical Properties

I can explain the choice of a material based on its properties.

Explanation of Concepts

Materials used in construction of technical objects have different properties.

When choosing a material for an object, the forces or constraints the object will be subjected to will help determine which material is most suitable.

Examples:

- Steel is selected for the construction of manhole covers because it is malleable, hard and resistant.
- Copper is selected for the construction of electrical cables. In addition to being conductive, it is highly ductile, allowing it to be drawn into long wires and cables.
- Glass is selected for the cover of fire alarms. The fragility of the glass allows it to be broken easily so the fire alarm can be accessed.

Questions

1. John wants to build a go-cart in order to enter a race taking place this summer. What material(s) should he use for each of the parts listed below? Explain your answer.
   a) Tire
   b) Body Frame
   c) Seats

2. Hockey sticks are made from a material that can resist indentation and shock when coming into contact with a puck or the ice. The material also has to be lightweight to be easily handled by the player. Here is a list of possible materials to choose from:

Materials	Properties
Steel	Hardness Resilience Ductility High density High thermal conductivity
Carbon fibre	Low density Hardness Resilience Electrical conductivity Resistant to corrosion Rigidity
Polymethyl (acrylic)	Hardness Rigidity Comes in a variety of colours Malleability Brittleness
Polyamide (nylon)	Resilient Medium hardness Flexible High moisture absorbance

Which of the materials above would be the best material to use for a hockey stick? Explain your choice by using the properties of the materials.

Answers

1.

a) *The tires should be made of rubber. The material needs to be strong enough to resist friction due to driving at fast speeds. It also needs to be able to grip the asphalt and provide as smooth a ride as possible. It must also be easily changeable in case of damage or accident.*

b) *The body frame should be made of aluminum due to its malleability and lightweight properties. This will allow the go-cart to go faster because it is lightweight and the malleability allows the builder to bend the structure according to their vision for the final product.*

c) *The seats should be made of various materials. Metal can be used to make the shape of the seat. Foam, covered by leather, vinyl, or cloth, can be used for the cushion*

2. *The best material would be carbon fibre because:*

Low density: light weight
Hardness and resilience: resistance to denting and shocks
Resistance to corrosion: subjected to ice and water
Rigidity: resistance to application of constraints.

Materials: Other Properties

*I can define certain **properties of materials**: chemical neutrality, corrosion resistance, electrical conductivity, heat resistance, and thermal conductivity.*

Explanation of Concepts

Properties of Materials

Property	Definition
Chemical Neutrality	Describes a material that is not chemically active
Resistance to Corrosion	Ability to resist the effects of corrosive substances, which cause the formation or rust for example.
Electrical Conductivity	Ability to carry an electric current.
Heat Resistance	Ability to resist heat while retaining its mechanical properties
Thermal Conductivity	Ability to transmit heat.

Questions (refers to previous 2 statements)

1. What mechanical properties should materials for a hard-hat have? Explain your answer.

White hard hat by Jessica, http://www.clker.com/clipart-white-hard-hat-5.html **Retrieved**: December 2013

Answers

1. *The purpose of a helmet is to protect the wearer from any dangers. The mechanical properties involved in the choice of material are:*
   - ***Hardness:*** *To avoid as much as possible any scratches or dents.*
   - ***Resilience:*** *In case of shocks or impact, the helmet needs to stay intact without breaking to protect the wearer.*
   - ***Stiffness:*** *The helmet needs to hold its shape when it is confronted with many constraints again to protect the wearer.*
   - ***Non-****electrically conductive*

Materials: Types and Properties

I can relate the use of thermoplastics to their properties.

I can relate the use of thermosetting plastics to their properties.

I can relate the use of ceramics to their properties

Explanation of Concepts

Plastics are materials made of polymers that combine in different ways to obtain various properties.

Plastics fit into two categories: thermoplastics and thermosetting plastics.

Thermoplastics can be heated to soften and shaped over and over again. They can harden when cooled and keep their properties. Some properties of thermoplastics are:

- Chemical neutrality (unreactive)
- Elasticity
- Lightness
- Resilience
- Corrosion resistance

Thermosetting plastics can only be heated and shaped once. Once shaped, they remain hard, even when re heated. Some properties of thermosetting plastics are:

- Hardness
- Resilience
- Heat resistance
- Stiffness

Since thermosetting plastics retain their shape and strength when heated, they are used in situations where resistance to heat is important. Cooking pot handles, kitchen counters and electrical fittings are made from thermoplastics.

Ceramics are the result of heating inorganic matter. Some properties of ceramics are:

- Hardness
- Low electrical conductivity
- Wear resistance
- Heat resistance
- Corrosion resistance

Summary of Properties

Properties of Materials	Ceramics	Thermoplastics	Thermosetting Plastics
Electrical conductivity	low or none	none	none
Thermal conductivity	variable	low	variable
Hardness	very high	variable	high
Elasticity	none	high	variable
Chemical neutrality	high	high	variable
Stiffness	very high	variable	high
Heat resistance	very high	variable	high
Corrosion resistance	high	high	high
Resilience	low	high	high

Questions

1. Why would a homeowner choose a ceramic floor in the kitchen and bathroom rather than a wooden floor?

Answers

1. *Ceramic floors in the kitchen and bathrooms are ideal because these rooms deal with water. Wood would rot if it was exposed to water over a longer period of time whereas ceramic does no absorb water, can be easily cleaned if exposed to water and can last a long time.*

Materials: Modification of Properties

I can describe different treatments to prevent degradation of materials.

Explanation of Concepts

Over time materials can degrade. As a result, several techniques and treatments have been developed to help prevent degradation and allow the material last longer.

Some techniques used to prevent degradation are described below.

Wood and Modified Wood*:*

- Varnish
- Paint
- Treatment with a special protective coating like an alkaline solution that contains copper (Turns the wood bluish).
- Subjecting it to high temperature

Ceramics:

- Heating
- Coating them in enamel a protective coating
- Avoiding exposing them to acids, bases and thermal shock
- Note: Ceramics are generally very durable. They are even found in archeological digs.

Metals and Alloys:

- Coating the metal with treatments.
- Metallic Coatings: zinc (galvanization), chrome, gold, silver, nickel, aluminum, lead
- Other Coatings: paint, enamel, grease, resin
- Exposing to high heat to make the material harder like steel

Plastics:

- Protecting the plastic with waterproof coatings
- Adding antioxidants like carbon to prevent oxidation
- Adding pigments that absorb UV rays

Composites:

- Two main problems with composites that lead to degradation are deformation and loss of adherence between the materials.
- To prevent degradation again depends on the materials used in making the composite and applying the protection to the material.

Questions

1. You are thinking of building of a deck in your backyard. You look at a neighbor's deck and see that it is discolored and rotten in certain places.
   a) How can you explain the state of your neighbor's deck?
   b) How could you prevent your deck from looking like your neighbor's?

Answers

1.

a) The neighbor's deck is discolored and rotten due to the fact that the wood was not treated against possible degradation. As a result, rotting occurred.

b) It is best to use wood that has been pressure treated with a preservative. The wood also needs to be sealed with varnish or a weather treatment to prolong the life span of the wood especially if it will be exposed to harsh climate conditions and many forms of precipitation

Graphical Language

I can interpret an exploded view drawing of a technical object.

Explanation of Concepts

An **exploded view** is a technical diagram of an object that shows the relationship or the order of assembly of the various components. The components of the object are shown slightly separated.

An example of an exploded view drawing is shown below. The legend indicates the name of each numbered component as well as the quantity (QTY) of those components required for the assembly of the object.

Gear Pump – Exploded View Drawing

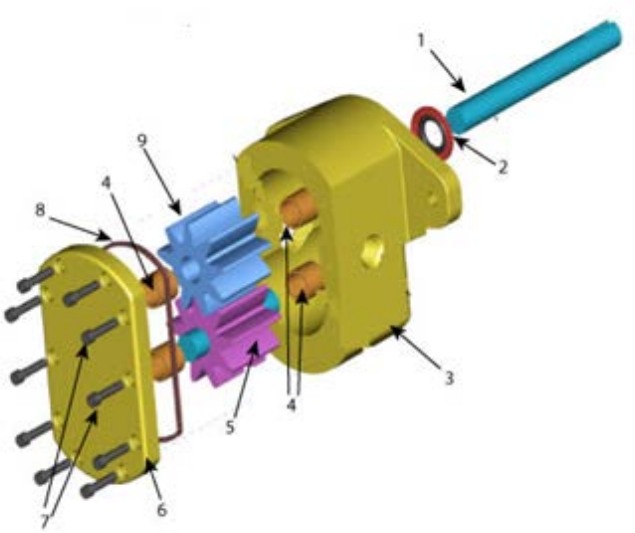


Image from:

http://commons.wikimedia.org/wiki/File:Gear_pump_exploded.png

In the example above, the component labelled, “1” is the axle and there is one axle in the Gear Pump. The component labelled “7” is a bolt and there are 10 bolts in the gear pump.

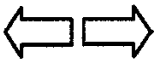
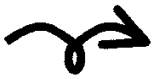
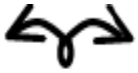
Item	QTY	Name
1	1	Axle
2	1	Seal
3	1	Housing
4	4	Bushings
5	1	Idler gear
6	1	Housing Cover
7	10	Bolts
8	1	Case seal
9	1	Driver Gear

Graphical Language

I can identify force and motion symbols.

Explanation of Concepts

Motion and Force Symbols

Motion		**Force**	
Motion is characterized by the change in the position of a body relative to another, which is called an *inertial* or *non-inertial reference system.*		Force refers to the capacity to act or produce an effect or any action that changes a body's state of rest or motion.	
Rectilinear translation in one direction		Force that tends to STRETCH the bodies or PULL them.	
Rectilinear translation in two directions		Force that tends to SQUEEZE the bodies or PUSH them.	
Rotation in one direction		Force that tends to TWIST bodies.	
Rotation in two directions		Force that tends to SPLIT bodies.	
Helical			
Helical motion in two directions