MATERIAL WORLD

Properties of Solutions: Concentration

I can determine the concentration of an aqueous solution (g/L, percentage 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. $\frac{15\text{ g}}{100\text{ mL}} = \frac{x\text{ g}}{450\text{ mL}}$

   $x = 67.5$ 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: Electrolytes

I can describe the concept of an electrolyte.

Explanation of Concepts

An **electrolyte** is a substance that can conduct an electric current when it is dissolved in water. Substances that are electrolytes include acids, bases and salts. Electrolytes will only conduct electricity if dissolved in water because when they dissolve in water, they dissociate into ions. It is the presence of ions that allows the flow of an electric current.

Compounds that do not conduct electricity when dissolved in water are called **non-electrolytes.** Non-electrolytes do not dissociate into ions. Substances that are non-electrolytes include sugars such as glucose ($C_6H_{12}O_6$) and alcohols such as methanol (CH_3OH).

Note: Although organic alcohols such as methanol contain an "OH" in the chemical formula, they are not bases since they do not dissociate into a metal ion and a hydroxide ion, OH^-.

Questions

1. Substance A was found in a laboratory and various tests were performed on it in order to classify it. The following was observed: substance A had no effect on litmus paper, was able to conduct electricity and turned cobalt chloride paper pink. This substance can be classified as a(n):

   A) Acid

   B) Base

   C) Electrolyte

   D) Non-electrolyte

2. What conditions must be met for a substance to be called an electrolyte?

3. Which of the compounds listed below are electrolytes? Explain your answer.

   CH_4, CaOH, $CaCl_2$, CH_3OH, $C_6H_{12}O_6$, H_3PO_4

Answers

1. *C*
2. *Acid, base, or salt dissolved in water and producing positive / negative ions*
3. *CaOH (base), $CaCl_2$ (salt), H_3PO_4 (acid) are electrolytes. They do dissociate into ions in aqueous solution. CH_4, CH_3OH, $C_6H_{12}O_6$ are non-electrolytes; they do not dissociate into ions in aqueous solutions.*

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

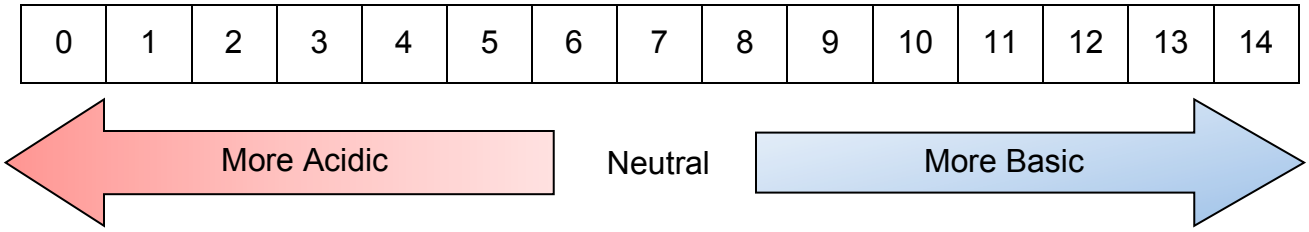
The pH scale is a measure of how acidic or basic a substance is. The pH scale ranges from 0 to 14, with 0 being the most acidic and 14 being the most basic.

A solution with a pH below 7 is acidic.

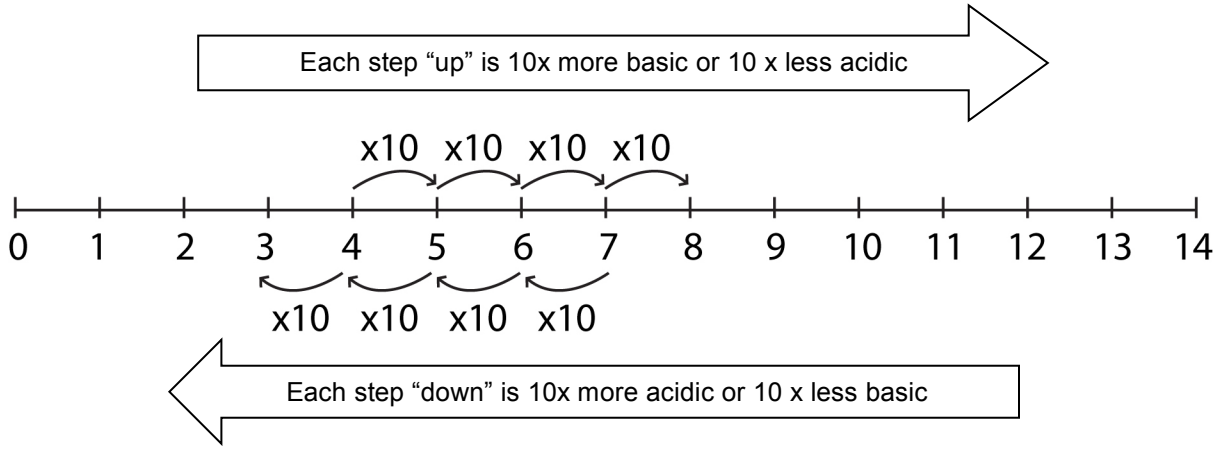
A solution with a pH above 7 is basic (alkaline).

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.

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.***

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.

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

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).

Explanation of Concepts

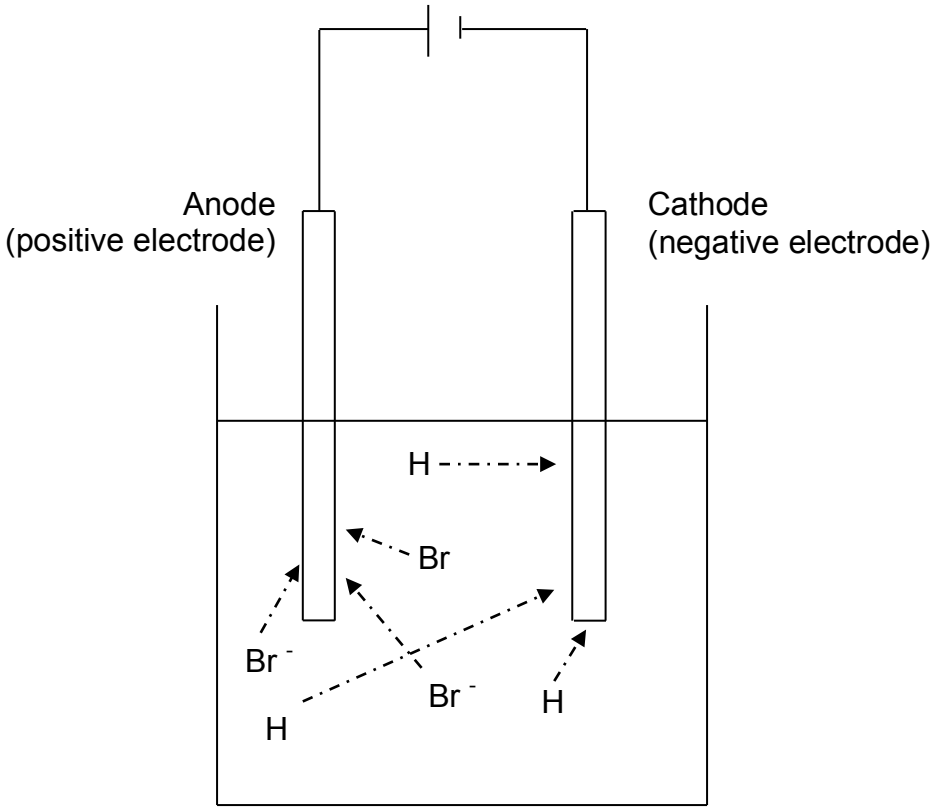
When an ionic substance dissolves in water, it dissociates into positive and negative ions.

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

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. *A*

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.

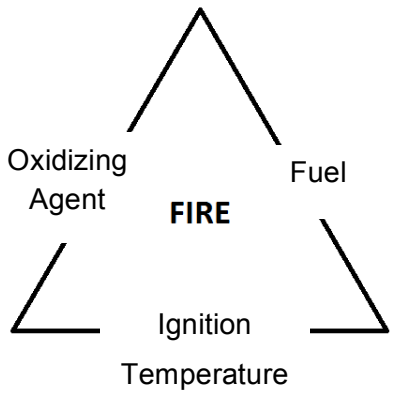
Explanation of Concepts

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.

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 H2O = 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. It starts with "**H**"
- 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

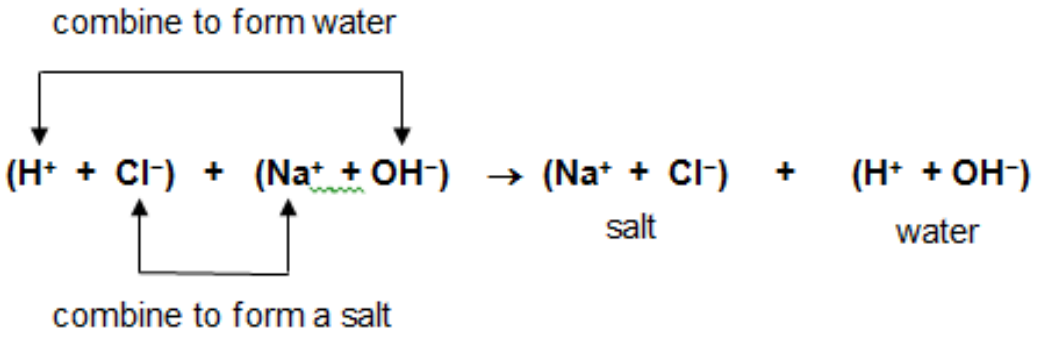
I can recognize an acid-base neutralization reaction from its equation.

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 → 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 → 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)?

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

   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 = sulfur trioxide

   320 g + 72 g = sulfuric acid

   392 g = sulfuric acid

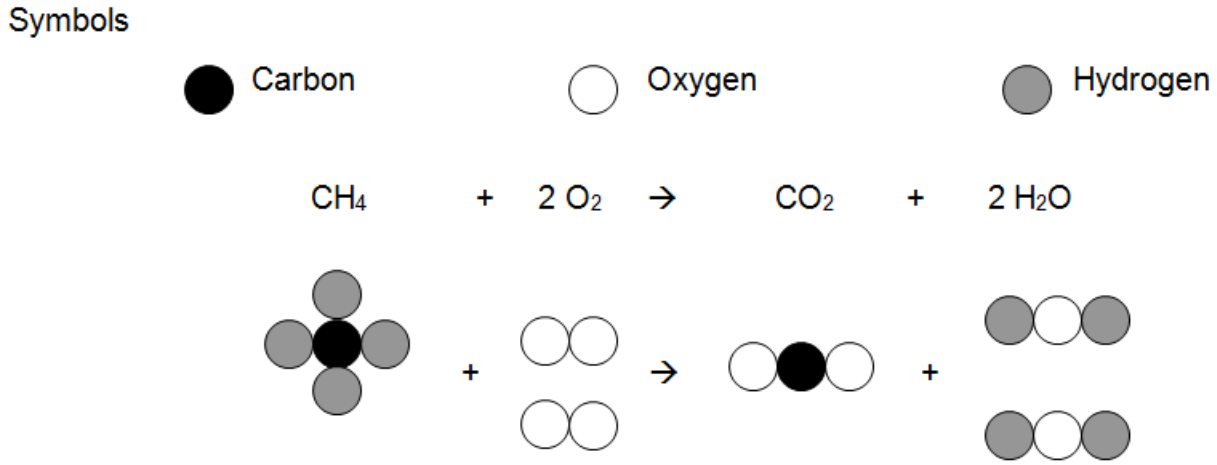
Chemical Changes: Law of Conservation of Mass

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.

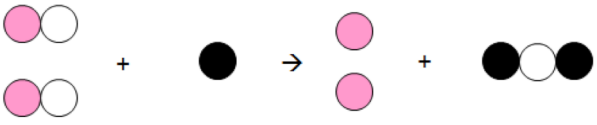
$$2\,CuO + C \rightarrow 2\,Cu + CO_2$$

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	C: 5(1) = 5
	H: 12	H: 6(2) = 12
	O: 8(2) = 16	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.

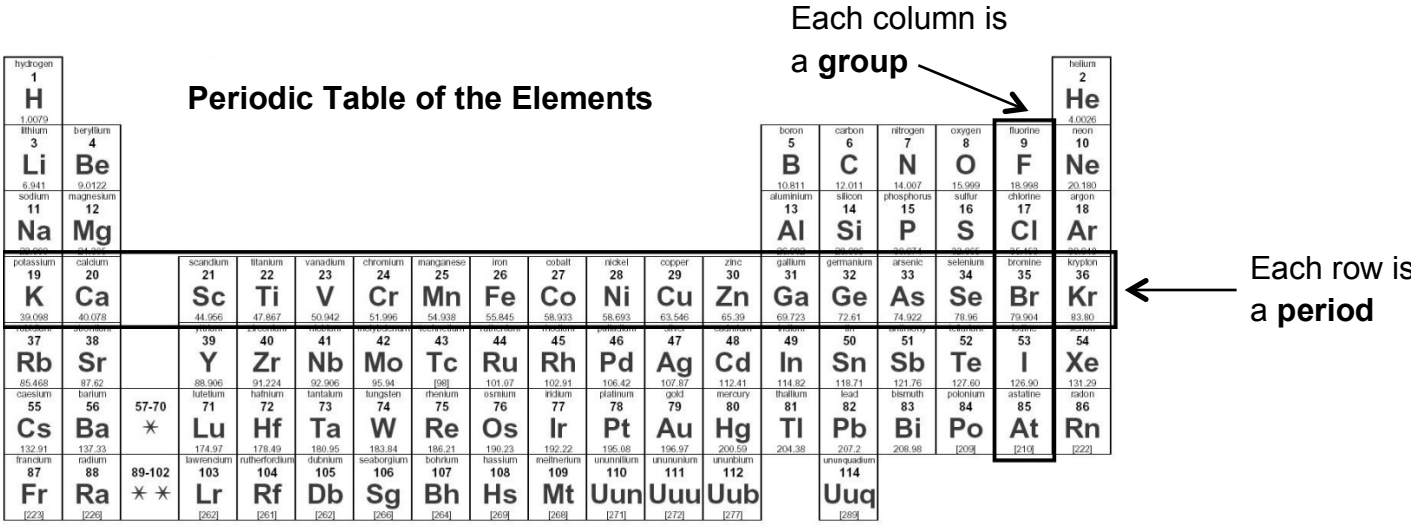


*Image modified from .http://commons.wikimedia.org/wiki/File:Periodic-table.jpg **Retrieved** March 12, 2014*

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

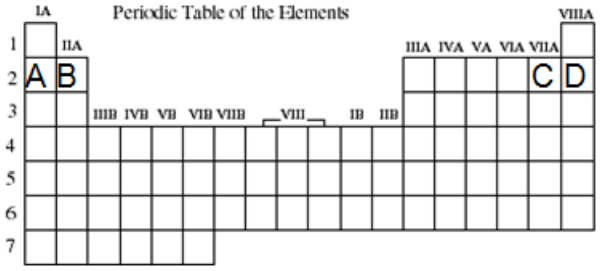
Group VIIA: Halogens	
General Description	• F, Cl, Br, I, At • Have seven valence electrons
Properties	• Very reactive (in nature they exist only in combined states) • Toxic and corrosive • Form salts when combined with alkali metals • Form strong acids in combination with Hydrogen

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 4^{th} 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

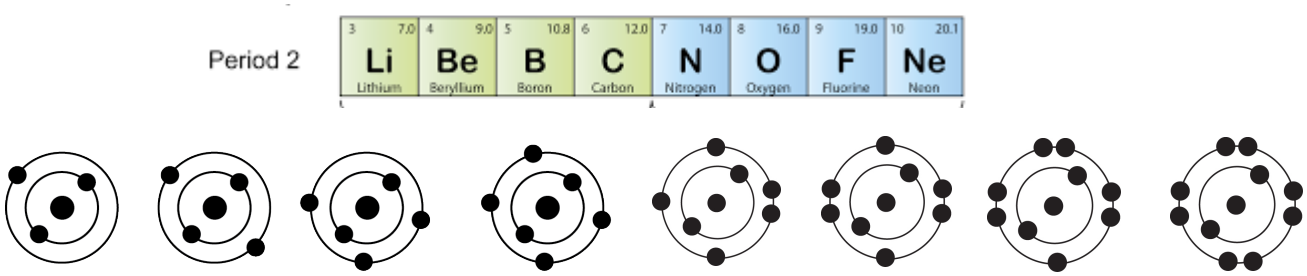
Organization of Matter:
Groups and Periods in the Periodic Table

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

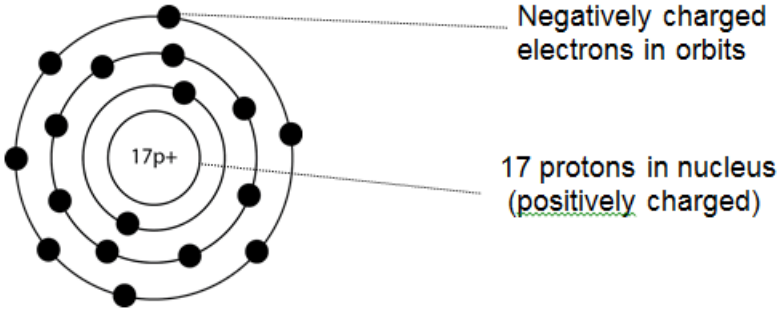
Nucleus

- 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)

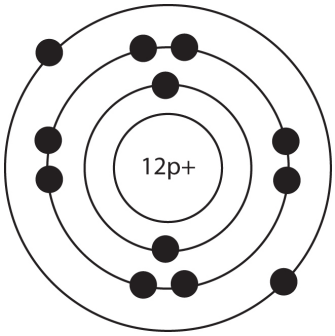
- Neils Bohr conducted experiments using light that allowed him to conclude that the electrons of an atom exist on specific orbitals which he called orbits.
- The orbitals hold the negatively charged electrons in their positions.
- Electron orbitals of an atom differ in the number of electrons that can 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

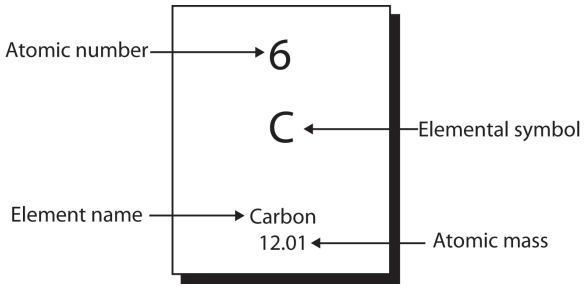
c) Magnesium

Organization of Matter: Rutherford-Bohr Atomic Model

I can represent atoms using the Rutherford-Bohr model.

Explanation of Concepts

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

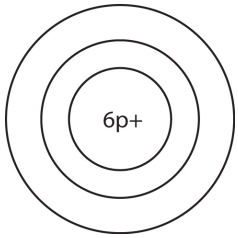


The **Atomic Number** represents the number of protons. The number of protons is equal to number of electrons. In this example, carbon has 6 protons and 6 neutrons.

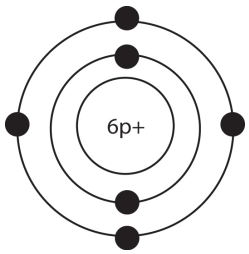
Step 2: Indicate the number of protons in the nucleus of the atom. Do not forget to include the charge symbol. (p^+ , +)

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

1. *A*
2. *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.

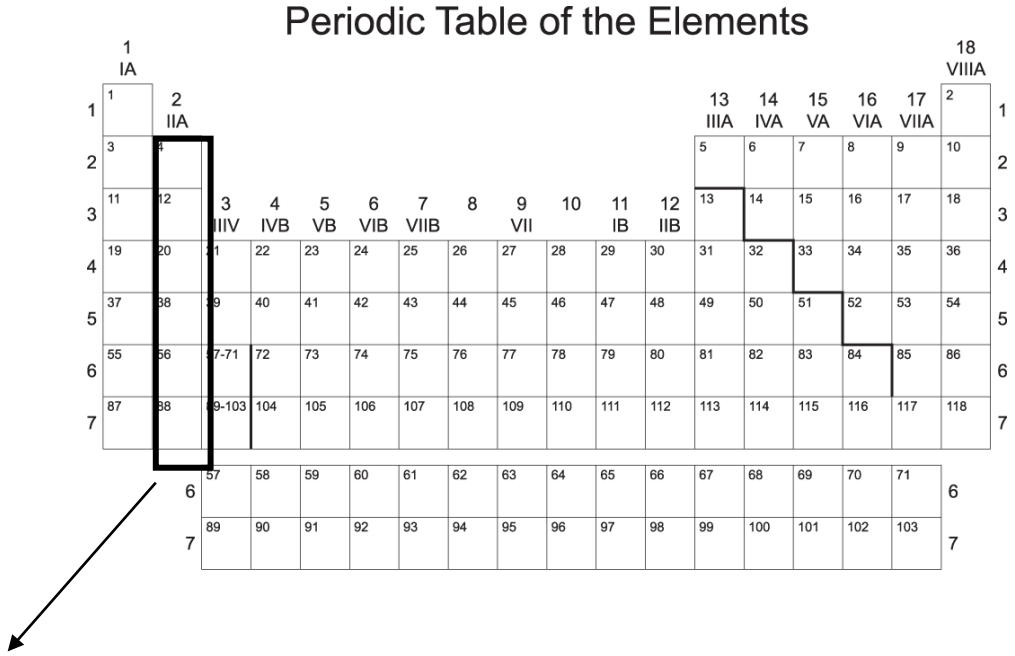
Organization of Matter: Lewis Notation

I can determine the number of valence electrons in an element.

Explanation of Concepts

The number of **valence electrons** in an atom refers to the number of electrons located in the last or outermost orbital or shell.

Using the periodic table of elements one can easily determine the number of valence electrons by looking at the group number in Roman Numerals. The group number is equal to the number of valence electrons. Every element in the group will have the same number of valence electrons.



Example:

All elements in Group II will have 2 electrons on their valence shell; they will have 2 valence electrons.

Questions

1. Which of the following correctly matches the element with the number of valence electrons it possesses?

   A) Helium (2), Carbon (4), Magnesium (2), Potassium (1)

   B) Helium (8), Carbon (4), Magnesium (2), Potassium (1)

   C) Helium (1), Carbon (2), Magnesium (3), Potassium (4)

   D) Helium (2), Carbon (2), Magnesium (3), Potassium (4)

2. Examine the elements in the table below:

Element	Number of Valence Electrons	Number of Electron Shells
Silicon		
Chlorine		
Argon		
Sodium		
Potassium		

   a) Indicate the number of valence electrons and number of electron shells for each of the elements listed in the table above.

   b) Which two of the elements listed above are in the same group? How do you know this?

Answers

1. *A*

2.

a)

Element	***Number of Valence Electrons***	***Number of electron shells***
Silicon	*4*	*2*
Chlorine	*7*	*3*
Argon	*8*	*3*
Sodium	*1*	*3*
Potassium	*1*	*4*

b) Sodium and Potassium because they have the same number of valence electrons. This means that these two elements will react in similar ways. Any element in the same group will have the same number of valence electrons and will share similar properties.

Organization of Matter: Lewis Notation

I can represent atoms using Lewis notation.

Explanation of Concepts

Lewis Notation is a simplified way to represent the atom. It is created by indicating the element's symbol followed by placing dots around the symbol corresponding to the number of valence electrons that atom has.

The valence electrons are placed one by one around the symbol, like the four points of a compass. When these four positions are filled, the electrons are then doubled to form pairs.

You can start at any point on any side of the symbol. In addition, it does not matter which side is left empty when doubling up electrons.

Example:

Chlorine has 7 valence electrons because it is in group VIIA of the periodic table. Therefore, 7 electrons need to be represented around the symbol for Chlorine, Cl. The Lewis structure would therefore look like the image on the below.

The Lewis dot diagrams for Period 2 of the periodic table. Note that the number of electrons represented (number of valence electrons) for each element corresponds to the group number on the periodic table.

Li ·	Be·	·B·	·C·	·N:	·O:	:F:	:Ne:

Questions

1. The salinity of water is due to the presence of mineral salts. Sodium chloride (NaCl) is one of the salts dissolved in seawater.

   Use Lewis notation to represent each atom that makes up sodium chloride (NaCl).

Answers

1.

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

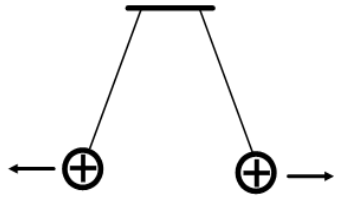
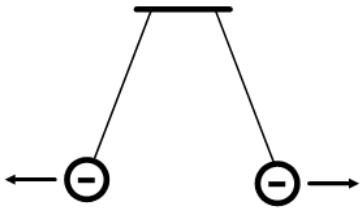
I understand that two objects with similar electrical charges will repel each other and that two objects with opposite electrical charges will attract each other.

Explanation of Concepts

Brought close together, two electrically charged objects interact.

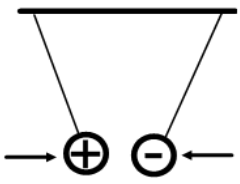
Possibility 1

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

positive repels positive	
negative repels negative	

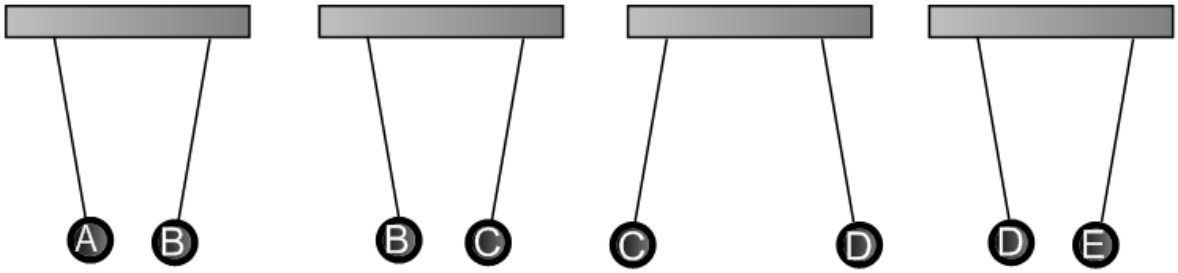
Possibility 2

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

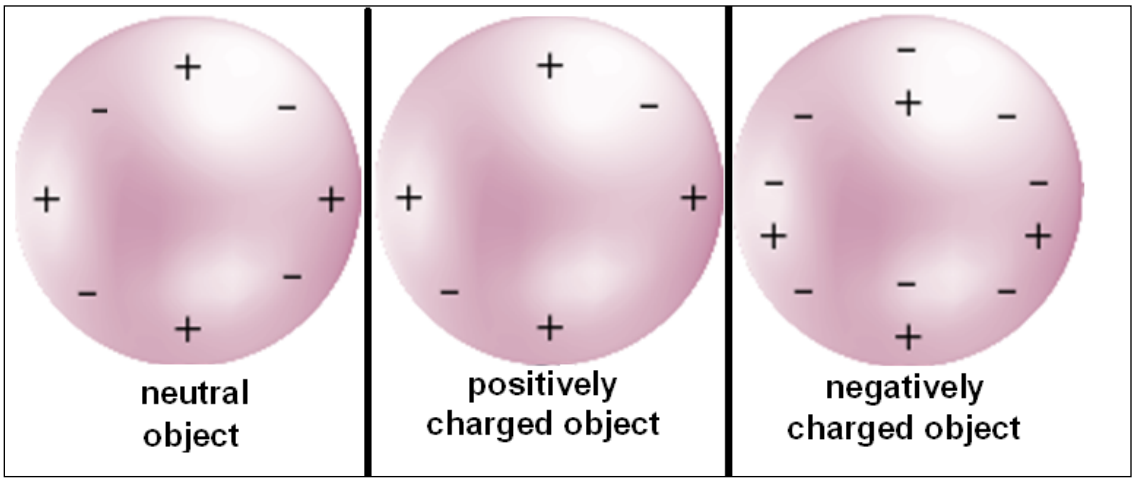
I can describe static electricity as the transfer of electrons from one body to another.

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.

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 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?

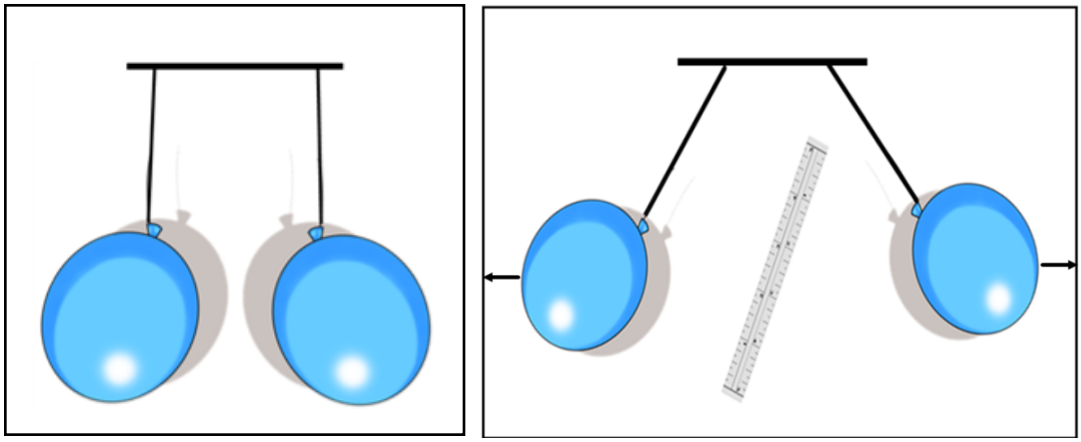
   A) Positively charged objects have a fewer protons than electrons.

   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.

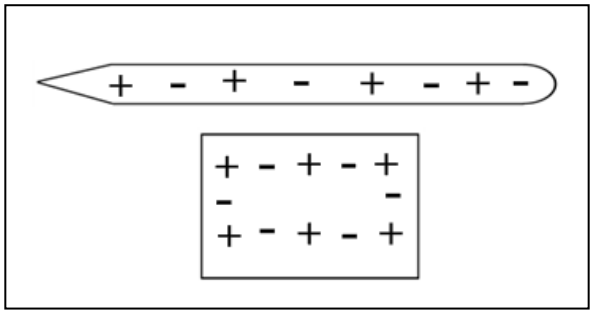
4. A student rubbed two identical inflated balloons on a piece of fur and suspended them from a high stand. He then rubbed a plastic ruler with a piece of wool and placed it between the two suspended balloons. The balloons quickly went high in the air as shown in the diagrams below.



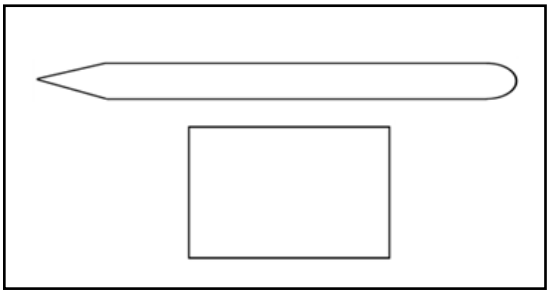
   Knowing that the wool cloth transferred electrical charges to the ruler, determine the overall charge of the balloons, fur, ruler and wool cloth. Explain your answer.

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.

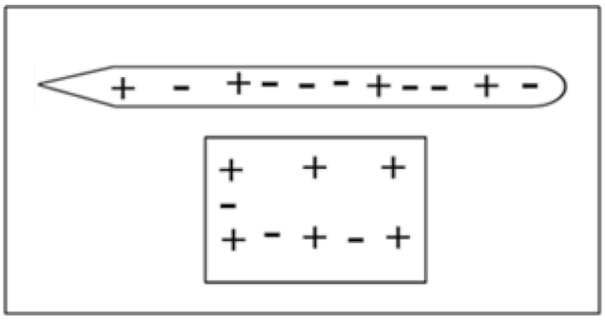
Answer

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 between two points 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 ↑ then I ↑
- If V ↓ then I ↓

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 ↑ then I ↓
- If R ↓ then I ↑

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) to calculate 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:

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

The above formula can be also written as:

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

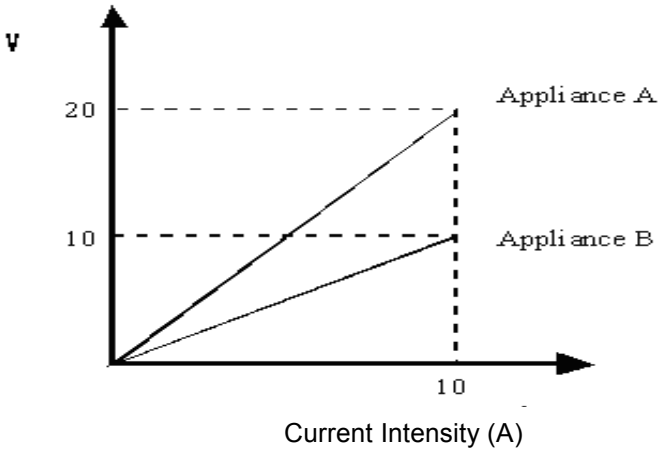
where:

- 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.

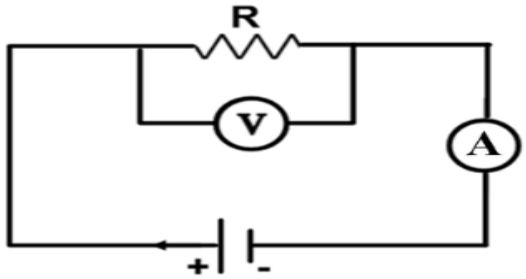
Appliance A	Appliance B
$R = \frac{20\ V}{10\ A}$	$R = \frac{10\ V}{10\ A}$

- Solve for R

Appliance A	Appliance B
$R = 2\ \Omega$	$R = 1\ \Omega$

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

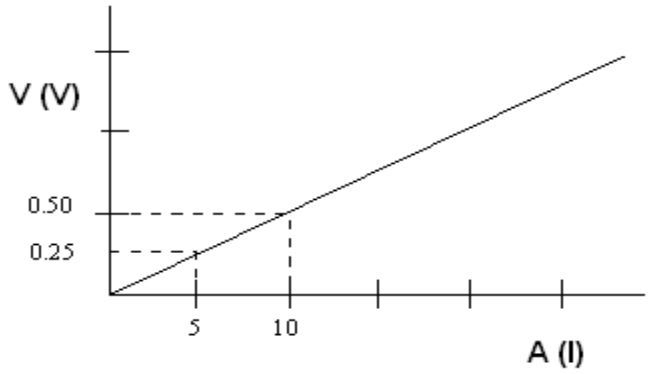
   B) 1.5 A

   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. *B*
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

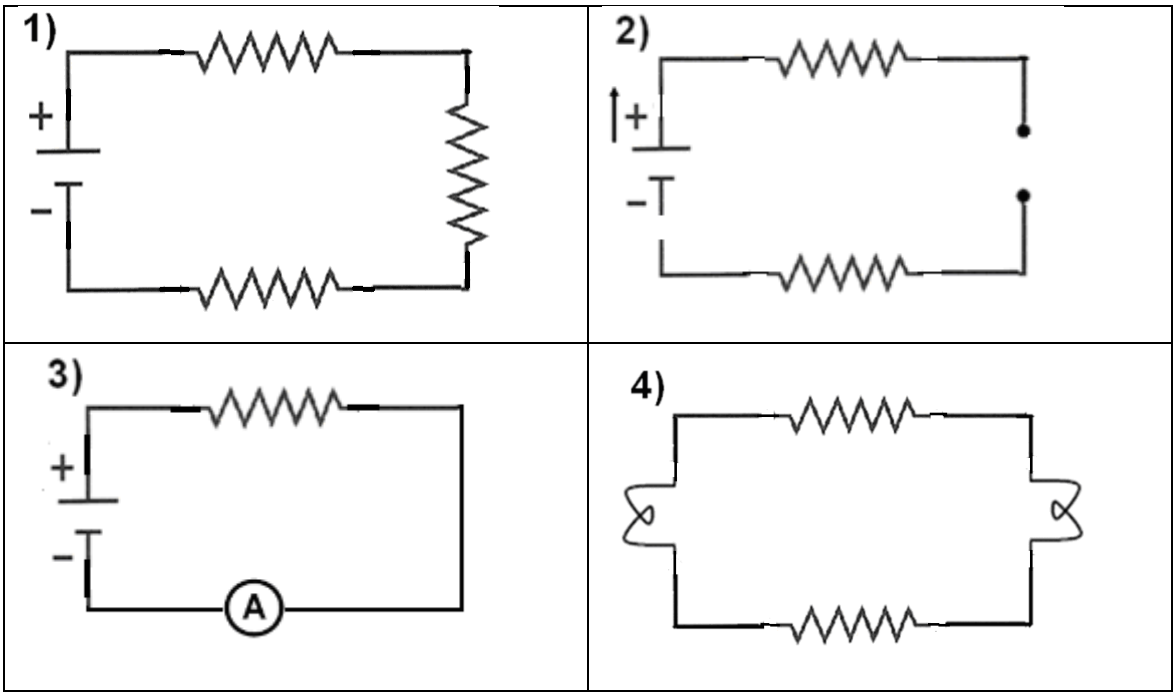
Electrical circuits transform electrical energy into other forms of usable energy (light, heat, sound, mechanical energy etc). The table below describes some components of electrical circuits and their specific role.

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

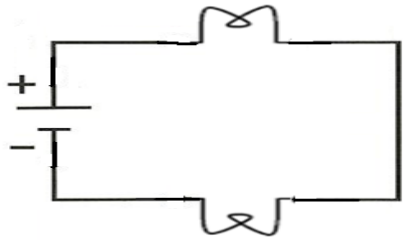
I can identify the two main types of electrical circuits (series, parallel).

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.

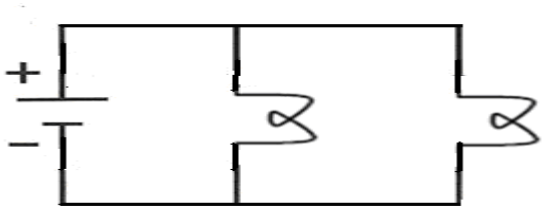
Series Circuits

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.



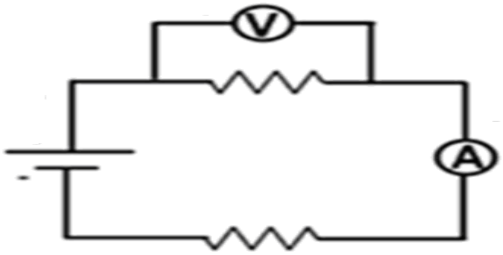
Parallel Circuits

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.



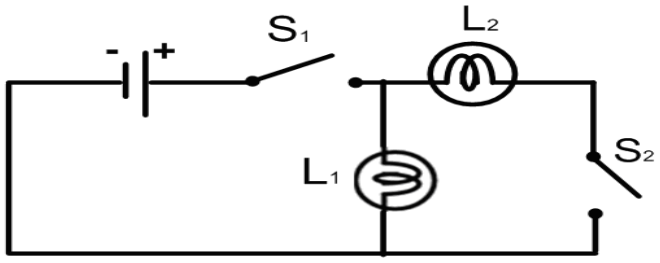
Measuring Instruments

- **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.

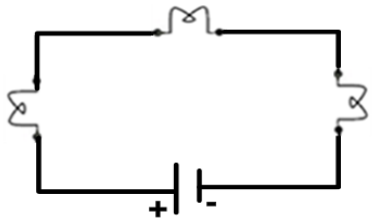


Which of the following statements about this circuit is TRUE?

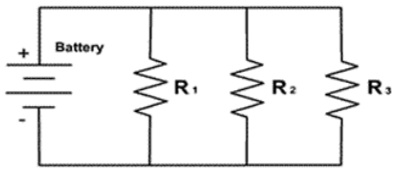
	S_1	S_2	L_1	L_2
A)	Opened	Closed	Off	On
B)	Closed	Opened	On	Off
C)	Opened	Closed	On	Off
D)	Closed	Opened	Off	On

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

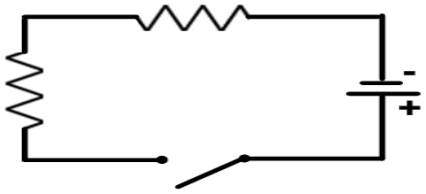
1)



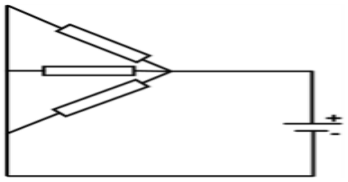
2)



3)



4)



A) 1 and 4

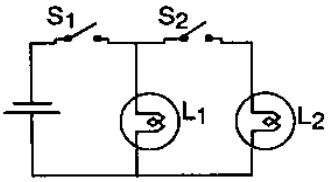
B) 2 and 4

C) 1 and 3

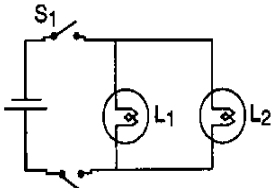
D) 2 and 3

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

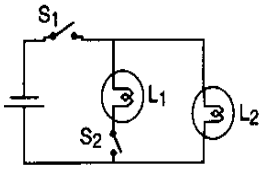
Circuit 1



Circuit 2



Circuit 3



Answers

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

   Circuit 2: light bulb 2 will light up

   Circuit 3: neither light bulb will light up

Electricity and Electromagnetism: Electrical Circuits

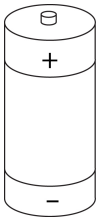
I can describe the differences between alternating and direct current.

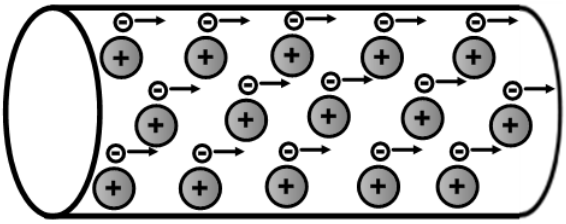
Explanation of Concepts

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

Direct Current (DC)

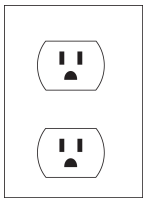
Electrons continuously move in the same direction. Batteries produce DC current.

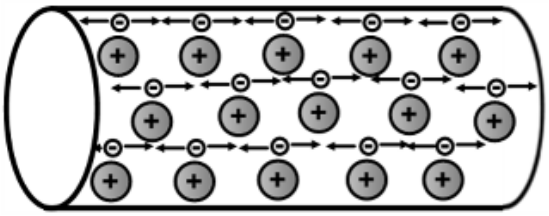




Alternating Current (AC)

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

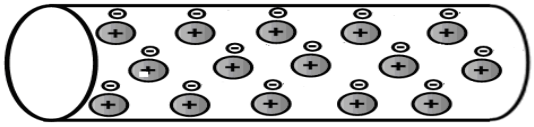




Questions

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.



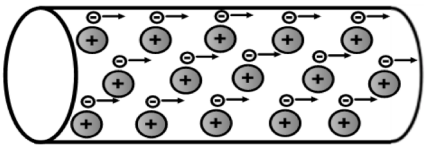
a) Use arrows to show the motion of the electrons if this wire was part of a circuit that had a battery as a power supply.

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*

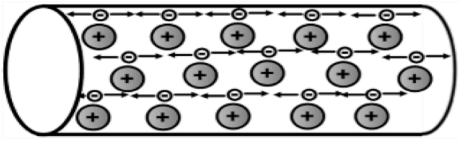
2.



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

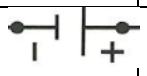
Explanation of Concepts

A simple electrical circuit contains at least the following components:

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

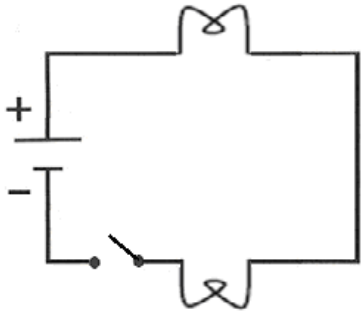
Circuits are represented by precise diagrams. Certain symbols are used to represent the elements of an electrical circuit:

Electrical Circuit Symbols

Wire	Power Supply	Resistor	Light Bulb	Switch	Ammeter	Voltmeter
						

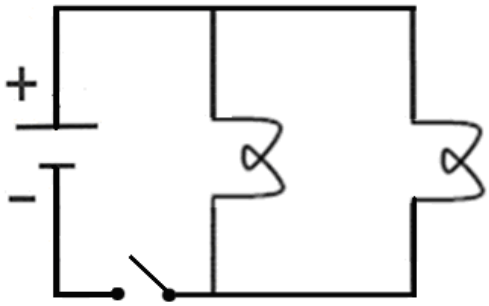
Series Circuit

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

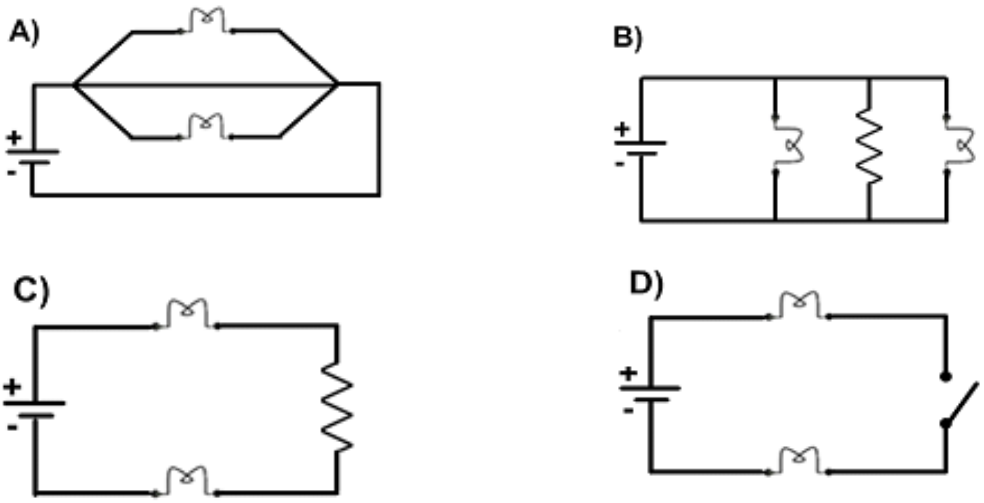
The figure below represents a parallel circuit consisting of a power supply (electrical battery) and two resistors (light bulbs) along with its representation using symbols, in an electrical diagram:

Circuit	Circuit Diagram
	

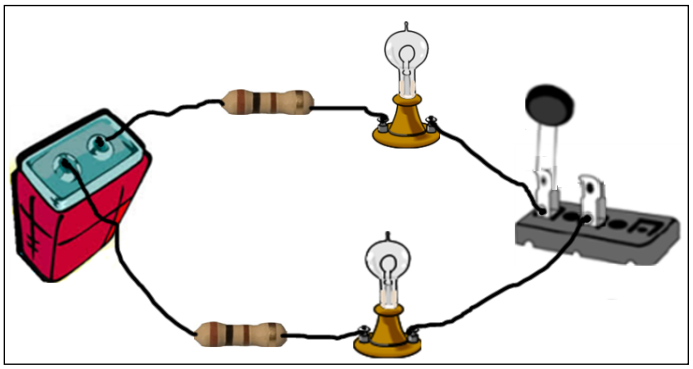
Questions

1. The figure below represents a simple electrical circuit containing a power source, two electrical bulbs and one resistor:

   Which of the circuit diagrams below best represents this circuit?



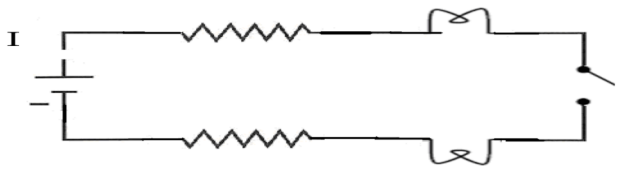
2. The electrical circuit below contains two resistors, two light bulbs, a power supply and a switch - all connected by copper wires as shown in the figure below.

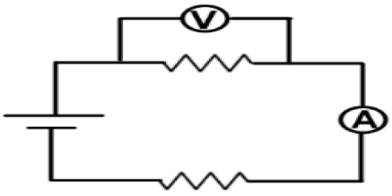


   Draw a diagram of this circuit using appropriate symbols used in electricity. Show the flow of charges on your diagram.

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 to calculate 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:

$$P = V I$$

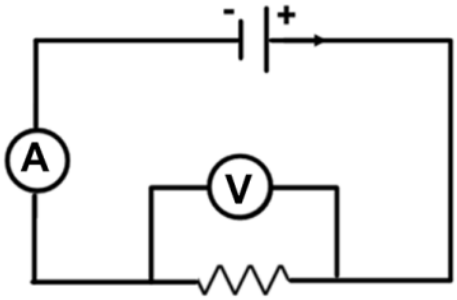
where:

- 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?

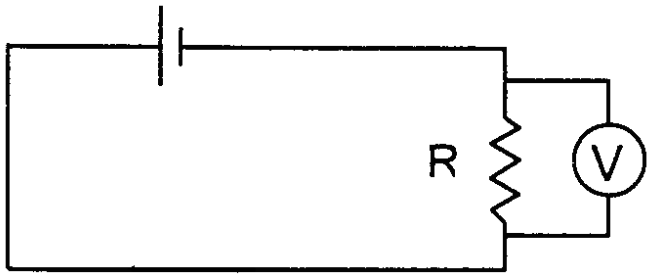
A) 0.11 V

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:

$$E = P\,\Delta t$$

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 ***

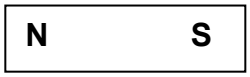
Electromagnetism: Forces of Attraction / Repulsion

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

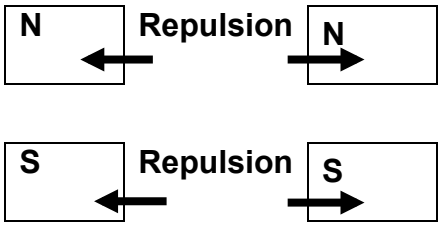
I can describe and interpret the magnetic field of a magnet and the behaviour of a compass in the magnetic field of a magnet.

Explanation of Concepts

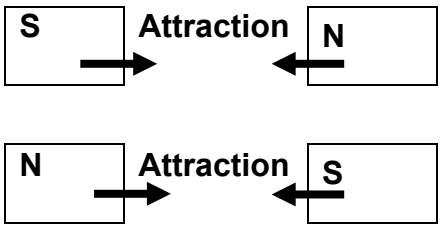
Every magnet has two poles: North (N) and South (S)



Like poles **repel**.



Opposite poles **attract**.

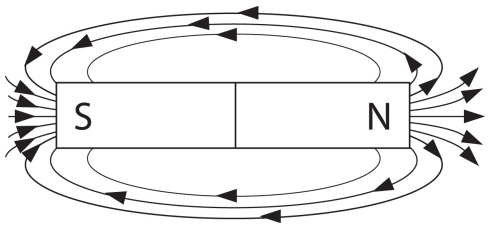


All magnets have a magnetic field. A magnetic field is the space around a magnet where magnetic forces are felt (both attraction and repulsion).

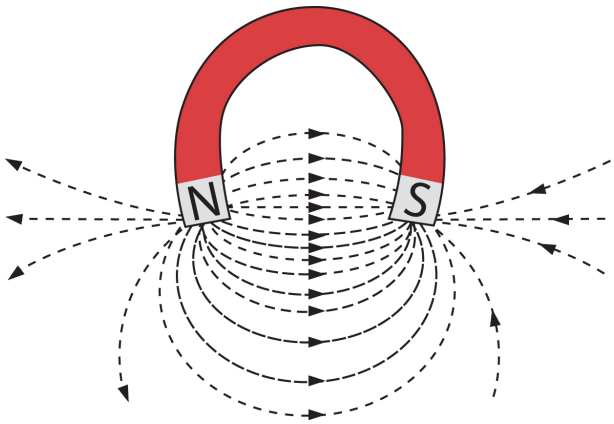
Lines of Force show you the shape, direction, and strength of the magnetic field around a magnet.

- **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

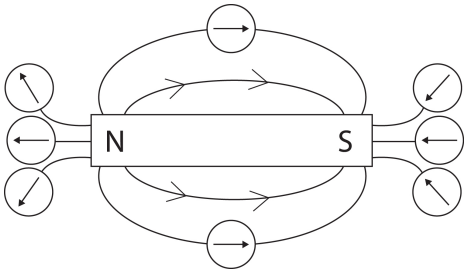


Example: Magnetic Field of a Horseshoe Magnet



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

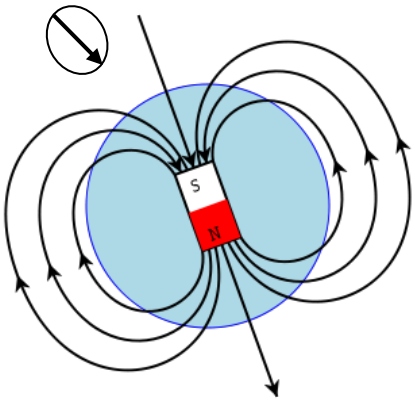
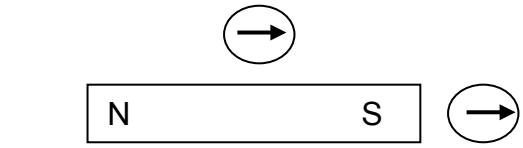
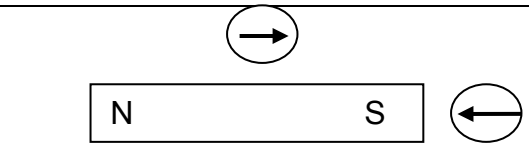
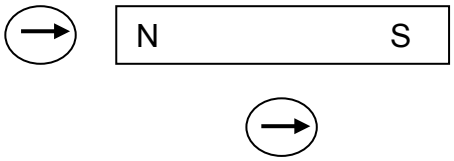
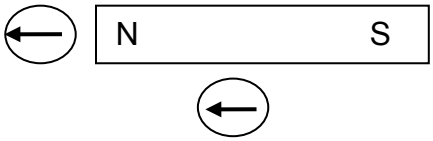


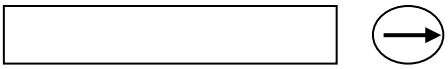
Image modified from http://commons.wikimedia.org/wiki/File:Earths_Magnetic_Field_Confusion.svg
Retrieved January 2014

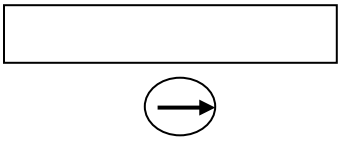
Questions

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

A)	
B)	
C)	
D)	

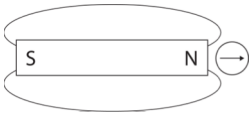
2. Indicate which pole is the North pole of the magnet. Draw the field lines.

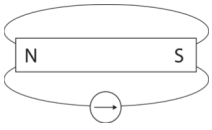
a) 

b) 

Answers

1. *B*
2.

a) 

b) 

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.

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?

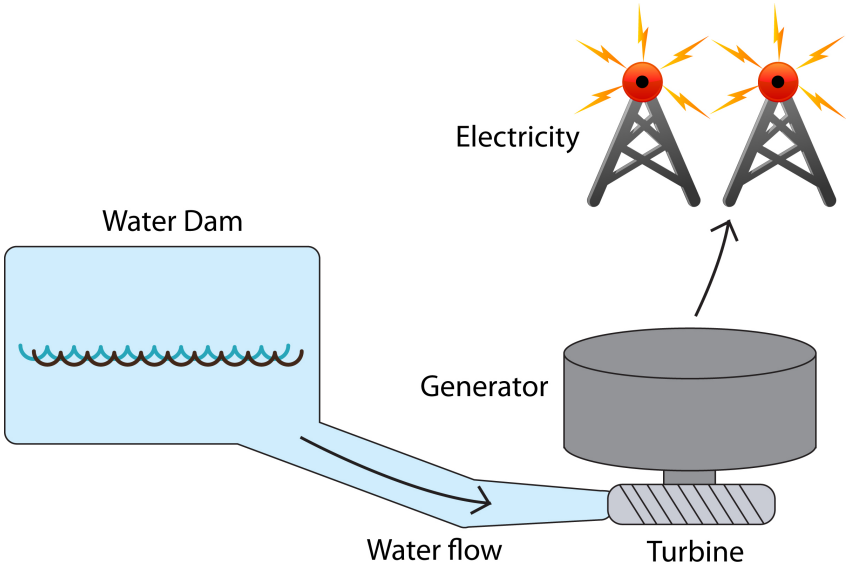
   A) 6.7 joules

   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
Energy Efficiency = $\frac{\text{amount of useful energy}}{\text{amount of energy consumed}}$ *x 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 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

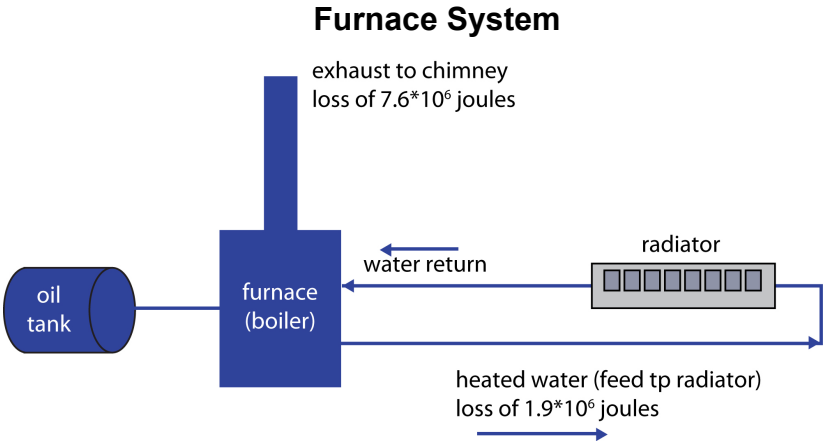
   B) 13 175 J

   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.



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

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

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

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

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

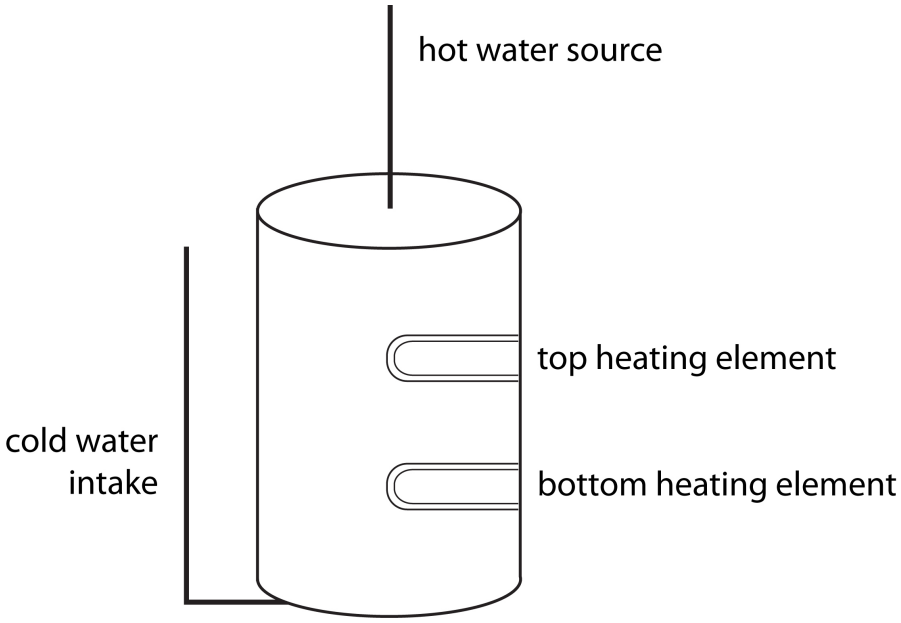
Questions

1. 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.*

Transformation of Energy:
Distinction Between Heat and Temperature

I can describe heat as a form of energy.

I can describe ***temperature*** *as a* ***'measurement of the degree of agitation of particles'****.*

I can describe the relationship between heat and temperature.

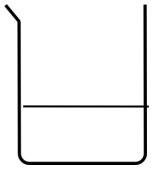
Explanation of Concepts

Heat is the amount of thermal energy that is transferred from one place to another because of a temperature difference.. The unit for heat is the joule (J).

Temperature is a measure of the thermal energy of a substance, or the average kinetic energy of the particles (how fast the particles are moving) that make up the substance. Temperature is usually measured in °C.

Example 1:

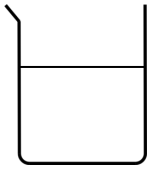
Two beakers contain different amounts of water at the same temperature.



Beaker A

100 mL water

T = 20 °C



Beaker B

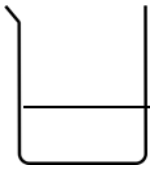
200 mL water

T = 20 °C

The water in Beaker B has more thermal energy than the water in Beaker A. There is more water in beaker B, and therefore a greater quantity of particles.

Example 2:

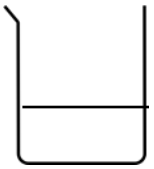
Two beakers contain the same amount of water at different temperatures.



Beaker A

100 mL water

T = 25 °C



Beaker B

100 mL water

T = 50 °C

The water in beaker B has more thermal energy.

Questions

1. A pot of water is put on the stove in order to make tea. The water boils because the kinetic energy of the water molecules increases. Which of the statements below are **false**:

    1. Heat is a measure of the thermal energy of the water molecules.
    2. Temperature is a measure of the thermal energy of the water molecules.
    3. The heat energy from the stove is being transferred into thermal energy in the water molecules.
    4. The temperature of the stove is being transferred into energy in the water molecules.

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

2. What does temperature measure?

    A) The number of particles in an object

    B) The amount of matter in an object

    C) The movement of particles in an object

The relationship between the volume and mass of a liquid

Answers

1. *B*
2. *C*