education

Department:
Education
PROVINCE OF KWAZULU-NATAL

CURRICULUM GRADE 10 -12 DIRECTORATE

NCS (CAPS)

LEARNER SUPPORT DOCUMENT

GRADE 10

PHYSICAL SCIENCES

STEP AHEAD PROGRAMME

2022

PREFACE

This support document serves to assist Physical Sciences learners on how to deal with curriculum gaps and learning losses as a result of the impact of COVID-19 in 2021. It also addresses the challenging topics in the Grade 10 curriculum in Term 1 and Term 2.

Activities serve as a guide on how various topics are assessed at different cognitive levels and also preparing learners for informal and formal tasks in Physical Sciences. It covers the following topics:

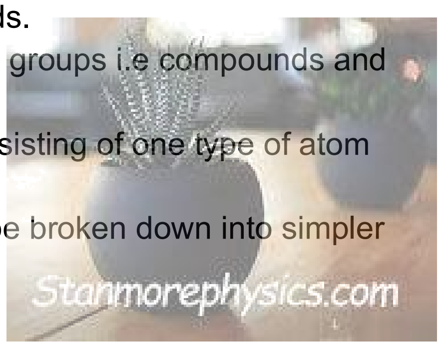
- Matter is described as being made up of particles whose properties determine the observable characteristics of matter and its reactivity
- The examples of anything made up of particles e.g. piece of chalk, air, conducting wires etc.
- The properties of materials are stated and defined as follows:-
    - Strength
    - Brittle: Hard but likely to break easy e.g. Piece of chalk, wood
    - Malleable: Ability to be hammered or pressed into shape without breaking or cracking e.g while Ductile; Ability to be stretched into a wire e.g.
    - Density: the mass per volume of a substance
    - Boiling point is defined as the temperature of a liquid at which its vapour pressure equals the external (atmospheric) pressure
    - Melting point is defined as the temperature at which a solid, given a sufficient heat, becomes a liquid e.g ice heated

- Matter is divided into two groups i.e mixtures and pure substances

MIXTURES:

- A mixture is the combination of two or more substances in which the substances retain their own properties e.g sand and water, suger dissolved in water
- Mixtures can be separated by physical methods without changing the properties of the substance.i.e to separate the mixture of iron filing from sand, magnet is used where only iron filing will be attracted to magnet
- A mixture's composition can vary.

- PURE SUBSTANCES
    - Pure substance is defined as a substance that cannot be separated into simpler components by physical methods.
    - Pure substances are further divided into two groups i.e compounds and elements
    - Element is defined as a pure substance consisting of one type of atom e.g Hydrogen, Sodium, Potassium etc
    - Elements are pure substances that cannot be broken down into simpler substances using chemical methods.



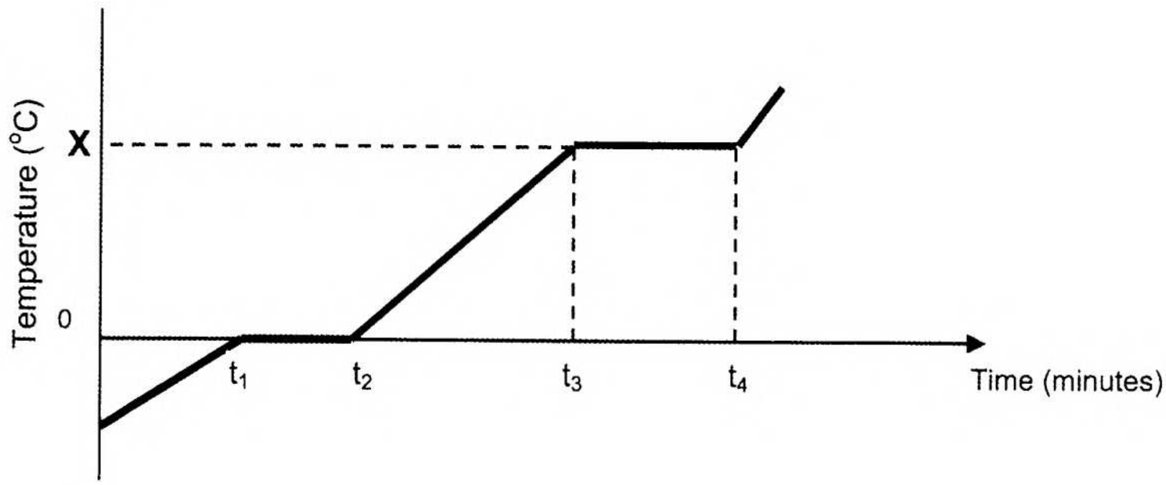
- COMPOUNDS

- Compound is defined as a pure substance consisting of two or more different elements.e.g H_2O, HNO_3, $Mg(OH)_2$ etc
- Compounds are made out of atoms of elements that are chemically bonded in a fixed ratio.
  e.g The educator explains that H_2O compound has two hydrogen atoms and one oxygen atom, HNO_3 has one Hydrogen atom,one Nitrogen atom and three Oxygen atoms
- Compounds can be separated using the chemical methods.

THREE STATES OF MATTER:

- Matter is made from tiny particles that are constantly moving
- Brownian motion is strong evidence that all substances are made of extremely small particles that are in constant motion.
- Smoke cell is used to demonstrate Brownian motion.
- The movement of atoms or molecules from an area of higher concentration to an area of lower concentration is called diffusion.
- Brownian motion: The random movement of microscopic particles suspended in a liquid or gas caused by collisions between these particles and the molecules of the liquid or gas.
- All substances exist in one of three states i.e solid, liquid and solid
  - In a solid state, matter maintains a fixed volume and shape
  - In a liquid state, matter maintains a fixed volume, but takes on the shape of the container.
  - In a gas state, matter expands to occupy whatever volume is available
- The state in which a substance exists depends on these factors:
  - The kinetic energy of its particles
  - The intermolecular forces between the particles
- Freezing point: The temperature at which a liquid changes to a solid by the removal of heat.
- Melting point: The temperature at which a solid, given sufficient heat , becomes a liquid.
- Boiling point: The temperature of a liquid at which its vapour pressure equals the external (atmospheric) pressure

HEATING CURVE GRAPH OF CRUSHED ICED AT STANDARD PRESSURE



- When the temperature is below 0^0c ice is in a solid state.

- As the temperature increases, the particles absorb energy and vibrate more vigorously. Eventually particles have enough energy to break free from forces holding them from their positions, and the ice melts.
- Between t_1 and t_2, the temperature remains constant because all energy is used to break the intermolecular forces between molecules.
- Between t_2 and t_3, temperature increases, particles of liquid is absorbing energy, when enough energy absorbed particles moves even more faster.
- Between t_3 and t_4, the temperature remains constant all energy is used to break liquid bonds, and particles escape to air and evaporation takes place.
- Above X, it is in a gas state.

- Melting is defined as the process during which a solid changes to liquid by application of heat.
- Evaporation: change of liquid into a vapour at any temperature below the boiling point.
- Freezing: the process during which a liquid changes to a solid by removal of heat.
- Sublimation: the process during which a solid change directly into a gas without passing through an intermediate liquid phase.

Condensation: the process during which a gas or vapour changes to liquid, either by cooling or by being subjected to increased pressure.

KINETIC MOLECULAR THEORY

- The kinetic model of matter describes the movement of the particles in three states.
- The differences between the states is described in terms of the spacing, ordering and motion of particles.

IN A SOLID:

- Particles are closely packed together in a regular arrangement or lattice.
- They are unable to move, and vibrate at their fixed positions.
- Strong forces of attraction between particles.

IN A LIQUID:

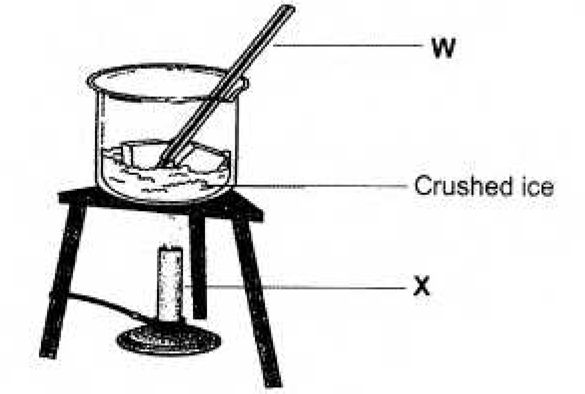
- Particles are packed together in an irregular arrangement.
- The particles are able to move in a confined space and take on the shape of a container.
- The attractive forces between particles are weaker than solids.

IN A GAS:

- Particles are arranged in irregular form, and are spread far apart with large spaces between them.
- The particles have the kinetic energy that enables them to move freely and randomly. There are almost no attractive forces between them.

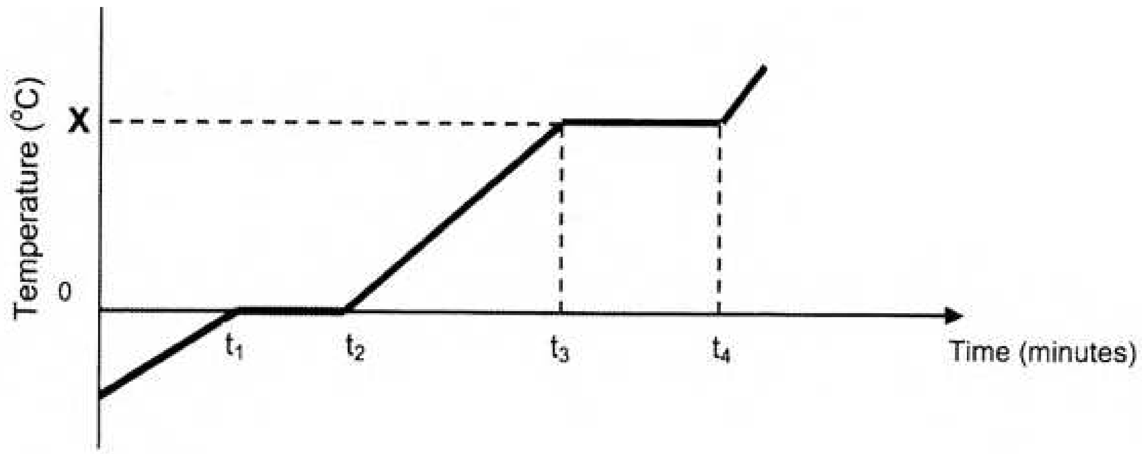
WORKSHEET

Grade 10 learners conducted an experiment to determine the heating curve of water by using crushed ice at standard pressure, as shown in the figure below.



1. Define the boiling point.
2. Write down the name of an instrument labelled W
3. Why crushed ice used instead of ice cubes?

The graph below, not drawn into scale shows the results obtained.



4.Write down the value represented by X
5.Name the predominantly phase of this substance between t_2 and t_3
6.Write down the process taking place between t_3 and t_4
7. Explain increase in temperature between t_2 and t_3
8.How will the above graph be affected if a larger quantity of crushed ice was used?

MATTER AND CLASSIFICATION

The material(s) of which an object is composed

- Describe matter as being made up of particles whose properties determine the observable characteristics of matter and its reactivity.
- Define properties of materials:
  - Strength
  - Brittle: Hard but likely to break easy.

  Malleable: Ability to be hammered or pressed into shape without breaking or cracking.

  Ductile: Ability to be stretched into a wire.
- Density: The mass per unit volume of a substance.
- Melting points and boiling points

  Boiling point: The temperature of a liquid at which its vapour pressure equals the external (atmospheric) pressure.

  Melting point: The temperature at which a solid, given sufficient heat, becomes a liquid.

Mixtures: heterogeneous and homogeneous

• Define a homogeneous mixture as a mixture of uniform composition and in which all components are in the same phase, e.g. a solution of salt and water.
• Define a heterogeneous mixture as a mixture of non-uniform composition and of which the components can be easily identified, e.g. sand and water.
• Give examples of heterogeneous and homogeneous mixtures.
• Classify given mixtures as homogenous and heterogeneous.

Pure substances: elements and compounds

• Use symbols to represent elements and compounds.
• Define an element as a pure substance consisting of one type of atom.
• Define a compound as a pure substance consisting of two or more different elements.
• Define a pure substance as a substance that cannot be separated into simpler components by physical methods.
• Classify given substances as pure or impure and as compounds or elements.

Names and formulae of substances

• Write names of compounds from given formulae or write down formulae of compounds from given names.
• Write names of ions from given formulae or formulae from given names.
• Write names of substances or ions ending on -ide, -ite and –ate.
• Write names of substances using the prefixes di-, tri-, etc.

Metals, metalloids and non-metals

• Classify substances as metals, metalloids and non-metals using their properties.
• Identify the metals, their positions on the periodic table and their numbers in comparison with the number of non-metals.
• Identify the non-metals and their positions on the periodic table.
• Describe metalloids as having properties of metals and non-metals.
• Describe the characteristic property of metalloids that show increasing conductivity with increasing temperature (the reverse of metals), e.g. silicon and graphite.

• Identify the metalloids and their position on the periodic table.

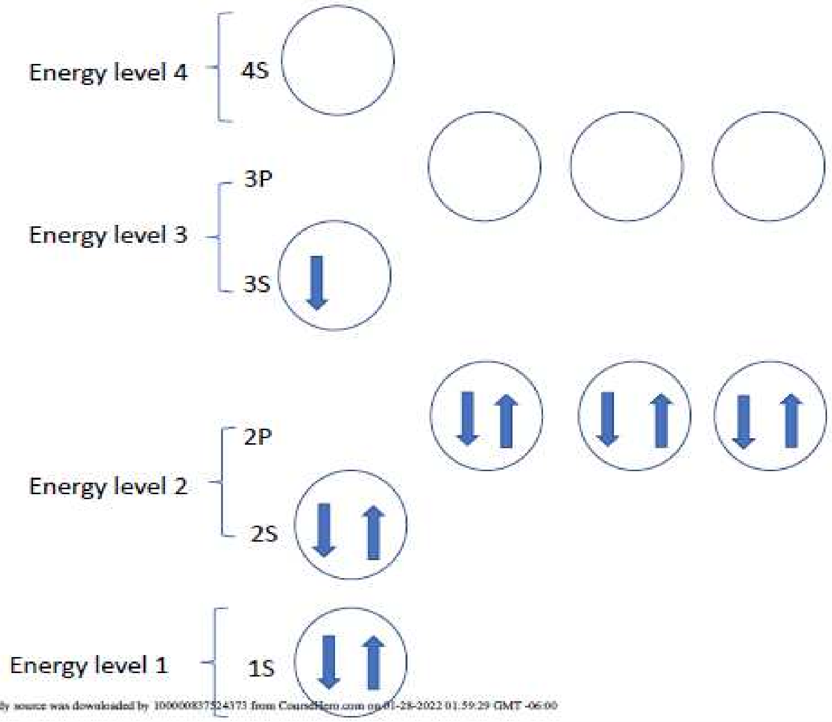
TOPIC	PREPARATION		GRADE	10
SUB-TOPIC		The structure of the atom	DATE	TERM 1: WEEK 4

EXAMPLES

1.Draw a labeled sketch of the structure of an atom. See textbook. (labels must include: protons, electrons, nucleus, neutrons)

2.

Electron configuration of: Sodium and oxygen respectively



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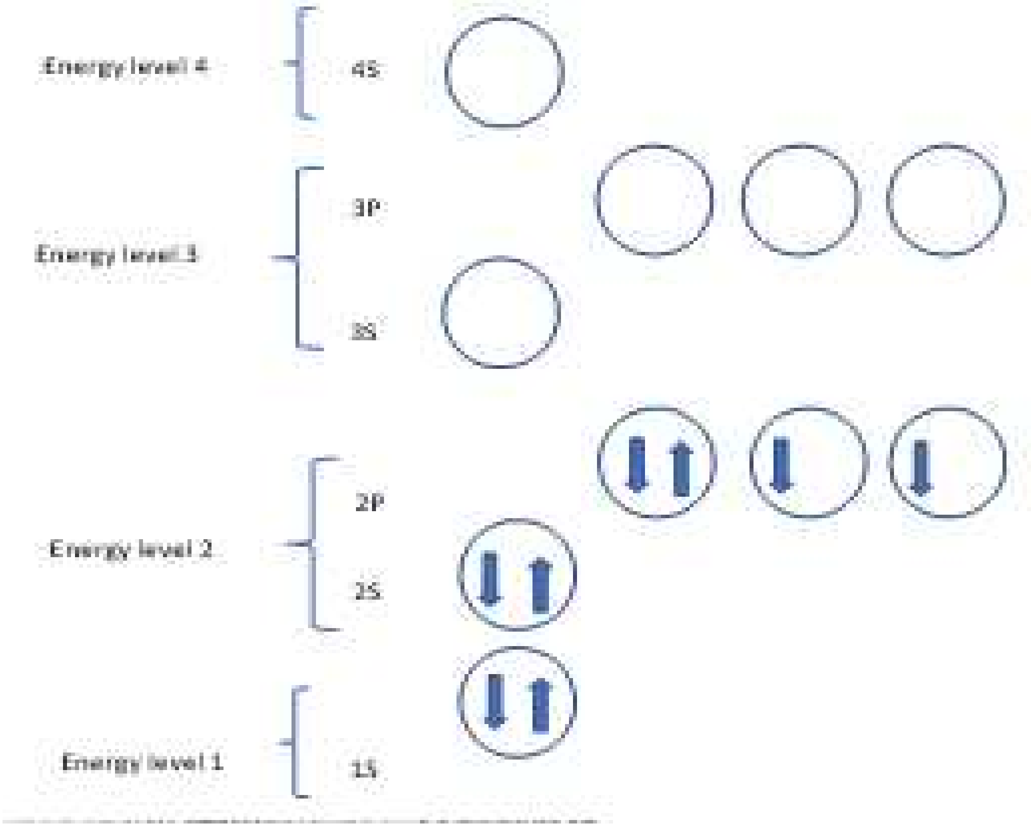


LEARNER ACTIVITIES

- **Write** the chapter heading in the notebook.
- **Write** the terminology in the previous column and define each
- **Make** some flash cards by cutting an A4 page in business card size pieces. Write the terminology and the definitions front to back on these cards. (This makes learning easy)
- **Draw** the electron configuration of the first 20 elements. How does the structure of the elements in the same group compare?

ASSESSMENT

1. The electron configuration of a neutral atom of an element X is $1s^2\ 2s^2\ 2p^3$. Which one of the following would be the electron configuration of X^{3-} ?

A. $1s^2\ 2s^2$

B. $1s^2\ 2s^2\ 2p^6$

C. $1s^2\ 2s^2\ 2p^3$

D. $1s^2\ 2s^2\ 2p^0$

2. From which of these atoms in the ground state can a valence electron be removed using the *least* amount of energy?

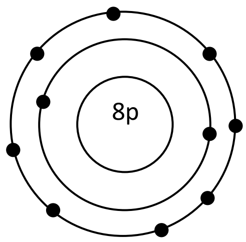
A. Nitrogen

B. Oxygen

C. Carbon

D. Fluorine

3. Which of the following does the Bohr model below represent?



A. An atom of neon

B. An ion of oxygen

C. A molecule of oxygen

D. A neutral atom of oxygen

4. Covalent bonding involves the _____________ of electrons, while ionic bonding involves the _____________ of electrons.

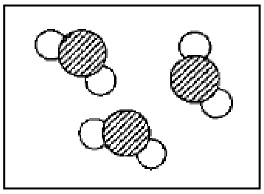
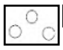
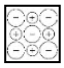
A. sharing; splitting

B. exchanging; sharing

C. sharing; transferring

D. transferring; sharing

5. Which diagram represents the structure of an ionic compound?

A.  B.  C.  D. 

6. A neutral atom of an element has an electron configuration of $1s^2 2s^2 2p^5$.

In which group and period of the periodic table is this element located?

A. Group II, Period 7
B. Group V, Period 2
C. Group VII, Period 2
D. Group VII, Period 5

TOPIC	MATTER AND MATERIALS	**GRADE**	10
SUB-TOPIC	The Periodic Table	**DATE**	Term 1: WEEK 5
ACTIVITIES			
1. Find an element on the Periodic Table when given theGroup and Period numbers			

2. Copy the table below into your notebook and complete it by filling in the missing answers. You will have to use your Periodic Table to find the answers. An example has been completed for you.

ELEMENT	SYMBOL	GROUP NUMBER	No OF VALENCE ELECTRONS	PERIOD	OUTERMOST ENERGY LEVEL
Magnesium	Mg	2	2	3	3
	S				
Chlorine					
	C				

3. Give one term/word for each of the following statements or descriptions.

3.1 The energy required to remove an electron from a neutral atom in its gaseous phase.
3.2 The ability of an atom in a molecule to attract electrons to itself.
3.3 The elements that are always found as diatomic molecules.
3.4 The electrons that are found closest to the nucleus.
3.5 The horizontal rows of the Periodic Table.
3.6 The elements found in group 7.

4. Refer to the list of neutral atoms below to answer the following questions.

Na P Cl Ar Si Mg Cl O

From the list, choose the atom (you may use an atom more than once) that:
4.1 has the lowest atomic radius
4.2 has the highest ionisation energy
4.3 has 2 valence electrons
4.4 has a stable electron structure
4.5 is found in period 2
4.6 has the highest electronegativity
4.7 is found in group 15 (V)
4.8 is a metalloid
4.9 is an alkaline-earth metal is a highly reactive element

ASSESSMENT

7.	Which of the following statements best describes the forces found in metallic lattices? A. Electrostatic forces between positive ions and electrons. B. Electrostatic forces between positive ions and negative ions. C. London forces between non-polar molecules. D. Hydrogen bonds between molecules.
8.	Which one of the following statements about the trends down Group VII (lowest to highest atomic number) in the Periodic Table is correct? A. The atomic size increases B. The ionisation energy increases C. The non-metallic character increases D. The number of valence electrons increases

9.	Consider the following elements: potassium (K); zinc (Zn); phosphorous (P); antimony (Sb); argon (Ar) Which of the following statements is true? A. All are metals. B. All are non-metals. C. All are chemically reactive. D. One is a metalloid (semi-conductor).
10.	What is the percent by mass of oxygen in H_2SO_4? A. 16% B. 33% C. 65% D. 98%

LESSON PLAN

TOPIC	MATTER AND MATERIALS	**GRADE**	10
SUB-TOPIC	CHEMICAL BONDING	**DATE**	TERM 1: WEEK 6

CONSEPTS AND SKILLS

Know the following definitions: Chemical bond; covalent bond; ionic bond; molecule; metal bond; Law of constant composition.

LEARNER ACTIVITIES

1) **Write** the chapter heading in your notebook.
2) **Write** the terminology in the previous column and define each
3) **Make** yourself some flash cards by cutting an A4 page in business card size pieces. Write the terminology and thedefinitions front to back on these cards. (This makes learning easy)
4) **Practice** now to find the correct number of valence electrons of an element e.g. An element's number of valence electrons are equal to its group number. i.e. (do you know this abbreviation? Language across curriculum): Mg = 2; Na = 1; O = 6; N = 5; P = 5.
5) **Try now** to predict the number of valence electrons of the following:

   Na; Mg; Li; Ca; Al; O; C; Cl; H.
6) **Tabulate** two differences between covalent and ionic bonds (see memo and **memorize)**
7) **Draw** the Lewis diagrams for the following compounds:

COVALENT: **H_2; O_2; $C\ell_2$; N_2; $HC\ell$; H_2O**

IONIC: **$NaC\ell$; MgO; Li_2O; CaO**

ASSESSMENT:

1.	Which one of the following provides the best description of an isotope? A. Atoms with the same number of protons but differing numbers of electrons. B. Atoms with the same mass number but differing atomic numbers. C. Atoms with the same mass numbers and the same atomic numbers. D. Atoms with the same atomic numbers but differing mass numbers.
2.	When alpha particles are used to bombard gold foil, most of the alpha particles pass through undeflected. This result indicates that most of the volume of a gold atom consists of ____. A. Deuterons B. Neutrons C. Protons D. Unoccupied space
3.	When electrons in an atom in an excited state fall to lower energy levels, energy is _______________. A. released, only B. absorbed, only C. neither released nor absorbed D. both released and absorbed
4.	An ion with 13 protons, 14 neutrons, and a charge of 3+ has an atomic number of ________. A. 13 B. 14 C. 17 D. 27
5.	What is the mass number of an atom that contains 24 protons, 24 electrons, and 28 neutrons? A. 24 B. 48 C. 52 D. 76
6.	Which element's ionic radius is smaller than its atomic radius? A. Neon B. Nitrogen C. Sodium D. Sulphur

7.	What is the formula of calcium sulphate? A. CSO_2 B. CSO_4 C. $CaSO_4$ D. Ca_2SO_4
8.	Species X has a valence electron configuration of s^2 and element Z has a valence electron configuration of s^2p^5. Which one of the following is the most likely formula of a compound formed between X and Z? A. X_2Z B. XZ C. X_2Z_3 D. XZ_2
9.	The electron configuration of an element in its ground state is: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$. Which one of the following statements is correct? A. Atoms of the element have two valence electrons B. Atoms of the element have four valence electrons C. The element is from Group 3 of the Periodic Table D. The element is from Period 4 of the Periodic Table
10.	Which of the following elements has the lowest first ionisation energy? A. Argon B. Fluorine C. Potassium D. Sodium

ENERGY

As a learner, you should be able to list as many forms of energy as possible, like solar, radiant, electrical, mechanical, kinetic, potential, nuclear, etc. You then pay attention to three:

1. **Gravitational potential energy** – energy an object has because of its position in the gravitational field relative to some reference point

- When the object moves up or down from the reference position its gravitational potential energy changes.
- Potential energy is calculated using the formula: $\mathbf{E_p = mgh}$

2. **Kinetic energy** – energy an object possesses because of its motion

- Any object which moves, possesses kinetic energy.
- A stationary object has no kinetic energy.
- Kinetic energy is calculated using the formula: $\mathbf{E_k = \frac{1}{2} mv^2}$

3. **Mechanical energy** – the sum of gravitational potential energy and kinetic energy

Equation: $\mathbf{E_M = E_k + E_p}$

The Law of Conservation of Energy: The total energy of an isolated system remains constant.

The Principle of Conservation of Mechanical Energy: The total mechanical energy in an isolated system remains constant.

Isolated system – a system that does not interact with its surroundings (there is no transfer of energy or mass between the system and the surroundings).

Examples

Gravitational Potential Energy

1. Let's look at the case of a suitcase, with a mass of 1 kg, which is placed at the top of a 2m high cupboard. By lifting the suitcase against the force of gravity, we give the suitcase potential energy. We can calculate its gravitational potential energy using the equation defined above as:

E_p = mgh

= 1x9,8x2

= 19, 6 J

If the suitcase falls off the cupboard, it will lose its potential energy. Halfway down to the floor, the suitcase will have lost half its potential energy and will have only

9, 8 J left.

E_p = mgh

= 1x9,8x1

= 9,8 J

At the bottom of the cupboard the suitcase will have lost all its potential energy and its potential energy will be equal to zero.

E_p = mgh

= 1x9,8x0

= 0 J

This example shows us that objects have maximum potential energy at a maximum height and will lose their potential energy as they fall.

2. A brick with a mass of 1 kg is lifted to the top of a 4 m high roof. It slips off the roof and falls to the ground. Calculate the gravitational potential energy of the brick at the top of the roof.

Solution

m = 1 kg g = 9,8 $m.s^{-2}$ h = 4 m

E_p = mgh

= 1.9,8.4

= 39, 2 J

3. A netball player, who is 1,7 m tall, holds a 0,5 kg netball 0,5 m above her head and shoots for the goal net which is 2,5 m above the ground. What is the gravitational potential energy of the ball:

3.1 when she is about to shoot it into the net?

3.2 when it gets right into the net?

3.3 when it lands on the ground after the goal is scored?

Solution

3.1 First we need to calculate h. The height of the ball above the ground when the girl shoots for goal is h = (1,7 + 0,5) = 2,2 m.

m = 0,5 kg g = 9,8 $m.s^{-2}$ h = 2,2 m

E_p = mgh

= 0,5.9,8.2, 2

= 10, 78 J

3.2 m = 0,5 kg g = 9,8 $m.s^{-2}$ h = 2,5 m

E_p = mgh

= 0,5.9,8.2,5

= 12,25 J

3.3 m = 0,5 kg g = 9,8 $m.s^{-2}$ h = 0 m

E_p = mgh

= 0,5.9,8.0

= 0 J

Kinetic Energy

Consider the 1 kg suitcase on the cupboard that was discussed earlier. When it is on the top of the cupboard, it will not have any kinetic energy because it is not moving:

1. $E_k = ½ mv^2$

= ½ $.1.0^2$

= 0 J.

When the suitcase falls, its velocity increases (falls faster), until it reaches the ground with a maximum velocity. As its velocity increases, it will gain kinetic energy. Its kinetic energy will increase until it is a maximum when the suitcase reaches the ground. If it has a velocity of 6,26 $m.s^{-1}$ when it reaches the ground, its kinetic energy will be:

2. $E_k = ½ mv^2$

= ½ $.1.(6,26)^2$

= 19, 6 J.

When the suitcase falls, its velocity increases (falls faster), until it reaches the ground with a maximum velocity. As its velocity increases, it will gain kinetic energy. Its kinetic energy will increase until it is a maximum when the suitcase reaches the ground.

3. A bullet, having a mass of 150 g, is shot with a muzzle velocity of 960 $m.s^{-1}$.
   Calculate its kinetic energy.

Solution

m = 150 g = 150/1 000 = 0,150 kg   g = 9,8 $m.s^{-2}$ v = 960 $m.s^{-1}$

$E_k = ½ mv^2$

$= ½ .0,150.960$

$= 69\ 120$ J

Mechanical Energy

$E_M = E_k + E_p$

$E_M = ½ mv^2 + mgh$

Example:

Calculate the total mechanical energy for a ball of mass 0,15 kg which has a kinetic energy of 20 J and is 2 m above the ground.

<u>Solution</u>

m = 0,15 kg E_k = 20 J   g = 9,8 $m.s^{-2}$ h = 2 m E_M = ?

$E_M = E_p + E_k$

$= mgh + E_k$

$= 0,15.9,8.2 + 20$

$= 22,94$ J

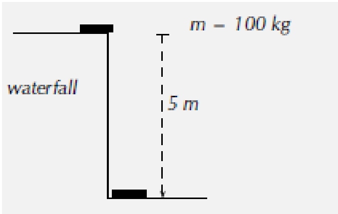
Conservation of Mechanical Energy

NB: Always start calculation with:

$$E_{k1} + E_{p1} = E_{k2} + E_{p2}$$

Examples:

1. Object moving vertically downward



During a flood a tree trunk of mass 100 kg falls down a waterfall. The waterfall is 5 m high.

If air resistance is ignored, calculate:

1.1 the potential energy of the tree trunk at the top of the waterfall.

1.2 the kinetic energy of the tree trunk at the bottom of the waterfall.

1.3 the magnitude of the velocity of the tree trunk at the bottom of the waterfall.

<u>Solution</u>

1.1 $E_p = mgh$

$= 100.9,8.5$

$= 4\ 900$ J

1.2 Total mechanical energy must be conserved, so

$$E_{k1} + E_{p1} = E_{k2} + E_{p2}$$

Since the trunk's velocity is zero at the top of the waterfall, $E_{k1} = 0$ J

At the bottom of the waterfall, h = 0 m, so $E_{p2} = 0$ J

Therefore $E_{k1} = E_{p2}$, and so the kinetic energy of the tree trunk at the bottom of the waterfall equals the potential energy at the top of the waterfall.

And so, Ek = 4 900J

1.3 Since $E_k = ½ mv^2$

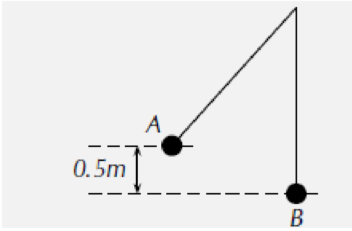
$4\ 900 = ½ .100.v^2$

$v^2 = 98$

$v = 9{,}90$ m.s^{-1}

2. A 2 kg metal ball is suspended from a rope as a pendulum. If it is released from point A and swings down to the point B (the bottom of its arc):

Pendulum



Calculate the velocity of the ball at point B.

<u>Solution</u>

Since there is no friction, mechanical energy is conserved.

$$E_{k1} + E_{p1} = E_{k2} + E_{p2}$$
$$mgh_1 + ½ mv_1^2 = mgh_2 + ½ mv_2^2$$
$$mgh_1 + 0 = 0 + ½ mv_2^2$$
$$2.9,8.0,5 = ½ .2.v^2$$
$$v^2 = 9.8$$
$$v = 3,13 \text{ m.s}^{-1}$$

3. A roller coaster ride at an amusement park starts from rest at a height of 50 m above the ground and rapidly drops down along its track. At some point, the track does a full 360 degree loop which has a height of 20 m, before finishing off at ground level. The roller coaster train itself with a full load of people on it has a mass of 850 kg.

Roller coaster

If the roller coaster and its track are frictionless, calculate:

3.1 the velocity of the roller coaster when it reaches the top of the loop

3.2 the velocity of the roller coaster at the bottom of the loop (i.e. ground level)

Solution

3.1 $E_{M1} = E_{M2}$

$E_{p1} + E_{k1} = E_{p2} + E_{k2}$

$mgh_1 + ½ mv_1^2 = mgh_2 + ½ mv_2^2$

$mgh_1 + 0 = mgh_2 + ½ mv_2^2$

$850.9,8.50 + 0 = 850.9,8.20 + ½ .850.v^2$

$v^2 = 588$

$v = 24,25\ m.s^{-1}$

3.2 $E_{M1} = E_{M3}$

$E_{p1} + E_{k1} = E_{p3} + E_{k3}$

$mgh_1 + ½ mv_1^2 = mgh_3 + ½ mv_3^2$

$mgh_1 + 0 = 0 + ½ mv_3^2$

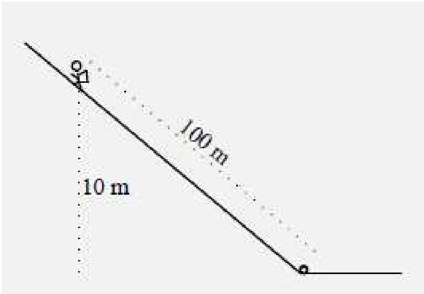
$850.9,8.50 = ½ .850.v_3^2$

$v_3^2 = 980$

$v_3 = 31,30\ m.s^{-1}$

4. A mountain climber who is climbing a mountain in the Drakensberg during winter, by mistake drops her water bottle which then slides 100 m down the side of a steep icy slope to a point which is 10 m lower than the climber's position. The mass of the climber is 60 kg and her water bottle has a mass of 500 g.

Inclined Plane



4.1 If the bottle starts from rest, how fast is it travelling by the time it reaches the bottom of the slope? (Neglect friction.)

4.2 What is the total change in the climber's potential energy as she climbs down the mountain to fetch her fallen water bottle? i.e., what is the difference between her potential energy at the top of the slope and the bottom of the slope?

<u>Solution</u>

4.1

$$E_{M1} = E_{M2}$$

$$E_{p1} + E_{k1} = E_{p2} + E_{k2}$$

$$mgh_1 + ½ mv_1^2 = mgh_2 + ½ mv_2^2$$

$$mgh_1 + 0 = 0 + ½ mv_2^2$$

$$0{,}5.9{,}8.10 = ½ .0{,}5.v_2^2$$

$$v_2^2 = 196$$

$$v_2 = 14 \text{ m.s}^{-1}$$

4.2 At the top of the slope, her potential energy is:

$E_{p1} = mgh_1$

$= 60.9{,}8.10$

$= 5880$ J

At the bottom of the slope, her potential energy is:

$E_{p2} = mgh_2$

$= 60.9,8.0$

$= 0$ J

Therefore, the difference in her potential energy when moving from the top of the slope to the bottom is:

$E_{p1} – E_{p2} = 5880 − 0$

$= 5880$ J

ACTIVITIES

Multiple Choice

1.1 An astronaut drops a hammer from 2 m above the surface of the Moon. If the acceleration due to gravity on the Moon is 1,62 $m{\cdot}s^{-2}$, how long will it take for the hammer to fall to the Moon's surface?

A. 0,62 s

B. 1,6 s

C. 1,2 s

D. 2,5 s

1.2 Mary rides an escalator that moves her downward at constant speed.

Select the option that best describes the change in her gravitational potential energy and kinetic energy.

	Gravitational Potential Energy	Kinetic Energy
A.	Decreases	Decreases
B.	Decreases	Remains the same
C.	Increases	Decreases
D.	Increases	Remains the same

1.3 A girl weighing 500 N takes 50 seconds to climb a flight of stairs 18 meters high. If her speed at the top of the stairs is 2 $m{\cdot}s^{-1}$, her potential energy at the top of the stairs is _____________J.

A. 9000

B. 8820

C. 102,04

D. 9102,4

1.4 A 0,10 kg ball, dropped vertically from a height of 1,0 m above the floor bounces back to a height of 0,80 meter. The mechanical energy lost by the ball as it bounces is __________ J.

A. 0,78

B. 0,30

C. 0,20

D. 0,08

Structured Questions

1. A father lifts his child (mass 20 kg) onto a table which is 1,2 m above the ground. Calculate
how much gravitational potential energy the child has gained.

2. A fisherman catches a fish in his fishing net. The fish has a mass of 2,5 kg and the net has
a mass of 250 g. He lifts the net to a height of 0,5 m above the river. Calculate how much
gravitational potential energy is gained by the net and the fish when he lifts them.

3. A boy standing on a bridge drops a stone 4,5 m into the river below. What is the mass of the stone, if it loses 158,76 J of gravitational potential during its fall?

4. A rock with a mass of 250 kg balances at the top of a cliff. In this position, it has 2 000 J gravitational potential energy. What is the height of the cliff?

5. How much kinetic energy has a car with a mass of 1 200 kg when it travels at 20 $m.s^{-1}$?

6. A 2 ton truck travels at 100 $km.h^{-1}$. What is its kinetic energy?

7. What is the mass of a vehicle travelling at 15 $m.s^{-1}$ when it has 300 000 J of kinetic energy?

8. A ball (mass 500 g) hits the ground with 200 J of kinetic energy. At what speed was it moving just before it hit the ground?

9. An aeroplane (mass 20 000 kg) flies horizontally at a speed of 250 $m\text{-}s^{-1}$ and at a height of 30 km above the ground. Calculate its mechanical energy.

10. A pendulum bob (mass 200 g) is raised to a height of 50 cm above its rest position, and then it is released. Assume that the system is frictionless and that there is no air resistance.

a. State the law of conservation of mechanical energy.

b. Explain why this system can be considered as “an isolated system”.

c. Calculate the maximum potential energy of the bob.

d. Determine the maximum kinetic energy of the bob.

e. Determine the maximum speed of the bob.

f. At what position in its swing will the bob travel at maximum speed?

11. A 40 kg girl slides from rest down a slide of height 3 m and reaches the bottom at a speed of 7.67 $m\cdot s^{-1}$.

11.1 Calculate the girl's gravitational potential energy at the top of the slide.

11.2 Calculate the girl's kinetic energy when she reaches the bottom of the slide.

11.3 When the girl is 1,5 m high her kinetic energy is 588 J. calculate the girl's mechanical energy.

12. While conducting an experiment, a stone with a mass 5 kg is dropped from the roof of the school's pavilion by Russell. The roof is 6,5 m above the ground. Ignore the effect of the air resistance.

12.1 What type of energy does the stone have, just before it is dropped?

12.2 Explain your answer in 12.1.

12.3 Calculate the energy referred to in question 12.1.

12.4 Define kinetic energy.

12.5 Calculate the kinetic energy of the stone just as it strikes the ground.

12.6 Name and state the principle used to do the calculation in question 2.5.

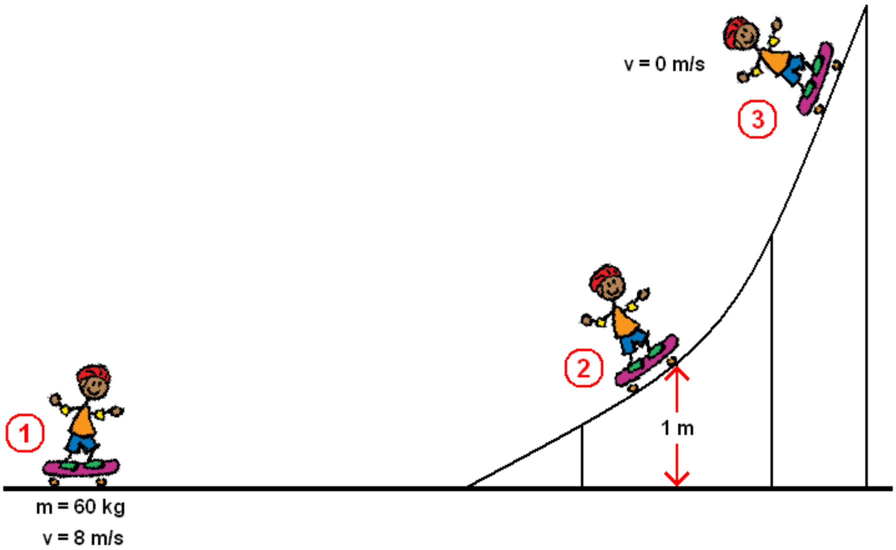
12.7 Calculate the velocity at with the stone strikes the ground.

13. A bullet, mass 50 g, is shot vertically up in the air with a muzzle velocity of 200 $m\cdot s^{-1}$. Use the Principle of Conservation of Mechanical Energy to determine the height that the bullet will reach. Ignore air friction.

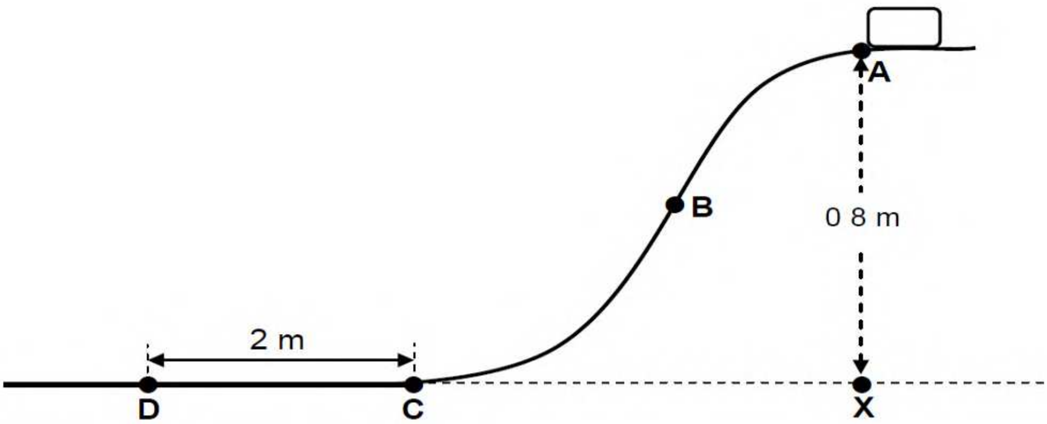
14. The diagram shows a boy playing with his skateboard.

14.1 Calculate the height h when the boy is in position 3.

14.2 Calculate the velocity when the boy is in position 2.



15. An object of mass 0,2 kg is released at point **A** and moves along the frictionless section **AC** of a curved track. Along section **CD** it experiences friction and stops at point **D**. The vertical height of point **A** above point **X** on the ground is 0,8 m as shown below.



15.1 Write down the *principle of conservation of mechanical energy in words*.

15.2 Calculate the gravitational potential energy of the object at point A just before it is released.

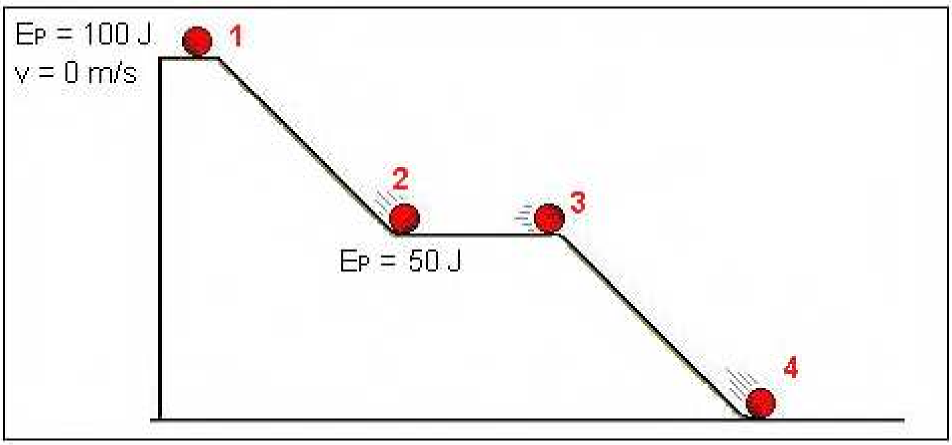
15.3 At point **B** the speed of the object is 3 $m \cdot s^{-1}$. Use the principle of conservation of mechanical energy to calculate the vertical height of point **B** above the ground.

15.4 The object reaches point **C** at a velocity of 3,96 $m \cdot s^{-1}$.

15.4.1 Write down the energy conversion which takes place as the object moves from point **C** to **D**.

15.4.2 Calculate the acceleration that the object experiences as it moves from point **C** to **D**.

16. The following drawing shows a 2 kg ball falling on a frictionless plane in four different positions. Ignore the circular motion of the ball and the air resistance.



16.1 Calculate at what height from the floor is the ball in position 1.

16.2 Using the Law of Conservation of Mechanical energy, calculate the velocity of the ball in position 2.

16.3 Calculate the Mechanical energy in position 3.

16.4 Use Law of conservation of mechanical energy to calculate the velocity of the ball in position 4.

(Do it using more than one option.)

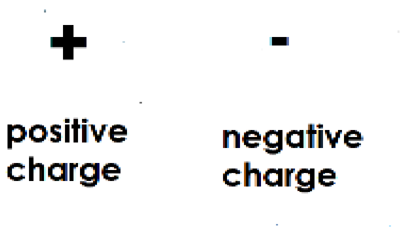
ELECTROSTATICS NOTE SUMMARY

Electrostatics is the study of electric charge which is at rest/stationary or static (not moving).

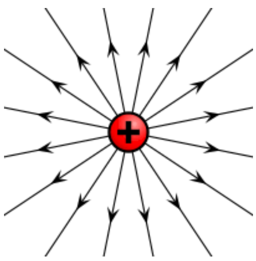
In this chapter we will look at electrostatics, the principle of conservation of charge and the principle of quantization of charge.

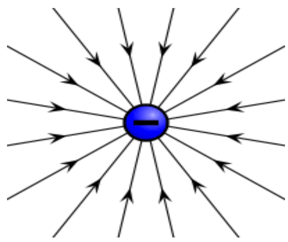
All objects surrounding us (including people!) contain large amounts of electric charge. There are two types of electric charge: **positive** charge and **negative** charge. If the same amounts of negative and positive charge are found in an object, there is *no net charge* and the object is electrically **neutral**. If there is more of one type of charge than the other on the object then the object is said to be **electrically charged**. The picture below shows what the distribution of charges might look like for a neutral, positively charged and negatively charged.

Two types of charges.

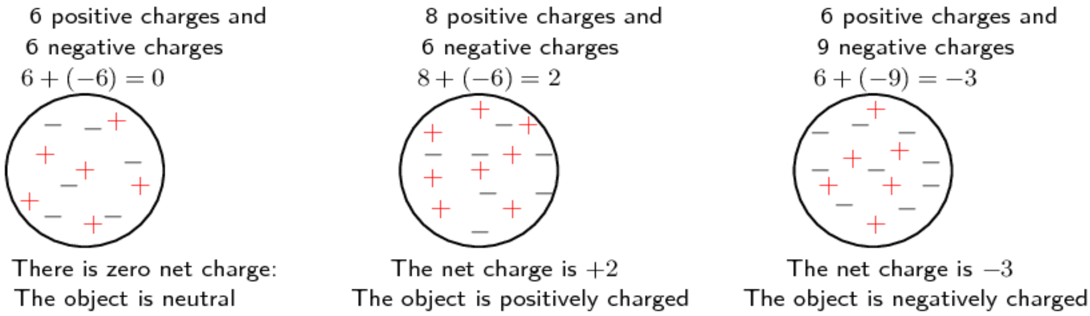


The electric field direction is always directed away from positive source charges and towards a negative source charge. See figures below:





BELOW are the illustrations of neutral, negatively charged and positively charged objects.



Positive charge is carried by the protons in material and **negative charge by electrons**. The overall charge of an object is usually due to changes in the number of electrons. To make an object.

- If two negatively charged objects are brought close together, then they will repel each other.
- If two positively charged objects are brought close together, then they will repel each other.
- If a positively charged object is brought near to a negatively charged object, they will attract each other.
- In conclusion unlike charges attract each other while like charges repels each other.

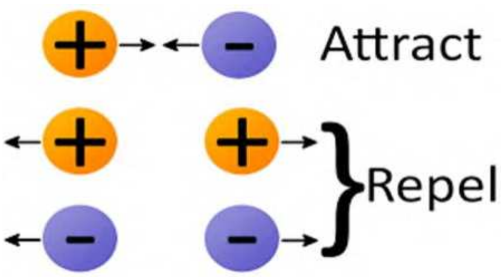


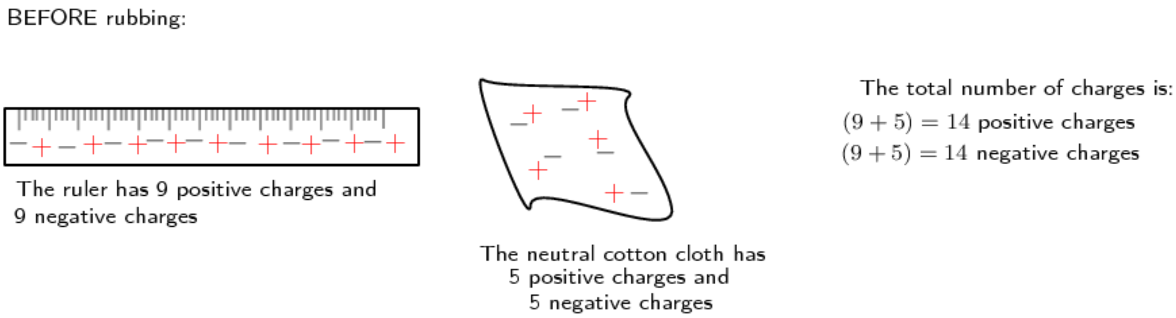
Figure showing unlike charges attracting and like charges repelling.

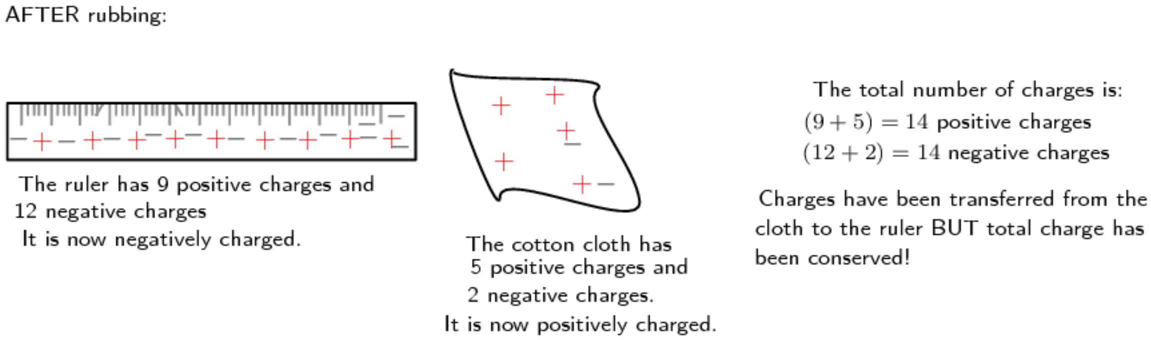
- An object is **positively charged**, as a result of having a shortage of electrons.
- An object is **negatively charged**, as a result of having excess electrons.
- An object is **neutral**, as it has equal numbers of protons and electrons.

The process of materials becoming charged when they come into contact with other materials is known as **tribo-electric charging**.

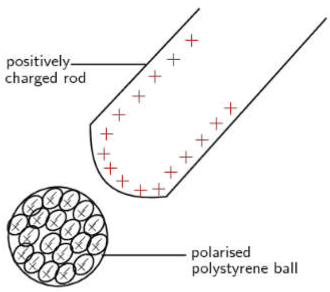
Objects may become charged in many ways, including by contact with or being rubbed by other objects.

During tribe electric charging the charge like energy is neither created nor destroyed but is conserved. See figure below:





Polarisation is the partial or complete polar separation or positive and negative



electric charge in a system.

Polarization illustration

- Other materials do not allow the charge carriers, the electrons, to move through them (e.g. plastic, glass). The electrons are bound to the atoms in the material. These materials are called **non-conductors or insulators eg, glass and plastic. Conductors** conduct electrical current very easily because of their free electrons, eg, silver and copper. **Insulators** oppose electrical current and make poor **conductors**.
- The effect of the shape on the charge distribution is the reason that we only consider identical conductors for the sharing of charge.

The principle of conservation of charge states that the net charge of an isolated system remains constant during any physical process, e.g. two charge objects making contacting and separating.

- Equation, $Q \frac{Q1 + Q2}{2}$

The principle of quantisation of charge states that every charge in the universe consists of integer multiples of the electron charge, i.e. $Q = nqe$.

Equation, Q = n q_{e-}.

Where:

- Q= Charge
- n= integer
- qe= charge on electron.

Activities

WORKED EXAMPLE 1

Choose the correct answer A, B, C or D

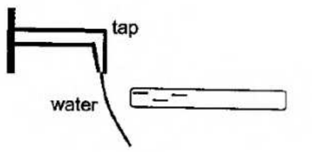
A plastic rod and a dry cloth are uncharged. The plastic rod is rubbed with the dry cloth and they both become charged. The rod becomes negatively charged because some particles move from the cloth to the rod.

	CHARGE ON ROD	PARTICLES THAT MOVED
A	**positive**	**protons**
B	**positive**	**electrons**
C	**negative**	**protons**
D	**negative**	**electrons**

Answer: B

Worked example 2

A Learner in Physical Sciences class rubs his hair with a plastic rod. The rod becomes negatively charged. The learner now opens a tap so that thin stream water runs from it. When the rod is brought close to the water without touching it, it is observed that the water bends towards the rod as shown in the diagram below.



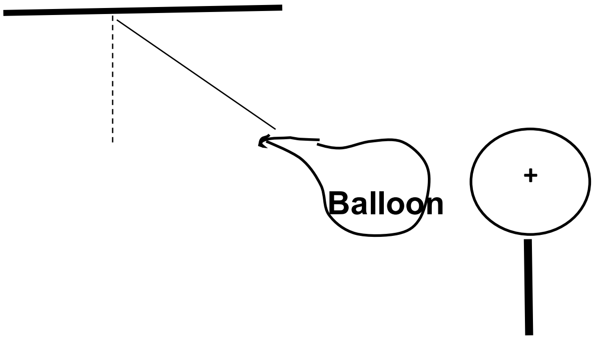
Question: Give a reason why the steam of water bends towards the rod.

Answer: Water molecules are polarised by the rod, the positive pole of the water is attracted to the negative pole, causing stream of water to bend towards the rod.

Activities

1. A balloon is brought closer to a positively charged sphere as shown in the diagram below.

The balloon is attracted to the sphere.



1. Which ONE of the following is the type of charge on the balloon?

A Positive

B Positive or neutral

C Negative or neutral

D Negative or positive

Answer:

2. A rubber balloon obtains a negative charge after it has been rubbed against Human hair.

Which ONE of the statements below best explains why this happens?

A. Negative charges are transferred from the rubber balloon to the human hair.

B. Positive charges are transferred from the rubber balloon to the human hair.

C. Positive charges are transferred from the human hair to the rubber balloon.

D. Negative charges are transferred from the human hair to the rubber balloon.

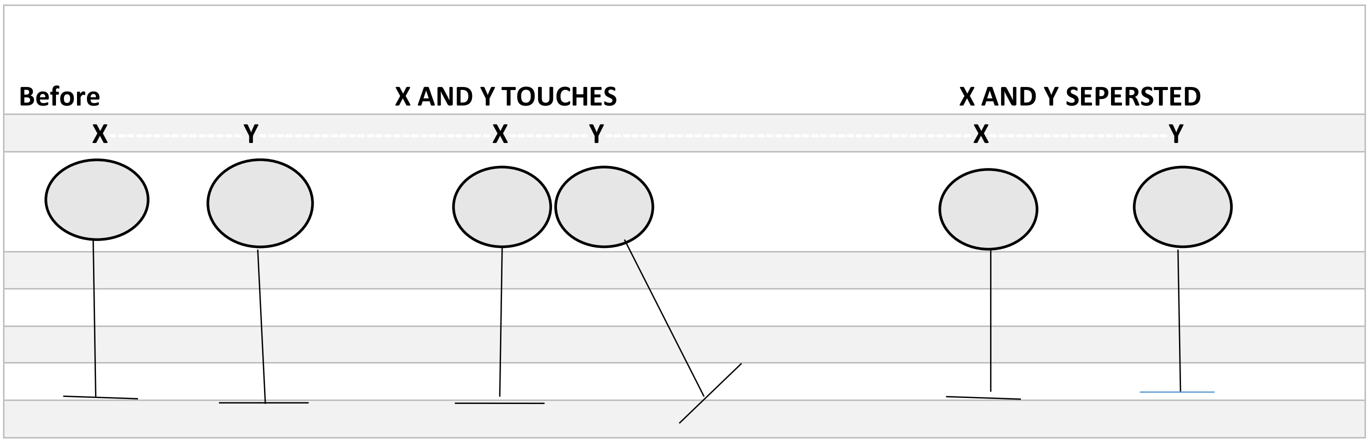
Answer:

THE PRINCIPLE OF CONSERVATION OF CHARGE ACTIVITIES

WORKED EXAMPLE

QUESTION 1

1. **X and Y are two identical spheres. Sphere X is on an insulated stand while Y has an insulated handle attached. The charge in sphere X is +6.4 x10^{-19}C and Y is NEUTRAL. Y is now brought nearer and touches X, after which they are separated again.**



1.1 State the Law of Conservation of charge in words (2)
1.2 Does sphere X has excess or deficiency of electrons before touching? (2)
1.3 Y was neutral before. Explain what this means: (2)
1.4 Are electrons transferred from X to Y or from Y to X when they touch? (1)
1.5 Calculate the new charge on Y after touching and separation. (4)

<u>Worked example QUESTION 1 (ANSWERS)</u>

1.1 Charge can neither be created nor destroyed but merely transferred from one body to another. (2)

OR

The total charge in a closed system remains constant.

OR

The total charge in an isolated system is conserved. (2)

1.2 X has a deficiency of electrons. (2)

1.3 Neutral means having equal number of electrons and protons. (2)

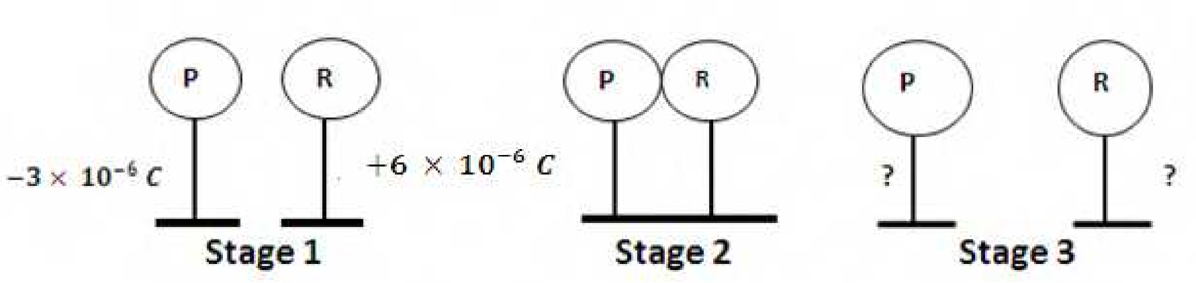
1.4 $Y\ to\ X$ (1)

1.

$Q = \frac{Q1 + Q2}{2}$
$=\frac{+6{,}4\times10-19}{2}$ (1 for Nr and 1 for Dr)
$=3{,}2 \times 10-19C$ (4)

ACTIVITY

1. Two small metal spheres, on insulated stands, carry charges of $-3\times 10^{-6}\ C$ and $+6\times 10^{-6}\ C$ respectively. The spheres were moved to touch one another, got separated and then returned to their original positions

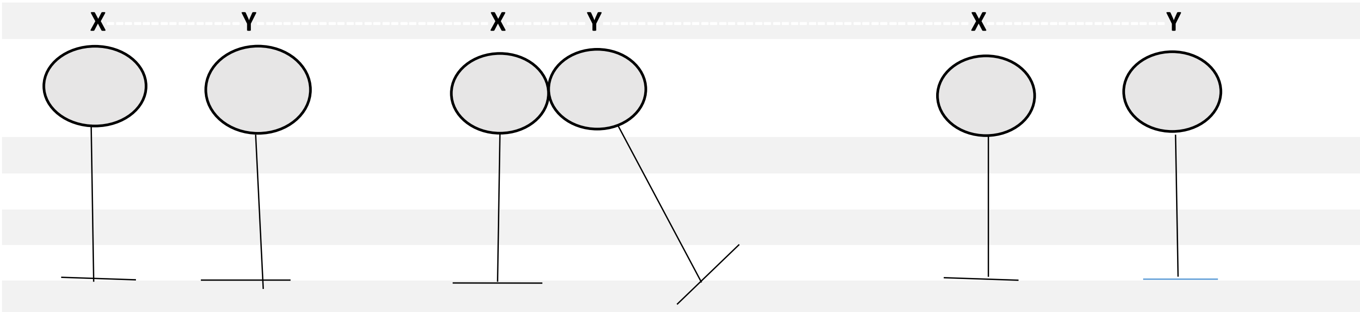


1.1 Which ONE of the two spheres, **P** or **R**, at Stage 1, has electron deficiency? (1)
1.2 Will the spheres at Stage 3 **Attract** or **Repel**? (1)
1.3 Write down the reason for your answer in 2. Above. (1)
1.4 State the principle of Conservation of Charge. (2)
1.5 Calculate the charge on **Sphere P** at **Stage 3** (3)

THE PRINCIPLE OF QUANTISATION OF CHARGE ACTIVITIES

1. **X and Y are two identical spheres. Sphere X is on an insulated stand while Y has an insulated handle attached. The charge in sphere X is +6.4 x10^{-19}C and Y is NEUTRAL. Y is now brought nearer and touches X, after which they are separated again.**

Before | **X AND Y TOUCHES** | **X AND Y SEPERSTED**



1.1 State the principle of charge quantization. (2)

1.2 Calculate the number of electrons transferred from one sphere to the other when X and Y touch.
(3)

QUESTION 1 Answers

1.1 Every charge in this universe is an integral multiples of the electron charge. 2)

1.2

$n = \frac{\Delta Q}{Qe}$

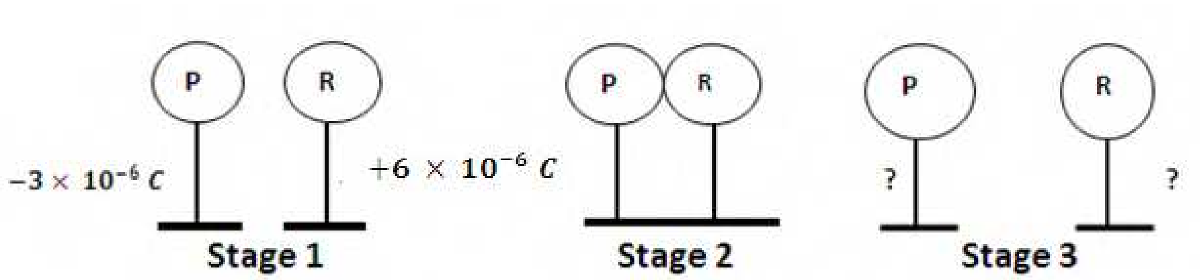
$= \frac{-3,2 \times 10-19}{-1,6 \times 10-19}$ OR $\frac{3,2 \times 10-19}{1,6 \times 10-19}$ (1 for Nr and 1 for Dr) ✓

$= 2$✓

(3)

ACTIVITIES

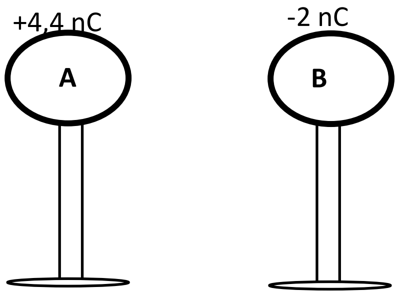
1. Two small metal spheres, on insulated stands, carry charges of −3× 10−6 C and +6× 10−6 C respectively. The spheres were moved to touch one another, got separated and then returned to their original positions



1.1Comparing stage 1 and stage 3, determine the number of electrons transferred. (3)

Activity 2

Two identical metal spheres **A** and **B** are placed on insulated stands. Spheres **A** and **B** carry charges of +4,4 nC and -2 nC respectively.

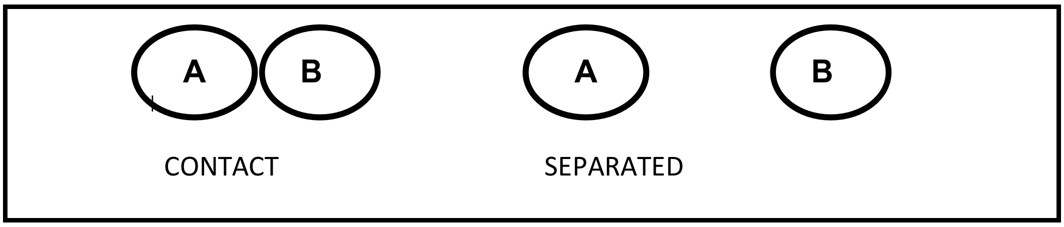


2.1 Which sphere (**A** or **B**) has FEWER electrons? (1)

2.2 Write down the NAME of the type of FIELD around the charged spheres.
Choose from MAGNETIC, ELECTRIC or GRAVITATIONAL. (1)

2.3 Give a reason why the charged spheres are placed on insulated stands. (2)

2.4 The spheres are brought into contact and then separated as shown below.

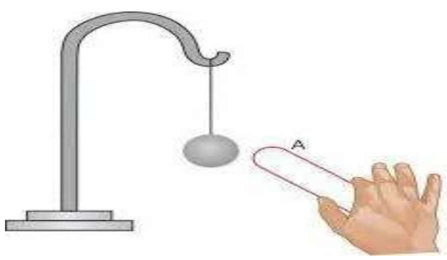


2.5 State the principle of conservation of charge. (2)

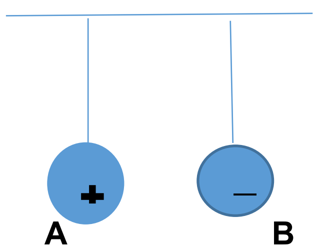
2.6 Which sphere loses electrons when the two spheres come into contact? (1)

2.7 Calculate how many electrons transferred from one sphere to the other when they come into contact. (5)

WORKSHEET: ELECTROSTATICS

<table>
<tr><td></td><td></td><td>CONSERVATION OF CHARGE</td><td></td></tr>
<tr><td></td><td></td><td>QUESTION 1</td><td>MARKS</td></tr>
<tr><td></td><td>1.1</td><td>Choose the correct answer A, B, C or D
A plastic rod and a dry cloth are uncharged. The plastic rod is rubbed with the dry cloth and they both become charged. The rod becomes negatively charged because some particles move from the cloth to the rod.
<table>
<tr><td></td><td>CHARGE ON ROD</td><td>PARTICLES THAT MOVED</td></tr>
<tr><td>A</td><td>POSITIVE</td><td>PROTONS</td></tr>
<tr><td>B</td><td>POSITIVE</td><td>ELECTRONS</td></tr>
<tr><td>C</td><td>NEGATIVE</td><td>PROTONS</td></tr>
<tr><td>D</td><td>NEGATIVE</td><td>ELECTRONS</td></tr>
</table></td><td>(2)</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>1.2</td><td>A positively charged plastic rod attracts small pieces of paper because…
A. The paper pieces are negatively charged.
B. The paper pieces are neutral.
C. The paper pieces are very small.
D. The paper pieces become polarised.</td><td>(2)</td></tr>
<tr><td></td><td></td><td>QUESTION 2</td><td></td></tr>
<tr><td></td><td>2.</td><td>A pith ball is a polystyrene sphere coated with metal paint. A plastic rod (A) is charged by rubbing it with a cloth. It is held next to an uncharged pith ball that is suspended on light cotton thread.

</td><td></td></tr>
<tr><td></td><td>2.1</td><td>Describe how the plastic rod becomes positively charged when it is rubbed with a cloth.</td><td>(2)</td></tr>
<tr><td></td><td>2.2</td><td>Describe what happens in the metal paint on the pith ball when the positively charged plastic rod is brought near to it.</td><td>(2)</td></tr>
<tr><td></td><td>2.3</td><td>The ball is attracted to the rod. Explain why this happens, given that the pith ball is uncharged.</td><td>(2)</td></tr>
<tr><td></td><td>2.4</td><td>Predict what you would see if the pith ball touches the positively charged rod. (2)</td><td>(2)</td></tr>
<tr><td></td><td>2.5</td><td>Explain your prediction in 2.2.4.</td><td>(2)</td></tr>
</table>

WORKSHEET: ELECTROSTATICS

	QUANTIZATION OF CHARGE		
	QUESTION 1		**19 MARKS**
	1.1	State the principle of quantisation of charge.	(2)
	1.2	An object has an excess charge of $-1{,}92\times10^{-17}$ C. How many excess electrons does it have?	(3)
	1.3	Two identical pith balls are suspended on light, inelastic cotton threads. Pith ball A has a positive charge of 5,4 nC. Pith ball B carries a negative charge of 8,2 nC. Calculate the extra number of electrons added to pith ball B.	(3)
	1.4	**Neutral plastic ruler becomes charged when it is rubbed with a woolen cloth. After Rubbing, the ruler has a charge of $-3{,}5 \times 10^{-15}$ C.** Distinguish between a neutral object and a charged object.	(2)
	1.5	Calculate the number of electrons transferred during the process of rubbing.	(3)
	2.	Two small identical spheres, A and B, are suspended on long silk threads, as shown in the sketch below. The spheres carry charges of $+3 \times 10^{-6}$ C and -2×10^{-6} C  **A ($+3\times10^{-6}$ C)** **B (-2×10^{-6}C)** **The two spheres are allowed to touch and then separated.**	
	2.1	Calculate the new charge on sphere B.	(3)
	2.2	Calculate the number of electrons transferred during contact.	(3)