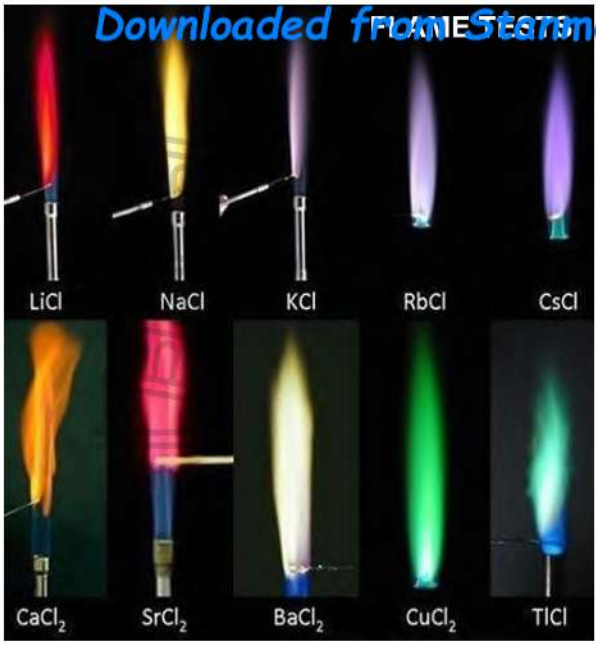


education
Department of
Education
FREE STATE PROVINCE

PHYSICAL SCIENCES
REVISION AND ACTIVITY BOOK
GRADE 10

2023

The Electromagnetic Spectrum

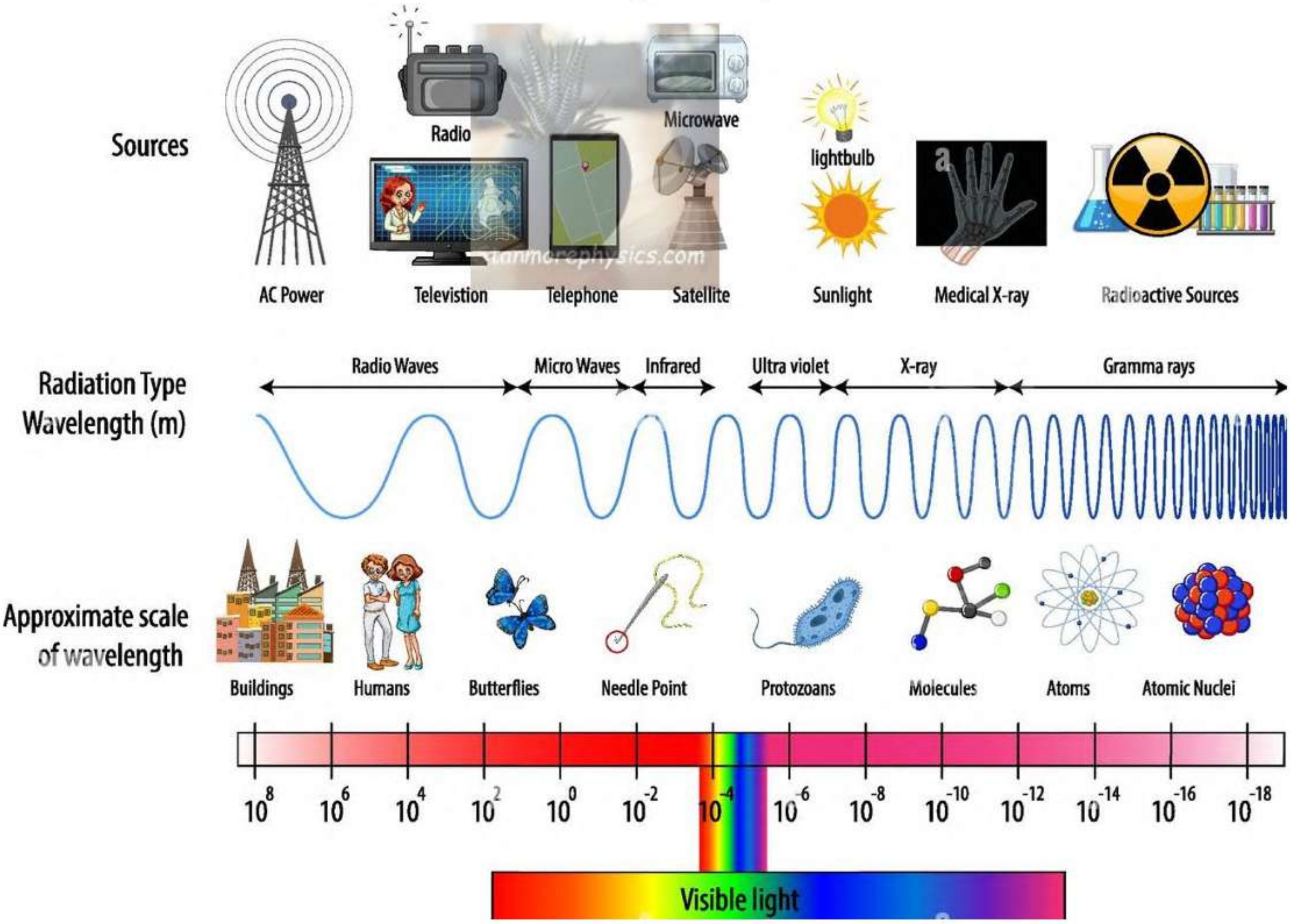
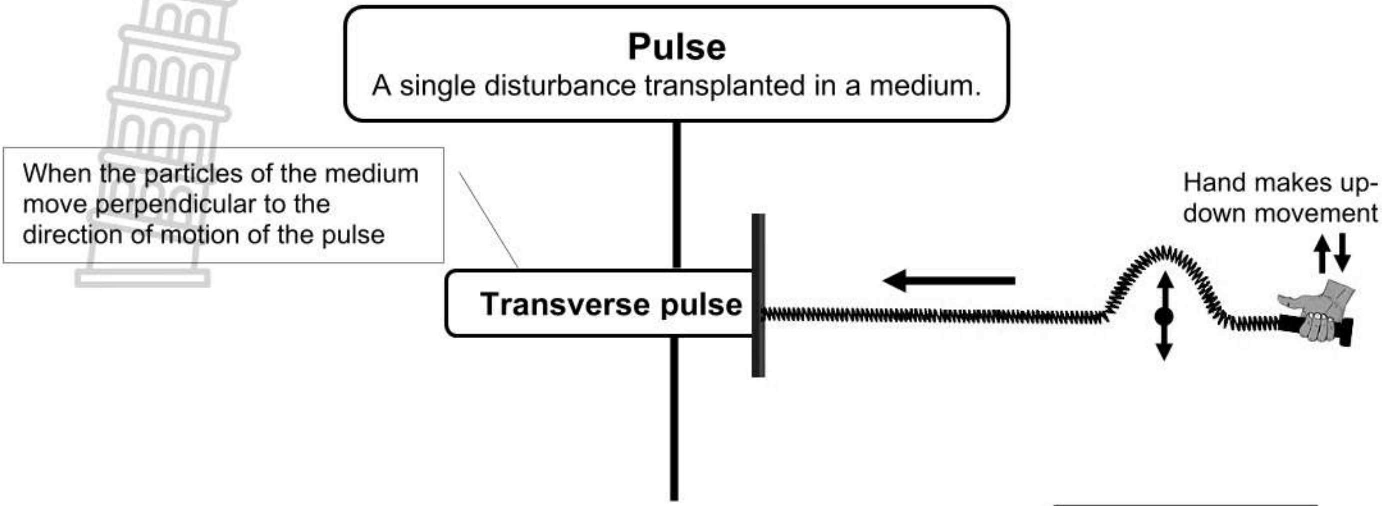
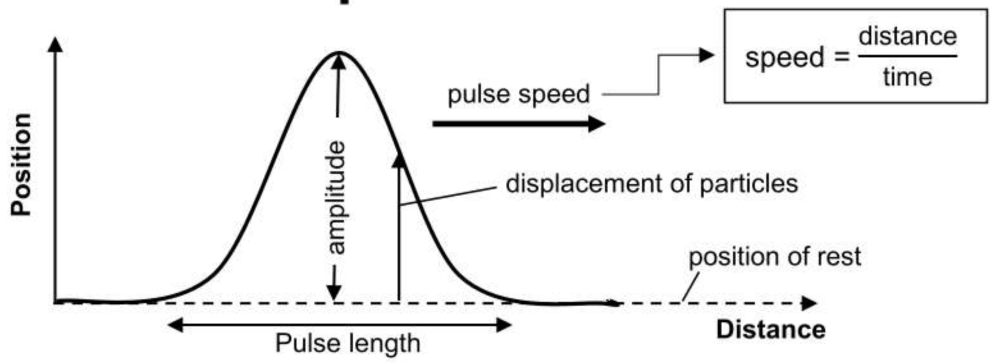


TABLE OF CONTENTS

Front cover spectrum:
https://www.alamy.com/stock-photo/electromagnetic-spectrum.html?cutout=1&sortBy=relevant

Topic 1: Transverse pulses on a string or spring





CONCEPTS AND DEFINITIONS	
Amplitude	The maximum displacement (disturbance) of a particle in a medium from its position of rest (equilibrium position).
Medium	Substance or material along which the pulse moves.
Pulse	A single disturbance that moves in a medium from one point to another.
Pulse length	Distance from the starting point to the endpoint of a pulse.
Position of rest (equilibrium)	The position of the medium (rope or spring) when no disturbance moves through it.
Speed	The distance travelled per time. / Rate of change of distance.
Transverse pulse	A single disturbance in a medium perpendicular to the direction of motion of the pulse.

Video 1: Transverse pulses and waves (Watch until 13:11)

Simulation of a transverse pulse on a string
https://phet.colorado.edu/sims/html/wave-on-a-string/latest/wave-on-a-string_en.html

Experiment 1: Generation of a transverse pulse

Aim: To generate a transverse pulse in a spring or rope

Apparatus
- Slinky (spiral spring) or strong rope
- Piece of string or ribbon

Method
1. Fasten the ribbon to one of the spirals of the slinky. Hold the slinky on the floor.
2. Let a friend hold the other end of the spring tightly or fasten it to an object.
3. Pull the free end of the spring and quickly move it to one side and back to its original position. Observe the motion of the ribbon.

Results and Questions
1. Sketch the pulse observed in the spring. On the sketch indicate the following:
   Position of rest, direction of movement of pulse, direction of displacement (disturbance)
2. In which direction did the pulse travel?
3. In which direction is the disturbance?
4. The ribbon represents a particle on the spring. Does the ribbon move in the direction of the pulse or in the direction of the disturbance?

Activity 1.1: Classwork/Homework

1. Define each of the following terms:
   1.1 Pulse
   1.2 Transverse pulse
   1.3 Position of rest
   1.4 Amplitude

2. A learner generates a transverse pulse in a slinky.
   2.1 How must the learner move his hand to generate a transverse pulse?
   2.2 How does the direction of motion of the coils of the spring compare to the direction of motion of the pulse?
   2.3 Explain how the motion of the coils of the spring allows the pulse to propagate.
   2.4 Sketch the transverse pulse. On the sketch indicate, using labels, the amplitude, position of rest and pulse length.

3. A pulse has a speed of 0,5 $m \cdot s^{-1}$. Calculate the time taken for the pulse to move 25 m.

Superposition of pulses

Pulses approach from different directions.

Pulses overlap and pulse has twice its height.

Pulses continue in their original directions.

Principle of Superposition

When two pulses meet simultaneously at the same point in a medium, the instantaneous displacement at the point is the algebraic sum of the displacements of each pulse at the moment.

Interference

Occurs when two or more pulses (waves) meet in the same space at the same time.

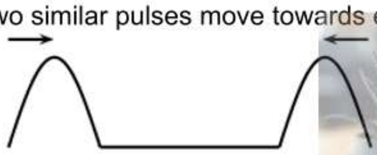
Constructive interference

Two pulses on the same side of the position of rest meet and STRENGTHEN each other to form a higher pulse.

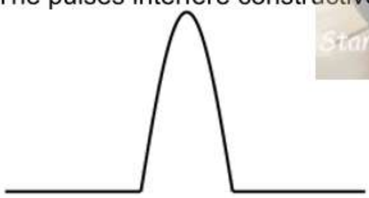
Destructive interference

Two pulses opposite sides of the position of rest meet and WEAKEN each other causing no pulse or a smaller pulse.

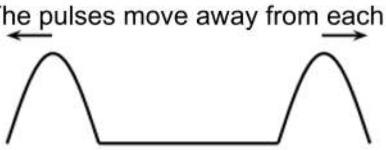
Two similar pulses move towards each other.



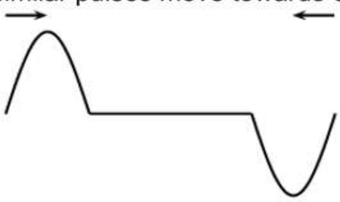
The pulses interfere constructively.



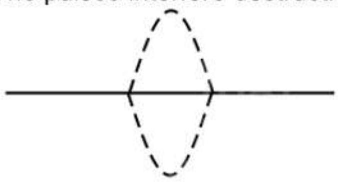
The pulses move away from each other.



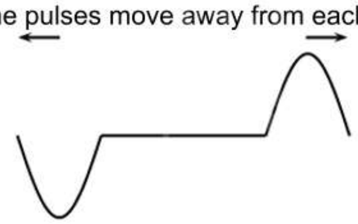
Two similar pulses move towards each other.



The pulses interfere destructively.



The pulses move away from each other.



Video 1: Transverse pulses and waves
(Watch from 13:11 until 20:34)
https://www.youtube.com/watch?v=Udwp49kaFC4

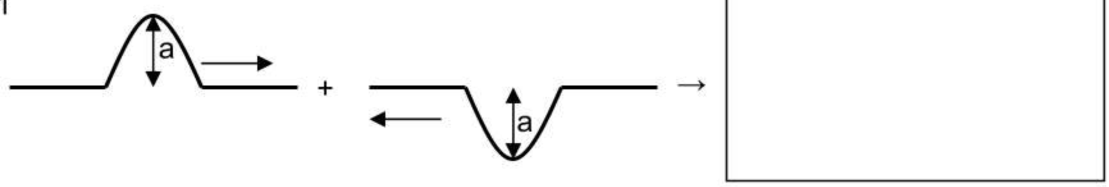
Video 2: Superposition of pulses.
(5 minutes)
https://www.youtube.com/watch?v=_w4o8_5THV8

CONCEPTS AND DEFINITIONS	
Constructive interference	Two pulses on the same side of the position of rest meet and strengthen each other to form a higher pulse.
Destructive interference	Two pulses on opposite sides of the position of rest meet and weaken each other causing no pulse or a smaller pulse.
Interference of pulses	The effect observed when two pulses in the same medium meet at the same point at the same time.
Superposition	The algebraic sum of the amplitudes of two pulses that occupy the same space at the same time.

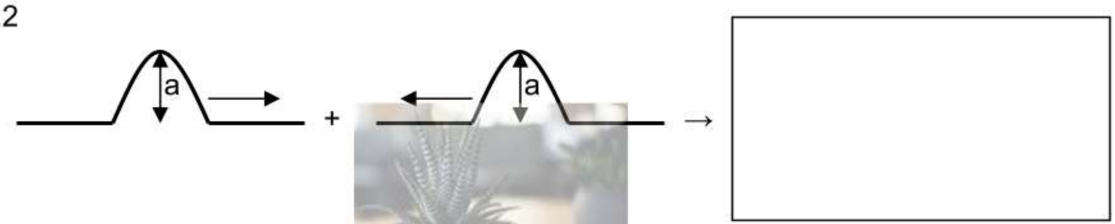
Activity 1.2: Classwork/Homework

1. State the principle of *superposition of pulses*.
2. Differentiate between:
   2.1 Constructive interference
   2.2 Destructive interference
3. Copy and complete the diagrams below to show how two pulses that reach the same point at the same time in the same medium superpose.

3.1

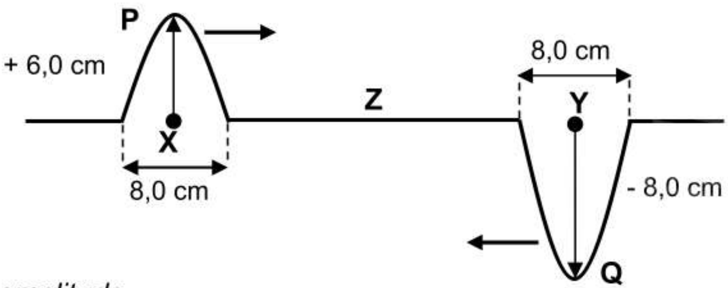


3.2



Activity 1.3: Classwork/Homework

The diagram below, not drawn to scale, shows two pulses, **P** and **Q**, moving towards each other at the same speed. Pulse **P** has an amplitude of + 6,0 cm at position **X**. Pulse **Q** has an amplitude of - 8,0 cm at position **Y**. Points **X** and **Y** are the same distance from point **Z**.



1. Define the term *amplitude*.
2. Write down the pulse length of pulse **P**.
3. Write down the name of the phenomenon that will occur when the two pulses meet at point **Z**.
4. Draw a labelled sketch to show what happens when pulse **P** and pulse **Q** meet at point **Z**. On the sketch, also indicate the amplitude and the pulse length.
5. Draw a labelled sketch of pulse **P** when it reaches point **Y** and pulse **Q** when it reaches point **X**.
6. Point **X** is 0,6 m from point **Y**. Pulse **P** moves from point **X** to point **Z** in 1,5 s. Calculate the speed of pulse **P**.

Experiment 2: Constructive and destructive interference

Aim: Observation of the interference of water waves.

Apparatus
Ripple tank
Two rulers
Water

Method
1. Set up a ripple tank. Fill the ripple tank with water to approximately 1 cm.
2. Place a ruler in the water to form a surface pulse.
3. Take a second ruler and place the two rulers into the water at opposite ends of the wave tank. Observe the two pulses when moving away from the rulers, when they meet and after they met.

Results
1. Draw the two pulses moving towards each other in the ripple tank.

2. Draw the pulses at the point where they cross.

3. Draw the two pulses after crossing.

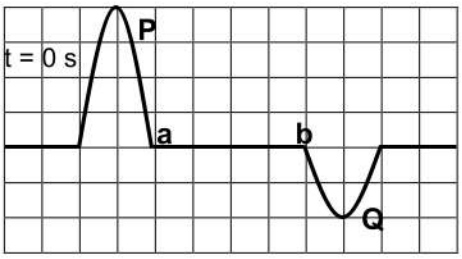
Simulation of water waves and interference of water waves
https://phet.colorado.edu/sims/html/wave-interference/latest/wave-interference_en.html

Activity 1.4: Classwork/Homework

1. A pulse moves at 0,25 m·s^{-1}. Calculate the distance moved by the pulse in 8 s.

2. A heavy rope is flicked UPWARDS, creating a single pulse in the rope. Sketch the pulse in the rope and indicate the following on the sketch:
   - The direction of motion of the pulse
   - Amplitude
   - Pulse length
   - Position of rest

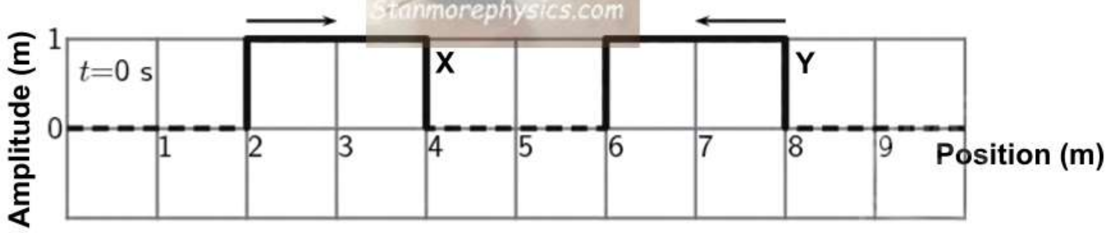
3. Pulses **P** and **Q** approach each other at a speed of 0,2 m·s^{-1}. The pulses are in the positions as shown below at time t = 0 s. Each block represents 20 mm x 20 mm.



   3.1 Calculate the time it takes for one pulse to move each 20 mm.
   3.2 Sketch the position of the two pulses relative to each other after:
      3.2.1 0,1 s
      3.2.2 0,2 s
      3.2.3 0,3 s
      3.2.4 0,4 s
   3.3 At what time did points **a** and **b** on the two pulses meet?
   3.4 At what time did the two pulses superimpose?

Activity 1.5: Classwork/Homework

Two pulses, **X** and **Y**, approach each other as illustrated below. The positions shown are at time t = 0 s.



Each pulse is travelling at 1 m·s^{-1}. Each block represents 1 m. The pulses are shown as thick black lines and the undisplaced medium as dashed lines.

1. Draw a grid in your homework book for each of QIESTIONS 1.1 to 1.3. Use a scale of 1 cm = 1 m. For each of the following, sketch the pulse that will form after:
   1.1 1 s
   1.2 2 s
   1.3 5 s
2. Write down the:
   2.1 Amplitude of the pulse at 2 s
   2.2 Distance travelled by pulse **X** after 10 s
   2.3 Pulse length of pulse **Y**

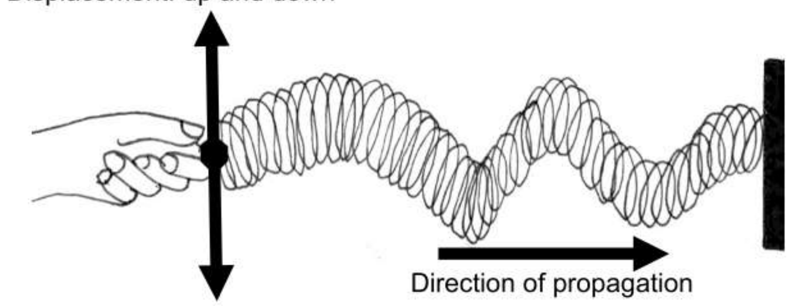
Topic 2: Transverse waves

Transverse wave

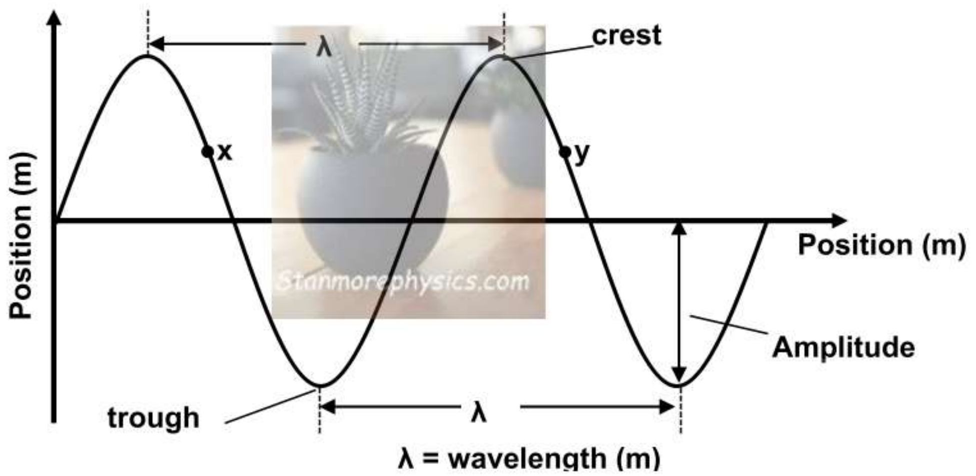
A wave in which the disturbance is at right angles to the direction of propagation (motion) of the wave.

A wave is a regular succession of pulses.

A transverse wave in a slinky



Graphical representation of a transverse wave



Video 1: Transverse pulses and waves
Watch from 20:34 to 28:08)
https://www.youtube.com/watch?v=Udwp49kaFC4

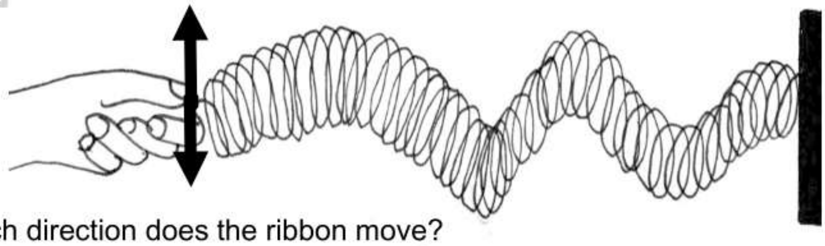
CONCEPTS AND DEFINITIONS	
Crest	The highest point (peak) on a wave.
Points in phase	Two points on a wave that move in the same direction at the same speed and have the same displacement from the position of rest. (Examples: x and y or any two crests or any two troughs)
Transverse wave	A wave in which the disturbance is at right angles to the direction of propagation (motion) of the wave.
Trough	The lowest point (valley) on a wave.
Wave	Regular succession/sequence of pulses.
Wavelength	The distance between two successive points in phase.

Experiment 3: Generation of transverse waves in a slinky

Aim: To generate a transverse wave in a slinky.

Method

1. Place a slinky on the floor or on the table.
2. Connect one end of the slinky to a fixed end.
3. Tie a coloured ribbon to one of the coils. The ribbon represents a particle of the slinky where the wave moves through.
4. Now move the spring up and down as illustrated below.

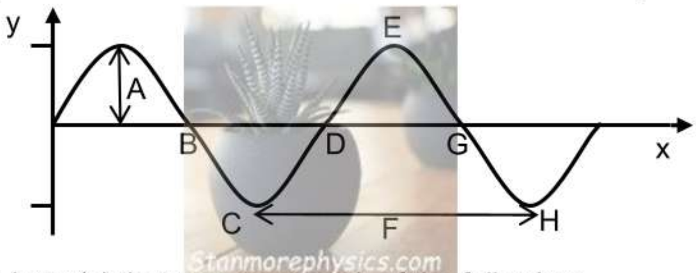


Questions

1. In which direction does the ribbon move?
2. In which direction does the wave move?
3. Formulate a definition for a transverse wave.

Activity 2.1: Classwork/Homework

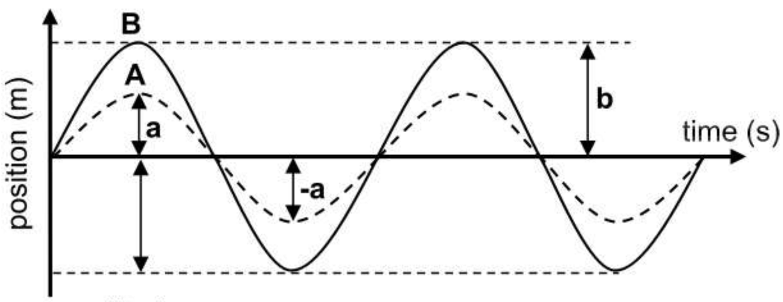
1. Define each of the following terms:
   1.1 Wavelength 1.2 Crest 1.3 Trough
   1.4 Position of rest 1.5 Points in phase
2. Differentiate between a *transverse pulse* and a *transverse wave*.
3. Study the diagram of a transverse wave below and answer the questions that follow.



Write down the letter(s) that represent each of the following:
3.1 One wavelength 3.2 Crest 3.3 Trough
3.4 Amplitude 3.5 Position of rest

Activity 2.2: Classwork/Homework

The diagram below shows two waves, **A** and **B**, of the same wavelength but different amplitudes, crossing each other.



1. Define the term *amplitude*.
2. Draw the shape of the resulting wave as the two waves (**A** and **B**) cross. On your diagram, show the resulting amplitude.
3. Which wave property is illustrated in QUESTION 2?
4. Name the principle used to answer QUESTION 2.

Frequency and Period

Frequency
The **number of waves**/vibrations **per unit time**.
Symbol: f
Unit: hertz (Hz) or per second (s^{-1})

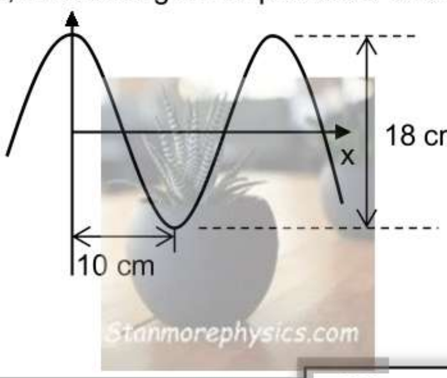
Period
The **time taken for one complete wave** / vibration.
Symbol: T
Unit: seconds (s)

$$\text{frequency} = \frac{1}{\text{period}} \qquad \text{In symbols: } f = \frac{1}{T}$$

$$\text{period} = \frac{1}{\text{frequency}} \qquad \text{In symbols: } T = \frac{1}{f}$$

Activity 2.3: Classwork/Homework

1. Calculate the period of a wave whose frequency is 50 Hz.
2. Calculate the frequency of a wave if its period is 0,5 s.
3. A wave, shown below, is travelling in the positive *x*-direction and has a frequency of 25 Hz.



Calculate its:
3.1 Amplitude
3.2 Wavelength
3.3 Period

Video 1: Transverse pulses and waves
(Watch from 28:08 to 50:29)
https://www.youtube.com/watch?v=Udwp49kaFC4

Wave Speed
The **distance that the wave covers in one second**.
Symbol: v
Unit: meter per second ($m \cdot s^{-1}$)

$$v = \frac{\text{distance covered}}{\text{time}} = \frac{\text{wavelength}}{\text{period}}$$

In symbols: $v = \frac{\lambda}{T}$

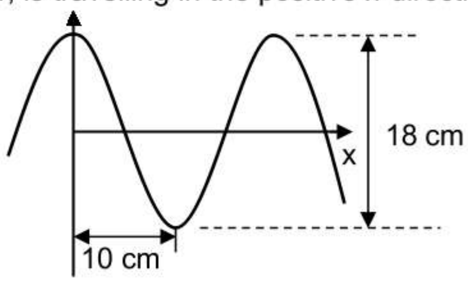
Substitute $T = \frac{1}{f}$ into $v = \frac{\lambda}{T}$: $v = f\lambda$

$$v = f\lambda$$

v: speed in $m \cdot s^{-1}$
f: frequency in hertz (Hz)
λ: wavelength in meter (m)

Activity 2.4: Classwork/Homework

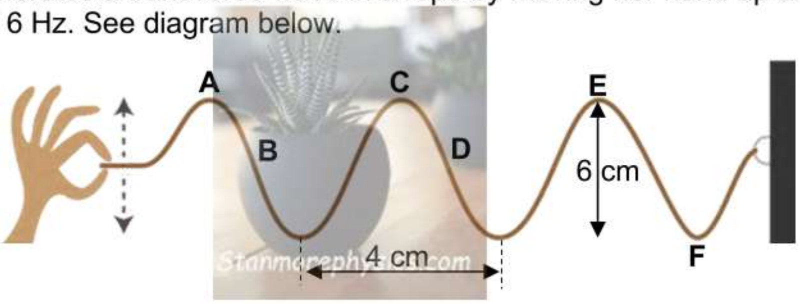
1. Calculate the speed of a periodic wave disturbance that has a frequency of 3,5 Hz and a wavelength of 0,7 m.
2. The speed of a transverse wave in a string is 15 $m \cdot s^{-1}$. If the source's frequency is 6 Hz, calculate the wavelength of the waves.
3. Calculate the speed of a wave, wavelength 0,015 m, if 40 peaks pass a certain point in 20 s.
4. Five pulses are generated in a tank of water every 0,1 s. Calculate the speed of propagation of the wave if the wavelength of the surface wave is 1,2 cm.
5. A cork on the surface of a pond bobs up and down two times per second on ripples having a wavelength of 8,5 cm. If the cork is 10 m from the shore, how long does it take a ripple, passing the cork, to move from the cork to the shore?
6. A wave, shown below, is travelling in the positive *x*-direction and has a frequency of 25 Hz.



Calculate the speed of the wave.

Activity 2.5: Classwork/Homework

1. A learner generates a transverse wave in a rope by moving her hand up and down at a frequency of 6 Hz. See diagram below.



For this motion, determine the:

1.1 Frequency
1.2 Period
1.3 Wavelength
1.4 Amplitude
1.5 Speed
1.6 Any two points that are in phase
1.7 Any two points that are out of phase
1.8 Any two points that re one wavelength apart

2. The rate at which the rope in QUESTION 1 above is moved up and down is now DOUBLED. If all other factors remain the same, how will each of the following be affected?

2.1 Frequency
2.2 Period
2.3 Wavelength
2.4 Amplitude
2.5 Speed

3. 80 full waves each with a wavelength of 2 m move past a point in 20 s. For these waves, calculate the:

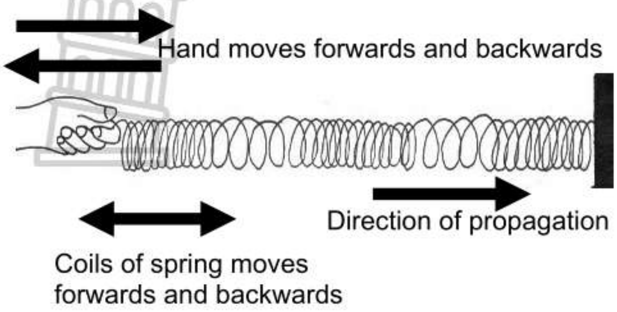
3.1 Frequency
3.2 Period
3.3 Speed

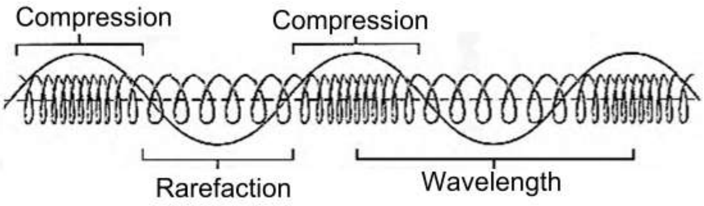
4. A learner stands on a harbour wall and sees four wave crests pass in 8 s. The distance between two successive crests is 4 m. The time is measured from the beginning of the first crest to the end of the fourth crest. For this wave, calculate the:

4.1 Period
4.2 Speed

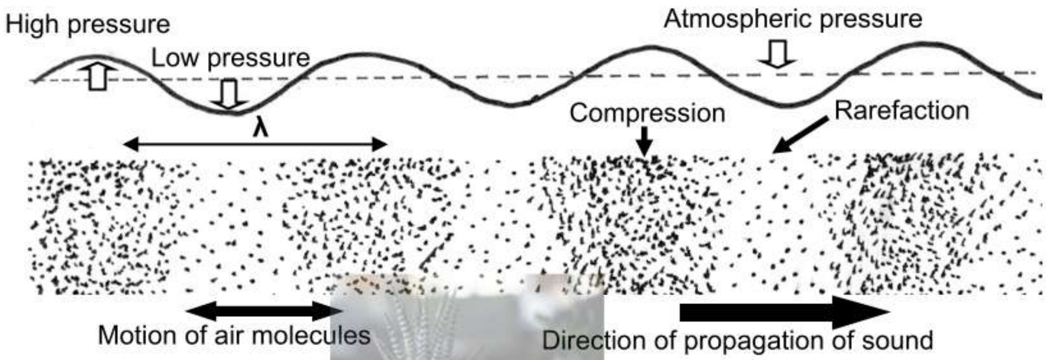
Topic 3: Longitudinal waves

Longitudinal wave

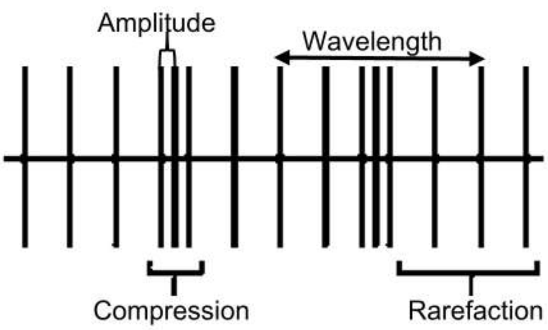




Sound wave



CONCEPTS AND DEFINITIONS	
Amplitude	The maximum displacement of the medium from its position of rest. (Maximum distance from the position of rest of the medium to a compression or a rarefaction.)
Compression	The region of high pressure in a longitudinal wave.
Frequency	The number of waves/vibrations (compressions/rarefactions) that pass a point per unit time (in one second).
Longitudinal wave	A wave in which the disturbance (of particles of the medium) is parallel to the direction of motion of the wave.
Period	The time taken for one complete wave/vibration/cycle to move past a point.
Rarefaction	The region of low pressure in a longitudinal wave.
Wavelength	The distance between two successive points in phase. (Distance between the centres of two successive compressions or two successive rarefactions.)
Wave speed	The distance travelled by a point on a wave per unit time.



Video 3: Types of waves: Transverse and Longitudinal (7 min 49 s)
https://www.youtube.com/watch?v=AUBAMlMoI1g

The speed of the particles of the medium

- The particles of the medium (spring) move to and fro.
- For one cycle the particles speed up from the position of rest in one direction and then move slower, still in the same direction, to the maximum displacement from the position of rest.
- The particles then return to the position of rest and accelerates in the opposite direction until they reach the maximum displacement on the other side of the position of rest.
- The particles again change direction and accelerate back to the position of rest.

The speed of the longitudinal wave

- The speed of the wave is the speed of at which pulses move through the medium in the direction of propagation of the wave.

Experiment 4: Generation of longitudinal pulses/waves in a slinky

Aim: To generate longitudinal pulses in a slinky.

Method

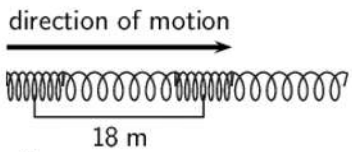
1. Place a slinky on the floor or on the table.
2. Connect one end of the slinky to a fixed end.
3. Tie a coloured ribbon to one of the coils. The ribbon represents a particle of the slinky where the wave moves through.
4. Now move the spring to and fro as illustrated below.

Questions

1. In which direction does the ribbon move?
2. In which direction does the wave move?
3. Formulate a definition for a longitudinal wave.

Activity 3.1: Classwork/Homework

1. The speed of sound in air at 20 °C is 343 $m \cdot s^{-1}$. Calculate the wavelength of a sound wave with a frequency of 18 Hz.
2. Calculate the frequency of sound waves of wavelength 3 m. Take the speed of sound in air to be 330 $m \cdot s^{-1}$.
3. Longitudinal waves in a spring have a wavelength of 25 cm. If the frequency of vibration of the spring is 50 Hz, calculate the speed of the waves.
4. A longitudinal wave in a slinky has a compression-to-compression distance of 18 m as shown below. It takes one complete wave 6 s to pass a point.



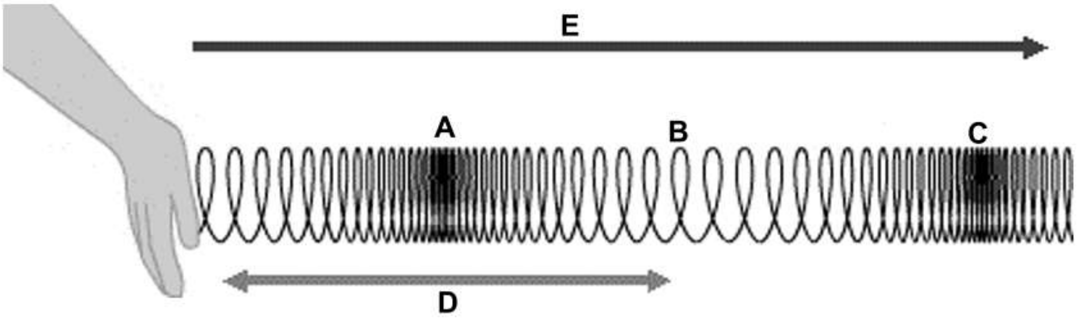
For the above wave, determine the:

4.1 Wavelength
4.2 Period
4.3 Frequency
4.4 Speed

Activity 3.2: Classwork/Homework

1. The distance between a compression and the following rarefaction is 10 cm. It takes 0,5 s for three consecutive compressions of a longitudinal wave to move past a certain point.
   For this wave, calculate the:
   1.1 Wavelength
   1.2 Period
   1.3 Frequency
   1.4 Speed
   1.5 Distance covered in 0,5 s

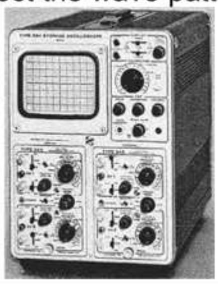
2. A longitudinal wave is generated in a spring as shown below.



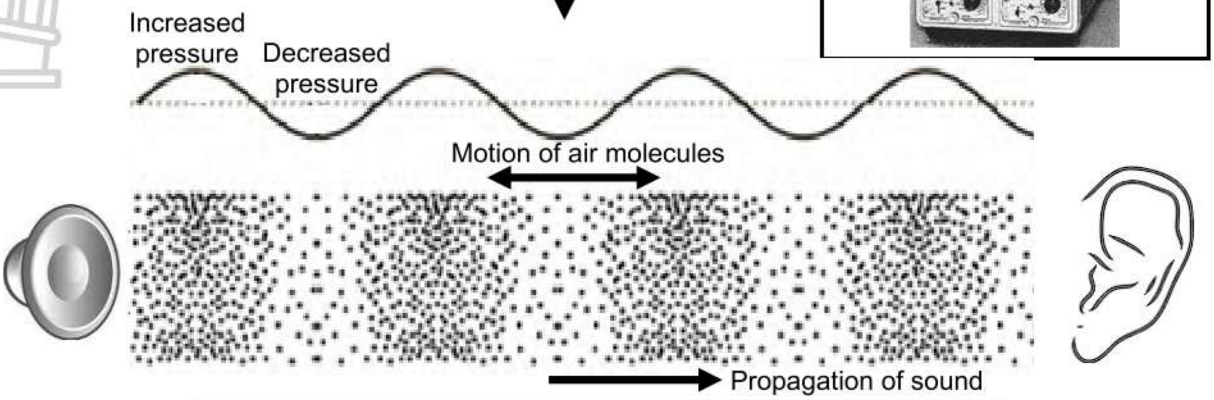
   2.1 Describe the motion of the hand to generate the wave.
   2.2 Label the parts **A**, **B** and **C**.
   2.3 Which letter, **D** or **E** represents the direction of motion of the wave/energy?
   2.4 Which letter, **D** or **E** represents the direction of motion of the coils of the spring?

Topic 4: Sound

An **oscilloscope** can detect the wave pattern.



Sound is a Longitudinal Wave



A material medium is needed for the propagation of sound. Sound cannot move through a vacuum.

Speed of Sound

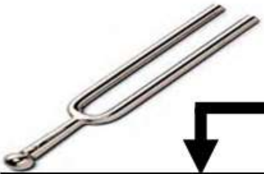
Transmission of sound waves is made possible by the collision of neighbouring particles within the medium. The closer the particles are to each other, the faster is the transmission of sound waves.

In different media

Steel: 5 900 $m \cdot s^{-1}$
Water: 1 500 $m \cdot s^{-1}$
Air: 340 $m \cdot s^{-1}$

Factors affecting speed in air

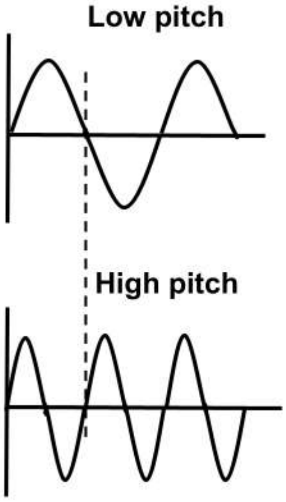
Higher **temperature**, faster speed
Increased **humidity**, faster speed



Properties of Sound

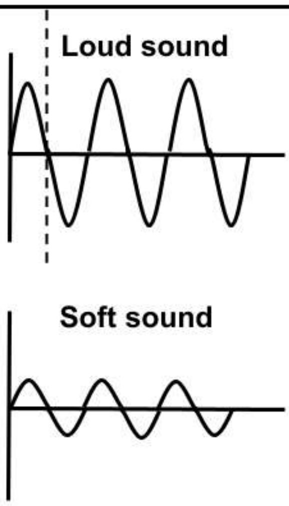
Pitch

Low pitch – low frequency
High pitch – high frequency



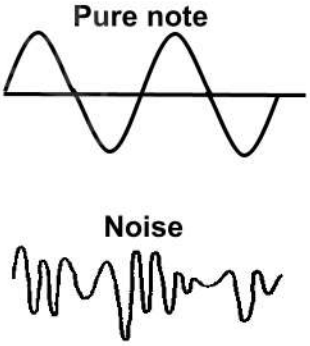
Loudness

Loud – large amplitude
Soft – small amplitude



Tone/Quality

Poor tone – frequency changes or more than one frequency together



CONCEPTS AND DEFINITIONS	
Amplitude	Maximum displacement from the position of rest.
Frequency	The number of waves/vibrations that passes a point per unit time (in one second)/produced by a vibrating body.
Loudness	A subjective term describing the strength of the ear's perception of a sound. (Loudness is proportional to amplitude – as the amplitude increases, loudness also increases.)
Noise	Irregular vibrations of an object.
Oscilloscope	An electronic instrument used to measure changing electric voltages. It displays the waveforms of electric vibrations on a screen.
Pitch	The effect perceived by the ear due to the sound of a particular frequency. (Pitch is proportional to frequency – pitch increases with increase in frequency.)
Tone	Quality of a sound
Ultrasound	Sound with frequencies higher than 20 000 Hz.
Wavelength	Distance between two consecutive points in phase.

Experiment 5: Determination of the speed of sound

Aim: To determine the speed of sound in air.

Apparatus
Stopwatch
Measuring tape
Starting pistol

Video 4: Measuring Speed of Sound Using Echoes
https://www.youtube.com/watch?v=1wrD4JLgb1c

Method
1. Find two points on the school grounds that are at least 300 m apart.
2. Measure the distance accurately.
3. The teacher stands at the one end and you at the other end with a stopwatch.
4. When the teacher fires a shot with the starting pistol, smoke leaves the pistol.
5. Start the stopwatch the moment you see the smoke. Measure the time from you see the smoke until you hear the pistol.
6. Repeat this procedure until a few sets of readings are obtained.

Results
Redraw the table below in your book and record the readings.

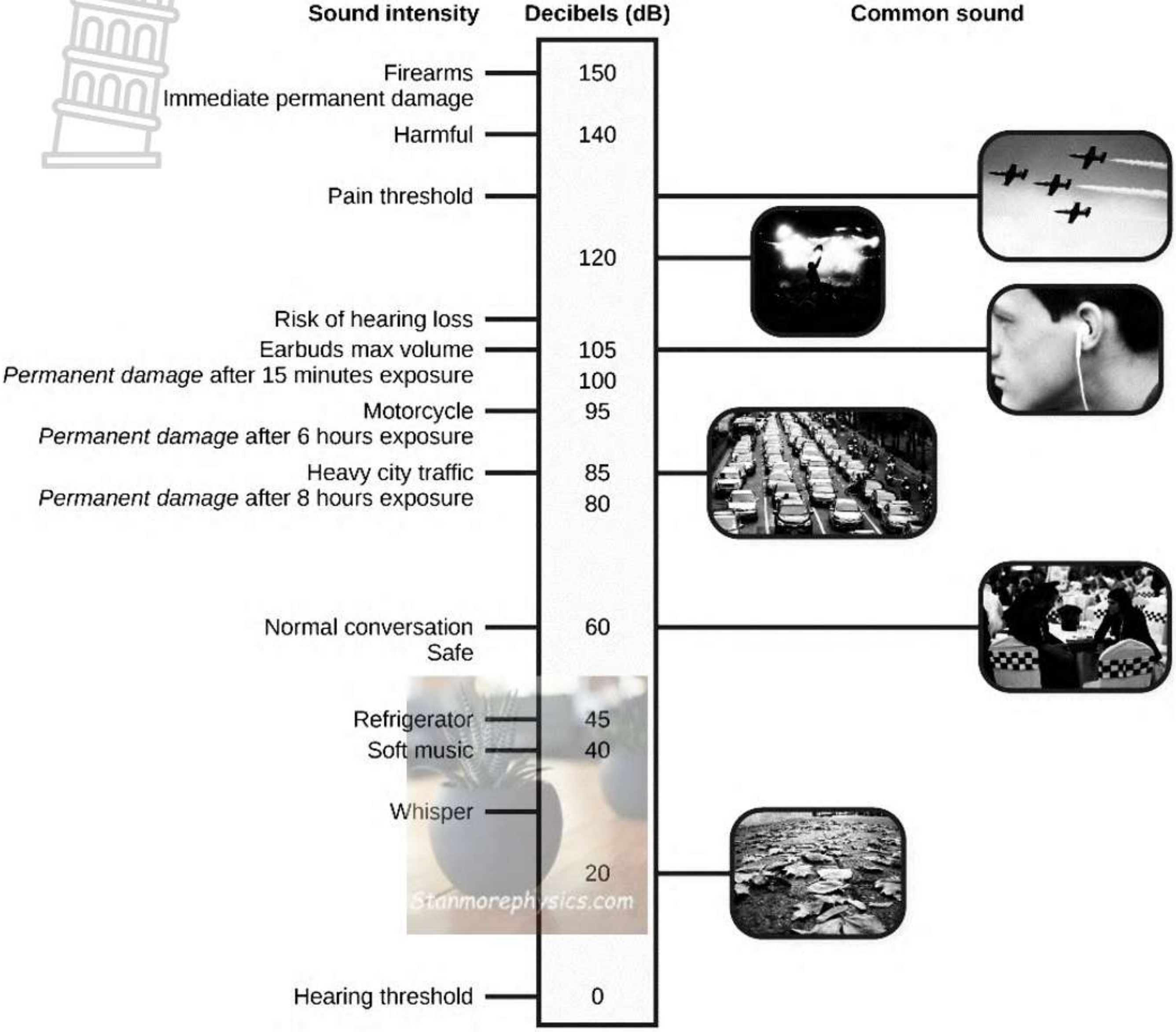
DISTANCE (m)	TIME (s)
AVERAGE TIME	

Questions
1. Use the formula speed = $\frac{\text{distance}}{\text{time}}$ to calculate the speed of sound in air.
2. List factor that could possibly affect the speed of sound on the day of measurement.

Video 5: Sound requires a medium – bell jar experiment
https://www.youtube.com/watch?v=jMEgzsmJdmQ

SOUND POLLUTION

Loudness is determined by the **amplitude**. The **decibel** is a u**nit used to compare loudness of different sounds**.



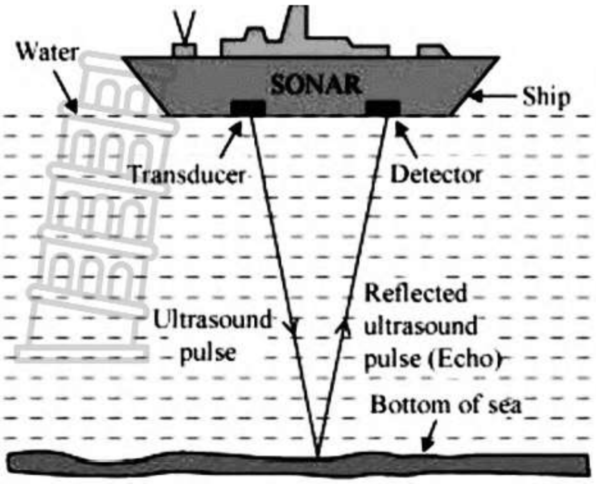
Source: *https://pressbooks.umn.edu/sensationandperception/chapter/auditory-sensitivity-function/*

ULTRASOUND

Sound waves with frequencies above 20 000 Hz (limit of human hearing) up to 100 000 Hz.

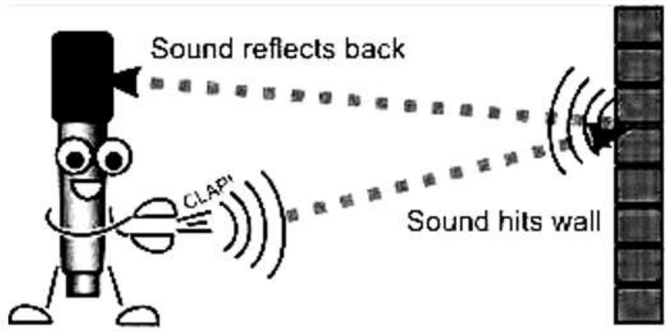
USES OF ULTRASOUND

- Cleaning of jewellery
- Testing for faults in materials and machinery
- Welding of plastic
- Medical uses e.g. tumour removal, ultrasound scan to see an image of an unborn baby, breaking up of kidney stones, reduce swelling
- Sonar used by ships to determine depth of ocean.



ECHO

Reflection of a sound wave from a hard surface.



Video 6: Medical Uses of Ultrasound
https://www.youtube.com/watch?v=VSCcCYe7Hus

Video 7: Applications of ultrasound
https://www.youtube.com/watch?v=yZty_W8ySng

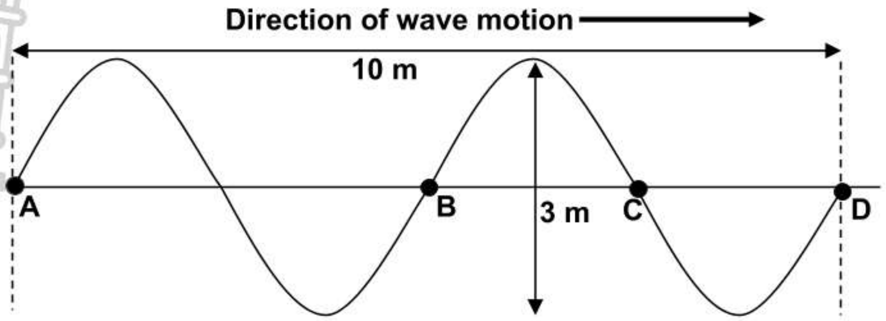
Video 8: Ultrasound and its applications
https://www.youtube.com/watch?v=4-wd3FDKqyM

Activity 4.1: Classwork/Homework

1. The lower limit of frequency that can be heard by the average human is about:
   - A 2 Hz
   - B 20 Hz
   - C 200 Hz
   - D 2 000 Hz
2. Which ONE of the following materials transplants sound the best?
   - A Air
   - B Steel
   - C Water
3. An airtight bell-jar is inverted on a platform connected to a vacuum pump. An electric bell fitted into the jar is operating, but its sound cannot be heard. This is because sound cannot travel through …
   - A a vacuum.
   - B air.
   - C glass.
4. The number of sound vibrations per second is the:
   - A Period
   - B Frequency
   - C Amplitude
   - D Wavelength
5. Which ONE of the following will produce sound with the highest pitch?
   - A A mosquito
   - B Women
   - C Men
   - D A lion
6. Echoes are often heard when talking in empty rooms.
   - 6.1 What is meant by *echo*?
   - 6.2 What are the conditions necessary for an echo to be heard?
   - 6.3 Why do echoes produced in an empty auditorium usually decrease when it is full of audience?
7. A boy fires a gun and hears the echo 2 seconds later. If he is 480 m away from a wall, calculate the speed of sound in air.
8. A girl claps her hands and hears the echo after reflection from a cliff which is 660 m away. If the velocity of sound in air is 330 m s^{-1}, calculate the time taken for the echo to travel to the girl.

Activity 4.2: Classwork/Homework

1. Refer to the following sketch of a longitudinal wave of frequency 50 Hz. **A, B, C** and **D** are points on the wave.



1.1 Calculate the time that the wave takes to travel the distance **AB**.
1.2 Calculate the wavelength of this wave.
1.3 Calculate the amplitude of this wave.
1.4 Are points **A** and **B** on the wave in phase? Explain the answer.
1.5 Calculate the speed of this wave.

2. Find the word/term in column **B** that completes the word/term in column **A**. Only write down the symbol representing the word/term in column **B** next to the question number.

	COLUMN A	COLUMN B	
2.1	Sound	A	Has a frequency greater than 20 000 Hz
2.2	The speed of a sound wave	B	Needs a medium to transplant
2.3	Ultrasound	C	Is an echo
2.4	Reflection of sound	D	Is proportional to the pitch of the sound
2.5	Frequency of sound	E	Increases in a denser medium

3. The pulse rate of a cyclist is found to be 45 beats in one minute. Calculate the:
3.1 Frequency of his heartbeat
3.2 Period of his heartbeat

4.
4.1 Echoes are caused by … of sound.
4.2 The loudness of sound depends on the … of the wave.
4.3 The effect of a sound of a particular frequency as perceived by the ear, is called the …
4.4 The maximum displacement of a vibrating body from its mean position is called …
4.5 The pitch of a note depends on the … of the vibrations.

5. The speed of sound in seawater is 1 500 $m \cdot s^{-1}$. A fishing boat sends out signals and receives the echo 20 s later. Calculate the depth of the seabed at this position.

6. A man stands between two tall buildings. When he claps his hands, he hears the echo from one building after 2 s and the echo from the other building after 3 s. Calculate the distance between the two buildings. Take the speed of sound in air as 330 $m \cdot s^{-1}$.

7. A rifle shot is fired in a valley between two parallel walls. The echo from one wall is heard 3 s later and the echo from the other wall is heard 8,3 s later.
The velocity of sound at 0 °C is 330 m s^{-1} and the temperature in the valley is 10 °C. For every 1 °C rise in temperature, the velocity of sound increases by 0,61 $m \cdot s^{-1}$.
Calculate the width of the valley.

Activity 4.3: Classwork/Homework

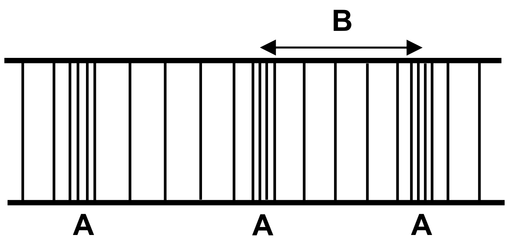
Dolphins communicate through the emission and reception of sounds. A young dolphin was separated from its mother and started whistling at a frequency of 130 kHz to call her.
The speed of sound in seawater is 1 480 m·s^{-1}.

1. Explain the term *ultrasound*.
2. Calculate the wavelength of the young dolphin's whistle.
3. Another dolphin hears the distress call of the young dolphin 2 s later. How far apart are the two dolphins from each other?
4. The speed of sound in air is 340 m·s^{-1}. Briefly explain why the speed of sound in air is different from the speed of sound in seawater.
5. Describe how dolphins use echolocation to hunt their prey.

Activity 4.4: Classwork/Homework

1. A sound wave produced by a vibrating musical instrument is represented in DIAGRAM 1 below.

DIAGRAM 1

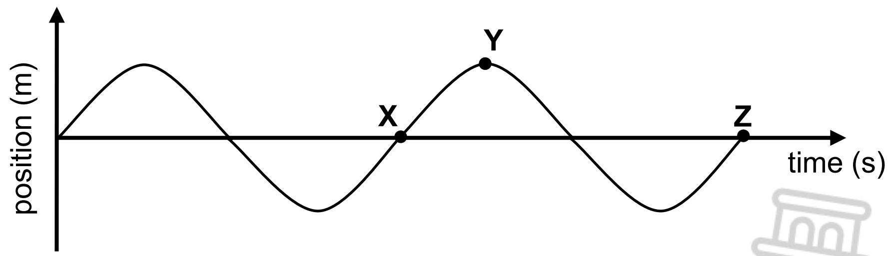


Label the sections marked:

1.1 **A** 1.2 **B**

2. The position-time graph in DIAGRAM 2 below represents the same sound wave produced by the above musical instrument.

DIAGRAM 2



2.1 Name the type of wave represented in DIAGRAM 2.
2.2 Which ONE of points **X**, **Y** or **Z** in DIAGRAM 2 corresponds to the section labelled **A** in DIAGRAM 1?
2.3 The same note is now played on the instrument, but much louder than before. How will this change affect the graph in DIAGRAM 2?
2.4 A note of higher frequency, but of the same original loudness is now played on the instrument. How will this change affect the graph in DIAGRAM 2?

Topic 5: Electromagnetic radiation (EM Radiation)

Source and Propagation of EM Radiation

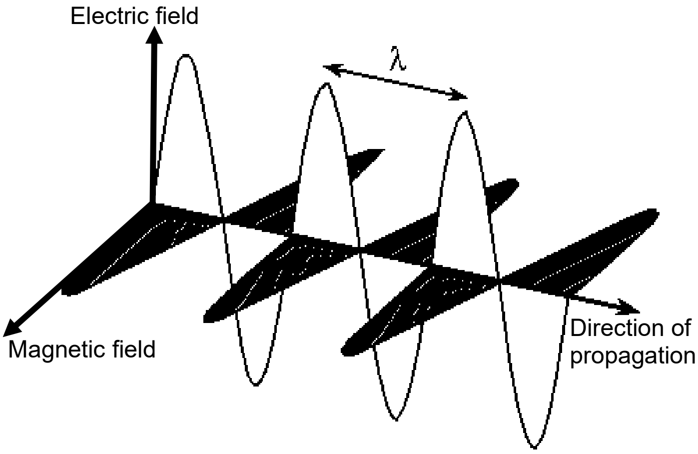
Source
Acceleration of electric charges cause a change in magnetic field that in turn causes a change in electric field.

Propagation
Changing magnetic field causes a changing electric field and the wave propagates as perpendicular changing electric and changing magnetic fields.

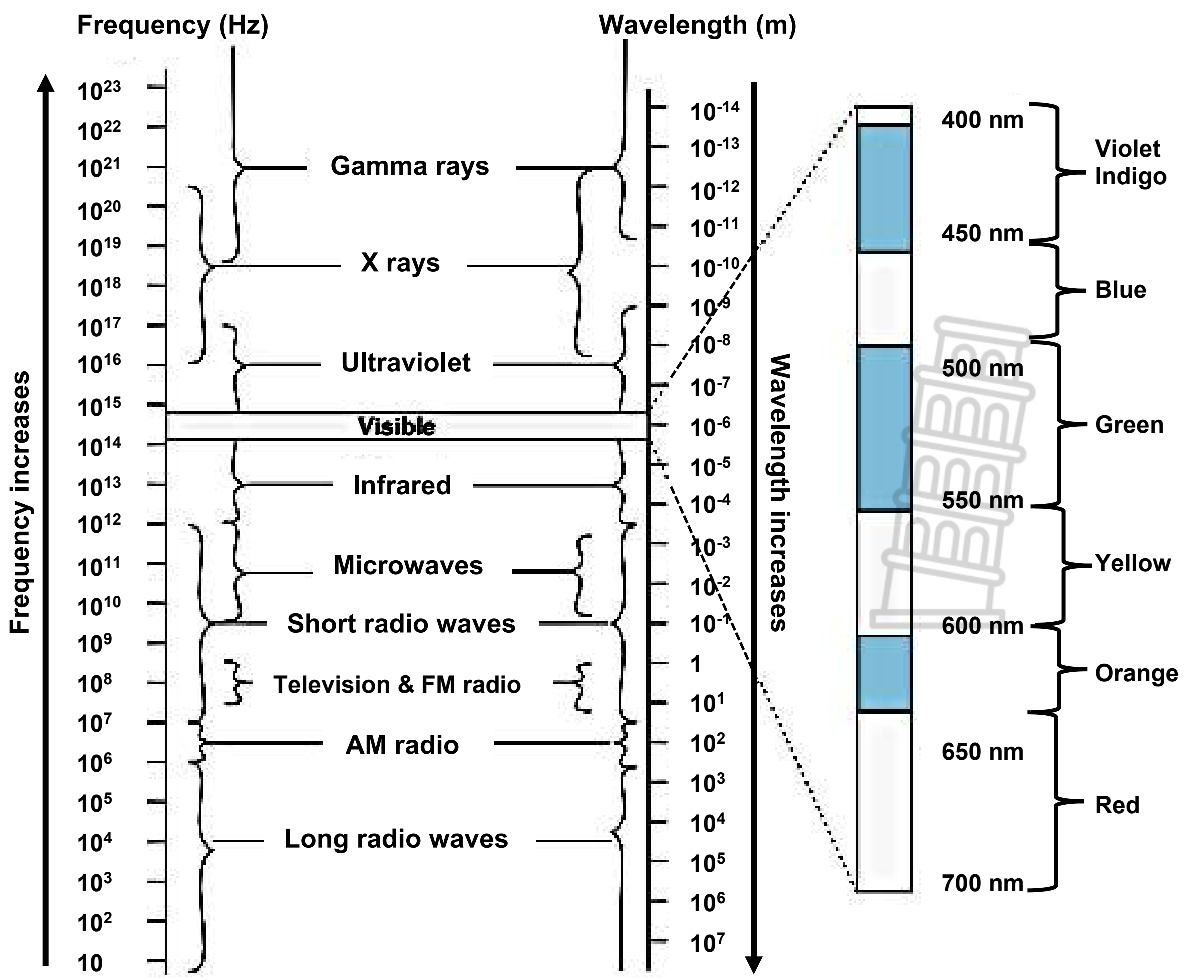
Properties of electromagnetic waves

Electromagnetic waves:

- Originate from accelerated electric charges
- Propagate as changing electric and magnetic fields that are perpendicular to each other
- Are transverse waves
- Transfers energy
- Can travel through a vacuum and a medium
- Have a speed of $c = 3 \times 10^8 \text{ m·s}^{-1}$
- Obey the wave equation: $c = f\lambda$ for EM waves



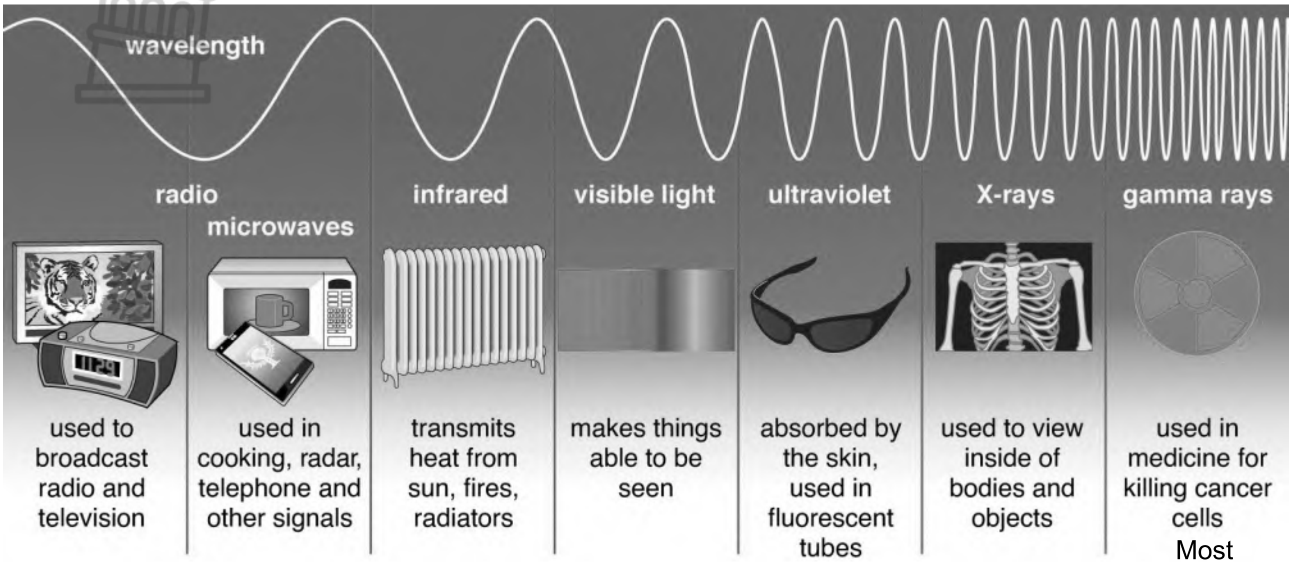
Electromagnetic Spectrum



Video 9: Understanding Electromagnetic Radiation!
https://www.youtube.com/watch?v=FWCN_uI5ygY

Video 10: Electromagnetic Waves
https://www.youtube.com/watch?v=508ZsmsIlno

Uses of EM Radiation *@Encyclopaedia Britannica*



Can damage the skin, eyes

Most penetrating

Dual nature - particle and wave motion

Dual nature of Electromagnetic Radiation

Waves

EM radiation behaves like waves when transplanted.

Evidence:

- Interference
- Diffraction – bending around corners.

Particles

EM radiation behaves like particles when interacting with matter.

Particle nature

EM radiation consists of **small particles** or quanta called **photons**.

Energy of photon is directly proportional to the frequency of the wave: E α f

$$E = hf$$

E: Energy of photon in joule (J)
h: Planck's constant ($6{,}63 \times 10^{-34}$ J·s^{-1})
f: Frequency of photon in hertz (Hz)

$$E = hf \text{ and } f = \frac{c}{\lambda}$$

$$E = \frac{hc}{\lambda}$$

E: Energy of photon in joule (J)
h: Planck's constant ($6{,}63 \times 10^{-34}$ J·s^{-1})
c: Speed of light (3×10^{8} m·s^{-1})
λ: Wavelength in meter (m)

The energy of a photon is:

- Directly proportional to the frequency of the wave (E α f)
- Inversely proportional to the wavelength of the wave ($E \alpha \frac{c}{\lambda}$)

CONCEPTS AND DEFINITIONS	
Amplitude	Maximum displacement from the position of rest.
Dual nature	Light has a wave and particle nature.
Electromagnetic radiation	A kind of radiation in which electric and magnetic fields vary simultaneously and included visible light, radio waves, gamma rays, and X-rays.
Frequency	The number of waves/vibrations that passes a point per unit time (in one second)/produced by a vibrating body.
Gamma rays	EM radiation with the highest frequency/shortest wavelengths arising from the radioactive decay of atomic nuclei. Gamma rays can easily penetrate object and are a radiation hazard for the entire body.
Infrared	EM radiation released by very hot objects and can be felt as heat. Longer wavelengths than visible light but shorter wavelengths than radio waves.
Microwaves	EM radiation with frequencies/wavelengths between radio waves and infrared radiation. Microwaves are used for cooking and to carry high-speed data transmissions between stations on Earth and between ground-based stations and satellites and space probes.
Oscilloscope	An electronic instrument used to measure changing electric voltages. It displays the waveforms of electric vibrations on a screen.
Photon	An energy packet of electromagnetic radiation.
Quantum	The smallest undividable amount of a physical quantity.
Radio waves	EM radiation with the longest wavelength and are used in communication. Waves with long wavelengths bend around objects.
Spectrum	Colour band consisting of seven colours into which visible white light can be divided.
Ultraviolet	Non-ionising radiation emitted by the sun.
Visible light	The only frequencies of the electromagnetic spectrum that humans can see. The different frequencies of visible light are seen as the colours of the rainbow: red, orange, yellow, green, blue, indigo, and violet.
Wavelength	Distance between two consecutive points in phase.
X rays	EM radiation of higher energy that can pass through most objects, including the body. Medical X rays are used to generate images of tissues and structures inside the body.

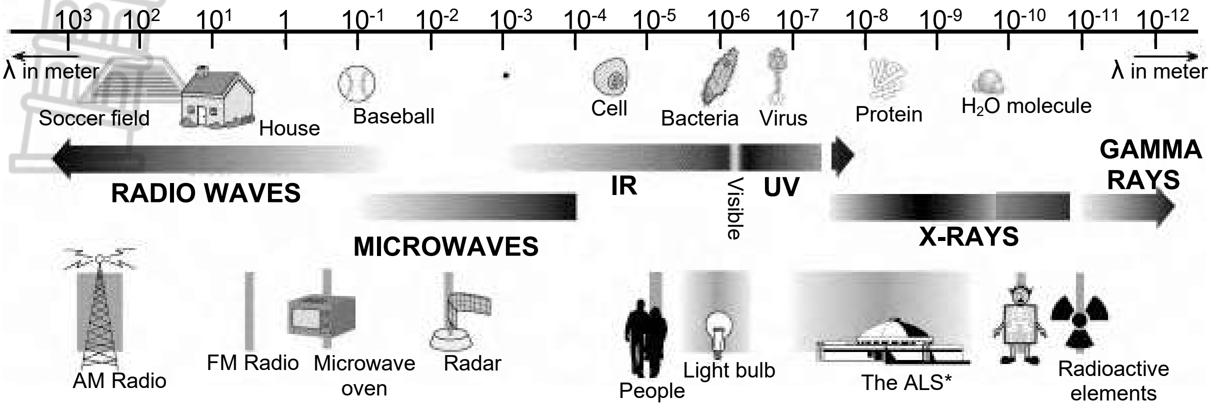
Activity 5.1: Classwork/Homework/Data-interpretation

Use the electromagnetic spectrum given on page 22 to answer the following questions.

1. Which type of EM radiation has the:
   1.1 Longest wavelength?
   1.2 Shortest wavelength?
   1.3 Highest energy?
   1.4 Lowest frequency?
2. Give one word for each of the following descriptions.
   2.1 The type of radiation that can travel through flesh, but not through bones. It therefore casts a shadow of bones.
   2.2 The type of radiation that causes the skin to become brown.
   2.3 Visible light with the longest wavelength.
3. Use the wave equation $v = f\lambda$ to answer the following questions.
   3.1 Calculate the highest frequency that radio waves can have.
   3.2 Calculate the lowest frequency that gamma rays can have. (1 nm = 1×10^{-9} m)
   3.3 What is the main difference between radio waves and gamma rays?
   3.4 Radio waves tend to move around objects, while gamma rays tend to move through objects. Explain this phenomenon.
4. What frequencies of light are visible to the human eye? (1 nm = 1×10^{-9} m)
5. Calculate the highest energy associated with X rays.

Activity 5.2: Classwork/Homework/Data-interpretation

1. The electromagnetic spectrum covers a wide range of wavelengths and frequencies. Light used to "see" an object must have a wavelength about the same size as or smaller than the object. Study the diagram of the electromagnetic spectrum and answer the questions.



1.1 What kind of electromagnetic radiation has the shortest wavelength?
1.2 What kind of electromagnetic radiation has the longest wavelength?
1.2 What kind of electromagnetic radiation could be used to "see" molecules? And a cold virus?
1.3 Why can't you use visible light to "see" molecules?
1.4 Some insects, like bees, can see light of shorter wavelengths than humans can see. What kind of radiation can bees see?

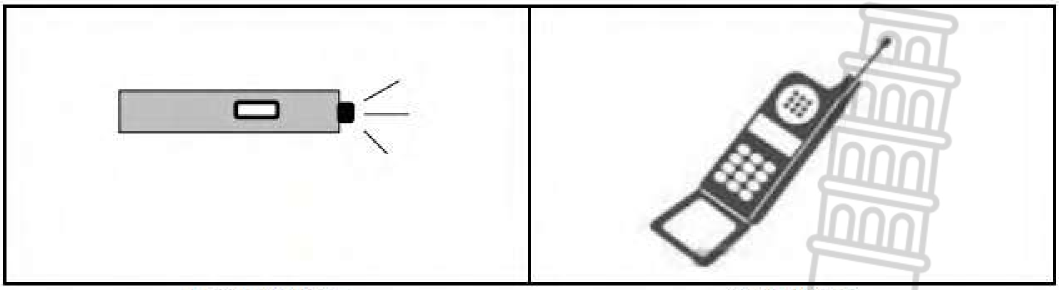
2. List at least four properties that all EM waves have in common.
3. How do the different types of EM radiation differ?
4. Which type of EM radiation can be considered the most harmful to people? Explain your choice.

* ALS The Advanced Light Source, a division of Berkeley Lab, is a user facility that generates intense light for scientific and technological research.

Video 11: Practical applications of electromagnetic radiation
https://www.youtube.com/watch?v=HcPHHPKeF5A

Activity 5.3: Classwork/Homework

Consider a laser pointer and cellphone, as shown below.



Laser pointer Cellphone

1. State the type of electromagnetic radiation that is emitted by the:
   1.1 Laser pointer
   1.2 Cellphone
2. A laser pointer uses red light photons with a wavelength of 620 nm.
   2.1 Define the term *photon*.
   2.2 Calculate the energy of a red-light photon.
   2.3 Refer to the answer to QUESTION 2.2. Explain why it is very dangerous to shine a laser pointer into a person's eyes.

Topic 6: Electrostatics

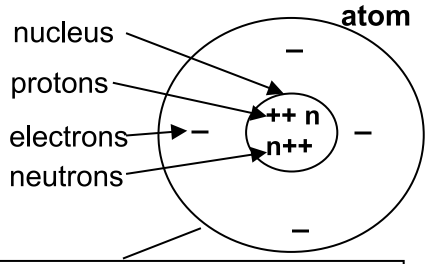
ELECTROSTATICS

Static electricity
Study of charges at rest

Two kinds of charge

Positive: electron shortage
Negative: excess of electrons

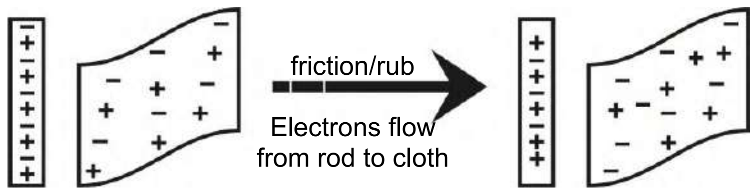
All matter consists of atoms.



Atoms are neutral (uncharged)
Number of protons = number of electrons

Charging objects

By contact: When two objects are rubbed against each other, electrons are transferred from one to the other.



Glass rod: neutral
Woollen cloth: neutral

Glass rod: positive (e^- lost)
Woollen cloth: negative (e^- gained)

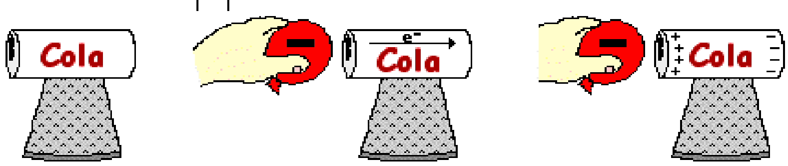
Tribo-electric series Materials	
Dry skin of humans	Stronger positive ↑
Leather	
Rabbit fur	
Glass	
Human hair	
Nylon	
Wool	
Lead	
Cat hair	
Silk	
Aluminium	
Paper	
Cotton (neutral)	
Steel (neutral)	
Wood (practically neutral)	Stronger negative ↓
Amber	
Rubber	
Nickel, Copper	
Brass, Silver	
Gold, Platinum	
Polyester	
Foam plastic	
Cling wrap	
Polyurethane (type of plastic)	
Polyethylene (Scotch tape)	
Polypropylene (type of plastic)	
Vinyl (PVC) (type of plastic)	

Electrostatic forces

Repulsion: Like charges
Attraction: Opposite charges

Polarisation of charge

Effect of a charged object on a neutral object.



A neutral can on an insulating stand.

Negative object held nearby: electrons in can repelled to the opposite side of can.

Charge within can **polarised** – separated into opposites.

Charge quantisation

All charges are multiples of smallest charge i.e. the charge on one electron:
$q_e = 1,6 \times 10^{-19}$ C
Total charge = no. electrons x q_e
$Q = n q_e$

Unit of charge

SI unit of charge is the coulomb (C)

Electron	negative charge	$1,6 \times 10^{-19}$ C
Proton	positive charge	$+ 1,6 \times 10^{-19}$ C
Neutron	neutral	zero

A charge of one coulomb

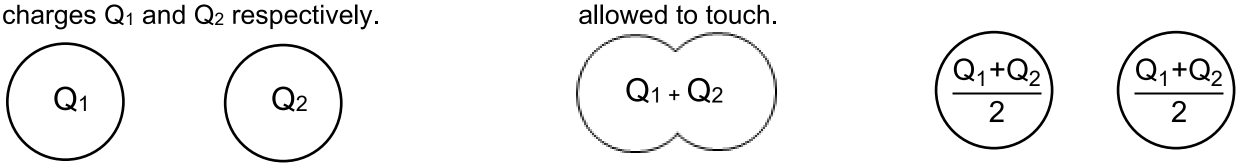
1 C is a huge charge. Charges we encounter are much smaller. Therefore, smaller units of charge are used as given below:

1 C	1 coulomb		
1 mC	1 millicoulomb	1 x 10^{-3} C	0,001 C
1 µC	1 microcoulomb	1 x 10^{-6} C	0,000 001 C
1 nC	1 nanocoulomb	1 x 10^{-9} C	0,000 000 001 C
1 pC	1 picocoulomb	1 x 10^{-12} C	0,000 000 000 001 C

Calculating charge on each of two identical conductors

Two identical conductors, each carrying a charge, will during contact share the charges equally and after separation they will have the same charge.

Two identical spheres with charges Q_1 and Q_2 respectively. The spheres are allowed to touch. The spheres are separated.



CONCEPTS AND DEFINITIONS	
Electrical conductor	A substance or material that allows electrical charges to flow through it.
coulomb	The unit of measurement of electric charge.
Electrons	Negative particles occupying space around an atomic nucleus.
Electrostatics	A study of charges at rest.
Elementary charge	An indivisible unit of charge i.e.1,6 x 10^{-19} C.
Electrical insulator	A substance or material in which electrical charge does not flow freely.
Neutrons	Neutral particles in the atomic nucleus.
Protons	Positive particles in the atomic nucleus.
Polarisation (of charge)	The partial or complete polar separation of positive and negative electric charge in a system.
Quantisation (of charge)	Division of charge in smaller units
Principle of conservation of charge	Charge cannot be created or destroyed but can only be transferred from one object to another.
Principle of charge quantization	An object has a charge that is an integer multiple of the elementary charge. In symbols: $Q = nq_e$ where $q_e = 1,6 \times 10^{-19}$ C
Triboelectric series	A table showing substances and their tendency to be either charged positively or negatively. Example: Nylon has the tendency to become positive and plastic has the tendency to become negative (see table on p 26). Therefore, if you rub a plastic ruler with a nylon cloth, the ruler will become negative and the cloth positive.

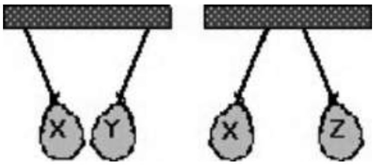
Video 12: Static Electricity - Charging Conductors by Contact
https://www.youtube.com/watch?v=hUIHAYjFxjg

Video 13: Experiment – opposites attract, likes repel
https://www.youtube.com/watch?v=F6v8wm7_vdQ

Video 14: Demos Van de Graaff Generator
https://www.youtube.com/watch?v=sKFI7Iinwf4

Activity 6.1: Classwork/Homework

1. Balloons **X**, **Y** and **Z** are hanging as shown.
If balloon **X** is positively charged, balloon **Z**:
A Must be positively charged
B Must be negatively charged
C Must be neutral
D Could be either negatively charged or neutral
E Could be either positively charged or neutral



2. Two small IDENTICAL metal spheres, **P** and **R**, on insulated stands carry charges of $+5 \times 10^{-9}$ C and -3×10^{-9} C respectively.

2.1 Which sphere has a(n):
2.1.1 Excess of electrons
2.1.2 Shortage of electrons
2.2 Calculate the number of electrons that was transferred during charging of sphere **P**. Were these electrons removed from or added to sphere **P**?
2.3. The spheres are now brought into contact and then separated again.
2.3.1 State the principle of conservation of charge in words.
2.3.2 Calculate the new charge on each sphere after separation.

3. Calculate the number of electrons in a charge of $-6{,}4 \times 10^{-19}$ C.

Activity 6.2: Classwork/Homework

1. A negatively charged plastic comb is brought close to, but does not touch, a small piece of paper. If the comb and the paper are now attracted to each other, the original charge on the paper was …
A negative.
B positive.
C negative or neutral.
D positive or neutral.

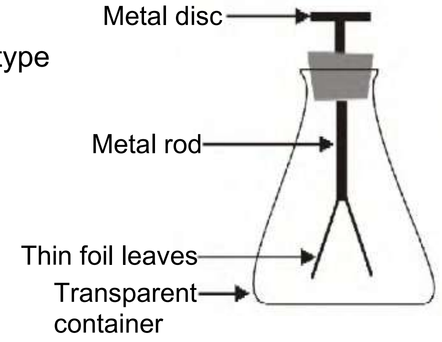
2. A positively charged metal sphere **X** on an insulated stand is brought into contact with an identical neutral metal sphere **Y** on an insulated stand. The two spheres are then separated. Which ONE of the following describes the charge on each sphere after they have been separated?

	Sphere X	Sphere Y
A	Positive	Neutral
B	Positive	Positive
C	Neutral	Positive
D	Neutral	Neutral

3. Two small identical metal spheres, each carrying equal charges Q, are brought into contact and then separated. The charge on each sphere will now be …
A zero.
B $\frac{1}{2}$Q.
C Q.
D 2Q.

4. **P**, **Q** and **R** are three charged spheres. When **P** and **Q** are brought near each other, they experience an attractive force. When **Q** and **R** are brought near each other, they experience a repulsive force. Which ONE of the following is TRUE?
A **P** and **R** have charges with the same sign.
B **P** and **R** have charges with opposite signs.
C **P**, **Q** and **R** have charges with the same sign.
D **P**, **Q** and **R** have equal charges.

Experiment 6: Charging by contact



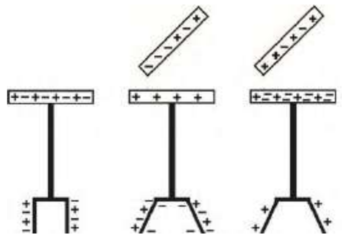
Aim: To use an electroscope to indicate charge and to indicate type of charge.

Apparatus
Electroscope
Glass or Perspex rod
Woollen cloth
(Use the Triboelectric Series to select materials available to obtain the desired charge)

Method, Results & Conclusion

1. Neutral electroscope

1.1 Charge a glass rod by rubbing it with a woollen cloth.
1.2 Hold a positively charged rod near the disc of the electroscope.
What do you observe?
Sketch your observation (like the accompanying diagram for a negative rod held close to a neutral electroscope).



1.3 Remove the charged glass rod. What do you observe?
1.4 Repeat the procedure with a negatively charged rod.
1.5 What was the function of the electroscope in this experiment?

2. Positively charged electroscope

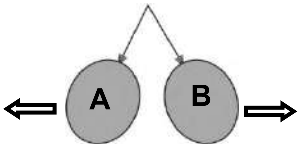
2.1 Charge an electroscope by touching it with a positively charged glass rod. It may be necessary to drag the glass rod across the disc.
Explain how the electroscope obtained a positive charge.
Sketch your observation after the glass rod has been removed.
2.2 Charge a glass rod by rubbing it with a woollen cloth and hold it near the disc of the charged electroscope.
What do you observe?
Sketch your observation.
2.3 Explain your observation in step 2.2.
2.4 What effect do two positively charged objects have on each other?
2.5 Rub a PVC rod with a woollen cloth and hold it near to the disc of a positively charged electroscope.
What do you observe?
Sketch your observation.
2.6 What is the charge on the PVC rod? Explain the answer.
2.7 How can this electroscope be used to indicate the charge on an object with an unknown charge?

Questions

1. State TWO functions of an electroscope.
2. Why are the disc, rod and leaves of the electroscope made from metal?
3. Explain how you would charge an electroscope negatively by means of contact. Use the Triboelectric Series to choose materials that will result in a negative charge on the rod. Illustrate your explanation with the necessary sketches.
4. What do you predict will happen when a charged glass rod is held near the disc of a negatively charged electroscope? Explain your answer.
5. What do you predict will happen when a charged PVC rod is held near the disc of a negatively charged electroscope? Explain your answer.

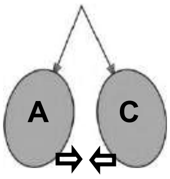
Activity 6.3: Classwork/Homework

1. A glass rod is positively charged by rubbing it with a silk cloth. During the charging process, …
   A electrons are transferred from the glass rod to the silk cloth.
   B electrons are transferred from the silk cloth to the glass rod.
   C protons are transferred from the glass rod to the silk cloth.
   D protons are transferred from the silk cloth to the glass rod.
2. Learners investigate two types of charges and the effect these charges have on each other. They rub two inflated balloons, **A** and **B**, with a woollen cloth. When holding the two balloons close to each other, the balloons REPEL each other, as shown below.



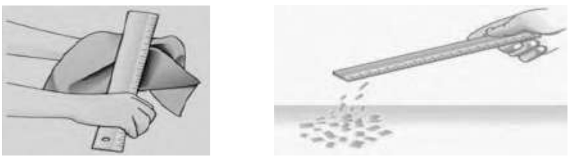
REPULSION

They then rub a third balloon, **C**, with cling wrap and hold it close to balloon **A**. They observe that the two balloons ATTRACT each other, as shown below.



ATTRACTION

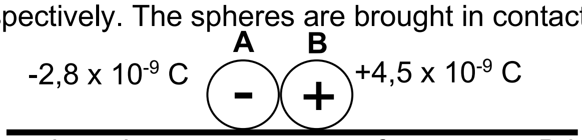
   2.1 How did the balloons become charged?
   2.2 Write down a conclusion that the learners can draw concerning the charge(s) on:
      2.2.1 Balloon **A** and balloon **B** 2.2.2 Balloon **A** and balloon **C**
3. A plastic ruler is rubbed with a woolen cloth and then used to pick up smaller pieces of paper.



   3.1 Use the Tribo electric series and determine the charge on each of the following after rubbing:
      3.1.1 Ruler 3.1.2 Cloth
   3.2 In which direction will electrons flow during charging. Choose from FROM THE CLOTH TO THE RULER or FROM THE RULER TO THE CLOTH.
   3.3 Explain why the ruler can be used to pick up small pieces of paper.
4. Two identical spheres are suspended from the ceiling using nylon thread. Spere **X** carries a charge of + 4 μC and sphere **Y** carries a charge of – 12 μC.

   + 4 μC (**X**) (**Y**) - 12 μC

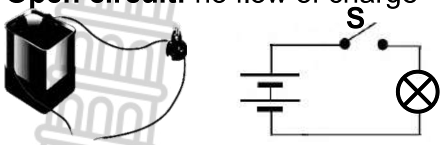
   4.1 Calculate the charge on each sphere after they are allowed to touch and then separated again.
   4.2 Calculate the number of electrons transferred during contact.
5. Two identical metal spheres, **A** and **B**, on an insulated surface, carry charges of -2,8 x 10^{-6} C and +4,5 x 10^{-6} C respectively. The spheres are brought in contact with each other.



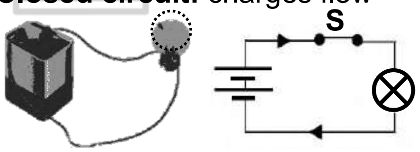
   5.1 It is observed that the spheres move apart after contact. Briefly explain the observation.
   5.2 Calculate the new charge on each sphere after they moved apart.
   5.3 Calculate the number of electrons transferred from one sphere to the other during contact.

Topic 7: Electric circuits

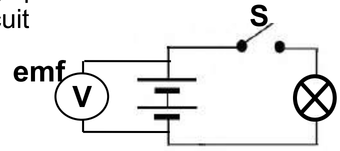
Open circuit: no flow of charge



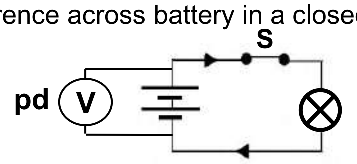
Closed circuit: charges flow



Emf of battery: potential difference across battery in an open circuit



Terminal potential difference:
Potential difference across battery in a closed circuit



Potential difference

Unit: volt (V)
Measuring instrument: Voltmeter - connected in parallel
Definition: The potential difference between the ends of a conductor is equal to the energy transferred per unit electric charge flowing through it. **In symbols:** $V = \frac{W}{Q}$

Current

Rate of flow of charge: $I = \frac{Q}{\Delta t}$

Unit: ampere (A)
Measuring instrument:
Ammeter - connected in series
Conventional current:
From positive to negative

Resistance

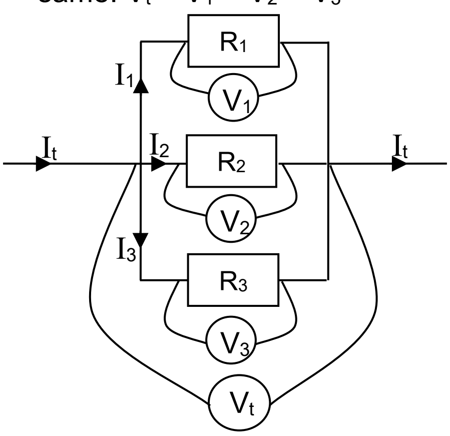
Opposition to flow of charge.
Unit: ohm (Ω)
Definition: Resistance is the ratio of potential difference across a conductor to the current through it: $R = \frac{V}{I}$

Electric circuits

Parallel circuit

More than one pathway for charges
One or more branches

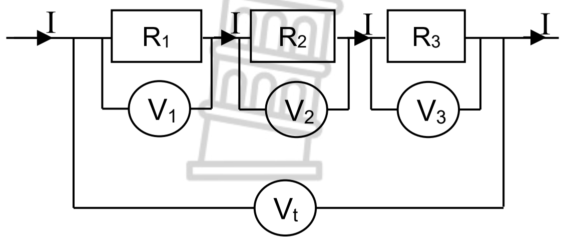
Resistors in parallel
1. Current dividers
   $I_t = I_1 + I_2 + I_3$
2. $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$
3. Potential difference everywhere the same: $V_t = V_1 = V_2 = V_3$



Series circuit

Only one pathway for charges
No branches

Resistors in series
1. Potential dividers
   $V_t = V_1 + V_2 + V_3$
2. $R_{total} = R_1 + R_2 + R_3$
3. Current everywhere the same



CONCEPTS AND DEFINITIONS	
ampere (A)	The unit of measurement of electric current.
Conventional current	Current flow in a circuit from the positive to the negative pole of the battery.
coulomb (C)	The unit of measurement of electric charge. **Definition:** A charge of one coulomb passes a given point in a conductor in one second when the current in the conductor is one ampere. (1 coulomb = 1 ampere·x 1 second: 1 C = 1 A·s)
Electric current	The rate of flow of charge. ($I = \frac{Q}{\Delta t}$)
Emf	The potential difference (voltage) measured across the terminals of a battery when no charge flows through the battery. **Definition:** Maximum energy provided/work done by a battery per coulomb/unit charge passing through it.
ohm (Ω)	Unit of measurement of resistance. **Definition:** A conductor has a resistance of one ohm if a current of one ampere flows through it when a potential difference of one volt is maintained across its ends. (1 ohm = $\frac{1\text{ volt}}{1\text{ ampere}}$ / 1 Ω = $\frac{1\text{ V}}{1\text{ A}}$ = 1 V·A^{-1})
Potential difference	The potential difference between the ends of a conductor is equal to the energy transferred per unit electric charge flowing through it. ($V = \frac{W}{Q}$)
Resistance	The opposition of a conductor to the flow of charge. **Definition:** Resistance is the ratio of the potential difference across a conductor to the current in the conductor. ($R = \frac{V}{I}$)
volt (V)	The unit of measurement of potential difference.
Voltmeter	The instrument used to measure potential difference. A voltmeter is connected in parallel and has a very high resistance.
Ammeter	The instrument used to measure electric current. An ammeter is connected in series and has a very low resistance.

Circuit Construction Kit: DC
https://phet.colorado.edu/sims/html/circuit-construction-kit-dc/latest/circuit-construction-kit-dc_en.html

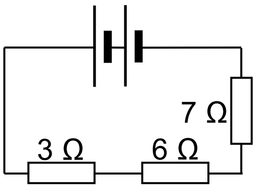
Simulation: Circuit Construction Kit: DC Virtual Lab
https://phet.colorado.edu/sims/html/circuit-construction-kit-dc-virtual-lab/latest/circuit-construction-kit-dc-virtual-lab_en.html

Activity 7.1: Classwork/Homework

1. Which ONE of the following statements regarding conventional current is TRUE?
   A The direction of the current is the same as the direction of the flow of electrons.
   B The direction of the current is perpendicular to the flow of electrons.
   C The direction of the current is opposite to the direction of flow of electrons.
2. Which ONE of the following is the unit of measurement of electric current?
   A volt B coulomb
   C ohm D ampere
3. A charge of 5 C passes through a conductor in 3 s. Calculate the current in the conductor. Give the answer to two decimal places.
4. The current in a wire is 3 A. Calculate the charge that flows through the wire in 1 minute.
5. Calculate the time that 84 C must flow through a copper wire to register a current of 7 A.
6. A variable resistor and a battery are connected in a circuit. How will the current in the circuit change if the resistance of the circuit is DOUBLED?
   A Doubles B Halves
   C Remains the same
7. Which ONE of the following statements is NOT true?
   A Potential difference (voltage) is inversely proportional to resistance.
   B Potential difference (voltage) is directly proportional to current.
   C Current is inversely proportional to resistance.

Activity 7.2: Classwork/Homework

1. Which ONE of the following will produce the highest resistance?
   A Two 1 ohm resistors in series
   B Two 2 ohm resistors in series
   C Three 3 ohm resistors in parallel
   D Two 1 ohm resistors in parallel
2. Which ONE of the following correctly describes the resistance of a circuit?
   Resistance is the:
   A Rate at which charge flow through a wire
   B Product of current and potential difference (voltage)
   C Opposition that the conductor has to flow of charge
   D Force of gravity applied on a wire
3. Calculate the total resistance of the circuit represented by the circuit diagram below.



4. A learner connects a battery, a wire, a voltmeter, and an ammeter to form a circuit. The reading on the voltmeter is 4 V and the reading on the ammeter is 3 A.
   3.1 How must the learner connect the ammeter in the circuit?
   3.2 How must the learner connect the voltmeter to measure the potential difference between the ends of the wire?
   3.3 Calculate the total resistance of the circuit.

Activity 7.3: Classwork/Homework

1. Study the circuit diagrams given below.

Diagram 1

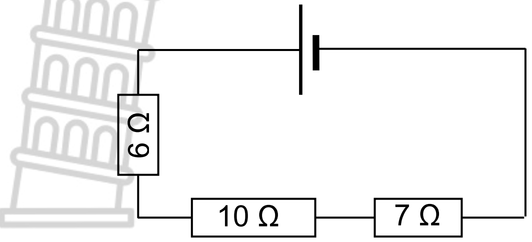
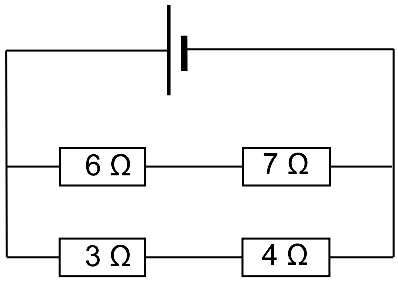


Diagram 2

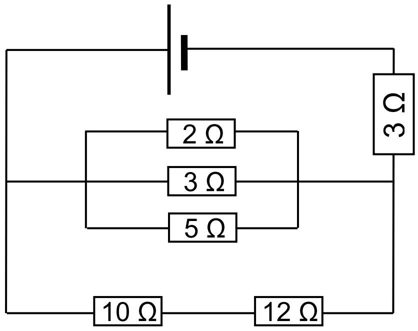


Calculate the total resistance of the circuit in:

1.1 **Diagram 1**

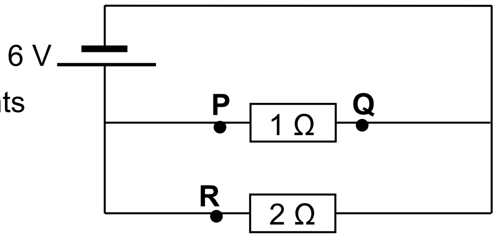
1.2 **Diagram 2**

2. Calculate the total resistance in the circuit represented in the diagram below.



Activity 7.4: Classwork/Homework

Diagram 1



Answer QUESTIONS 1 and 2 by referring to diagram 1.

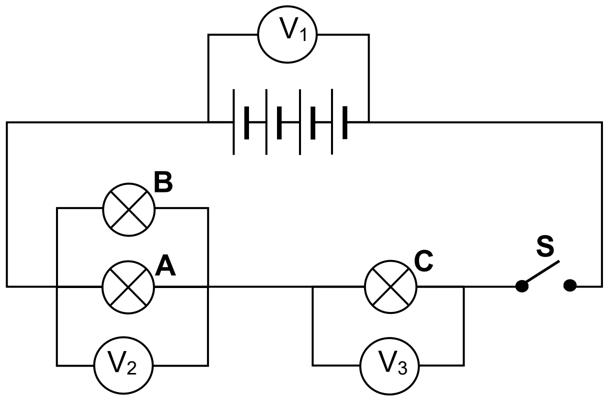
1. Which ONE of the following correctly shows the potential difference per coulomb charge at each of points **P**, **Q**, and **R**?

A 6 J; 6 J; 6 J
B 3 J; 3 JV; 0 J
C 6 J; 0 J; 6 J
D 1 J; 2 JV; 3 J

2. Which ONE of the following correctly represents the electric current at each of points **P**, **Q**, and **R**?

A 4,5 A; 4,5 A; 4,5 A
B 6 A; 6 A; 3 A
C 6 A; 3 A; 4,5 A
D 2,5 A; 1,5 A; 6,5 A

3. Learners set up a circuit as shown in the diagram below. The emf of each cell is 1,5 V. Each of bulb **A** and bulb **B** has a resistance of 2 Ω and bulb **C** has a resistance of 3 Ω.



3.1 Calculate the effective resistance of bulbs **A** and **B**.

Switch **S** is now closed for a short time.

3.2 Determine the reading on:

3.2.1 Voltmeter V_1

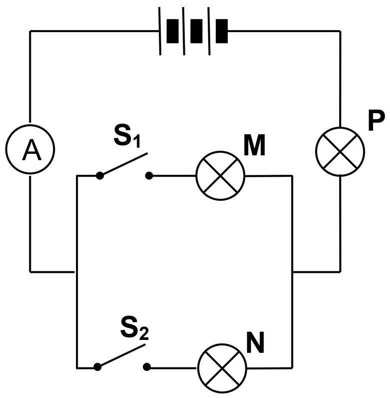
3.2.2 Voltmeter V_3

3.3 Calculate the energy transferred in bulb **C** in 3 seconds if the current in the circuit is 2 A.

3.4 ALL the bulbs are now connected in parallel. How will the total current in the circuit be affected? Write down only INCREASES, DECREASES or REMAINS THE SAME.

Activity 7.5: Classwork/Homework

1. In the circuit diagram below, three identical bulbs are connected as shown. The ammeter, connecting wires and battery have negligible resistance. Study the diagram and then answer the questions that follow.

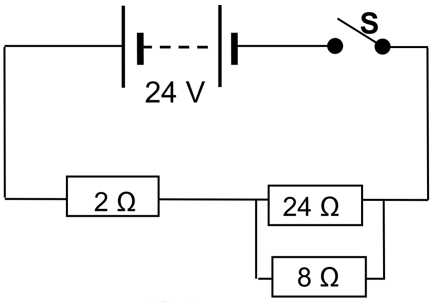


1.1 Switches S_1 and S_2 are OPEN. Which bulbs, if any, will light up?
1.2 Switch S_1 is CLOSED and S_2 is OPEN. Compare the brightness of bulbs **M**, **N** and **P**.
1.3 *Switches* S_1 *and* S_2 *are CLOSED*. Compare the potential differences across bulbs **M**, **N** and **P**.

For QUESTIONS 1.4 and 1.5, choose the correct answer from those given in the brackets.

1.4 Adding bulbs in parallel causes the:
  1.4.1 Resistance of the circuit to (increase/decrease/remain the same)
  1.4.2 Potential difference across the battery to (increase/decrease/ remain the same)
1.5 Parallel circuits can be regarded as (current/potential) dividers.

2. Consider the circuit diagram alongside.
1.1 Copy the circuit diagram into your book but add symbols to show how to connect a voltmeter to measure the potential difference across the battery and how to connect an ammeter to measure the current through the battery. Show the direction of the current passing through the battery using a labelled arrow.



1.2 Calculate the equivalent resistance of the resistors connected in parallel.

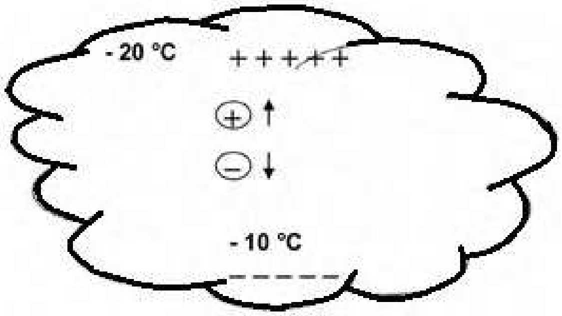
1.3 Calculate the total resistance of the circuit.

1.4 If the potential difference across the 2 Ω resistor is 6 V, deduce the potential difference across the parallel combination.

1.5 A charge of 18 C flows through the battery in 6 s.
  1.5.1 Calculate the current that passes through the battery.
  1.5.2 Deduce the current passing through the 8 Ω resistor if the current passing through the 24 Ω resistor is 0,75 A.

Activity 7.6: Classwork/Homework

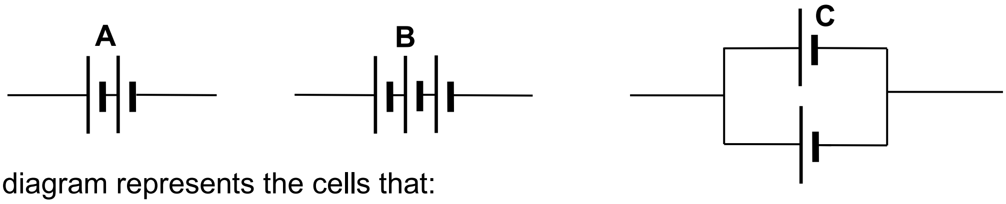
1. During a thunderstorm, strong air currents inside clouds rub ice crystals against each other. This results in a separation of charge and hence a potential difference. The potential difference between the top and the bottom of a storm cloud can be millions of volts. Friction leaves the top of the cloud positively charged and the bottom of the cloud negatively charged. Generally, low lying clouds have a temperature of – 10 °C at the bottom and – 20 °C at the top.



When lightning strikes, negative charge from the bottom of the cloud leaps down through the air to the ground. A lightning flash usually consists of several static discharges one after another. The temperature inside a flash can be around 25 000 °C.

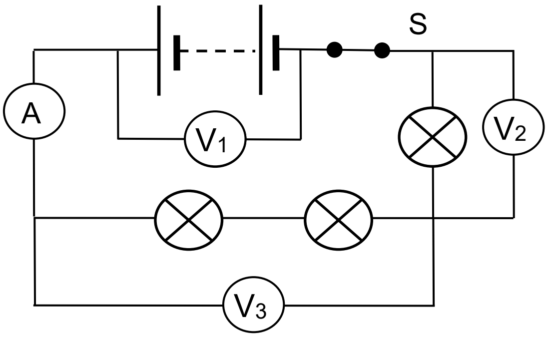
1.1 Define the following terms:
 1.1.1 Electric current
 1.1.2 Potential difference
1.2 Explain why ice crystals are formed in the clouds.
1.3 In one of the lightning flashes 75 A of electric current passes from the bottom of the cloud to the ground below in 1,5 s. Calculate the amount of charge that passes from the cloud to the ground in the lightning flash.
1.4 The potential difference between the bottom of the cloud and the ground is 2 000 000 V. Use your answer from QUESTION 1.3 to calculate the amount of heat energy produced during the lightning flash.

2. The diagrams (**A**, **B** and **C**) below show identical cells connected in different ways.



Which diagram represents the cells that:
2.1 Will let a bulb glow the brightest
2.2 Will last the longest

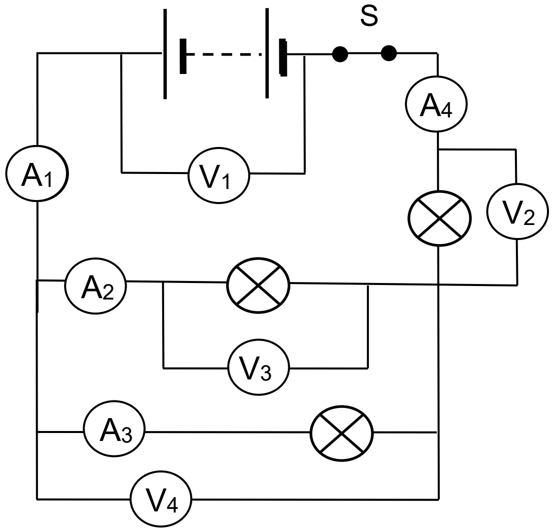
3. In the circuit diagram below, the three bulbs are identical and the reading on voltmeter V_1 is 12 V.



Determine the reading on voltmeter:
3.1 V_2
3.2 V_3

Activity 7.7: Classwork/Homework

1. Three identical bulbs are connected in a circuit as shown alongside.
Compare the readings on:

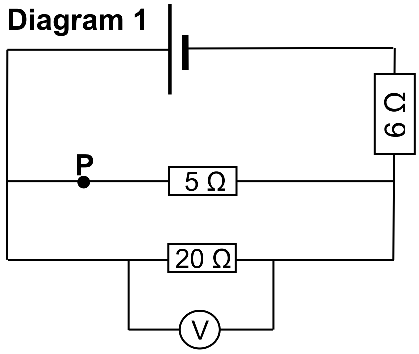


1.1 A_1, A_2 and A_3
1.2 A_1 and A_4
1.3 A_2 and A_3
1.4 V_1 and V_4
1.5 V_1, V_3 and V_4
1.6 V_1, V_2 and V_4
1.7 V_1, V_2 and V_3
1.8 V_3 and V_4

2. Consider **diagram 1** alongside.

The current at point **P** is measured to be 1,6 A. Determine the potential difference (voltage) of the battery.

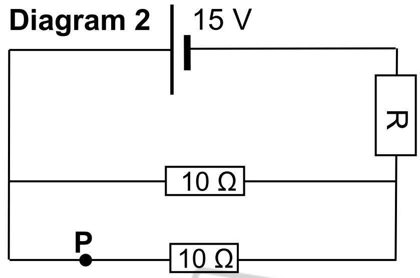
Diagram 1



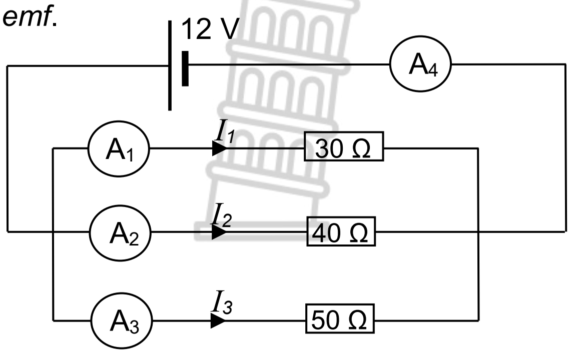
3. Consider **diagram 2** alongside.

The current at point **P** is measured as 0,5 A. Determine the resistance of **R**.

Diagram 2



4. The accompanying circuit diagram shows three resistors connected to a cell.
4.1 The emf of the cell is 12 V. Define the term *emf*.
4.2 Are the resistors connected in series or in parallel?
4.3 Calculate the:
4.3.1 Total resistance of the circuit
4.3.2 Current through the 30 Ω resistor
4.3.3 Current through the 40 Ω resistor
4.3.4 Current through the 50 Ω resistor
4.4 Calculate the total current in the circuit.



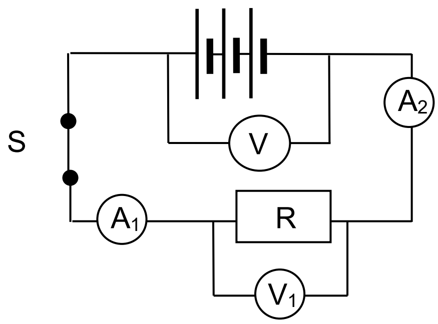
5. A circuit consists of a 10-ohm resistor and carries a current of 5 A. Calculate the potential difference (voltage) across the resistor.

6. A 6 V power source is connected to a conductor with resistance of 4 Ω. Calculate the current in the conductor.

Experiment 7: A circuit with an ammeter in series and a voltmeter in parallel

Aim: Set up a circuit to measure the current through and the potential difference across a light bulb or resistor.

Apparatus
- Three 1,5 V cells
- A resistor
- Two voltmeters or else one voltmeter can be moved to different positions in the circuit.
- One or two ammeters
- Conducting wires
- Switch
- Circuit board if available



Method
1. Set up the circuit as shown in the accompanying diagram.
2. Connect a voltmeter (V) across the three cells and take the reading.
3. Connect the other voltmeters (V_1) as shown in the diagram. Take the reading on each voltmeter. Alternatively, one voltmeter can be moved from one position to the other.
4. Move the ammeter to different positions in the circuit or else connect a second ammeter on the opposite side of the cell as shown in the diagram. Take the readings on the ammeter(s) in two different positions in the circuit.

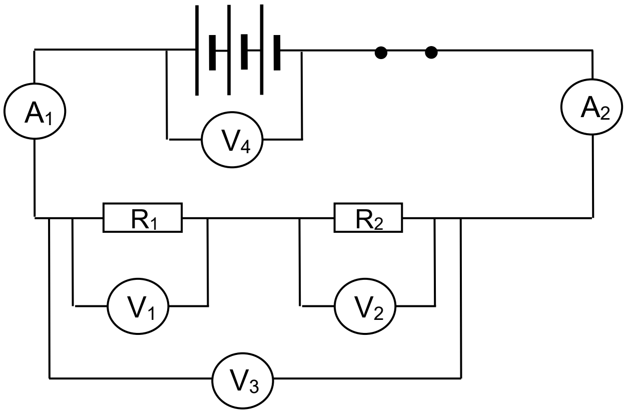
Results/Observations
Redraw the following table in your workbook and record the results obtained.

Voltmeter reading V (V)	Voltmeter reading V_1 (V)	Ammeter reading A_1 (A)	Ammeter reading A_2 (A)

Interpretation/Conclusion
1. How do the ammeter readings compare when the switch is closed? What conclusion can be drawn regarding the current in a series circuit?
2. How do the voltmeter readings compare when the switch is closed? What conclusion can be drawn from these readings?
3. How do we connect an ammeter in a circuit?
4. How do we connect a voltmeter in a circuit?

Experiment 8: Resistors in series

Aim: To compare the potential differences across two resistors in series with the sum of the potential differences across each of the two resistors and to compare the currents measured at different positions in the circuit.



Apparatus

- Three 1,5 V cells
- Two resistors
- Four voltmeters or else one voltmeter can be moved to different positions in the circuit.
- One or two ammeters
- Conducting wires
- Switch
- Circuit board if available

Method:

1. Set up the circuit as shown in the accompanying diagram.
2. Connect a voltmeter (V_4) across the three cells and take the reading.
3. Connect the other three voltmeters (V_1, V_2 and V_3) as shown in the diagram. Take the reading on each voltmeter. Alternatively, one voltmeter can be moved from one position to the other.
4. Move the ammeter to different positions in the circuit or else connect a second ammeter on the opposite side of the cell as shown in the diagram. Take the readings on the ammeter(s) in two different positions in the circuit.
5. Repeat the procedure. If available, two different resistors may be used.

Results/Observations

Redraw the following table in your practical book and record the results obtained.

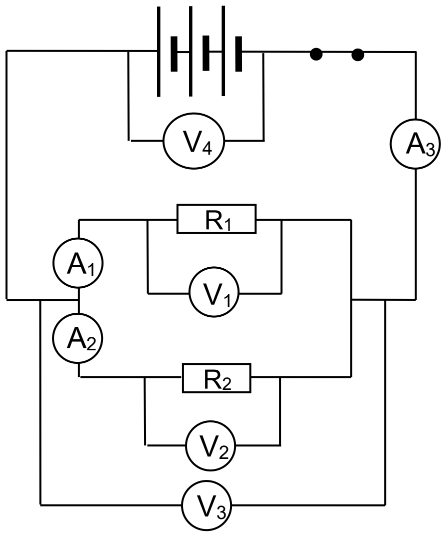
	Voltmeter reading V_4	Voltmeter reading V_1	Voltmeter reading V_2	Voltmeter reading V_3	Ammeter reading A_1	Ammeter reading A_2
Trial 1						
Trial 2						

Interpretation/Conclusion

1. For this investigation, write down the:
   1.1 Investigative question
   1.2 Hypothesis
2. How does the ammeter readings compare? What conclusion can be drawn regarding the current in a series circuit from these readings?
3. How do the voltmeter readings compare? What conclusion can be drawn from these readings?

Experiment 9: Resistors in parallel

Aim: To compare the potential differences across resistors in parallel with the potential differences across each of the resistors in parallel and to compare the current in each branch with the main current in the circuit.



Apparatus

- Three 1,5 V cells
- Two resistors
- Four voltmeters or else one voltmeter can be moved to four different positions.
- Three ammeters or else one ammeter can be moved to three different positions.
- Conducting wires
- Switch
- Circuit board if available

Method:

1. Set up the circuit as shown in the accompanying diagram.
2. Connect the four voltmeters as shown or else move one voltmeter to the different positions in the circuit. Voltmeter V_4 measures the potential difference across the three cells, voltmeters V_1 and V_2 measure the potential difference across resistors R_1 and R_2 respectively, and voltmeter V_3 measures the potential difference across the combination of resistors R_1 and R_2.
3. Connect an ammeter (A_1 and A_2) in each of the parallel branches to measure the current in each branch. Alternatively, one ammeter can be moved from one position to another. Connect an ammeter (A_3) to measure the total current in the circuit.
4. Repeat the procedure. If available, two different resistors may be used.

Results/Observations

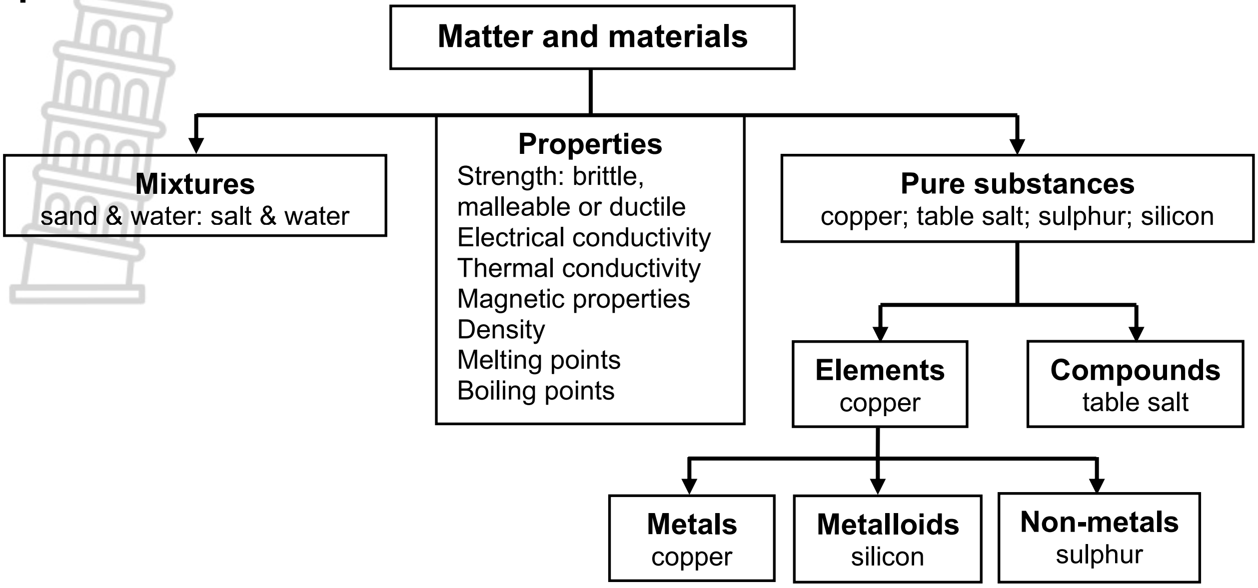
Redraw the following table in your practical book and record the results obtained.

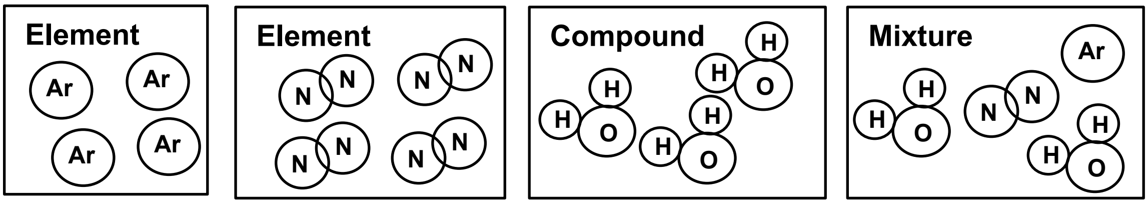
TRIAL	Voltmeter reading V_4	Voltmeter reading V_1	Voltmeter reading V_2	Voltmeter reading V_3	Ammeter reading A_1	Ammeter reading A_2	Ammeter reading A_3
1							
2							

Interpretation/Conclusions:

1. For this investigation, write down the:
   1.1 Investigative question
   1.2 Hypothesis
2. How does the ammeter readings compare? What conclusion can be drawn regarding the current in a parallel circuit?
3. How do the voltmeter readings compare? What conclusion can be drawn from these readings?

Topic 8: Matter and its classification





CONCEPTS AND DEFINITIONS	
Boiling point	The temperature of a liquid at which its vapour pressure equals the external (atmospheric) pressure.
Brittle	A hard substance that can easily break.
Compound	A pure substance consisting of two or more DIFFERENT elements that are chemically bonded to form a single substance.
Density	The mass per unit volume of a substance. (density = $\frac{\text{mass}}{\text{volume}}$)
Ductile	The ability to be stretched into a thin wire without breaking.
Electrical conductivity	Substances that conduct electricity. Metals are good conductors of electricity whilst non-metals are electrical insulators.
Element	A pure substance consisting of one type of atom and cannot be broken into simpler substances by chemical methods.
Malleable	The ability to be hammered into a thin sheet without breaking.
Melting point	The temperature at which the solid and liquid forms of a substance can exist in equilibrium.
Mixture	A mixture in which components can be easily identified and separated by physical methods.
Metalloids/semi-metals/half metals	An element with properties intermediate between those of a metal and a non-metal.
Pure substance	A substance (element or compound) that contains only one kind of matter and cannot be separated into simpler pieces by physical methods.
Strength	A property of a materials to support a heavy load without breaking, tearing, or changing form.
Thermal conductivity	Substances that conduct heat. Metals are good thermal conductors whilst non-metals are thermal insulators.

Table 1: Positive and negative ions

POSITIVE IONS					
+1 symbol	**Name**	**+2 symbol**	**Name**	**+3 symbol**	**Name**
H^+	hydrogen	Be^{2+}	beryllium	Al^{3+}	aluminium
Li^+	lithium	Mg^{2+}	magnesium	Fe^{3+}	iron(III)
Na^+	sodium	Ca^{2+}	calcium	Cr^{3+}	chromium(III)
K^+	potassium	Sr^{2+}	strontium	As^{3+}	arsenic(III)
Ag^+	silver	Ba^{2+}	barium	Sb^{3+}	antimony(III)
Hg^+	mercury(I)	Sn^{2+}	tin(II)	Bi^{3+}	bismuth(III)
Cu^+	copper(I)	Pb^{2+}	lead(II)		
NH_4^+	ammonium	Zn^{2+}	zinc		
H_3O^+	Hydronium (oxonium)	Fe^{2+}	iron(II)		
		Hg^{2+}	mercury(II)		
		Mn^{2+}	manganese		
		Ni^{2+}	nickel		
		Cd^{2+}	cadmium		
		Cr^{2+}	chromium(II)		
		Cu^{2+}	copper(II)		

NEGATIVE IONS					
–1 symbol	**Name**	**–2 symbol**	**Name**	**–3 symbol**	**Name**
F^-	fluoride	O^{2-}	oxide	N^{3-}	nitride
$C\ell^-$	chloride	S^{2-}	sulphide	PO_4^{3-}	phosphate
Br^-	bromide	CO_3^{2-}	carbonate		
I^-	iodide	SO_4^{2-}	sulphate		
OH^-	hydroxide	SO_3^{2-}	sulphite		
NO_3^-	nitrate	CrO_4^{2-}	chromate		
NO_2^-	nitrite	$Cr_2O_7^{2-}$	dichromate		
CN^-	cyanide	$S_2O_3^{2-}$	thiosulphate		
HCO_3^-	hydrogen carbonate	MnO_4^{2-}	manganate		
HSO_4^-	hydrogen sulphate				
$C\ell O_3^-$	chlorate				
MnO_4^-	permanganate				
IO_3^-	iodate				
CNS^-	thiocyanate				
CH_3COO^-	ethanoate (acetate)				

Table 2: Chemical and usernames of well-known compounds

Chemical name	Username	Chemical name	Username
ammonium carbonate	smelling salts	sodium hydroxide	caustic soda
ammonium nitrate	fertiliser	hydrogen nitride	ammonia
ammonium sulphate	fertiliser	hydrogen oxide	water
calcium carbonate	marble	hydrogen chloride	hydrochloric acid/pool acid
calcium sulphate	Plaster of Paris	hydrogen sulphate	sulphuric acid/battery acid
calcium oxide	quicklime	hydrogen nitrate	nitric acid
calcium hydroxide	slaked lime	hydrogen carbonate	carbonic acid
magnesium sulphate	Epsom salts	hydrogen sulphite	sulphurous acid
potassium hydroxide	caustic potash	hydrogen nitrite	nitrous acid
potassium nitrate	saltpetre	carbon dioxide	carbonic acid gas
sodium chloride	table salt	ethanoic acid	acetic acid
sodium carbonate	washing soda	copper(II) sulphate	blue vitriol
sodium hydrogen carbonate	baking soda		

Activity 8.1: Classwork/Homework

1. Draw the following table in your workbook and classify each of the items as an element, compound, or a mixture. In each case supply a reason for your answer.

	Item	Element, compound, or a mixture	Reason
1.1	milk		
1.2	tap water		
1.3	stainless steel		
1.4	air		
1.5	diamond		
1.6	blood		
1.7	brick wall		
1.8	vegetable soup		
1.9	aluminium foil		
1.10	tea		
1.11	tea with milk		
1.12	wood		
1.13	oxygen gas		
1.14	tea and sugar		
1.15	iodine crystals		
1.16	polystyrene		
1.17	copper		
1.18	brass		
1.19	9 carat gold earring		
1.20	platinum ore		

Activity 8.2: Classwork/Homework

1. Write down the names of the following compounds:
   1.1 $KMnO_4$ 1.2 K_2CO_3 1.3 $KC\ell$ 1.4 $FeC\ell_2$
   1.5 Na_2SO_4 1.6 $FeC\ell_3$ 1.7 Na_2S 1.8 Na_2SO_3

2. Write down the formula of each of the following compounds:
   2.1 ammonium nitrate 2.2 zinc oxide 2.3 cobalt(II) chloride
   2.4 zinc sulphide 2.5 magnesium chloride 2.6 calcium nitrate
   2.7 copper(II) sulphate 2.8 potassium chromate 2.9 potassium nitrate

Activity 8.3: Classwork/Homework/Practical investigation

1. In your own words, explain the difference between an electrical conductor, an electrical non-conductor (insulator) and a semi-conductor.

2. The following materials are supplied: a piece of wire, a ruler, a pen, and a pencil. Plan an investigation to determine which of the mentioned items are conductors and which are insulators. The following steps will help you with your planning:

   Step 1: Ask an investigative question – what do you want to determine during this investigation?
   Step 2: Hypothesis – Make a prediction about which materials are electrical conductors and which are insulators.
   Step 3: List of apparatus – Supply a list of all the apparatus you will need for the investigation. Explain what each of the listed items will be used for.
   Step 4: Method – Write down how you will test the materials for electrical conductivity. Use a circuit diagram to show how you will set up the apparatus.

Activity 8.4: Classwork/Homework/Practical investigation

A learner collects the materials listed in the table below to investigate some of their physical properties. Three of the observations made during the investigation are shown (as YES or NO) in the table, whilst others are represented by the letters (a) to (f).

Material	Conduction of electricity	Shiny / Metallic	Malleable
Copper rod	Yes	Yes	(a)
Sodium chloride crystals		(b)	
Magnesium strip	Yes		(c)
Sulphur lump	(d)	(e)	
Carbon powder			(f)

1. To investigate the conductivity of the materials, the learner connects the materials alternately in a closed circuit containing a battery and a light bulb.
   For this investigation, write down:
   1.1 The independent variable
   1.2 The dependent variable
   1.3 An investigative question
2. Briefly describe how you will test whether the above materials are:
   2.1 Shiny or not
   2.2 Malleable or not
3. Write down the observations, represented by the letters (a) to (f) in the above table, that the learner should make. Copy the letter (a) to (f) into your workbook and next to each letter write down only YES or NO.
4. Give TWO reasons why lightning conductors are made of copper.
5. State TWO other physical properties of magnesium not investigated in this investigation.

Video 15: Matter and Classification
https://www.youtube.com/watch?v=Hx9rRnxckwc

Activity 8.5: Classwork/Homework

1. Write down chemical names for the following compounds:
   1.1 CO_2 1.2 $MgSO_4$ 1.3 $CuC\ell_2$ 1.4 $CrC\ell_3$
   1.5 $NaHCO_3$ 1.6 $ZnSO_4$ 1.7 NH_3 1.8 H_2O
2. Write down the formula for each of the following compounds:
   2.1 saltpetre 2.2 caustic soda 2.3 sulphuric acid
   2.4 slaked lime 2.5 smelling salts 2.6 nitric acid
   2.7 sodium sulphate 2.8 hydrochloric acid 2.9 table salt

Topic 9: States of matter and the kinetic molecular theory

Kinetic Molecular Theory

1. Matter consists of small particles.
2. The particles are in constant motion.
3. There are forces of attraction between the particles.
4. Particles collide (with each other and with the sides of the container) and exert pressure.
5. The temperature of a substance is a measure of the average kinetic energy of the particles.
6. A phase change may occur when the energy of particles changes.

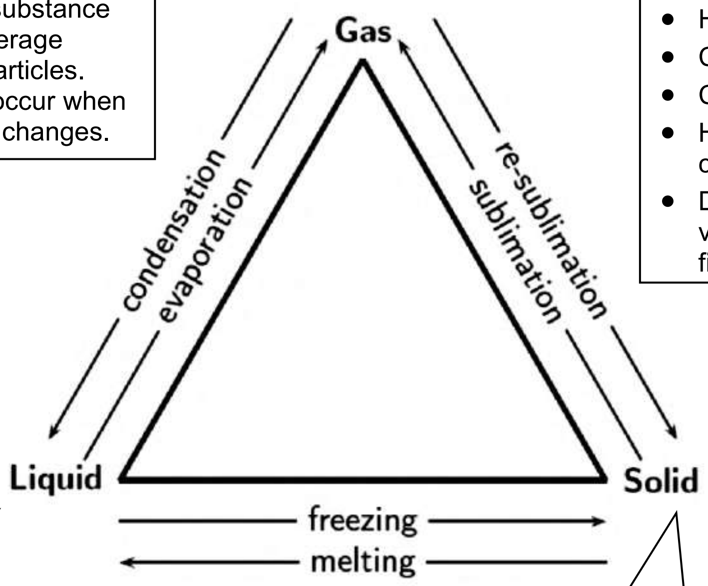
Phases of matter
gases, liquids, solids

Particles in gases:

- Are **very far apart**
- **Move** around **in all directions**
- Have **weak forces of attraction** between them

Gases:

- Have low density
- Can be compressed
- Can flow
- Have the shape of their container
- Do not have a fixed volume – spread out and fill container



Particles in liquids:

- Are **close together,** but not as close as they are in solids.
- Can **move around** in any direction and are **not fixed in position**.
- Have **quite strong forces of attraction** between them but not as strong as in solids.

Liquids:

- Have a medium density
- Cannot be compressed
- Can flow
- Have the shape of their container – no fixed form
- Have a fixed volume

Particles in solids:

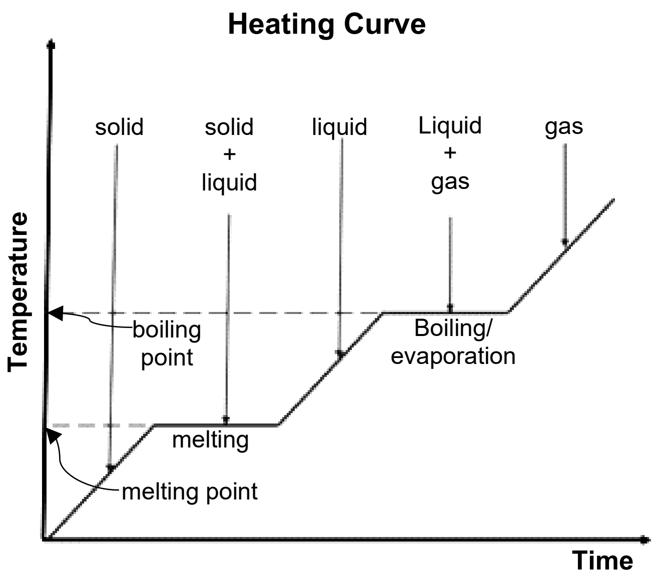
- Vibrate about **fixed positions**.
- Have **strong forces** of attraction between them.
- Are **closely packed**.

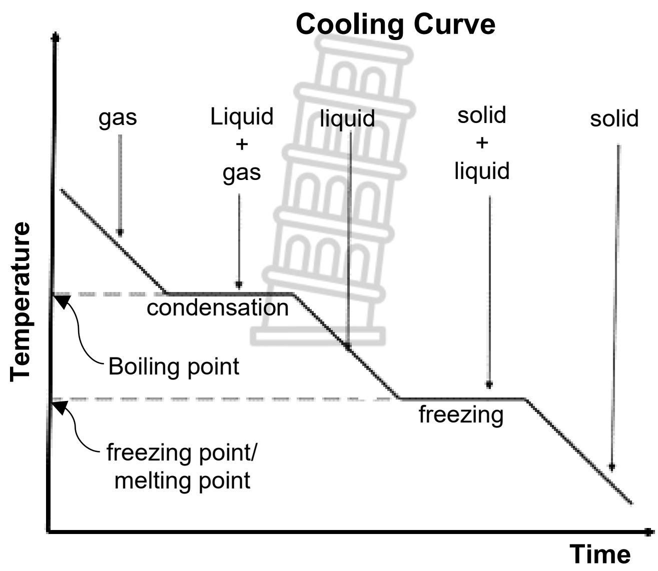
Solids:

- Have a high density
- Cannot be compressed
- Cannot flow
- Have a solid form
- Have a fixed volume

Boiling versus evaporation	
Boiling	**Evaporation**
• Takes place at boiling point. • Takes place throughout liquid. • Temperature remains constant during boiling. (All the energy is used for the phase change from liquid to gas.)	• Takes place at any temperature. • Takes place on surface of liquid. • Temperature of the liquid decreases during evaporation - molecules with high energy leaves the solution. (Heat leaves the liquid.)

CONCEPTS AND DEFINITIONS	
Boiling point	The temperature at which the vapour pressure of a liquid equals the external (atmospheric) pressure. (Boiling points are measured at sea level. At higher altitudes, where atmospheric pressure is lower, boiling points are lower. The boiling point of water at sea level is 100 °C, while at the top of Mount Everest it is 71 °C.)
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. (This movement is named after its identifier, Scottish botanist Robert Brown (1773-1858)).
Condensation	The process during which a gas or vapour changes to a liquid, either by cooling or by increased pressure.
Cooling curve	A line graph (temperature vs time) that represents the phase changes during cooling.
Deposition (Re-sublimation)	Deposition is a process in which a gas transforms into a solid. The reverse of deposition is sublimation.
Diffusion	The movement of atoms or molecules from an area of higher concentration to an area of lower concentration.
Heating curve	A line graph (temperature vs time) that represents the phase changes as heat is applied.
Phase equilibrium	The state when the two components of phases stay constant e.g., the amount of water and the amount of water vapour remains the same. For every water molecule that evaporates, a water vapour molecule condenses.
Evaporation	The change of a liquid into a vapour at a temperature below the boiling point.
Freezing	The process during which a liquid change to a solid by the removal of heat.
Freezing point	The temperature of a liquid at which it changes its state from liquid to solid at atmospheric pressure.
Melting	The process during which a solid change to a liquid by the application of heat.
Melting point	The temperature at which the solid and liquid forms of a substance can exist in equilibrium. (For a given substance, the melting point of its solid form is the same as the freezing point of its liquid form and depends on such factors as the purity of the substance and pressure.)
Sublimation	The process during which a solid change directly into a gas without passing through an intermediate liquid phase.





Activity 9.1: Classwork/Homework

1. Matter exists as three phases: gases, liquids, or solids.
   1.1 Compare these three phases in a table about the movement of the constituent particles, distance between the particles and the forces between the particles.
   1.2 List a few substances that occur in each of the following phases at room temperature:
      1.2.1 Solid
      1.2.2 Liquid
      1.2.3 Gas
2. Give one word/term for each of the following descriptions:
   2.1 Ice changes to water
   2.2 Water changes to ice
   2.3 Water changes to water vapour
   2.4 Water vapour changes to water
3. Explain each of the phase changes in Question 2 in terms of the kinetic theory.

Activity 9.2: Classwork/Homework/Data-interpretation

1. The following table shows the melting and boiling point of five substances.

	Water	Ethanol	Chlorine	Bromine	Phosphorus
Melting point (°C)	0	-114	-102	-7	44
Boiling point (°C)	100	78	-34	59	280

   Which of these substances:
   1.1 Has the lowest boiling point?
   1.2 Are solids at room temperature (25 °C)?
   1.3 Are liquids at room temperature (25 °C)?
   1.4 Are gasses at room temperature (25 °C)?
2. Explain the following use: In places where it snows, the traffic department pours salt on snow-covered roads.
3. Explain each of the following in terms of the kinetic molecular theory of matter:
   3.1 A metal laundry line which hang droop on a very warm day
   3.2 Water that vanish out of an open container
   3.3 The need for gaps in railway lines

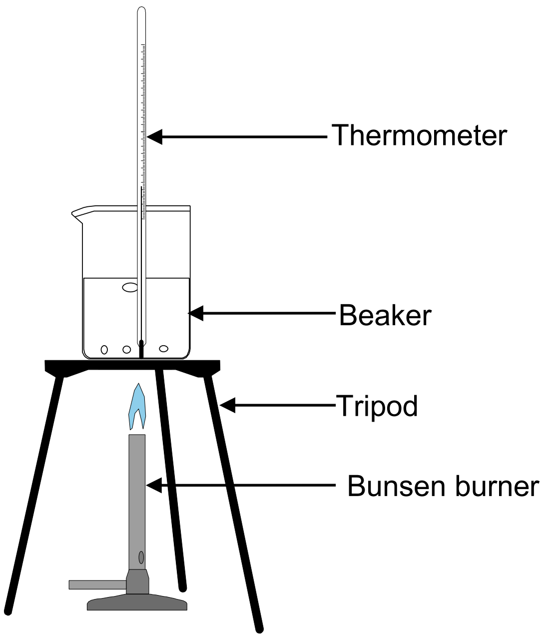
Activity 9.3: Classwork/Homework/Data-interpretation

1. Container **A** contains 1 ℓ of water and container **B** contains 1 ℓ of petrol. Both containers are left open at a temperature of 25 °C. After 50 minutes, half of the liquid in one of the containers has disappeared.
   1.1 Identify the container in which half of the liquid has disappeared. Give a reason for your answer.
   1.2 What happened to the liquid that disappeared?
   1.3 How does the average kinetic energy of the molecules in container **A** compares to that of the molecules in container **B**?
   1.4 Use the kinetic theory to explain why the liquid in one of the containers has disappeared, but not in the other. Use drawings in your explanation.
   1.5 What can be done to prevent the liquid from disappearing?
   1.6 If left long enough the liquid in both containers will disappear. Explain.
2 A bath is filled with 150 ℓ of water at a temperature of 35 °C. A pot contains 1,5 ℓ of water at a temperature of 80 °C. Classify, with reason, the following statements as CORRECT, INCORRECT or CANNOT TELL.
   2.1 The average kinetic energy of the water in the pot is more than that of the water in the bath.
   2.2 The total kinetic energy of the water in the pot is more than that of the water in the bath.

Experiment 10A: Heating curve of water

Aim: To obtain the heating curve of water.

Apparatus:
- A glass beaker
- Crushed ice
- Thermometer
- Burner/ heat source



Method:
1. Set up apparatus as shown in the diagram.
2. Place at least 100 g (100 mℓ) ice in the glass beaker.
3. Measure and record the temperature.
4. Melt the ice over a slow flame whilst stirring it continuously. Take the temperature every 30 seconds until the water boils.
5. Take the temperature readings for another 2 minutes after reaching boiling point.

Hint: It is advisable to first test how long it takes to melt the ice and boil the water before deciding on the time interval. Depending on the heat source, intervals for taking the temperature may vary from 30 s to 2 minutes.)

Results
1. Draw the following table in your workbook and record the results in the table.

Time (s)	Temperature (°C)	Observation (What do you see in the ice mixture?)
0	0	

2. Draw a graph of temperature versus time.

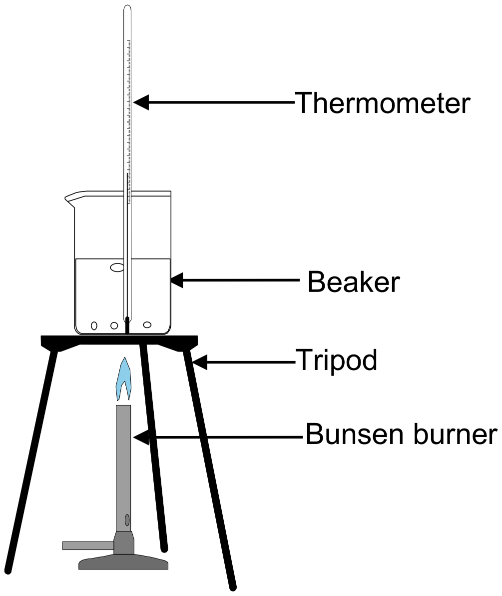
Questions
1. Identify the:
   1.1 Dependent variable
   1.2 Independent variable
   1.3 Controlled variables
2. What happened to the water's temperature while the ice was melting?
3. What happened to the temperature after all the ice had melted?
4. What happened to the water's temperature while the water was boiling?
5. Water underwent two phase changes during the investigation. Redraw the following table in your workbook. Summarise all the changes in the table.

Process	Reaction equation for the phase change	Was energy released or absorbed during the change?

Video 16: Heating and Cooling Curve Practical
https://www.youtube.com/watch?v=oW7Qb1U0hrw

Video 17: Heating and Cooling Curve Explained
https://www.youtube.com/watch?v=XEgQ2ToXRhw

Experiment 10B: Cooling curve of water



Aim: To obtain the cooling curve of water.

Apparatus:

- A glass beaker
- 60 mℓ water
- Crushed ice
- Thermometer
- Burner/ heat source

Method:

1. Set up apparatus as shown in the diagram.
2. Heat the water until it boils.
3. Remove the burner and allow the water to cool down, whilst measuring the temperature every 30 s.
4. Place the beaker in an ice bath below 0 °C when it reaches room temperature.
5. Measure and record the temperature every 30 seconds until the water freezes.

Results

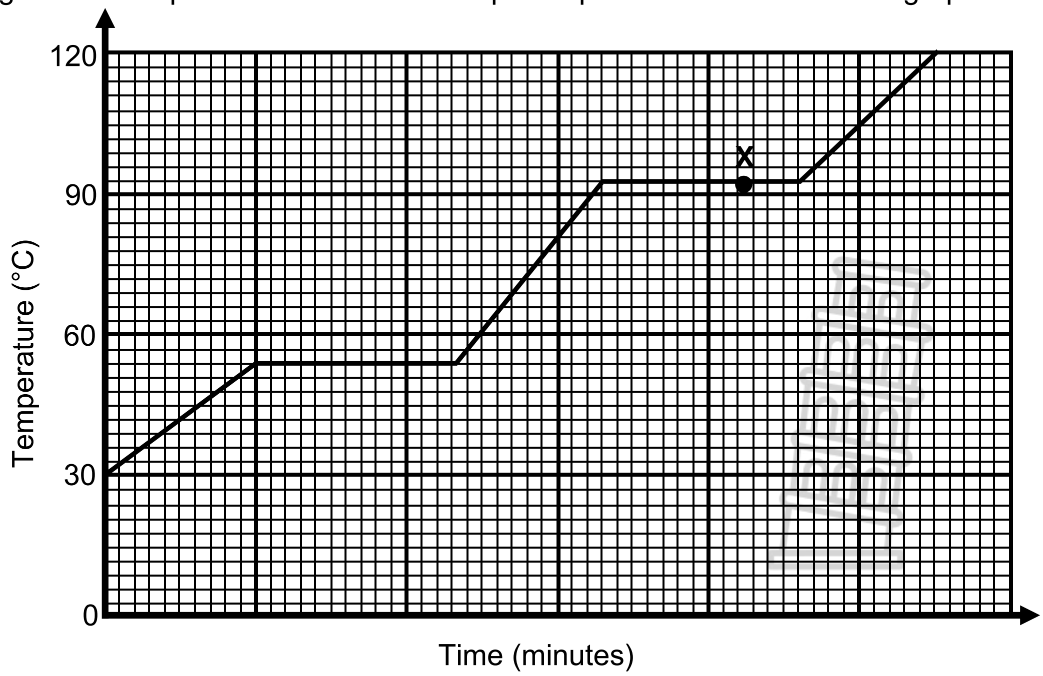
1. Draw the following table in your workbook and note the results in the table.

Time (s)	Temperature (°C)	Observation (What do you see in the ice mixture?)

2. Draw a graph of temperature versus time.

Activity 9.4: Classwork/Homework/Data-interpretation

The heating curve for a pure substance at atmospheric pressure is shown in the graph below.



1. For this pure substance, write down its:
   1.1 Melting point
   1.2 Boiling point
2. Is this pure substance water? Give a reason for the answer.
3. What is the physical state of the substance at:
   3.1 Point **X** shown on the graph
   3.2 Room temperature
4. What happens to the temperature while the substance melts? Explain this observation.

Topic 10: The atom: basic building block of all matter

The atom

↓

Atomic Mass — Actual mass of an atom - very small and impractical to use.

↓

Relative Atomic Mass — Mass of an atom on a scale where carbon-12 has a mass of 12.

Particle	Actual Mass (kg)	Relative mass	Charge (C)	Relative charge
proton	$1,67 \times 10^{-27}$	1	$1,6 \times 10^{-19}$	+1
neutron	$1,67 \times 10^{-27}$	1	0	0
electron	$9,1 \times 10^{-31}$	$\frac{1}{2000}$	$-1,6 \times 10^{-19}$	–1

↓

Structure of the Atom — Protons and neutrons in the nucleus and electrons move around the nucleus.

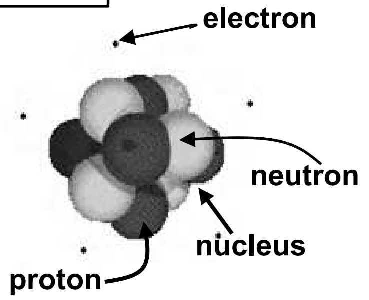
Representing Atoms

$$^{A}_{Z}E$$

Mass number (A): Number of nucleons i.e. number of protons + neutrons

Symbol of element (E)

Atomic number (Z): Number of protons; In a neutral atom also equal to number of electrons



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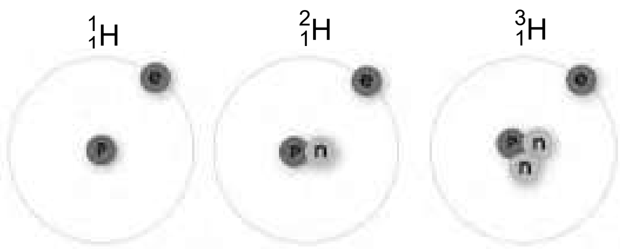
Isotopes — Atoms of the same element with the same atomic number, but different mass numbers due to a different number of neutrons.

Isotopes of hydrogen



Protium | Deuterium | Tritium

Percentage abundance:

99,985% | 0,015% | negligible

https://www.youtube.com/watch?v=Qtu1hM3535E

Relative atomic mass of an element with isotopes:

Consider 100 atoms:

$$\text{Rel. mass} = \frac{\text{rel. mass(\%abundance)} + \text{rel mass (\%abundance)} + \ldots}{100}$$

Relative atomic mass of hydrogen:

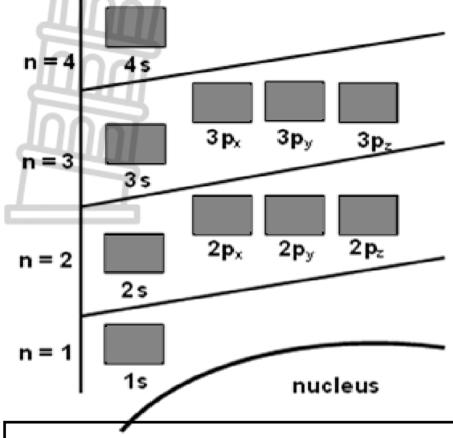
$$\text{Rel. mass} = \frac{1(99,985) + 2(0,015)}{100}$$

$$= 1,00015$$

Electron configuration

Arrangement of electrons around the atomic nucleus.

Aufbau diagram



Rules

- n = 1 to 4 are the main energy levels
- Orbitals with lowest energy fill first.
- Use circles or blocks to represent orbitals.
- Use arrow to represent electrons.
- Two electrons per orbital provided they spin in opposite directions.
- No pairing in p orbitals before there is not at least one electron in each.

sp notation

Element	Electron Configuration	Element	Electron Configuration
H	$1s^1$	Na	$1s^22s^22p^63s^1$
He	$1s^2$	Mg	$1s^22s^22p^63s^2$
Li	$1s^22s^1$	Al	$1s^22s^22p^63s^23p^1$
Be	$1s^22s^2$	Si	$1s^22s^22p^63s^23p^2$
B	$1s^22s^22p^1$	P	$1s^22s^22p^63s^23p^3$
C	$1s^22s^22p^2$	S	$1s^22s^22p^63s^23p^4$
N	$1s^22s^22p^3$	Cl	$1s^22s^22p^63s^23p^5$
O	$1s^22s^22p^4$	Ar	$1s^22s^22p^63s^23p^6$
F	$1s^22s^22p^5$	K	$1s^22s^22p^63s^23p^64s^1$
Ne	$1s^22s^22p^6$	Ca	$1s^22s^22p^63s^23p^64s^2$

Chemical behaviour of elements

- The electronic structure of an atom determines its chemical behaviour.
- Atoms with the same outer energy electron structure have the similar chemical properties.

CONCEPTS AND DEFINITIONS	
Atomic number (Z)	The number of protons in the nucleus of an atom.
Electrons	Negative particles occupying space around nucleus.
Excited state	When an electron gains energy and moves into higher energy level it is in the excited state.
Ground state	The lowest energy state of an electron.
Hund's rule	No pairing in p orbitals before there is not at least one electron in each p orbital.
Inner electrons	Electrons in the innermost part of atom – also known as core electrons.
Ion	An atom with a charge formed when an atom either gains or loses one or more electrons.
Ionisation energy	The energy needed to remove an electron(s) from an atom in the gaseous phase.
Isotopes	Atoms of the same element with the same atomic number, but different mass numbers due to a difference in the number of neutrons.
Mass number (A)	The sum of protons and neutrons in the nucleus.
Negative ion	Formed when a neutral atom gains one or more electrons.
Neutrons	Neutral particles in the atomic nucleus.
Nucleons	The particles in the nucleus of an atom i.e., protons and neutrons.
Orbital	The most probable region around the nucleus where electrons will be found.
Pauli's exclusion principle	Maximum two electrons per orbital if they spin in opposite directions.
Positive ion	Formed when a neutral atom loses one or more electrons.

CONCEPTS AND DEFINITIONS	
Protons	Positive particles in the atomic nucleus.
Quantised energy level	An energy level that can only have specific amounts of energy.
Relative atomic mass	The mass of an atom of an element on a scale where carbon-12 has a mass of 12.
Valence electrons (Outer electrons)	Electrons in the highest filled energy level of an atom and that are responsible for chemical bonding.

Activity 10.1: Classwork/Homework

1. Name the particle(s) found in the atom which:
   - 1.1 Carry no electrical charge
   - 1.2 Has the smallest mass of all
   - 1.3 Carry one positive electrical charge
   - 1.4 Carry one negative electrical charge
   - 1.5 Occur in the nucleus of the atom

2. Define the following terms:
   - 2.1 Nucleons
   - 2.2 Mass number
   - 2.3 Atomic number
   - 2.4 Relative atomic mass

3. Copy the table below into your answer book and complete the open spaces.

	Element	Atomic number	Number of protons	Number of electrons	Number of neutrons	Mass number
${}^{6}_{12}X$						
${}^{8}_{16}X$						
${}^{15}_{31}X$						
${}^{16}_{31}X$						
${}^{16}_{32}X$						

4. Use the table completed in QUESTION 3 to answer the following questions.
   - 4.1 What relationship exists between the atomic number of an element and the number of protons in a neutral atom of the element?
   - 4.2 State ONE similarity and ONE difference between the 4th and 5th elements in the table.
   - 4.3 What do we call atoms of elements with the same atomic number but different mass numbers?
   - 4.4 Use the periodic table and write down the names of the first three elements in the table in QUESTION 3.

5. Use the ${}^{A}_{Z}X$ notation to represent each of the following atoms:
   - 5.1 Uranium-235
   - 5.2 Calcium-40

6. A certain element **Q** has an atomic number of 10. It occurs as the following three isotopes:

   Q-20: 90,92%; Q-21: 0,26%; Q-22: 8,82%

   - 6.1 Define the term *isotope*.
   - 6.2 Write down the NAME of element **Q**.
   - 6.3 Write down the number of neutrons in the nucleus of the LEAST abundant isotope of element **Q**.
   - 6.4 Draw an Aufbau diagram for element **Q**.
   - 6.5 Write down the name of TWO rules that you applied when answering QUESTION 6.4

Activity 10.2: Classwork/Homework

1. Redraw the following table in your workbook. Complete all the cells with the necessary information.

Element	Symbol	Mass number	Atomic number	Nucleons	Protons	Neutrons	Electrons
Magnesium	Mg			24			12
Magnesium	Mg^{2+}		12			12	
	O^{2-}	16	8				
	Na^{+}	23			11		
	S		16	32			
Potassium		39	19				
	Br^{-}					45	36
	Fe^{3+}	56			26		

2. The control rods in nuclear reactors often contain boron. Natural boron is composed of 20% B-10 ($^{10}_{5}B$) and 80% B-11 ($^{11}_{5}B$).
   2.1 Do a calculation to indicate that the relative atomic mass of boron is 10,8.
   2.2 What is the composition of the nucleus of each of these isotopes?

Activity 10.3: Classwork/Homework

1. A mass spectrum of natural uranium indicates that 1% of the uranium atoms have a mass of 235 and that 99% have a mass of 238. Use this experimental information to determine the relative atomic mass of uranium.
2. Naturally occurring chlorine consists of the two stable isotopes $C\ell^{35}_{17}$ (75%) and $C\ell^{37}_{17}$ (25%). Calculate the mass of the average chlorine atom on the relative atomic mass scale.
3. Atoms of the element silicon consist of 92,2% of silicon-28, 4,7% of silicon-29 and 3,1% of silicon-30. Calculate the relative atomic mass of silicon.
4. Carbon's relative atomic mass is 12,011. Determine the percentage occurrence of each of the isotopes if we assume that carbon occurs only as C-14 and C-12 (Tip: Assume that *x*% C-12 and y% is C-14.)

Activity 10.4: Classwork/Homework

1. Draw Aufbau diagrams for all the elements in Period II (from Li to Ne) and Period III (Na to Ar). Indicate the following next to each of the Aufbau diagrams of the elements:
   1.1 Number of the highest filled energy level
   1.2 Number of the period in the periodic table
   1.3 Number of valence electrons
   1.4 Number of inner electrons (core electrons)
   1.5 Group number in the periodic table
   1.6 Electron configuration (sp notation)
2. Use your answers in Question 1 to answer the following questions.
   2.1 What is the relationship between the group number and the number of valence electrons?
   2.2 What is the relationship between the period number and the number of highest filled energy level?
   2.3 Explain the following: Elements in the same group of the periodic table have similar chemical properties.
   2.4 The noble gases (group 18) are so called because they do not bond easily with other elements or with each other. Look at the electron structure of the two noble gases in periods II and III and provide a reason for this unreactivity.

Experiment 11: Flame tests

Aim: To identify metals using their flame colours.

Background

Why do some metal ions give different characteristic flame colours?

- The valence electrons in some metallic elements are loosely held and can be excited to higher energy levels when heated.
- When the excited electrons (unstable state) fall to the lower energy level to obtain stability, a characteristic light is emitted. For most group I and II metals, the range of wavelengths of these emitted lights are around that of the visible spectrum. As a result, the visible radiations could colour the flames in different colours when some metallic ions are heated at high temperatures in a Bunsen flame.

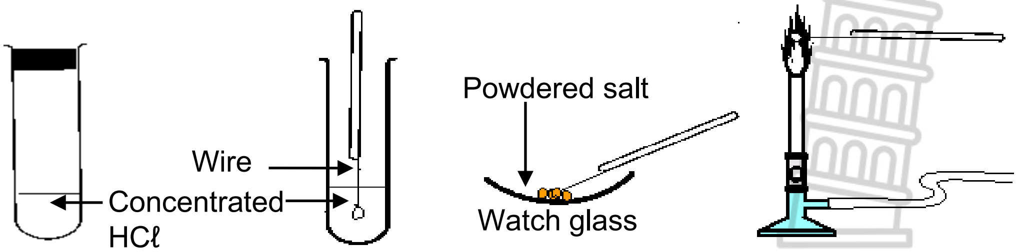
Apparatus & chemicals

Looped platinum / nichrome wire OR wooden splints OR cotton swabs
Wash bottle with distilled water
Bunsen burner
Concentrated hydrochloric acid
Watch glass
Metal salts: $LiC\ell$, $NaC\ell$, $KC\ell$, $CuC\ell_2$, $BaC\ell_2$ and $CaC\ell_2$

Method

1. Clean the platinum or nichrome loop. Dip the wire into hydrochloric acid, followed by rinsing with distilled water. Test the cleanliness of the loop by inserting it into a gas flame. If a burst of colour is produced, the loop is not sufficiently clean.

   OR
   Wooden splints or cotton swabs offer an inexpensive alternative to wire loops. Soak the wooden splints overnight in distilled water. Pour out the water and rinse the splints with clean water, being careful to avoid contaminating the water with sodium (from sweat on your hands). Take a damp splint or cotton swab through the flame. Do not hold the sample in the flame as this would cause the splint or swab to ignite.
2. Dip the clean wire (or wooden splint or cotton swab) into a small amount of powdered metallic salt in a watch glass.
3. Hold the wire (or wooden splint or cotton swab) in the cooler part of a non-luminous flame, i.e. the bottom of the flame. Then move the wire (or wooden splint or cotton swab) to the edge of the flame.
4. Observe the characteristic colour of the flame when the wire (or wooden splint or cotton swab) is in the edge of the flame.
5. Clean the wire as describe in step 1 above and test a second metallic salt OR use a new splint or cotton swab and test a second metallic salt.



Results

Redraw the following table in your workbook and record your observations.

Metal salt	Flame colour

Limitations of the flame test

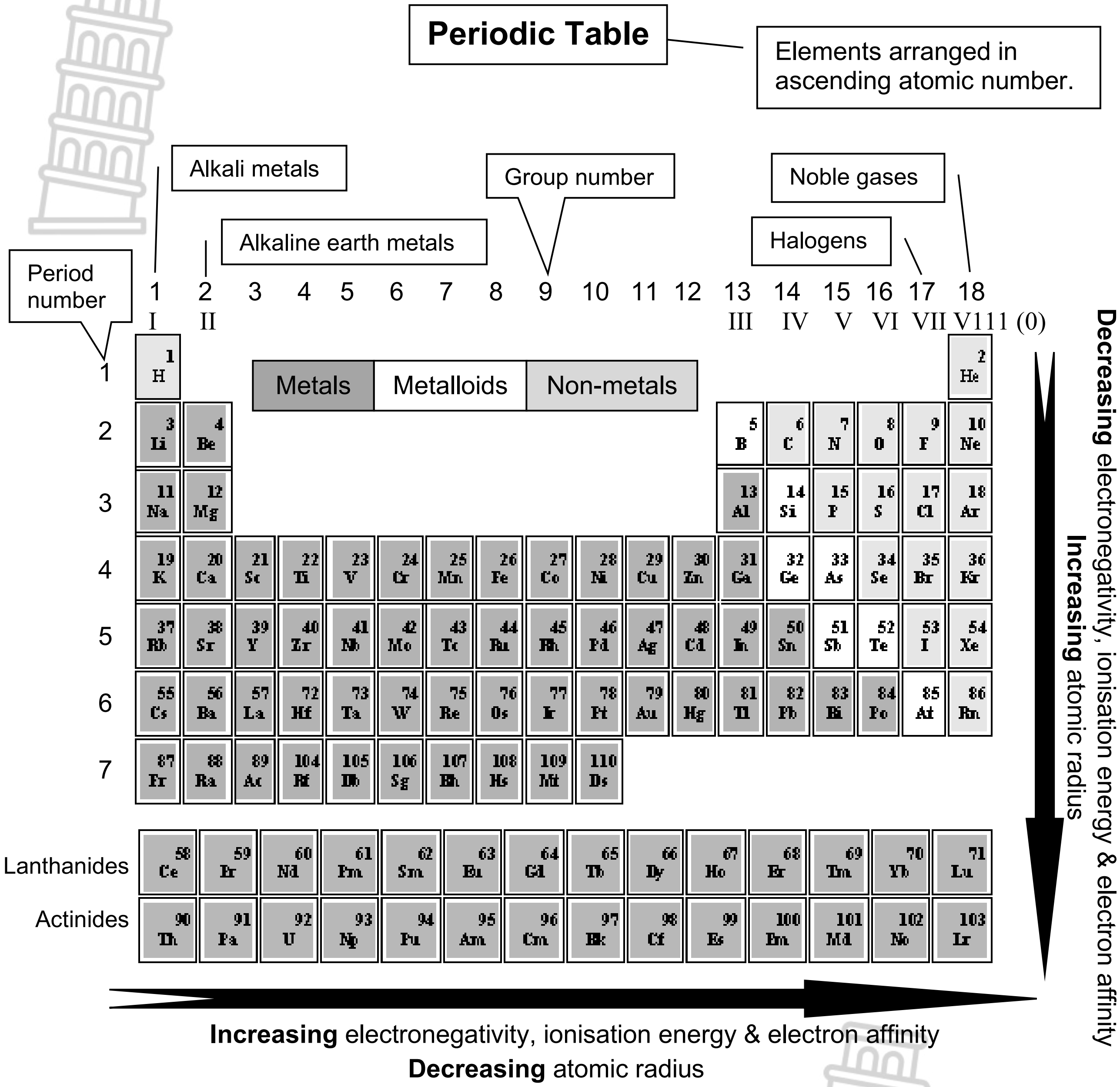
- The test cannot detect low concentrations of most ions.
- The brightness of the signal varies from one sample to another. For example, the yellow emission from sodium is much brighter than the red emission from the same amount of lithium.
- Impurities or contaminants affect the test results. Sodium is present in most compounds and will colour the flame. Sometimes a blue glass is used to filter the yellow colour of sodium.
- The test cannot differentiate between all elements. Several metals produce the same colour. Some compounds do not change the colour of the flame at all.

Characteristic flame colours of metal ions

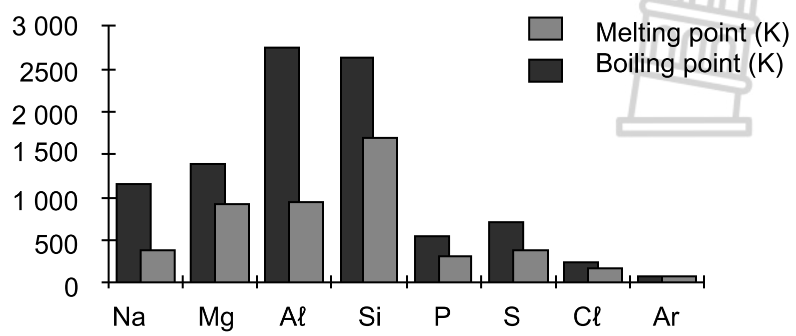
Metal ion	Flame colour	Metal ion	Flame colour
lithium ion Li^{+}	deep red	calcium ion Ca^{2+}	brick red
sodium ion Na^{+}	golden yellow	strontium ion Sr^{2+}	blood red
potassium ion K^{+}	lilac	barium ion Ba^{2+}	apple green
rubidium ion Rb^{+}	bluish red	copper(II) ion Cu^{2+}	bluish green
caesium ion Cs^{+}	blue		

Video 18: Firework colours and Electron Excitation
https://www.youtube.com/watch?v=heLTiUjWzIl
Video 19: Flame Tests of Metal Ions, With Labels
https://www.youtube.com/watch?v=1EXr_L7Ojqg
Video 20: Flame test colours
https://www.youtube.com/watch?v=TMz_XR3o5mg

Topic 11: Periodic Table



Melting point & boiling points of elements in period 3



Video 21: The Periodic Table Explained Introduction
https://www.youtube.com/watch?v=uPkEGAHo78o

CONCEPTS AND DEFINITIONS	
Atomic number	Number of protons in the nucleus of an atom.
Atomic radius	The distance from the atomic nucleus to the outermost stable electron in an atom.
Boiling point	The temperature of a liquid at which its vapour pressure equals the external (atmospheric) pressure.
Density	The mass per unit volume of a substance.
Electron affinity	The energy released when an electron is attached to an atom or molecule to form a negative ion.
Electronegativity	The tendency of an atom in a molecule to attract bonding electrons closer to itself.
First ionisation energy	Energy needed to remove the first electron from an atom in the gaseous phase.
Groups	Vertical columns in the periodic table. Some groups have names.
Ion	A charged particle made from an atom by the loss or gain of electrons.
Ionisation energy	Energy needed to remove an electron(s) from an atom in the gaseous phase.
Melting point	The temperature at which a solid, given sufficient heat, becomes a liquid.
Periods	Horizontal rows in the periodic table.
Periodicity	The repetition of similar properties in chemical elements, as indicated by their positioning in the periodic table. (With increasing atomic number, the electron configuration of the atoms displays a periodic variation.)
Second ionisation energy	Energy needed to remove an electron from a positive ion with a charge of +1 in the gaseous phase.
Valence electrons	Electrons in the highest (outer) energy level of an atom and that are responsible for chemical bonding.

Periodic Table of the Elements

KEY/*SLEUTEL*

29
1,9 Cu
63,5

Atomic number / *Atoomgetal*
Electronegativity / *Elektronegatiwiteit*
Symbol / *Simbool*
Approximate relative atomic mass / *Benaderde relatiewe atoommassa*

1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
1 2,1 H 1																	2 He 4
3 1,0 Li 7	4 1,5 Be 9											5 2,0 B 11	6 2,5 C 12	7 3,0 N 14	8 3,5 O 16	9 4,0 F 19	10 Ne 20
11 0,9 Na 23	12 1,2 Mg 24											13 1,5 Aℓ 27	14 1,8 Si 28	15 2,1 P 31	16 2,5 S 32	17 3,0 Cℓ 35,5	18 Ar 40
19 0,8 K 39	20 1,0 Ca 40	21 1,3 Sc 45	22 1,5 Ti 48	23 1,6 V 51	24 1,6 Cr 52	25 1,5 Mn 55	26 1,8 Fe 56	27 1,8 Co 59	28 1,8 Ni 59	29 1,9 Cu 63,5	30 1,6 Zn 65	31 1,6 Ga 70	32 1,8 Ge 73	33 2,0 As 75	34 2,4 Se 79	35 2,8 Br 80	36 Kr 84
37 0,8 Rb 86	38 1,0 Sr 88	39 1,2 Y 89	40 1,4 Zr 91	41 Nb 92	42 1,8 Mo 96	43 1,9 Tc	44 2,2 Ru 101	45 2,2 Rh 103	46 2,2 Pd 106	47 1,9 Ag 108	48 1,7 Cd 112	49 1,7 In 115	50 1,8 Sn 119	51 1,9 Sb 122	52 2,1 Te 128	53 2,5 I 127	54 Xe 131
55 0,7 Cs 133	56 0,9 Ba 137	57 La 139	72 1,6 Hf 179	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 201	81 1,8 Tℓ 204	82 1,8 Pb 207	83 1,9 Bi 209	84 2,0 Po	85 2,5 At	86 Rn
87 0,7 Fr	88 0,9 Ra 226	89 Ac															

58 Ce 140	59 Pr 141	60 Nd 144	61 Pm	62 Sm 150	63 Eu 152	64 Gd 157	65 Tb 159	66 Dy 163	67 Ho 165	68 Er 167	69 Tm 169	70 Yb 173	71 Lu 175
90 Th 232	91 Pa	92 U 238	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Activity 11.1: Classwork/Homework

Consider the first 18 elements in the periodic table. From these elements, choose the element that matches the following requirements:

1. The most reactive metal
2. A non-metal that can form four bonds
3. A yellow solid that is a non-metal
4. A noble gas with two protons
5. The lightest alkali metal
6. A member of the alkali earth metals with 12 neutrons
7. A metalloid in group III
8. A gas in period 2 that is used in combustion reactions
9. A semiconductor in period 3
10. A noble gas with the electron configuration $1s^22s^22p^63s^23p^6$
11. Its diatomic molecules form the most abundant gas in the atmosphere
12. A halogen in period 3
13. A yellowish gas that forms an ion with a -1 charge
14. A light, silvery metal with a valency of 3
15. An element with 4 protons
16. The element with the smallest atoms
17. An element with the notation $^{31}_{15}Q$
18. A non-metal that is a liquid at room temperature

Activity 11.2: Classwork/Homework

The letters **A** to **H** in the table below represents eight elements from period 3 in the periodic table. Study the information in the table below and answer the question that follow.

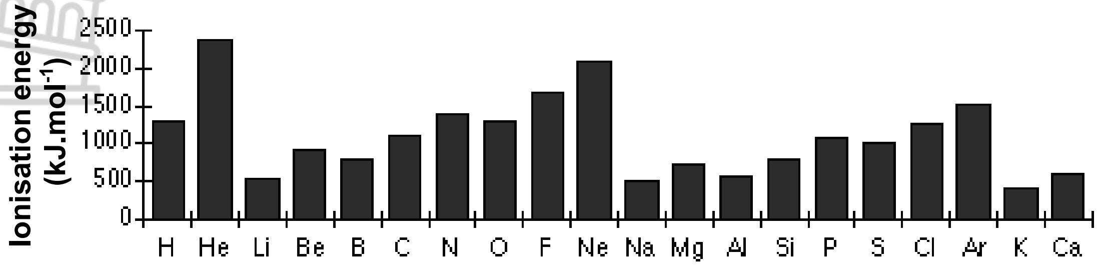
Element	Physical properties	Melting point (°C)	Electrical conductivity
A	Hard, greyish shiny solid	1 410	Semiconductor
B	Very light silver metal	660	Good conductor
C	Colourless gas	-189	Non conductor
D	Very reactive yellow solid	590	Non conductor
E	Extremely soft, silver metal	98	Good conductor
F	Soft, yellow solid	114	Non conductor
G	Yellow-green gas	-101	Non conductor
H	Slightly hard silver metal	650	Good conductor

1. Write down the letter of the element that represents:
   1.1 The metalloid
   1.2 An unreactive non-metal
   1.3 A very reactive metal
2. Describe the trend in electrical conductivity across period 3.
3. Elements **E** and **H** react with oxygen to form oxides. Write down the respective chemical formulae of these oxides.
4. Arrange the elements **A** to **H** in the sequence that they appear in period 3 in the periodic table.

Activity 11.3: Classwork/Homework/Data-interpretation

1. The graph below shows the first ionisation energies of the first 20 elements in the periodic table.

First ionisation energies of the first 20 elements



1.1 Define the term *first ionisation energy*.
1.2 What does *periodicity* of ionisation energy mean?
1.3 Which three elements have the lowest first ionisation energies? In which group of the periodic table do these elements occur?
1.4 Which group's elements have the highest first ionisation energy?
1.5 Arrange the elements on the graph in order of decreasing tendency to lose electrons.
1.6 Which of the metals or non-metals will preferably form positive ions? Justify your answer with data from the graph.

2. Refer to the table below which gives the melting and boiling points of a number of elements.

Element	Melting point (°C)	Boiling point (°C)
copper	1 083	2 567
magnesium	650	1 107
oxygen	-218,4	-183
carbon	3 500	4 827
helium	-272	-268,6
sulphur	112,8	444,6

2.1 Write down the symbol of each element and next to it the phase in which each element occurs at room temperature.
2.2 Which of these elements has the strongest forces between its atoms? Give a reason for your answer.
2.3 Which of these elements has the weakest forces between its atoms? Give a reason for your answer.

Topic 12: Chemical bonding

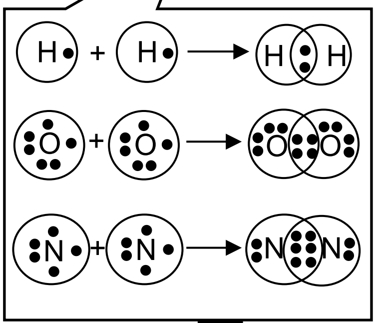
Chemical bonding

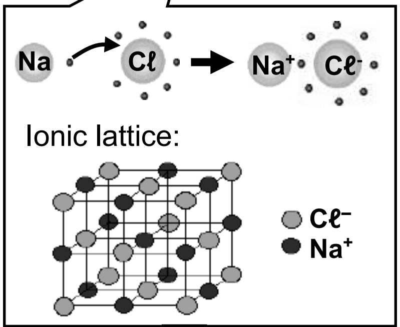
Simultaneous attraction between two nuclei. Energy of combined atoms is lower than that of individual atoms – higher stability

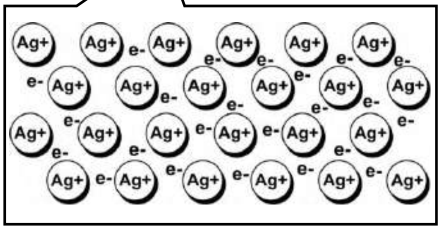
Covalent bond
Sharing of electrons between non-metallic atoms to form molecules

Ionic bond
Transfer of electrons from a metallic atom to a non-metallic atom

Metallic bond
Between metallic atoms
Positive ions and a sea of delocalised valence electrons

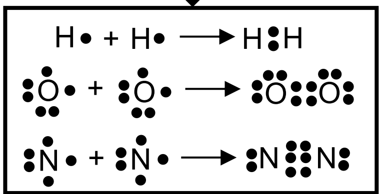


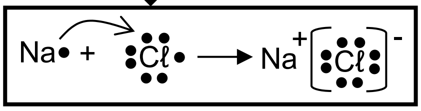




Represented with
Lewis structures

A formula in which valence electrons are represented by dots; two dots between atoms represent a covalent bond.





Couper structures

H-H	**Single bond**
O=O	**Double bond**
N≡N	**Triple bond**

Revision
- Cation and the anion tables done in grade 9.
- Names of compounds.
- Relative molecular mass for covalent molecules.
- Relative formula mass for ionic compounds.

CONCEPTS AND DEFINITIONS	
Anion	A charged particle made from an atom by the gain of electrons.
Cation	A charged particle made from an atom by the loss of electrons.
Crystal lattice	An orderly three-dimensional arrangement of particles (ions, molecules, or atoms) in a solid structure
Ion	A charged particle made from an atom by the loss or gain of electrons.
Lewis diagram / Lewis structure	A structural formula in which valence electrons are represented by dots; two dots between atoms represent a covalent bond. Also known as electron-dot formula or Lewis formula or electron diagrams.
Molecule	Group of two or more atoms that are covalently bonded and function as a unit.
Valence electrons	Electrons in the highest filled energy level of an atom and that participate in chemical bonding.

Activity 12.1: Classwork/Homework

1. Draw Lewis structures for each of the following elements:
   1.1 H   1.2 He   1.3 Na   1.4 Ne   1.5 Cℓ
   1.6 S   1.7 C   1.8 O   1.9 K   1.10 Mg
   1.11 Si   1.12 Br

2. Water exists as the H_2O molecule. Use Aufbau diagrams for oxygen and hydrogen, as well as Lewis structures to explain the existence of the H_2O molecule.

3. PH, PH_2 or PH_3? Use Aufbau diagrams and predict which one of the three is the correct formula. Explain the formation of the correct molecule with a Lewis structure.

4. What is the valency of carbon? Illustrate the formation of the methane molecule (CH_4) using Lewis structures.

Activity 12.2: Classwork/Homework

1. Draw a Lewis structure and a Couper structure for each of the following molecules:
   1.1 Carbon dioxide   1.2 Chlorine   1.3 Hydrogen chloride
   1.4 Ammonia   1.5 O_2 1.6 N_2

2. Potassium bromide is a white crystalline solid.
   2.1 Which two elements make up potassium bromide?
   2.2 What are the relative positions of these two elements on the periodic table?
   2.3 How many valence electrons does each of these elements have?
   2.4 What is the valency of each of these two elements?
   2.5 What type of bond will form between these two elements?
   2.6 Illustrate the formation of this bond using Lewis structures. Briefly explain how the bond will form.

3. Explain the difference between an ionic bond and a covalent bond.

4. Name the type of bonds that hold particles together in each of the following:
   4.1 Na(s)   4.2 $CuSO_4$(s)   4.3 iron
   4.4 potassium chloride   4.5 A water molecule

Activity 12.3: Classwork/Homework

1. Write down the names of the following compounds:
   1.1 $K_2Cr_2O_7$ 1.2 Na_2CO_3 1.3 $KC\ell O_3$
   1.4 $FeSO_4$ 1.5 $Ca_3(PO_4)_2$ 1.6 $CrC\ell_3$
   1.7 NH_4NO_3 1.8 $Pb(NO_3)_2$ 1.9 $Na_2S_2O_3$

2. Write down the formula of each of the following compounds:
   2.1 Ammonium sulphate   2.2 Mercury(II) oxide   2.3 Nickel chloride
   2.4 Sodium sulphite   2.5 Sodium sulphide   2.6 Potassium nitrite
   2.7 Iron(III) sulphate   2.8 Potassium nitrate

3. Use Aufbau diagrams to explain why argon does not bond chemically, while chlorine always occurs as a compound in which it is bonded either to itself or to other elements.

4. Calculate the relative molecular mass of:
   4.1 H_2O 4.2 $HC\ell$ 4.3 NH_3 4.4 H_2

5. Calculate the relative formula mass of:
   5.1 $NaC\ell$ 5.2 $CuSO_4$ 5.3 $K_2Cr_2O_7$ 5.4 $Fe(NO_3)_2$

Topic 13: Physical and Chemical Change

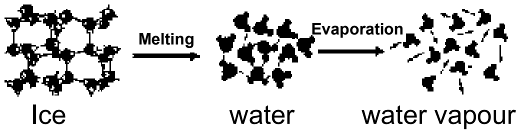
Physical and Chemical Change

A change that does not result in the formation of new substances.

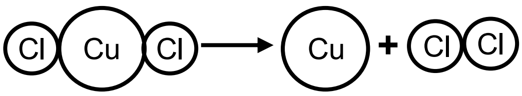
A change during which a new substance is formed.

Separation of particles

Physical change



Chemical change



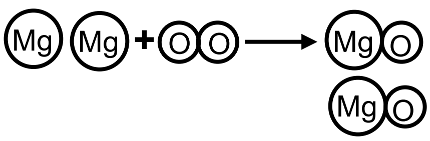
New products with new properties formed

Energy involved:

Energy transferred during a chemical reaction = Energy absorbed to break bonds - Energy released when new bonds form

Conservation of atoms and mass

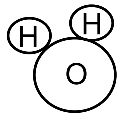
$2Mg + O_2 \rightarrow 2\,MgO$



Left hand side of the equation:
Total mass = (2 x 24) + (2 x 16) = 80 g
Number of atoms = (2 x Mg) + (2 x O)

Right hand side of the equation:
Total mass = 2 x (24 + 16) = 80 g
Number of atoms = (2 x Mg) + (2 x O)

Law of constant composition



H:O ratio always 2:1 for water

CONCEPTS AD DEFINITIONS	
Atom	The smallest particle matter consists of.
Catalyst	A substance that speeds up the rate of a chemical reaction without undergoing a change itself.
Chemical change	A change during which a new substance with new properties is formed.
Decomposition reaction	A chemical reaction during which a reactant forms two or more products.
Endothermic reaction	A chemical reaction that absorbs energy.
Exothermic reaction	A reaction that releases energy.
Law of conservation of mass	Matter cannot be created or destroyed in a chemical reaction. The total mass of reactants equals total mass of products.
Law of conservation of energy	Energy cannot be created or destroyed, but it can only be transformed from one form to another.
Law of constant composition	A particular compound always has the same elements joined together in the same proportions by mass.
Mass	The amount of matter in a body.
Physical change	A change that does not result in the formation of new products.
Synthesis reaction	A chemical reaction during which two or more simple reactants combine to form a more complex product.

Experiment 12: Heating of iron and sulphur

Aim: To investigate the properties of substances before and after a chemical reaction

Apparatus & chemicals

- Iron filings
- Sulphur (powder or flowers of sulphur)
- Magnet
- Test tube
- Bunsen burner or hot plate or stove
- Spatula

Video 22: Elements, Mixtures and Compounds: Iron and Sulphur
https://www.youtube.com/watch?v=SAL21S-zgpc

Method

1. Prepare a mixture containing iron powder and sulphur powder in the ratio 7:4 by mass. Do this by weighing out 7 g of iron powder and 4 g of finely powdered sulphur onto separate pieces of filter paper.
2. Mix the two powders by pouring repeatedly from one piece of paper to the other.
3. Note the appearance of the pure elements and the mixture.
4. Wrapping the end of a small bar magnet in a paper tissue and dip it into a teaspoon-sized heap of the mixture on a watch glass. Record your observations.
5. Place about 2 g of the mixture into a test-tube.
6. Insert a plug of mineral wool (mineral fibre) into the mouth of the test-tube. Clamp the test-tube as shown in the diagram.
7. Heat the powder mixture at the base of the test-tube – gently at first and then more strongly (use a blue flame throughout).
8. Heat until an orange glow is seen inside the test-tube. Immediately stop heating. Observe what happens inside the test tube.
9. Allow the tube to cool down. Once cool, it is possible to break open the test-tube to show the appearance of the product. It is advisable to wear protective gloves.
10. Bring the magnet close to the product. Record your observations.

Results

1. Redraw the following table into your workbook, record your observations and complete the rest of the table.

	Iron filings	Sulphur powder	Product after heating
Magnetic or non-magnetic			
Appearance			
Metal or non-metal			
Formula/Symbol			
Element/compound			

2. The test tube is heated until an orange glow is visible. What do you observe immediately after removal of the heat?

Questions

1. Briefly describe how the mixture if iron filings and sulphur can be separated. Is this a physical or a chemical change?
2. Write down a balanced equation for the reaction that takes after heating the mixture in the test tube.
3. Write down the name of the product formed in the reaction.
4. Is this reaction *exothermic* or *endothermic*? Give a reason for your choice.
5. Is this reaction a *physical* or a *chemical* change? Give a reason for your answer.
6. Classify the reaction that takes place as either a *synthesis* or a *decomposition*.

Experiment 13: Reaction of lead(II) nitrate and potassium iodide

Aim: To observe the product formed when lead(II) nitrate reacts with potassium iodide

Apparatus & chemicals

- Eye protection (goggles)
- Test tube
- Trough with water
- Spatula
- Lead(II) nitrate (toxic, dangerous for the environment)
- Potassium iodide (low hazard)

Video 23: Double displacement reaction
https://www.youtube.com/watch?v=X2mB-q2NQXY
Video 24: Double displacement reaction
https://www.youtube.com/watch?v=k0W0NphQAtQ

Method 1

1. Add one spatula of lead(II) nitrate into the test tube.
2. Add one spatula of potassium iodide to the lead(II) nitrate in the test tube.
3. Close the test tube with a stopper and shake vigorously.

Method 2

1. Add one spatula of lead(II) nitrate into the test tube and add enough water to make a clear solution.
2. Add one spatula of potassium iodide into the test tube and add enough distilled water to make a clear solution.
3. Pour the contents of one test tube into other.

Results

Record all observations made in the table below.

Method 1	Method 2

Questions

1. Which method results in the faster reaction? Refer to the kinetic theory to explain this observation.
2. Lead(II) iodide is a yellow insoluble solid. Write down a balanced equation for the reaction that takes place in both procedures.
3. Is the above reaction a physical or chemical change? Give a reason for your answer.
4. Briefly describe how the solid product formed in Method 2 can be retrieved from the solution.
5. How will the total mass of the reactants compare to that of the products? Briefly explain.

Activity 13.1: Classwork/Homework

1. Explain the difference between the following concepts in your own words.
   1.1 A chemical and a physical change
   1.2 Exothermic and endothermic reactions
2. Classify, with reason, each of the following changes as chemical or physical.
   2.1 With pressure and heat graphite becomes a diamond.
   2.2 An egg is cooked.
   2.3 A tree dies.
   2.4 Lightning makes ozone (O_3) from oxygen (O_2). The ozone then reverts to oxygen.
3. Copy the following table in your workbook and classify each of the following changes as a physical or a chemical change.

Change	Chemical or physical?
Digesting an apple	
Burning wood	
Bad odour released by a skunk	
Making a volcano with baking soda and vinegar	
Freezing water	
Rusting of a nail	
Carbon dioxide dissolves in water	
Table salt dissolves in water	

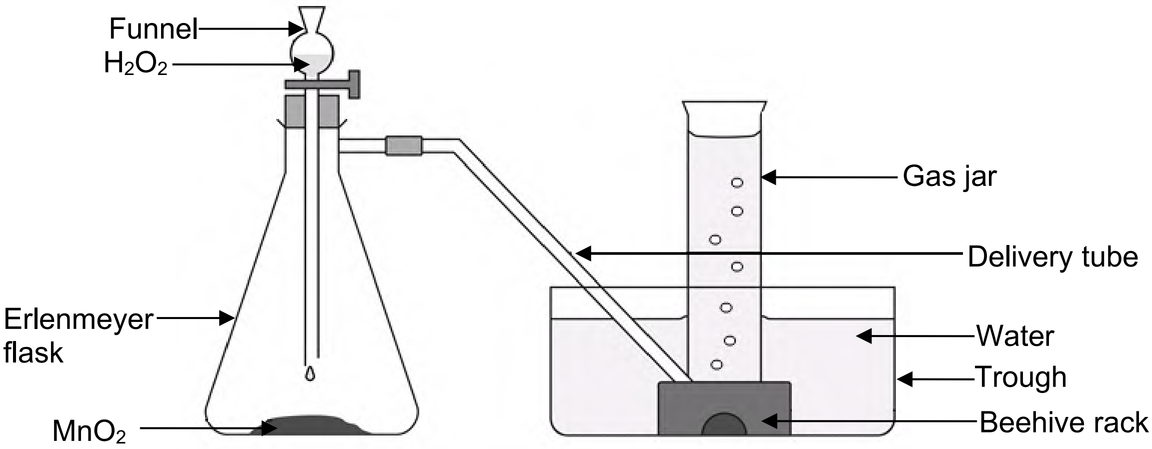
Experiment 14: Preparation of oxygen from H_2O_2
(Teacher demonstration)

Aim: To prepare oxygen and collect it by the downward displacement of water

Apparatus & chemicals
- 20% - 30% hydrogen peroxide solution (H_2O_2)
- Manganese dioxide (MnO_2)
- Round-bottomed flask or Erlenmeyer flask with a rubber stopper with two holes fitting tightly
- Delivery tube
- Gas jar
- Beehive rack
- Trough with water
- Spatula

Video 25: Preparation of oxygen gas
https://www.youtube.com/watch?v=z_P5Z-LJYSk

Method
1. Place one teaspoon (approximately 10 g) of manganese dioxide in a 500 cm^3 flask.
2. Add 10 cm^3 of water.
3. Use a rubber stopper with two holes, through which a thistle funnel (or dropping funnel) and a delivery tube have been fitted, to close the flask. Alternatively, a flask with a side-arm can be used as shown in the diagram below.
4. Fill the funnel with 20% to 30% hydrogen peroxide solution. (Use a fresh solution.)
5. Fill a clean gas jar with water from the glass trough and invert it over the beehive rack.
6. Carefully allow the hydrogen peroxide to run from the funnel so that the oxygen can be collected in the gas jar. **Be careful:** If O_2 is released too quickly the stopper will shoot out.



Results
1. Oxygen is a colourless gas. Write down an observation that you can make to know that a gas is indeed released.
2. Describe a test that you can perform to identify the gas as oxygen.

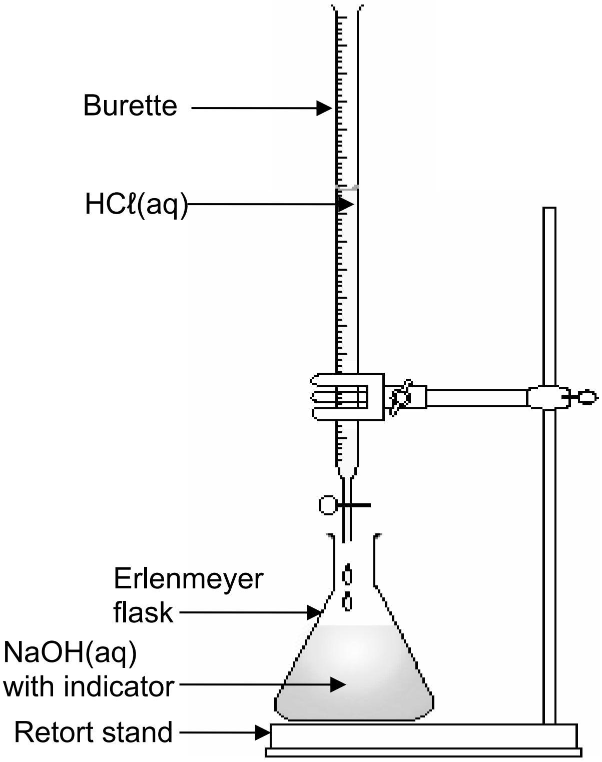
Questions
1. Write down a balanced equation for the reaction that takes place.
2. Is the above reaction a *physical* or a *chemical* change? Give a reason for your answer.
3 After completion of the reaction, all the manganese dioxide is still present. What was the role of manganese dioxide in this reaction?
4. Which other substance remained in the flask after the reaction is completed? Assume that all the hydrogen peroxide has reacted.
5. Oxygen is collected by the downward displacement of water. Briefly explain the meaning of this statement.
6. Show with a calculation that mass is conserved during this reaction.
7. Classify this reaction as either a *synthesis* or a *decomposition* reaction.

Experiment 15: The reaction of hydrochloric acid and sodium hydroxide

Aim: To investigate the reaction of hydrochloric acid and sodium hydroxide

Apparatus & chemicals

- Hydrochloric acid solution (Add 20 cm^3 of concentrated hydrochloric acid to 60 cm^3 of distilled water.)
- Sodium hydroxide solution (Dissolve 12 g of sodium hydroxide crystals in 100 cm^3 of distilled water.)
- Retort stand
- Measuring cylinder
- Burette
- Erlenmeyer flask
- Thermometer
- Bromothymol blue indicator



Method

1. Rinse the burette with a little bit of the hydrochloric acid solution. Fill it to the zero mark with hydrochloric acid. Use a funnel when filling the burette.
2. Use a pipette to place 20 cm^3 of the sodium hydroxide solution in the Erlenmeyer flask.
3. Add 5 – 7 drops of the bromothymol to the sodium hydroxide solution in the Erlenmeyer flask.
4. Measure the temperature of the solution in the flask.
5. Slowly run 3 cm^3 of acid from the burette into the flask whist stirring the solution with the thermometer. Record the temperature after addition of the 3 cm^3 of acid.
6. Repeat the procedure by adding further quantities of 3 cm^3 acid until the indicator changes colour. Measure the temperature after the addition of each 3 cm^3 of acid.
7. Add another three quantities of 3 cm^3 acid after the colour change and record these temperatures.

Results

1. Copy the table below into your workbook and record your results.

Volume of HCℓ(aq) added (cm^3)	Colour of solution with indicator	Temperature (°C)
0		

2. Draw a graph of temperature versus volume of acid added. Use a graph paper. Choose an appropriate scale on each axis and label the axes. Plot the point and draw the graph.
3. Calculate the total change in temperature.

Questions

1. This is an example of the reaction between an acid and a base to form a salt and water. Write down a balanced equation for the reaction that takes place.
2. Is this reaction exothermic or endothermic? Give a reason for your answer.
3. Briefly describe the shape of the graph. Give reasons for the change in shape after at a certain volume of acid added.
4. Was there any change in temperature after the indicator changes colour? Give a reason for this observation.
5. Write down the name of the salt formed in this reaction.
6. Show with a calculation that mass is conserved in this chemical reaction.

Topic 14: Representing chemical change

Chemical equations
A chemical equation is a way to describe what happens during a chemical reaction. Chemical equations are written as follows:

- Symbols indicate elements, ionic or covalent compounds, aqueous solutions, ions, or particles.
- An arrow points to the right to indicate the action of the reaction.
- There are also reversible reactions, i.e. reactions during which the products reassemble to form the original reactants. Reversible reactions are symbolised in chemical equations by a double arrow ($\leftrightharpoons$).
- The substances to the left of the arrow are the reactants, i.e. the substances that are going to react.
- The substances to the right of the arrow are the products, i.e. the substances that have been produced by the reaction.
- The phases of the reactants and products are indicated in brackets after the formula of the compound. Solids are indicated as (*s*), liquids as (*ℓ*), gases as (*g*) and solutions in water as (*aq*).

Steps for balancing of chemical equations

Step 1: Write down a word equation for the reaction.
Nitrogen + hydrogen → ammonia

Step 2: Write down the correct molecular formulae.
$N_2 + H_2 \rightarrow NH_3$

Step 3: Balance by adding coefficients in the equation (if necessary).
$N_2 + 3H_2 \rightarrow 2NH_3$

Step 4: Add state symbols.
$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

Activity 14.1: Classwork/Homework

1. Consider the reaction $Ag(s) + H_2S(g) \rightarrow Ag_2S(s) + H_2(g)$.
   1.1 State the law of conservation of mass.
   1.2 Show with calculations that mass is conserved in this reaction.
   1.3 Are atoms conserved in this reaction? Give a reason for your answer.
   1.4 Are molecules/formula units conserved in this reaction? Give a reason for your answer.
   1.5 Use the formula of silver sulphide to explain what is meant by *the law of constant proportions.*

3. Balance each of the following chemical reactions.
   2.1 $Mg + O_2 \rightarrow MgO$
   2.2 $Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$
   2.3 $H_2SO_4 + Mg \rightarrow MgSO_4 + H_2$
   2.4 $BaC\ell_2 + Na_2SO_4 \rightarrow BaSO_4 + NaC\ell$
   2.5 $P_4 + O_2 \rightarrow P_2O_5$
   2.6 $CaCO_3 \rightarrow CaO + CO_2$
   2.7 $Fe + O_2 \rightarrow Fe_2O_3$
   2.8 $HgO \rightarrow Hg + O_2$
   2.9 $Cu + AgNO_3 \rightarrow Cu(NO_3)_2 + Ag$
   2.10 $(NH_4)_2Cr_2O_7 \rightarrow Cr_2O_3 + N_2 + H_2O$

3. Use relative atomic masses to prove that the balanced chemical equations above adhere to the *law of conservation of mass.*

Activity 14.2: Classwork/Homework

Write balanced chemical equations for the following equations:

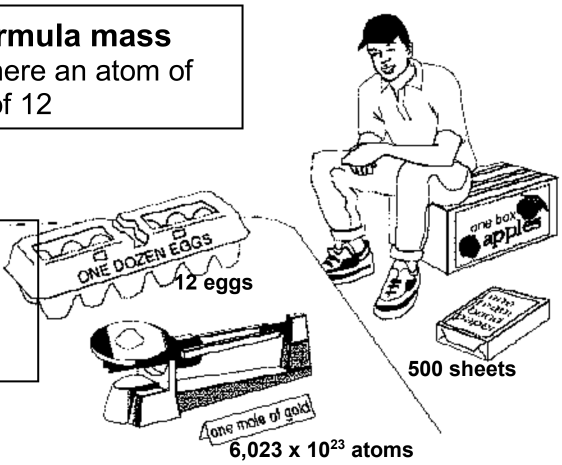
1. hydrogen + oxygen → water
2. methane + oxygen → carbon dioxide + water
3. silver nitrate + sodium chloride → silver chloride + sodium nitrate
4. sulphur dioxide + oxygen → sulphur trioxide
5. nitric acid + copper → copper(II) nitrate + nitrogen dioxide + water
6. iron(III) oxide + carbon monoxide → iron + carbon dioxide

Topic 15: Quantitative aspects of chemical change

Quantitative aspects of chemical change

Relative atomic/molecular/formula mass
Mass of ONE particle on a scale where an atom of carbon -12 has a mass of 12

Mole (n)
Amount of substance having the same number of particles as there are atoms in 12 g of carbon-12



Avogadro's number
Number of particles (atoms, molecules, formula-units) present in mole
N_A = 6,023 x 10^{23} particles·mol^{-1}

Molar gas volume (mol·dm^{-3})
Volume of 1 mole gas
At STP (standard temperature and pressure): V_M = 22,4 dm^3·mol^{-1}

Number of particles (atoms, ions, molecules

$n = \frac{\text{number of particles}}{N_A}$

x N_A ; ÷ N_A

Volume of gas (dm^3)

$n = \frac{V}{V_M}$

x V_M ; ÷ V_M

n

$c = \frac{n}{V}$

÷ V ; x V

Concentration (c) of solutions (mol·dm^{-3})

Volume of solution in dm^3

÷ M ; x M

$n = \frac{m}{M}$

Mass (g)

Molar mass (in g·mol^{-1})
Mass of one mole of a substance

Percentage composition
% of each element in a compound

Stoichiometric calculations

Empirical formula
Gives the simplest whole-number ratio of atoms in a compound.

Steps to be followed when doing stoichiometric calculations:
1. Write a balanced chemical equation for the reaction.
2. Convert the known (mass, volume, or number of particles) to number of moles.
3. Use the balanced equation to find the mole of the unknown.

CONCEPTS AND DEFINITIONS	
Actual yield	The quantity physically obtained from a chemical reaction.
Anhydrous	Without water - A substance is anhydrous if it contains no water.
Avogadro's law	One mole of any gas occupies the same volume at the same temperature and pressure. At STP: V_M = 22,4 $dm^3 \cdot mol^{-1}$
Avogadro's number (N_A)	Number of particles (atoms, molecules, or formula units) present in one mole of a substance. (N_A) = 6,023 x 10^{23} particles·mol^{-1}
Empirical formula	A formula that gives the simplest whole-number ratio of atoms in a compound.
Hydrate	Solid ionic compounds in which water molecules are captured.
Limiting reactant	The reactant that is completely consumed in a chemical reaction.
Concentration	The number of moles of solute per liter (cubic decimeter) of solution.
Molar mass (M)	The mass of one mole of a substance. Unit: g·mol^{-1}
Molar volume (V_M)	The volume of one mole of a gas.
Mole (n)	The amount of substance with the same number of particles as there are atoms in 12 g carbon-12.
Molecular formula	A formula that indicates the ratio of atoms in a compound as well as the actual number of atoms of each element in the compound.
Percentage composition	The mass of each atom in a compound expressed as a percentage of the total mass of the compound. (A pure sample of a given compound always has the same composition.)
Relative atomic mass	The relative atomic mass of an element is the mass of an atom on a scale where a carbon-12 atom has a mass of 12 units.
Relative formula mass	The relative formula mass of an ionic substance (e.g. NaCℓ) is the mass of one formula unit on a scale where a carbon-12 atom has a mass of 12 units.
Relative molecular mass	The relative molecular mass of a molecular substance (e.g. H_2O) is the mass of one molecule on a scale where a carbon-12 atom has a mass of 12 units.
Solute	The dissolved substance. (Usually the substance present in lesser amount.)
Solution	A homogeneous mixture of two or more substances that acts as a unit.
Solvent	The substance in which the solute is dissolved. (Usually the substance present in greater amount.)
Stoichiometric calculations	Calculations involving the mole ratios of reactants and products in a chemical reaction. (Molar masses and mole ratios, together with other factors, are used to determine information about one reactant or product in a chemical reaction from known information about another.)
Stoichiometry	The branch of chemistry that deals with the relative quantities of reactants and products in chemical reactions.
STP	Standard Temperature and Pressure (T = 273 K (0 °C) and p = 101,3 kPa)
Theoretical yield	Calculated yield of a product in a chemical reaction.
Water of crystallisation	Water that is stoichiometrically bound into a crystal e.g. the H_2O in $CuSO_4.5H_2O$.

Video 26: Concept of Mole
https://www.youtube.com/watch?v=4q2elWPfB6A

Steps for determining percentage composition

1. Calculate the molar mass of the given compound.
2. Determine the contribution (to the total molar mass of the compound) of each element present in the compound and express it as a percentage of the molar mass of the compound.

EXAMPLE:
Determine the percentage composition of methane (CH_4).

Step 1:
$M(CH_4) = 16\ g{\cdot}mol^{-1}$

Step 2:
$\%C = \frac{12}{16} \times 100 = 75\%$ $\%H = \frac{4}{16} \times 100 = 25\%$

Steps for determining empirical formulae

1. Express percentages as masses.
2. Convert the mass of each element to number of moles.
3. Determine the ratio of the different elements in the compound by dividing the number of moles of each element by the smallest number of moles.
4. Express these ratios as the smallest whole number. These values are the subscripts of atoms in the empirical formula.
5. Determine the molar mass represented by the empirical formula. If this mass is the same as the given molar mass of the compound, the empirical formula and the molecular formula is the same.
6. IF NOT THE SAME, divide the molar mass of the compound by the molar mass of the empirical formula. This value indicates the amount of empirical formula units in the molecular formula.

EXAMPLE:
Octane contains 84,2% carbon and 15,8% hydrogen by mass. Its relative molecular mass is 114. Determine the molecular formula of octane.

Step 1:
84,2 g C & 15,8 g H

Step 2:
$n(C) = \frac{m}{M} = \frac{84,2}{12} = 7,0167\ mol$ $n(H) = \frac{m}{M} = \frac{15,8}{1} = 15,8\ mol$

Step 3:
n (C)is the smallest, thus: $n(C) : n(H) = \frac{7,0167}{7,0167} : \frac{15,8}{7,0167} = 1 : 2,25$

Step 4:
1 : 2,25 = 4 : 9 Empirical formula: C_4H_9

Step 5:
$M(C_4H_9) = 57\ g{\cdot}mol^{-1}$

$\frac{M(octane)}{M(C_4H_9)} = \frac{114}{57} = 2$ Molecular formula: C_8H_{18}

Steps for determining the formula of a hydrate

1. Calculate the number of moles of water.
2. Calculate the number of moles of the anhydrous salt.
3. Calculate the mole ratio - water : anhydrous salt
4. Write down the formula for the hydrate.

EXAMPLE:
2,5 g hydrated copper(II) sulphate ($CuSO_4.xH_2O$) is heated. After heating the mass of white anhydrous copper(II) sulphate ($CuSO_4$) is determined as 1,59 g. Determine the formula of the hydrate.

Step 1:
$m(H_2O) = 2,5 – 1,59 = 0,91\ g$ $n(H_2O) = \frac{m}{M} = \frac{0,91}{18} = 0,05\ mol$

Step 2:
$n(CuSO_4) = \frac{m}{M} = \frac{1,59}{159,5} = 0,0097\ mol$

Step 3:
$n(H_2O) : n(CuSO_4) = \frac{0,05}{0,0097} = 5,15$

Step 4:
x = 5, thus the formula is: $CuSO_4{\cdot}5H_2O$

Activity 15.1: Homework/Classwork

1. Determine the relative atomic mass of:
   - 1.1 silver
   - 1.2 Cu
   - 1.3 H
   - 1.4 O
   - 1.5 Fe
   - 1.6 mercury
   - 1.7 Cℓ
   - 1.8 Br

2. Calculate the relative molecular mass of:
   - 2.1 water
   - 2.2 chlorine
   - 2.3 H_2
   - 2.4 O_2
   - 2.5 NH_3
   - 2.6 SO_2
   - 2.7 NO_2
   - 2.8 bromine

3. Calculate the relative formula mass of:
   - 3.1 iron(III) chloride
   - 3.2 sodium chloride
   - 3.3 KNO_3
   - 3.4 $MgSO_4$
   - 3.5 K_2SO_4
   - 3.6 lead(II) nitrate
   - 3.7 Na_2CO_3
   - 3.8 $CuSO_4.5H_2O$

Activity 15.2: Homework/Classwork

1. Define the following terms:
   - 1.1 Mole
   - 1.2 Molar mass
   - 1.3 Relative formula mass
   - 1.4 Avogadro's number

2. Calculate the molar mass of:
   - 2.1 Water
   - 2.2 Chlorine
   - 2.3 HOCℓ
   - 2.4 O_2
   - 2.5 $NH_4Cℓ$
   - 2.6 SO_2
   - 2.7 Nitrogen dioxide
   - 2.8 Br_2
   - 2.9 $FeCℓ_2$
   - 2.10 Potassium chloride
   - 2.11 Barium nitrate
   - 2.12 Na_2SO_4
   - 2.13 Silver sulphide
   - 2.14 $Pb(NO_3)_2$
   - 2.15 $CuSO_4.5H_2O$

Activity 15.3: Homework/Classwork

1. Calculate the number of moles in:
   - 1.1 320 g of magnesium oxide
   - 1.2 21,6 g of silver
   - 1.3 6,4 g SO_2
   - 1.4 0,46 g sodium
   - 1.5 10 g potassium sulphate
   - 1.6 3 g iron(II) sulphide
   - 1.7 12 g sodium sulphite
   - 1.8 5 g ammonia

2. Calculate the mass of:
   - 2.1 2 moles of water
   - 2.2 0,5 moles of iodine, I_2
   - 2.3 1,2 moles of sodium chloride
   - 2.4 0,125 moles of oxygen, O_2
   - 2.5 10 moles of HCℓ
   - 2.6 0,6 moles of sulphur dioxide
   - 2.7 1 mole sodium hydroxide
   - 2.8 0,25 moles of silver nitrate

3. Calculate the number of moles at STP in:
   - 3.1 56 dm^3 xenon
   - 3.2 10 dm^3 oxygen, O_2
   - 3.3 2,24 dm^3 of chlorine, $Cℓ_2$
   - 3.4 2,24 dm^3 sulphur dioxide
   - 3.5 2,24 m^3 nitrogen
   - 3.6 12 m^3 neon

4. Calculate the volume at STP occupied by:
   - 4.1 5 moles of carbon dioxide
   - 4.2 3 moles of ammonia
   - 4.3 2 moles of oxygen, O_2
   - 4.4 64 moles of sulphur dioxide
   - 4.5 2 moles of hydrogen, H_2
   - 4.6 0,01 moles of nitrogen, N_2

5. Calculate the number of:
   - 5.1 Molecules in 2 moles of carbon dioxide
   - 5.2 Atoms in 4 moles of sodium
   - 5.3 Molecules in 0,5 moles of water
   - 5.4 Formula units in 10 moles of sodium chloride

Activity 15.4: Homework/Classwork

1. 1 mole of sodium carbonate (Na_2CO_3) contains 2 moles of sodium atoms, 1 mole of carbon atoms and 3 moles of oxygen atoms. In the same way, write down the number of moles of each atom present in 1 mole of:
   1.1 PbO 1.2 NH_4NO_3 1.3 $Ca(OH)_2$
   1.4 CH_3COOH 1.5 $FeSO_4.7H_2O$ 1.6 Pb_3O_4
2. Calculate the:
   2.1 Mass of 44,8 dm^3 carbon dioxide at STP
   2.2 Mass of 3,0115 x 10^{24} silver atoms
   2.3 Volume of 20 g H_2 at STP
   2.4 Number of formula-units in 2 g NaCℓ
   2.5 Number of atoms in 12 g Mg
   2.6 Volume of 32 g oxygen at STP
   2.7 Number of Mg atoms in 20 g $MgSO_4$
   2.8 Number of K atoms in 20 g K_2SO_4
   2.9 Number of oxygen atoms in 10 g $AgNO_3$
   2.10 Mass of 30 dm^3 ammonia at STP

Activity 15.5: Homework/Classwork

1. Calculate the volume of a:
   1.1 0,4 $mol·dm^{-3}$ salt solution that contains 0,1 mol of salt
   1.2 0,4 $mol·dm^{-3}$ solution of X that contains 2 moles of X
2. Calculate the number of moles of solute in:
   2.1 500 cm^3 of a solution of concentration 2 $mol·dm^{-3}$
   2.2 2 liters of a solution of concentration 0,5 $mol·dm^{-3}$
3. Calculate the concentration of a solution containing:
   3.1 11,7 g of NaCℓ in 500 cm^3 solution
   3.2 2,54 g of I_2 in tetrachloromethane to give a 100 cm^3 solution
   3.3 53 g sodium carbonate dissolved in 1 litre of water
   3.4 62,5 g $CuSO_4.5H_2O$ dissolved in 1 litre of water
4. Calculate the mass of sodium hydroxide present in:
   4.1 500 cm^3 of a 1 $mol·dm^{-3}$ solution
   4.2 25 cm^3 of a 0,5 $mol·dm^{-3}$ solution

Activity 15.6: Homework/Classwork

1. Define the following terms:
   1.1 Percentage composition 1.2 Empirical formula
2. Fertilisers contain nitrogen needed by plants to grow. Ammonium nitrate is used as fertiliser. It has the formula NH_4NO_3. Calculate the:
   2.1 Percentage of nitrogen in ammonium nitrate
   2.2 Mass of nitrogen in a 20 kg bag of fertiliser
3. Calculate the percentage of copper in each of the following copper compounds:
   $CuCℓ_2$; $Cu(NO_3)_2$; $CuSO_4.5H_2O$
4. Calculate the empirical formula of each of the compounds having the following percentage compositions:
   4.1 31,8% K; 29% Cℓ; 39,2% O 4.2 30,5% N; 69,6% O
   4.3 53% Aℓ; 47% O 4.4 45,3% O; 43,4% Na; 11,3% C
   4.5 40% S; 60% O
5. 56 g of iron combine with 32 g of sulphur to form iron(II) sulphide. Find the empirical formula of iron(II) sulphide.

Activity 15.7: Homework/Classwork

1. A compound contains 92,2% C and 7,7% H. The molar mass of the substance is 104 g·mol^{-1}. Determine this compound's:
   1.1 Empirical formula   1.2 Molecular formula
2. Vinegar is a dilute form of ethanoic acid with a molar mass of 60 g·mol^{-1}. The percentage composition of ethanoic acid is as follows: 39,9% C; 6,7% H and 53,4% O
   For ethanoic acid, determine its:
   2.1 Empirical formula   1.2 Molecular formula
3. 1,628 g of hydrated magnesium iodide is heated to remove the crystal water. Its mass is reduced to 1,072 g when all the crystal water is removed. Determine the formula of hydrated magnesium iodide.
4. Determine the formula of a hydrate that is 85,3% barium chloride and 14,7% water.
5. A 4,89 g sample of calcium sulfate was heated. After the water was driven off, 3,87 g of the anhydrous calcium sulfate remained. Determine the formula of this hydrate.

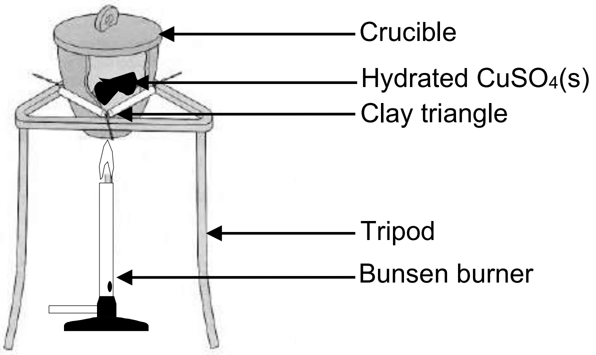
Activity 15.8: Homework/Classwork

1. Consider the following balanced equation: $N_2 + 3H_2 \rightarrow 2NH_3$
   How many moles of:
   1.1 N_2 will react with 3 moles of H_2
   1.2 H_2 will react with 3 moles of N_2
   1.3 NH_3 will be formed from 11 moles of H_2
   1.4 NH_3 will be formed from 11 moles of N_2
2. Consider the following balanced equation: $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$
   How many moles of:
   2.1 Fe_3O_4 will be formed from 12 moles of Fe
   2.2 Fe are needed to produce 16 moles of H_2
   2.3 H_2 will be formed if 40 moles of Fe_3O_4 are formed
   2.4 H_2O are needed to react with 14,5 moles of Fe
3. Calculate the mass of carbon that reacts with 7,95 g of copper(II) oxide. The balanced equation for the reaction is: $2CuO + C \rightarrow 2Cu + CO_2$
4. Calcium metal reacts with water to form an insoluble suspension of calcium hydroxide and hydrogen gas. Calculate the mass of hydrogen produced from 10 g of calcium.
5. Calculate the volume of hydrogen produced at STP from 1 dm^3 of ammonia in the following reaction: $2NH_3 \rightarrow N_2 + 3H_2$
6. Calculate the mass of sodium that will react with 230 g of oxygen to form sodium oxide.
7. Hydrogen burns in oxygen to from water. Calculate the mass of:
   7.1 Oxygen needed to burn 1 g of hydrogen
   7.2 Mass of water produced from 1 g of hydrogen
8. Calcium carbonate reacts completely with 30 cm^3 hydrochloric acid of concentration 0,5 mol·dm^{-3}.
   8.1 Write down a balanced equation for this reaction.
   8.2 Calculate the number of moles of acid that has reacted.
   8.3 Calculate the mass of calcium carbonate that has reacted.
   8.4 Calculate the volume of gas that will be formed at STP.
   8.5 Calculate the number of calcium carbonate formula units that have reacted.

Experiment 16: Water of crystallisation

Aim: To determine the formula of hydrated copper(II) sulphate i.e. solve for x in the formula $CuSO_4.xH_2O$.

Apparatus & chemicals
- Tripod
- Clay triangle
- Crucible
- Spatula
- Hydrated copper(II) sulphate
- Bunsen burner
- Chemical balance



Method
1. Determine the mass of crucible and record it in the table.
2. Half fill the crucible with hydrated copper(II) sulphate.
3. Determine the mass of the crucible and its contents and record the mass in the table.
4. Place the crucible on the clay triangle and heat using a clean blue flame.
5. Heat strongly for about five minutes until no further change is observed.
6. Remove the crucible from the flame and allow it to cool down.
7. Determine the mass of the crucible and its contents again.
8. Repeat the heating until the mass of the crucible and its contents remain constant. Record this constant mass in the table.

Results
Redraw the following table in your workbook. Record all the masses in the table and calculate the mass of water of crystalisation.

1	Mass of crucible (g)	
2	Mass of crucible and hydrated $CuSO_4$ (g)	
3	Mass of hydrated $CuSO_4$ (g) [2 – 1]	
4	Mass of crucible and anhydrous $CuSO_4$ (g)	
5	Mass of anhydrous $CuSO_4$ (g) [4 – 1]	
6	Mass of water of crystalisation [3 – 5]	

Conclusion and questions
1. Define the following terms:
   1.1 Water of crystalisation
   1.2 Hydrated salt
   1.3 Anhydrous salt
2. What do you initially see happening when the crystals are heated?
3. How do you know when all the water of crystallisation has been lost?
4. What is the colour of:
   4.1 Hydrated copper(II) sulphate
   4.2 Dehydrated copper(II) sulphate
5. What is the formula of a water molecule? Calculate the molar mass of water.
6. Use the results obtained to calculate the number of moles of water of crystalisation in hydrated copper(II) sulphate.
7. Write down the formula of anhydrous copper(II) sulphate. Calculate its molar mass.
8. Use the results obtained to calculate the number of moles of anhydrous copper(II) sulphate.
9. Calculate the ratio of the number of moles of water of crystalisation to the number of moles of anhydrous copper(II) sulphate.
10. Express your answer to QUESTION 9 as a whole number and write down the formula of hydrated copper(II) sulphate.

Topic 16: Vectors and scalars

Physical Quantities

Vector
A physical quantity with magnitude and direction. (Example: force)

Scalar
A physical quantity with magnitude only. (Example: time)

Graphical representation

- Line drawn to scale
- Arrowhead to indicate direction

Example:
Vector: 4 N to the right

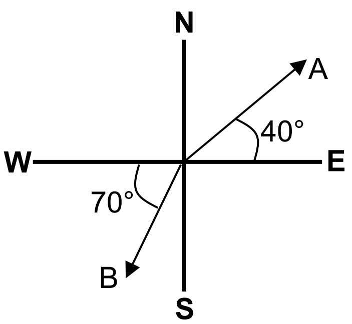
- Choose a scale: 1 cm = 1 N
- Draw a line 4 cm long.
- Add an arrow to indicate the direction to the right.
- Label the vector.

4 N, to the right →

Direction of vectors

The direction of a vector can be indicated by one of the following:

1. Use the directions of the compass as reference from which to measure angles



Direction of vector A:

- 40° north of east or 50° east of north
- E 40° N or N 50° E

Direction of vector B:
70° south of west or 20° west of south
W70°S or S20°W

2. Measure angles clockwise from a reference direction, usually north
   Direction of vector A: 50°
   Direction of vector B: 200°.
3. Use another vector or a fixed point as reference e.g. 30 m at an angle of 20° to the bank of the river.
4. Use words/phrases such as upward, downward, to the left, to the right, in the direction of motion.

Properties

Equality:

- Same magnitude
- Same direction

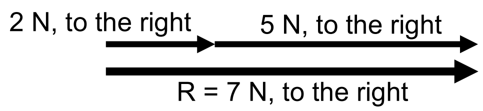
Equal vectors: → 2 N, to the right
→ 2 N, to the right

Unequal vectors:

- Different magnitudes and different directions
- Same magnitude, different directions
- Different magnitudes, same direction

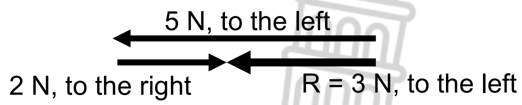
Vector addition:

Example 1:
2 N to the right + 5 N to the right:
Scale drawing:



Resultant (R or F_{net}) = 7 N to the right
Calculation:
To the right as positive:
2 N + 5 N = 7 N

Example 2 (Subtraction)
2 N to the right + 5 N to the left:
Scale drawing:



Resultant (R or F_{net}) = 3 N to the left

Calculation:
To the right as positive:
2 N + (- 5 N) = - 3 N ∴ 3 N to the left

The head-to-tail method to determine the sum of two or more vectors

1. Choose a scale and indicate it on a sheet of paper, e.g. SCALE: 1 cm = 20 m. The best choice of scale is one that will result in a diagram that is as large as possible yet fits on the sheet of paper.
2. Pick a starting location and draw the first vector *to scale* in the indicated direction. Label the magnitude and direction of the vector on the diagram.
3. Starting from where the head (arrow) of the first vector ends, draw the second vector *to scale* in the indicated direction. Label the magnitude and direction of this vector on the diagram.
4. Repeat steps 2 and 3 for all vectors that are to be added.
5. Draw the resultant from the tail of the first vector to the head of the last vector. Label this vector as **Resultant** or simply **R**.
6. Using a ruler, measure the length of the resultant and determine its magnitude by converting to real units using the scale (e.g. if the length is 4,4 cm: $4{,}4 \text{ cm} \times \frac{20 \text{ m}}{1 \text{ cm}} = 88 \text{ m}$)
7. Measure the direction of the resultant using a suitable method, e.g. clockwise from a north-south line.

LIST OF VECTORS		
Physical quantity	**Symbol**	**Unit of measurement**
Force	F	newton (N)
Weight	w	newton (N)
Acceleration	a	metre per second squared ($m \cdot s^{-2}$)
Velocity	v	metre per second ($m \cdot s^{-1}$)
Displacement (change in position in straight line)	$\Delta x / \Delta y$	metre (m)

LIST OF SCALARS		
Physical quantity	**Symbol**	**Unit of measurement**
Temperature	T	kelvin (K) / degrees Celsius (°C)
Mass	m	kilogram (kg)
Time	t	second (s)
Volume	V	cubic decimetre (dm^3)
Distance	D	metre (m)

CONCEPTS AND DEFINITIONS	
Displacement	The change in position of an object from a point of reference. (Length and direction of the straight line drawn from the beginning to the endpoint.)
Distance	The total path length travelled by an object.
Force	Any influence which tends to change the motion of an object.
Mass	The amount of matter in an object.
Resultant	A single vector having the same effect than two or more vectors acting together.
Scalar	A physical quantity with magnitude only.
Tail-to-head method	Used to determine the resultant of two or more vectors - draw the first vector anywhere you wish, and then draw the second vector with its tail at the head of the first vector. If there are more vectors to be added draw each one with its tail at the head of the preceding one. The resultant is a vector drawn from the tail of the first vector to the head of the last vector. Vectors can be added in any order.
Vector	A physical quantity with magnitude and direction.
Weight	The force of attraction of the earth on an object.

Activity 16.1: Homework/Classwork

1. Define the following terms:
   1.1 Vector 1.2 Scalar
   1.3 Resultant

2. Distinguish between *displacement* and *distance* in words and with the aid of a sketch.

3. Which ONE of the following terms does not fit with the rest?
   A Distance B Force
   C Time D Speed

4. Two forces, **K** and **P**, are applied to a crate. The crate does not move. Which ONE of the following statements is the BEST explanation for this observation?
   The two forces:
   A Are equal B Act in the same direction
   C Act in opposite directions D Are equal and act in opposite directions

5. Choose a relevant scale to represent the following vectors graphically:
   5.1 10 N, 30°
   5.2 35 N, N50°W
   5.3 94 N, 20° north of east
   5.4 43 N to the left
   5.5 223 N east

Activity 16.2: Homework/Classwork

1. Use a calculation to determine the resultant of the following pairs of forces:
   1.1 25 N, 0° and 34 N, 180°
   1.2 54 N to the right and 60 N to the right

2. Use the tail-to-head method to determine the resultant of the following pairs of forces:
   2.1 25 N, 0° and 34 N, 180°
   2.2 54 N to the right and 60 N to the right
   2.3 60 N, 90° and 80 N, 30°

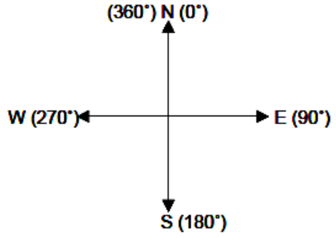
3. Four forces of magnitudes 10 N, 8 N, 6 N and 4 N act on the same point on an object. The directions of the forces are 0°; 90°; 135° and 270° respectively. Use the tail-to-head method to determine the resultant of these forces.

Video 27: Introduction to vectors
https://www.youtube.com/watch?v=NP9paqrd3z4

Topic 17: Motion in one dimension

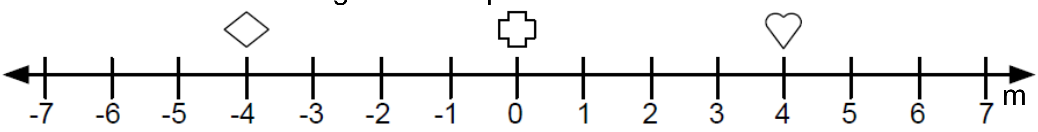
Motion in one direction

Frame of reference



Position

- Given relative to a point of reference
- Can be positive or negative
- Origin: zero of position



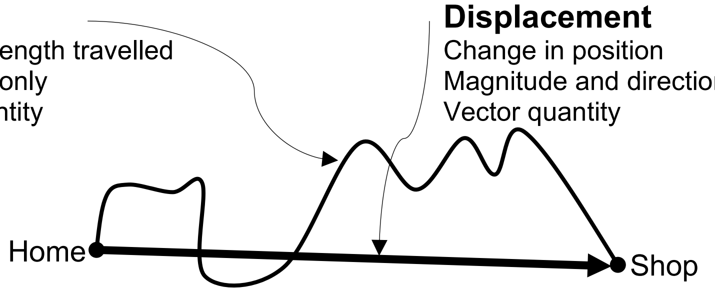
Position of square: - 4 m   Position of cross: 0   Position of heart: 4 m

Distance

Total path length travelled
Magnitude only
Scalar quantity

Displacement

Change in position
Magnitude and direction
Vector quantity



Average speed

(Scalar quantity)

$$\text{average speed} = \frac{\text{distance}}{\text{time}}$$

Unit: $m \cdot s^{-1}$

Average velocity

(Vector quantity)

$$\text{average velocity} = \frac{\text{displacement}}{\text{time}}$$

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$$

Unit: $m \cdot s^{-1}$ + direction

Acceleration

Vector quantity

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{change in time}}$$

In symbols: $a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$

Unit: $m \cdot s^{-2}$ + direction

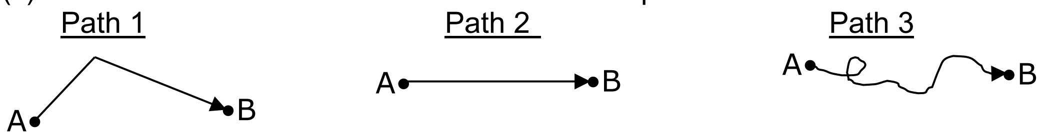
Acceleration – increasing velocity: acceleration in same direction as motion
Deceleration – decreasing velocity: acceleration opposite to direction of motion

Positive acceleration: Increase in velocity in the direction chosen as positive
OR: Decrease in velocity in the direction chosen as negative
Negative acceleration: Increase in velocity in the direction chosen as negative
OR: Decrease in velocity in the direction chosen as positive

CONCEPTS AND DEFINITIONS	
Acceleration	The rate of change of velocity.
Average speed	The distance covered per time interval.
Average velocity	The displacement per time interval.
Displacement	The change in position of an object. (Length and direction of the straight line drawn from the beginning to the endpoint.)
Distance	The total path length travelled by an object.
Frame of reference	The reference point (origin) and a set of axes with set directions from which position or motion can be measured.
Instantaneous speed	The distance divided by a very short time interval.
Instantaneous velocity	The displacement divided by a very short time interval.
Motion in one dimension	Motion of an object in one direction (in a straight line).
Position	The place where an object finds itself as observed from a point of reference.

Activity 17.1: Homework/Classwork

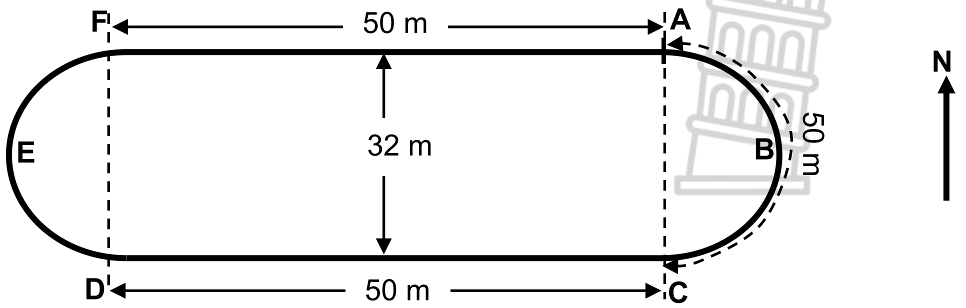
1. Classify the following quantities as vectors or scalars:
   displacement, distance, speed, velocity, acceleration, time
2. Classify the following statement as TRUE or FALSE.
   An object can move for 10 seconds and still have a zero displacement.
   If true, give an example. If false, give a reason.
3. Suppose you run along three different paths from position **A** to position **B**. Along which path(s) would the distance travelled differ from the displacement?



4. You run from your house to a friend's house that is 3 kilometres away. From there, you walk back home.
   4.1 What distance did you travel?
   4.2 What was the displacement for the entire trip?

Activity 17.2: Homework/Classwork

A toy train travels at a constant speed in a clockwise direction on a track set up as shown below.

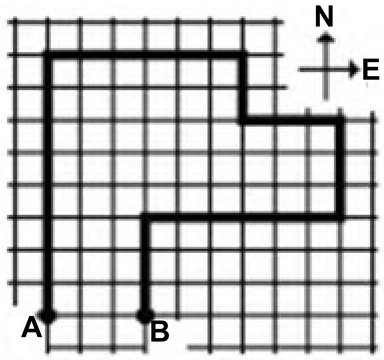


It takes the train 20 s to complete one round starting at point **A** on the track. On reaching point **C** for the second time, calculate, for the train, the:

1. Total distance travelled
2. Displacement
3. Average speed
4. Average velocity
5. Instantaneous speed at point **B**
6. Instantaneous velocity at point **B**

Activity 17.3: Homework/Classwork

1. Consider the diagram below. A person starts at **A** and walks along the path shown in bold to **B**. Each square represents 1 km x 1 km.

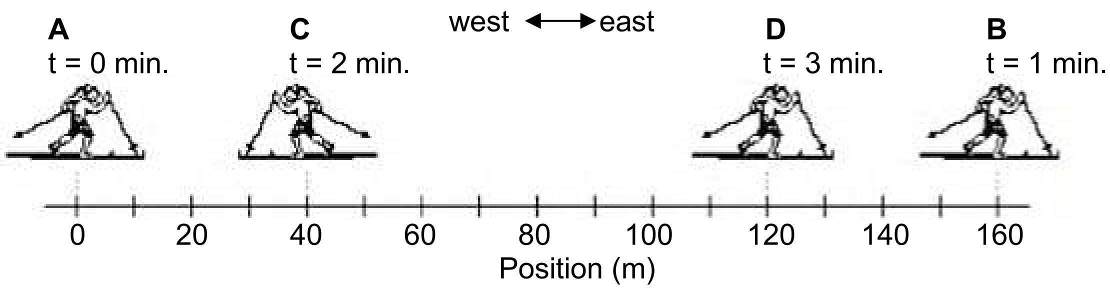


Determine the:

1.1 Distance walked by the person

1.2 Displacement of the person

2. A cross-country skier moves from position **A** to position **B**, then from position **B** to position **C** and then from position **C** to position **D** as illustrated below. Each leg of the back and-forth motion takes 1 minute to complete. The total time taken in moving from position **A** to position **D** is 3 minutes.



Calculate the:

2.1 Total distance travelled by the skier during the three minutes

2.2 Displacement of the skier during the three minutes

2.3 Displacement during the second minute (from 1 min. to 2 min.)

2.4 Displacement during the third minute (from 2 min. to 3 min.)

Activity 17.4: Homework/Classwork

The table below shows data obtained for the motion of an object.

time (s)	0	1	2	3	4	5
position (m)	0	20	50	130	150	200

1. Draw the position-time graph for the motion of the object.
2. From the graph, determine the:

   2.1 Average speed during the first 2 seconds

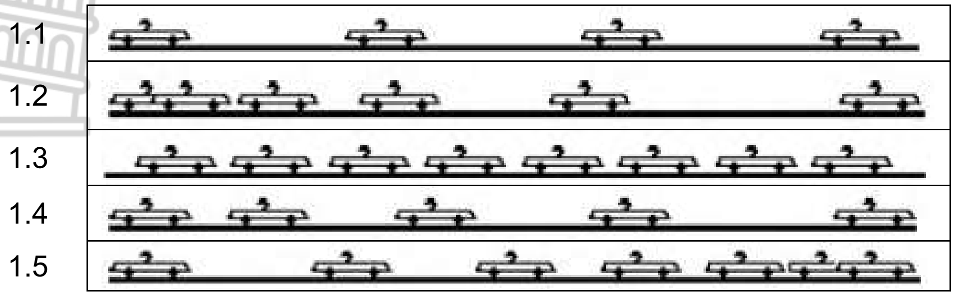
   2.2 Average speed between the 2nd and the 3rd second

   2.3 Average speed for the whole trip
3. Determine the tangent of the graph between the 2nd and the 3rd second.
4. How does the answer to QUESTION 2.2 compare to the answer to QUESTION 3?

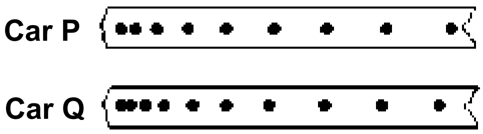
Video 28: Motion in one dimension
https://www.youtube.com/watch?v=APQtOpRTQq8

Activity 17.5: Homework/Classwork/Data-interpretation

1. The motion of a car in an amusement park is illustrated below. The position of the car is shown at regular time intervals. For each of the diagrams (7.1 to 7.5), write down whether the car is accelerating or moving with constant velocity. If accelerating, indicate the direction (right or left) of acceleration. Support your answer with reasoning.



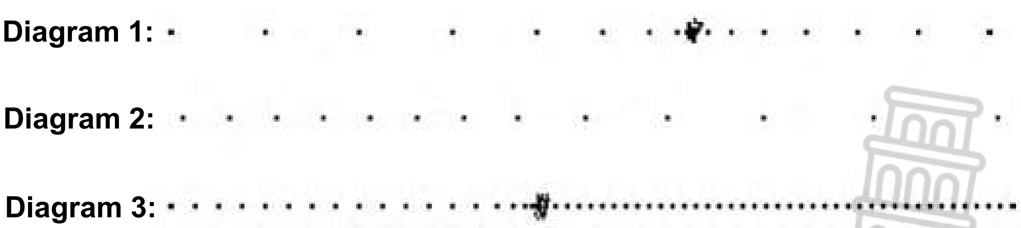
2. The diagram below shows the oil drop pattern left by two cars, **P** and **Q**, on a road.



Based on the oil drop pattern for the two cars, classify each of the following statements as TRUE or FALS.

A Both cars have a constant velocity.
B Both cars have an accelerated motion.
C Car **P** is accelerating; car **Q** is not.
D Car **Q** is accelerating; car **P** is not.
E Car **P** has a greater acceleration than car **Q**.
F Car **Q** has a greater acceleration than car **P**.

3. Puleng's car has an oil leak and leaves a trace of oil drops on the streets as she drives through Senekal. A study of Senekal's streets reveals the following traces.



Match the diagram (**1**, **2** or **3**) with the verbal descriptions (**3.1** to **3.3**) given below. For each match, verify your reasoning.

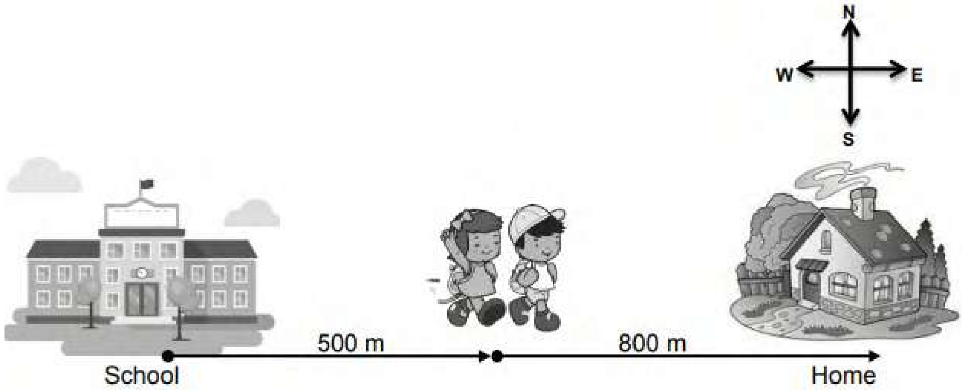
3.1 Puleng was driving at a slow constant speed and then decreased speed and came to rest. The car remained at rest for 30 seconds after which she then drove again at a slow constant speed.
3.2 Puleng decreased speed from a very high speed until the car came to rest. The car then accelerated until it reached a moderate speed.
3.3 Puleng drove at a moderate speed and then accelerated.

Activity 17.6: Homework/Classwork

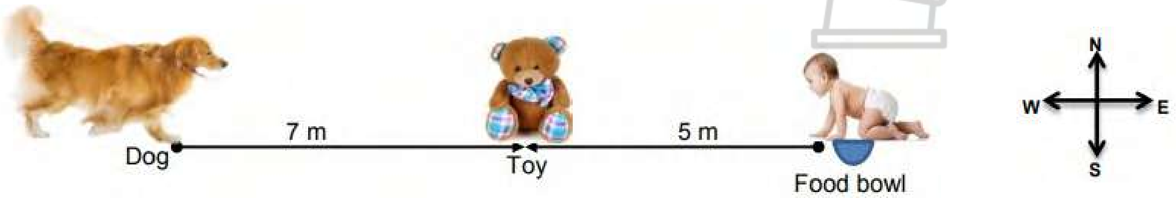
1. The speed of sound in air is about 330 $m \cdot s^{-1}$. A lightning bolt strikes a tree that is 1,5 km away from you.
   1.1 Calculate the time from the moment that you see the lightning flash until you hear the thunder that accompanies it.
   1.2 Give a reason why you see the lightning flash before you hear the thunder.
2. A car accelerates from rest to 90 $km \cdot h^{-1}$ in 8,8 s. Calculate the average acceleration of the car in $m \cdot s^{-2}$.
3. A jet aircraft landing on an aircraft carrier is brought to a complete stop in 2,7 seconds from a velocity of 215 $km \cdot h^{-1}$. Calculate the average acceleration in $m \cdot s^{-2}$.
4. A certain car accelerates constantly at 2,4 $m \cdot s^{-2}$. If it starts from rest, how long (in seconds) will the car require to obtain a velocity of 90 $km \cdot h^{-1}$?
5. A car starts from rest and accelerates at 2 $m \cdot s^{-2}$ for 3 seconds. Calculate the car's velocity at t = 3 s.
6. A bicyclist travels at an average velocity of 15 $km \cdot h^{-1}$ north for 20 minutes. Calculate his displacement during this time.
7. A car moves 20 km east and then 60 km west in 2 hours. Calculate its average velocity.
8. A car moves at 20 $m \cdot s^{-1}$ for 15 minutes. Calculate the distance travelled.

Activity 17.7: Homework/Classwork

1. A brother and sister walk home from school. After walking 500 m eastwards, the brother realises that he has left a book at school, and he returns to school. His sister continues walking another 800 m to their home. She arrives home 30 minutes after leaving school.



   1.1 Define the term *average speed*.
   1.2 Calculate the average speed of the girl from the school to her home.
   1.3 Use a vector scale diagram and represent the displacement of the boy from the time he realised he left his book at school until he reached home. Include ALL relevant information in the diagram. Use scale 1 cm = 100 m for the diagram.
   1.4 If the average speed of the boy is the same as that of the girl, calculate how long it would take the boy to reach home from the time they both left the school together.
2. A baby leaves a bowl of food on the floor and crawls westwards to fetch a toy placed 5 m away. At the same time a dog walks eastwards towards the baby. It takes the baby 30 s to reach the toy. The dog walks past the toy to eat the baby's food in the bowl.



   2.1 Define the term *displacement* in words.
   2.2 Determine the position of the dog relative to the baby before they both moved.
   2.3 Calculate the average velocity of the baby.
   2.4 If the average speed of the dog is TWICE that of the baby, calculate how long it would take the dog to reach the food bowl from the moment the dog started moving.

Experiment 17: Measurement of average velocity

Aim: To determine the average velocity of a moving object

Apparatus
Ball
Measuring tape
Stopwatch

Method
1. Allow a ball to roll in a straight line across the floor from one marked point to another.
2. Use the stopwatch to measure the time it takes the ball to roll from the one point to the other.
3. Measure the distance between the two points.
4. Record the results.

Results
Redraw the table below in your workbook, record the measured data and calculate the average velocity.

Distance between two points (m)	
Time (s)	
Average speed ($m \cdot s^{-1}$)	

Questions
1. Explain the difference between:
   1.1 Distance and displacement
   1.2 Speed and velocity
2. Which ONE of the following represents the car that moves at a higher average speed?
   A: A car that travels 150 km in 3 hours
   B: A car that travels 40 km in 0,5 hours
   C: A car that travels 250 km in 8 hours
3. In the 2008 Olympics, Jamaican Usain Bolt became the fastest man in history by winning a Gold Medal for running the 100 m dash in a World Record time of 9,69 s (*while seemingly not even trying for the last 15 meters!).*
   3.1 What was his average speed (in $m \cdot s^{-1}$) during this race?
   3.2 Several days later Bolt also won Gold and broke another World Record in the 200 m dash with a time of 19,30 s. In which race did he have a higher average speed?

Experiment 18: Uniform velocity

Aim: To investigate the uniform velocity of a moving trolley.

Apparatus
Ticker timer
Ticker tape
Power source
Trolley
Trolley track

Method
1. Attach a long strip of paper tape to the trolley and pass the tape through the ticker timer.
2. Connect the ticker timer to the power source.
3. Raise the one end of the runway sufficiently so that the trolley moves down the runway at constant speed. (This adjustment which compensates for friction is most important for the success of this investigation.)
4. Cut off the beginning and end portions of the tape where the motion was not uniform and keep only the portion of the tape where the dots are evenly spaced.
5. Measure the length of the tape and count the number of spaces. Record the results in Table 1.
6. Now mark the tape in lengths of 10 spaces (0,20 s if the frequency of the timer is 50 Hz) each. Measure the displacement (from the first chosen dot) for successive time intervals, i.e. for t = 5 time intervals, displacement = the total length of tape for 50 spaces. For each 10 space interval, calculate the *average velocity* during that interval by dividing the length of the interval (10 spaces), in meters, by 0,20 s (the time for 10 spaces). Record all results in Table 2.

Results
1. Copy Table 1 into your workbook. Record the length of the tape as well as the number of spaces as determined in step 5 of the method. The frequency of the ticker timer depends on the power source used. If connected to 220 V AC, the frequency is 50 Hz.

TABLE 1	
Length of tape (x) m	
No. of spaces (*n*)	
Frequency of timer (f)	50 Hz
Period of timer (T)	
Total time (*n* x T)	
Average velocity ($\frac{\Delta x}{\Delta t}$)	

2. Copy Table 2 into your practical book and then complete the open cells.

TABLE 2				
1 Time t (s)	2 Δt (s)	3 Displacement (m)	4 Δx (m)	5 $\Delta v = \frac{\Delta x}{\Delta t}$ ($m \cdot s^{-1}$)
0	0,20			
0,20	0,20			
0,40	0,20			
0,60	0,20			
0,80	0,20			
1,00	0,20			
1,20	0,20			
1,40	0,20			

Conclusion and questions

1. What is the main reason for failure when performing this experiment? How can you try to compensate for that?
2. What is the meaning of the phrase *frequency of the timer*?
3. What is the meaning of the *period* of the timer?
4. Is it necessary to use the whole length of the tape for your calculations? Explain.
5. Show by a calculation that the time for one interval is 0,2 s.
6. Plot a graph of displacement versus time on a graph paper. What is the shape of the graph?
7. What do you conclude from this regarding the relationship between x and t?
8. Calculate the gradient of the graph ($\frac{\Delta x}{\Delta t}$) in $m \cdot s^{-1}$.
9. How do these results compare with the answers obtained in column 5 of Table 2?
10. What does the gradient of a displacement versus time graph represent?
11. Plot a graph of velocity vs. time. What is the shape of the graph?
12. Draw a perpendicular from the end of the graph to the time axes. Calculate the area enclosed by the graph, the perpendicular and the two axes.
    How does this compare with the total displacement during the same time?
13. What does the area under a velocity versus time graph represent?
14. What is the magnitude of the gradient of this graph?
15. How does this compare with the acceleration or the object?
16. What does the gradient of a velocity versus time graph represent?

Topic 18: Instantaneous speed & velocity and the equations of motion

Instantaneous speed
Magnitude of instantaneous velocity

Instantaneous velocity
Displacement divided by an infinitesimal (very small) time interval

Speed, velocity, graphs & equations of motion

Equations of motion

$v_f = v_i + a\Delta t$ $\quad$ $\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$

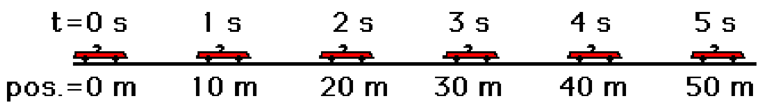
$v_f^2 = v_i^2 + 2a\Delta x$ $\quad$ $\Delta x = \left(\frac{v_f + v_i}{2}\right)\Delta t$

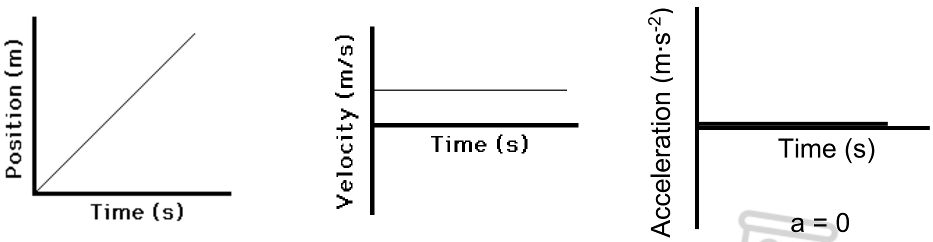
v_f: final velocity in $m \cdot s^{-1}$ (vector)
v_i: initial velocity in $m \cdot s^{-1}$ (vector)
a: acceleration in $m \cdot s^{-2}$ (vector)
Δt: time interval in s (scalar)
$\Delta x/\Delta y$: displacement in m (vector)

Diagrams & graphs

Uniform (constant) motion

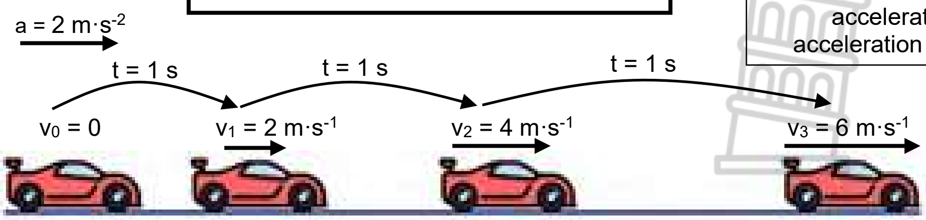
Equal distances travelled in equal time intervals.
Velocity is constant
Acceleration = 0

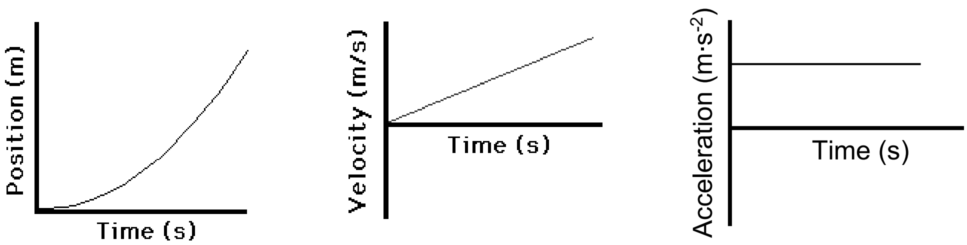




Uniform accelerated motion

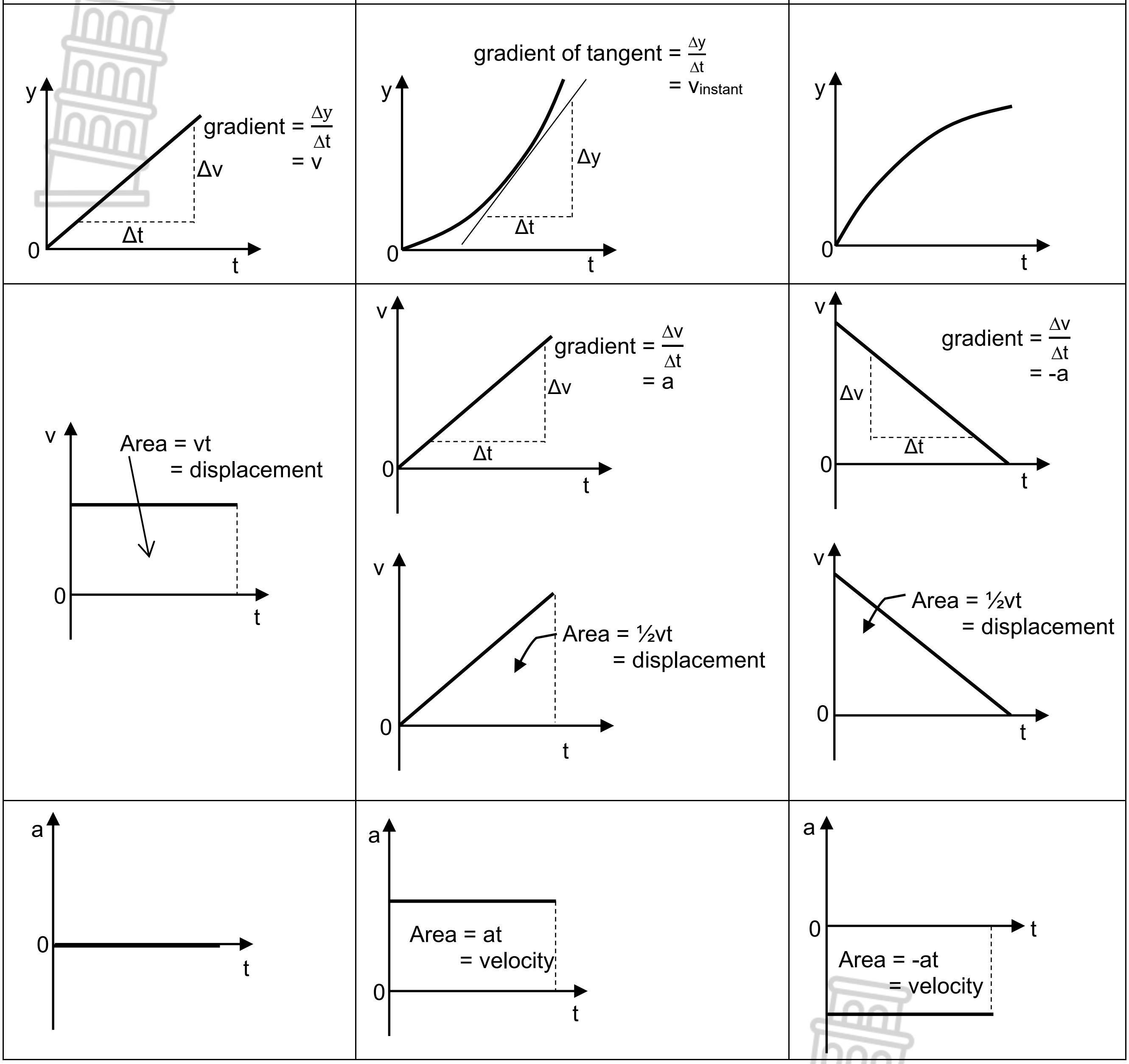
Equal INCREASE in velocity in each time interval.
acceleration ≠ 0
acceleration is constant





SUMMARY OF GRAPHS OF MOTION

Constant velocity	Constant positive acceleration	Constant negative acceleration

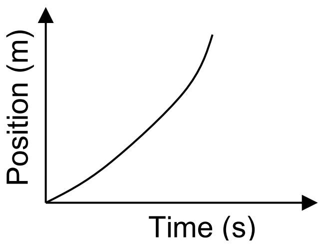


CONCEPTS AND DEFINITIONS	
Acceleration	The rate of change of velocity.
Average speed	The distance covered per time interval.
Average velocity	The displacement per time interval.
Displacement	The change in position of an object from a point of reference. (Length and direction of the straight line drawn from the beginning to the endpoint.)
Distance	The total path length travelled by an object.
Frame of reference	The reference point (origin) and a set of axes with set directions from which position or motion can be measured.
Gradient of a graph	The slope of a graph – how steep the graph is. Gradient = $\frac{\Delta x}{\Delta y}$
Instantaneous speed	The distance divided by a very short time interval.

CONCEPTS AND DEFINITIONS	
Instantaneous velocity	The displacement divided by a very short time interval.
Motion in one dimension	Motion of an object in one direction (in a straight line).
Position	The place occupied by an object - a measurement of a location with reference to an origin.
Speed	The rate of change of distance.
Velocity	The rate of change of position.

Activity 18.1: Homework/Classwork

1. Which one of the following is not a vector quantity?
   A Velocity B Acceleration
   C Time D Displacement
2. Which ONE of the following can be used to calculate the velocity from a displacement versus time graph?
   A Area under the graph B Gradient of the graph
   C Addition of all values given on graph
3. Moving from rest implies:
   A A final velocity of zero B An initial velocity of zero
   C No acceleration
4. A car moves at an initial velocity of 40 $m \cdot s^{-1}$. It then accelerates until it reaches a velocity of 55 $m \cdot s^{-1}$. It takes the car 15 s to reach this new velocity. Calculate the acceleration of the car.
5. Thabo is cycling at 20 $m \cdot s^{-1}$ when he sees a hole in the road. He applies brakes and stops after 4 s. Calculate his acceleration.
6. Draw the velocity time graph for the motion described below:
   A lift accelerates from rest for 2 s and then moves at a constant velocity for 5 s before it slows down and comes to a standstill in 2 s.
7. Describe the motion of the objects depicted by the graphs given below. In your description, include such information as the direction of the velocity vector (i.e., positive or negative), whether there is a constant velocity or an acceleration, and whether the object is moving slow, fast, from slow to fast or from fast to slow. Be complete in your description.

7.1


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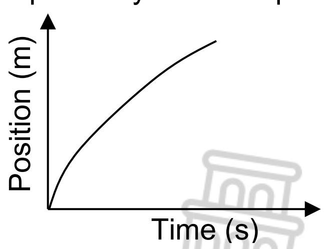

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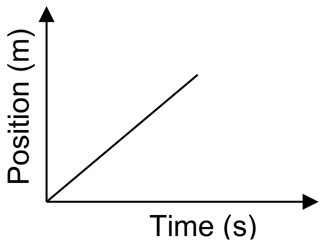

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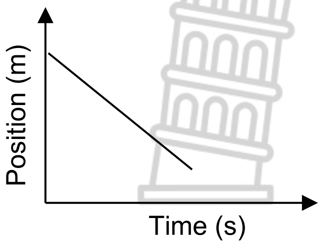

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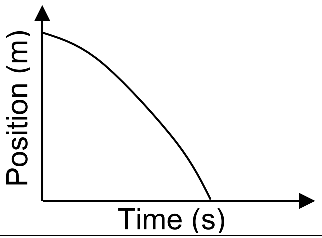

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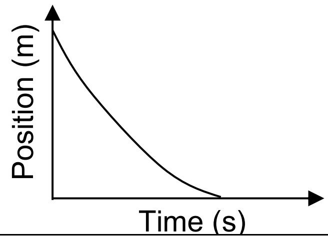
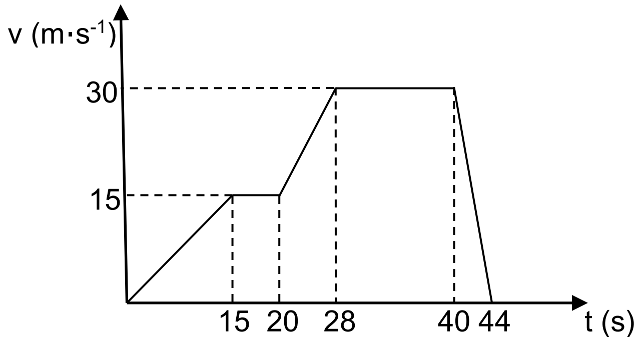


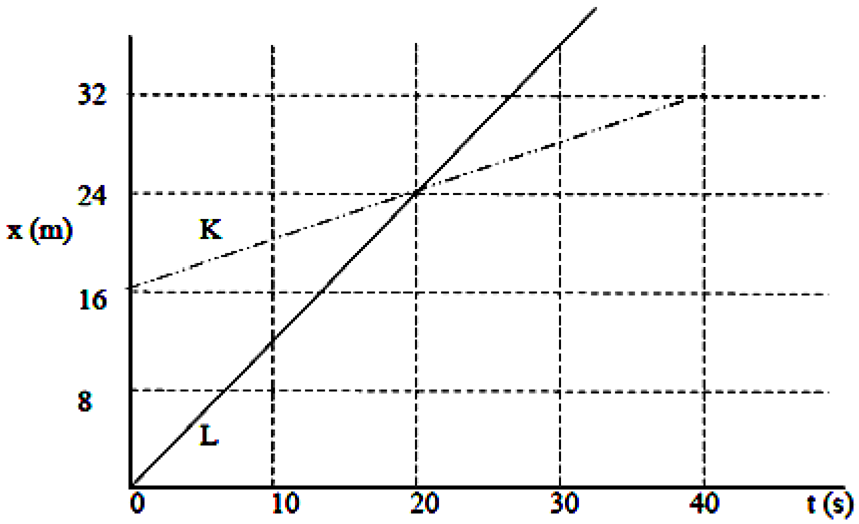
Activity 18.2: Homework/Classwork

1. The following graph represents the motion of a train.



1.1 Describe the motion of the train.
1.2 Calculate the acceleration of the train between 20 and 28 s.
1.3 Calculate the distance travelled in the 44 s.
1.4 Draw an acceleration time graph from this velocity time graph.

2. The position – time graph below represents the motion of two cars, **K** and **L**. The position of each car was marked at the instant t = 0 s.



2.1 Identify the car with the greatest velocity.
2.2 How far apart are the two cars at t = 0 s?

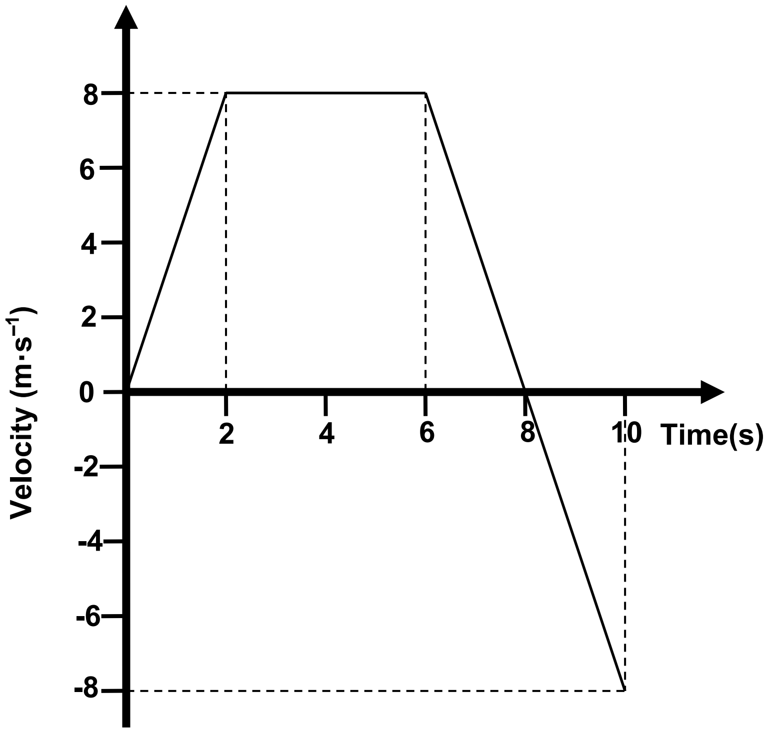
3. The following table provides the displacement of a car during a period of 10 seconds. Initially, the car moves in a northerly direction.

Time (s)	Displacement (m)
0	0
2	14
4	28
6	28
8	20
10	12

3.1 Draw an accurate displacement-time graph to represent the motion of the car.
3.2 Use the graph to determine the velocity of the car after 3 seconds.
3.3 What was the car's velocity after 5 seconds? Justify your answer.
3.4 Use the graph to determine the car's velocity after 9 seconds.
3.5 In words, describe the motion of the car during the 10 seconds.

Activity 18.3: Homework/Classwork

1. Study the velocity-time graph for the motion of an object in a straight line. Initially the object moves in an easterly direction.



1.1 Describe the motion of the object in words. Refer to the magnitude and the direction of the velocity, in your description.

1.2 Use the graph to determine the acceleration of the object over the following periods:

1.2.1 Between 0 and 2 s

1.2.2 Between the 2nd and 6th second

1.2.3 In the 8th second

1.3 Determine the total displacement of the object.

1.4 Determine the total distance covered by the object.

2. A car accelerates uniformly in 12 s from 10 m·s^{-1} to a speed of 18 m·s^{-1}. Calculate the distance travelled by the car while it is accelerating.

3. An aeroplane with a velocity of 45 m·s^{-1} comes into land at the start of the runway and brakes at - 5 m·s^{-1}. Will it be able to stop in time if the runway is 275 m long? Use the necessary calculations to explain our answer.

4. A motorcycle moving at 30 m·s^{-1} due west on a straight road, brakes and comes to a standstill after 6 s. Calculate the acceleration of the motorcycle.

5. Sipho is cycling at 5 m·s^{-1} on a gravel road when he spots a bull 20 m ahead of him. It takes him 30 seconds before he starts to apply the brakes. If he stops after 3 minutes, will he stops before he collides with the bull?

Activity 18.4: Homework/Classwork

1. A car accelerates from rest at 2,5 m·s^{-2}.
   Calculate the:
   1.1 Distance covered after 10 s
   1.2 Velocity after 10 s
   1.3 Average velocity during the first 10 s
   1.4 Distance covered when the car reaches a velocity of 33 m·s^{-1}

2. A train moves at 22 m·s^{-1}. The velocity of the train decreases to 12 m·s^{-1} over a distance of 500 m. Calculate the acceleration of the train.

3. A car moves at 33 m·s^{-1} on a straight road. The motorist sees an obstruction in the road and brings the car to a stop over a distance of 150 m. Calculate the:
   3.1 Acceleration of the car
   3.2 Time it takes the car to stop

4. The engineers at a car company conduct various tests on their cars. During one of the tests, they measure the change in position during equal time intervals. The results obtained are recorded in the table below.

TIME (s)	POSITION (m)
0	0
1	5
2	10
3	15
4	20

   4.1 Give the correct term for *change of position per unit time*.
   4.2 For this test, write down the:
   4.2.1 Independent variable
   4.2.2 Dependent variable
   4.3 Use the information in the table above and draw an accurate position-time graph on a graph paper.
   4.4 Calculate the gradient of the graph.
   4.5 Draw (NOT to scale) a corresponding velocity-time graph for the motion of the car. Label the axes.
   4.6 Hence, deduce the magnitude of the acceleration of the car.

Experiment 19: Uniform accelerated motion

Aim: To investigate the motion of a trolley running down an inclined plane.

Apparatus

Ticker timer
Ticker tape
Power source
Trolley
Trolley track

Method

1. Attach a long strip of paper tape to the trolley and pass the tape through the ticker timer.
2. Connect the ticker timer to the power source.
3. Raise the one end of the runway sufficiently so that the trolley moves down the runway at increasing speed.
4. Cut off the beginning and end portions of the tape where the dots cannot be clearly distinguished.
5. Mark the tape in lengths of 10 spaces (0,20 s if the frequency of the timer is 50 Hz) each. Measure the displacement (from the first chosen dot) for successive time intervals, i.e. for t = 5 time intervals, displacement = the total length of tape for 50 spaces. For each 10 space interval, calculate the *average velocity* during that interval by dividing the length of the interval (10 spaces), in meters, by 0,20 s (the time for 10 spaces). Record all results in the table.

Results

Copy the table below into your workbook.

Time ***t*** **(s)**	**Displacement** ***x*** **(m)**	**Change in displacement** Δx **(m)**	**Change in time** Δt **(s)**	$\bar{v} = \frac{\Delta x}{\Delta t}$ **(m·s⁻¹)**	Δv **(m·s⁻¹)**	$a = \frac{\Delta v}{\Delta t}$ **(m·s⁻²)**
0						
0,1						
0,2						
0,3						
0,4						
0,5						
0,6						
0,7						
0,8						
0,9						
1,0						

Conclusion and questions

1. **Displacement-time graph**
   1.1 Draw an accurate displacement-time graph for the motion of the trolley.
   1.2 What shape is the graph? What can you deduce from the shape concerning the velocity of the trolley?
2. **Velocity-time graph**
   2.1 Draw an accurate velocity-time graph for the motion of the trolley.
   2.2 What shape is the graph? What can you deduce from this?
   2.3 Use the velocity-time graph to determine the acceleration of the trolley. How does this value compare with the calculated value for acceleration in the table?
   2.4 Use the velocity-time graph to determine the displacement of the trolley after 3 s. How does this answer compare with the value of displacement after 3 s, as indicated in the table?
3. **Acceleration-time graph**
   Draw an accurate acceleration-time graph for the motion of the trolley.

Topic 19: Energy

Energy – Ability to do work

↓ one of many types of energy

Mechanical energy

Gravitational potential energy
$E_p = mgh$
E_p: gravitational potential energy in joule (J)
m: mass of object in kilogram (kg)
g: gravitational acceleration in $m \cdot s^{-2}$ ($g = 9{,}8\ m \cdot s^{-2}$)
h: vertical height above point of reference in meter (m)

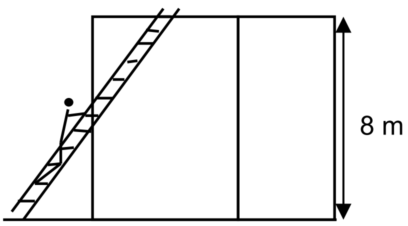
Kinetic energy
$E_k = \frac{1}{2}mv^2$
E_k: kinetic energy in joule (J)
m: mass of object in kilogram (kg)
v: speed of object in $m \cdot s^{-1}$

Principle of conservation of mechanical energy
$(E_p + E_k)_i = (E_p + E_k)_f$
$(mgh + \frac{1}{2}mv^2)_{initial} = (mgh + \frac{1}{2}mv^2)_{final}$

CONCEPTS AND DEFINITIONS	
Gravitational potential energy (E_P)	The energy that an object has due to its position in the earth's gravitational field relative to a reference point.
Isolated system	A system on which no external forces (e.g. friction) acts.
Kinetic energy (E_K)	The energy of an object due to of its motion.
Law of conservation of energy	Energy cannot be created or destroyed – it can only be transferred from one form to another.
Mechanical energy (E_m)	The sum of the gravitational potential energy and the kinetic energy of an object.
Principle of conservation of mechanical energy	The total mechanical energy in an isolated system remains constant.

Activity 19.1: Homework/Classwork

1. Define the following terms:
   1.1 Gravitational potential energy
   1.2 Kinetic energy
   1.3 Mechanical energy
2. A car of mass 1 000 kg and a truck of mass 40 000 kg are travelling side by side along a straight road at 30 $m \cdot s^{-1}$. Calculate the kinetic energy of the:
   2.1 Car
   2.2 Truck
3. State, in words, the:
   3.1 Law of conservation of energy
   3.2 Principle of conservation of mechanical energy
4. A 70 kg man climbs up a ladder to the top of a building which is 8 m high.



Calculate the potential energy of the man at the top of the building.

Activity 19.2: Homework/Classwork

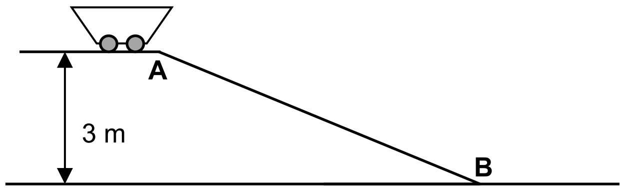
1. A stone with a mass of 4 kg has 627,2 J gravitational potential energy (E_p) when it is held at rest 16 m above the ground. When the stone is dropped all the potential energy (E_p) is converted to kinetic energy (E_k). Ignore the effect of air resistance.

   1.1 Complete the following table to show the energy change of the stone during the fall.

Height above the ground (m)	Potential energy (E_p in J)	Kinetic energy (E_k in J)	Mechanical energy ($E_p + E_k$ in J)
16	627,2 J		
12			
8		313,6 J	
4			
0			

   1.2 Calculate the speed at which the stone strikes the ground.
   1.3 Calculate the height above the ground when the stone has a kinetic energy of 392 J.

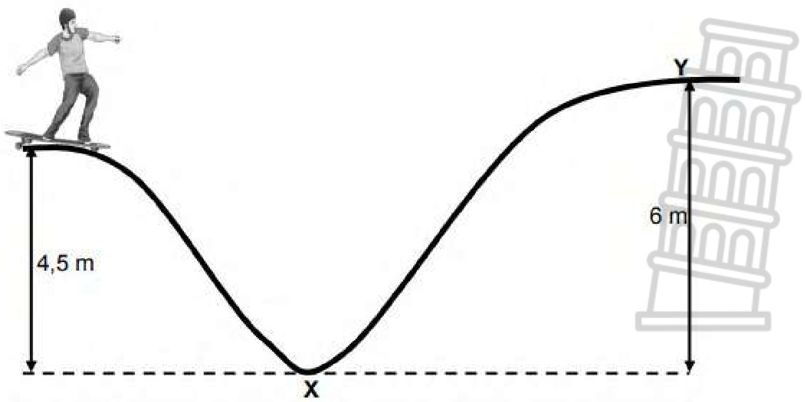
2. A cart of mass 20 kg is hoisted 3 m to the top of a ramp. It is then allowed to run freely from rest down the slope. Ignore the effects of friction.



   2.1 Calculate the total mechanical energy of the cart at position **A**.
   2.2 Write down its mechanical energy at position **B**.
   2.2 Calculate its kinetic energy at position **B**.
   2.3 Calculate its speed at position **B**.

Activity 19.3: Homework/Classwork

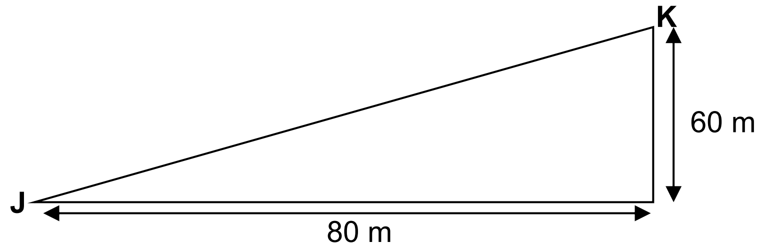
A skateboarder, starting from the top of a ramp 4,5 m above the ground, skates down the ramp, as shown in the diagram below. The mass of the skateboarder and his board is 65 kg. Ignore the effects of friction.



1. Define the term *gravitational potential energy* in words.
2. Calculate the gravitational potential energy of the skater just before he skates down the ramp.
3. State the principle of conservation of mechanical energy in words.
4. Use the principle stated in QUESTION 3 to calculate the magnitude of the velocity of the skateboarder when he reaches the ground at point **X**.
5. Will the skateboarder be able to reach point **Y** if he were to remain on his skateboard? Write YES or NO and support the answer with a relevant calculation.

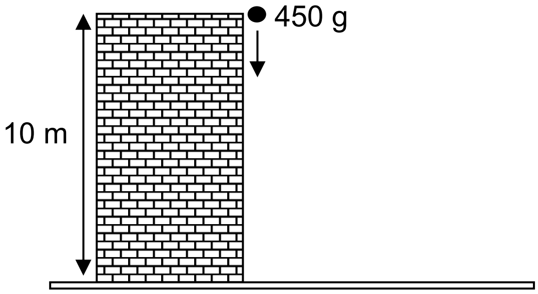
Activity 19.4: Homework/Classwork

1. A car of mass 1 200 kg moves up a hill of height 60 m. Ignore the effect of frictional forces.



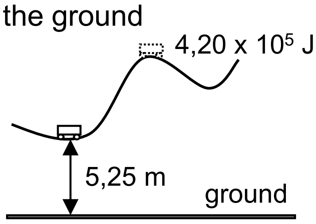
1.1 Calculate the:
   1.1.1 Distance that the car moves uphill along slope **JK**
   1.1.2 Potential energy of the car at **K**
   1.1.3 Work done by the car's engine to drive the car from **J** to **K**
1.2 If the car freewheels from rest from **K** to **J**, calculate its maximum kinetic energy at **J**.
1.3 Calculate the speed of the car **J**.

2. A ball of mass 450 g is dropped from a height of 10 m above the ground.

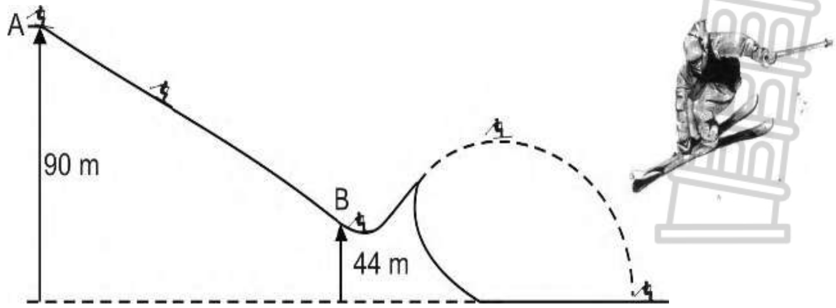


Calculate the:
2.1 Kinetic energy of the ball after it has fallen 5 m from the top of the building
2.2 Speed of the ball after falling 5 m from the top of the building.
2.3 Speed at which the ball strikes the ground
2.4 Total mechanical energy the moment when the ball strikes the ground

3. A roller coaster car begins its journey 5,25 m above the ground. As the motor tows it to the top of the first hill, it gains $4,20 \times 10^5$ J of gravitational potential energy. If the mass of the car and its passengers is 875 kg, calculate the height of the hill above the ground.



4. A ski jumper, with a mass of 70 kg, starts from rest at the top of a ski jump (**A**). On reaching the take-off point (**B**), his kinetic energy is 31,556 kJ. Ignore the effects of friction and air resistance.



4.1 Calculate the gravitational potential energy of the ski jumper at the top of the ski jump.
4.2 How much work was done by the ski jumper to reach the top of the ski jump?
4.3 How much kinetic energy does the ski jumper have at the top of the ski jump?
4.4 Calculate his gravitational potential energy at the take-off point.
4.5 Calculate his speed at the take-off point.
4.6 Determine the sum of E_p and E_k at position **A** as well as position **B**. What relationship is there between the sum of these two energies at positions **A** and **B**?

QUESTION PAPERS FOR REVISION

EXAMPLE 1: PHYSICAL SCIENCES PAPER 1

MARKS: 100 **TIME: 2 hours**

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Each question has only ONE correct answer. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.10) in the ANSWER BOOK, e.g. 1.11 D.

1.1 An object is positively charged if it has more …

A electrons than protons.
B electrons than neutrons.
C protons than electrons.
D protons than neutrons. (2)

1.2 A car is travelling at a speed of 30 $m \cdot s^{-1}$ on a straight road. What would be the speed of the car in $km \cdot h^{-1}$?

A 8,33 $km \cdot h^{-1}$
B 30 $km \cdot h^{-1}$
C 108 $km \cdot h^{-1}$
D 130 $km \cdot h^{-1}$ (2)

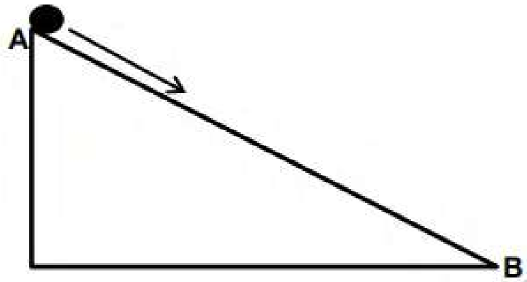
1.3 The UNIT in which the rate of flow of charge is measured, is called …

A ampere.
B coulomb.
C volt.
D watt. (2)

1.4 The gradient of a velocity versus time graph is equivalent to the …

A acceleration.
B displacement.
C position.
D total distance covered. (2)

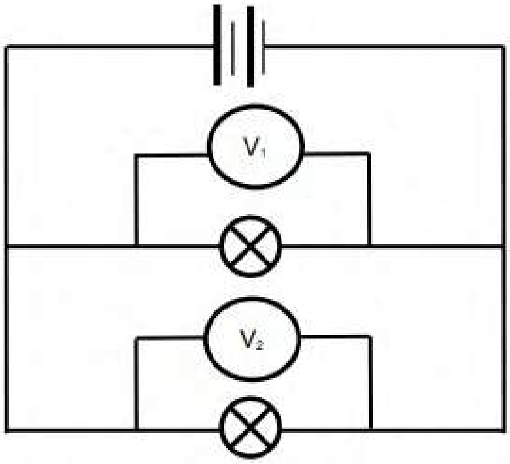
1.5 An object is released from the top of a frictionless inclined plane, **AB**, as shown below.



Which ONE of the following statements regarding the total mechanical energy of the object is CORRECT?

A $(E_p + E_k)_A > (E_p + E_k)_B$
B $(E_p + E_k)_A < (E_p + E_k)_B$
C $(E_p + E_k)_A = (E_p + E_k)_B$
D $(E_p + E_k)_A = -(E_p + E_k)_B$ (2)

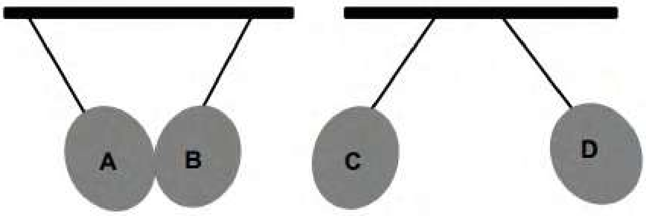
1.6 Two identical light bulbs are connected in parallel, as shown in the circuit diagram below. Voltmeters V_1 and V_2 are connected across each light bulb.



Which ONE of the following voltmeter readings is CORRECT?

A $V_1 = V_2$
B $V_1 = 2V_2$
C $V_1 = ½V_2$
D $V_1 = ¼V_2$ (2)

1.7 Four identical balloons, each carrying a charge, are suspended from a ceiling, as shown in the diagram below.



Balloon **B** is negatively charged. Which combination is CORRECT regarding the charges on the balloons?

	SIGN OF CHARGE ON A	SIGN OF CHARGE ON C	SIGN OF CHARGE ON D
A	–	+	–
B	+	+	+
C	–	–	–
D	+	+	–

(2)

1.8 Two cyclists are cycling in opposite directions along the side line of a rectangular field. It is observed that they covered the same distance over a time interval of 3 s. Which ONE of the following physical quantities is the SAME regarding the cyclists over the interval of 3 s?

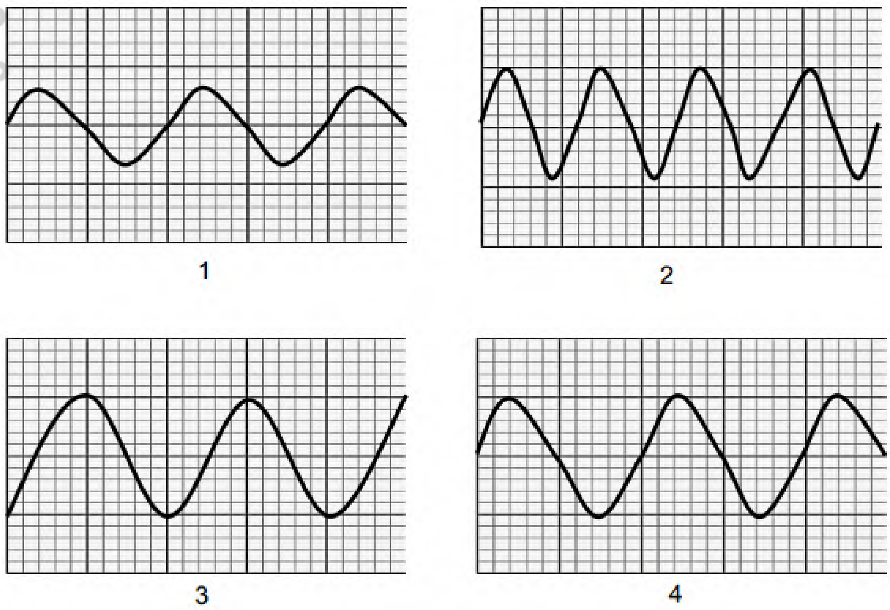
A Acceleration
B Average speed
C Average velocity
D Displacement (2)

1.9 Red light of frequency f and wavelength λ shines on an object. The red light is then replaced by light of a higher energy. How do the frequency and the wavelength of light shining on the object now compare with that of red light?

	FREQUENCY	WAVELENGTH
A	Greater than f	Remains the same (λ)
B	Less than f	Greater than λ
C	Greater than f	Less than λ
D	Remains the same (f)	Less than λ

(2)

1.10 Study the following wave patterns:



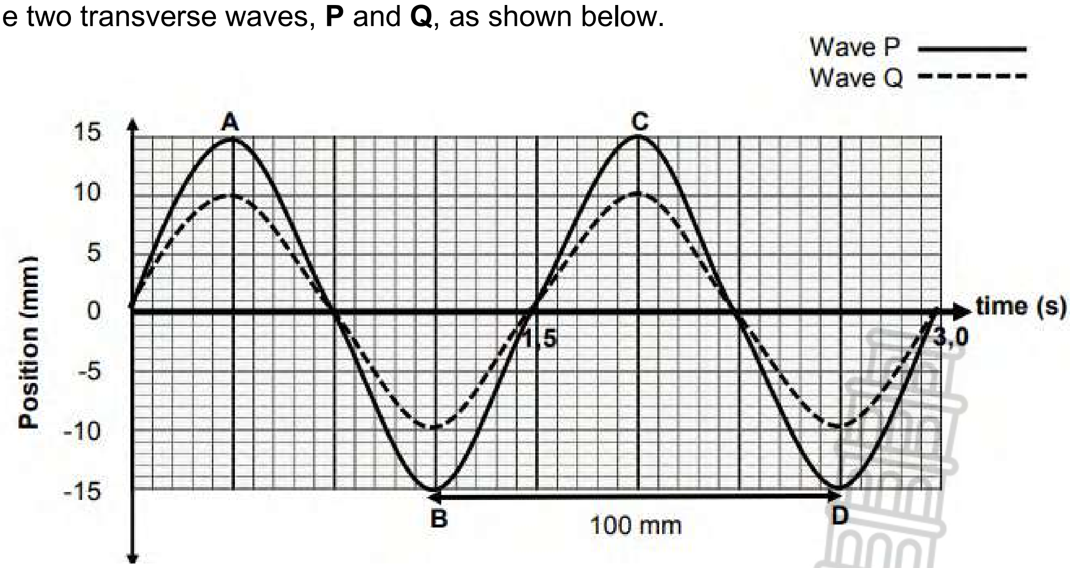
Which COMBINATION is the CORRECT representation of the wave patterns with the same pitch?

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

[20]

QUESTION 2 (Start on a new page.)

Study the two transverse waves, **P** and **Q**, as shown below.



2.1 Write down ONE difference and ONE similarity between wave **P** and wave **Q**. (2)

2.2 For wave pattern **P**, write down:

2.2.1 Two points that are out of phase (1)

2.2.2 The amplitude of the wave (1)

2.3 Define the term *frequency of the wave* in words. (2)

2.4 For wave pattern **Q**, calculate the:

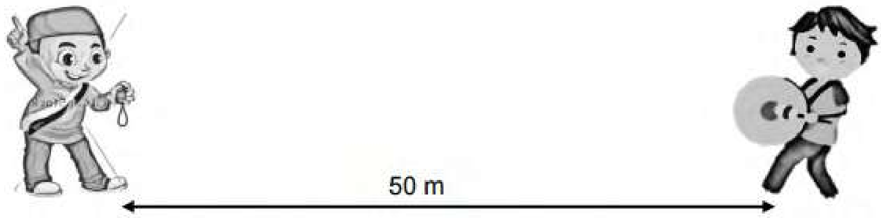
2.4.1 Frequency of the wave (3)

2.4.2 Speed of the wave (3)

[12]

QUESTION 3 (Start on a new page.)

Experiments were done to investigate the effect of temperature on the speed of sound. One person beat a drum while another person, who was standing 50 m away from the sound source, recorded the time travelled by the sound.



They performed the experiment at different temperatures at different times of the day. They recorded their findings in the table below.

TEMPERATURE (°C)	TIME (s)
0	0,151
5	0,150
10	0,148
15	0,147
20	0,146
25	0,145

3.1 For the investigation, write down the:

3.1.1 Independent variable (1)

3.1.2 Dependent variable (1)

3.2 Calculate the speed of sound at 20 °C. (3)

3.3 Write down a conclusion for the investigation. (2)

The person who beat the drum, noticed that the sound reflected after a while.

3.4 Name the term used to describe the reflection of sound waves. (1)

[8]

QUESTION 4 (Start on a new page.)

The types of electromagnetic radiation are arranged according to frequency in the table below.

TYPE OF RADIATION	FREQUENCY (Hz)
Radio waves	10^5 - 10^{10}
Microwaves	10^{10} – 10^{11}
Infrared	10^{11} - 10^{14}
Visible light	10^{14} - 10^{15}
Ultraviolet	10^{15} - 10^{16}
X-rays	10^{16} - 10^{18}
Gamma rays	10^{18} – 10^{21}

4.1 How are electromagnetic waves generated? (1)

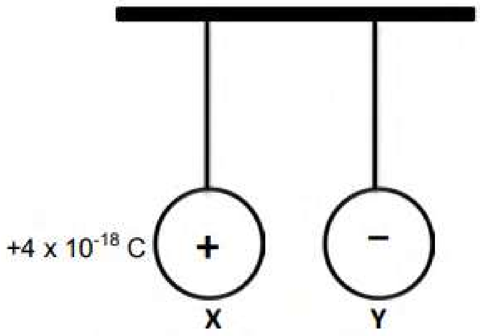
4.2 What type of electromagnetic radiation has the highest energy? (1)

4.3 Give a reason for the answer to QUESTION 4.2. (1)

4.4 A certain type of electromagnetic radiation has a wavelength of 600×10^{-10} m. Identify the type of electromagnetic radiation by performing a calculation. (4)

[7]

QUESTION 5 (Start on a new page.)
Two identical insulated spheres, **X** and **Y**, suspended by threads from a ceiling, are held at a small distance apart, as shown in the diagram below.



Sphere **X** carries a charge of + 4 x 10^{-18} C, while sphere **Y** has an excess of 30 electrons.

5.1 Calculate the magnitude of the charge on sphere **Y**. (2)

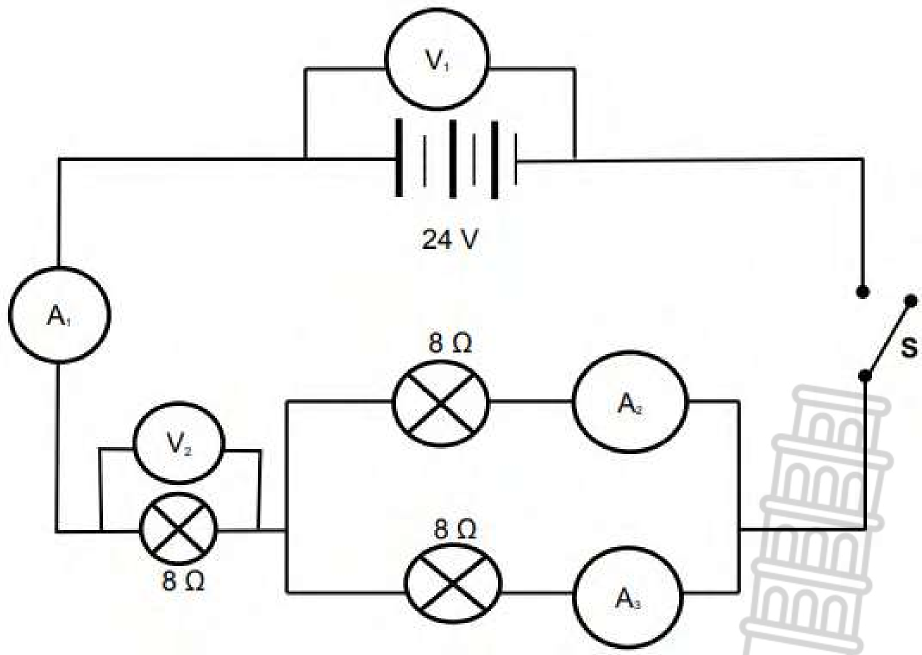
The spheres are now released and they move towards each other.

5.2 Give a reason why spheres **X** and **Y** move towards each other. (1)

The spheres are allowed to touch each other. After touching, they move away from each other.

5.3 State the *principle of conservation of charge* in words. (2)
5.4 Calculate the charge on each sphere after they have separated. (3)
[8]

QUESTION 6 (Start on a new page.)
6.1 Consider the circuit diagram below.



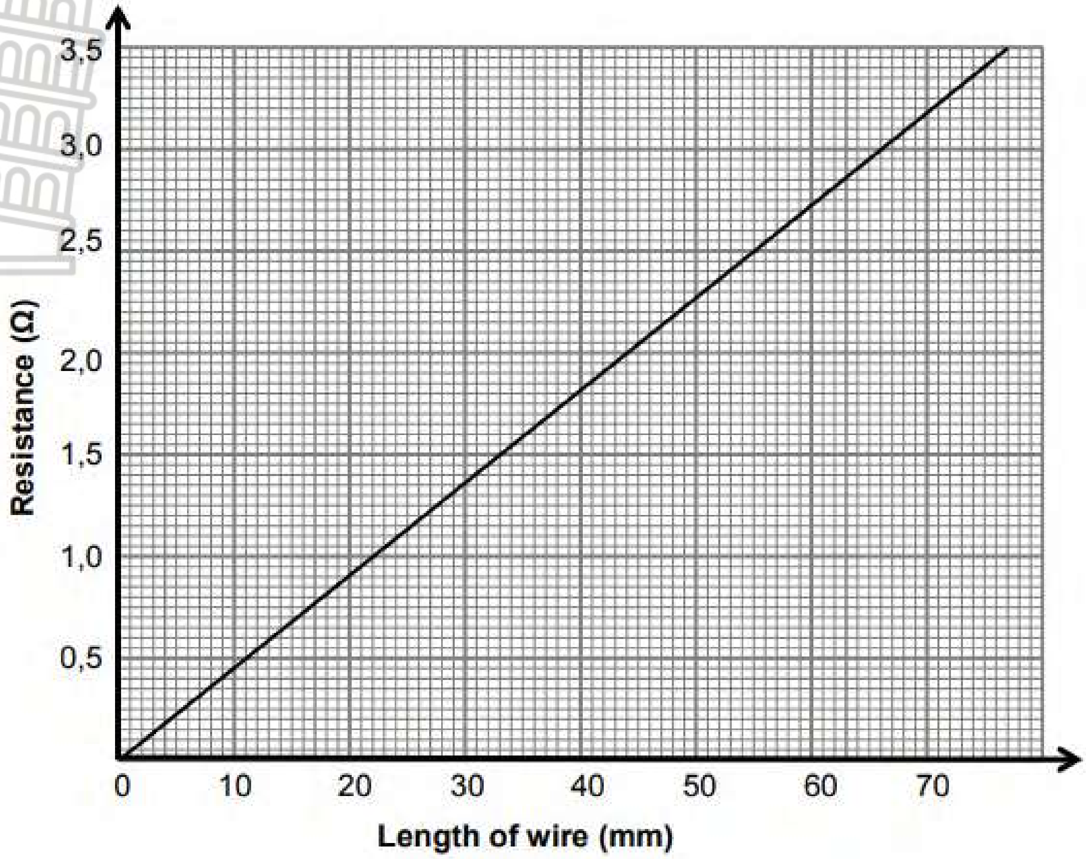
Switch **S** is OPEN.

6.1.1 Write down the reading on the following:
(a) Voltmeter (V_1) (1)
(b) Ammeter (A_1) (1)

Switch **S** is now CLOSED.

6.1.2 Calculate the equivalent resistance of the circuit. (3)
6.1.3 Calculate the reading on voltmeter V_2. (3)
6.1.4 How do the readings on ammeters A_2 and A_3 compare with each other? (1)

6.2 The graph below shows the relationship between the resistance and the length of the conducting wire.



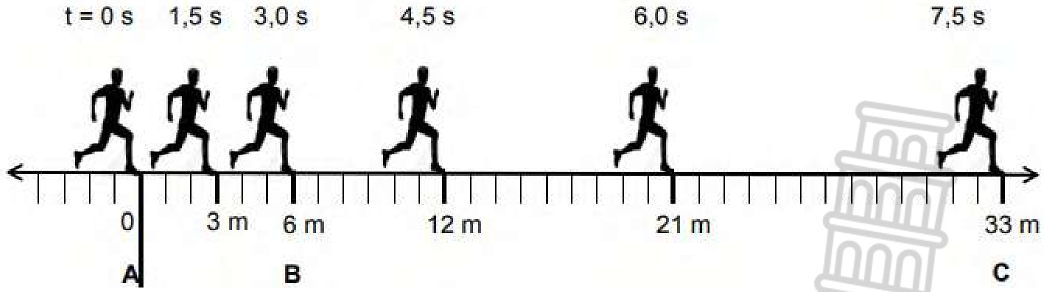
6.2.1 Write down the relationship between the resistance and the length of the conducting wire. (1)

6.2.2 Determine the resistance of wire with a length of 30 mm. (1)

[11]

QUESTION 7 (Start on a new page.)

The diagram below shows the positions of an athlete at different time intervals during a race.



7.1 Distinguish between motion with *uniform velocity* and *uniformly accelerated motion*. (2)

7.2 What type of motion (motion with uniform velocity or uniformly accelerated motion) is represented by the following intervals?

7.2.1 **A** to **B** (1)

7.2.2 **B** to **C** (1)

7.3 Use the information in the diagram above to draw an accurate position versus time graph on a graph paper. (5)

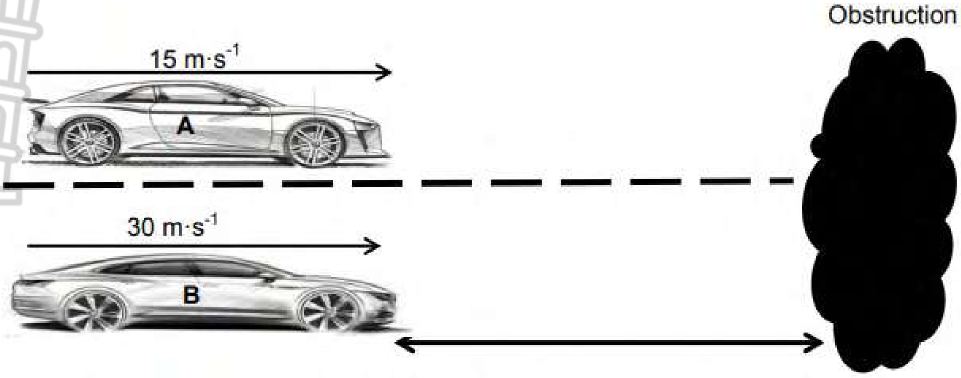
7.4 Define the term *instantaneous velocity* in words. (2)

7.5 On the graph drawn for QUESTION 7.3, show how you would determine the instantaneous velocity. (1)

7.6 Calculate the velocity of the athlete at 3 s. (4)

[16]

QUESTION 8 (Start on a new page.)
Two cars, **A** and **B**, are moving at speeds of 15 m·s^{-1} and 30 m·s^{-1} in the same direction. They are side by side when both drivers observe an obstruction ahead of them, as shown in the diagram below.



Both drivers apply their brakes and accelerate at –4,5 m·s^{-2} until both cars come to rest. Ignore the reaction time of the drivers.

8.1 Define the term *acceleration* in words. (2)

8.2 Calculate the:

8.2.1 Time it takes car **A** to come to rest (4)

8.2.2 Stopping distance of car **A** (4)

8.3 Which car (**A** or **B**) has the longer stopping distance? Support the answer with a calculation. (6)

8.4 What conclusion can be made about the relationship between speed and stopping distance? (2)

[18]

GRAND TOTAL: 100

EXAMPLE 2: PHYSICAL SCIENCES PAPER 1

MARKS: 100 **TIME: 2 hours**

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Each question has only ONE correct answer. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.10) in the ANSWER BOOK, e.g. 1.11 D.

1.1. Which ONE of the following is the correct definition for a transverse wave?

A The oscillations of a transverse wave are perpendicular to the direction in which the waves transfer energy.

B The oscillations of a transverse wave are parallel to the direction in which the waves transfer energy.

C The oscillations of a transverse wave are at 45° to the direction in which the waves transfer energy.

D The oscillations of a transverse wave are in the same direction in which the waves transfer energy. (2)

1.2 Sound waves cannot travel through…

A matter. B solids.

C vacuum. D a gas. (2)

1.3 The amplitude of a sound wave is increased without changing the frequency. How does this change affect the loudness and pitch of the sound?

	LOUDNESS	PITCH
A	Decreases	Decreases
B	Decreases	Increases
C	Increases	Unchanged
D	Increases	Increases

(2)

1.4 Two identical spheres, **X** and **Y**, on insulated stands, carry charges of 3 μC and -5 μC respectively. The spheres are brought into contact with each other and returned to their original positions. The charge on EACH sphere after contact is …

A 8 μC B -4 μC

C -2 μC D -1 μC (2)

1.5 The energy transferred per unit electric charge in a circuit is …

A current. B charge.

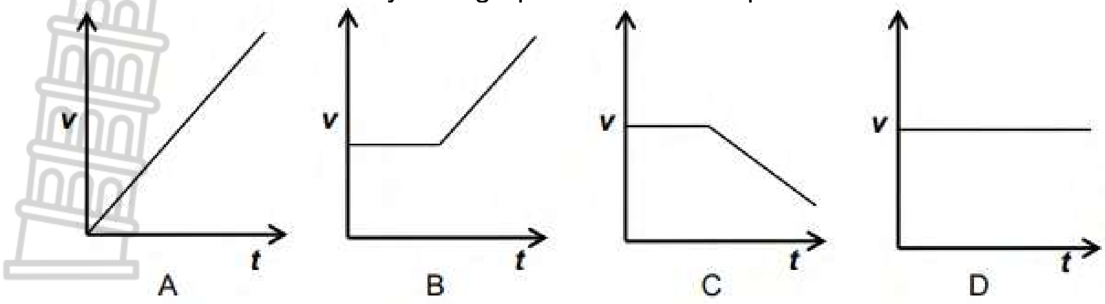
C power. D potential difference. (2)

1.6 Which ONE of the following pairs of physical quantities consists of one scalar and one vector quantity?

A Distance and speed B Speed and acceleration

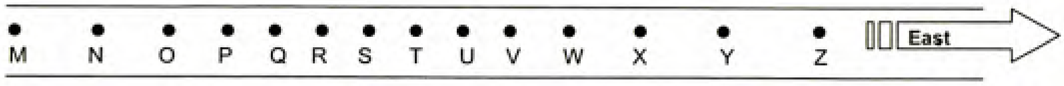
C Displacement and velocity D Velocity and acceleration (2)

1.7 A car is travelling at a constant velocity along a straight road. It then slows down uniformly. Which ONE of the velocity-time graphs below best represents the motion of the car?



(2)

1.8 Oil dripping from a truck at equal time intervals leaves the pattern below on the road.



If the truck is moving eastwards, which ONE of the combinations below best describes the speed of the truck during the intervals **M to Q**, **Q to V** and **V to Z**?

	M TO Q	Q TO V	V TO Z
A	Decreases	Remains constant	Increases
B	Increases	Remains constant	Decreases
C	Remains constant	Increases	Increases
D	Increases	Decreases	Remains constant

(2)

1.9 A motorbike moving at a speed *v*, has a kinetic energy *E*. If the speed of the motorbike increases to 3*v*, the kinetic energy will be …

A 3*E*
B $\frac{1}{3}E$
C 6*E*
D 9*E* (2)

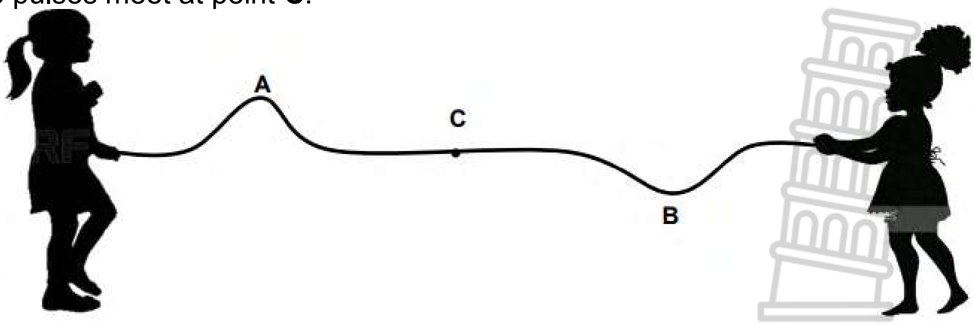
1.10 The SI unit for gravitational potential energy is …

A $kg{\cdot}m{\cdot}s^{-1}$
B $kg{\cdot}m{\cdot}s^{-2}$
C $kg{\cdot}m^{2}{\cdot}s^{-2}$
D $kg{\cdot}m^{-1}{\cdot}s^{-1}$ (2)

[20]

QUESTION 2 (Start on a new page.)

Two girls, standing at opposite ends of a rope, each makes a pulse of the same speed. Pulse **A**, with an amplitude of 4 cm, moves to the right and pulse **B**, with an amplitude of -6 cm, moves to the left. The pulses meet at point **C**.



2.1 Define the term *amplitude*. (2)
2.2 State the phenomenon observed when the two pulses meet at point **C**. (2)
2.3 Draw a labelled diagram to show the resultant pulse when the two pulses meet at point **C**. Label the pulses clearly. (3)
2.4 Name the type of interference that takes place when the pulses meet. (1)
2.5 Determine the resultant amplitude of the pulses at point **C**. (2)
2.6 How will the amplitude of pulse **A** be affected after passing point **C**? Write down only INCREASES, DECREASES or REMAINS THE SAME. (2)

[12]

QUESTION 3 (Start on a new page.)

A certain radio station emits radio waves with a frequency of 94,4 MHz. (1 MHz = 1 x 10^6 Hz).

3.1. Calculate the wavelength of these waves. (3)

3.2. Define the term *photon*. (2)

3.3 Calculate the energy of a photon of these waves. (3)

3.4. Explain in detail why radio stations use radio waves and not sound waves to transmit their music. (3)

[11]

QUESTION 4 (Start on a new page.)

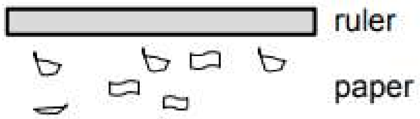
A neutral plastic ruler becomes charged when it is rubbed with a woollen cloth. After rubbing, the ruler has a charge of -3,5 x 10^{-15} C.

4.1 Distinguish between a *neutral object* and a *charged object*. (2)

4.2 Does the ruler GAIN or LOSE electrons? (1)

4.3 Calculate the number of electrons transferred during the process of rubbing. (3)

4.4 The charged ruler is now brought closer to pieces of paper. The pieces of paper are attracted to the ruler, as shown below.



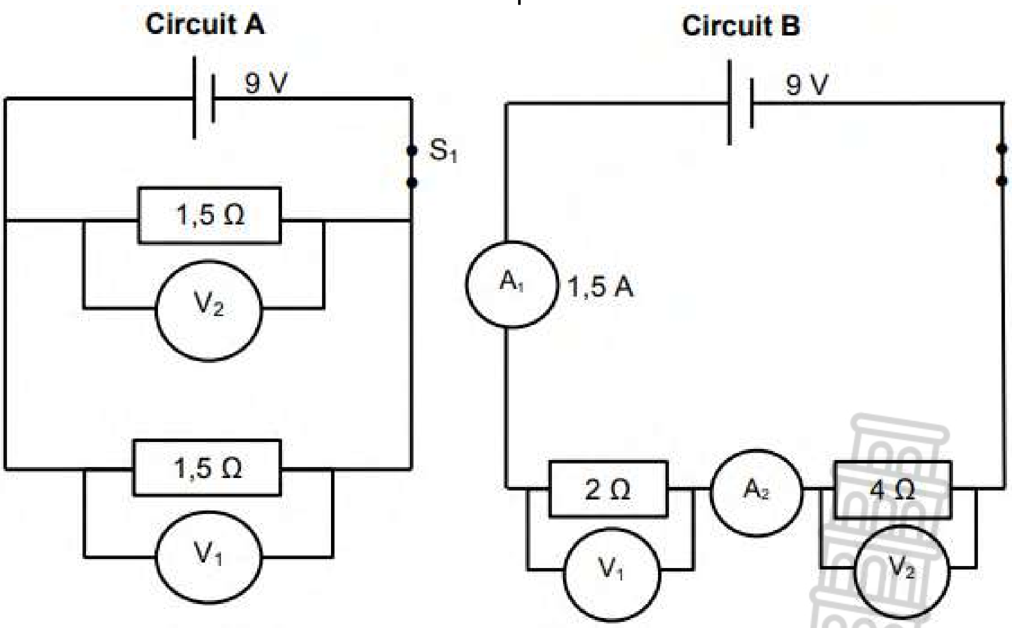
4.4.1 Explain why the pieces of paper are attracted to the ruler. (3)

4.4.2 Name ONE application of electrostatics in our daily lives. (1)

[10]

QUESTION 5 (Start on a new page.)

Refer to Circuits **A** and **B** below and answer the questions that follow.



5.1 Define the term *emf*. (2)

5.2 Calculate the total resistance of Circuit **A**. (2)

5.3 Consider Circuit **B**.

11.3.1 Write down the reading on A_2. (1)

11.3.2 Calculate the reading on V_1. (3)

5.4 If a third resistor (1,5 Ω) is placed in parallel with the existing resistors in Circuit **A**, would the total current in the circuit INCREASE, DECREASE or REMAIN THE SAME? Explain the answer. (3)

[11]

QUESTION 6 (Start on a new page.)

A car accelerates from rest at 15 m·s^{-2} for 2 s on a horizontal road.

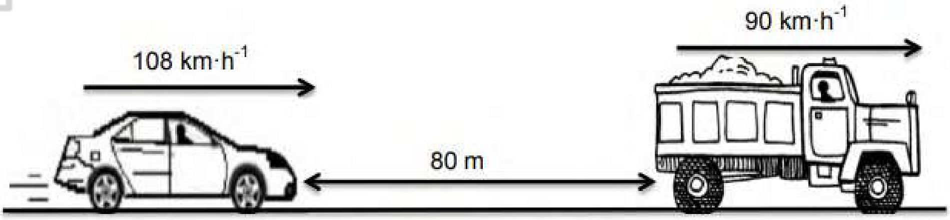
6.1 Define the term *acceleration*. (2)

6.2 Calculate the:

6.2.1 Distance covered by the car (3)

6.2.2 Velocity of the car (3)

While travelling at a constant velocity of 108 km·h^{-1}, the driver of a car notices a sign warning motorists to keep a safe 2-second following distance. At that instant the car is 80 m behind a truck that is travelling at a constant velocity of 90 km·h^{-1}.



6.3 Explain the meaning of a *safe 2-second following distance*. (2)

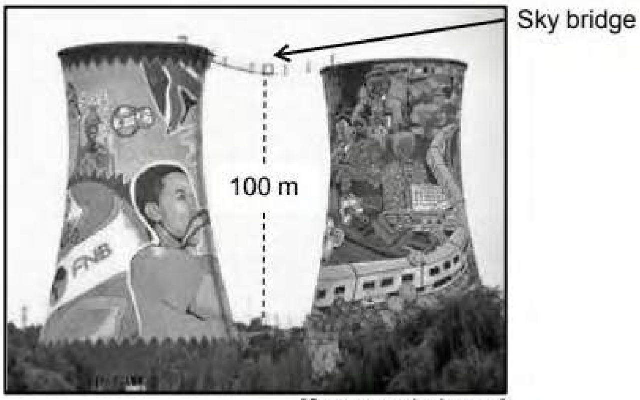
6.4 Calculate the safe 2-second following distance behind the truck. (6)

6.5 Calculate how long it will take the motorist to get to a safe 2-second following distance behind the truck. (5)

[21]

QUESTION 7 (Start on a new page.)

A lift takes a man to a sky bridge, which is 100 m above the ground, as shown below. He makes a bungee jump from the sky bridge. Ignore the effects of air resistance.



[Source: myjozi.co.za]

7.1 Define the term *kinetic energy*. (2)

7.2 The man and his gear have a mass of 72 kg. Calculate the gravitational potential energy of the man just before he jumps from the sky bridge. (3)

7.3 State the law of conservation of mechanical energy. (2)

7.4 Use the law in QUESTION 7.3 to calculate the velocity of the man at a height of 50 m above the ground. (5)

7.5 Draw a graph of E_p versus E_k for the motion of the man from the instant he jumps until he reaches the ground. (3)

[15]

GRAND TOTAL: 100

EXAMPLE 1: PHYSICAL SCIENCES PAPER 2

MARKS: 100 **TIME: 2 hours**

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Each question has only ONE correct answer. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.10) in the ANSWER BOOK, e.g. 1. 11 E.

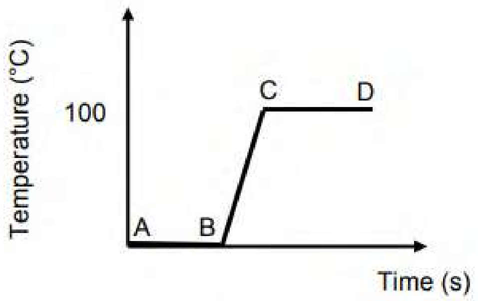
1.1 Which ONE of the following substances is NOT a pure substance?

A Iron
B Sugar
C Steel
D Graphite (2)

1.2 The CORRECT chemical formula for potassium nitrate is …

A K_3N
B PNO_3
C KNO_3
D K_2NO_3 (2)

1.3 The graph below shows the heating curve of a substance.



In which part(s) of the graph does the substance gain kinetic energy?

A BC only
B CD only
C AB and CD
D AB, BC and CD (2)

1.4 Different isotopes of the same element have different …

A atomic numbers.
B numbers of neutrons.
C numbers of protons.
D numbers of electrons. (2)

1.5 Which ONE of the following ionisation equations represents the second ionisation of magnesium?

A $Mg(g) + energy \rightarrow Mg^+ + e^-$
B $Mg^+(s) + energy \rightarrow Mg^{2+} + 2e^-$
C $Mg^+(g) + energy \rightarrow Mg^{2+} + 2e^-$
D $Mg(s) + energy \rightarrow Mg^+ + e^-$ (2)

1.6 Which PAIR of elements is most likely to have a similar arrangement of outer electrons and similar chemical behaviour?

A Boron and aluminium
B Helium and fluorine
C Carbon and nitrogen
D Chlorine and oxygen (2)

1.7 Which ONE of the following statements is INCORRECT about the properties of a physical change?

A When a physical change occurs, the compounds may rearrange themselves, but the bonds in between the atoms will not break.
B Physical change in matter is reversible.
C Energy is absorbed when matter changes from a solid to a liquid.
D Molecules are not conserved during a physical change. (2)

1.8 In the compound, H_2O, the ratio of the MASS of hydrogen to oxygen is always …

A 1 : 2. B 2 : 1.
C 1 : 8. D 1 : 16. (2)

1.9 One mole of H_2SO_4 contains …

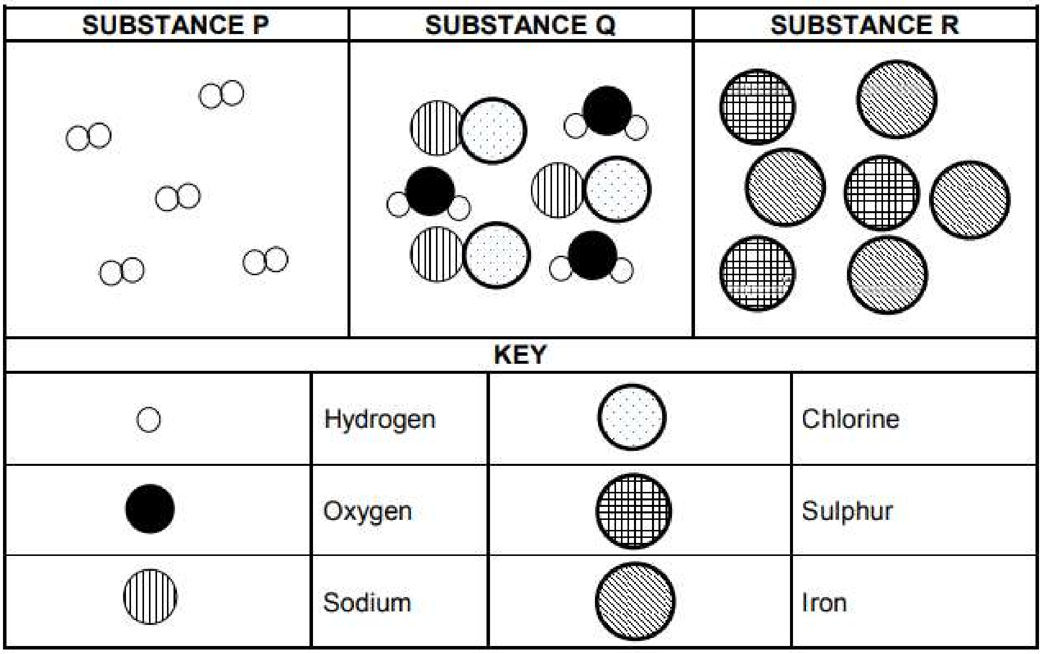
A 7 atoms. B 1 molecule.
C $6{,}02 \times 10^{23}$ molecules. D $42{,}14 \times 10^{23}$ molecules. (2)

1.10 A one $mol \cdot dm^{-3}$ solution contains one mole of a solute in …

A 1000 g of the solvent. B one litre of the solvent.
C one litre of the solution. D 22,4 litres of the solution. (2)
[20]

QUESTION 2 (Start on a new page.)

The diagram below shows three different substances, **P**, **Q** and **R**.



2.1 Define the term *element*. (2)

Use the diagram and the key provided to answer the questions that follow.

2.2 Write down a LETTER that represents the following:

2.2.1 Pure substance (1)
2.2.2 Mixture (1)
2.2.3 Element (1)

2.3 Indicate whether the pure substance identified in QUESTION 2.2.1 is an element or a compound. (1)

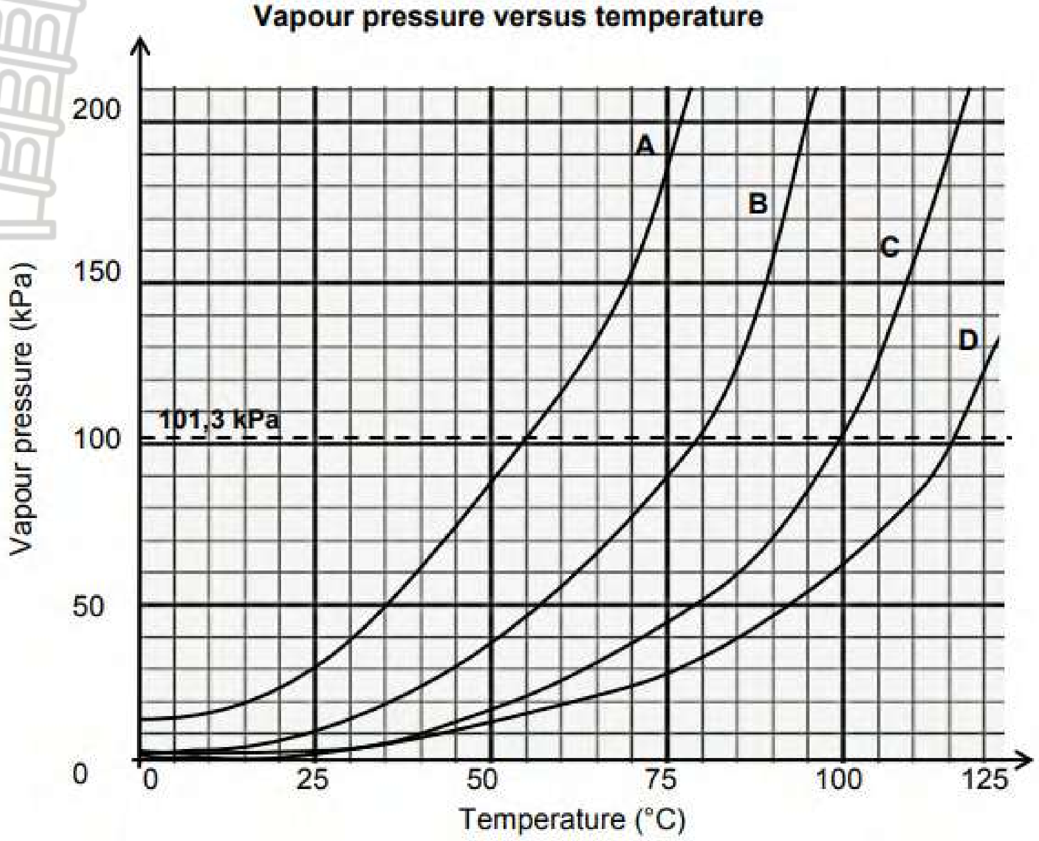
2.4 Which physical method would you use to separate substance **Q** into its components? (1)

2.5 Write down the physical property upon which the separation techniques are based to separate the following substances into their individual components:

2.5.1 **Q** (1)
2.5.2 **R** (1)
[9]

QUESTION 3 (Start on a new page.)

The vapour pressure versus temperature graph below was obtained for four unknown liquids (**A**, **B**, **C** and **D**). Atmospheric pressure is measured as 101,3 kPa.



3.1 Define the term *boiling point*. (2)

Use the information given in the graph to answer the questions that follow.

3.2 Write down the:

- 3.2.1 Boiling point of liquid **B** (1)
- 3.2.2 Liquid which remains a liquid at 115 °C (1)
- 3.2.3 Liquid that is most likely to be water (1)

3.3 State the PHASE CHANGE that takes place at the stage when the vapour pressure is equal to atmospheric pressure. (1)

3.4 What happens to the temperature of a liquid during a phase change? Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)

3.5 Explain the answer to QUESTION 3.4. (2)

3.6 Which liquid (**A**, **B**, **C** or **D**) has the weakest intermolecular forces? Give a reason for the answer. (3)

3.7 What is the relationship between vapour pressure of the liquid and temperature? (2)

[14]

QUESTION 4 (Start on a new page.)

Study the table below and answer the questions that follow.

ELEMENT/ION	NUMBER OF PROTONS	NUMBER OF NEUTRONS	NUMBER OF ELECTRONS
P	11	12	11
Q	14	16	14
R	16	16	18

4.1 Define the term *atomic number*. (2)

4.2 Write down the:

- 4.2.1 Chemical symbol of element **Q** using the notation $^{A}_{Z}X$ (2)

4.2.2 Element (**P**, **Q** or **R**) that is an alkali metal (1)
4.2.3 Chemical symbol of **R** (2)

4.3 Element **P** reacts with oxygen to form the compound with the chemical formula P_2O.
4.3.1 Predict the chemical formula that element Rb in the periodic table will form when it reacts with oxygen. (2)
4.3.2 Explain the answer to QUESTION 4.3.1. (2)

4.4 What is the trend in ionisation energy as you move from element **P** to element **R**? Write down only INCREASES, DECREASES or REMAINS THE SAME. Explain the answer. (4)

4.5 How many electrons does an ION of element **P** have? Draw the Aufbau diagram of this ion. (3)

4.6 When orbitals of identical energy are available, electrons are placed in individual orbitals before they are paired. Give the name of this rule. (1)

4.7 Element **Y** occurs as these isotopes in the following proportions:

Y – 28(92,23%); **Y** – 29(4,68%); **Y** – 30(3,09%)

Calculate the relative atomic mass of element **Y**. (4)
[23]

QUESTION 5 (Start on a new page.)

Study the physical and chemical processes below and answer the questions that follow.

X: $H_2O(s) \rightarrow H_2O(g)$

Y: $CaCO_3(s) \xrightarrow{\Delta} CaO(s) + CO_2(g)$

Z: iron + oxygen $\rightarrow$ iron(III) oxide

5.1 Define the term *physical change*. (2)

5.2 Write down the LETTER of the process that represents the following:
5.2.1 Physical change (1)
5.2.2 Decomposition reaction (1)

5.3 Give the name of the physical change stated in QUESTION 5.2.1. (1)

5.4 State TWO properties of a reaction that indicate that a chemical change has taken place. (2)

5.5 For process **Z**, write down:
5.5.1 What the symbol Δ represents (1)
5.5.2 A BALANCED CHEMICAL EQUATION (Show the phases of ALL reactants and products.) (4)

5.6 A 20 g sample of $CaCO_3(s)$ in process **Y** decomposes to form 11,2 g of CaO. In a second sample, 30 g decomposes to form x g of CO_2.
5.6.1 State the *law of constant composition*. (2)
5.6.2 Use the law in QUESTION 5.6.1 to calculate mass x of the CO_2 formed. (5)
[19]

QUESTION 6 (Start on a new page.)

A group of learners prepare a 0,25 $mol{\cdot}dm^{-3}$ solution of sodium carbonate by dissolving a 14,2 g sample of hydrated sodium carbonate ($Na_2CO_3{\cdot}xH_2O$) in 200 cm^3 of water.

6.1 Explain the meaning of the term *hydrated*. (2)

6.2 Write down a BALANCED CHEMICAL EQUATION to show how sodium carbonate dissociates in water. (2)

6.3 Learners then take 10 cm^3 of the prepared solution and allow it to react completely with 5 cm^3 of dilute hydrochloric acid, according the following balanced chemical equation:

$$Na_2CO_3 + 2HC\ell \rightarrow 2NaC\ell + H_2O + CO_2$$

6.3.1 Define the term *a mole of a substance*. (2)
6.3.2 What type of chemical reaction is represented by the chemical equation above? (1)
6.3.3 Calculate the number of moles of hydrochloric acid in 5 cm^3 of hydrochloric acid if its concentration is 1 $mol{\cdot}dm^{-3}$. (3)

6.4 Calculate the mass of sodium chloride formed in the reaction in QUESTION 6.3. (5)
[15]

GRAND TOTAL: 100

EXAMPLE 2: PHYSICAL SCIENCES PAPER 2

MARKS: 100 **TIME: 2 hours**

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Each question has only ONE correct answer. Choose the answer and write only the letter (A–D) next to the question number (1.1–1.10) in the ANSWER BOOK, for example 1.11 E.

1.1 Air can be classified as a/an …

A element. B compound.
C mixture. D pure substance. (2)

1.2 Sodium tends to form ions which have the electronic configuration of a noble gas. What is the electronic configuration of the noble gas which the sodium ion mimics?

A $1s^2$
B $1s^2\ p^6$
C $1s^2 2s^2 2p^6$
D $1s^2 2s^2 2p^6 3s^2$ (2)

1.3 In which ratio will group (I) elements react with group (VI) elements?

A 2 : 1 B 1 : 6
C 6 : 1 D 1 : 3 (2)

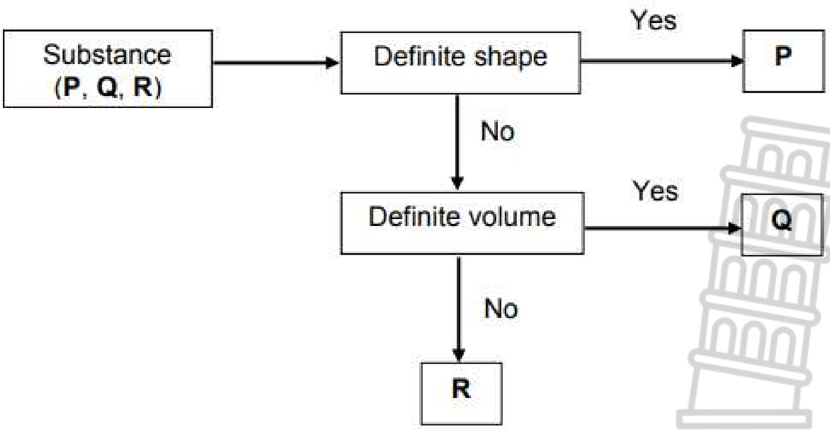
1.4 What is the total number of nucleons in the ion of calcium when calcium loses two electrons to form Ca^{2+}?

A 40 B 18
C 22 D 20 (2)

1.5 Which ONE of the following groups of elements shows the CORRECT trend of the density of metals?

A Rb < K < Na < Li B K < Na < Li < Rb
C Li < Na < K < Rb D Na < Li <Rb < K (2)

1.6 A learner used the flow chart below to classify some examples of substances **P**, **Q** and **R**.



What could substances **P**, **Q** and **R** possibly be?

	P	**Q**	**R**
A	Marble	Oil	Oxygen
B	Oil	Marble	Oxygen
C	Oxygen	Oil	Marble
D	Oxygen	Marble	Oil

(2)

1.7 In a 20 g sample of molecules, which sample below has the greatest number of moles?

A NH_3 B N_2
C CO_2 D H_2 (2)

1.8 Carbon dioxide can change directly from the solid phase to the gas phase. This process is known as …

A sublimation. B evaporation.
C decomposition. D melting. (2)

1.9 The chemical name for $Fe_2(SO_4)_3$ is …

A iron sulphite. B iron(III) sulphate.
C iron(II) sulphate. D iron sulphide. (2)

1.10 Which one of the following pairs of gases contains the same number of molecules?

A 16 g of O_2 and 14 g of N_2 B 8 g of O_2 and 22 g of CO_2
C 28 g of N_2 and 22 g of CO_2 D 32 g of O_2 and 32 g of N_2 (2)

[20]

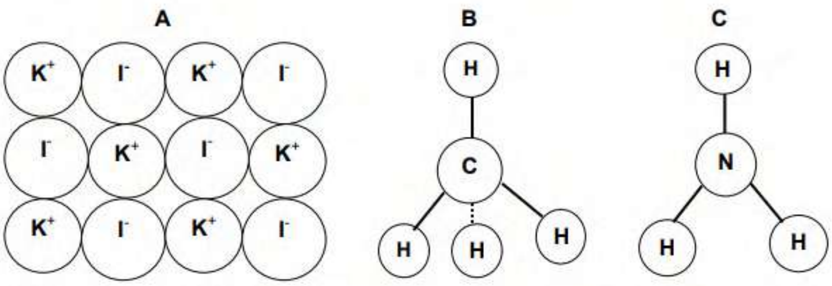
QUESTION 2 (Start on a new page.)

Consider the following substances: C_{90}; NaCℓ; CO_2; Fe; H_2O

2.1 Write down a substance from the list above that is the following:

2.1.1 Is a metal (1)
2.1.2 Consists of atoms covalently bonded (1)
2.1.3 Consists of ions (1)

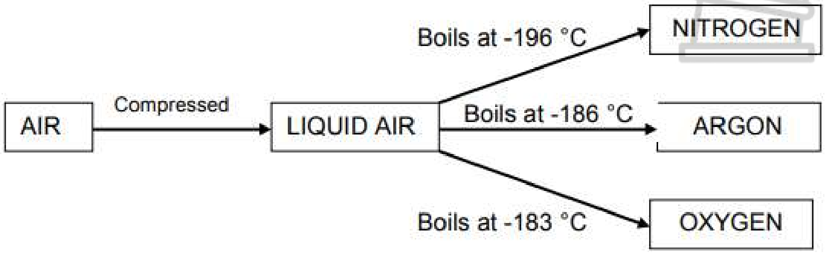
2.2 Draw the Lewis dot diagram for the CO_2 molecule. (2)
2.3 Identify the type of chemical bond in H_2O. (1)
2.4 Draw the Lewis dot diagrams to show the formation of NaCℓ. (3)
2.5 Study the models of compounds **A**, **B** and **C** below and answer the questions that follow.



Write down the:

2.5.1 Chemical name of compound **A** (1)
2.5.2 Chemical formula of compound **B** (1)
2.5.3 Common name of compound **C** (1)

2.6 Many of the gases in air are very useful. An important industrial process, fractional distillation of liquid air, separates these gases from one another.
Consider the diagram below and answer the questions that follow.



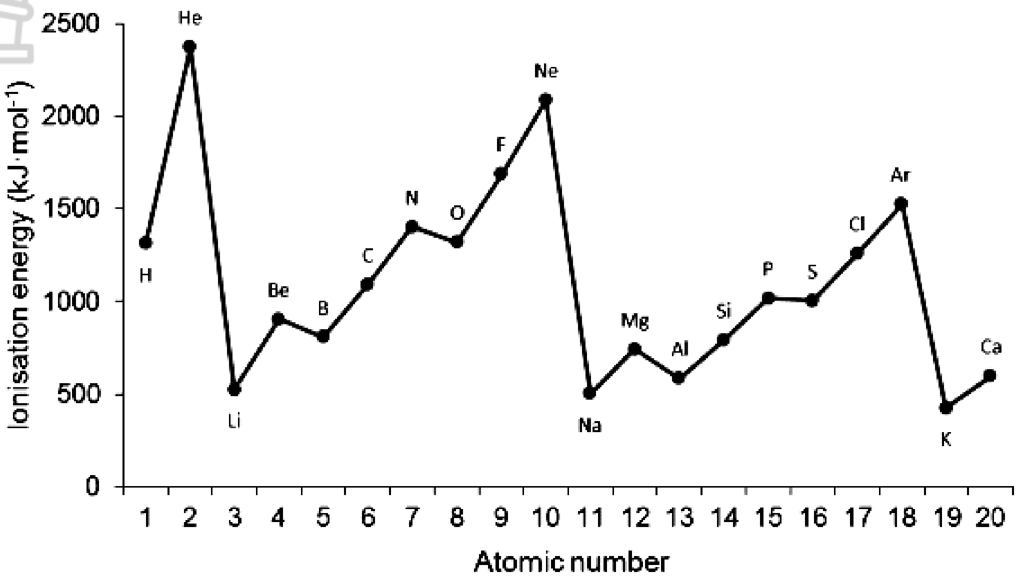
2.6.1 Is this separation process PHYSICAL or CHEMICAL? (1)
2.6.2 Which physical property is used to separate the gases after they have been liquefied? (1)
2.6.3 Which gas has the weakest intermolecular forces? Explain the answer. (2)

2.7 State how EACH of the following changes when liquid nitrogen changes into gaseous nitrogen. Write down only INCREASE, DECREASE or REMAIN THE SAME.
- 2.7.1 Spaces between the particles (1)
- 2.7.2 Strength of the forces between the particles (1)
- 2.7.3 Energy of the particles (1)

[19]

QUESTION 3 (Start on a new page.)

Consider the graph of the first ionisation energy and answer the questions that follow.



3.1 Define the term *ionisation energy*. (2)

3.2 State the general trend in ionisation energy from left to right across a period on the periodic table. (1)

3.3 There is a drop in ionisation energy from beryllium to boron.
- 3.3.1 Write down the sp-notation for beryllium AND boron. (2)
- 3.3.2 Explain this drop in ionisation energy. (2)

3.4 Is the following statement TRUE or FALSE? If false, rewrite the statement correctly.
The ionisation energy of noble gases is high because of the half-filled s- and p-orbitals. (2)

3.5 Study the ionisation energy of the group (I) elements in the graph above and answer the questions that follow.
- 3.5.1 Give the general name of the group (I) elements. (1)
- 3.5.2 State the trend in the reactivity of elements in group (I). (1)
- 3.5.3 Explain the reason for the trend in QUESTION 3.5.2 by using the graph of ionisation energy. (2)

[13]

QUESTION 4 (Start on a new page.)

A certain element, **X**, has two isotopes in nature. One isotope has an atomic mass of 106,9 amu. The percentage appearance of this isotope is 50%.
The atomic mass of the other isotope is 109,1.

4.1 Define the term *isotope*. (2)

4.2 Calculate the relative atomic mass of element **X**. (5)

4.3 Identify element **X** in QUESTION 4.1.2. (1)

[8]

QUESTION 5 (Start on a new page.)

Hydrogen peroxide decomposes at room temperature according to the following balanced chemical equation:

$$2H_2O_2(aq) \rightarrow O_2(g) + 2H_2O(\ell)$$

5.1 What does the (aq) represent in the equation above? (1)

5.2 Identify the type of reaction above. Choose between PRECIPITATION and REDOX. Give a reason for the answer. (2)

5.3 Is the reaction an example of a physical or a chemical change? (1)

5.4 Define the term *one mole of a substance*. (2)

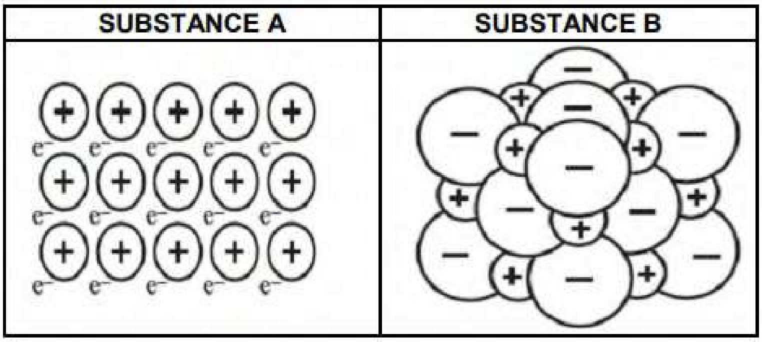
5.5 If 4 moles of hydrogen peroxide decompose, calculate the volume of gas formed at STP. (4)

5.6 Calculate the number of oxygen atoms in H_2O_2 if 17 g of H_2O_2 decomposes. (4)

[14]

QUESTION 6 (Start on a new page.)

Study the diagram below showing two different substances (**A** and **B**) and answer the questions that follow.



6.1 Choose the substance (**A** or **B**) that describes a metal. (1)

6.2 Name the type of bond that exists in substance **B**. (1)

6.3 Magnesium and chlorine react to form the compound magnesium chloride.

6.3.1 Define the term *compound*. (2)

6.3.2 Write down the valency of a chlorine atom. (1)

6.3.3 Use a Lewis dot diagram to show the formation of magnesium chloride. (3)

[8]

QUESTION 7 (Start on a new page.)

7.1 Study the balanced chemical equation of the reaction between sodium carbonate (Na_2CO_3) and hydrochloric acid ($HC\ell$) and answer the questions that follow.

$$Na_2CO_3 + 2HC\ell \rightarrow 2NaC\ell + CO_2 + H_2O$$

7.1 Identify the type of reaction above. Choose between REDOX and GAS FORMING. (1)

7.2 In a reaction, 10,6 g of sodium carbonate reacts completely with excess hydrochloric acid.

7.2.1 Calculate the molar mass of sodium carbonate. (1)

7.2.2 Calculate the initial number of moles of sodium carbonate. (2)

7.2.3 Calculate the mass of CO_2 produced during this reaction. (4)

7.2.4 Calculate the mass of sodium chloride produced if 4,87 dm^3 of carbon dioxide was produced at STP. (5)

7.3 14,2 g of a sample of hydrated sodium carbonate, $Na_2CO_3 \cdot xH_2O$, was strongly heated until no further change in mass was recorded. On heating, all the water of crystallisation evaporated as follows:

$$Na_2CO_3 \cdot xH_2O \rightarrow Na_2CO_3 + xH_2O$$

Calculate the number of moles of water of crystallisation in the sodium carbonate sample, if 5,3 g of solid remained after strong heating. (5)

[18]

GRAND TOTAL: 100