Physical Sciences

CLASS TEXT & STUDY GUIDE

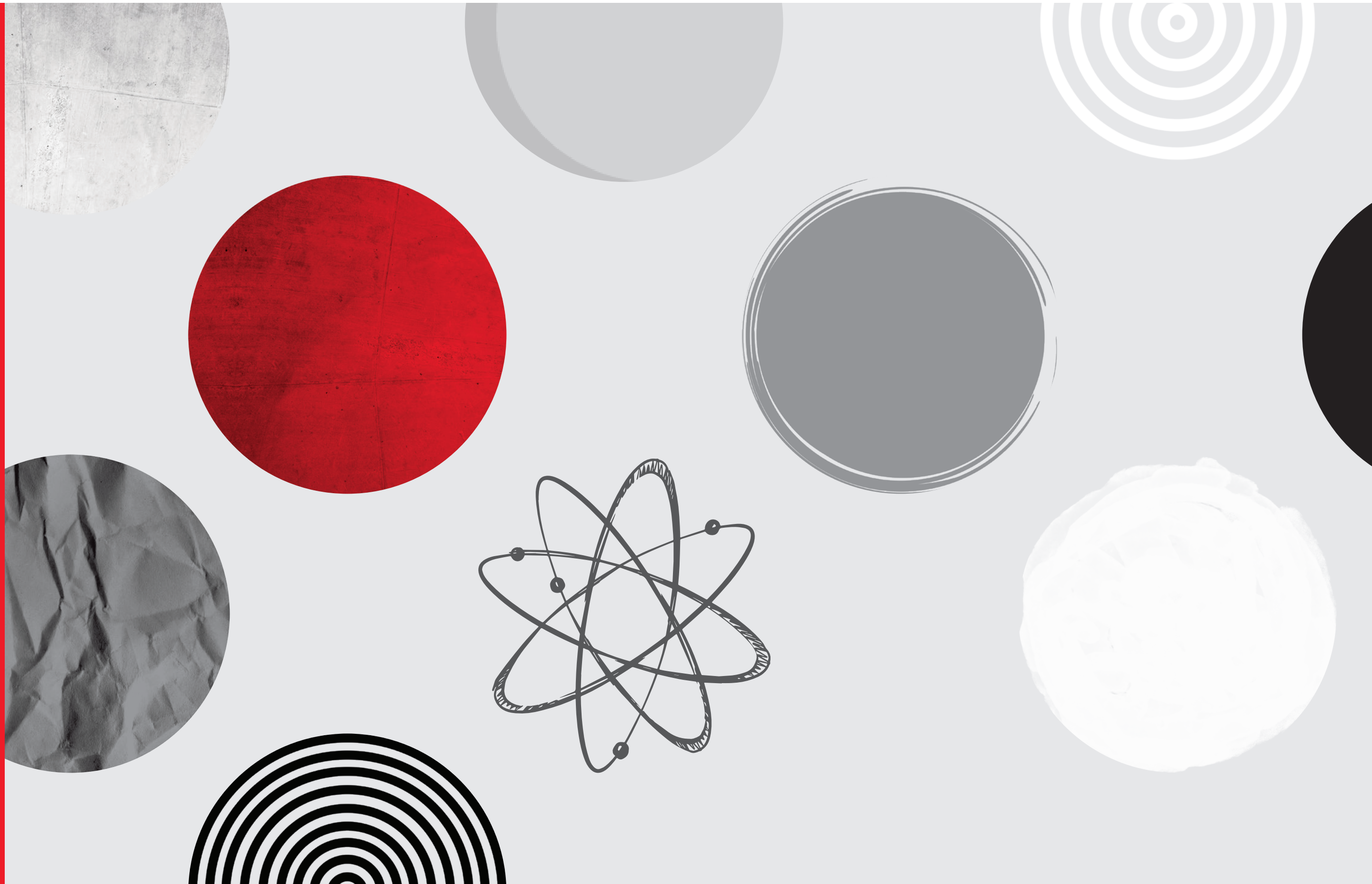
Retha Louw & Debbie Watson

GRADE

10

CAPS

3-in-1



THE ANSWER SERIES
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Grade 10 Physical Sciences 3-in-1 CAPS

CLASS TEXT & STUDY GUIDE

This Grade 10 Physical Sciences 3-in-1 study guide uses a methodical, step-by-step approach to simplify the theory, techniques and basic concepts of a challenging subject. The format is designed to guide you through the essential principles to a point where you can tackle more complex problems with confidence.

Key features:

- Comprehensive, explanatory notes and worked examples per topic
- Exercises and exam questions per topic
- Detailed answers with explanations and handy hints

The clear, concise notes and graded questions comply with the requirements of the CAPS curriculum and develop a thorough understanding of each topic.

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THIS CLASS TEXT & STUDY GUIDE INCLUDES

1 Comprehensive Notes

2 Exercises and Exam Questions

3 Detailed Memos with Explanations

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NOTES with QUESTIONS and ANSWERS:

NOVEMBER EXAM

Paper	Content	Marks	Total marks per paper	Duration (hours)	Weighting of questions across cognitive levels			
					Level 1	Level 2	Level 3	Level 4
Paper 1: Physics focus	**Mechanics (Module 5)**	75	150	2	15%	35%	40%	10%
	Waves, Sound and Light (Module 2)	40						
	Electricity and Magnetism (Module 4)	35						
Paper 2: Chemistry focus	**Chemical Change (Module 3)**	60	150	2	15%	40%	35%	10%
	Chemical Systems (Module 6)	20						
	Matter and Materials (Module 1)	70						

SKILLS REQUIRED FOR PHYSICAL SCIENCES

Science as a field of study developed from the human need to better understand and explain the world in which we live. Physical Sciences is divided into two disciplines: Physics and Chemistry. Physics deals mainly with the study of the laws of the universe and Chemistry with the study of matter and materials.

In both disciplines it is necessary to do scientific investigations, solve problems and formulate findings. Mathematics plays a very important role to help us with this.

Scientific notation

- In science we often work with very small and very large numbers, from the mass of an atom to the radius of the earth.
- In scientific notation, a number is expressed as a product of two numbers, i.e.:

$$\underset{\text{coefficient: } 1 \le N < 10}{N} \times \underset{\text{base } 10}{10}^{\overset{\text{any integer}}{n}}$$

For example: $2{,}57 \times 10^{-3}$; $-1{,}09 \times 10^{4}$

- ***N** is any number from 1 to 9,999... (we refer to it as the coefficient of 10^n)*
- ***n** is any integer, so that 10^n represents a power of 10, e.g. 10^{-12}, 10^{-5}, 10^{0}, 10^{9}, 10^{29} etc.*
- *Negative numbers get a negative sign (-) before the scientific notation.*

Conversion of ordinary notation to scientific notation

- Move the comma until there is only one place (digit) before the comma.
- If the comma has to move **n** places to the **left**, then the notation is: $N \times 10^{+n}$
- If the comma has to move **n** places to the **right**, then the notation is: $N \times 10^{-n}$

Therefore, a very large number has a positive exponent and a very small number has a negative exponent.

For example:

$$2\,5789{,}4 = 2{,}57894 \times 10^{4}$$

OR $0{,}000257894... = 2{,}57894 \times 10^{-4}$

Example:

Convert the following numbers to scientific notation:

1) 2 000,4

2) 0,0000000789

Solution:

1) $2{,}0004 \times 10^{3}$ — positive exponent

2) $7{,}89 \times 10^{-8}$ — negative exponent

Conversion of scientific notation to ordinary notation

- Take away the 10^n and move the comma **n** places to the left (for a negative exponent) or **n** places to the right for a positive exponent.

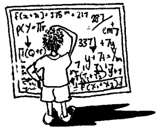
For example:

$$3{,}78 \times 10^{-1} = 0{,}378$$

comma moves 1 place to the left

OR $2{,}54 \times 10^{4} = 25\ 400$

comma moves 4 places to the right



Addition and subtraction with scientific notation

- Make all the exponents of the powers with base 10 (n values) the same.
- Add the coefficients (n values).
- Just copy the power of 10 (10^n).

- *Compounds with an: - S^{2-} (sulphur) ion, are called* ***sulphides***
  - *SO_3^{2-} ion, are called* ***sulphites***
  - *SO_4^{2-} ion, are called* ***sulphates***

Writing the formula when the name is given

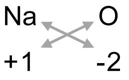
The following rules can be applied to determine the formulae of compounds:

- First write the cation (element with positive charge), followed by the anion.
- The number of positive charges and negative charges should be equal and must add up to zero to form a neutral compound.
- If the charges of **two** combining ions add up to zero, they are combining in a one-to-one ratio.
- If they do not add up to zero, one or both ions must be multiplied so that the net charge is zero (*see crossover method below*).

Examples:

1) **Calcium oxide:**
   - Valencies: Ca (+2) and O (-2)
   - The charges add up to zero: +2 + -2 = 0
   - ∴ The ions combine in a one-to-one ratio, i.e. CaO

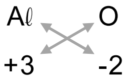
2) **Sodium oxide:**
   - Valencies: Na (+1) and O (-2)
   - The charges +1 and -2 do not add up to zero.



2(+1) + (-2) = 0

   - Therefore, take two Na^+ ions and one O^{2-} ion.
   - Use a subscript '2' for the Na^+ ions.
   - ∴ The formula is Na_2O

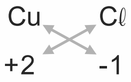
3) **Aluminium oxide:**
   - Valencies: Aℓ (+3) and O (-2)
   - The charges +3 and -2 do not add up to zero.



2(+3) + 3(-2) = 0

   - Take two $A\ell^{3+}$ and three O^{2-} ions and indicate them in subscripts.
   - ∴ The formula is $A\ell_2O_3$

4) **Copper(II)chloride:**
   - Valencies: Cu (+2) and Cℓ (-1)
   - The charges +2 and -1 do not add up to zero.



The valency of Cu is indicated by the Roman numeral (II).

   - Take one Cu^{2+} and two $C\ell^-$ ions.
   - Use a subscript '2' for the $C\ell^-$ ions.
   - The formula is $CuC\ell_2$

5) **Calcium nitrate:**

Nitrate (NO_3^-) is a polyatomic ion and is handled as a unit.

   - Take two NO_3^- ions for each Ca^{2+} ion. The NO_3^- is placed in brackets with a subscript 2, i.e. $Ca(NO_3)_2$.

Using prefixes in names

- A second bonding type is **covalent** bonding in which atoms share an electron pair or electron pairs and **small molecules** are formed *(see p. 1.34)*.
- The formulae of these compounds (molecules) also include subscripts to show the ratio of atoms in the compound, e.g. CO; CO_2.
- When writing the names of these compounds, the following prefixes indicate the number of atoms of the same type:

mon-	1	tetra-	4
di- or bi-	2	pent-	5
tri-	3	hex-	6

Examples:

CO = carbon **mon**oxide

CO_2 = carbon **di**oxide

SO_3 = sulphur **tri**oxide

V_2O_5 = vanadium **pent**oxide

CS_2 = carbon **bi**sulphide (here, 'bi-' relates to the number of S atoms)

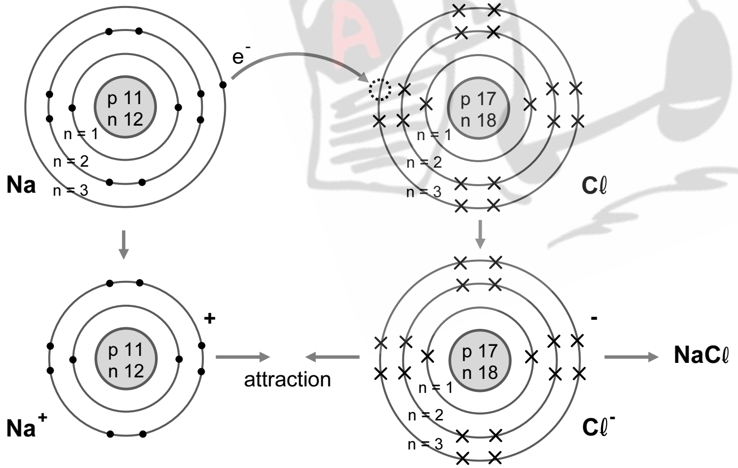
- The non-metal atoms (on the right-hand side of the Periodic Table) have five or more valence electrons and high electron affinity values. Therefore, they readily accept/gain electrons to fill the valence level, forming negative ions (anions).
- The positive and negative ions attract each other with strong electrostatic forces (Coulomb forces) and pack together in a specific ratio in a **crystal lattice**:
  - a crystal lattice refers to the orderly arrangement of the ions in the crystalline compound.
  - it consists of millions of alternating **+** and **–** ions arranged in such a way that each ion is surrounded by oppositely charged ions.
- The formula of the ionic bond indicates the ratio in which the ions are combined in the crystal lattice. An ionic crystal as a whole is neutral.

The strong electrostatic forces of attraction between ions results in high melting and boiling points. A lot of energy is required to overcome these forces to free the ions from the crystal lattice.

Example:

Consider the reaction between **sodium** and **chlorine**:

${}_{11}Na)\ 1s^2\,2s^2\,2p^6\,3s^1$ ${}_{17}C\ell)\ 1s^2\,2s^2\,2p^6\,3s^2\,3p^5$



- According to the above electron configuration and Bohr models, it is clear that Na has one valence electron, i.e. $3s^1$, and that Cℓ has seven valence electrons, i.e. $3s^2\ 3p^5$.
- If an Na atom and a Cℓ atom make contact, the Na atom donates its valence electron to the Cℓ atom. The Na atom forms a Na^+ ion and the Cℓ atom forms a $C\ell^-$ ion.
- These ions attract each other with electrostatic forces and combine in a crystal lattice in a 1:1 ratio to form NaCℓ.

Lewis dot diagrams

The bonding can be set out in three steps using Lewis diagrams, i.e.:

❶ $Na\bullet \rightarrow Na^+ + e^-$

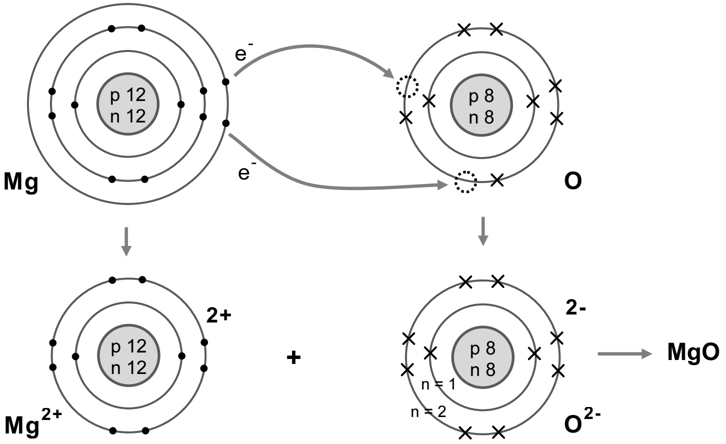
❷ ${}^{\times}_{\times}\overset{\times\times}{\underset{\times\times}{C\ell}}{}_{\times} + e^- \rightarrow \left[{}^{\times}_{\times}\overset{\times\times}{\underset{\times\times}{C\ell}}{}^{\times}_{\times}\right]^-$

❸ $Na^+ + \left[{}^{\times}_{\times}\overset{\times\times}{\underset{\times\times}{C\ell}}{}^{\times}_{\times}\right]^- \rightarrow NaC\ell$

Sodium (Na) is a soft metal and chlorine (Cℓ) is a poisonous yellow-green gas. Both elements are very reactive. When they bond chemically a totally new substance NaCℓ (table salt) is formed, with new properties.

Other examples:

1. **Magnesium with oxygen:**
   Mg has two valence electrons in its 3s orbital. It donates both electrons to attain a full outer energy level (noble gas structure), forming an Mg^{2+} ion. An O atom has six valence electrons and readily accepts the two electrons of the Mg atom to fill its valence level. The O atom thus forms an O^{2-} ion and the Mg^{2+} and O^{2-} ions attract each other and combine in a crystal lattice in a 1:1 ratio to form MgO.



Calculations with the wave equation

Wave speed can be calculated in two ways:

❶ speed (v) = $\dfrac{\text{distance covered}}{\text{time taken}}$

$$\mathbf{v} = \frac{\Delta x}{\Delta t}$$

❷ Suppose the distance of λ is covered in time T

λ = wavelength
T = period of the wave

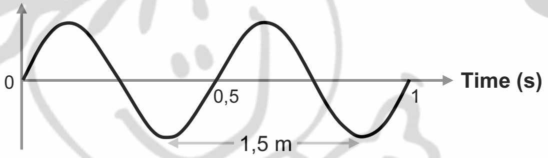
$\therefore$ v = $\dfrac{\lambda}{T}$ $\left(v = \dfrac{\lambda}{1}.\dfrac{1}{T}\right)$

$\therefore$ **v = $f\lambda$** $\left(\dfrac{1}{T} = f\right)$ ← *Universal wave equation*

Example:

Indicate the f, T, λ and v for the accompanying wave:

2 waves move past a point in 1 s.
The distance between 2 troughs is 1,5 m.



$\therefore$ f = 2 Hz and λ = 1,5 m

$\therefore$ T = $\dfrac{1}{f}$ = 0,5 s

v = $f\lambda$ = 2 × 1,5 = 3 m·s^{-1} **OR** v = $\dfrac{\lambda}{T}$ = $\dfrac{1,5}{0,5}$ = 3 m·s^{-1}

Question 1:

Calculate the speed of a wave if the wavelength is 3 m and the period of the wave is 0,1 s.

Answer:

v = $f\lambda$ = 10 × 3 = 30 m·s^{-1} **OR**

v = $\dfrac{\Delta x}{\Delta t}$ = $\dfrac{3\text{ m}}{0,1\text{ s}}$ = 30 m·s^{-1}

λ = 3 m
T = 0,1 s
$\therefore$ f = $\dfrac{1}{T}$ = $\dfrac{1}{0,1}$ = 10 Hz

Question 2:

Calculate the frequency of waves with a speed of 8 m·s^{-1} and a wavelength of 200 mm.

Answer:

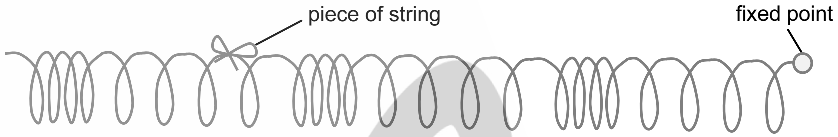
f = $\dfrac{v}{\lambda}$ = $\dfrac{8\text{ m·s}^{-1}}{0,2\text{ m}}$ = 40 Hz

v = 8 m·s^{-1}
λ = 200 mm
= 0,2 m

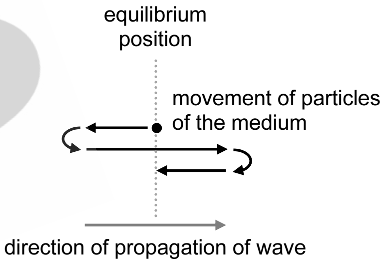
LONGITUDINAL WAVES

LONGITUDINAL WAVES IN A SPRING

- Take the same slinky spring and move the one end in a regular to-and-fro (backwards and forwards) movement while the other end is fixed. Clearer observations can be made by attaching a piece of string to one coil.



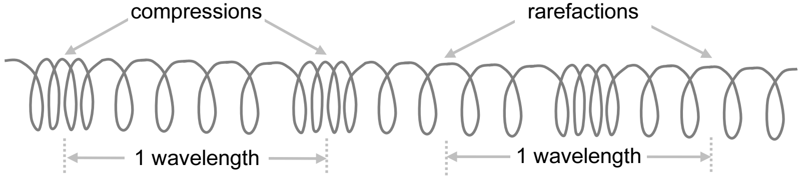
- The string moves backwards and forwards around its original or rest/ equilibrium position and then comes to rest in that position again.
- The disturbance at the one end of the spring transfers energy to the particles of the medium. In this process energy is transferred between the particles.
- The particles of the medium vibrate backwards and forwards around their rest/ equilibrium positions, parallel to the direction of the disturbance.



In **longitudinal waves** the direction of the disturbance, i.e. the direction in which the particles in the medium vibrate, is parallel to the direction of propagation of the wave.

Compressions and rarefactions

- The coils of the spring vibrate around their rest positions and therefore produce:
  - **Compressions:** Parts of the spring where the coils are pressed together.
  - **Rarefactions:** Parts of the spring where the coils are stretched out.

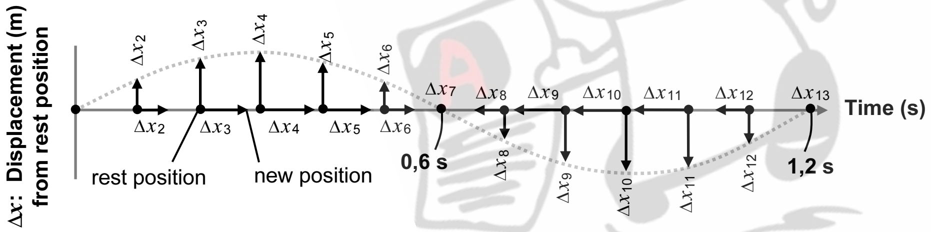


- This causes a wave motion along the spring (parallel to the direction of the disturbance) which transfers energy from the one end to the other end of the spring.
- More energy results in a greater displacement of the particles. At a certain time point, the **displacement** of the particles of the medium, from their rest positions, can be determined and represented graphically.

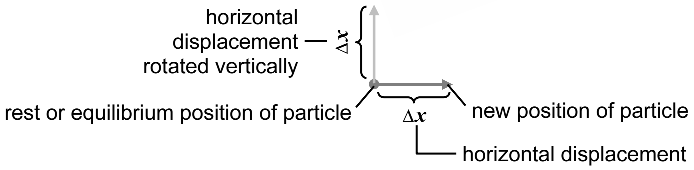
Consider the following diagram that shows the horizontal displacement of a single particle, every 0,1 s, during a longitudinal wave motion.

Rest positions of a particle of the medium:

New positions of a particle of the medium:



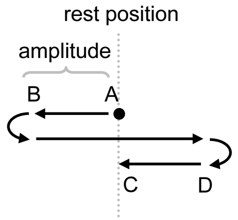
e.g. at t = 0,3 s:



By vertically rotating the arrows (vectors) showing the displacement, a sine wave pattern, as for transverse waves, is obtained.

WAVELENGTH, FREQUENCY, AMPLITUDE, PERIOD, WAVE SPEED

Wave terms

Term	Symbol	Unit	Description
Amplitude	A	metre (m)	The maximum displacement of particles of the medium from their equilibrium (rest) position. 
Wavelength	λ	metre (m)	The distance between the centres of two successive compressions or rarefactions (as for transverse waves this is the distance between two successive points which are in phase).
Frequency	f	Hertz (Hz)	The number of compressions (or rarefactions) i.e. the number of waves passing a fixed point in 1 second.
Period	T	seconds (s)	The time (in seconds) it takes for one complete wave to pass a fixed point. $f = \frac{1}{T}$ and $T = \frac{1}{f}$

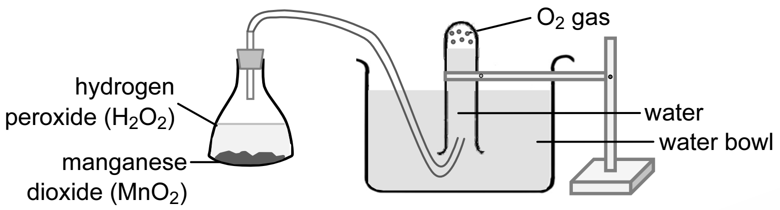
Wave speed (v)

The wave speed indicates the speed at which a rarefaction or compression moves. The formula used for calculating the wave speed is the same as for transverse waves:

$$\boxed{v = f\lambda \quad \text{OR} \quad v = \frac{\Delta x}{\Delta t}}$$

Practical Investigation 3

The decomposition of hydrogen peroxide (H_2O_2)



> *O_2 gas is less dense than water and doesn't dissolve in water. It is collected by the **downward displacement** of water.*

- Fill a test tube with water and set it up in a water bowl as shown in the diagram above.
- Add a little MnO_2 to H_2O_2 in a flask and seal it with a rubber stopper attached to a delivery tube. The delivery tube leads to the lower end of the test tube so that the gas that is produced displaces the water downwards and collects in the test tube.
- Seal the test tube with a rubber stopper once enough gas has been collected.
- Test with a glowing wooden splint.

> *Sometimes special reaction conditions, e.g. heat (∆) or a catalyst, are required to initiate (start) a reaction. A catalyst is a substance that increases the rate of the chemical reaction, without itself reacting or being used up. In this experiment the MnO_2 acts as a catalyst.*

Observation and conclusions:

- An increase in temperature takes place, which shows that the reaction is exothermic.
- The glowing wooden splint catches alight; thus the gas collected in the test tube is oxygen.
- Therefore, the reaction is as follows:

$$2H_2O_2 \xrightarrow[MnO_2]{cat} 2H_2O + O_2$$

2 molecules/8 atoms → 2 molecules/6 atoms + 1 molecule/2 atoms

$m = 2[2(1) + 2(16)]$ $= 68$ units

$m = 2[2(1) + 1(16)] + 2(16)$ $= 68$ units

- Again, from the above reaction it is clear that the mass and the number of atoms are conserved, but not the number of molecules.

> ***NB:** Ion exchange reactions are discussed on p. 3.12.*

CONSERVATION OF ATOMS AND MASS

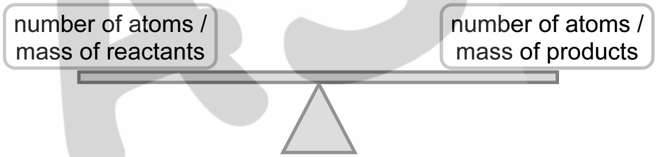
When substances chemically combine to form new products, or when compounds decompose to produce simpler substances, the **Law of Conservation of Matter**, i.e. matter cannot be created or destroyed, applies.

The Law of Conservation of Matter:

During a chemical reaction:

number of atoms of reactants = number of atoms of products **OR**

total mass of all the reactants = total mass of all the products



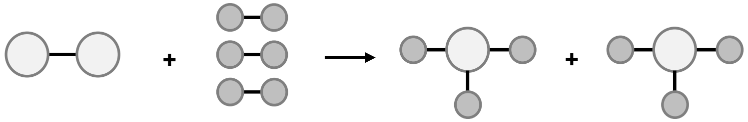
> ***NB:** The number of molecules is not necessarily conserved.*

This can be illustrated by a balanced chemical equation.

Example:

Consider the reaction between $N_2(g)$ and $H_2(g)$ to form $NH_3(g)$ (ammonia):

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



2 N atoms + 6 H atoms → 2 N atoms + 6 H atoms (conserved)

1 molecule + 3 molecules → 2 molecules (not conserved)

Test for the presence of specific ions in a solution

The presence of certain ions can be tested for by adding another ion that forms a precipitate with it. If no precipitate forms, it means that the specific ion is not present.

❶ Test for chlorides, bromides and iodides:

Add $AgNO_3$ (therefore add Ag^+ ions) and then add a strong acid, e.g. nitric acid (HNO_3):

$$C\ell^-(aq) + (Ag^+ NO_3^-)(aq) \rightarrow \underset{\text{white}}{\underline{AgC\ell(s)}} + NO_3^-(aq)$$

$$Br^-(aq) + (Ag^+ NO_3^-)(aq) \rightarrow \underset{\text{cream}}{\underline{AgBr(s)}} + NO_3^-(aq)$$

$$I^-(aq) + (Ag^+ NO_3^-)(aq) \rightarrow \underset{\text{pale yellow}}{\underline{AgI(s)}} + NO_3^-(aq)$$

$$AgC\ell(s) / AgBr(s) / AgI(s) + \text{acid} \rightarrow \text{no reaction}$$

❷ Test for sulphates:

Add $Ba(NO_3)_2$ (therefore add Ba^{2+} ions) and then add concentrated HNO_3:

- $SO_4^{2-}(aq) + Ba^{2+}(aq) + 2NO_3^-(aq) \rightarrow \underset{\text{white}}{\underline{BaSO_4}}(s) + 2NO_3^-(aq)$
- $BaSO_4(s) + HNO_3 \rightarrow$ no reaction (the precipitate does not dissolve)

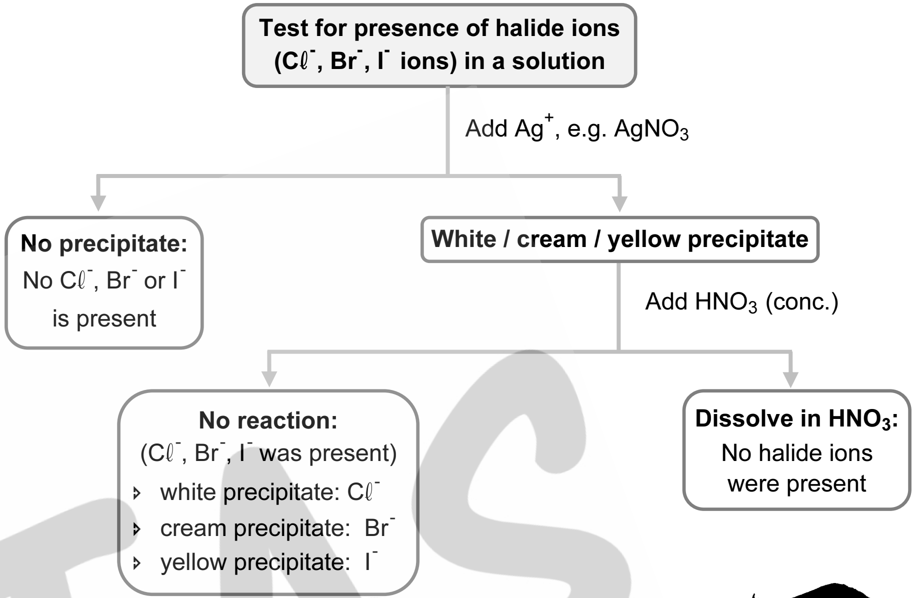
❸ Test for carbonates:

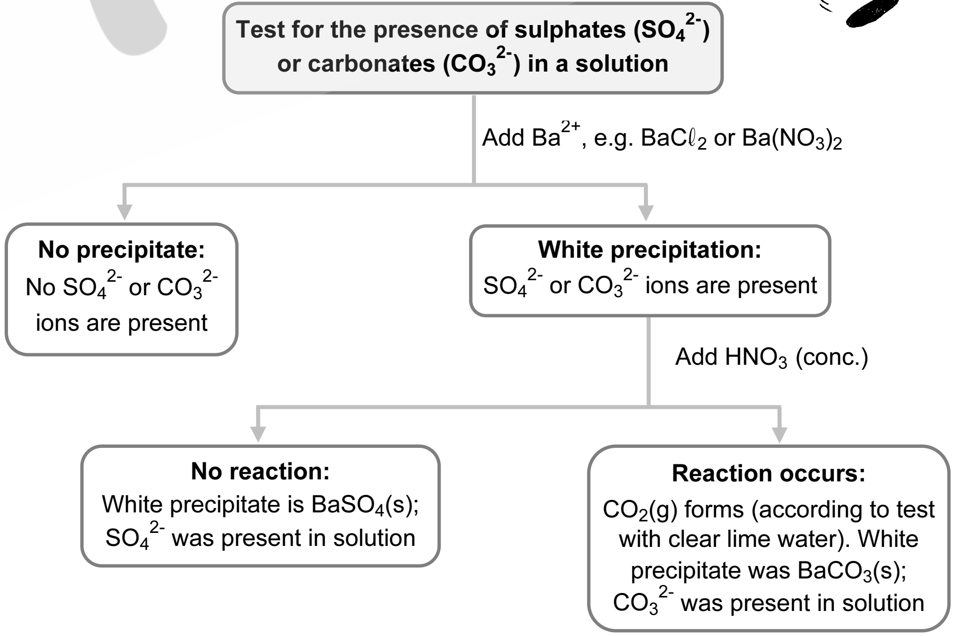
Add $Ba(NO_3)_2$ (therefore add Ba^{2+} ions) and then add any strong acid:

- $CO_3^{2-}(aq) + Ba^{2+}(aq) + 2NO_3^-(aq) \rightarrow \underset{\text{white}}{\underline{BaCO_3(s)}} + 2NO_3^-$
- $BaCO_3(s) + 2HNO_3 \rightarrow Ba(NO_3)_2(aq) + H_2O + CO_2(\uparrow)$

By adding an acid, a distinction can be made between a carbonate and a sulphate salt. The barium carbonate precipitate dissolves in nitric acid (HNO_3) and the gas that forms is CO_2, while the barium sulphate doesn't react with the acid.

Remember: *Test for CO_2 gas: clear lime water becomes milky white if CO_2 gas is bubbled through it.*

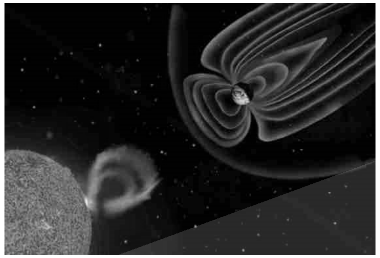




Phenomena due to the earth's magnetic field

Solar winds

The influence of the sun is experienced throughout our solar system due to the effect of **solar winds**.



Solar winds

- A solar wind mainly consists of a flux (flood) of electrically charged particles or charges, i.e. ions, protons and electrons, which are emitted at high speed from the sun.
- The **magnetosphere**, the region in space around the earth (where the earth's magnetic field is predominant), acts on magnetic and charged particles and deflects most of the charged particles of the solar winds.
- Therefore, the magnetic field of the earth plays an important role in protecting the earth from the energy of solar winds.

Northern lights

- Northern lights (*aurora borealis*) refer to a beautiful, bright glow of light that can be seen near the North Pole in the night sky. The same phenomenon, called the Southern lights (*aurora australis*), occurs in the Antarctic regions.
- Charged particles (mostly protons and electrons) in solar winds are attracted to the polar regions by the earth's magnetic field. When the particles pass through the ionosphere, they collide with the atoms and molecules of gases such as nitrogen (N_2) and oxygen (O_2).

Northern lights (*aurora borealis*)

- These gas molecules obtain energy and start to glow, resulting in a magnificent, colourful pattern of red, green, blue and purple light in the night sky.

Solar wind: A current of high-energy electrically charged particles that are radiated from the sun and move in space to form a cloud or plasma.

Plasma is sometimes called the fourth state of matter. It consists of ionised gases and has unusual properties because of the strong forces between the particles.

The **magnetosphere** is the area in space around the earth where the earth's magnetic field acts on magnetic and electrically charged particles and deflects them.

The **ionosphere** is the upper layer of the atmosphere. This upper atmosphere is ionised by radiation from the sun, i.e. molecules are broken down into atoms and atoms lose or gain electrons to form ions.

Magnetic storms

A **magnetic storm** develops when a disturbance occurs in the magnetic field of the earth due to a solar flare/eruption, during which the sun radiates many more charged particles than usual.

- The high-energy charged particles from the sun move in space as a cloud or plasma known as a solar wind.
- The magnetosphere protects the earth from solar winds, but it can be disturbed during an interaction with such heavy solar winds.
- A magnetic storm begins approximately 24 hours after the eruption on the sun, as soon as the solar wind reaches the ionosphere.
- Magnetic storms can interfere with the earth's magnetic field and can destroy the satellites that are used for communication and navigation systems.
- They involve massive amounts of energy and can cause immense damage.

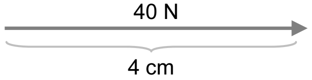
Interesting facts:

Some birds and fishes annually travel thousands of kilometres to other parts of the world for food, shelter or breeding. Scientists have found that magnetic Fe_2O_3 crystals in their brains enable them to stay on course.

Magnetic storm

Scaled vector diagrams

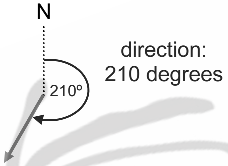
- The length of the vectors are measured to a relevant scale, e.g. 10 N : 1 cm. In this case, a 40 N force vector would be 4 cm long.



- The direction is determined accurately, using a compass or protractor if necessary.

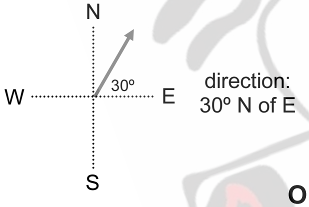
Ways to indicate direction:

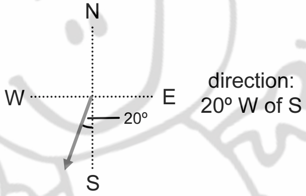
- *The direction is indicated as an angle (in degrees) clockwise from North.*



OR

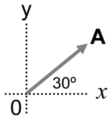
- *The direction is indicated as an angle (in degrees) relative to one of the 4 cardinal points of a compass, e.g.:*





OR

- *The direction is indicated by an angle (in degrees) relative to the x-axis or y-axis in the Cartesian plane, e.g.:*



0A is 30° anticlockwise relative to/above the positive x-axis **OR** 0A is 60° clockwise relative to the positive y-axis.

PROPERTIES OF VECTORS

Equal vectors

Vectors are equal if they have the same magnitude and direction, e.g.:

force $F_1 = F_2$
(they are parallel and have the same magnitude, i.e. 50 N.)

Vectors can be equal even if they do not start at the same point.

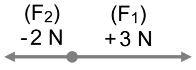
Negative vectors

The directions of vectors acting along a straight line in exactly opposite directions are indicated by opposite signs.

Example:

If $F_1 = 3$ N east and $F_2 = 2$ N west, we can indicate their respective directions as positive (**+**) and negative (**-**).

Assume east is positive (**+**), then $F_1 = 3$ N and
$F_2 = -2$ N



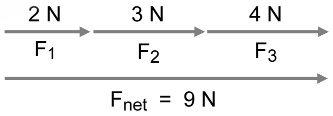
Addition of vectors

If different forces act upon the same object at the same time, it is sometimes useful to determine the combined or **net effect** of the force vectors. We do this by **vector addition**.

Example:

- Vector addition of vectors in the same direction:
  e.g. $F_1 = 2$ N east, $F_2 = 3$ N east, $F_4 = 4$ N east

Graphically:



Algebraically:

The **resultant** force or **net** force:

$$F_{net} = F_1 + F_2 + F_3$$
$$= 2 + 3 + 4$$
$$= 9 \text{ N east}$$

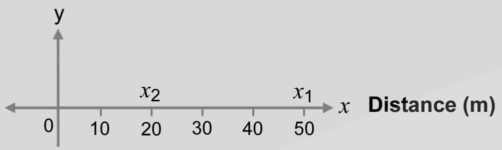
Take east **+**

Calculations

Use the formulae for distance and displacement to do calculations in one dimension.

Question 1:

Calculate the displacement of a person moving from position x_1 to position x_2.



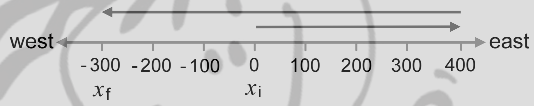
Answer:

$\Delta x = x_2 - x_1$
$= 20 - 50$
$= -30$
$=$ 30 m left

The negative sign indicates a displacement to the left, because right has been taken as **+**.

Question 2:

A cyclist travels 400 m east along a straight line, turns around, and cycles another 700 m in the opposite direction.



1) Calculate the distance travelled.
2) Calculate the displacement of the cyclist.

Answer:

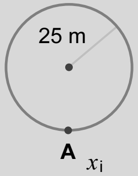
1) distance (D) = $D_1 + D_2$
= 400 m + 700 m = 1 100 m

Treat like adding vectors in the same straight line.

2) displacement (Δx) = $x_f - x_i$ **OR** $\Delta x = x_1 + x_2$
= -300 - 0 = +400 + (-700)
= -300 = 300 m west = -300 = 300 m west

Question 3:

A girl runs around a circular track with a radius of 25 m. She starts at the southern-most point A, runs right round the track and completes two laps.



1) Calculate (i) the distance she covers, and (ii) her displacement after completing the two laps.
2) Calculate her displacement after completing half a lap.

Answer:

1) (i) Circumference of ⊙ $= 2\pi r$
$= 2\pi(25)$
$= 157{,}08$ m

Use $\pi = 3{,}142$

∴ after 2 laps: D = $2 \times 157{,}08$
$= 314{,}16$ m

(ii) $\Delta x = 0$ m (she is back at the starting point ($x_i = x_f$))

2) After $\frac{1}{2}$ a lap, she is directly opposite point A.

∴ $\Delta x = 50$ m north

Question 4:

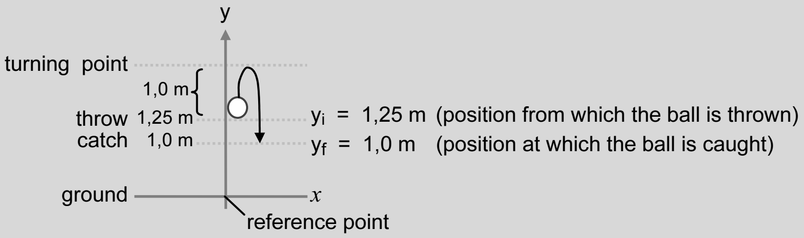
A ball is thrown vertically upwards, leaving the thrower's hand at a height of 1,25 m above the ground. The ball moves 1 m upwards into the air, turns and falls back into the thrower's hand, now 1 m above the ground.

Calculate:

1) the distance that the ball travelled through the air.
2) the final position and displacement of the ball, with the ground as the reference point.
3) the final position and displacement of the ball, with the initial position of the ball as the reference point.

Answer:

Draw a sketch to represent the situation:



1) Distance $D_{tot} = D_{up} + D_{down}$
$= 1 + 1{,}25$
$= 2{,}25$ m

2: WAVES, SOUND AND LIGHT

Question 1

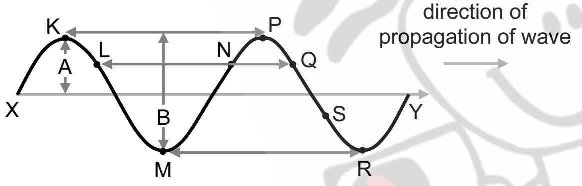
1.1 Define:

- 1.1.1 a pulse
- 1.1.2 a transverse pulse
- 1.1.3 a transverse wave

1.2 Define the following terms and in each case give the symbol and the unit:

- 1.2.1 wavelength
- 1.2.2 frequency
- 1.2.3 period
- 1.2.4 crest (only definition)
- 1.2.5 trough (only definition)

1.3



Use the letters in the above diagram to indicate the following:

- 1.3.1 one wavelength
- 1.3.2 the amplitude
- 1.3.3 two points that are in phase
- 1.3.4 two points that are out of phase
- 1.3.5 a trough
- 1.3.6 the direction in which a medium particle moves at point S

1.4 What is meant by the following:

- 1.4.1 the superposition of waves
- 1.4.2 constructive interference
- 1.4.3 destructive interference
- 1.4.4 two points on a wave are in phase
- 1.4.5 two waves are in phase

1.5 For each diagram, A and B, state whether the waves are *in phase* or *out of phase*.

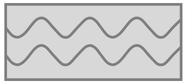


Diagram A

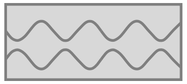
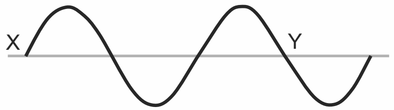


Diagram B

1.6 The diagram indicates two points X and Y on a wave train. The distance between X and Y is 45 cm. Use the diagram to answer the questions.



1.6.1 What is the wavelength of the wave?

A 45 cm **B** 60 cm
C 30 cm **D** 15 cm

1.6.2 The series of waves on the sketch arose in 0,4 s. The frequency of the wave train is:

A 0,2 Hz **B** 5 Hz
C 0,4 Hz **D** 2,5 Hz

1.6.3 The speed of this wave is:

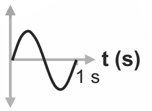
A 1,8 $m{\cdot}s^{-1}$ **B** 0,09 $m{\cdot}s^{-1}$
C 0,15 $m{\cdot}s^{-1}$ **D** 1,5 $m{\cdot}s^{-1}$

1.7 Answer the following questions about sound waves:

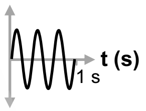
- 1.7.1 How are sound waves generated?
- 1.7.2 Through which type of medium do sound waves travel the fastest?
- 1.7.3 What is meant by the *pitch* of a sound wave?
- 1.7.4 What property of a sound wave determines the pitch?
- 1.7.5 What property of a sound wave determines the loudness of the sound?
- 1.7.6 What other factor determines how loud we perceive a sound?

1.8 Determine which of the wave patterns below represent sound waves or a sound wave that:

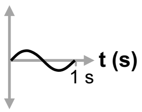
A



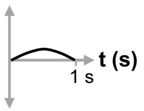
B



C



D



- 1.8.1 are equally loud
- 1.8.2 have the same pitch
- 1.8.3 contains the highest note
- 1.8.4 contains the lowest note

Question 2

2.1.1 What is the relationship between period and frequency?

2.1.2 Calculate the frequency of a wave with a period of 2 ms.

2.1.3 Calculate the period of a wave with a frequency of 20 Hz.

2.2.1 Give the equation that indicates the relationship between the speed of a wave, its frequency and its wavelength.

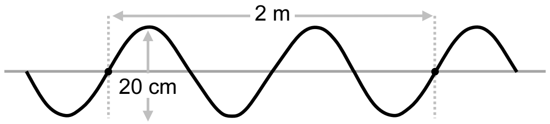
2.2.2 Calculate the speed of a wave with a frequency of 6×10^{14} kHz and a wavelength of 2×10^{-5} m.

2.2.3 Calculate the period of a wave with a speed of 3×10^{8} $m{\cdot}s^{-1}$ and a wavelength of 700 nm.

2.3 How does the speed, frequency and wavelength of water waves change as they wash ashore?

Question 3

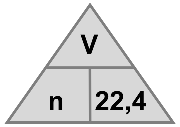
The wave motion illustrated in the diagram below completes 3 vibrations in 15 seconds.



3.1 How long does it take four waves to pass a specific point?

Question 19

19.1 It is the volume that 1 mol of any gas occupies at standard temperature and pressure (STP), i.e. $22,4\ dm^3$.



19.2.1 $V = n \times 22,4$
$= 1,5 \times 22,4 = 33,6\ dm^3$

19.2.2 $V = n \times 22,4$
$= 0,02 \times 22,4 = 0,448\ dm^3$

19.2.3 $V = n \times 22,4$
$= 3 \times 22,4 = 67,2\ dm^3$

19.2.4 $V = n \times 22,4$
$= 2,5 \times 22,4 = 56\ dm^3$

19.3.1 $22,4\ dm^3 = 1\ mol = 6,02 \times 10^{23}$ particles

$n = \frac{V}{22,4} = \frac{50}{22,4} = 2,23\ mol$

no. of $C\ell_2$ molecules $= 2,23 \times 6,02 \times 10^{23}$
$= 13,44 \times 10^{23}$

number of atoms $= 2 \times 13,44 \times 10^{23}$
$= 2,69 \times 10^{24}$

Each $C\ell_2$ molecule has 2 atoms

19.3.2 $100\ cm^3 = 0,1\ dm^3$

$n = \frac{0,1}{22,4} = 4,46 \times 10^{-3}$ mol NO_2 gas

Each NO_2 molecule has one N atom

number of N atoms
$= 4,46 \times 10^{-3} \times 6,02 \times 10^{23} = 2,69 \times 10^{21}$

19.3.3 3 litres $= 3\ dm^3$ $n = \frac{3}{22,4} = 0,13\ mol$

number of helium atoms $= 0,13 \times 6,02 \times 10^{23}$
$= 8,06 \times 10^{22}$

Each helium atom has 2 protons and 2 electrons, i.e. 4 charged particles.

No. of charged particles $= 4 \times 8,06 \times 10^{22}$
$= 3,225 \times 10^{23}$

19.3.4 $250\ cm^3 = 0,25\ dm^3$

$n = \frac{V}{22,4}$
$= \frac{0,25}{22,4}$
$= 0,011\ mol$

no. of CH_4 molecules $= 0,011 \times 6,02 \times 10^{23}$
$= 6,67 \times 10^{21}$

number of C atoms $= 6,67 \times 10^{21}$

number of H atoms $= 4 \times 6,67 \times 10^{21}$

Each molecule has 1 C and 4 H atoms

number of protons
$= \underbrace{6(6,67 \times 10^{21})}_{\text{C-atoms}} + \underbrace{1 \times 4(6,67 \times 10^{21})}_{\text{H-atoms}}$
$= 6,67 \times 10^{22}$

Each C atom has 6 protons and each H atom has 1 proton

Question 20

20.1 NaOH:

$V = 200\ cm^3 = 0,2\ dm^3$
$m = 0,08\ g$
$M(NaOH) = 40\ g{\cdot}mol^{-1}$

$n = \frac{m}{M}$
$= \frac{0,08}{40}$
$= 0,002\ mol$

$c = \frac{n}{V}$
$= \frac{0,002}{0,2}$
$= 0,01\ mol{\cdot}dm^{-3}$

20.2 Na_2CO_3:

$V = 500\ cm^3 = 0,5\ dm^3$
$m = 10,6\ g$
$M(Na_2CO_3)$
$= 2(23) + 12 + 3(16)$
$= 106\ g{\cdot}mol^{-1}$

$n = \frac{m}{M}$
$= \frac{10,6}{106}$
$= 0,1\ mol$

$c = \frac{n}{V} = \frac{0,1}{0,5} = 0,2\ mol{\cdot}dm^{-3}$

20.3 NH_4NO_3:

$V = 250\ cm^3 = 0,25\ dm^3$
$m = 2\ g$
$M(NH_4NO_3)$
$= 14 + 4(1) + 14 + 3(16)$
$= 80\ g{\cdot}mol^{-1}$

$n = \frac{m}{M}$
$= \frac{2}{80}$
$= 0,025\ mol$

$c = \frac{n}{V} = \frac{0,025}{0,25} = 0,1\ mol{\cdot}dm^{-3}$

20.4 $KMnO_4$:

$V = 2\ \ell = 2\ dm^3$
$m = 31,6\ g$
$M(KMnO_4)$
$= 39 + 54,9 + 4(16)$
$= 157,9\ g{\cdot}mol^{-1}$

$n = \frac{m}{M}$
$= \frac{31,6}{157,9}$
$= 0,2\ mol$

$c = \frac{n}{V} = \frac{0,2}{2} = 0,1\ mol{\cdot}dm^{-3}$

Question 21

21.1 A solution of known concentration.

21.2 NaOH:

$V = 200\ cm^3 = 0,2\ dm^3$
$c = 0,1\ mol{\cdot}dm^{-3}$
$M(NaOH) = 40\ g{\cdot}mol^{-1}$

$c = \frac{n}{V}$ (first determine the number of moles needed and then the mass)

$n = c \times V = 0,1 \times 0,2 = 0,02\ mol$

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

$\therefore m = n \times M = 0,02 \times 40 = 0,8\ g$

Question 22

22.1 Balanced equation:
$HC\ell + NaOH \rightarrow NaC\ell + H_2O$

$HC\ell : NaOH$
$= 1 : 1$
$= 0,2 : 0,2$

0,2 mol $HC\ell$ requires a minimum of 0,2 mol NaOH to react completely.