Interesting Science fact #7

When a flea jumps, the rate of acceleration is 20 times that of the space shuttle during launch.

PHYSICAL SCIENCES

Content Booklet: Targeted Support

GRADE 10 TERM 2

A MESSAGE FROM THE NECT

NATIONAL EDUCATION COLLABORATION TRUST (NECT)

Dear Teachers

This learning programme and training is provided by the National Education Collaboration Trust (NECT) on behalf of the Department of Basic Education (DBE)! We hope that this programme provides you with additional skills, methodologies and content knowledge that you can use to teach your learners more effectively.

What is NECT?

In 2012 our government launched the National Development Plan (NDP) as a way to eliminate poverty and reduce inequality by the year 2030. Improving education is an important goal in the NDP which states that 90% of learners will pass Maths, Science and languages with at least 50% by 2030. This is a very ambitious goal for the DBE to achieve on its own, so the NECT was established in 2015 to assist in improving education.

The NECT has successfully brought together groups of people interested in education so that we can work collaboratively to improve education. These groups include the teacher unions, businesses, religious groups, trusts, foundations and NGOs.

What are the learning programmes?

One of the programmes that the NECT implements on behalf of the DBE is the 'District Development Programme'. This programme works directly with district officials, principals, teachers, parents and learners; you are all part of this programme!

The programme began in 2015 with a small group of schools called the Fresh Start Schools (FSS). Curriculum learning programmes were developed for Maths, Science and Language teachers in FSS who received training and support on their implementation. The FSS teachers remain part of the programme, and we encourage them to mentor and share their experience with other teachers.

The FSS helped the DBE trial the NECT learning programmes so that they could be improved and used by many more teachers. NECT has already begun this scale-up process in its Universalisation Programme and in its Provincialisation Programme.

Everyone using the learning programmes comes from one of these groups; but you are now brought together in the spirit of collaboration that defines the manner in which the NECT works. Teachers with more experience using the learning programmes will deepen their knowledge and understanding, while some teachers will be experiencing the learning programmes for the first time.

Let's work together constructively in the spirit of collaboration so that we can help South Africa eliminate poverty and improve education!

CONTENTS

PROGRAMME ORIENTATION 5
PROGRAMME ORIENTATION 5
PHYSICAL SCIENCES PLANNING AND PREPARATION 11
CREATING A POSITIVE LEARNING ENVIRONMENT 18
TOPIC 11: PARTICLES SUBSTANCES ARE MADE OF 21
INTRODUCTION 21
SEQUENTIAL TABLE 22
GLOSSARY OF TERMS 23
ASSESSMENT OF THIS TOPIC 24
BREAKDOWN OF TOPIC AND TARGETED SUPPORT OFFERED 25
TARGETED SUPPORT PER SUB TOPIC 26
TOPIC 12: PHYSICAL AND CHEMICAL CHANGE 41
INTRODUCTION 41
SEQUENTIAL TABLE 42
GLOSSARY OF TERMS 43
ASSESSMENT OF THIS TOPIC 44
BREAKDOWN OF TOPIC AND TARGETED SUPPORT OFFERED 45
TARGETED SUPPORT PER SUB TOPIC 46
TOPIC 13: REPRESENTING CHEMICAL CHANGE 58
INTRODUCTION 58
SEQUENTIAL TABLE 59
GLOSSARY OF TERMS 60
ASSESSMENT OF THIS TOPIC 60
BREAKDOWN OF TOPIC AND TARGETED SUPPORT OFFERED 61
TARGETED SUPPORT PER SUB TOPIC 62
TOPIC 14: MAGNETISM 70
INTRODUCTION 70
SEQUENTIAL TABLE 71
GLOSSARY OF TERMS 72
ASSESSMENT OF THIS TOPIC 73
BREAKDOWN OF TOPIC AND TARGETED SUPPORT OFFERED 74
TARGETED SUPPORT PER SUB TOPIC 75
TOPIC 15: ELECTROSTATICS 87
INTRODUCTION 87

CONTENTS

SEQUENTIAL TABLE 88
GLOSSARY OF TERMS 89
ASSESSMENT OF THIS TOPIC 90
BREAKDOWN OF TOPIC AND TARGETED SUPPORT OFFERED 91
TARGETED SUPPORT PER SUB TOPIC 92
TOPIC 16: ELECTRIC CIRCUITS 102
INTRODUCTION 102
SEQUENTIAL TABLE 103
GLOSSARY OF TERMS 104
ASSESSMENT OF THIS TOPIC 105
BREAKDOWN OF TOPIC AND TARGETED SUPPORT OFFERED 106
TARGETED SUPPORT PER SUB TOPIC 107

PROGRAMME ORIENTATION

Welcome to the NECT Physical Sciences learning programme! This CAPS compliant programme consists of:

- A Content Booklet: Targeted Support
- A Worksheet Booklet
- A Planner & Tracker to help you plan lessons and monitor curriculum coverage
- A Practical Booklet and Videos
- A Set of Posters
- A Formal Assessment Support Booklet

OVERVIEW AND APPROACH OF PROGRAMME

The FET Physical Sciences curriculum is long and complex. There are many quality textbooks and teachers' guides available for use. This programme does not aim to replace these resources, but rather, to supplement them in a manner that will assist teachers to deliver high quality Physical Sciences lessons.

Essentially, this programme aims to provide targeted support to teachers by doing the following:

1. Clarifying and explaining key concepts.
2. Clarifying and explaining possible misconceptions.
3. Providing worked examples of questions at an introductory level.
4. Providing worked examples of questions at a challenge level.
5. Providing the key teaching points to help learners deal with questions at challenge level.
6. Providing worksheet examples and corresponding memoranda for each topic.
7. Providing a Planner & Tracker that helps teachers to plan their lessons for a topic, and track their progress, pacing and curriculum coverage.
8. Providing videos of formal assessment practicals, together with worksheets and memoranda.
9. Providing guidance on how to structure formal assessment tasks.
10. Providing a 'bank' of questions and memoranda that may be used to structure formal assessment tasks.
11. Providing a set of posters with key information to display in the classroom.

PROGRAMME ORIENTATION

CONTENT BOOKLET: TARGETED SUPPORT

1. The booklet starts with a ***contents page*** that lists all the topics for the term.

2. Every topic begins with a ***general introduction*** to the topic that states how long the topic runs for and the value of the topic in the final exam. It also gives a general idea of what is covered in the topic, and why this is important for our everyday lives.

3. This is followed by a ***list of requirements*** for the teacher and the learner. Try to ensure that you have all requirements on hand for the topic, and that your learners always have their requirements ready for each lesson. This is a simple classroom management practise that can improve your time-on-task and curriculum coverage significantly!

4. Next, you will see a ***sequential table*** that shows the prior knowledge required for this topic, the current knowledge and skills that will be covered, and how this topic will be built on in future years. Use this table to give learners an informal quiz to test their prior knowledge. If learners are clearly lacking in the knowledge and skills required, you may need to take a lesson to cover some of the essential content and skills. It is also useful to see what you are preparing learners for in the years to follow, by closely examining the 'looking forward' column.

5. This is followed by a **glossary of terms**, together with an explanation of each term. It is a good idea to display these words and their definitions somewhere in the classroom, for the duration of the topic. It is also a good idea to allow learners some time to copy down these definitions into their books. You must explicitly teach the words and their meanings as and when you encounter these words in the topic.

   Once you have taught a new word or phrase, try to use it frequently in statements and questions. It takes the average person 20 – 25 authentic encounters with a new word to fully adopt it and make it their own.

6. Next, there are some very brief notes about the ***assessment*** of this topic. This just informs you of when the topic will be assessed, and of the kinds of questions that are usually asked. Assessment is dealt with in detail in the Assessment Booklet.

7. The next item is very useful and important. It is a table showing the ***breakdown of the topic and the targeted support offered.***

   This table lists the ***sub topic***, the classroom ***time allocation*** for the sub topic, and the ***CAPS page reference***.

   The table also clearly states the ***targeted support*** that is offered in this booklet. You will see that there are three main kinds of support offered:
   a. Key concepts are clarified and explained.
   b. Possible misconceptions are clarified and explained.

   c. Questions are modelled and practised at different levels (introductory level and challenge level).

8. After this introduction, the ***targeted support for each sub topic*** commences. This generally follows the same routine:
   a. A key concept or key c**oncepts are clarified and explained.** It may be useful for you to work through this carefully with learners, and do any demonstrations that are included.
   b. **Questions** related to the key concepts are worked and explained.
      - These questions may be done at introductory level, at challenge level, or both.
      - It is important to expose learners to **challenge level questions**, as this is often how questions are presented in exams.
      - These questions also challenge learners to apply what they have learnt about key concepts. Learners are, essentially, challenged to think at a critical and analytical level when solving these problems.
      - Please note that when calculations are done at challenge level, the key teaching points are identified.
      - Make sure that you effectively share these key teaching points with learners, as this can make all the difference as to whether learners cope with challenge level questions or not.
   c. At key points in the topic, **checkpoints** are introduced.
      - These checkpoints involve asking learners questions to check that they understand everything to that point.
      - The checkpoints also refer to a worksheet activity that is included in the Worksheet Booklet.
      - Use checkpoints to ascertain whether more consolidation must be done, or if your learners are ready to move to the next key concept.

9. Every topic ends with a ***consolidation exercise*** in the Worksheet Booklet. This exercise is not scaffolded as a test, it is just a consolidation of everything covered in this programme for that topic.

10. Finally, a section on ***additional reading / viewing*** rounds off every topic. This is a series of web links related to the topic. Please visit these links to learn more about the topic, and to discover interesting video clips, tutorials and other items that you may want to share with your learners.

PROGRAMME ORIENTATION

THE WORKSHEET BOOKLET

1. The Worksheet Booklet has different worksheets and corresponding memoranda for each topic.
2. First, there is a ***practice worksheet***, with questions that learners must complete during the topic. These are referred to in the checkpoints.
3. Once learners have completed these calculations, it is important to mark their work, using the ***memorandum*** supplied. Either do this together as a whole class, or display copies of the memorandum around the classroom, in spaces where learners can go and mark their work for themselves.
4. It is important that learners see how marks are allocated in the memorandum, so that they fully understand how to answer questions in tests and exams.
5. At the end of each topic, there is a ***consolidation worksheet*** and memorandum. This worksheet is a consolidation exercise of all the calculations covered in the topic. The consolidation worksheet is NOT scaffolded and it not designed to be used as a formal test. The level of the worksheet will be too high to be used as a test.
6. Again, it is important for learners to mark their work, and to understand how marks are allocated for each question.
7. Please remember that these worksheets do not replace textbook activities. Rather, they supplement and extend the activities that are offered in the textbook.

THE PLANNER & TRACKER

1. The Planner & Tracker is a useful tool that will help you to effectively plan your teaching programme to ensure that it is CAPS compliant.
2. The Planner & Tracker has a section for every approved textbook, so that regardless of the textbook that you use, you will be able to use this tool.
3. It also has space for you to record all lessons completed, which effectively allows you to monitor your curriculum coverage and pacing.
4. In addition, there is space for you to reflect on your progress and challenges at the end of each week.
5. At the end of the Planner & Tracker, you will find a series of resources that may be useful to you when teaching.
6. You will also find a sample formal assessment and memorandum.

PROGRAMME ORIENTATION

THE PRACTICALS BOOKLET AND VIDEOS

1. The following practicals must be completed as part of the formal assessment programme:
   a. Grade 10 Term 1: Heating and cooling curve of water
   b. Grade 10 Term 2: Electric circuits with resistors in series and parallel - measuring potential difference and current
   c. Grade 10 Term 3: Acceleration
   d. Grade 11 Term 1: Relationship between force and acceleration
   e. Grade 11 Term 2: The effects of intermolecular forces on: BP, MP, surface tension, solubility, capillarity
   f. Grade 12 Term 1: Preparation of esters
   g. Grade 12 Term 2:
      1) Titration of oxalic acid against sodium hydroxide
      2) Conservation of linear momentum
   h. Grade 12 Term 3:
      a) Determine the internal resistance of a battery
      b) Set up a series-parallel network with known resistor. Determine the equivalent resistance using an ammeter and a voltmeter and compare with the theoretical value.
2. Videos of all the listed practicals are supplied as part of this programme.
3. These videos should ideally be used as a teacher's guide. After watching the video, set up and complete the practical with your learners. However, if this is not possible, then try to show the video to your learners and allow them to record and analyse results on their own.
4. The videos should be used in conjunction with the practical worksheets. Learners should complete the worksheet whilst watching the video.

THE POSTERS

1. Every FET Physical Sciences teacher will be given the following set of five posters to display in the classroom:
   a. Periodic Table
   b. Chemistry Data Sheet
   c. Physics Data Sheet Part 1
   d. Physics Data Sheet Part 2
   e. Chemistry Half Reactions
2. <u>Please note that you will only be given these videos and posters once</u>.
   a. Make sure you store the videos safely.
   b. It is also important for you to make these posters as durable as possible. Do this by:

- Writing your name on all posters
- Laminating posters, or covering them in contact paper

3. Have a dedicated wall or notice board in your classroom for Physical Sciences, per grade:
   - Use this space to display the posters
   - Display definitions and laws
   - Display any additional relevant or interesting articles or illustrations
   - Try to make this an attractive and interesting space

THE ASSESSMENT BOOKLET

1. A separate Assessment Booklet is provided for Grade 10, Grade 11 and Grade 12.

2. These booklets first show you how to structure the formal assessment tasks for each term, according to CAPS requirements.

3. Next, the booklets provide you with a ‘bank’ of sample assessment questions for each topic.

4. This is followed by the memoranda for all the different questions that details the allocation of marks.

5. This booklet gives you all the support required to structure and design different tests and exams correctly.

PHYSICAL SCIENCES PLANNING AND PREPARATION

1. Get into the habit of planning every topic by using the following documents together:
   a. The Physical Sciences Planner & Tracker
   b. The Content Booklet: Targeted Support
   c. The Worksheet Booklet
   d. The Practicals Booklet and Videos
   e. Your Textbook

2. Planning should always be done well in advance. This gives you the opportunity to not only feel well prepared but also to ask a colleague for help if any problems arise.

3. Follow these steps as you plan to teach a topic:
   a. <u>Turn to the relevant section in the **Planner & Tracker** for your textbook.</u>
      - Look through the breakdown of lessons for the topic.
      - In pencil, fill in the dates that you plan to teach each lesson. This will help with your sequencing.

   b. <u>Next, look at the topic in the Content Booklet: **Targeted Support.**</u>
      - Read through all the introduction points, including the table that shows the breakdown of lessons, and the targeted support offered.
      - Take note of the targeted support that is offered for each section.
      - Read through the whole topic in the Content Booklet: Targeted Support.
      - Complete all the examples in the Worksheet Booklet for the topic, including the Consolidation Worksheet.
      - Check your solutions against the memorandum.
      - Make notes in your Planner & Tacker to show where you will include the targeted support teaching and activities.

   c. <u>Next, turn to the relevant section in your **Textbook**.</u>
      - Read through each key concept in the Textbook.
      - Complete as many examples as possible. This will also help in your teaching – you will remember more points to share with the learners if you have done all of the work yourself.
      - Make careful notes in your Planner and Tracker of which sections and activities you will teach from the Textbook, and which you will teach from the Content Booklet: Targeted Support.
      - It will strengthen your teaching to use a combination of the two resources, but be careful not to leave anything out!

   d. <u>If the Topic includes one of the Practicals for formal assessment, then consult the **Practical Booklet and Video.**</u>
      - Complete the worksheet for the practical, whilst watching the video.
      - Try by all means to set up the practical and to conduct it with your learners. However, if this is not possible, ensure that learners see the video and complete the worksheet.

e. Document your **lesson plans** in the way that you feel most comfortable.
   - You may like to write notes about your lesson plans in a notebook.
   - You may like to use a standardised template for lesson planning. (A template is provided at the end of this section).
   - Remember to make notes about where you will use the textbook activities, and where you will use the targeted support activities.

f. Ideally, **Lesson Planning** for a topic should include:
   - Time to introduce the topic to learners
   - Time to establish the learners' prior knowledge
   - If required, time to address critical gaps in learners' prior knowledge
   - Introduction of terminology (glossary words)
   - Time to introduce and teach each key concept
   - Time for learners to complete practise exercises for each key concept
   - Time to correct and remediate each key concept
   - Time for a consolidation worksheet
   - Time to complete the required practicals

Note: Avoid giving learners an exercise to do that you haven't already completed yourself. This is useful for when the learners ask questions or get stuck on a question. You will be ready to assist them immediately instead of wasting time reading the question and working it out then.

PREPARATION AND ORGANISATION

1. Once you have completed your planning for a topic, you must make sure that you are properly prepared and organised to teach it.

2. Do this by completing all the steps listed in the planning section, including completing all the textbook and worksheet examples.

3. Have your lesson plans or teaching notes ready to work from.

4. Next, make sure that you have all resources required for the lesson.

5. Prepare your notice board for the topic, to give learners something visual to anchor their learning on, and to generate interest around the topic.

6. Print copies of the worksheets for all learners.

SAMPLE TEMPLATE FOR LESSON PLANNING

PHYSICAL SCIENCES LESSON PLAN

School	
Teacher's name	
Grade	
Term	
Topic	
Date	
Lesson Duration	

1. CONCEPTS AND SKILLS TO BE ACHIEVED:
   By the end of the lesson learners should know and be able to:

2. RESOURCES REQUIRED:

3. HOMEWORK REVIEW / REFLECTION:

Exercises to be reviewed and notes:

4. LESSON CONTENT / CONCEPT DEVELOPMENT

Explanation and examples to be done:

5. CLASSWORK ACTIVITY

Resource 1	
Page	
Exercise	
Resource 2	
Page	
Exercise	

Notes:

6.HOMEWORK ALLOCATION

Resource 1	
Page	
Exercise	
Resource 2	
Page	
Exercise	

7. LESSON REFLECTION:

What went well:
What could have gone better:

TERM 2 EXAM PREPARATION

Note: It is important to start preparing learners for their **exam from the beginning of the term**.

1. Make sure that your learners know exactly when their Physical Sciences exams will be written.
2. Ask learners to take out their exercise books, and to mark off what must be studied.
   a. Go through all their written work and textbook activities, and get them to tick off the work that they must study and practise.
   b. If learners are missing notes, they must copy the missing work from another learner.
   c. As you complete more work during the term that will be in the exam, tell learners to tick it off and to add it to their study plans.
3. If necessary, help learners to work out a study schedule.
   a. Estimate how long learners will need to study all the content required for the exam. This will differ from grade to grade, and from learner to learner.
   b. Be aware that some learners, even in the FET stage, have not yet developed these planning skills.
   c. Tell learners the number of hours that you think they need to study before the exam.
   d. Break this down into the number of hours they should study each week.
   e. Tell learners to think about their own lives and habits, and to work out when they have time to study, and when they study best.
   f. They must then use all of this information to work out their study and revision plan.

USEFUL REVISION RESOURCES

1. **Assessment Booklets**

   a. THE Assessment Booklets that form part of this series may be used as a very useful exam preparation tool.

   b. These booklets include a ‘bank’ of questions for each topic at the different conceptual levels.

   c. If your province or district provides standardised tests and exams, use the questions in this booklet at revision and exam preparation for learners.

   d. Remember to carefully explain the question structure and meaning, together with the mark allocation.

2. **DBE Grade 12 ‘Mind the Gap’ Study Guide**s

   a. Grade 12 learners can access the ‘Mind the Gap’ Study Guides on the DBE website: https://www.education.gov.za/Curriculum/LearningandTeachingSupportMaterials(LTSM)/MindtheGapStudyGuides.aspx

   b. This series includes Grade 12 study guides for:

      - Physical Science: Physics
      - Physical Science: Chemistry

   c. These guides include an overview of the Grade 12 exam structures, useful study techniques, a guide to questions types, a comprehensive list of question words / terms, as well as a summary of key content and skills.

   d. Consider downloading a copy of these guides, and making copies for Grade 12 learners if possible.

   e. Alternately, tell learners how to access this useful resource.

3. **Vodacom e-school**

   a. If learners have a Vodacom number, they are eligible to use the Vodacom e-school as a free service, i.e. no data costs: http://www.vodacom.co.za/vodacom/test-templates/eschool-two

   b. This e-school includes Physical Science lessons as part of its curriculum.

   c. Tell learners how to access this useful resource.

CREATING A POSITIVE LEARNING ENVIRONMENT

The best learning takes place when learners feel safe and confident enough to participate. It is up to you, as the teacher, to create the kind of atmosphere that will promote discussion and learning. Below are some tips to help you with this important challenge:

1. **Work constantly to create the atmosphere that you want.** It takes time for teachers and learners to understand and adopt the behaviours required for a safe, positive classroom. Don't give up if it doesn't happen straight away – keep working towards creating a feeling of emotional safety in your classroom.

2. **Take an interest in learners' work.** Most of the time, you will probably get learners to correct their own work, either by working through the solutions on the chalkboard, or by posting up the memoranda for learners to see. However, it is a good idea to look through learners' exercise books from time to time. This allows you to verify that your learners are doing their work, and are on track. It is also a time for you to show interest in learners' progress. Tell learners when you are pleased or impressed with their progress or efforts. This shows learners that you are interested, supportive, and that you value their work.

3. **Establish and implement ground rules.** Work out a set of ground rules for your classroom – it is a good idea to do this together with the learners.
    - Tell learners that you need a set of ground rules to set the tone for the classroom, and to manage how you work together.
    - Ask learners to contribute their ideas for the ground rules. As a learner makes a suggestion, write it down. Do not reject anyone's suggestion at this point.
    - When everyone has contributed their ideas, read through the list together. Eliminate duplicate ideas. If there are key rules missing, ask prompting questions, to try and get learners to suggest them.
    - Finally, ask learners if they are all prepared to accept and live by these rules. If there is a rule that needs to be adjusted or removed, do so. Make it clear that these are their rules, and that they have accepted them, and must therefore abide by them.
    - Also talk to learners about self-moderation.
    - This means that you accept that they are young adults, and that they should not need a teacher to tell them how to behave.
    - By this stage of their lives, they should be able to assess if their behaviour is out-of-line, and to adjust or self-moderate their behaviour.
    - Whilst you should expect learners to self-moderate their behaviour by the FET stage, if a learner behaves really badly, particularly in a way that makes another learner feel bad or unsafe, you need to implement consequences.
    - Learners need to know that you will take action against harmful behaviour. If you do not do this, it will be difficult for learners to trust you.

4. **Correct mistakes clearly, but without derision.** When learners make mistakes, thank them for trying, but point out that a mistake has been made. Correct the mistake clearly and quickly, and then move on. Do not labour the point – learners must see that it is perfectly acceptable to make mistakes as long as one tries.

5. **Tell learners if you do not know something.** Learners appreciate it when teachers are honest, and say things like, 'I'm not really sure. Does anyone else know? Should we look up the answer?'

6. **Model the kind of behaviour you expect in your class.** We often hear the phrase 'respect is earned', or 'respect is a two-way street', but we don't always think about what that means.
   - The simplest explanation is to model the behaviour that you expect from your learners, and to treat them the way that you want to be treated.
   - Be punctual and prepared for lessons; work diligently; keep your space clean, tidy and organised; never use your cell phone in class; look after your apparatus and resources; greet learners; be considerate of their feelings; praise learners for a job well done; thank learners for going the extra mile; and go the extra mile yourself.
   - This may not be reciprocated immediately, but in time, learners will learn from your model, and will begin to behave as you do within your environment.
   - Feel free to hold an open, honest discussion with learners about this concept. Let learners know that you will try to always treat them with consideration and respect, and that you will always work hard for them.
   - Let your learners know that you will appreciate them trying to do the same.

7. **Move around the classroom.** As learners work, walk around the classroom. Use this opportunity to stop and look at individual learner's work. Stop and discuss challenges – help individual learners as much as you can. Look out for problems between learners, and deal with issues that arise. Get to know your learners better. If tension is building between learners, put a stop to the argument. Then, find time for the learners to talk it out while you mediate.

8. **Laugh with your learners.** If you can find something to laugh about with your learners, do so! This is an excellent way to bond with learners, and to make them feel closer to you. Laughter is also an excellent way to break down tensions, and to get learners to relax.

9. **Leave your problems outside of the classroom.** Learners pick up on your stress, anxiety and unhappiness, and this can affect them negatively. Try your best to be in the habit of leaving your problems at the classroom door, and to focus on your learners once you are inside the classroom.

10. **Praise your learners for their efforts.** This is one of the easiest and most effective behaviours that you can implement.

- Praise learners not for their achievements, but for their efforts. This will encourage learners to try and do more.
- This is known as building a ‘growth mindset’. This means that learners believe that they can learn and progress.
- The opposite of a growth mindset is a ‘fixed mindset’, where learners believe they are born with a certain ability, and that they cannot change this.

TOPIC 11: Particles substances are made of

A INTRODUCTION

- This topic runs for 8 hours.
- For guidance on how to break down this topic into lessons, please consult the NECT Planner & Tracker.
- Particles substances are made of forms part of the content area Matter and Materials (Chemistry).
- Matter and Materials counts as 48 % in the final exam.
- Particles substances are made of counts approximately 6% to 8% of the final examination.
- All matter is ultimately made up of atoms, whether the atoms are on their or in combination with others. It is these combinations that make it possible for the multitude of different substances that are present in our world. In this topic we will discuss the nature of molecular substances and ionic substances.

CLASSROOM REQUIREMENTS FOR THE TEACHER

1. Chalkboard.
2. Chalk.
3. Grade 10 Physics Examination data sheet

CLASSROOM REQUIREMENTS FOR THE LEARNER

1. A4, 3 Quire exercise book, for notes and exercises
2. Pen
3. Periodic table

B

SEQUENTIAL TABLE

PRIOR KNOWLEDGE	CURRENT	LOOKING FORWARD
Grade 7-9	**Grade 10**	**Grade 11-12**
• Atoms and subatomic particles • Basic knowledge of the periodic table	• Understanding of the periodic table • Lewis diagrams • Covalent bonding • Ionic bonding • Metallic bonding • Covalent molecular structures • Covalent network structures • Ionic substances • Represent molecules in various ways. • Molecular formula and empirical formula	• Intermolecular forces • Molecular structure • Quantitative aspects of chemical change

C

GLOSSARY OF TERMS

Please note: The highlighted definitions and laws are ones that learners must be able to state and are given in the CAPS document. For examination purposes, learners must know these definitions and laws by heart, and must write them exactly as they appear here.

TERM	DEFINITION
Compound	A group of two or more different atoms that are attracted to each other by relatively strong forces or bonds and combine in a fixed ratio.
Molecule	The particle that results from the covalent bonding of two or more atoms.
(A) salt	A substance that results from ionic bonding.
Delocalised electrons	Electrons in a lattice that are not bonded to specific atoms but are spread over the entire structure.
Covalent molecular structures	Substances made of separate molecules.
Covalent network structures	Consist of giant repeating lattices of covalently bonded atoms.
Molecular formula	Is a chemical formula showing the exact number of atoms of each element in a molecule.
Empirical formula	This represents the smallest ratio of atoms of each element in a giant structure.
Polyatomic	Consisting of many atoms.
Monatomic	Consisting of one atom.
Diatomic	Consisting of two atoms.
Electrolysis	This is the process of splitting up compounds by passing an electric current through them.
Allotropes	These are different physical forms of the same element.

D ASSESSMENT OF THIS TOPIC

- This topic is assessed by means of a class test and the June and term 4 examinations.
- Recommended experiment: Investigate elements and compounds.
- Recommended experiment: Electrolysis of water.
- Recommended project: Making models of various compounds and elements.

E

BREAKDOWN OF TOPIC AND TARGETED SUPPORT OFFERED

TIME ALLOCATION	SUB TOPIC	CAPS PAGE NUMBER	TARGETED SUPPORT OFFERED
8 hours	Atoms and compounds: • Molecular substances • Ionic substances and metals	32-34	a. Description of a compound b. Covalent molecular structures c. Covalent network structures d. Ionic substances e. Metals f. Models including drawing circle structures, space filling models and ball and stick models g. Molecular formulae and empirical formulae

F

TARGETED SUPPORT PER SUB TOPIC

1. ATOMS AND COMPOUNDS: MOLECULAR SUBSTANCES

INTRODUCTION

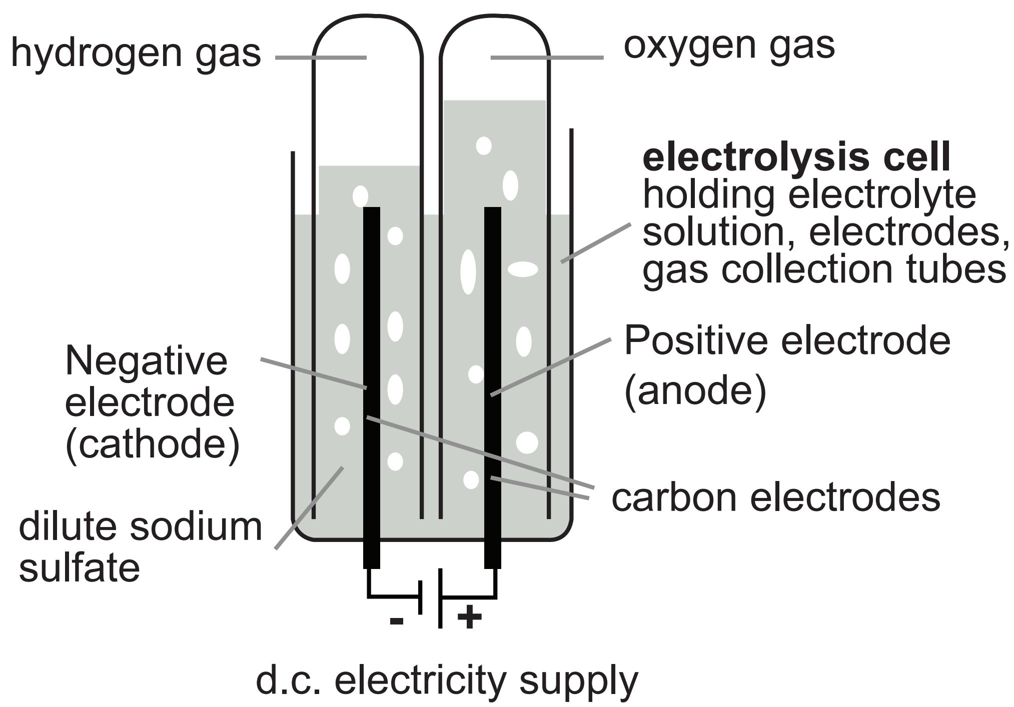
Molecular substances consist of molecules and comprise many common substances.

CONCEPT EXPLANATION AND CLARIFICATION: ATOMS AND COMPOUNDS: MOLECULAR SUBSTANCES

Description of a compound

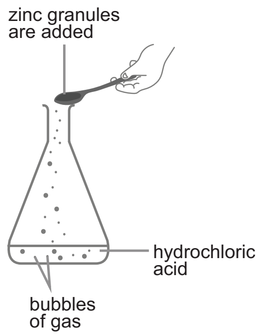
- Atoms are the smallest particles of which everything is made. The only substances that occur in the atomic form in nature are the noble gases. Some elements occur as diatomic molecules, e.g. H_2, N_2, O_2.
- Atoms join to form compounds (although as mentioned some atoms bond and remain elements. This includes metals.).
- When different atoms join, they either form molecular substances or ionic substances. When compounds form, they combine in a specific ratio. Compounds can be separated into their elements by chemical means.

Recommended experiment: The electrolysis of water. Below is an illustration of the apparatus used for this experiment.



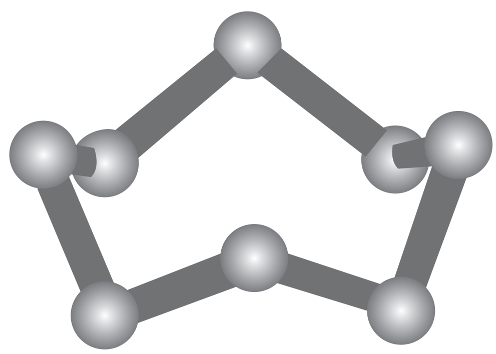
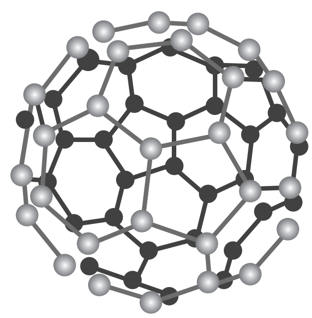
Note that some dilute sodium sulfate must be added to the water first. The gases produced are hydrogen and oxygen, and are collected in a ratio of 2:1. This is the ratio of hydrogen to oxygen in water.

Recommended experiment: The reaction between zinc and dilute hydrochloric acid. The apparatus used is shown in the illustration.

	This can also be done in a test tube. The gas coming off can be ignited with a match to show that it is hydrogen gas.

Covalent molecular structures

- Atoms form covalent bonds when there is a sharing of electrons between atoms. The resulting group of atoms that are joined together are called a molecule. As mentioned in the previous topic, molecular substances are composed of non-metal atoms.
- Covalent molecular substances consist of separate molecules. Examples of these are water, carbon dioxide, carbon disulfide (CS_2), etc.
- Elements made up of molecules are not limited to diatomic molecules. Substances like sulfur (which occurs as S_8 molecules) and Buckminsterfullerine (which consists of molecules made up of 60 carbon atoms) are examples of these.

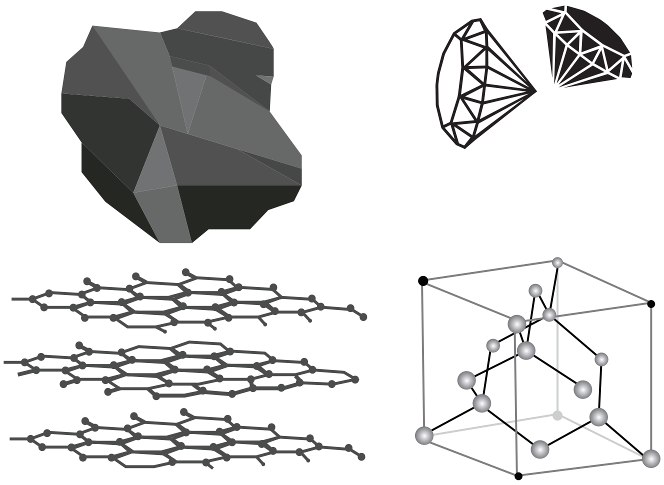
Molecule of sulfur (S_8)	Buckminsterfullerine (C_{60})
	

- A molecule of buckminsterfullerine looks just like a standard soccer ball.
- Covalent molecular structures made up of simple molecules generally have low melting points and boiling points because the molecules are held together by weak

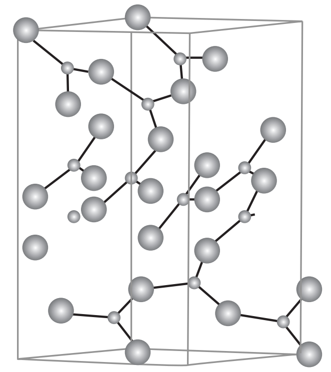
intermolecular forces.

Covalent network structures

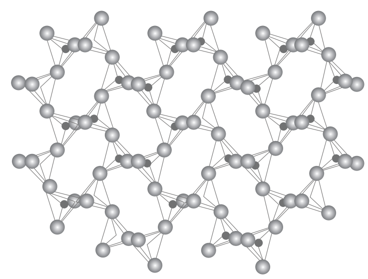
- Covalent network structures consist of giant molecules and have repeating crystal lattices. The atoms are bonded covalently.
- The structures are very strong because of the strength of covalent bonds. This means that this type of substance has very high melting and boiling points.
- An example of these substances is diamond, which is made up of carbon atoms only and every carbon atom is bonded covalently to four others. Diamond is hardest natural substance known and has a melting point of about 3 600 °C.
- Another example of this type of substance is graphite, which also consists only of carbon atoms. In this case the carbon atoms are covalently bonded to three others to form hexagonal rings that result in flat planes of graphite which are held together by weak intermolecular forces. However, there is one unpaired electron on each carbon atom, which results in there being delocalised electrons between the planes. This makes graphite the only non-metal that conducts electricity.



- Diamond and graphite are said to be allotropes of carbon. Allotropes are different physical forms of the same element.
- There are also network structures formed by molecules. Examples of these are silicon dioxide (SiO_2) and boron trioxide (B_2O_3).
- The molecules of SiO_2 and the molecules of B_2O_3 in these structures bond covalently with each other to form network structures.



Boron trioxide



Silicon dioxide

INTRODUCTORY LEVEL QUESTIONS

a. These are the basic questions that learners will be required to answer at this stage in the topic.

b. Their purpose is to familiarise the learners with the content.

How to tackle these questions in the classroom:

- Work through these examples with learners.
- Learners must copy the question as well as the solution into their workbook.

1. List two examples of:

   a. Monatomic elements

   b. Molecular elements, which are diatomic.

   c. Molecular elements, which are polyatomic.

Solution

a. He, Ne, Ar… (any noble gases)

b. F_2, $C\ell_2$, O_2, H_2, N_2, any halogen

c. Sulfur (S_8), Buckminsterfullerine (C_{60})

2. Give a description of the differences between covalent molecular substances and covalent network substances. Give an example of each type of substance.

Covalent molecular substances are those that are made up of molecules, whether elements or compounds. In these substances, the molecules are held together by weak intermolecular forces and so they have generally low melting points and boiling points. An example is CO_2. Other examples are H_2O, O_2, N_2, etc.

Covalent network structures are made up atoms (or molecules) that are held together by strong covalent bonds. The result is that substances have very high melting points and boiling points.

An example is diamond (or graphite). Also included are substances that have molecules that are covalently and have similar properties. An example is SiO_2 (or B_2O_3).

CHECKPOINT

At this point in the topic, learners should have mastered:

1. Basic knowledge about covalent bonding.
2. The fact that covalent substances can occur as molecular structures or network structures.
3. What substances are examples of each of these.

Check learners' understanding of these concepts by getting them to work through:

Worksheet Pack: Particles that substances are made of: Questions 1 – 4

- Check learners' understanding by marking their work with reference to the memorandum.
- If you cannot photocopy the memorandum for each learner, make three or four copies of it and place these on the walls of your classroom.
- Allow learners time to mark their own work.
- Encourage the learners to learn from the mistakes they make.

2. ATOMS AND COMPOUNDS: IONIC SUBSTANCES AND METALSINTRODUCTION

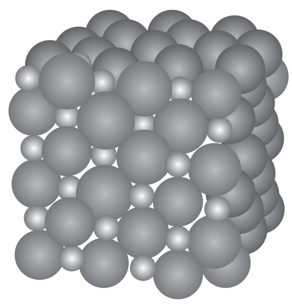
Introduction

Ionic compounds and metals cover a whole host of very different substances. Many of these are elements (metals) while others are minerals from which metals are recovered.

Ionic substances

CONCEPT EXPLANATION AND CLARIFICATION: ATOMS AND COMPOUNDS: IONIC COMPOUNDS AND METALS

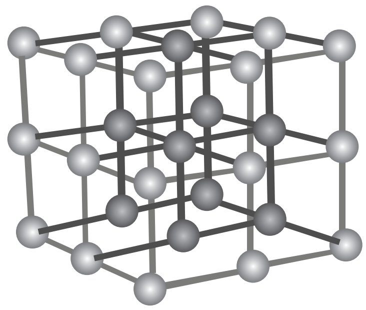
- Ionic bonding, as we know, involves the transfer of electrons. When electron transfer takes place, usually between metals and non-metals, the atom that loses electrons becomes a positive ion (cation) and the one that gains the electrons becomes a negative ion (anion).
- Ionic compounds are usually formed when metals react with non-metals. The metal atoms form cations and the non-metal atoms form anions.
- The ions thus formed, having opposite electrical charges, are attracted to each other and come together in millions upon millions to form a crystal lattice.
- This illustration represents the crystal lattice of calcium sulfide (CaS). In the lattice there are positive calcium ions (grey spheres) and negative sulfide ions (yellow spheres).



- Other examples of ionic compounds are sodium chloride (table salt – $NaC\ell$) and potassium permanganate ($KMnO_4$).
- Ionic substances are hard and brittle because of the strong ionic bonds between the ions. They also have high melting points and boiling points. They do not conduct electricity in the solid state because there are no charged particles that are free to move and carry charge. When they are molten or in solution, however, they ions are free to move and carry charge and they then conduct electricity.

Metals

- Metal atoms do not lose their electrons entirely when they combine with other atoms of the same metal. The valence electrons become delocalised over the entire structure and are not associated with any particular atom.
- The positive metal ions form a crystal lattice when they are surrounded by the delocalised electrons. The structure is held together by the attraction between the positive ions and delocalised electrons.
- The following model shows the positive ion arrangement in a metallic crystal lattice.



Metallic crystal lattice

- All metals form crystal lattices containing positive ions only. However; there are a number of possible arrangements of the ions in different metals. This is beyond our discussions at this stage.
- The properties of metals are that they are good conductors of electricity because they all contain delocalised electrons. They generally have relatively high melting points and boiling points. They are soft and can be shaped. Examples of metals are copper, iron, aluminium, etc. The table summarises the properties of the substances discussed so far.

Type of substance	Melting point and boiling point	Hardness	Conduction of electricity	Units that make up the solid
Covalent	Low	Soft	Does not conduct	Molecules
Ionic	High	Hard	Only when molten or in solution	Positive and negative ions
Metallic	High/low	Soft	Good conductors	Positive ions
Giant covalent	Extremely high	Hard	Graphite does conduct. Diamond does not conduct.	Atoms

TOPIC 11: Particles substances are made of

INTRODUCTORY LEVEL QUESTIONS

a. These are the basic questions that learners will be required to answer at this stage in the topic.

b. Their purpose is to familiarise the learners with the content.

How to tackle these questions in the classroom:

- Work through these examples with learners.
- Learners must copy the question as well as the solution into their workbook.
- Explain each step of the question to the learners as you complete it on the chalkboard.

1. Give the chemical names for the following compounds:

   a. $CaBr_2$

   b. K_2S

   c. LiF

   d. $A\ell_2S_3$

Solution

a. calcium bromide

b. potassium sulfide

c. lithium fluoride

d. aluminium sulfide

2. Give three differences between the properties and of ionic compounds and metals.

Solution

- Metals conduct electricity whether they are solid or molten. Ionic compounds only conduct electricity when they are molten or in solution.
- Ionic compounds generally have higher melting points and boiling points than metals.
- Metals are soft and can be shaped, ionic compounds are hard and brittle.

TOPIC 11: Particles substances are made of

CHECKPOINT

At this point in the topic, learners should have mastered:

1. The differences between ionic bonding and metallic bonding.
2. The difference between the crystal lattices of ionic compounds and those of metals.

Check learners' understanding of these concepts by getting them to work through:

Worksheet Pack: Particles that substances are made of: Questions 5,6

- Check learners' understanding by marking their work with reference to the memorandum.
- If you cannot photocopy the memorandum for each learner, make three or four copies of it and place these on the walls of your classroom.
- Allow learners time to mark their own work.
- Encourage the learners to learn from the mistakes they make.

Models including drawing circle structures, space filling models and ball and stick models

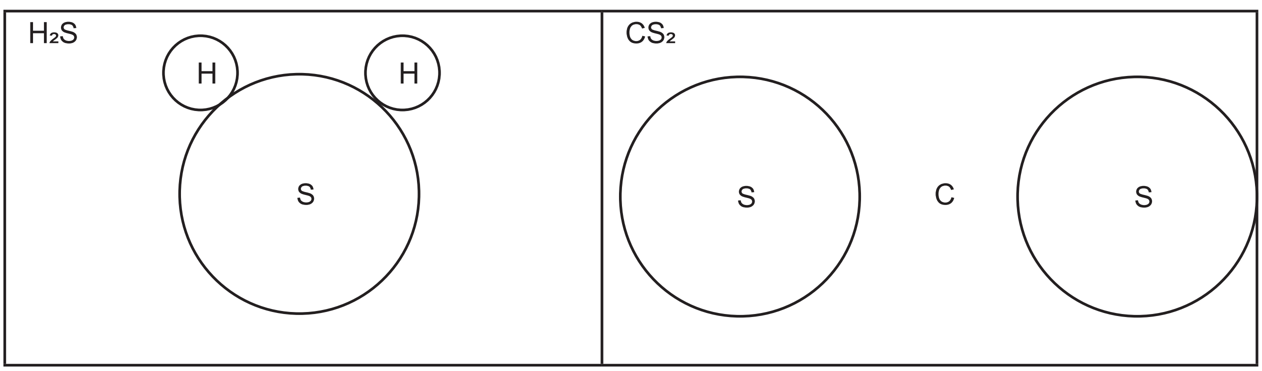
There are various ways of representing molecules, among them:

a. Circle diagrams
b. Ball and stick models
c. Space filling models
d. Molecular formulae
e. Empirical formulae

a. Circle diagrams

In this representation each atom is represented by circles and molecules are represented by placing the circles together.

Examples are:

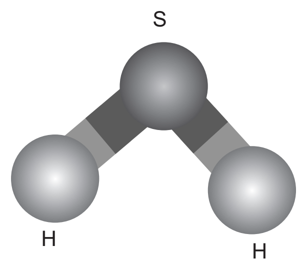
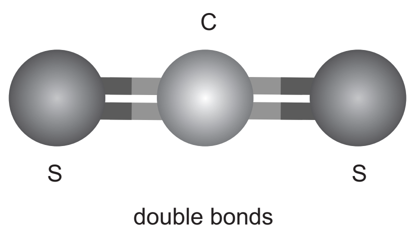


The size of the circles should reflect the relative sizes of the atoms. Also, the arrangement should, as far as possible, reflect the shape of the molecule. (Actual shape of molecules will only be done in grade 11).

b. Ball and stick models

These are difficult to draw and are usually provided to the learners in tests and examinations and they have to deduce the chemical formula from the diagram.

Examples:

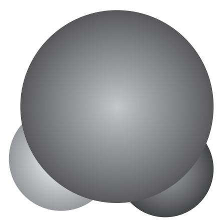
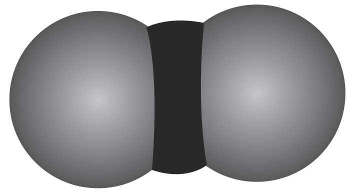
H_2S	CS_2
	

In the H_2S molecule there are only single bonds. In the CS_2 molecule there are two double bonds. The shapes of the molecules are also reflected here.

c. Space filling models

These models represent the molecules by solid 3D spheres and are probably the most accurate of the representations. These are also difficult to draw and are usually provided to the learners in tests and examinations and they have to deduce the chemical formula from the diagram.

Examples:

H_2S	**CS_2**
	

In the diagram for CS_2, notice the extent to which the carbon atom is 'squashed' by the orbital overlap. Again, these reflect the shapes of the molecules.

d. Molecular formulae

These are chemical formulae that show the actual number of atoms of each element in the molecule. Note that the usual sequence of atoms in a formula is that they should appear in order from left to right across the periodic table. Encourage learners to write elements in the correct sequence. Note that there are exceptions, e.g. in organic molecules the carbon comes first because it is always the central molecule.

Examples: H_2S, CS_2, CO_2, etc.

e. Empirical formulae

An empirical formula simply shows the lowest ratio of elements in a compound. It does not give an indication of exactly how many atoms of each element there are in the molecule. For example, in the molecule C_6H_6, there are 6 carbon atoms and 6 hydrogen atoms. The empirical formula of the compound, however, is CH, because the simplest ratio of 6:6 is 1:1.

This means that the actual formula of the compound could be C_2H_2 or C_4H_4. We can't tell from the empirical formula which one it actually is. Note that CH does not exist.

Example: If the empirical formula of a compound is NO_2, the formula of a molecule could be NO_2 itself or it could be N_2O_4. Both of these compounds actually exist.

INTRODUCTORY LEVEL QUESTIONS

a. These are the basic questions that learners will be required to answer at this stage in the topic.
b. Their purpose is to familiarise the learners with the content.

How to tackle these questions in the classroom:

- Work through these examples with learners.
- Explain each step of the question to the learners as you complete it on the chalkboard.
- Learners must copy the question as well as the solution into their workbook.

1. A molecule has the molecular formula $C_4H_8O_2$. What is its empirical formula?

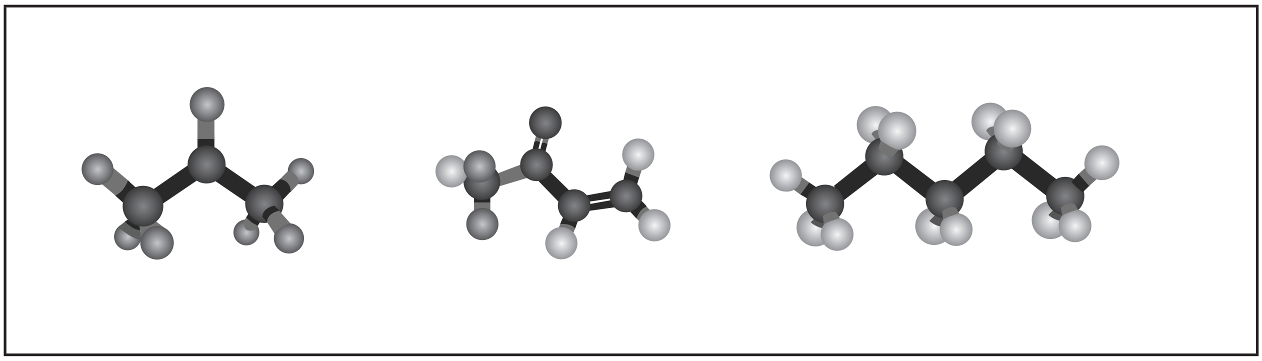
Solution

The empirical formula is the lowest ratio of each element present in the compound, so it will

be C_2H_4O.

2. Consider the following diagrams:

a. b. c.



Note that standard colour representations are: black for carbon, red for oxygen and white for hydrogen. For each of the above diagrams, give the following information:

I. The molecular formula

II. The empirical formula

III. The number of single bonds and the number of double bonds in each molecule

IV. What type of model these are

Solution

a. I. C_3H_6O

II. C_3H_6O

III. 8 single bonds and 1 double bond

IV. Ball and stick

b. I. C_4H_6O

II. C_4H_6O

III. 8 single bonds and 2 double bonds

IV. Ball and stick

c. I. C_5H_{12}

II. C_5H_{12}

III. 16 single bonds and no double bonds

IV. Ball and stick

CHALLENGE LEVEL QUESTIONS

a. Now that learners have mastered the basic questions, they are ready to deal with more challenging questions.

b. These questions require learners to apply their knowledge and to show some critical thinking.

How to tackle these questions in the classroom:

- Work through these examples with learners.
- Tell learners that this is a more challenging version of what they have been doing.
- Write the first example on the chalkboard.
- Ask learners to look at the example and see if they can work out what must be done / what is different.
- Discuss learners' ideas, and ask probing questions to extend their answers.
- Try to be positive in these interactions, to encourage critical thinking and questioning.
- Ensure that learners copy down both the question and the solution into their workbooks.

Key Teaching:

a. In these more challenging examples, learners must apply their knowledge and be prepared to use multilevel thinking skills.

b. They must first decide what type of representation they are dealing with, and then carefully look at the number of atoms of each element are involved in the representation.

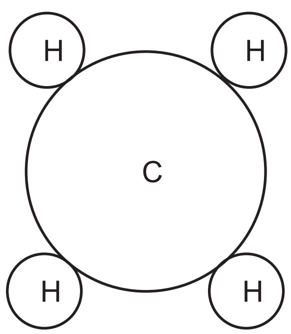
1. Draw circle diagrams to represent the following molecules:

   a. CH_4

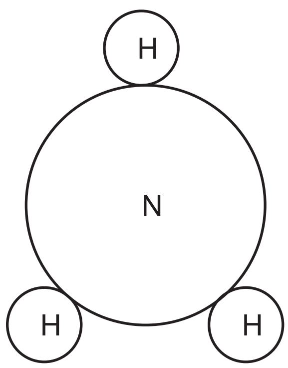
   b. NH_3

Solution

a.



b.



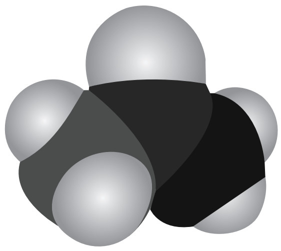
2. The empirical formula of a compound is CH_2. Give three possible molecular formulae that the molecule could have.

Solution

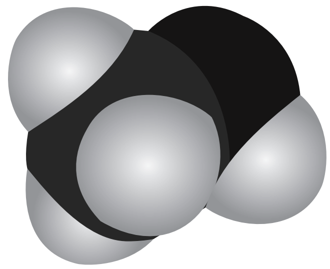
C_2H_4; C_3H_6; C_4H_8; or any formula where the ratio of C:H is 1:2.

3. Consider the space filling models of molecules shown below.

a.



b.



Write down the chemical formula for each of these substances. Note that standard colour representations are: black for carbon, red for oxygen and white for hydrogen.

Solution

a. C_3H_6O

b. CH_4O

CHECKPOINT

At this point in the topic, learners should have mastered:

1. The interpretation of ball and stick models and space filling models of molecules.
2. How to write chemical formulae and know what they mean.
3. The concept of empirical formula.

Worksheet Pack: Particles that substances are made of: Questions 7,8

- Check learners' understanding by marking their work with reference to the memorandum.
- If you cannot photocopy the memorandum for each learner, make three or four copies of it and place these on the walls of your classroom.
- Allow learners time to mark their own work.
- Encourage the learners to learn from the mistakes they make.

TOPIC 11: Particles substances are made of

CONSOLIDATION

- Learners can consolidate their learning by completing: **Worksheet Pack: Particles substances are made of Consolidation Exercise**.
- Photocopy the exercise sheet for the learners. If that is not possible, learners will need to copy the questions from the board before attempting to answer them.
- The consolidation worksheet should be marked by the teacher so that she/he is aware of each learner's progress in this topic.
- Please remember that further consolidation should also be done by completing the examples available in the textbook.
- **It is important to note that this consolidation exercise is NOT scaffolded.**
- **It should not be administered as a test, as the level of the work may be too high to in its entirety.**

ADDITIONAL VIEWING / READING

In addition, further viewing or reading on this topic is available through the following web links:

1. https://www.khanacademy.org/science/biology/chemistry--of-life/chemical-bonds-and-reactions/v/ionic-covalent-and-metallic-bonds
   This is a video about the three types of bonding. It is suitable for learners.
2. https://www.siyavula.com/read/science/grade-10/the-particles-that-substances-are-made-of/12-the-particles-that-substances-are-made-of-01
   This is reading matter and visual representations – suitable for both teachers and learners.
3. https://www.youtube.com/watch?v=wnRaBWvhYKY
   This is a video explaining the difference between molecular formula and empirical formula. Suitable for learners.
4. https://phet.colorado.edu/en/simulation/legacy/build-a-molecule
   This is a simulation where you can build a molecule, rotate it 3-dimesnionally and also see the stick-and-ball and space filling model of each molecule.

TOPIC 12: Physical and chemical change

A INTRODUCTION

- This topic runs for 4 hours.
- For guidance on how to break down this topic into lessons, please consult the NECT Planner & Tracker.
- Physical and chemical change forms part of the content area Chemical change (Chemistry).
- Chemical change counts as 40 % in the final exam.
- Physical and chemical change counts approximately 8% to 10% of the final examination.
- Learners must be able to distinguish between physical changes (changes in phase, colour, shape, etc.) and chemical changes which involve the change of one substance into another.

CLASSROOM REQUIREMENTS FOR THE TEACHER

1. Chalkboard.
2. Chalk.
3. Grade 10 Physics Examination data sheet

CLASSROOM REQUIREMENTS FOR THE LEARNER

1. A4, 3 Quire exercise book, for notes and exercises
2. Pen
3. Periodic table

B SEQUENTIAL TABLE

PRIOR KNOWLEDGE	CURRENT	LOOKING FORWARD
Grade 7-9	**Grade 10**	**Grade 11-12**
• The concept of the particle model • Change of state • Expansion and contraction of materials • Reactants and products	• The difference between physical and chemical change • Rearrangement of molecules during physical changes • Examples of chemical change • Decomposition and synthesis reactions • The energy involved in chemical change • Conservation of atoms and mass • The law of constant composition	• Explaining changes of phase and interpreting melting points and boiling points

C

GLOSSARY OF TERMS

Please note: The highlighted definitions and laws are ones that learners must be able to state and are given in the CAPS document. For examination purposes, learners must know these definitions and laws by heart, and must write them exactly as they appear here.

TERM	DEFINITION
Chemical change	This is a change that involves the transformation of one or more substances into one or more different substances.
Physical change	This is a change that does not alter the chemical nature of a substance.
Conservation (of atoms or mass)	The term means that the total mass or total number of atoms present does not change.
Decomposition	Breaking up of a substance into two or more other substances.
Synthesis	The joining together of two substances to form a third substance.
Reactants	The substance(s) present at the start of a chemical reaction.
Products	The substance(s) present after the reaction has taken place.

D ASSESSMENT OF THIS TOPIC

- This topic is assessed by means of a class test and the June and term 4 examinations.
- Recommended experiment: Prove the law of conservation of matter by:
    - o The reaction of lead(II) nitrate with sodium iodide, OR
    - o The reaction of sodium hydroxide with hydrochloric acid, OR
    - o The reaction of a Cal-C-Vita tablet with water

E

BREAKDOWN OF TOPIC AND TARGETED SUPPORT OFFERED

TIME ALLOCATION	SUB TOPIC	CAPS PAGE NUMBER	TARGETED SUPPORT OFFERED
3 hours	Separation of particles in physical change and chemical change	35 – 36	a. Understanding physical change b. The rearrangement of molecules in physical changes c. Understanding chemical change d. Decomposition reactions e. Synthesis reactions
3 hours 1 hour	Conservation of atoms and mass	36	a. Using diagrams to represent rearrangement of molecules b. The law of conservation of mass
	Law of constant composition	37	a. Law of constant composition

F

TARGETED SUPPORT PER SUB TOPIC

1. SEPARATION OF PARTICLES IN PHYSICAL CHANGE AND CHEMICAL CHANGEINTRODUCTION

Introduction

There is a rearrangement of molecules during both physical and chemical changes. Chemical changes involve bigger energy changes than physical changes.

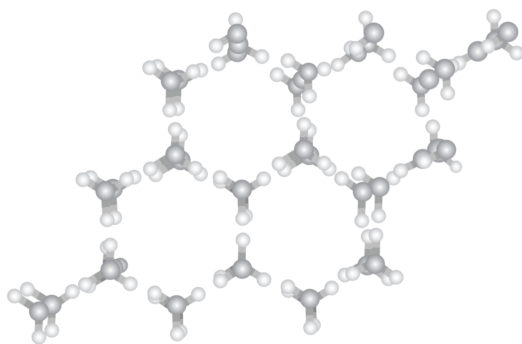
CONCEPT EXPLANATION AND CLARIFICATION: SEPARATION OF PARTICLES IN PHYSICAL CHANGE AND CHEMICAL CHANGE

Understanding physical change

- A physical change is a change that does not alter the chemical nature of a substance.
- The above definition implies that no new substances are formed during a physical change.
- Emphasise the fact that there is a rearrangement of molecules during physical changes without any bonds being broken or formed.
- Remind learners that during physical changes the number of atoms and molecules and mass, are all conserved.
- Use the example of rearrangement of water molecules when water changes from one phase to another.

The rearrangement of molecules in physical changes

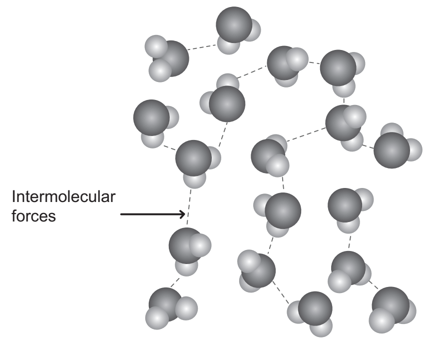
- In solid water (ice) there is a crystalline structure. The molecules occupy fixed positions in a crystal lattice that has a specific structure.



The arrangement of water moleculs in ice

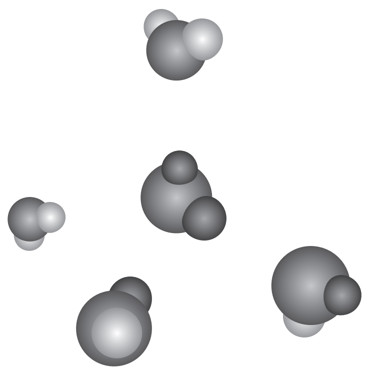
- When the temperature of ice rises (energy is supplied), the molecules begin to vibrate more vigorously and the intermolecular forces weaken. The forces are no longer strong enough to keep the molecules in place in the crystal lattice and its structure is destroyed. Water is now in the liquid phase. A rearrangement and disordering of the molecules occurs.

TOPIC 12: Physical and chemical change



How molecules are rearranged in (liquid) water

- When water is heated further, the intermolecular forces are completely broken and the water turns into water vapour, when water boils. Further disordering takes place. Note that evaporation, however, can occur at any temperature.



Water molecules in water vapour

- The energy changes that occur during changes of phase are relatively small, as weak intermolecular forces require relatively little energy for them to be broken or weakened.

Understanding chemical change

- A chemical change is a change in which the chemical nature of the substances involved changes.
- This implies that new chemical substances are formed.
- Chemical changes are accompanied by large energy changes as bonds have to be broken (which involves energy being absorbed) and then new bonds are formed (during which energy is released).
- Observations that can indicate that a chemical change has taken place can be:
  - o A change in temperature
  - o A change in colour
  - o The formation of a precipitate
  - o The release of a gas
- During a chemical change mass and number of atoms are conserved but not the number of molecules.

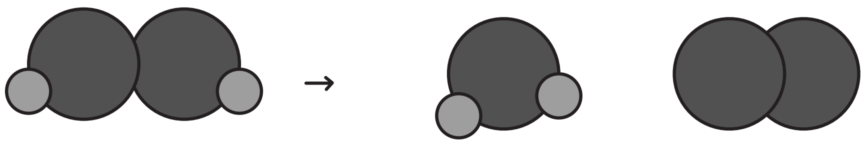
- Two examples of reactions that are chemical are changes are decomposition reactions and synthesis reactions.

Decomposition reactions

- These are reactions during which a single substance changes into two or more other substances. The number of molecules present increases.
- An example of a decomposition reaction is the breaking up of hydrogen peroxide:

hydrogen peroxide → water + oxygen

- The diagram below represents this change



H_2O_2 → H_2O O_2

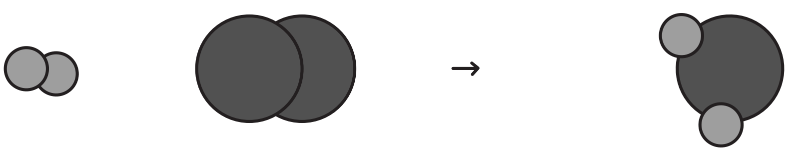
- In the above reaction, the chemical nature of hydrogen peroxide changes and new substances are formed, i.e. water and oxygen gas.

Synthesis reactions

- These are reactions in which two or more substances combine to form a single substance. The number of molecules present decreases.
- An example of a decomposition reaction is the reaction between hydrogen and oxygen to form water:

hydrogen + oxygen → water

- The diagram below represents this change:



H_2 O_2 H_2O

- Hydrogen and oxygen no longer have their original chemical nature. Water is a totally new substance.

TOPIC 12: Physical and chemical change

INTRODUCTORY LEVEL QUESTIONS

a. These are the basic questions that learners will be required to answer at this stage in the topic.

b. Their purpose is to familiarise the learners with the content.

How to tackle these questions in the classroom:

- Work through these examples with learners.
- Learners must copy the question as well as the solution into their workbook.

1. Define a chemical change.

Solution

A chemical change is a change that involves the transformation of one or more substances into one or more different substances.

2. Define a physical change.

Solution

A physical change is a change that does not alter the chemical nature of a substance.

CHALLENGE LEVEL QUESTIONS

a. Now that learners have mastered the basic questions, they are ready to deal with more challenging questions.

b. These questions require learners to apply their knowledge.

How to tackle these questions in the classroom:

- Work through these examples with learners.
- Tell learners that this is a more challenging version of what they have been doing.
- Write the first example on the chalkboard.
- Ask learners to look at the example and see if they can work out what must be done / what is different.
- Discuss learners' ideas, and ask probing questions to extend their answers.
- Try to be positive in these interactions, to encourage critical thinking and questioning.
- Ensure that learners copy down both the question and the solution into their workbooks.

TOPIC 12: Physical and chemical change

Key Teaching:

a. In these more challenging examples, learners must use the facts that they have learned and apply them correctly in answering questions.

b. It will be necessary for learners to interpret the questions before answering them.

1. In terms of conservation of mass, molecules and atoms, distinguish between physical and chemical changes.

Solution

In a physical change, all of mass, molecules and atoms are conserved. In a chemical change, only mass and atoms are conserved.

2. Distinguish between decomposition reactions and synthesis reactions.

Solution

In decomposition reactions, one substance breaks up to form two or more new substances. In synthesis reactions two or more substances combine to form a new substance.

CHECKPOINT

At this point in the topic, learners should have mastered:

1. The differences between physical and chemical changes
2. The understanding of conservation of mass, molecules and atoms
3. The difference between decomposition and synthesis reactions

Check learners' understanding of these concepts by getting them to work through:

Worksheet Pack: Physical and chemical change: Questions 1 – 5

- Check learners' understanding by marking their work with reference to the memorandum.
- If you cannot photocopy the memorandum for each learner, make three or four copies of it and place these on the walls of your classroom.
- Allow learners time to mark their own work.
- Encourage the learners to learn from the mistakes they make.

2. CONSERVATION OF ATOMS AND MASS

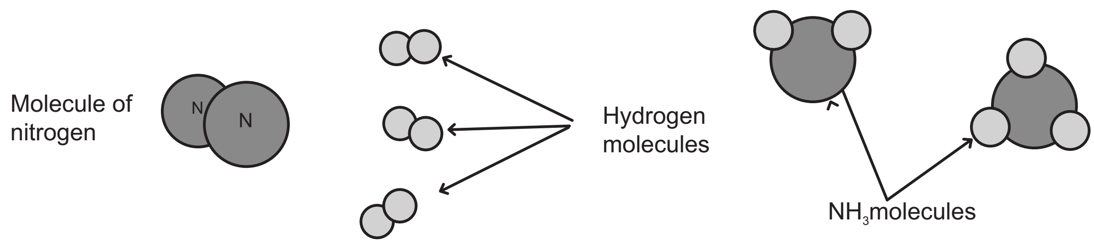
Introduction

It is important for learners to understand the principle of conservation of atoms but not molecules during chemical changes.

CONCEPT EXPLANATION AND CLARIFICATION: CONSERVATION OF ATOMS AND MASS

Using diagrams to represent rearrangement of molecules

- During a chemical change, the number of atoms is conserved.
- Ensure that learners understand what conservation of atoms really means. Explain the fact that atoms cannot be created nor destroyed in chemical reactions, so that the total number of atoms of each element present at the end of the reaction is the same as the number that were there at the start of the reaction.
- The substances present at the beginning of a chemical reaction are called the reactants and the substances produced by the reaction are called products.
- Although the number of atoms of each element remains constant throughout a chemical reaction, they do undergo rearrangement, so that the number and type of molecule present will change.
- The following example serves to illustrate this:



In this reaction, we begin with 3 molecules of hydrogen and 1 molecule of nitrogen. After the reaction we end up with 2 molecules of NH3 (ammonia). However; the number of nitrogen atoms (blue circles) at the start is 2 and we also end with 2. We start with 6 atoms of hydrogen (white circles) and we end with 6 atoms of hydrogen.

So, the number of molecules is not the same before and after reaction, but the number of atoms of each element is. Atoms are conserved but not molecules. This is also an example of a synthesis reaction, in that we start with two substances and end up with only one.

The law of conservation of mass

- The law of conservation of mass states that the total mass of reactants in a chemical reaction is equal to the total mass of the products.
- Use the relative atomic masses from the example above to illustrate this law:

Reactants:

1 molecule N_2 – $M_r(N_2)$ = 2 x 14 = 28

3 molecules H_2 – $M_r(H_2)$ = 2 x 1 = 2 x 3 = 6

Total mass = 34

Products:

2 molecules NH_3 – $M_r(NH_3)$ = 14 + (3 x 1) = 17 x 2 = 34

Total mass = 34

Total mass of reactants = total mass of products

INTRODUCTORY LEVEL QUESTIONS

a. These are the basic questions that learners will be required to answer at this stage in the topic.

b. Their purpose is to familiarise the learners with the content.

How to tackle these questions in the classroom:

- Work through these examples with learners.
- Learners must copy the question as well as the solution into their workbook.

1. Explain what is meant by the term conservation of mass in a chemical reaction.

Solution

Conservation of mass means that the total mass of the products is equal to the total mass of the reactants.

2. Explain why the number of atoms is conserved during a chemical reaction but not the number of molecules.

Solution

The total number of atoms of each element in the reactants and the products remains the same, but there is a rearrangement of the atoms into different types and numbers of molecules. So, while the total number of atoms of each element remains the same, the total number of molecules can differ.

CHALLENGE LEVEL QUESTIONS

a. Now that learners have mastered the basic questions, they are ready to deal with more challenging questions.

b. These questions require learners to apply the principles that they have learned.

How to tackle these questions in the classroom:

- Work through these examples with learners.
- Tell learners that this is a more challenging version of what they have been doing.
- Write the first example on the chalkboard.
- Ask learners to look at the example and see if they can work out what must be done / what is different.
- Discuss learners' ideas, and ask probing questions to extend their answers.
- Try to be positive in these interactions, to encourage critical thinking and questioning.
- Ensure that learners copy down both the question and the solution into their workbooks.

Key Teaching:

a. In these more challenging examples, learners must apply their knowledge and think critically.

b. Learners must be able to show that the law of conservation of mass is valid by doing their own calculations.

1. In a chemical reaction, 2 molecules of hydrogen react with 1 molecule of oxygen to form two molecules of water. By using relative atomic masses show that mass is conserved in this reaction.

Solution

Reactants:

$2H_2$ – M_r = 2(2 X 1) = 4

O_2 – M_r = 2 X 16 = 32

Total reactants = 36

Products:

$2H_2O$ – M_r = 2(2 X 1 + 16) = 36

Total reactants = 36

Mass is conserved.

CHECKPOINT

At this point in the topic, learners should have mastered:

1. The concept of conservation of mass
2. The concept of conservation of atoms
3. How to prove that mass is conserved by using relative atomic and molecular masses.

Check learners' understanding of these concepts by getting them to work through:

Worksheet Pack: Physical and chemical change: Questions 6,7

- Check learners' understanding by marking their work with reference to the memorandum.
- If you cannot photocopy the memorandum for each learner, make three or four copies of it and place these on the walls of your classroom.
- Allow learners time to mark their own work.
- Encourage the learners to learn from the mistakes they make.

3. LAW OF CONSTANT COMPOSITION

Introduction

When elements combine to form a certain compound they always react in the same ratio, so that the compound always has the same chemical formula.

CONCEPT EXPLANATION AND CLARIFICATION: LAW OF CONSTANT COMPOSITION

- This law is also known as the law of constant proportions.
- The law states that the ratio of elements in a certain compound is always the same.
- It means that no matter how a compound is made, the number of atoms of each element in the compound is always the same.
- Mention that it is possible for more than one compound to be produced when elements combine e.g. when hydrogen and oxygen combine, they can form water, H_2O, in which the ratio of hydrogen to oxygen is 2:1. They can also form hydrogen peroxide, H_2O_2, in which the ratio is 1:1. This depends on the conditions under which they react.

TOPIC 12: Physical and chemical change

INTRODUCTORY LEVEL QUESTIONS

a. These are the basic questions that learners will be required to answer at this stage in the topic.

b. Their purpose is to familiarise the learners with the law of constant composition.

How to tackle these questions in the classroom:

- Work through these examples with learners.
- Learners must copy the question as well as the solution into their workbook.

1. Give the fixed ratio of the atoms of each element in each of the following:

   a. KNO_3

   b. Na_2SO_4

   c. CF_4

   d. K_2O_2

Solutions

a. K:N:O = 1:1:3

b. Na:S:O = 2:1:4

c. C:F = 1:4

d. K:O = 1:1

TOPIC 12: Physical and chemical change

CHECKPOINT

At this point in the topic, learners should have mastered:

1. The law of constant composition
2. The concept of a constant ratio of atoms for a particular substance

Check learners' understanding of these concepts by getting them to work through:

Worksheet Pack: Physical and chemical change: Questions 8

- Check learners' understanding by marking their work with reference to the memorandum.
- If you cannot photocopy the memorandum for each learner, make three or four copies of it and place these on the walls of your classroom.
- Allow learners time to mark their own work.
- Encourage the learners to learn from the mistakes they make.

CONSOLIDATION

- Learners can consolidate their learning by completing; **Worksheet Pack: Physical and chemical changes**
- Photocopy the exercise sheet for the learners. If that is not possible, learners will need to copy the questions from the board before attempting to answer them.
- The consolidation worksheet should be marked by the teacher so that she/he is aware of each learner's progress in this topic.
- Please remember that further consolidation should also be done by completing the examples available in the textbook.
- **It is important to note that this consolidation exercise is NOT scaffolded.**
- **It should not be administered as a test, as the level of the work may be too high to in its entirety.**

ADDITIONAL VIEWING / READING

In addition, further viewing or reading on this topic is available through the following web links:

1. https://www.thoughtco.com/physical-and-chemical-changes-examples-608338
   This is text and provides a good explanation of physical and chemical changes, and gives a lot of examples of each as well as a short video. Good extra reading for teachers.
2. https://www.youtube.com/watch?v=FZwHH7Sm4hI
   A video showing an experiment to prove that mass is conserved during chemical reactions. Suitable for learners.

3. https://www.thoughtco.com/law-of-constant-composition-chemistry-605850

   This is text suitable for teachers and learners.

TOPIC 13: Representing chemical change

A INTRODUCTION

- This topic runs for 4 hours.
- For guidance on how to break down this topic into lessons, please consult the NECT Planner & Tracker.
- Energy forms part of the content area Chemical change (Chemistry).
- Chemical change counts as 40 % in the final exam.
- Representing chemical change counts approximately 8% to 10% of the final examination.
- Understanding how we represent chemical change on paper is extremely important as the whole of Chemistry and its calculations rely on balanced chemical equations.

CLASSROOM REQUIREMENTS FOR THE TEACHER

1. Chalkboard.
2. Chalk.
3. Grade 10 Physics Examination data sheet

CLASSROOM REQUIREMENTS FOR THE LEARNER

1. A4, 3 Quire exercise book, for notes and exercises
2. Pen
3. Periodic table

B SEQUENTIAL TABLE

PRIOR KNOWLEDGE	CURRENT	LOOKING FORWARD
Grade 7-9	**Grade 10**	**Grade 11-12**
• Chemical equations to represent reactions • Balanced equations • Reactants and products	• Using reaction equations to represent chemical change • How to balance chemical equations • Representation in the form of coloured circles	• Using balanced chemical equations to perform calculations • Using mole ratios for equilibrium and other calculations

C

GLOSSARY OF TERMS

Please note: The highlighted definitions and laws are ones that learners must be able to state and are given in the CAPS document. For examination purposes, learners must know these definitions and laws by heart, and must write them exactly as they appear here.

TERM	DEFINITION
Reaction equation	A chemical equation that represents the changes occurring during a chemical reaction.
Balanced (equation)	A chemical equation in which the atoms of each element in the substance(s) making up the reactants are equal to the number of atoms of the same elements in the products.
Reactants	The substances present at the beginning of a chemical reaction.
Products	The substances present after a chemical reaction has taken place.

D

ASSESSMENT OF THIS TOPIC

- This topic is assessed by means of a class test and the June and term 4 examinations.

TOPIC 13: Representing chemical change

E BREAKDOWN OF TOPIC AND TARGETED SUPPORT OFFERED

TIME ALLOCATION	SUB TOPIC	CAPS PAGE NUMBER	TARGETED SUPPORT OFFERED
4 hours	4 hours Balanced chemical equations	37	a. Revision of chemical formulae b. Translating reaction equations from words into symbols c. Balancing reaction equations d. Circle diagrams to represent chemical reactions e. Interpretation of balanced reaction equations

F

TARGETED SUPPORT PER SUB TOPIC

1. BALANCED CHEMICAL EQUATIONS

Introduction

Balanced reaction equations are universally used to represent chemical change and form the basis of all calculations involving chemical change. They are the foundation of all quantitative analysis.

CONCEPT EXPLANATION AND CLARIFICATION: BALANCED CHEMICAL EQUATIONS

Revision of chemical formulae

It is worth spending some time to revise the writing of chemical formulae from names and vice versa. Remind learners about the need to balance charges in ionic compounds.

INTRODUCTORY LEVEL QUESTIONS

a. These are the basic questions that learners will be required to answer at this stage in the topic.
b. Their purpose is to refresh in the learners' minds how chemical formulae are written and how compounds are named.

How to tackle these questions in the classroom:

- Work through these examples with learners.
- Learners must copy the question as well as the solution into their workbook.

1. Write down the chemical formulae for each of the following compounds:
   a. potassium permanganate
   b. calcium hydroxide
   c. iron(III) carbonate
   d. chromium(ii) phosphate
   e. ammonium dichromate

Solution

a. $KMnO_4$

The permanganate ion has a charge of −1 and the potassium ion has a charge of +1.

b. $Ca(OH)_2$

The calcium ion has a charge of +2 and the hydroxide ion has a charge of −1. It requires two hydroxide ions to neutralise the calcium ion.

c. $Fe_2(CO_3)_3$

The iron ion has a charge of +3 and the carbonate ion has a charge of −2. In order to balance positive and negative charges, it requires 2 iron ions and 3 carbonate ions.

d. $Cr_3(PO_4)_2$

The chromium ion has a charge of +2 and the phosphate ion has a charge of −3. In order to balance positive and negative charges, it requires 3 chromium ions and 2 phosphate ions.

e. $(NH_4)_2Cr_2O_7$

The ammonium ion has a charge of +1 and the dichromate ion has a charge of −2. It requires two ammonium ions to balance the charge.

2. Write down correct chemical names for the following compounds:
   a. Cu_2O
   b. $CaSO_4$
   c. $A\ell(OH)_3$
   d. $PbC\ell_2$
   e. Ag_2SO_4

Solution

a. Copper(I) oxide

The oxide ion has a charge of −2. There are two copper ions to balance this, so the charge on each copper ion is +1.

b. Calcium sulfate

c. Aluminium hydroxide

The aluminium ion has a charge of +3, and each hydroxide ion has a charge of −1.

d. Lead(II) chloride

The chloride ion has a charge of −1 and there are two of them, so the charge on the lead ion must be +2. Remind learners to use Stock notation where an element can form ions with more than one charge.

e. Silver sulfate

TOPIC 13: Representing chemical change

CHECKPOINT

At this point in the topic, learners should have remembered how to write correct chemical formulae and names of compounds.

Translating reaction equations from words into symbols

- More often than not, chemical reactions between substances are expressed in words before they are written in symbols.
- Emphasise to learners how important it is to write down correct chemical formulae for each of the substances described in words.
- Remind learners to write down the phase of each substance that appears in the reaction equation.

INTRODUCTORY LEVEL QUESTIONS

a. These are the basic questions that learners will be required to answer at this stage in the topic.

b. Their purpose is to familiarise the learners with translating reaction equations into symbols.

How to tackle these questions in the classroom:

- Work through these examples with learners.
- Learners must copy the question as well as the solution into their workbook.

3. Sodium hydroxide reacts with sulfuric acid to produce sodium sulfate and water. Write down a reaction equation for this reaction.

Solution

$NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + H_2O(l)$

4. Magnesium metal reacts with hydrochloric acid to produce magnesium chloride and hydrogen gas. Write down a reaction equation for this reaction.

Solution

$Mg(s) + HC\ell(aq) \rightarrow MgC\ell_2(aq) + H_2(g)$

5. Carbon powder burns in oxygen to form carbon dioxide gas. Write down a reaction equation for this reaction.

Solution

$C(s) + O_2(g) \rightarrow CO_2(g)$

o Ensure that learners copy down both the question and the solution into their workbooks.

CHECKPOINT

At this point in the topic, learners should have mastered the ability to convert word equations to reaction equations.

Balancing reaction equations

- When balancing reaction equations, there a few hints that learners could follow:
  - Write down the correct chemical formulae from the words given.
  - In order to balance the equation, ensure that the number of atoms of each element on the reactants side is equal to the number on the products side.
  - To bring this about, the ONLY thing to do is to place coefficients (numbers) in front of chemical formulae. Do not put numbers in the middle of a chemical formula.
  - Once the correct chemical formula for a substance has been written, it may not be changed when trying to balance the equation.
  - The number that is put in front of a chemical formula for balancing applies to every element in the chemical formula.
  - It is useful to balance elements other than hydrogen and oxygen first. Then balance hydrogen, if necessary and finally oxygen.

INTRODUCTORY LEVEL QUESTIONS

a. These are the basic questions that learners will be required to answer at this stage in the topic.

b. Their purpose is to familiarise the learners with the balancing of reaction equations.

How to tackle these questions in the classroom:

- Work through these examples with learners.
- Learners must copy the question as well as the solution into their workbook.

6. Magnesium oxide powder reacts with dilute nitric acid to form aqueous magnesium nitrate and water. Write down a balanced reaction equation for this reaction.

Step 1: Write down an equation in chemical formulae from the words

$$MgO(s) + HNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + H_2O(l)$$

There is 1 magnesium on the reactants side and 1 on the right – balanced for now.

There is one nitrogen on the left and 2 on the right needs to be balanced by putting a 2 in front of HNO_3.

The 2 must go in front of the
H not in front of the N

Step 2:

$$MgO(s) + 2HNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + H_2O(l)$$

2 x 3 oxygen=6 2 x 3 oxygen=6

Let's check again: both Mg and N are now balanced. There are 2 H on the left and 2 on the right. There are 7 x O on the left and 7 x O on the right. The equation is balanced.

CHALLENGE LEVEL QUESTIONS

a. Now that learners have mastered the basic questions, they are ready to deal with more challenging questions.

How to tackle these questions in the classroom:

- Work through these examples with learners.
- Tell learners that this is a more challenging version of what they have been doing.
- Write the first example on the chalkboard.
- Ask learners to look at the example and see if they can work out what must be done / what is different.
- Discuss learners' ideas, and ask probing questions to extend their answers.
- Try to be positive in these interactions, to encourage critical thinking and questioning.
- Ensure that learners copy down both the question and the solution into their workbooks.

Key Teaching:
In these more challenging examples, learners must undertake more complex balancing of equations.

7. Balance the following reaction equation:

$$A\ell + O_2 \rightarrow A\ell 2O_3$$

Solution

There is 1 Aℓ on the left and there are 2 on the right. This is balanced by putting a 2 in front of Aℓ on the left:

$$2A\ell + O_2 \rightarrow A\ell_2O_3$$

Now there are 2 O on the left and 3 O on the right. To balance this, a 3 is placed in front of O_2 and a 2 in front of $A\ell_2O_3$:

$$2A\ell + 3O_2 \rightarrow 2A\ell_2O_3$$

Now the Aℓ is no longer balanced: there are 2 Aℓ on the left and 4 on the right, so there needs to be a 4 in front of Aℓ:

$$4A\ell + 3O_2 \rightarrow 2A\ell_2O_3$$

The equation is now balanced.

Inform learners that they may have to change coefficients more than once, in order to balance equations. There is nothing unusual in this.

CHECKPOINT

At this point in the topic, learners should have mastered the process that it is necessary to follow in order to balance reaction equations.

Check learners' understanding of these concepts by getting them to work through:

Worksheet Pack: Physical and chemical change: Questions 1-6

- Check learners' understanding by marking their work with reference to the memorandum.
- If you cannot photocopy the memorandum for each learner, make three or four copies of it and place these on the walls of your classroom.
- Allow learners time to mark their own work.
- Encourage the learners to learn from the mistakes they make.

Circle diagrams to represent chemical reactions

- Circle diagrams can be used to make the understanding of balancing reaction equations more visual for learners.

INTRODUCTORY LEVEL QUESTIONS

a. These are the basic questions that learners will be required to answer at this stage in the topic.

b. Their purpose is to familiarise the learners with the balancing of reaction equations.

How to tackle these questions in the classroom:

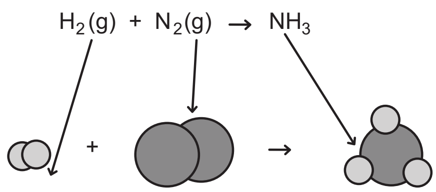
- Work through these examples with learners.
- Learners must copy the question as well as the solution into their workbook.

8. Consider the reaction between hydrogen gas and nitrogen gas to form ammonia gas.
   a. Balance the equation and represent the reaction by means of circle diagrams.
   b. Show that mass is conserved during this reaction.

Solution

a. In symbols the equation is:

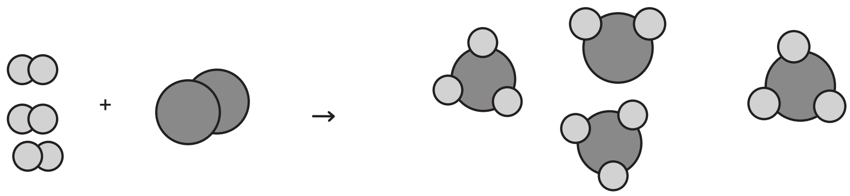
Representing this in terms of circle diagrams:



It is obvious that the equation is not balanced. There are 2 H on the left and 3 on the right. To balance, there needs to be a 3 in front of H_2 and a 2 in front of NH_3. Thus:

$3H_2(g) + N_2(g) \rightarrow 2NH_3$

In terms of circle diagrams, this will be:



There are 6 white circles on the left and 6 on the right. There are 2 blue circles on the left and 2 on the right. So, the number of atoms is conserved as we learned in topic 12.

b. Reactants:

H_2: m = 3(2 x 1)

= 6

N_2: m = 2 x 14

= 28

Total reactants = 28 + 6

= 34

Products:

NH_3: m = 2[14 + (3 x 1)]

= 34

Total products = 34

Mass of reactants = mass of products

TOPIC 13: Representing chemical change

CHECKPOINT

At this point in the topic, learners should have mastered:

1. The balancing of reaction equations.
2. How to represent a balanced reaction equation by means of circle diagrams.

Check learners' understanding of these concepts by getting them to work through:

Worksheet Pack: Physical and chemical change: Questions 7,8

- Check learners' understanding by marking their work with reference to the memorandum.
- If you cannot photocopy the memorandum for each learner, make three or four copies of it and place these on the walls of your classroom.
- Allow learners time to mark their own work.
- Encourage the learners to learn from the mistakes they make.

CONSOLIDATION

- Learners can consolidate their learning by completing; **Worksheet Pack: Representing chemical change Consolidation Exercise.**
- Photocopy the exercise sheet for the learners. If that is not possible, learners will need to copy the questions from the board before attempting to answer them.
- The consolidation worksheet should be marked by the teacher so that she/he is aware of each learner's progress in this topic.
- Please remember that further consolidation should also be done by completing the examples available in the textbook.
- **It is important to note that this consolidation exercise is NOT scaffolded.**
- **It should not be administered as a test, as the level of the work may be too high to in its entirety.**

ADDITIONAL VIEWING / READING

In addition, further viewing or reading on this topic is available through the following web links:

1. https://www.youtube.com/watch?v=UGf60kq_ZDI

   This video on balancing chemical equations is very good for learners.
2. https://www.youtube.com/watch?v=_B735turDoM

   Video also shows circle diagrams. Suitable for learners
3. http://www.webqc.org/balance.php

   This is reading material suitable for teachers. Lots of questions on balancing equations.

TOPIC 14: Magnetism

A INTRODUCTION

- This topic runs for 2 hours.
- For guidance on how to break down this topic into lessons, please consult the NECT Planner & Tracker.
- These topics form part of the content area of Electricity and Magnetism.
- Electricity and Magnetism counts 35% of the final examination.
- Magnetism counts about 6% in the final examination.
- Magnetism has fascinated mankind for thousands of years, and people have used magnets as compasses for almost as long. The earth's magnetic field is responsible for shielding us from harmful cosmic rays, and we have made use of it for navigation over many thousands of years. Some species of the animal kingdom use magnetism to find their way during migrations.

CLASSROOM REQUIREMENTS FOR THE TEACHER

1. Chalkboard.
2. Chalk.

If possible:

3. Two bar magnets (wrapped in transparent cling wrap)
4. Iron filings
5. Cling wrap
6. Various objects: ferromagnetic (containing iron, nickel or chromium) and non-ferromagnetic (copper, aluminium, plastic, wood)

CLASSROOM REQUIREMENTS FOR THE LEARNER

1. A4 3-quire exercise book for notes and exercises.
2. Scientific calculator – Sharp or Casio calculators are highly recommended.
3. Pen.

B SEQUENTIAL TABLE

PRIOR KNOWLEDGE	CURRENT	LOOKING FORWARD
Grade 7-9 **Qualitative aspects**	**Grade 10**	**Grade 11-12**

• Static electricity
• The magnetic effect of electric current (electromagnets)
• Forces and force fields (gravitational, magnetic and electric fields)
	• Magnetic field of permanent magnets
	• Poles of permanent magnets
	• Attraction and repulsion
	• Magnetic field lines
	• Earth's magnetic field
	• Compass
		• Electromagnetism
		  o The magnetic field associated with current carrying wires
		  o Faraday's Law
		• Electrodynamics
		  o Electric motors
		  o Generators

C

GLOSSARY OF TERMS

Please note: The highlighted definitions and laws are ones that learners must be able to state and are given in the CAPS document. For examination purposes, learners must know these definitions and laws by heart, and must write them exactly as they appear here.

TERM	DEFINITION
Magnetic field	A region in space where another magnet or ferromagnetic material experiences a (noncontact) force.
Electric field	A region in space where an electric charge experiences an electric force.
A magnet	An object with a pair of opposite poles, called north and south poles, which experiences magnetic force in a magnetic field.
Gravitational fields	A region in space where a mass experiences a gravitational force.
Law of (magnetic) attraction and repulsion	Like magnetic poles repel each other; opposite magnetic poles attract each.
A compass	A device that uses a magnetic needle to show the direction of a magnetic field.
Geographical north pole	The northernmost point of the Earth's axis of rotation.
Magnetic north pole of the Earth	The direction toward which the (magnetic) north pole of a magnet points when it is free from any local magnetic influence.
Solar wind	A stream of energetic particles ejected by the Sun. These particles include electrons, protons, alpha particles (nuclei of helium atoms) and the atomic nuclei of carbon, nitrogen, neon, oxygen and magnesium.

D

Aurora Borealis (Northern Lights)	The beautiful display of light in the northern hemisphere which happens when the solar wind strikes atoms in the Earth's atmosphere. The charged particles in the solar wind cause electrons in the atoms to jump to higher energy states. When the electrons drop back to their lower energy states, they emit a photon of light. NB. The Aurora Australis (Southern Lights) has a similar display in the southern hemisphere.

ASSESSMENT OF THIS TOPIC

- This topic is assessed by class tests and/or in the Term 2 examination. There may be multiple-choice type questions, match the phrase type questions, or problems to solve, where the learners are expected to show their method, give some explanation and/or write down definitions or laws.

E

BREAKDOWN OF TOPIC AND TARGETED SUPPORT OFFERED

TIME ALLOCATION	SUB TOPIC	CAPS PAGE NUMBER	TARGETED SUPPORT OFFERED
0,5 h	Magnetic field of permanent magnets	38	Common misconceptions related to magnetic fields.
1 h	Poles of permanent magnets, attraction and repulsion, magnetic field lines.	38-39	
0.5 h	Earth's magnetic field, compass	39	Distinguishing between magnetic and geographic north.

F

TARGETED SUPPORT PER SUB TOPIC

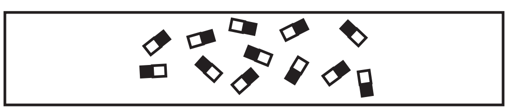
1. BALANCED CHEMICAL EQUATIONS

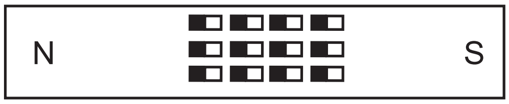
Introduction

Magnetic fields are often confused with electric fields. Learners have difficulty distinguishing between positive and negative charge and the north and south poles of magnets. Although only two hours of teaching time is allocated to this topic, it is worth pointing out the differences between electric and magnetic fields so that learners understand their differences.

CONCEPT EXPLANATION AND CLARIFICATION: BALANCED CHEMICAL EQUATIONS

Here are some common misconceptions about magnets and magnetic fields.

	MISCONCEPTION	PRACTICAL PROOF TO CONTRADICT IT
1	All metals are magnetic.	Test metals for their magnetic properties e.g. iron, nickel (in South African coins), copper, aluminium foil, by bring a magnet close to each and observing whether the material is attracted to the magnet.Only iron (steel), nickel and chromium are naturally magnetic. Copper and aluminium are non-magnetic (as are most of the metals on the Periodic Table).
2	A magnetic field exerts force on a stationary charge.	Charge a Perspex rod (positively), hold it stationary, and bring a plotting compass up to it. The needle of the compass will not move when it is brought near the charged rod. Magnetic fields have no effect on stationary charges.
3	Magnets are formed by placing magnetic material in a magnetic field.	Sometimes this statement may be true, if the magnetic material is made of hard iron. But in general, the ferromagnetic material loses its magnetism when it is taken out of the magnetic field. Ferromagnetic materials consist of clusters of atoms which act as tiny magnets. We call these magnetic domains. Domains before magnetization are arranged randomly.  Domains after magnetization are aligned with the magnetic field forming opposite poles at each end.

		 Permanent magnets are usually made by heating the material to above its Curie temperature (the temperature at which permanent magnets lose their magnetic properties). The heated material is then placed in a steady magnetic field, and its temperature is reduced to room temperature. The magnetic domains inside the ferromagnetic material align themselves to form a strong permanent magnet.
4	Whenever there is an electric field, there will be an induced magnetic field.	The electric field around a stationary charge does not set up a magnetic field because the electric field remains constant. A changing electric field sets up a magnetic field. Therefore, when current passes through a conductor there is a magnetic field associated with the current. This is how we make an electromagnet.
5	Magnetic fields can be blocked by surrounding the magnet with other materials e.g. concrete, sand, aluminium, or an iron cage.	Magnetic fields cannot be blocked easily. We know this because the earth's magnetic field penetrates layers of earth, and we can still feel its effects. Wrap a magnet in various materials and demonstrate that it will still attract iron filings.
6	Cutting a magnet in half will separate the north and south pole making a magnetic monopole.	Cutting a magnet in half produces two smaller magnets each with a north and south pole. There are no magnetic monopoles in our known universe (so far!).
8	Magnetic force and magnetic field are terms that can be used interchangeably.	Force is a push or a pull. A field is a region around a magnet in which another magnet or magnetic material experiences magnetic force (a push or a pull). Help your learners to use these terms correctly.

TOPIC 14: Magnetism

INTRODUCTORY LEVEL QUESTIONS

a. These are the basic questions that learners will be required to answer at this stage in the topic.

b. Their purpose is to familiarise the learners with terminology.

How to tackle these questions in the classroom:

- Work through these examples with learners.
- Explain each step to the learners as you complete it on the chalkboard.
- Learners must copy the question as well as the solution into their workbook.

1. A bar magnet is divided into two pieces. Which of the following statements is true?

   A The bar magnet is demagnetised.

   B The magnetic field of each separated piece becomes stronger.

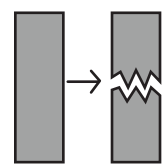
   C The magnetic poles are separated.

   D Two new bar magnets are created.

Solution:

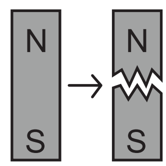
D When a magnet is cut into two pieces, two new bar magnets are created, each with their own north and south poles.

2. A bar magnet is divided into two pieces as shown in the diagram alongside. Which of the following statements is true about the force between the broken pieces if they face each other with a small separation?



Solution:

D A force of magnetic attraction arises between the two broken pieces because each of these breaks has produced opposite poles.



3.1 Describe what is meant by "a magnetic field".

3.2 Draw a neat sketch of the magnetic field lines around a bar magnet.

3.3 Describe what is meant by "the north pole of a magnet".

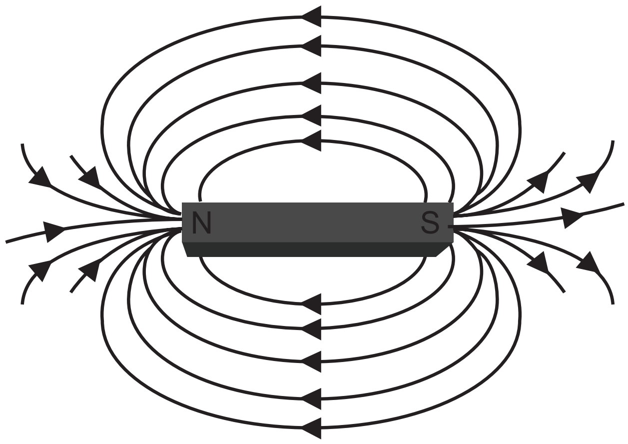
3.4 Give two ways in which magnets should be stored so that they retain their magnetism for as long as possible.

3.5 What is meant by ferromagnetic materials? Give the names of three elements which are ferromagnetic.

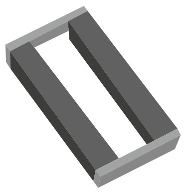
Solution:

3.1 A magnetic field is a region in which a magnet or ferromagnetic material experiences a magnetic force.

3.2



3.3 The north pole of a magnet is the place on the magnet where the field is strongest and if the magnet is able to rotate it will point this (north-seeking) pole towards the earth's magnetic north pole.

3.4 Magnets are stored by placing them in pairs with their north and south poles adjacent to each other. Two pieces of soft iron, called keepers, are placed at each of the poles. Magnets should be stored away from electric currents. Magnets should be stored at room temperature.	

3.5 Ferromagnetic materials are substances which exhibit strong magnetism in the same direction of the field when a magnetic field is applied to it. Iron, nickel and chromium are ferromagnetic elements.

CHALLENGE LEVEL QUESTIONS

a. Now that learners have mastered the basic questions, they are ready to deal with more challenging questions.

b. These questions require learners to use the facts and terminology and to apply these to solving problems.

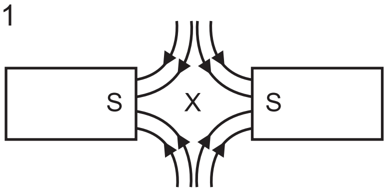
How to tackle these questions in the classroom:

- Work through these examples with learners.
- Tell learners that this is a more challenging version of what they have been doing.
- Write the first example on the chalkboard.
- Ask learners to look at the example and see if they can work out what must be done / what is different.
- Discuss learners' ideas, and ask probing questions to extend their answers.
- Try to be positive in these interactions, to encourage critical thinking and questioning.
- Ensure that learners copy down both the question and the solution into their workbooks.

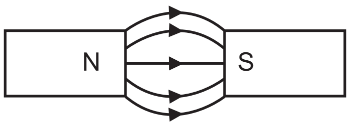
4. Sketch the magnetic field between two bar magnets placed:
   4.1 with their south poles facing each other.
   4.2 with opposite poles facing each other.

   Solution.

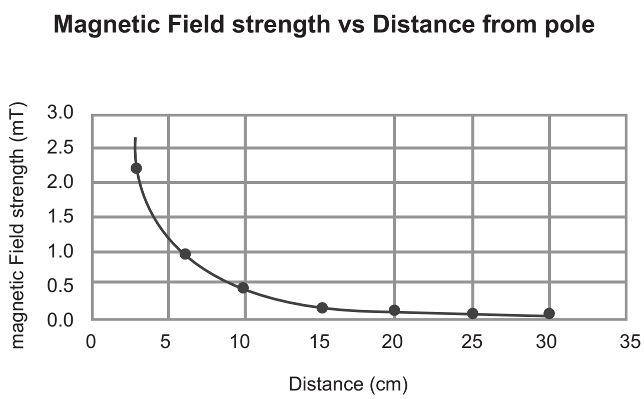
   4.1



   4.2



5. The strength of the magnetic field of a bar magnet is measured at various distances away from its north pole. The results are shown in the graph below.



5.1 Does the magnetic field strength change at a constant rate as the distance increases? If not, describe where the magnetic field strength changes fastest, and where it changes slowest.

5.2 How would you expect the graph to change if you replaced the magnet with one which is stronger?

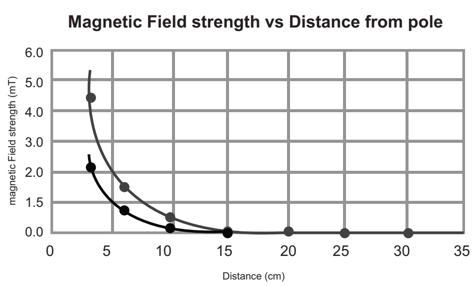
5.3 How would you expect the graph to change if you turned the original magnet around and measured the magnetic field strength from the other pole?

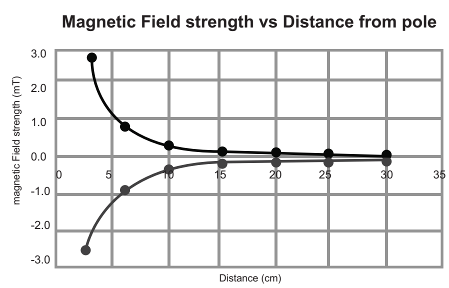
Solution:

5.1 The rate of the magnetic field strength vs distance changes fastest when it is measured nearer to the magnetic pole. The slope (gradient) of the graph is steepest at these positions.

When the strength was measured further away, the slope of the graph was very slight, showing that there is only a gradual change in the magnetic field strength at greater distance from the magnet.

5.2 If a stronger magnet was used, the field strength would be higher at every distance. It would curve up higher at the beginning, and remain higher at the end.





5.3 The original field strength would be the same value, but the graph would be the reflection about the horizontal axis, because the field is directed in the opposite direction. (It would be the reflection of the graph about the horizontal axis).

Key Teaching:

a. In these more challenging examples, learners must apply their knowledge of terminology and analysis of data to solving the problems.

b. It is good practice for the learners to describe variations in patterns (such as the steepness of the slope of the graph). Many learners have great difficulty in finding the words and phrases to use when describing trends from data in graphs.

c. Predicting how the graph would change is another skill which challenges learners. With a stronger magnet the magnetic field is stronger therefore the values at each distance from the pole will be higher.

d. Predicting the type of graph that would be obtained from the opposite pole requires two key pieces of knowledge: a) the magnetic field strength at each ol is of the same magnitude and b) the field direction is opposite (therefore all positive values of field strength will now be negative values.)

CHECKPOINT

At this point in the topic, learners should have mastered:

1. The terminology associated with magnets, magnetic fields and magnetism.
2. Learners should be able to apply the facts such as the laws of attraction and repulsion to different situations.
3. Sketch the magnetic field patterns for a bar magnet, and combinations of two bar magnets.

Check learners' understanding of these concepts by getting them to work through:

Worksheet Pack: Magnetism Worksheet: Questions 1 - 4

- Check learners' understanding by marking their work with reference to the memorandum.
- If you cannot photocopy the memorandum for each learner, make three or four copies of it and place these on the walls of your classroom.
- Allow learners time to mark their own work.
- Encourage the learners to learn from the mistakes they make.

TOPIC 14: Magnetism

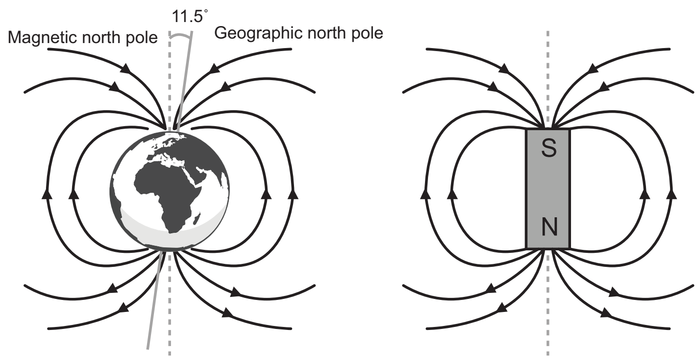
DISTINGUISHING BETWEEN MAGNETIC AND GEOGRAPHIC NORTH.

INTRODUCTION

A compass is used to determine magnetic north. It does this by aligning it magnetic needle with magnetic north. Geographic north is about 11o east of the magnetic north. This notion of there being two “north poles” can be very confusing!

CONCEPT EXPLANATION AND CLARIFICATION:

The earth’s magnetic field axis is inclined at about 11o west of the spin axis of the earth. The spin axis is the axis of rotation of the earth. The earth rotates about the spin axis every 24 hours. The top of the spin axis is geographic North, and the bottom is geographic South. The line of longitude that connects North and South is longitude 0o. (the Greenwich meridian).



Diagrams from
Grade 10
Everything Science

The magnetic axis shifts slightly over time. Scientists monitor the position of the magnetic axis on a daily basis even though it changes its position slowly over many decades and centuries. Almost every 200 000 years there have been reversals of the magnetic field of the Earth. In fact, there has been no reversal of the magnetic field in the last 800 000 years, so perhaps we are due for this to happen soon? Very little is known about the effects of a reversal in the earth’s magnetic field. Some scientists believe a reversal of the magnetic field has been accompanied by extinctions in the past.

A bar magnet has two poles – a north pole and a south pole. These poles are actually called the north seeking pole and the south seeking pole of the bar magnet. The north pole of a bar magnet seeks the north magnetic pole of the earth. The south pole of a bar magnet seeks the magnetic south pole of the earth.

The north pole of a bar magnet is attracted to a south pole of another magnet. Therefore, the magnetic north pole of the earth is actually a south pole! The lines of magnetic field are directed downwards at the magnetic north pole, and upwards at the magnetic south pole, as you see in the diagram above.

A compass needle points to the magnetic north pole which is actually slightly different from the geographic north pole.

INTRODUCTORY LEVEL QUESTIONS

a. These are the basic questions that learners will be required to answer at this stage in the topic.

b. Their purpose is to familiarise the learners with the idea of there being two north and two south poles, and to distinguish between these

How to tackle these questions in the classroom:

- Work through these examples with learners.
- Explain each step to the learners as you complete it on the chalkboard.
- Learners must copy the question as well as the solution into their workbook.

7. What is the magnetic north pole?

A The position that the north pole of a compass points to.

B The position that the south pole of a compass points to.

C The northernmost point on the earth's spin axis.

D The southernmost point on the earth's spin axis.

Solution:

A The north pole of a compass is a north-seeking pole; it seeks magnetic north.

8. One of the differences between the geographic north pole and the magnetic north pole is

A the magnetic north pole always remains in the same position.

B the geographic north pole always remains in the same position.

C the magnetic north pole is found in the southern hemisphere.

D the geographic north pole is found in the southern hemisphere.

Solution:

B The geographic north pole is always located at the top of the earth's spin axis.

CHALLENGE LEVEL QUESTIONS

a. Now that learners have mastered the basic questions, they are ready to deal with more challenging questions.

b. These questions require learners to apply their knowledge to solve problems related to the earth's magnetic field.

How to tackle these questions in the classroom:

- Work through these examples with learners.
- Tell learners that this is a more challenging version of what they have been doing.
- Write the first example on the chalkboard.
- Ask learners to look at the example and see if they can work out what must be done / what is different.
- Discuss learners' ideas, and ask probing questions to extend their answers.
- Try to be positive in these interactions, to encourage critical thinking and questioning.
- Ensure that learners copy down both the question and the solution into their workbooks.

9. Explain why the magnetic north pole of the earth is actually a south pole.

Solution:

The north pole of a bar magnet seeks the magnetic north pole of the earth's magnetic field. Since the north pole of a magnet is attracted to a south pole, the magnetic north pole of the earth must be a south pole.

10. The magnetic field of the earth shields us from cosmic radiation and from solar winds. How does it manage to do this?

Solution:

Magnetic fields interact with electric current (moving electric charges). The solar wind (and cosmic radiation) consists of streams of charged particles. When these charged particles strike living organisms, they damage cells and tissues. Life on earth would cease is the earth's magnetic field did not repel these particles away from the earth, shielding us from their effects.

TOPIC 14: Magnetism

Key Teaching:

a. In these more challenging examples, learners must apply knowledge and explain phenomena.

b. Learners must also visualise the context in which the problem is set.

CHECKPOINT

At this point in the topic, learners should have mastered:

1. The differences between the magnetic and geographic north poles
2. Drawing a diagram of the earth's magnetic field
3. Explaining how a compass works
4. Explaining the importance of the earth's magnetic field

Check learners' understanding of these concepts by getting them to work through:

Worksheet Pack: Magnetism Worksheet: Question 5

- Check learners' understanding by marking their work with reference to the memorandum.
- If you cannot photocopy the memorandum for each learner, make three or four copies of it and place these on the walls of your classroom.
- Allow learners time to mark their own work.
- Encourage the learners to learn from the mistakes they make.

CONSOLIDATION

- Learners can consolidate their learning by completing; **Worksheet Pack: Magnetism Consolidation Questions.**
- Photocopy the exercise sheet for the learners. If that is not possible, learners will need to copy the questions from the board before attempting to answer them.
- The consolidation worksheet should be marked by the teacher so that she/he is aware of each learner's progress in this topic.
- Please remember that further consolidation should also be done by completing the examples available in the textbook.
- **It is important to note that this consolidation exercise is NOT scaffolded.**
- **It should not be administered as a test, as the level of the work may be too high to in its entirety.**

ADDITIONAL VIEWING / READING

In addition, further viewing or reading on this topic is available through the following web links:

1. https://www.intemag.com/magnetic-materials-faqs
   For teachers: Notes of magnetism and magnets

2. https://www.siyavula.com/read/science/grade-10/magnetism
   For teachers and learners: Notes and examples of magnetism from Siyavula: Everything Science Grade 10

3. https://www.youtube.com/watch?v=uj0DFDfQajw
   For teachers and learners: Video explaining what is a magnetic field and how to draw magnetic fields.

4. https://phet.colorado.edu/en/simulation/legacy/magnet-and-compass
   Simulation on magnets and compasses.

TOPIC 15: Electrostatics

A INTRODUCTION

- This topic runs for 4 hours.
- For guidance on how to break down this topic into lessons, please consult the NECT Planner & Tracker.
- These topics form part of the content area of Electricity and Magnetism.
- Electricity and Magnetism counts 35% of the final examination.
- Magnetism counts about 12% in the final examination.
- Electrostatics is evident most dramatically in everyday life during thunderstorms. It also affects us especially during dry seasons when there is very little moisture in the air. When you take your jersey off on such a day you can hear soft clicking sounds as the jersey and you exchange electrons – you can also feel slight electric shocks from door handles when you touch them. Electrostatics has many practical uses e.g. photocopiers, laser printers, paint sprayer and dust precipitators all make use of principles of electrostatics.

CLASSROOM REQUIREMENTS FOR THE TEACHER

1. Chalkboard.
2. Chalk.

If possible:

3. Two balloons
4. Cotton thread

CLASSROOM REQUIREMENTS FOR THE LEARNER

1. A4 3-quire exercise book for notes and exercises.
2. Scientific calculator – Sharp or Casio calculators are highly recommended.
3. Pen.

B

SEQUENTIAL TABLE

PRIOR KNOWLEDGE	CURRENT	LOOKING FORWARD
Grade 7-9 **Qualitative aspects**	**Grade 10**	**Grade 11-12**
• Static electricity • The magnetic effect of electric current (electromagnets) • Forces and force fields (gravitational, magnetic and electric fields)	• Two types of charge • Charge conservation • Charge quantization • Force exerted by charge on each other (qualitative) • Polarisation	• Electromagnetism o The magnetic field associated with current carrying wires o Faraday’s Law • Electrodynamics o Electric motors o Generators

C

GLOSSARY OF TERMS

Please note: The highlighted definitions and laws are ones that learners must be able to state and are given in the CAPS document. For examination purposes, learners must know these definitions and laws by heart, and must write them exactly as they appear here.

TERM	DEFINITION
The principle of conservation of charge	The net charge of an isolated system remains constant during any physical process.
The principle of charge quantization	Every charge in the universe consists of integer multiples of the electron charge. Q = nq where Q = amount of charge (C), n is an integer, q = 1,6 x 10^{-19} C (charge on an electron).
Magnetic field	A region in space where another magnet or ferromagnetic material experiences a (noncontact) force.
Electric field	A region in space where an electric charge experiences an electric force.
Gravitational field	An object with a pair of opposite poles, called north and south poles, which experiences magnetic force in a magnetic field.
Two kinds of charge	A region in space where a mass experiences a gravitational force.
Conductor	Like magnetic poles repel each other; opposite magnetic poles attract each.
Insulator	A device that uses a magnetic needle to show the direction of a magnetic field.
Positively charged	The northernmost point of the Earth's axis of rotation.
Negatively charged	The direction toward which the (magnetic) north pole of a magnet points when it is free from any local magnetic influence.

Tribo-electric charging	A stream of energetic particles ejected by the Sun. These particles include electrons, protons, alpha particles (nuclei of helium atoms) and the atomic nuclei of carbon, nitrogen, neon, oxygen and magnesium.
Polarised	Positive and negative charges within an object or a molecule have collected in separate locations.
Law of electrostatic attraction and repulsion	Like charges repel each other; opposite charges attract each other.
Pith ball	A polystyrene sphere coated with graphite. The surface of the pith ball is a good conductor so charge spreads evenly on the surface of a pith ball.

D ASSESSMENT OF THIS TOPIC

- This topic is assessed by class tests and/or in the Term 2 examination. There may be multiple-choice type questions, match the phrase type questions, or problems to solve, where the learners are expected to show their method, give some explanation and/or write down definitions or laws.

E

BREAKDOWN OF TOPIC AND TARGETED SUPPORT OFFERED

TIME ALLOCATION	SUB TOPIC	CAPS PAGE NUMBER	TARGETED SUPPORT OFFERED
0,5 h	Two kinds of charge	40	Misconceptions about electrostatics a. Electrostatics is the study of charges at rest. b. Charge is separated by friction. c. Neutral objects have no charge. d. How are objects polarised?
1 h	Conservation of charge	41	
1 h	Quantization of charge	41 - 42	
0.5 h	Force exerted by charge on each other (descriptive). Attraction between charged and uncharged objects (polarisation).	42	

F

TARGETED SUPPORT PER SUB TOPIC

1. ELECTROSTATICS IS THE STUDY OF CHARGES AT REST.

Introduction

Electrostatics is not the study of charges at rest. It is not the study of stationary charges. Electrostatics is the study of ….

- the imbalance of charge in or on an object,
- the forces that charges exert on each other and on neutral objects,
- the electric field surrounding charges, and
- the interactions that take place when there is an imbalance of charge.

At Grade 10 level we study the two kinds of charge, conservation of electric charge, the quantization of charge and the forces that charges exert on each other, as well as polarisation in materials due to forces exerted by charges on each other. We do not study the electric fields surrounding charged objects, or calculate the magnitude of electric force or fields.

CONCEPT EXPLANATION AND CLARIFICATION: BALANCED CHEMICAL EQUATIONS

Electrostatics is about an imbalance of charge within a material. All materials contain both positive and negative charge because they are made up of atoms which contain both protons and electrons. A charged object has an imbalance of charge – positive objects have less electrons than protons; negative objects have more electrons than protons.

The reason why we should not refer to electrostatics as the study of stationary charge or of charge at rest, is because the effects of the imbalance of charge continue to exist even when the charge is moving. A stationary electron sets up an electric field around it. When that electron moves, its electric field moves with it. The effect that the electron has on other charges in its region does not depend on the electron being at rest (stationary). The effect depends on the electron being charged.

Electrostatics is the study of charges, their forces and their interactions. It does not depend on whether the charge is stationary or moving.

2. CHARGE IS SEPARATED BY FRICTION.

Charge can be separated by friction if a rough surface is rubbed against a smooth (or rough) surface. Electrons can be transferred from one surface to the other by friction. But friction is not the only way in which charge can be separated.

Charge can also be transferred by touching two different “neutral” insulating materials together and then separating them. All that is required is for the two surfaces to touch each other. This is called triboelectric charging.

CONCEPT EXPLANATION AND CLARIFICATION:

When two different "neutral" insulating materials touch each other, chemical bonds are formed at the place where they are in contact with each other. If the atoms in surface A tend to hold electrons more tightly than the atoms in surface B, electrons will move from surface B to surface A. This causes an imbalance in electric charge at the two surfaces. When the surfaces are separated from each other, surface A will have more electrons and be negatively charged; surface B will have transferred those electrons to A, so surface B will be positively charged. This process occurs without friction!

Charging can also occur through contact. A positively charged Perspex rod can transfer charge to a balloon, or to another Perspex rod. The positively charged rod "steals" electrons from the other material leaving both of the materials positively charged. No friction is involved in this method of charging.

3. NEUTRAL OBJECTS HAVE NO CHARGE.

All materials contain charge.

CONCEPT EXPLANATION AND CLARIFICATION:

All materials contain atoms. All atoms contain positive and negative charge, in the form of protons and electrons.

Neutral objects contain an equal number of protons and electrons. They have no imbalance of charge. Charged objects either have an extra number of electrons, and are negatively charged, or they have less electrons than protons, and are positively charged.

Only electrons are transferred between materials to cause an imbalance of charge (or to charge the object). Electrons are found outside the nucleus of atoms, so the outermost electrons of atoms and molecules can be removed from the materials, or attached to the materials with relative ease in comparison to removing or adding an extra proton to a nucleus. Electrostatic phenomena arise from the transfer of electrons – not protons.

4. HOW ARE OBJECTS POLARISED?

Polarisation is the separation of charge in an object that remains neutral. Polarisation explains how charged objects attract neutral objects.

TOPIC 15: Electrostatics

CONCEPT EXPLANATION AND CLARIFICATION:

It is important to describe “polarisation” as the shift of positive and negative charge within an object (or within molecules inside the object), which results in two electric dipoles being formed. Electric dipoles consist of two electric poles: a slightly negative pole and slightly positive pole. The overall charge on the object (or molecule) is zero.

Polarisation occurs inside a neutral object. The overall (total) charge of the object remains zero because the same number of negative and positive charges are present in the object. There is only a shift of negative and positive charge inside the object.

How does a charged object attract a neutral object?

When a charged rod is brought near to small pieces of paper (e.g. pieces of paper from a paper punch) the pieces of paper are attracted to the rod.

Let us assume that the charged rod is negatively charged. The pieces of paper are neutral. They have no imbalance of charge. They have the same number of protons and electrons inside them.

The negatively charged rod repels electrons on the surface of the paper pieces when it is brought nearby. The closer the rod is to the piece of paper the stronger the force exerted on the electrons. This repulsion of electrons causes a temporary shift in charge on the molecules inside the piece of paper. The outer electrons in the molecules are repelled from the part of the molecule which is closest to the negative rod. This causes the molecule to become polarised; it has a slightly positive part and a slightly negative part due to the shift in charge inside it.

Oppositely charges attract each other. The positively charged parts of the paper molecules are attracted to the negatively charged rod. Each piece of paper experiences enough electric force to overcome its weight (gravitational force) so it “jumps up” to attach itself to the negatively charged rod.

While the piece of paper is in contact with the negatively charged rod, the molecules on the surface of the paper gain extra electrons from the rod. They become negatively charged. The piece of paper is repelled away from the rod because like charges repel each other. The piece of paper drops down to the table top because the force of repulsion and its weight pulls it down again.

<u>Note</u>: In place of using pieces of paper you can use crushed Rice Krispies. They jump around merrily when you insert a charged rod into a small amount of crushed Rice Krispies – first being attracted to the rod and then vigorously jumping off it.

Some molecules are polar molecules e.g. water molecules are polar molecules. Water molecules have a slightly positive side near their hydrogen atoms and a slightly negative side near their oxygen atom. Polar molecules are especially affected by other charged objects. They are able to rotate when a charged rod is brought near them due to attraction of opposite charges.

Materials which contain polar molecules show greater polarisation effects in the presence of electric fields from other charged objects than other materials which have molecules with uniform charge distribution (non-polar molecules).

INTRODUCTORY LEVEL QUESTIONS

a. These are the basic questions that learners will be required to answer at this stage in the topic.

b. Their purpose is to familiarise the learners with terminology.

How to tackle these questions in the classroom:

- Work through these examples with learners.
- Explain each step to the learners as you complete it on the chalkboard.
- Learners must copy the question as well as the solution into their workbook.

1. A glass rod is positively charged by rubbing it with fur. The rod is held near a neutral graphite-coated insulated sphere which hangs freely from light cotton thread.

1.1 Explain how the rod gains a positive charge when it is rubbed with fur.

1.2 Draw diagrams to show:

   a. The rod and sphere when they are far apart from each other.

   b. The rod and sphere when they are close to each other.

   c. The rod and sphere after they have touched each and been moved a small distance apart from each other.

1.3 The fur becomes charged after it has rubbed the glass rod.

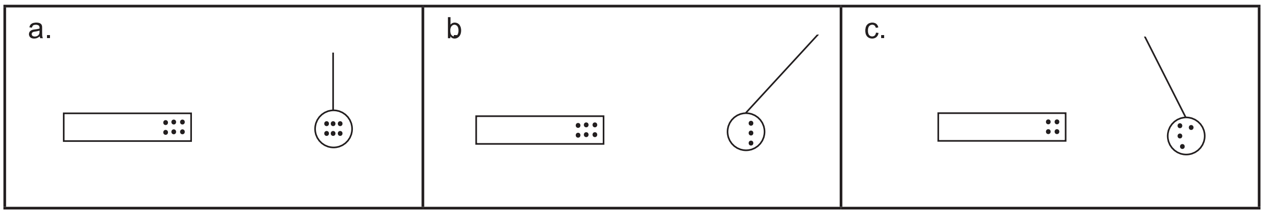
   a. What kind of charge does the fur gain?

   b. Where does this charge come from?

Solution:

1.1 The fur rubs electrons off the glass rod because fur particles attract electrons more strongly than the molecules of glass do. The rod has less electrons than protons, therefore it is positively charged.

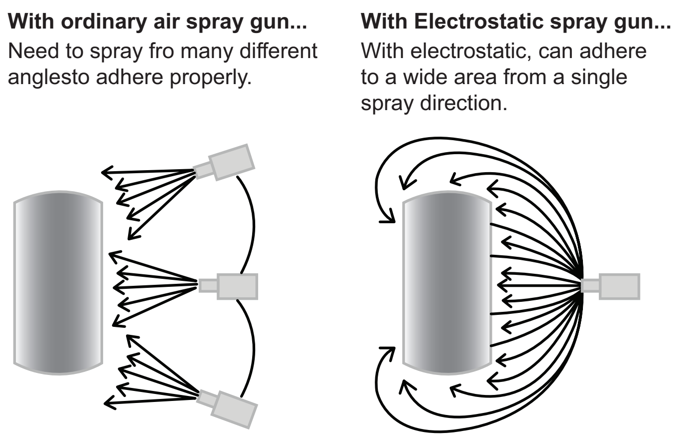
1.2



1.3 a. The fur gains negative charge.

b. The fur gains electrons from the glass rod. (Electrons are transferred to the fur from the glass rod.)

2. This question is about spray painting a metal surface. An ordinary air spray gun sprays paint from a neutral nozzle. The nozzle of an electrostatic spray gun is positively charged and the object which is being coated with paint is earthed. Study the diagram shown below.



http://ultrasealamerica.com/userfiles/electro.jpg

2.1 Explain what it means when we say, “The object is earthed”.

2.2 In terms of electrostatics, explain how the electrostatic spray painting system works.

2.3 Give TWO advantages of using the electrostatic spray painting.

Solution:

2.1 The object is connected by a conducting wire to the earth so that it will always remain neutral. If it has an excess of electrons, they will flow away into the earth. If it lacks electrons (is positively charged), it will receive electrons from the earth.

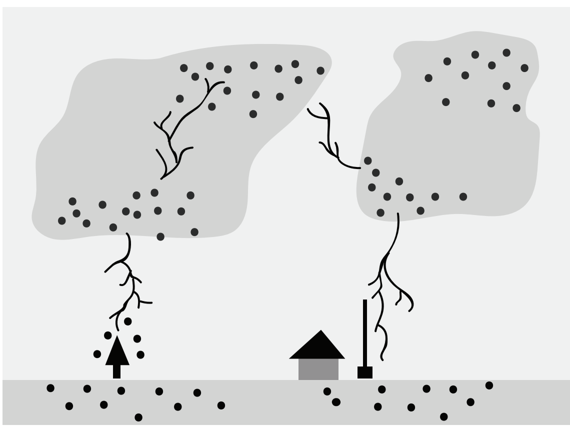
2.2 The positively charged paint droplets repel each other as they leave the nozzle because like charge repels. The positively charged paint droplets are attracted to the earthed object because they cause electrons from earth to be attracted to the object. Opposite charges attract each other.

2.3 The paint sticks tightly to the object. The paint surrounds the object because its surface is oppositely charged.
Very little paint is wasted – very little paint falls to the ground because it is attracted to the object. You don't have to move the nozzle around the object as much as you would have to do with the other spray paint.

3. Lightning conductors are used to protect homes from being struck by lightning. Briefly explain how a lightning conductor works.

Solution:

A lightning conductor is a tall metal spike which has its base buried in the ground, and its spike a few metres taller than the house or the trees which surround the house. When lightning strikes it moves through the air taking the path of least resistance. The bases of the clouds become negatively charged, so the electrons in the lightning conductor are repelled down into the earth. The spike becomes positively charged. Lightning will therefore follow a path through the earth and down the conductor, safely taking extra electrons deep into the earth.



[Actually, lightning travels both ways: up to the sky and down to earth during a storm. Positively charged ions in the air move from around the spike of the lightning conductor up towards the base of the clouds.]

CHALLENGE LEVEL QUESTIONS

a. Now that learners have mastered the basic questions, they are ready to deal with more challenging questions.

b. These questions require learners to **use** the facts and terminology and to apply these to solving problems.

How to tackle these questions in the classroom:

- Work through these examples with learners.
- Tell learners that this is a more challenging version of what they have been doing.
- Write the first example on the chalkboard.
- Ask learners to look at the example and see if they can work out what must be done / what is different.
- Discuss learners' ideas, and ask probing questions to extend their answers.
- Try to be positive in these interactions, to encourage critical thinking and questioning.
- Ensure that learners copy down both the question and the solution into their workbooks.

4. Two positively charged spheres are brought up to touch each other. The charge on sphere A is +20 nC and that sphere B is +6 nC.

4.1 State the Law of Conservation of Charge.

4.2 Calculate the charge on each sphere when they are separated from each other.

4.3 Describe how charge was transferred from one sphere to the other.

Solution:

4.1 The total charge in an isolated system remains constant.

4.2
$$\begin{aligned} Q &= \frac{Q_1 + Q_2}{2} \\ &= \frac{20+6}{2} nC \\ &= +13 nC \end{aligned}$$

4.3 Electrons were transferred from the +6nC charge to the +20nC until both had reached 13 nC.

5. Two spheres A and B are attached to cotton threads and allowed to hang next to each other as shown in diagram 1. After they are brought up to touch each other, they move to form the pattern shown in diagram 2.

Which of the following statements is TRUE?

(Note: More than one of these statements may be true).

A Sphere A and B are both charged before they are hung near each other.

B Sphere A may have been charged before they are hung near each other.

C Sphere B may have been charged before they are hung near each other.

D Both A and B are oppositely charged before they are hung near each other.

E A and B have like charge before they are hung near each other.

F The charge on A is greater than the charge on B.

G The charge on B is greater than the charge on A.

Solution:

The two spheres repel each other when they are first hung close together. After they have touched they repel each other with less force. They must have shared charge with each other, so that they both have the same, but less charge therefore they repel each other with less force.

Statements A, B, C, D are true. E or F is true.

Key Teaching:

a. In these more challenging examples, learners must apply knowledge and explain phenomena.

b. It is good practice for the learners to predict and explain how charge is transferred, and how one charge affects another when placed near to each other, and/or they touch each other.

TOPIC 15: Electrostatics

CHECKPOINT

At this point in the topic, learners should have mastered:

1. The terminology associated with charge, conservation of charge, the effect of charged objects on other objects (charged or neutral) and polarisation.
2. Learners should be able to apply the facts such as the laws of electrostatic attraction and repulsion, and the conservation of charge to different situations.
3. Explain the effect of charges objects on other objects (charged or neutral), and polarisation.
4. Explain briefly how a system works when given a diagram or a description of an application of electrostatics e.g. spray painting, air pollution control systems.

Check learners' understanding of these concepts by getting them to work through:

Worksheet Pack: Magnetism Worksheet: Question 1-6

- Check learners' understanding by marking their work with reference to the memorandum.
- If you cannot photocopy the memorandum for each learner, make three or four copies of it and place these on the walls of your classroom.
- Allow learners time to mark their own work.
- Encourage the learners to learn from the mistakes they make.

CONSOLIDATION

- Learners can consolidate their learning by completing; **Worksheet Pack: Electrostatics Consolidation Questions.**
- Photocopy the exercise sheet for the learners. If that is not possible, learners will need to copy the questions from the board before attempting to answer them.
- The consolidation worksheet should be marked by the teacher so that she/he is aware of each learner's progress in this topic.
- Please remember that further consolidation should also be done by completing the examples available in the textbook.
- **It is important to note that this consolidation exercise is NOT scaffolded.**
- **It should not be administered as a test, as the level of the work may be too high to in its entirety.**

TOPIC 15: Electrostatics

ADDITIONAL VIEWING / READING

In addition, further viewing or reading on this topic is available through the following web links:

1. https://www.siyavula.com/read/science/grade-10/electrostatics
   For teachers and learners: Notes and examples of electrostatics from Siyavula: Everything Science Grade 10
2. https://www.youtube.com/watch?v=ViZNgU-Yt-Y
   For teachers and learners: Video showing interesting electrostatic demonstrations which can be carried out with ordinary household equipment.
3. https://www.youtube.com/watch?v=Opz_GrI_vQA
   For teachers and learners: Video showing how planes are refuelled to avoid excess build-up of electrostatic charge on the plane and the tanker.
4. https://www.youtube.com/watch?v=zHJkJGBdvwE
   For teachers and learners: Video introducing positive and negative charge (Bozeman science).
5. http://amasci.com/emotor/stmiscon.html
   For teachers: A website that addresses misconceptions in electrostatics.

Topic 16: Electric circuits

A INTRODUCTION

- This topic runs for 8 hours.
- For guidance on how to break down this topic into lessons, please consult the NECT Planner & Tracker.
- These topics form part of the content area of Electricity and Magnetism.
- Electricity and Magnetism counts 35% of the final examination.
- Electric circuits count about 18% in the final examination.
- Electrical appliances, cell phones, cars, household lighting and industry all run on electricity. It is therefore important to know and understand the basic principles of electric circuits, and to work with circuits safely. This topic deals with DC (direct current) battery powered circuits. The voltages and currents cannot harm the learners when they experiment with circuits.

CLASSROOM REQUIREMENTS FOR THE TEACHER

1. Chalkboard.
2. Chalk.

CLASSROOM REQUIREMENTS FOR THE LEARNER

1. A4 3-quire exercise book for notes and exercises.
2. Scientific calculator – Sharp or Casio calculators are highly recommended.
3. Pen.

B

SEQUENTIAL TABLE

PRIOR KNOWLEDGE	CURRENT	LOOKING FORWARD
Grade 7-9 **Qualitative aspects**	**Grade 10** **Qualitative and quantitative aspects**	**Grade 11-12** **Further applications**
• Static electricity • The magnetic effect of electric current (electromagnets) • Forces and force fields (gravitational, magnetic and electric fields)	• Emf and terminal pd • Current • Measurement of current and pd • Resistance • Resistors in series • Resistors in parallel	• Electromagnetism o The magnetic field associated with current carrying wires o Faraday's Law • Electrodynamics o Electric motors o Generators

C

GLOSSARY OF TERMS

Please note: The highlighted definitions and laws are ones that learners must be able to state and are given in the CAPS document. For examination purposes, learners must know these definitions and laws by heart, and must write them exactly as they appear here.

TERM	DEFINITION
Potential difference (pd or voltage)	The amount of work done or energy transferred per unit charge between two points.
Terminal potential difference (terminal pd or terminal voltage)	The voltage measured across the terminals of a battery when current is flowing through the battery is called terminal potential difference.
Current	The rate of flow of charge.
Resistance	Resistance is the opposition to the flow of electric current.
The ohm (Ω)	One ohm of resistance allows one ampere of current to pass through when a potential difference of one volt is applied across it. (One ohm is one volt per ampere).
Emf	The voltage measured across the terminals of a battery when no current is flowing through the battery is a measure of the emf of the battery. NB. The definition of emf is the total amount of work done or energy transferred per unit charge passing through the battery. Grade 10 learners do not need to recall this definition.
Conductor	An object with properties that allow charges to move about freely inside it.
Insulator	An object which does not allow charges to move about freely inside it.
In series	A set of components (batteries, resistors or other components) arranged so that the current passes through each of them successively.

In parallel	A set of components connected to common points at each end; not in series.
Current divider	A parallel circuit divides the current in each of its branches. The sum of the currents in the branches is equal to the total current. $I_T = I_1 + I_2 + I_3 + \ldots..$
Voltage divider	A series circuit is a voltage divider; the sum of potential difference across each component equals the total voltage across that part of the circuit. $V_T = V_1 + V_2 + V_3 + \ldots$
Equivalent resistance	The total resistance of the arrangement of resistors. In series $R_{eq} = R_1 + R_2 + R_3 + \ldots$ In parallel $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$ For two resistors in parallel: $R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$

D ASSESSMENT OF THIS TOPIC

- This topic is assessed by class tests and/or in the Term 2 examination. There may be multiple-choice type questions, match the phrase type questions, or problems to solve, where the learners are expected to show their method, give some explanation and/or write down definitions or laws.

Topic 16: Electric circuits

E

BREAKDOWN OF TOPIC AND TARGETED SUPPORT OFFERED

TIME ALLOCATION	SUB TOPIC	CAPS PAGE NUMBER	TARGETED SUPPORT OFFERED
1 h	Emf and terminal pd	42	a. Electrical symbols e.g. I for current, A for amperes, can be confusing for learners b. Common misconceptions concerning the battery. c. Common misconceptions concerning current, energy and potential difference.
1 h	Current	43	
1 h	Measuring current and pd	43	
1 h	Resistance	44	
2 h	Resistors in series	44	
2 h	Resistors in parallel	45	

F

TARGETED SUPPORT PER SUB TOPIC

1. ELECTRICAL SYMBOLS CAN BE CONFUSING TO LEARNERS.

Introduction

A number of formulae related to electric circuits appear on the Physics data sheet. The symbols that are used, though pretty clear-cut and straight-forward to teachers, can be very challenging to the learners. If the learner does not know the difference between the symbol for a quantity and its SI units, the problem can become so insurmountable that (s)he does not know where to start when solving problems.

CONCEPT EXPLANATION AND CLARIFICATION:
This confusion often goes unnoticed by the teacher, who could be trying very hard to pinpoint the source of the learners' problems – ascribing them to misconceptions about electric current – instead of just ignorance (lack of knowledge of the symbols)!

So first establish the facts with your class – and keep helping them to interpret the formulae appropriately.

Quantity	Symbol	SI units	SI unit symbol
Current	I	amperes	A
Potential difference (voltage, pd)	V	volts	V
emf	$\mathcal{E}$ OR emf	volts	V
Resistance	R	ohms	Ω
Internal resistance	r	ohms	Ω
Work done (energy transferred)	W	joules	J
Power	P	watts	W
Charge	Q	coulombs	C
Time	Δt	seconds	s

2. COMMON MISCONCEPTIONS CONCERNING THE BATTERY.

Introduction

When the battery is connected in the circuit it provides electrical energy to the components of the circuit. There are many misconceptions which stem from misunderstanding the function of the battery, and the way in which it carries out its function e.g.

- the battery is a source of constant current irrespective of the total resistance of the circuit
- the battery stores charge
- batteries can be "recharged".

Topic 16: Electric circuits

CONCEPT EXPLANATION AND CLARIFICATION:

Let's start with the statement "I am going to recharge my battery". This is what most people think or say when they connect their cell phone to a "charger". The everyday use of these terms can lead to many faulty ideas about the battery, current, charge and what is actually going on in the battery.

Batteries work by transferring chemical energy into electrical energy. When providing current to a circuit the battery provides energy which moves charge through the circuit. The battery does not provide charge to the circuit components. The conductors, resistors and light bulbs are made from materials which already have charge that is free to flow in them. The battery causes charge to move from low potential to a higher potential in the circuit.

The statement about recharging a battery should say "I am going to re-energise my battery". The process of "recharging" involves running a current through the battery in the opposite direction from which the battery supplies current. This causes the chemical reactions inside the battery to reverse. Electrical energy is transferred to chemical energy during this process. A "fully charged" battery is one which has received the maximum amount of chemical energy – the process of reversing the chemical reactions is complete.

Can you see how our everyday use of these terms (charging, recharging, charger etc) leads to so many faulty ideas of what is happening in a battery and an electric circuit? It is no wonder that this topic of electric circuits is such a challenge!

When we buy 'electricity' from ESKOM we buy energy – not electrons or charge. ESKOM bills us for the energy it supplies (in units of 1kW.h).

Let's convert 1 kW·h to J.

1 kW.h = 1 x 1 000 x 60 x 60 = 3 600 000 J

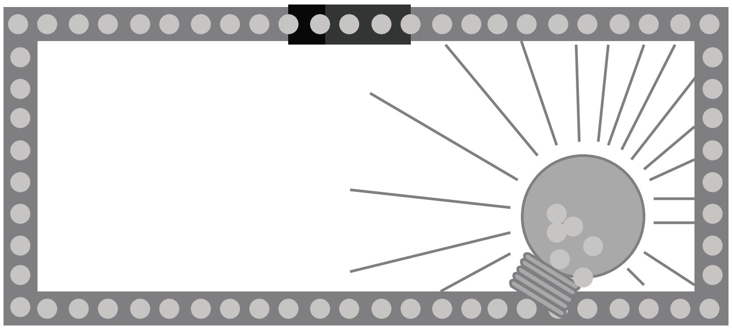
Consider a simple circuit consisting of a (filament) light bulb, a switch, connecting wires and a battery as shown in the diagram below.

When the switch is closed the light bulb glows immediately. There is no apparent time delay between closing the switch and the light bulb glowing. Many people believe that charge travels through the wires at the speed of light, and that is how they explain that the bulb glows instantly.

In fact, charge travels relatively slowly through a circuit. The speed is about 5 $mm \cdot s^{-1}$.

This diagram from pHet Electric Construction Kit shows clearly that electrons (or charge) is present in all the components of a circuit. As soon as the battery supplies energy to the circuit

ALL the charge begins to move. There is no delay in the bulb lighting because charge begins to flow in every part of the circuit when the switch is closed.



Another misconception relates to the amount of current the battery provides to the circuit. Many people believe that each battery provides a fixed constant current to the circuit, regardless of the total resistance of the circuit.

One way of overcoming this faulty reasoning is to first connect one bulb in the circuit, and take a reading of the current. Then to use the same battery and two bulbs in series, and take a reading of the current. The current will be almost half of the initial current reading because the total resistance of the circuit has increased.

The battery has a fixed emf which tells us about the maximum amount of energy it can provide per unit charge passing through it. If there is more resistance to the flow of charge, the battery will provide the same maximum amount of energy per unit charge passing through it. The amount of charge passing through per unit time will decrease – the current will decrease.

A fresh (new) battery has a fixed emf and a low internal resistance. We can measure the emf of the battery by taking the potential difference across its terminals when no current passes through it. When a bulb is connected across its terminals, the terminal potential difference will be just a little less than the emf of the battery, because the amount of work done in moving charge through the battery is low. (The resistance inside the battery is low).

A well-used (nearly flat) battery will have a greater difference in emf and terminal potential difference when it is connected to the same bulb. So, the current that the battery provides will not remain constant.

Topic 16: Electric circuits

INTRODUCTORY LEVEL QUESTIONS

a. These are the basic questions that learners will be required to answer at this stage in the topic.

b. Their purpose is to familiarise the learners with terminology.

How to tackle these questions in the classroom:

- Work through these examples with learners.
- Explain each step to the learners as you complete it on the chalkboard.
- Learners must copy the question as well as the solution into their workbook.

1. A cell (battery) with an emf of 1,50 V is connected to a light bulb. The terminal potential difference measured across the light bulb is 1,45 V.

1.1 Describe the term “potential difference”.

1.2 Name the apparatus used to measure the potential difference across the bulb.

1.3 Explain what is meant by “the battery has an emf of 1,5 V”.

1.4 The terminal potential difference is slightly less than the emf of the battery. What happened in the battery to cause this difference?

Solution:

1.1 The potential difference is the amount of energy transferred per unit charge across two points.

1.1 Voltmeter.

1.2 The emf of a battery is the potential difference measured across the battery when no current passes through it.
OR The emf of a battery is the maximum energy transferred per unit charge passing through the battery.

1.3 Energy is transferred per unit charge passing through the battery because the battery has internal resistance.
OR Work was done on the charge as it passed through the battery because there is resistance inside the battery.

2. Explain why the following statement is false.
“A battery supplies charge to the electric circuit”.

Solution:

A battery supplies energy to the circuit. All the components of the circuit have free charge in them which is able to flow when the charge receives energy.

3. What actually happens when a battery is flat?
   A It has run out of charge.
   B It has a emf of 0 V.
   C It has transferred its chemical energy to electrical energy.
   D All of the above.

Solution:

C The battery has transferred all available chemical energy to electrical energy.

Option A is incorrect. Batteries do not store charge so they cannot run out of charge.

Option B is incorrect. When you measure the emf of a flat battery it still measures 1,5 V. You can only find out if it is a "flat" battery by connecting it in circuit, and measuring its terminal potential difference (or measuring how much current that passes through the circuit). If the battery is flat, the terminal pd will be close to zero, and there will be no current, or a very small current.

CHALLENGE LEVEL QUESTIONS

a. Now that learners have mastered the basic questions, they are ready to deal with more challenging questions.

b. These questions require learners to **use** the facts and terminology and to apply these to solving problems.

How to tackle these questions in the classroom:

- Work through these examples with learners.
- Tell learners that this is a more challenging version of what they have been doing.
- Write the first example on the chalkboard.
- Ask learners to look at the example and see if they can work out what must be done / what is different.
- Discuss learners' ideas, and ask probing questions to extend their answers.
- Try to be positive in these interactions, to encourage critical thinking and questioning.
- Ensure that learners copy down both the question and the solution into their workbooks.

4. When two cells (batteries) are connected in series with each other to a light bulb, the bulb glows brighter. This happens because:
   A Each battery shares the current through the light bulb.
   B The light bulb offers less resistance to the current.

C Two batteries supply twice as much charge to the circuit.

D The terminal potential difference across the bulb increased.

Solution:

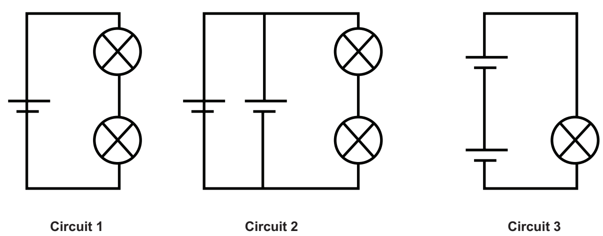
D The terminal potential difference will be doubled therefore there will be twice the amount of energy per unit charge supplied to the light bulb. It will glow brighter.

Option A is incorrect because both batteries allow the same current to pass through them. They do not share the current.

Option B is incorrect because the resistance of the light bulb is fixed. It is a property of the materials of the bulb.

Option C is incorrect. Batteries do not supply charge to the circuit.

5. Two identical light bulbs are connected in series as shown in circuits 1, 2 and 3 below. The cells (batteries) are all identical. Two cells are connected in parallel in Circuit 2, and in series in Circuit 3.



5.1 In which circuit will the light bulbs glow brightest?

5.2 Briefly explain your answer to 5.1.

Solution:

5.1 Circuit 3.

5.2 The cells in series provide double the amount of energy per unit charge to the bulbs. OR The emf of the two cells in series will be twice that of one cell.
NB. The bulbs will glow with the same intensity (brightness) in Circuits 1 and 2. Two cells in parallel have the same emf as a single cell.

Key Teaching:

a. In these more challenging examples, learners must apply their knowledge of terminology and analysis of data to solving the problems.

b. It is good practice for the learners to explain how a battery operates in terms of energy transfers, and the effect on the circuit of connecting batteries in series or in parallel.

CHECKPOINT

At this point in the topic, learners should have mastered:

1. The terminology associated with batteries: emf and terminal potential difference.
2. Learners should be able to state that batteries are a source of electrical energy.
3. Explain the effect on the circuit of connecting identical batteries in series or in parallel.

Check learners' understanding of these concepts by getting them to work through:

Worksheet Pack: Magnetism Worksheet: Question 1-4

- Check learners' understanding by marking their work with reference to the memorandum.
- If you cannot photocopy the memorandum for each learner, make three or four copies of it and place these on the walls of your classroom.
- Allow learners time to mark their own work.
- Encourage the learners to learn from the mistakes they make.

3. COMMON MISCONCEPTIONS CONCERNING CURRENT, ENERGY AND POTENTIAL DIFFERENCE.

Current, energy and potential difference are terms which learners often use interchangeably as if they were the same. Other faulty ideas are that:

- Current (or voltage) is used up in a circuit.
- Voltage flows through components.

CONCEPT EXPLANATION AND CLARIFICATION:

Current is the rate of flow of charge. In a metal current consists of electrons moving in the conductor. In an electrolyte current consists of cations and anions passing through the solution. We measure current in amperes (A) with an ammeter which is connected in series in the circuit (so that charge passes through the ammeter). We calculate current using:

$$I = \frac{Q}{\triangle t}$$

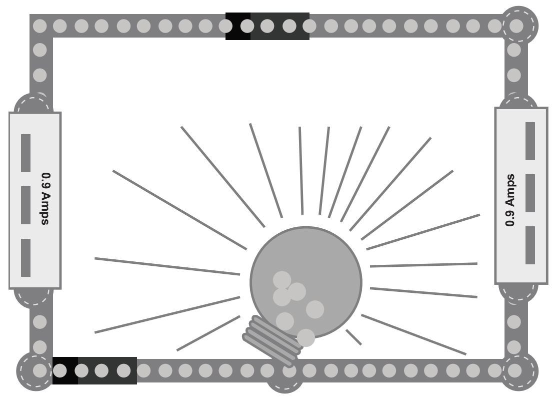
Energy is the ability to do work. It is measured in joules. Electrical energy is transferred by the charge moving through the circuit.

Potential difference is measured across two points in a circuit. The voltmeter is connected across two points to measure pd. Negligible current passes through the voltmeter, because the voltmeter has an extremely high resistance compared to any of the components of the circuit. For our purposes we can assume that no current passes through the voltmeter.

When we measure potential difference, we are measuring the amount of energy transferred per unit charge. If the voltage across a light bulb is 3 V while it is glowing, then 3 J of energy is being transferred per coulomb of charge passing through the globe. NB. The charge passes through the bulb. The voltage is measured across the bulb. Voltage does not flow – it's a measurement of the energy transferred per coulomb of charge. Charge flows – and that is measured by the current (rate of flow of charge).

It is a good idea to introduce each of these terms while demonstrating the electric circuits (or perhaps if you have access to a video projector and laptop to construct the circuits using the pHet simulation mentioned under Additional Viewing). The syllabus tends to define the terms first and then to discuss how to measure each using ammeters and voltmeters. During the stage of defining the terms, it can help the learners to see a circuit in operation as a demonstration. Later on, they will get to take measurements for themselves, and to hopefully consolidate their understanding.

The idea of current being used up in a circuit is a common error. One way of combatting this is to set up a circuit with two ammeters reading the current before and after it passes through a light bulb.



The reading on the ammeter before the bulb is the same as the reading on the ammeter after the bulb. In order for one electron to pass from the battery into the wires every electron in the circuit must move forward immediately. So, if the current is 0,9 A before the bulb, it will be 0,9 A after the bulb.

So, what gets "used up" in an electric circuit?

Actually, nothing is used up. Energy is transferred, from chemical energy in the battery to electrical energy in the components. In the bulb electrical energy is transferred to light and heat. By the law of conservation of energy, energy cannot be created or destroyed. It can only be transferred from one form to another.

Some people believe that voltage is "used up". In a series circuit, the terminal potential difference is equal to the sum of the potential differences across each of the components. It does not mean that the voltage is used up in a component. It simply means that amount of the energy was transferred per unit charge to that component. The energy was not used up – it was transferred to other forms e.g. heat in a resistor, or heat and light in a bulb, or motion in an electric motor.

Topic 16: Electric circuits

INTRODUCTORY LEVEL QUESTIONS

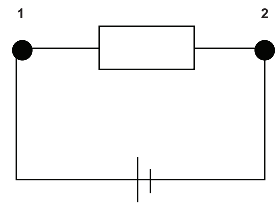
a. These are the basic questions that learners will be required to answer at this stage in the topic.

b. Their purpose is to familiarise the learners with terminology.

How to tackle these questions in the classroom:

- Work through these examples with learners.
- Explain each step to the learners as you complete it on the chalkboard.
- Learners must copy the question as well as the solution into their workbook.

6. Study the circuit diagram shown alongside.
   The current is measured at Point 1 and at Point 2.
   6.1 Compare the readings of current at Points 1 and 2.
   6.2 Briefly explain your reasoning.

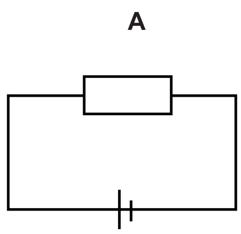


Solution:

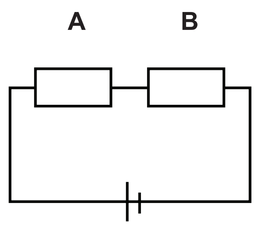
6.1 The current at Point 1 is the same as the current at Point 2.

6.2 Current that travels through the battery is the same as current that travels through the resistor OR current in a series circuit remains the same at all point in the circuit.

7. Two circuit diagrams are shown alongside. Resistors A and B are identical, and the cells are identical. The cells have negligible internal resistance.



Circuit 1



Circuit 2

   7.1 In Circuit 2 how does the current through resistor A compare the current through resistor A in Circuit 1?
   7.2 Briefly explain your reasoning to 7.1.
   7.3 In Circuit 2 how does the current through resistor A compare with the current through resistor B?
   7.4 Briefly explain your reasoning to 7.3.
   7.5 In Circuit 2 how does the potential difference across A compare with that of B?
   7.6 Explain your reasoning to 7.5.
   7.7 In Circuit 2 how does the potential difference across A compare with that across A in Circuit 1?
   7.8 Explain your reasoning to 7.7.

Solution:

7.1 Current in Circuit 2 is less than the current in Circuit 1. (Current in Circuit 2 is half that of Circuit 1).

7.2 Circuit 2 has greater resistance than Circuit 1 therefore charge experiences greater opposition to flow in Circuit 2 (OR vice versa).

7.3 The same current passes through resistor A and B.

7.4 Circuit 2 is a series circuit. The current is the same at all points in a series circuit.

7.5 The pd across A is equal to the pd across B.

7.6 The resistors are identical. Each receives half of the terminal pd from the battery.

7.7 The pd across A in Circuit 1 is twice the pd across A in Circuit 2.

7.8 A is connected to the battery in Circuit 1 therefore it has the whole emf connected across it. In Circuit 2 there are two resistors in series, so A receives only half the pd from the battery.

CHALLENGE LEVEL QUESTIONS

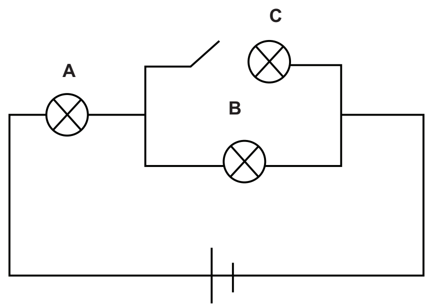
a. Now that learners have mastered the basic questions, they are ready to deal with more challenging questions.

b. These questions require learners to **use** the facts and terminology and to apply these to solving problems.

How to tackle these questions in the classroom:

- Work through these examples with learners.
- Tell learners that this is a more challenging version of what they have been doing.
- Write the first example on the chalkboard.
- Ask learners to look at the example and see if they can work out what must be done / what is different.
- Discuss learners' ideas, and ask probing questions to extend their answers.
- Try to be positive in these interactions, to encourage critical thinking and questioning.
- Ensure that learners copy down both the question and the solution into their workbooks.

8. Study the circuit diagram shown alongside. The battery has negligible internal resistance. The three bulbs A, B and C are identical.



   8.1 Describe the brightness of bulbs A, B and C when the switch is open.
   8.2 Briefly explain your answer to a.
   8.3 Describe the brightness of bulbs A, B and C when the switch is closed.
   8.4 Briefly explain your answer to c.

Solution:

8.1 Bulbs A and B are equally bright. Bulb C does not light up.

8.2 Bulbs A and B are connected in series therefore they receive the same current and the same voltage. Bulb C is not connected into the circuit.

8.3 Bulb A is the brightest. Bulbs B and C are equally bright as each other, but dimmer than bulb A. Bulb A is brighter than it was when the switch was open.

8.4 Bulbs B and C are connected in parallel so they each glow equally bright. They have the same pd across them, and the same current passing through them. Bulb A has twice the amount of current passing through it, and it has twice the pd across it (compared with bulbs B and C). It therefore shines twice as brightly as B and C.
The parallel connection of bulbs B and C decreases the total resistance of the circuit, so a greater current can pass through it. Bulb A has a greater current and a greater pd across it when the switch is closed; therefore. it shines brighter when the switch is closed than it did when the switch was open.

Key Teaching:

a. In these more challenging examples, learners must apply knowledge and explain phenomena.

b. It is good practice for the learners to predict and explain what will happen to the current, voltage or effective resistance of the circuit if a switch in the circuit is opened or closed, or if another bulb or resistor is added or removed from the circuit.

Topic 16: Electric circuits

CHECKPOINT

At this point in the topic, learners should have mastered:

1. The terminology associated with current, potential difference, resistance, and effective resistance of the circuit.
2. Drawing a simple circuit diagram with a maximum of four resistors in series and/or in parallel.
3. Interpreting data from a simple circuit diagram, with a maximum of four resistors in series and/or in parallel.
4. Calculations of the effective resistance of series and parallel combinations of resistors.
5. Determining the currents in the branches of two resistors in parallel. (Parallel circuits are current dividers).
6. Determining the potential difference across two resistors in series. (Series circuits are potential difference dividers).

Check learners' understanding of these concepts by getting them to work through:

Worksheet Pack: Magnetism Worksheet: Question 5-9

- Check learners' understanding by marking their work with reference to the memorandum.
- If you cannot photocopy the memorandum for each learner, make three or four copies of it and place these on the walls of your classroom.
- Allow learners time to mark their own work.
- Encourage the learners to learn from the mistakes they make.

CONSOLIDATION

- Learners can consolidate their learning by completing; **Worksheet Pack: Electric circuits Consolidation Questions.**
- Photocopy the exercise sheet for the learners. If that is not possible, learners will need to copy the questions from the board before attempting to answer them.
- The consolidation worksheet should be marked by the teacher so that she/he is aware of each learner's progress in this topic.
- Please remember that further consolidation should also be done by completing the examples available in the textbook.
- **It is important to note that this consolidation exercise is NOT scaffolded.**

- **It should not be administered as a test, as the level of the work may be too high to in its entirety.**

ADDITIONAL VIEWING / READING

In addition, further viewing or reading on this topic is available through the following web links:

1. https://www.stem.org.uk/elibrary/resource/30937
   Teachers resource: how to teach electricity. You will need to register and log in to this site. Registration is free, and most materials are also free.
2. http://www.physicsclassroom.com/class/circuits/Lesson-2/Common-Misconceptions-Regarding-Electric-Circuits
   Teachers resource: misconceptions in electric circuits
3. http://www.ncsu.edu/per/Articles/Engelhardt&Beichner.pdf
   Teacher's resource describing research on misconceptions in electricity, and it includes a diagnostic test on electric circuits.
4. http://phet.colorado.edu/en/simulation/circuit-construction-kit-ac
   Teacher's and learner's resource: A simulation of electric circuits. A wonderful resource for schools which have limited access to electric circuit kits.