GRADE	12	SUBJECT	Physical Sciences	WEEK	23	TOPIC	Electrical machines	Lesson	1

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	

LESSON OBJECTIVES	At the end of this lesson learners should know: • Learners should know what is meant by electrical machines The following results will be the outcome of this lesson: • Learners must be able to state that o Generators convert mechanical energy to electrical energy. o Motors convert electrical energy to mechanical energy. • Learners must be able to use Faraday's Law to explain why a current is induced in a coil that is rotated in a magnetic field.

TEACHER ACTIVITIES	LEARNER ACTIVITIES	TIMING	RESOURCES NEEDED
1. TEACHING METHODS USED IN THIS LESSON Question and answer, Explanation **2. LESSON DEVELOPMENT:** **2.1 <u>Introduction</u>** • Introduce the lesson with the baseline questions Pre-knowledge • Electromagnetic induction **BASELINE ASSESSMENT** • Baseline questions ▪ Define electromagnetism. ▪ What is a magnetic field? ▪ What is a solenoid? ▪ Define an electromagnet. ▪ Mention three factors on which the strength of electromagnets depend on. **2.2 <u>Main Body (Lesson presentation)</u>** • Lesson starts with the educator asking the learners the baseline questions. • Educator and learners discuss the following answers of the baseline assessment ▪ Electromagnetism is the study of the properties of and relationship between electric currents and magnetic fields.	1. Learners answer the baseline questions. 2. Learners take notes from the board. 3. Learners write the classwork. **CLASSWORK** 1. What type of energy conversions takes place within (a) generators (b) electric motors? 2. Name two ways to increase the strength of the induced current. 3. How do generators and motors operate? 4. Use Faraday's Law to explain why a current is induced in a coil that is rotated in a magnetic field. **SOLUTIONS** 1. a) Generator: mechanical energy to	10 min 25 min 15 min	Chalkboard for notes, discussions and classwork

▪ A magnetic field is a region around a magnetic material or a moving electrical charge where the force of magnetism acts. ▪ A solenoid is a large number of insulated turns forming a cylindrical coil. ▪ An electromagnet is a conductor which becomes magnetic where there is current flowing through it. ▪ Factors on which the strength of electromagnets depends on: o the current in the conductor o the number of turns around the core o the type of substance used in the core Educator explain and discuss with learners the following **Electrical machines** • There are various forms of rotating electrical machines. • These can be divided into: o Generators – which convert mechanical energy into electrical energy. Based on the principle of Faraday's Law of Electromagnetic Induction. o Motors – which convert electrical energy into mechanical energy. Based on the principle of Fleming's Motor Rule. • Both types operate through the interaction between a magnetic field and a set of windings (coils). • A current- carrying conductor has a magnetic field induced around it. • A magnetic field can cause an electric current i.e. a changing magnetic field can induce an emf, resulting in the flow of current. Such a current is called an induced current. • The strength of the induced current increases when o the speed of movement of magnet relative to the coil increases o the magnetic flux linkage is increased (i.e. a stronger magnet) o the number of turns increases	electrical energy. b) Motor: electrical energy to mechanical energy. 2. Increase the number of turns around the conductor. Increase the speed of the movement of the magnet relative to the coil. 3. Through the interaction between a magnetic field and a set of coils. 4. o A current is induced when a magnet is moved toward a coil, momentarily increasing the magnetic field through the coil. o The induced current is opposite when the magnet is moved away from the coil (magnetic field decreases). o No current is induced if the magnet does not move relative to the coil. It is relative motion that counts here: the magnet can be held steady and the coil moved, which also induces an emf.		

• Faraday's law of electromagnetic induction states that whenever there is a change in the magnetic field linked with the conductor, a potential difference is induced, the magnitude of which is directly proportional to the rate of change of the magnetic field linked with the conductor • Faraday's law can be used to explain why a current is induced in a coil that is rotated in a magnetic field: o A current is induced when a magnet is moved toward a coil, momentarily increasing the magnetic field through the coil. o The induced current is opposite when the magnet is moved away from the coil (magnetic field decreases). o No current is induced if the magnet does not move relative to the coil. It is relative motion that counts here: the magnet can be held steady and the coil moved, which also induces an emf. **2.3 Conclusion** • Ask learners about the main aspects of the lesson • Give learners classwork			

Reflection/Notes:

Name of Teacher		**HOD:**	
Sign:		**Sign:**	
Date:		**Date:**	

GRADE	12	SUBJECT	Physical Sciences	WEEK	23	TOPIC	Electrical machines	Lesson	2

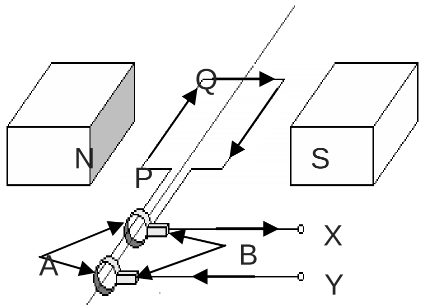
LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should know: • The learners must know the meaning of the AC generator and DC generator. The following results will be the outcome of this lesson: • Learners must be able to use word and pictures to explain the basic principle of o An AC generator (alternator) in which a coil is mechanically rotated in a magnetic field (converts mechanical energy into electrical energy). o How a DC generator works and how it differs from an AC generator. • Learners must be able to explain why a current carrying coil placed in a magnetic field (but not parallel) to the field will turn, by referring to the force exerted on moving charges by a magnetic field and the torque on the coil. o In an AC generator: the two ends of the coil are attached to a slip ring that makes contact with brushes as it turns. The direction of the current changes with every half turn of the coil. o A DC generator – constructed the same way as AC generator except that the slip ring is split into two pieces, called a commutator, so the current in the external circuit does not change direction.		

TEACHER ACTIVITIES	LEARNER ACTIVITIES	TIMING	RESOURCES NEEDED
1. TEACHING METHODS USED IN THIS LESSON Question and answer, Explanation **2. LESSON DEVELOPMENT:** **2.1 <u>Introduction</u>** • Introduce the lesson with the baseline questions Pre-knowledge • Electromagnetic induction **BASELINE ASSESSMENT** • Baseline questions ▪ State Faraday's Law **2.2 <u>Main Body (Lesson presentation)</u>** • Lesson starts with the educator asking the learners the baseline questions. • Educator and learners discuss the following answers of the baseline assessment	1. Learners answer the baseline questions. 2. Learners take notes from the board. 3. Learners write the classwork. **CLASSWORK** 1. Why does the output of an AC generator oscillates? 2. List two ways in which the output of an AC generator would change if the coil was rotated faster. 3. What is the function of the commutator?	10 min 25 min 15 min	Chalkboard for notes, discussions and classwork

- Faraday's law of electromagnetic induction states that whenever there is a change in the magnetic field linked with the conductor, a potential difference is induced, the magnitude of which is directly proportional to the rate of change of the magnetic field linked with the conductor
- Educator explain and discuss with learners the following

AC generators

- The principle of rotating a conductor in a magnetic field is used in electrical generators.
- A generator converts mechanical energy (motion) into electrical energy.
- The layout of a simple generator is shown below:



[Source: 2008 Hilton College Form 5 Trials, Question 6]

- The conductor in the shape of a coil is connected to a slip ring (A in the picture).
- The conductor is then manually rotated in the magnetic field generating an alternating emf.
- The slip ring commutators are connected to the load via brushes (B in the picture).
- If a machine is constructed to rotate a magnetic field around a set of stationary wire coils with the turning the turning of a shaft, AC voltage will be produced across the wire coils as that shaft is rotated, in accordance with Faraday's Law of electromagnetic induction.
- This is the basic operating principle of an AC generator.
- In an AC generator the two ends of the coil are each attached to a slip ring commutators that makes contact with brushes as the coil turns.
- The direction of the current changes with every half turn of the coil.
- As one of the loop moves to the other pole of the magnetic field, the current in the loop changes direction.

4. Give two advantages of using AC over DC for the long transmission of power.

[Source: Star School Supplementary Guide, Grade 12]

SOLUTION

1. The output oscillates because each side of the coil changes direction every half turn. This causes the current to change direction every half turn.
2. The current strength would increase.
   The frequency of the AC would increase.
3. The commutators change the direction of the current in the coil so that the coil always rotates in the same direction.
4. Easier to generate and transport from place to place.

Voltage can be stepped up or down to save energy during transportation.

• The two slip rings commutators of the AC generator allow the coil to turn without breaking the connections to the load circuit. • This type of current which changes direction is known as alternating current. **DC generator** • A simple DC generator is constructed the same way as an AC generator except that there is one slip ring which split into two pieces, called a commutator, so the current in the external circuit does not change direction. • The split-ring commutator accommodates for the change in direction of the current in the loop, thus creating direct current going through the brushes and out to the circuit. [Source: Siyavula Technology-Powered Learning] **2.3 Conclusion** • Ask learners about the main aspects of the lesson • Give learners classwork			

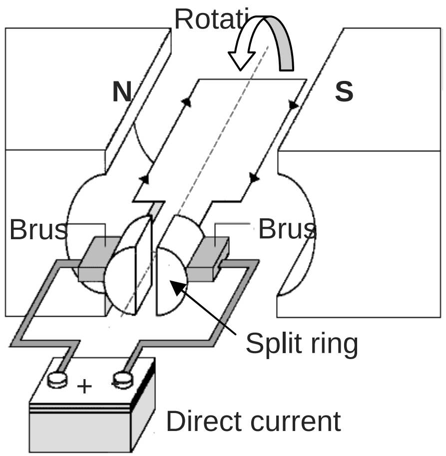
Reflection/Notes:

Name of Teacher		**HOD:**	
Sign:		**Sign:**	
Date:		**Date:**	

GRADE	12	SUBJECT	Physical Sciences	WEEK	23	TOPIC	Electrical machines	Lesson	3

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should know: • The learners must know the meaning of the DC motor The following results will be the outcome of this lesson: • Learners must be able to use word and pictures to explain the basic principle of o An electric motor (converts electrical energy to mechanical energy). • Learners must be able to explain why a current carrying coil placed in a magnetic field (but not parallel) to the field will turn, by referring to the force exerted on moving charges by a magnetic field and the torque on the coil. o Both motor and generators: coil rotates in a magnetic field. o In a motor, a current-carrying coil in a magnetic field experiences a force on both sides of the coil, creating a torque, which makes it turn. • Learners must be able to mention the use of AC and DC generators and the electric motor – give examples.		

TEACHER ACTIVITIES	LEARNER ACTIVITIES	TIMING	RESOURCES NEEDED
1. TEACHING METHODS USED IN THIS LESSON Question and answer, Explanation **2. LESSON DEVELOPMENT:** **2.1 <u>Introduction</u>** • Introduce the lesson with the baseline questions Pre-knowledge • AC and DC generators. • Electromagnetic induction. **BASELINE ASSESSMENT** • Baseline questions ▪ Mention the basic parts which make up an AC generator. ▪ Mention the energy conversion in the generator. ▪ Define magnetic flux. **2.2 <u>Main Body (Lesson presentation)</u>** • Lesson starts with the educator asking the learners the baseline questions. • Educator and learners discuss the following answers of the baseline assessment ▪ Magnets; slip rings; coil; brushes.	1. Learners answer the baseline questions. 2. Learners take notes from the board. 3. Learners write the classwork. **CLASSWORK** 1. In a DC motor, what is the function of the a) Commutator b) Brushes ? 2. Mention two uses of an ac generator. 3. What energy conversion takes place in all electrical motors? 4. What is the essential difference between DC motors and AC motors with regard to key components?	10 min 25 min 15 min	Chalkboard for notes, discussions and classwork

▪ Mechanical energy to electrical energy. ▪ Magnetic flux is a measure of the strength of a magnetic field over a given area. • Educator explain and discuss with learners the following **DC motors** • The basic principles of operation for a motor are the same as that of a generator, except that a motor converts electrical energy into mechanical energy. • The diagram below shows a simple diagram of a dc motor.  [Source: Durban Girls College Paper 1 Trials, 2008] • The split commutator serves as a change switch which reverses the current after every half revolution. • The brushes maintain electrical contact between the battery and the turning commutator. • The current in the coil flows through the magnetic field in the opposite direction. • The coil will therefore turn clockwise until it is vertical. • In the vertical position the gaps between the commutator segments are bridged by the brushes, and the current is therefore short-circuit for a moment through the commutator, and no current flows in the coil. • The momentum of the coil, however, carries it past this position.	5. What keeps the armature of a motor to continue moving once the coiled armature has reached the vertical position? **SOLUTIONS** 1. The a) The commutator serves as a change switch which reverses the current after every half revolution. b) The brushes maintain electrical contact between the battery and the turning commutator. 2. Used to generate electricity at power station. Provision of electricity to equipment at construction sites. 3. Electrical energy to mechanical energy. 4. A DC motor reverses current direction whenever the coil is in the vertical position to ensure continuous rotation. An AC motor, with alternating current as input, works without a commutator since the current alternates. 5. Its own momentum.		

• As soon as the coil passes the vertical position, each one of the brushes makes contact with the other commutator segment. • The direction of the current in the coil is therefore reversed and the coil continues turning. • After every half revolution, the current through the coil is reversed and in this way the coil continues turning clockwise. [Source: Sangari PowerPoint lessons] **Motors and generators** • Both motors and generators can be explained in terms of a coil that rotates in a magnetic field. • In a generator the coil is attached to an external circuit that is turned, resulting in a changing flux that induces an emf. • In a motor, a current carrying coil in a magnetic field experiences a force on both sides of a coil, creating a twisting force (called a torque) which makes it turn. [Source: Siyavula Technology – Powered Learning] **Uses of AC generators** • To generate electricity at power stations. • Provision of electricity to equipment at construction sites. • Provision of electricity to funfairs • Bicycle dynamo **Uses of DC generators** • Factories that do electroplating require huge amount of direct current. • In older vehicles DC generators are used to charge batteries to supply the vehicle with electricity. **2.3 Conclusion** • Ask learners about the main aspects of the lesson • Give learners classwork			

Reflection/Notes:

Name of Teacher		HOD:	
Sign:		Sign:	
Date:		Date:	

GRADE	12	SUBJECT	Physical Sciences	WEEK	23	TOPIC	Electrical Machines	Lesson	4

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	

LESSON OBJECTIVES	At the end of this lesson learners should know: • The learners must know the meaning of electrical machines. The following results will be the outcome of this lesson: • Learners must be able to use word and pictures to explain the basic principle of o An AC generator (alternator) in which a coil is mechanically rotated in a magnetic field (converts mechanical energy into electrical energy). o A DC generator works and how it differs from an AC generator. • Learners must be able to explain why a current carrying coil placed in a magnetic field (but not parallel) to the field will turn, by referring to the force exerted on moving charges by a magnetic field and the torque on the coil. o In an AC generator: the two ends of the coil are attached to a slip ring that makes contact with brushes as it turns. The direction of the current changes with every half turn of the coil. o A DC generator – constructed the same way as AC generator except that the slip ring is split into two pieces, called a commutator, so the current in the external circuit does not change direction. • Learners must be able to use word and pictures to explain the basic principle of o An electric motor (converts electrical energy to mechanical energy). • Learners must be able to explain why a current carrying coil placed in a magnetic field (but not parallel) to the field will turn, by referring to the force exerted on moving charges by a magnetic field and the torque on the coil. o Both motor and generators: coil rotates in a magnetic field. o In a motor, a current-carrying coil in a magnetic field experiences a force on both sides of the coil, creating a torque, which makes it turn. • Learners must be able to mention the use of AC and DC generators and the electric motor – give examples.

TEACHER ACTIVITIES	LEARNER ACTIVITIES	TIMING	RESOURCES NEEDED
1. TEACHING METHODS USED IN THIS LESSON Question and answer, Explanation **2. LESSON DEVELOPMENT:** **2.1 <u>Introduction</u>** • Introduce the lesson with the baseline questions Pre-knowledge • Electrical machines, alternating current **BASELINE ASSESSMENT** • Baseline questions	1. Learners answer the baseline questions. 2. Learners write the consolidation exercise. 3. Learners and educator discuss the answers of the consolidation exercise **SOLUTIONS OF THE CONSOLIDATION EXERCISE**	5 min 25 min 20 min	Chalkboard for notes, discussions and consolidation exercise

- What type of energy conversions takes place within generators and electric motors

2.2 Main Body (Lesson presentation)

- Lesson starts with the educator asking the learners the baseline questions.
- Educator and learners discuss the following answers of the baseline assessment
  - Generators: mechanical energy to electrical energy.
  - Motors: electrical energy to mechanical energy.
- Educator gives learners the consolidation exercise

Question 1

1.1 Describe the energy change that occurs in a motor.

1.2 What does DC mean?

1.3 Using the motor effect explains why the coil will experience a force.

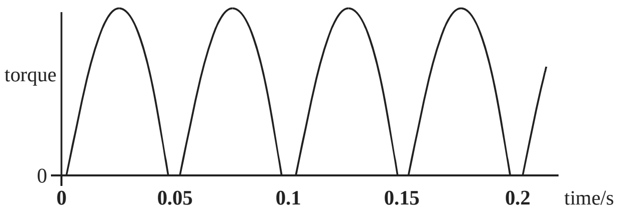
1.4 Give two factors that will affect the power of the motor.

1.5 The brushes and commutator allow the movement of the motor to be continuous in one direction. Explain how this works.

Question 2

[Kingsmead College Prelim 2008 Physics]

In the figure below shows the induced emf versus time graph for a generator.



2.1 Is this graph representing an AC or DC generator? Explain.

2.2 Determine whether the coil is horizontal or vertical at 0,05s.

2.3 Give two advantages of using AC over DC for the long distance transmission of power.

Question 3 [2008 Paper 1 June Exam, Trinity House College]

The simplified sketch below shows the principle of operation of the alternating current (AC) generator.

Question 1

1.1 Electrical energy is converted to mechanical energy.

1.2 The current in one direction only.

1.3 The electrical charge carriers moving through the coil of wire create a magnetic field around the coil. This field will interact with the field of the permanent magnet and will create a movement of a coil.

1.4 Strength of the permanent magnet; Induced emf; Number of turns in the coil.

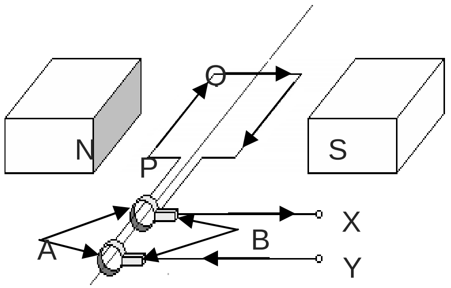
1.5 As the motor turns through half a rotation the brushes will switch contact points with the incoming current. The direction of the current will be switched in the coil resulting in that side of the coil experiencing a force in the opposite direction. This will ensure a continuous rotation.

Question 2

2.1 DC, current is in one direction only.

2.2 Vertical.

2.3 Easier to generate and transport over long distance.



3.1 Name the parts labelled A and B respectively.

3.2 In which direction does segment PQ have to be rotated in order to cause the current direction as shown in the diagram? Write only clockwise or anticlockwise.

3.3 Write down TWO changes that be brought about to improve the output of the generator.

3.4 What changes must be made to the AC generator to make it function as a DC generator?

Question 4 [DoE Preparatory Examination, 2008]

Electric motors are important components of many modern electrical appliances.

4.1 What energy conversion takes place in electric motors?
4.2 What is the essential difference in the design between DC motors and AC motors?
4.3 List THREE ways in which the efficiency of the motor can be improved.

2.3 Conclusion

- Emphasize the problem areas identified during the answering of the consolidation exercise.

Voltage can be stepped up or down to save energy during transportation. High frequency used makes it suitable for motors.

Question 3

3.1 A – slip ring commutators ;
B – brushes

3.2 Clockwise

3.3 More coils
Stronger magnets
Spin faster (Any two)

3.4 Replace the slip ring commutators with the split ring commutators.

Question 4

4.1 Electrical energy is converted to mechanical energy.

4.2 A DC motor reverses current direction with the aid of the commutator whenever the coil is in the vertical position to ensure continuous rotation.
An AC motor, with alternating current as input, works without commutators since the current alternates.

4.3 Increase the number of turns.
Stronger magnet.
Bigger current.

Reflection/Notes:

Name of Teacher		**HOD:**	
Sign:		**Sign:**	
Date:		**Date:**	

GRADE	12	SUBJECT	Physical Sciences	WEEK	24	TOPIC	Alternating current	Lesson	1

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should know: • The learners must know the meaning of alternating current. The following results will be the outcome of this lesson: • Learners must be able to explain the advantage of alternating current o Voltage can be changed using transformers – the voltage can be stepped up at power stations to a very high voltage so that electrical energy can be transmitted along power lines at low current and therefore experience low energy loss due to heating. The voltage can be stepped down for use in buildings, street lights, etc		

TEACHER ACTIVITIES	LEARNER ACTIVITIES	TIMING	RESOURCES NEEDED
1. TEACHING METHODS USED IN THIS LESSON Question and answer, Explanation **2. LESSON DEVELOPMENT:** **2.1 <u>Introduction</u>** • Introduce the lesson with the baseline questions Pre-knowledge • Electric current, Electromagnetic induction **BASELINE ASSESSMENT** • Baseline questions ▪ What is meant by induced current? ▪ What is a step-up transformer? ▪ What is a step-down transformer? **2.2 <u>Main Body (Lesson presentation)</u>** • Lesson starts with the educator asking the learners the baseline questions. • Educator and learners discuss the following answers of the baseline assessment ▪ Induced current is current that starts to flow due to the variation in the magnetic field surrounding its conductor. ▪ A step-up transformer is a transformer that increases voltage. ▪ A step-down transformer is a transformer that reduces voltage.	1. Learners answer the baseline questions. 2. Learners take notes from the board. 3. Learners write the classwork. **CLASSWORK** 1. Define alternating current. 2. The frequency of the generator in the power station is 40 Hz. What does this mean? 3. Why is it important that the frequency remains constant when AC is used for domestic purposes? 4. Why is AC used, rather than DC, to transport electrical energy between cities and towns?	10 min 25 min 15 min	Chalkboard for notes, discussions and classwork

• Educator explain and discuss with learners the following **Alternating current (AC)** • An alternating current (AC) is current that keeps changing direction backwards and forwards in a repetitive manner. • The electricity supplied by Eskom is alternating current, it changes direction 50 times per second i.e. it has a frequency of 50 Hz. • It is important that this frequency is kept to avoid damage to electrical equipment. • Alternating, rather than direct current is used because electricity needs to be distributed through the country at a higher voltage to reduce unnecessary losses in the power cables, • In order to be able to increase the voltages from the power stations and to reduce it again before it reaches the home. Transformers must be used to step the voltage down in order to reduce the heating effect. • Transformers make use of the concept of mutual induction and this can only work on alternating current. • It is also easier to generate alternating current than direct current. **Characteristics of AC include the following** - It causes self-inductance in the wires that carry it, i.e. when the current changes direction, the magnetic field associated with it in such a way as to oppose the change. - Because of self-inductance, some of the electrical energy of the current is wasted and as a result of this, appliances will get a lower maximum voltage than the peak value supplied. • This lower maximum voltage is known as the root-mean-square (RMS) value. **2.3 Conclusion** • Ask learners about the main aspects of the lesson • Give learners classwork	**SOLUTIONS** 1. Alternating current is current that keeps changing direction, backwards and forwards, in a repetitive manner. 2. 40 Hz means that the current is produced at 40 wavelengths per second. 3. To avoid damage to electrical components. 4. Electrical energy has to be transported from power plants to cities and towns through cables. Power is given by the equation P = VI. So in order to deliver enough power we can either make V large or make I large, However, if we push a large current through a cable hundreds of kilometres long we lose huge amounts of electrical energy due to the heating effect. Therefore the current must be kept small and so the voltage must go up. So we increase the voltage using transformers which only work on AC.		

Reflection/Notes:

Name of Teacher		**HOD:**	
Sign:		**Sign:**	
Date:		**Date:**	

GRADE	12	SUBJECT	Physical Sciences	WEEK	24	TOPIC	Alternating Current	Lesson	2

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should know: • The learners must know the meaning of alternating current. The following results will be the outcome of this lesson: • Learners must be able to write expressions for current and voltage in an AC circuit. • Learners must be able to calculate and define the root mean square values for current and voltage as $I_{rms.} = \frac{I_{max}}{\sqrt{2}}$ and $V_{rms.} = \frac{V_{max}}{\sqrt{2}}$ • Learners must be able to calculate rms – using $P_{average} = V_{rms}I_{rms}$		

TEACHER ACTIVITIES	LEARNER ACTIVITIES	TIMING	RESOURCES NEEDED
1. TEACHING METHODS USED IN THIS LESSON Question and answer, Explanation **2. LESSON DEVELOPMENT:** **2.1 <u>Introduction</u>** • Introduce the lesson with the baseline questions Pre-knowledge • Alternating current **BASELINE ASSESSMENT** • Baseline questions ▪ Define root mean square **2.2 <u>Main Body (Lesson presentation)</u>** • Lesson starts with the educator asking the learners the baseline questions. • Educator and learners discuss the following answers of the baseline assessment ▪ Root mean square is the effective value of alternating current that corresponds with a direct current that produces the same heating effect. • Educator explain and discuss with learners the following:	1. Learners answer the baseline questions. 2. Learners take notes from the board. 3. Learners write the classwork. **CLASSWORK** 1. An electric stove is marked 2000 W, 240 V. a) Calculate the maximum voltage through the stove. b) Calculate the resistance of the stove. 2. An AC voltage, whose peak value is 180 V, is across a 330 Ω resistor. What are the rms and peak currents in the resistor? 3. The maximum value of an alternating current in a 700 W device is 2,7 A. What is the rms voltage across it?	5 min 25 min 20 min	Chalkboard for notes, discussions and classwork

• The voltage in an AC circuit is given by the frequency by the equation: $V = V_{max} \sin 2\pi ft$ and the current in an AC circuit is given by the frequency by the equation: $I = I_{max} \sin 2\pi ft$. V_{max} is the peak voltage and I_{max} is the peak current. • Root mean square (abbreviated RMS or rms), also known as the quadratic mean, is a statistical measure of the magnitude of a varying quantity. • It is especially useful when variants are positive and negative, e.g. waves. • It can be calculated for a series of discrete values or for a continuously varying function. • The name comes from the fact that it is the square root of the <u>mean</u> of the <u>squares</u> of the values. • We use the following formulae: $I_{rm.} = \frac{I_{max}}{\sqrt{2}}$ and $V_{rms.} = \frac{V_{max}}{\sqrt{2}}$ • Average power in an AC circuit is given by $P_{average} = V_{rms}I_{rms}$ **Example** Calculate the peak current in a 1000 W hair dryer connected to a 120 V line. **Solution** $P_{average} = V_{rms}I_{rms}$ $1000 = (120)I_{rms}$ $\therefore I_{rms} = 8,33$ A $I_{rms.} = \frac{I_{max}}{\sqrt{2}}$ $8,33 = \frac{I_{max}}{\sqrt{2}}$ $\therefore I_{max} = 11,8$ A	4. A 1600 W drill machine is connected to a 660 V_{rms} AC line. Calculate the peak voltage. **SOLUTION** 1. a) $V_{rms.} = \frac{V_{max}}{\sqrt{2}}$ $240 = \frac{V_{max}}{\sqrt{2}}$ $V_{max} = 339,41$ V b) $P_{average} = V_{rms}I_{rms}$ $2000 = 240\ I_{rms}$ $I_{rms} = 8,33$ A $R = \frac{V_{rms}}{I_{rms}}$ $R = \frac{240}{8,33}$ $R = 28,81\ \Omega$		

2.3 Conclusion • Ask learners about the main aspects of the lesson • Give learners classwork	2. $R = \frac{V_{rms}}{I_{rms}}$ $330 = \frac{180}{I_{rms}}$ $I_{rms} = 0{,}55$ A $I_{rms.} = \frac{I_{max}}{\sqrt{2}}$ $0{,}55 = \frac{I_{max}}{\sqrt{2}}$ $I_{max} = 0{,}77$ A 3. $I_{rms.} = \frac{I_{max}}{\sqrt{2}}$ $I_{rms} = \frac{2{,}7}{\sqrt{2}}$ $\therefore I_{max} = 1{,}91$ A $P_{average} = V_{rms}I_{rms}$ $700 = V_{rms}(1{,}91)$ $V_{rms} = 366{,}49$ V		

	4. $V_{rms.} = \frac{V_{max}}{\sqrt{2}}$ $660 = \frac{V_{max}}{\sqrt{2}}$ $V_{max} =$ 933,33 V		

Reflection/Notes:

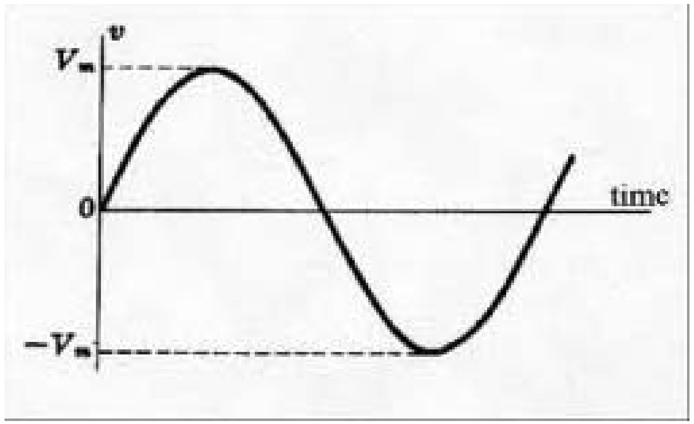
Name of Teacher		**HOD:**	
Sign:		**Sign:**	
Date:		**Date:**	

GRADE	12	SUBJECT	Physical Sciences	WEEK	24	TOPIC	Alternating Current	Lesson	3

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should know: • The learners must know the meaning of alternating current. The following results will be the outcome of this lesson: • Learners must be able to draw graphs of: o Voltage vs time o Current vs time for an AC circuit.		

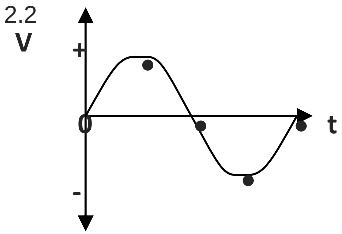
TEACHER ACTIVITIES	LEARNER ACTIVITIES	TIMING	RESOURCES NEEDED
1. TEACHING METHODS USED IN THIS LESSON Question and answer, Explanation **2. LESSON DEVELOPMENT:** **2.1 <u>Introduction</u>** • Introduce the lesson with the baseline questions Pre-knowledge • RMS values for current and voltage. • Average power in AC circuits. **BASELINE ASSESSMENT** • Baseline questions ▪ Define root mean square. ▪ Define alternating current. **2.2 <u>Main Body (Lesson presentation)</u>** • Lesson starts with the educator asking the learners the baseline questions. • Educator and learners discuss the following answers of the baseline assessment ▪ Root mean square is the effective value of alternating current that corresponds with a direct current that produces the same heating effect. ▪ An alternating current (AC) is current that keeps changing direction backwards and forwards in a repetitive manner. • Educator explain and discuss with learners the following	1. Learners answer the baseline questions. 2. Learners take notes from the board. 3. Learners write the classwork. **CLASSWORK SOLUTIONS** **Question 1** 1.1 DC, current is in one direction only. 1.2 Vertical. 1.3 Replace split ring commutators with slip ring commutators. **Question 2** 2.1 Mechanical energy to electrical energy.	10 min 25 min 15 min	Chalkboard for notes, discussions and classwork

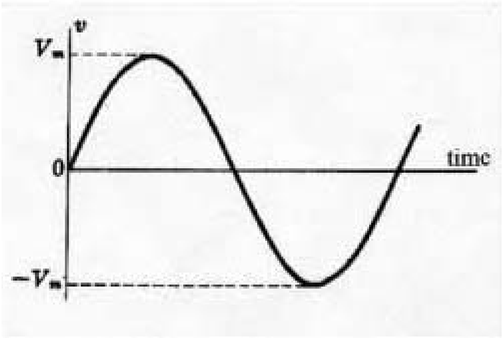
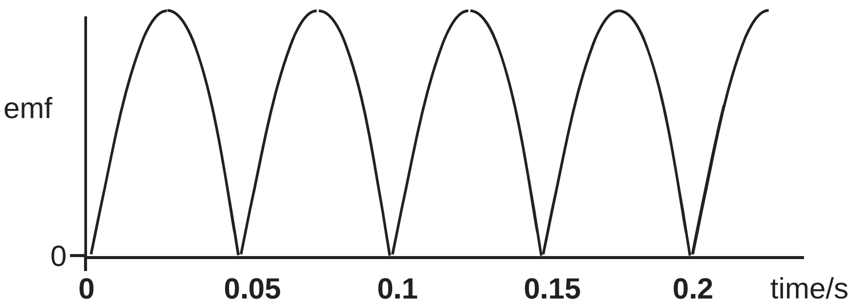
- We have seen that the electricity produced by some generators alternates and is therefore known as alternating current.
- The main advantage of alternating current is that the voltage can be changed using alternating current.
- We have also seen that alternating
  - Causes self-inductance in the wires that carry it, i.e. when the current changes direction, the magnetic field associated with it in such a way as to oppose the change.
- We have also seen that appliances will get a lower maximum voltage than the peak value supplied
- We call this lower maximum voltage the root-mean-square (RMS) value.
- The following graph shows the RMS values



[Source: www.iaei.org]

2.2



• A similar graph can be drawn for current  [Source: www.iaei.org] **2.3 Conclusion** • Ask learners about the main aspects of the lesson • Give learners classwork **CLASSWORK** **Question 1** The figure below shows the induced emf versus time graph for a generator.  1.1 Is this graph representing an AC or DC generator? Explain. 1.2 Determine whether the coil is horizontal or vertical at 0,05s.			

1.3 What structural change can be made on the generator to convert it to the other type? **Question 2** 2.1 What energy conversions take place in an ac generator? 2.2 Draw a sketch graph of emf vs time for one full rotation of the coil of an ac generator.			

Reflection/Notes:

Name of Teacher		**HOD:**	
Sign:		**Sign:**	
Date:		**Date:**	

GRADE	12	SUBJECT	Physical Sciences	WEEK	24	TOPIC	Alternating Current	Lesson	4

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should know: • The learners must know the meaning of alternating current. The following results will be the outcome of this lesson: • Learners must be able to explain the advantage of alternating current o Voltage can be changed using transformers – the voltage can be stepped up at power stations to a very high voltage so that electrical energy can be transmitted along power lines at low current and therefore experience low energy loss due to heating. The voltage can be stepped down for use in buildings, street lights, etc • Learners must be able to write expressions for current and voltage in an AC circuit. • Learners must be able to calculate and define the root mean square values for current and voltage as $I_{rms.} = \frac{I_{max}}{\sqrt{2}}$ and $V_{rms.} = \frac{V_{max}}{\sqrt{2}}$ • Learners must be able to calculate rms – using $P_{average} = V_{rms}I_{rms}$ • Learners must be able to draw graphs of: o Voltage vs time o Current vs time for an AC circuit.		

TEACHER ACTIVITIES	LEARNER ACTIVITIES	TIMING	RESOURCES NEEDED
1. TEACHING METHODS USED IN THIS LESSON Question and answer, Explanation **2. LESSON DEVELOPMENT:** **2.1 <u>Introduction</u>** • Introduce the lesson with the baseline questions Pre-knowledge • Generators and motors; RMS equations **BASELINE ASSESSMENT** • Baseline questions ▪ What is an alternating current? ▪ Define the root mean square. **2.2 <u>Main Body (Lesson presentation)</u>** • Lesson starts with the educator asking the learners the baseline questions.	1. Learners answer the baseline questions. 2. Learners answer the consolidation exercise. 3. Learners and teacher discuss the answers of the consolidation exercise. **SOLUTIONS OF THE CONSOLIDATION EXERCISE** **Question 1**	10 min 25 min 15 min	Chalkboard for notes, discussions and classwork

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- Educator and learners discuss the following answers of the baseline assessment
  - An alternating current (AC) is current that keeps changing direction backwards and forwards in a repetitive manner.
  - Root mean square is a statistical measure of the magnitude of a varying quantity.
- Educator gives learners the consolidation exercise.
- Educator allows learners to answer a question and then allow discussions and/or correction on the question.

Consolidation exercise

Question 1

1.1 Explain the advantage of using alternating current in power stations.

1.2 Calculate the average power dissipated by an ac generator if the rms values for current are 13 A and 325 V

Question 2 [NSC November 2008 Paper 1]

The municipality of Dinaledi implements a power cutback in the town. As a result of the cutback the rms voltage drops from 220 V_{rms} to 200 V_{rms}.

2.1 Calculate the peak voltage during the cutback.

2.2 A certain electrical appliance dissipates 1200 W when it is operated at 220 V_{rms}. Calculate the power at which it will operate during the cutback.

2.3 It is common practice to connect many appliances to a multi-plug. Modern types of multi-plugs have a cut-off switch built in.

Using principles in Physics, explain clearly why this cut-off switch is important.

2.3 Conclusion

- Emphasize aspects learners struggle with from the exercise.

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1.1 The voltage can change using the transformers. Electrical energy can be transmitted over long distance at low current and experience low energy loss.

1.2

$V_{rms.} = \frac{V_{max}}{\sqrt{2}}$

$V_{rms.} = \frac{325}{\sqrt{2}}$

$V_{rms} = 230$ V

$P_{average} = V_{rms}I_{rms}$

$= (230)(13)$

$= 2990$ W

Question 2

2.1

$V_{rms.} = \frac{V_{max}}{\sqrt{2}}$

$200 = \frac{V_{max}}{\sqrt{2}}$

$\therefore V_{max} = 282,84$ V

2.2 $P_{average} = V_{rms}I_{rms}$

$1200 = (220)I_{rms}$

$I_{rms} = 5,45$ A

$R = V_{rms}/I_{rms}$

$R = \frac{220}{5,45}$

$R = 40,33\ \Omega$

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	At 200V: $P_{average} = V^2_{rms}/R$ $= \frac{200^2}{40,33}$ $= 991,82$ W 2.3 V stays constant As more appliances are connected to the multi-plug the total resistance decrease causing the main current drawn by the multi-plug to increase. Due to the high current the heating effect will increase and can cause damage to the main switch.		

Reflection/Notes:

Name of Teacher		**HOD:**	
Sign:		**Sign:**	
Date:		**Date:**	

GRADE	12	SUBJECT	Physical Sciences	WEEK	25	TOPIC	Electromagnetic radiation	Lesson	1

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should know: • the meaning of electromagnetic radiation. The following results will be the outcome of this lesson: • Learners must be able to explain behaviour of EM radiation by a o wave model – EM waves do not need a medium to travel through. o Particle – Nature of EM as particle – energy of a photon related to frequency and wavelength. o Calculate the energy using $E = hf = hc/\lambda$		

TEACHER ACTIVITIES	LEARNER ACTIVITIES	TIMING	RESOURCES NEEDED
1. TEACHING METHODS USED IN THIS LESSON Question and answer, Explanation **2. LESSON DEVELOPMENT:** **2.1 <u>Introduction</u>** • Introduce the lesson with the baseline questions Pre-knowledge • Waves, photoelectric effect **BASELINE ASSESSMENT** • Baseline questions ▪ Define a photon ▪ Define frequency ▪ Define wavelength **2.2 <u>Main Body (Lesson presentation)</u>** • Lesson starts with the educator asking the learners the baseline questions. • Educator and learners discuss the following answers of the baseline assessment ▪ A photon is a particle representing a quantum of light or other electromagnetic radiation. ▪ Frequency is the number of waves that pass a point per unit time. ▪ Wavelength is the distance between two successive points that are in phase. • Educator explain and discuss with learners the following:	1. Learners answer the baseline questions. 2. Learners take notes from the board. 3. Learners write the classwork. **CLASSWORK** 1. A photon of light has a frequency of 325 Hz. Find its energy. 2. What is the energy of a photon with a) wavelength of 827 nm b) wavelength of 2 nm? 3. A photon has energy of 3×10^{-19} J. Find its wavelength.	5 min 25 min 15 min	Chalkboard for notes, discussions and classwork

Dual nature of EM radiation	SOLUTIONS		
▪ Changing electric and magnetic fields create a disturbance which is propagated as an electromagnetic wave. ▪ Whenever charges are accelerated, a changing magnetic field is formed. ▪ The changing magnetic field again causes a changing electric field. ▪ The magnetic field and electric field are at right angles to each other. ▪ The electromagnetic wave formed in this way is propagated in a direction at right angles to the electric field and magnetic field. ▪ Electromagnetic waves are transverse waves and do not need a medium for propagation. • Electromagnetic radiation acts as a wave when it undergoes reflection, refraction, diffraction and interference. • Electromagnetic waves acts like particles when it displays the photoelectric effect. • Thus, as a result of the observation, we have to accept both models as true. • Wave and particles models of light complement each other. • Neither model can be used to exclusively explain all properties of light. • The wave and particle models relate to each other via the relationship between the wavelength/frequency of light and the energy of photon. [www.chemistry.sc.chula.ac] • **E = hf** where E is the energy of the photon and h is the Planck's constant = $6,63 \times 10^{-34}$ J•s • The equation E = hf can be written as **E = hc/λ,** where c is the speed of light = 3×10^{8} m•s^{-1} and λ is the wavelength in meters (m). **2.3 Conclusion** • Ask learners about the main aspects of the lesson. • Give learners classwork.	1. E = hf $= (6,63 \times 10^{-34})(325)$ $= 2,16 \times 10^{-31}$ J 2. a) E = hc/λ $= \frac{(6,63 \times 10^{-34})(3 \times 10^{8})}{(827 \times 10^{-9})}$ $= 2.41 \times 10^{-19}$ J b) E = hc/λ $= \frac{(6,63 \times 10^{-34})(3 \times 10^{8})}{(2 \times 10^{-9})}$ $= 9,95 \times 10^{-17}$ J 3. E =hf $3 \times 10^{-19} = (6,63 \times 10^{-34})f$ $f = 4,53 \times 10^{14}$ Hz c= fλ $3 \times 10^{8} = (4,53 \times 10^{14})\lambda$ $\therefore \lambda = 6,62 \times 10^{-7}$ m		

Reflection/Notes:

Name of Teacher		HOD:	
Sign:		Sign:	
Date:		Date:	

GRADE	12	SUBJECT	Physical Sciences	WEEK	25	TOPIC	Electromagnetic radiation	Lesson	2

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	

LESSON OBJECTIVES	At the end of this lesson learners should know: • The learners must know the nature of an EM wave. The following results will be the outcome of this lesson: • Learners must be able to describe the source of electromagnetic waves as an accelerating charge. • Learners must be able to use words and diagrams to explain EM wave propagation- when an electric field oscillating in one plane produces a magnetic field oscillating in a plane at right angles to it, which produces an oscillating electric field, and so on. • Learners must be able to state the mutually regenerating fields travel through space at a constant speed 3 x10^8 m•s^{-1}, represented by c.

TEACHER ACTIVITIES	LEARNER ACTIVITIES	TIMING	RESOURCES NEEDED
1. TEACHING METHODS USED IN THIS LESSON Question and answer, Explanation **2. LESSON DEVELOPMENT:** **2.1 <u>Introduction</u>** • Introduce the lesson with the baseline questions Pre-knowledge • Charges, waves **BASELINE ASSESSMENT** • Baseline questions ▪ What is meant by the term polarisation? ▪ What is a transverse wave? ▪ Define reflection. ▪ Define refraction. ▪ What is meant by the terms interference and diffraction? **2.2 <u>Main Body (Lesson presentation)</u>** • Lesson starts with the educator asking the learners the baseline questions. • Educator and learners discuss the following answers of the baseline assessment ▪ Polarisation is the phenomenon in which waves of light or other radiation are restricted in direction of vibration.	1. Learners answer the baseline questions. 2. Learners take notes from the board. 3. Learners write the classwork. **CLASSWORK** 1. Evidence that electromagnetic waves are transverse waves is that A. the electric charges undergo acceleration. B. they undergo interference. C. they undergo diffraction through narrow slits. D. they can be polarised. 2. List four properties of electromagnetic waves.	10 min 25 min 15 min	Chalkboard for notes, discussions and classwork

▪ A transverse wave is a wave vibrating at right angles to the direction of its propagation. ▪ Reflection is the change in direction of a wave, such as a light or sound wave, away from a boundary the wave encounters. ▪ Refraction is the bending of light as it passes from one substance to another. ▪ Interference is the combining or cancelling of two or more waves of the same frequency whilst diffraction is the bending of waves around an object. • Educator explain and discuss with learners the following: **Nature of an EM- wave as a mutual induction of oscillating magnetic/electric fields.** • We have established that light is an electromagnetic wave. • James Maxwell: If a changing magnetic field creates a changing electric field, a changing electric field therefore ought to produce a changing magnetic field. • This means that when any charges accelerate - a changing magnetic field is produced, - the changing magnetic field creates a changing electric field at right angles to it, - an electric field generates another magnetic field and the process continues. • Maxwell concluded that this process could continue without any loss of energy if the fields move at a speed of 3×10^8 m•s^{-1}, the speed of light.. **Properties of electromagnetic waves** • Electromagnetic waves - Originate from accelerating charges. - Consist of electric and magnetic field at right angles to each other. - Have a speed of 3×10^8 m•s^{-1} in a vacuum. - Are transverse waves and can be polarised. - Can pass through a vacuum. - Do not carry charge. - Can be reflected and refracted. - Show the effects of diffraction and interference. - Are generated by oscillating charges. • Radio waves for example are produced when electrons move backwards and forwards in the antenna of a transmitter.	3. Explain how EM wave can be propagated without a medium. **SOLUTIONS** 1. D 2. a) Originate from accelerating charges. b) Are transverse and can be polarized. c) Have a speed of 3×10^8 m•s^{-1}. d) Can pass through a vacuum. 3. The EM wave is generated by the mutual induction of the two fields (magnetic and electric) that keep the wave moving.		

2.3 Conclusion • Ask learners about the main aspects of the lesson • Give learners classwork			

Reflection/Notes:

Name of Teacher		**HOD:**	
Sign:		**Sign:**	
Date:		**Date:**	

GRADE	12	SUBJECT	Physical Sciences	WEEK	25	TOPIC	Electromagnetic radiation	Lesson	3

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should know: • The learners must know the meaning of EM spectrum. The following results will be the outcome of this lesson: • Learners must be able to arrange different types of EM radiation in order of frequency (from given list). • Learners must be able to do calculations – given the wavelength of EM waves they must calculate the frequency and vice versa, using the equation $c = f\lambda$.		

TEACHER ACTIVITIES	LEARNER ACTIVITIES	TIMING	RESOURCES NEEDED
1. TEACHING METHODS USED IN THIS LESSON Question and answer, Explanation **2. LESSON DEVELOPMENT:** **2.1 Introduction** • Introduce the lesson with the baseline questions Pre-knowledge • Nature of electromagnetic wave **BASELINE ASSESSMENT** • Baseline questions ▪ Mention four properties of electromagnetic waves **2.2 Main Body (Lesson presentation)** • Lesson starts with the educator asking the learners the baseline questions. • Educator and learners discuss the following answers of the baseline assessment ▪ Properties of EM waves 1. They are produced by oscillating charges. 2. They are transverse waves. 3. They do not need a physical medium to travel in.	1. Learners answer the baseline questions. 2. Learners take notes from the board. 3. Learners write the classwork. **CLASSWORK** 1. Which has the lower frequency between infrared and X-rays? 2. Which has a shorter wavelength between infrared and X-rays? 3. Using the equation $E = hf$, explain why gamma rays are harmful to humans. 4. Name in order of increasing frequency, the seven regions in the electromagnetic spectrum.. 5. Calculate the wavelength of Metro FM radio waves of frequency 96,4 MHz.	5 min 25 min 15 min	Chalkboard for notes, discussions and classwork

4. All travel at a speed of 3 x10^8 m•s^{-1}. • Educator explain and discuss with learners the following **The Electromagnetic spectrum** • Visible light is only one part of a whole range of possible frequencies and wavelengths of electromagnetic waves. • The whole range is known as the electromagnetic spectrum. • Given the wavelength of EM waves we are able to calculate the frequency and vice versa using the equation: **$c = f\lambda$** where c is the speed of light = 3 x10^8 m•s^{-1}, f is the frequency in Hz, and λ is the wavelength in meters (m). • The EM spectrum consists of seven groups, in order of increasing frequency - Radio waves - Microwaves - Infrared - Visible light - Ultraviolet light - X-rays - Gamma rays • Low frequency (long wavelength) radio waves have low energy and are not harmful to humans. • High frequency (short wavelength) gamma rays have very high energy and are extremely harmful to humans. • Thus as the frequency increases, the wavelength decreases. **2.3 Conclusion** • Ask learners about the main aspects of the lesson • Give learners classwork	6. An electromagnetic wave has a wavelength of 986 nm. Find its frequency. **SOLUTIONS** 1. Infrared 2. X-rays 3. According to the equation E = hf, E is directly proportional to f. A higher frequency will result in a higher energy, so gamma rays which have a higher frequency than radio waves will have very high energy and as a result will be harmful to humans. 4. Radio waves; microwaves, Infrared; Visible light; Ultraviolet; X-rays; Gamma rays. 5. $c = f\lambda$ $3\times10^8 = (96{,}4\times10^6)\lambda$ $\therefore \lambda = 3{,}11$ m 6. $c = f\lambda$ $3\times10^8 = f(986\times10^{-9})$ $\therefore f = 3{,}04\times10^{14}$ Hz		

Reflection/Notes:

Name of Teacher		**HOD:**	
Sign:		**Sign:**	
Date:		**Date:**	

GRADE	12	SUBJECT	Physical Sciences	WEEK	25	TOPIC	Electromagnetic radiation	Lesson	4

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	

LESSON OBJECTIVES	At the end of this lesson learners should know: • The learners must know the meaning of EM spectrum. The following results will be the outcome of this lesson: • Learners must be able to give an example of the use of each type of EM radiation, (gamma rays, X-rays, UV light, visible light, infrared, microwaves and radio and TV waves). • Learners must be able to indicate the penetrating ability of the different kinds of EM radiation and relate it to energy of the radiation. • Learners must be able to describe the dangers of gamma rays, X-rays and the damaging effect of ultra-violet radiation on skin.

TEACHER ACTIVITIES	LEARNER ACTIVITIES	TIMING	RESOURCES NEEDED
1. TEACHING METHODS USED IN THIS LESSON Question and answer, Explanation **2. LESSON DEVELOPMENT:** **2.1 <u>Introduction</u>** • Introduce the lesson with the baseline questions Pre-knowledge • Electromagnetic spectrum, Radio waves, Microwaves **BASELINE ASSESSMENT** • Baseline questions ▪ What is the penetrative ability of radio waves? ▪ What is the reason for this ability? ▪ Why are radio waves easily diffracted? **2.2 <u>Main Body (Lesson presentation)</u>** • Lesson starts with the educator asking the learners the baseline questions. • Educator and learners discuss the following answers of the baseline assessment ▪ Radio waves have low penetrative ability. ▪ They are low in energy. ▪ Radio waves are easily diffracted because they have long wavelengths. • Educator explain and discuss with learners the following:	1. Learners answer the baseline questions. 2. Learners take notes from the board. 3. Learners write the classwork. **CLASSWORK** 1. Which type of waves are energetic and able to penetrate the soft skin tissue of the body easily but are stopped by other parts such as bones? A. Radio waves B. UV rays C. X-rays D. Infrared	10 min 25 min 15 min	Chalkboard for notes, discussions and classwork

Radio waves

- Radio waves range from long waves (LW) to ultrahigh frequency (UHF).
- The wavelength of these waves varies from several kilometres to a few centimetres.
- Long waves and short waves can easily diffract over mountains and around buildings.
- Originally these waves were used in radio communication, but were soon expanded to include waves for television broadcast.
- Because they are low in energy, they have a low penetrative ability.

Microwaves

- Microwaves ovens are only one application of microwaves; they are more widely used by satellites for communication such as satellite television.
- Microwaves have a low penetrative ability, so microwaves towers have to be in line of sight with each other and must have no obstructions.
- Used in satellite communications, radar air traffic and radar speed trapping guns

Infrared (IR)

- Any hot object, such as the sun or a fire, produces infrared waves. These are basically heat waves.
- The word "infra" means below and indicated that the frequency of infrared waves is below that of the red end of the visible spectrum.
- Burglar alarms use passive infrared sensors (PIR) that detect the heat of the intruder's body.
- Some animals, like snakes, are able to detect the infrared waves that their prey emits.
- The military uses night vision equipment that detects infrared to help them to see at night.
- The IR wavelengths have low penetrative ability and are easily absorbed.

Visible light

- It has a spectrum of colours from red to violet in decreasing wavelength.
- It makes only a small part of the electromagnetic spectrum and it is slightly more penetrative than infrared.

2. These rays are emitted by radioactive substances and they are especially dangerous to humans and have enough energy to damage and change the structure of our body cells.

A. Gamma rays
B. UV rays
C. X-rays
D. Infrared

3. Which region of the spectrum would you expect to exhibit marked diffraction effects? Explain.

4. Name two types of electromagnetic radiation which have high penetrative power.

5. The range of wavelengths in the EM spectrum is from 1×10^{-13} m to 1×10^{3} m

5.1 Name the two types of EM radiation found at the extremes of the wavelength spectrum stated above.

Ultraviolet (UV) • Ultra means beyond and indicates that ultraviolet waves have a frequency higher than the violet end of the spectrum. • It comes primarily from the sun but also from welding arcs and mercury vapour lamps. • Human skin needs small quantities of low frequency UV light for the formation of vitamin D and this is obtained from UV-B rays from the sun. • A high frequency UV light however is dangerous to the eye and can cause sunburn and skin cancer. These are known as UV-A rays. • UV light is quite penetrative and cause damage to sensitive areas of the body. **X-rays** • These were called X-rays because at first nobody knew what they were. • They are quite energetic and they are able to penetrate the soft skin tissue of the body easily but are stopped by other parts such as bones. • They are used in medicine for taking X-ray photographs of the interior of the body. **Gamma rays** • They are the most energetic and penetrative of all UV radiation a will easily pass through several centimetres of lead or concrete. • They are one of the types of rays emitted by radioactive substances and they are especially dangerous to humans and have enough energy to damage and change the structure of our body cells. • These abnormal body cells can then form the basis of cancerous growth. • The horrible effects of exposure to nuclear radiation are the driving force behind the concern about the use of nuclear weapons and nuclear energy. [Source: Sangari PowerPoint lessons] **2.3 Conclusion** • Ask learners about the main aspects of the lesson • Give learners classwork	5.2 Give one application of each of these types of EM waves in 5.1 above. [Source: ST MARY'S-2008 PHYSICS PRELIM] **SOLUTIONS** 1. C 2. A 3. Radio waves – because of their long wavelengths. 4. X-rays and gamma rays. 5.1 Gamma rays and Radio waves. 5.2 Gamma- medicine: cancer treatment; Radio waves – communication: radio, TV, satellites		

Reflection/Notes:

Name of Teacher		HOD:	
Sign:		Sign:	
Date:		Date:	

GRADE	12	SUBJECT	Physical Sciences	WEEK	26	TOPIC	Chemical Systems(Chlor-alkali Industry) – Time: 60 min	Lesson	1

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should be able to: • identify reactants and products of the chlor-alkali process • give uses of each product of the chlor-alkali process • define the term electrolytic cell • describe the function of a membrane in the membrane cell • identify the anode and cathode of the membrane cell • explain the chlor-alkali process using half reactions and the overall redox reactions taking place in the membrane cell.		

TEACHING and LEARNING ACTIVITIES

1. TEACHING METHOD/S USED IN THIS LESSON:

Question and Answer; Narrative

2. LESSON DEVELOPMENT

2.1 Introduction:

Educator introduces the lesson by using a diagram of a simple electrolytic cell and asks questions related to electrolysis.

Teacher draws a simple electrolytic cell on the board or uses a chart. The parts of the cell should be labelled A, B and C. He/she asks learners whether it is a galvanic cell or an electrolytic cell. Learners have to give a reason for their answer. .He/she then asks learners to name the parts labelled A, B and C. A short discussion is held on what happens in the cell during electrolysis. The educator has to reinforce those concepts which learners seem not to remember. [5min.]

PRE-KNOWLEDGE

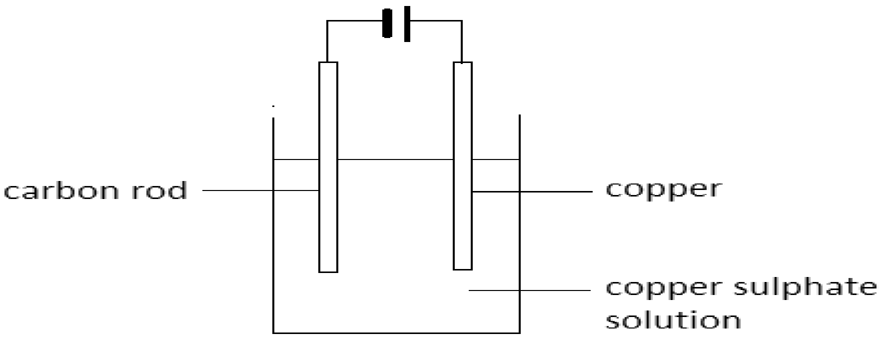
A basic understanding of :

- The structure of an electrolytic cell
- The process of electrolysis, i.e. anode and cathode reactions.
- The position of chlorine in the periodic table.
- Chlorine as a diatomic molecule
- The structure and symbol of the chloride ion

EDUCATOR tests pre-knowledge by using the question and answer method as indicated in the baseline assessment.

BASELINE ASSESSMENT: QUESTIONS/ ACTIVITY [15min.]

- Figure 1 shows an electrolytic cell.



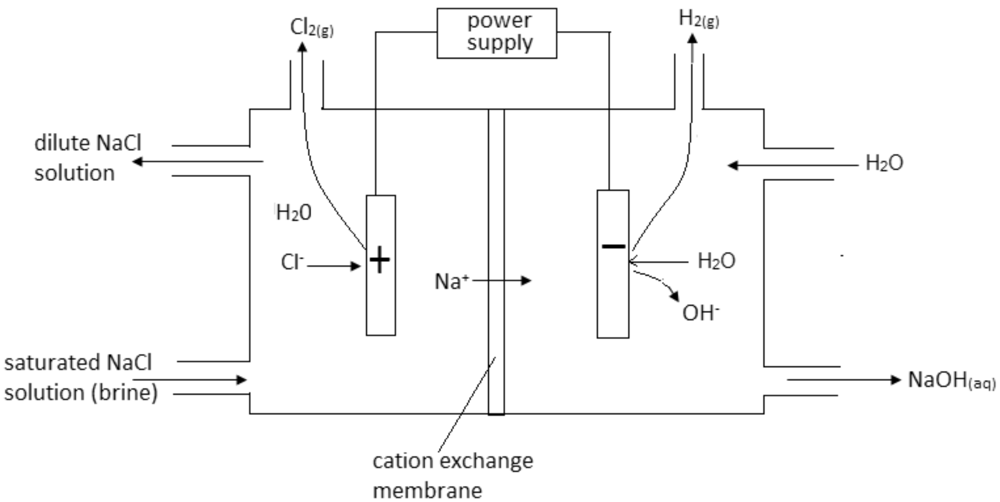
- Which one is an anode in the diagram?
- Which ions are found in the electrolyte?
- Write down equations that represent an anode reaction and a cathode reaction.

2.2 Main Body (Lesson presentation)

- Educator starts a lesson with a discussion on the properties and uses of chlorine. [30 min.]

- Chlorine is a yellowish green gas.
- Chlorine has the following uses:
- Purification of water, production of bleaching agents, production of hydrochloric acid , production of paint, production of plastics and for the extraction of copper, titanium and gold. There could be more uses but these are the common ones.
- Industrial production of chlorine
- Because chlorine is so important there is therefore a need for it to be produced in large quantities. There are three methods for producing chlorine industrially and all these involve the electrolysis of brine (concentrated sodium chloride solution). The three types of electrolytic cells used for this process are the mercury cell, the diaphragm cell and the membrane cell. In the three types of cells sodium hydroxide and hydrogen are produced as by-products.
- The membrane cell
- The membrane cell is the most modern and most commonly used. It consists of two compartments, an anode compartment and a cathode compartment. These compartments are separated by a cation exchange membrane made of a fluorocarbon polymer. This membrane can only allow cations (positive ions) to pass through it. The anode is made of titanium whilst the cathode is made of nickel. Both metals are used are unreactive.
- Brine is fed into the anode compartment whilst water is fed into the cathode compartment.

Figure 1: A membrane cell



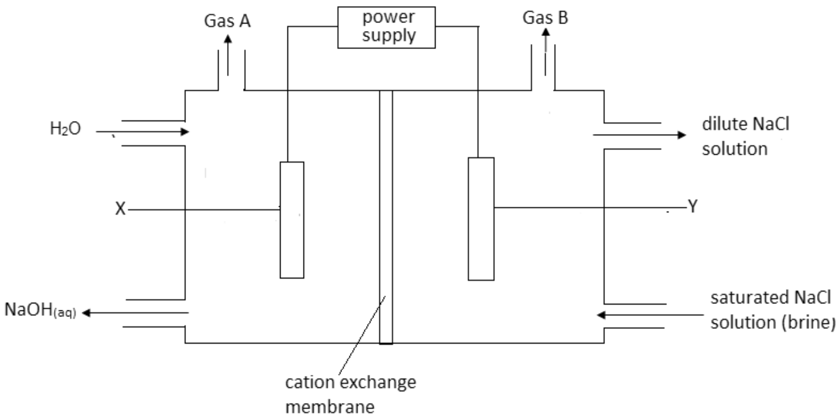
- Anode reaction
- Chloride ions in the solution are attracted by the anode where they lose electrons to become chlorine atoms which then pair up to form chlorine gas molecules.
- $2Cl^-_{(aq)} \longrightarrow Cl_{2(g)} + 2e^-$
- Cathode reaction
- Water molecules are split into H^+ ions and OH^- ions. The H^+ ions gain electron to become hydrogen atoms which then pair to form hydrogen gas molecules.
- $2H_2O_{(l)} + 2e^- \longrightarrow H_{2(g)} + 2OH^-_{(aq)}$
- The depletion of chloride ions in the anode compartment results in the excess of sodium ions which are positively charged. The cathode reaction also provides an excess of hydroxide ions. Sodium ions therefore migrate to the cathode compartment through the cation exchange membrane to maintain neutrality in both compartments.
- When the sodium ions migrate or move into the cathode compartment they react with the hydroxide ions to form sodium hydroxide.
- $Na^+(aq) + OH^-(aq) \longrightarrow NaOH(aq)$
- Dilute sodium chloride and sodium hydroxide solutions are removed periodically and are replaced by brine and water in the relevant compartments.
- The by-products, hydrogen and sodium hydroxide are also useful to humans.

3. Conclusion and Chalkboard summary

Activity to Re-enforce lesson (Educator gives learners an written exercise covering the main concepts of the lesson and revises the exercise with them.). [15min.]

Class work

- The diagram below shows a membrane cell used in the production of chlorine.



- Identify the electrodes X and Y. Answer: X is cathode and Y is the anode(Check what is fed into the compartments)
- Name gases A and B. Answer: Gas A is hydrogen and gas B is chlorine
- Write an equation of the reaction that occurs at electrode Y. Answer: $2Cl^{-}_{(aq)} \longrightarrow Cl_{2(g)} + 2e^{-}$
- Is the reaction taking place at electrode Y a reduction reaction or an oxidation reaction? Give a reason for your answer. Answer: The reaction is oxidation because electrons are lost.
- Sodium chloride that is fed into the cell is concentrated but the sodium chloride that is removed from the cell is dilute. Explain why this is so.
  Answer: Some chloride ions from sodium chloride solution are used in the production of chlorine gas and sodium ions migrate to the other compartment via the cation exchange membrane. This reduces the concentration of sodium chloride hence sodium chloride solution becomes dilute.

HOMEWORK QUESTIONS/ ACTIVITY (Educator must ask learners to read about a diaphragm cell and write a summary of how it works using the format that was used for the membrane cell in the lesson.

RESOURCES USED:

Any of the prescribed text books, charts or overhead projector and transparencies for diagrams.

Reflection/Notes:

Name of Teacher		**HOD:**	
Sign:		**Sign:**	
Date:		**Date:**	

GRADE	12	SUBJECT	Physical Sciences	WEEK	26	TOPIC	Chemical Systems(Chchlor-alkali Industry) – Time: 60 min	Lesson	2

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should be able to: • Distinguish between a membrane cell, diaphragm cell and mercury cell • Describe the operation of a diaphragm cell and a mercury cell • Identify all products of the chlor-alkali cells		

TEACHING and LEARNING ACTIVITIES

1. TEACHING METHOD/S USED IN THIS LESSON:

Question and Answer; Narrative

2. LESSON DEVELOPMENT

2.1 Introduction:

Educator introduces the lesson by asking questions about the three types of the chlor-alkali electrolytic cells in general and the membrane cell.

Teacher asks learners to mention the three types of electrolytic cells. The educator also asks questions related to the process and explains those concepts diagnosed not to have been grasped well in the previous lesson. [5 min.]

PRE-KNOWLEDGE

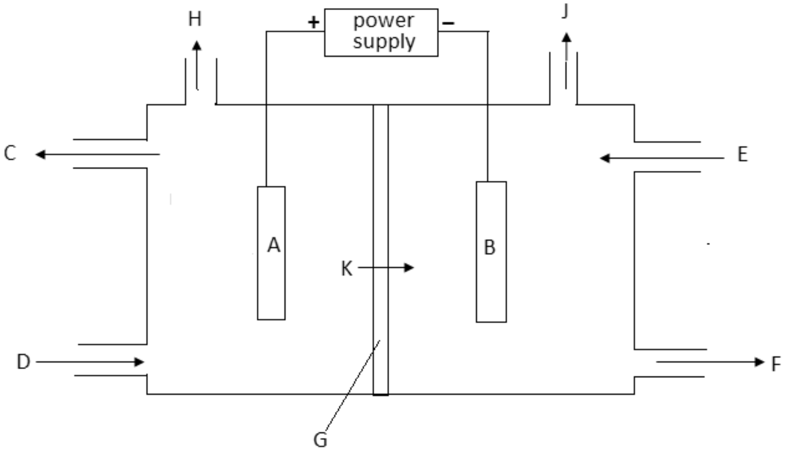
A basic understanding of :

- The structure of a membrane cell
- The raw materials and products of the chlor-alkali process.
- The anode and cathode reactions in the membrane cell.

EDUCATOR tests pre-knowledge by using the question and answer method as indicated in the baseline assessment.

BASELINE ASSESSMENT: QUESTIONS/ ACTIVITY [15 min]

The diagram below represents a membrane cell.



i. You are given only the terminals of the power supply, identify parts labelled A, B and G. Answer: A is the anode and B is the cathode. (Clue: Check terminals to which they are connected)

ii. Two raw materials, D and E are fed into the membrane cell. What substances are these? Answer: D is brine and E is water. (Clue: brine is added to the anode compartment whilst water is added to the cathode compartment.)

iii. Two gases H and J are produced during the chlor-alkali process. Which gases are these? Answer: H is chlorine and J is hydrogen. (Clue: Chlorine is obtained from sodium chloride which in this case is brine and hydrogen is produced from hydrogen ions obtained from the splitting of water molecules. Alternatively, chloride atoms are negatively charged hence will be attracted by a positively charged electrode and likewise hydrogen gas is formed from hydrogen ions which are positively charged hence they will be attracted by the cathode).

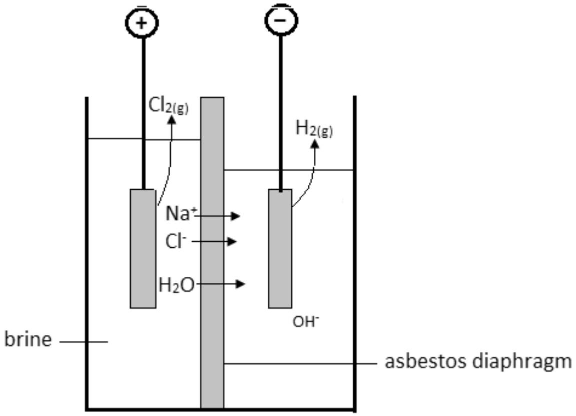
iv. Name substances C and F which are periodically tapped off the cell. Answer: C is dilute sodium chloride solution and F is sodium hydroxide solution. (Clue: Dilute sodium chloride results from the loss of sodium and chloride ions from brine hence it comes out from the side into which brine is fed.

v. Write an equation for the reaction that occurs at electrode B. Answer: $2H_2O_{(l)} + 2e^- \longrightarrow H_{2(g)} + 2OH^-_{(aq)}$ (Clue: B is a cathode hence the reaction occurring there is a cathode reaction, which is a reduction reaction.

N.B. In revising the exercise the educator should insist on learners giving reasons for the answers they give to ensure that they understand the concepts.

2.2 <u>Main Body (Lesson presentation)</u>

- Educator introduces the structures of a diaphragm cell and a mercury cell and then leads a discussion on the operation of the cells. [35 min.]
- <u>The diaphragm cell</u>
- A diaphragm cell also consists of two compartments, an anode compartment and a cathode compartment. These compartments are separated by an inert asbestos diaphragm. The anode is either made of titanium or coated with the metal and the cathode is made of steel.



- Brine is fed into the anode chamber whilst water is fed into the cathode chamber. The level of brine in the anode chamber has to be much higher than that of water in the cathode chamber.
- Anode reaction: $2Cl^-_{(aq)} \rightarrow Cl_{2(g)} + 2e^-$
- Cathode reaction: $2H_2O_{(l)} + 2e^- \rightarrow H_{2(g)} + 2OH^-_{(aq)}$
- When the asbestos diaphragm is wet it allows ions and water molecules to pass through it. Na^+ and Cl^- ions diffuse from the anode compartment into the cathode compartment. Some water molecules from the anode compartment also move across the asbestos diaphragm to the cathode compartment due to pressure.
- Pressure also prevents the OH^- ions from diffusing into the anode compartment.
- The sodium hydroxide solution formed in the cathode chamber is contaminated by sodium chloride formed by the ions sodium and chloride that migrate into the chamber. It is also diluted by the water entering the chamber through the asbestos diaphragm.

The mercury cell

- A mercury cell also has an anode made of titanium and this is immersed in concentrated sodium chloride solution. The cathode is flowing mercury mercury and this is found at the base of the chamber.
- Chloride ions from the solution are attracted by the titanium anode where they lose the extra electrons to form chlorine gas (Anode reaction: $2Cl^-_{(aq)} \rightarrow Cl_{2(g)} + 2e^-$)
- Na^+ ions are attracted to the mercury cathode where they gain electrons and become Na atoms (Cathode reaction: $Na^+_{(aq)} + e^- \rightarrow Na(s)$).
- The sodium produced mixes with mercury to form a sodium-mercury amalgam. The sodium-mercury amalgam flows through a pipe leading to a decomposer (sometimes referred to as a soda cell), chamber containing water and graphite pebbles. In this chamber, sodium in the amalgam reacts with water to produce hydrogen gas and sodium hydroxide. $2Na_{(s)} + H_2O_{(l)} \rightarrow 2NaOH_{(aq)} + H_{2(g)}$ From the decomposer mercury is pumped back to the electrolyser for re-use.

3. Conclusion and Chalkboard summary

Activity to Re-enforce lesson (Educator gives learners a written exercise covering concepts of the lesson. [15 min.]

1. (a) In the diaphragm cell, what process enables the Na^+ ions to migrate to the cathode compartment? Answer: Diffusion.

(b) Define the process stated in 1.(a). Answer: Diffusion is the process by which particles spread in a fluid.

(c) Why does the same process not occur for OH- ions in the cathode compartment? Answer: Positive pressure prevents the hydroxyl ions to flow from the cathode chamber

2. What other role is played by the asbestos diaphragm in the diaphragm cell? Answer: It prevents chlorine produced at the anode from mixing with hydrogen produced at the cathode. When the two combine they form an explosive mixture.

3. What makes sodium hydroxide produced from the diaphragm cell to have low purity? Answer: It is contaminated by NaCl which forms in the cathode chamber.

4. Why should the anode be coated with titanium? Answer: To prevent the anode material from reacting. Titanium is inert.

5. In a mercury cell, what role is played by the decomposer? Answer: It is a site for the removal of sodium from the sodium-mercury amalgam. It is also a site for the production of hydrogen and sodium hydroxide.

6. State two positive effects of using mercury pump? Answer: It pumps mercury to the electrolyser to be used again. It also prevents the accumulation of sodium at the cathode by enabling the amalgam to flow away from the electrolyser.

HOMEWORK QUESTIONS/ ACTIVITY (Educator has to ask learners to list the disadvantages of each cell discussed. Learners should also suggest the method they would recommend if asked to and give reasons for their choice.

RESOURCES USED:

Any of the prescribed text books, charts or overhead projector and transparencies for diagrams.

Reflection/Notes:

Name of Teacher		**HOD:**	
Sign:		**Sign:**	
Date:		**Date:**	

GRADE	12	SUBJECT	Physical Sciences	WEEK	26	TOPIC	Chemical Systems(Chemical Industry) – Time: 60 min	Lesson	3

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	

LESSON OBJECTIVES	At the end of this lesson learners should be able to: • Describe and explain the stages in the manufacture of ammonium nitrate and ammonium sulphate. • Write correct balanced chemical equations for production of ammonium nitrate and ammonium sulphate from nitric acid and sulphuric acid respectively. • Link the Haber process to the manufacture of fertilisers.

TEACHING and LEARNING ACTIVITIES

1. TEACHING METHOD/S USED IN THIS LESSON:

Question and Answer; Narrative

2. LESSON DEVELOPMENT

2.1 Introduction:

Educator introduces the lesson by asking questions from the previous lesson.[10 min.]

Teacher draws flow diagrams for the Haber process, Ostwald process and the Contact process. He/she then asks learners to briefly describe the processes. Educator corrects any misconceptions identified if any.

PRE-KNOWLEDGE

A basic understanding of :

- Neutralisation reactions
- Writing chemical formulae when given names of compounds.
- Balancing equations

EDUCATOR tests pre-knowledge by using the question and answer method as indicated in the baseline assessment.

BASELINE ASSESSMENT: QUESTIONS/ ACTIVITY [10min.]

1. Write down word equations for the last reaction for each of the following:

(i) Haber process

(ii) Ostwald’s process

(iii) Contact process

2. Write balanced chemical equations for word equations written in 1.

2.2 Main Body (Lesson presentation) [30 min.]

- Educator starts a lesson with a discussion on neutralisation reactions.
- Ammonia is required for the production of both ammonium nitrate and ammonium sulphate. Ammonia is a base hence these reactions are neutralisation reactions.
- Acid + base $\longrightarrow$ salt + water
- Ammonium nitrate

  Ammonia is reacted with nitric acid to produce ammonium chloride: $NH_{3(aq)} + HNO_{3(aq)} \longrightarrow NH_4NO_{3(aq)}$
- Ammonium sulphate

  Ammonia is reacted with sulphuric acid to produce ammonium sulphate: $2NH_3 + H_2SO_{4(aq)} \longrightarrow (NH_4)_2SO_{4(aq)}$
- Potash
- KNO_3, K_2SO_4, and KNO_2 are collectively known as potash and are mined from salt layers.
- **.Eutrophication**

  This is the enrichment of water by plant nutrients, especially nitrates and phosphates.
- Causes

  If too much fertiliser is used, excess fertiliser remains in the soil. When it rains some inorganic fertilisers in the soil dissolve in seepage and run-off. These fertilisers end up in water bodies, e.g. dams, lakes or rivers. The water then acquires a high concentration of nutrients.
- Consequences

  The high concentration of nutrients in the water promotes excessive growth of algae. When the algae die they are decomposed by aerobic bacteria. The algae die in large quantities resulting in an increase in the amount of aerobic bacteria. The huge amounts of aerobic bacteria deplete the level of oxygen available in water. Aquatic organisms like fish die due to lack of oxygen.
- Prevention of eutrophication

- Using the correct amount of fertiliser
- Applying fertiliser at the same time
- Using more of organic fertilisers
- Using efficient techniques for fertiliser application

- Effect of inorganic fertilisers on humans and development

Negative effects

- Eutrophication
- Nutrients leach into the soil and contaminate soil water which is used for drinking. Dissolved phosphates cause blue-baby syndrome, a fatal disease.
- The soil is impoverished more hence the need for continuous application of fertilisers

Positive effects

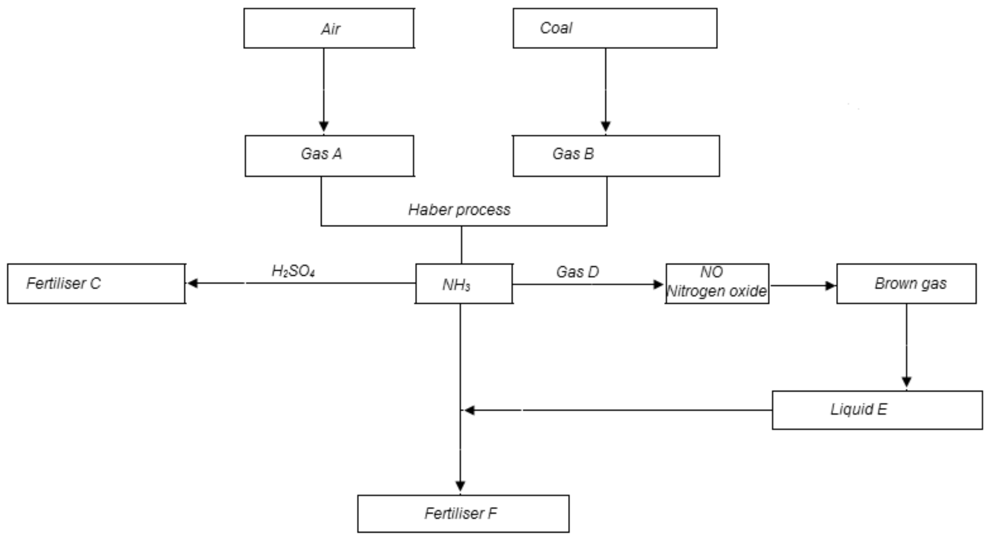
- Use of inorganic fertilisers increase food production for the growing population.

- It boosts the economies of counties that export agricultural produce.

3. Conclusion and Chalkboard summary

Activity to Re-enforce lesson (Educator gives learners a written exercise covering the main concepts of the lesson and revises the exercise with them.). [15min.]

Study the diagram below and answer the questions that follow.



1. Identify substances the following substances:

(i) Gas A <u>Answer:</u> Nitrogen

(ii) Gas B <u>Answer:</u> Hydrogen

(iii) Fertiliser C <u>Answer:</u> Ammonium sulphate

(iv) Gas D <u>Answer:</u> Oxygen

(v) The brown gas <u>Answer:</u> Nitrogen dioxide

(vi) Liquid E <u>Answer:</u> Nitric acid

(vii) Fertiliser F <u>Answer:</u> Ammonium nitrate

2. By what process is gas A obtained from the air? <u>Answer:</u> Fractional distillation of liquid air

3. Write a balanced chemical equation for the reaction that results in the production of liquid E. <u>Answer:</u> $4NO_{(g)} + O_{2(g)} + 2H_2O_{(l)} \rightarrow 4HNO_{3(aq)}$

HOMEWORK QUESTIONS/ ACTIVITY (Educator must ask learners to make posters from the following choices: Haber process, Ostwald process, Contact process or reactions for the production of inorganic fertilisers. The learners should be promised that the best two posters from each category will be displayed in the science class.

RESOURCES USED:

Any of the prescribed text books, charts or overhead projector and transparencies for diagrams.

Reflection/Notes:

Name of Teacher		**HOD:**	
Sign:		**Sign:**	
Date:		**Date:**	

GRADE	12	SUBJECT	Physical Sciences	WEEK	27	TOPIC	Chemical Systems(Chlor-alkali Industry) – Time: 60 min	Lesson	1

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should be able to: • Demonstrate their understanding of the chlor-alkali process • Identify the purpose of a sequence of steps for a given process.		

TEACHING and LEARNING ACTIVITIES

1. TEACHING METHOD/S USED IN THIS LESSON:

Question and Answer; Narrative, Written work

2. LESSON DEVELOPMENT

2.1 Introduction:

Educator the learners the properties of chlorine, hydrogen and sodium hydroxide. [5 min.]

PRE-KNOWLEDGE

A basic understanding of :

- The structures of the three chlor-alkali electrolytic cells
- The operation of the three chlor-alkali electrolytic cells
- The reactions that lead to the formation of the three products of the chlor-alkali process.
- The process of purification of sodium hydroxide.
- The uses of chlorine, hydrogen and sodium hydroxide

EDUCATOR tests pre-knowledge by using the question and answer method as indicated in the baseline assessment.

BASELINE ASSESSMENT: QUESTIONS/ ACTIVITY [15min.]

- Educator shows a diagram of one of the electrolytic cell and asks them to identify the cell and also give a reason for their choice.
- Teacher asks for two uses of each of the products of the chlor-alkali process.

2.2 Main Body (Lesson presentation)

- Educator asks learners to go into their groups of three from the previous lesson. [40 min.]

- In their groups of three learners make presentations to one another. They present on the structure and operation of the three types of electrolytic cells. Each learner also gives the chemical equations for the production of chlorine, hydrogen and sodium hydroxide.
- Teacher asks learners to state challenges or disagreements they had in their groups so that these are discussed by the whole class.
- Individually learners answer the following questions under test conditions:

1. Give two reasons why would recommend a membrane cell for the preparation of chlorine.

   Answer: It is cheap to maintain and is environmentally friendly.
2. State one risk that is associated with the diaphragm cell.

   Answer: The cell uses an asbestos diaphragm and asbestos can cause a lung disease.
3. Why is it wise to use unreactive materials as electrodes?

   Answer: If reactive materials are used they would react and therefore interfere with the desired reactions.
4. Write an equation for the reaction that takes place at the cathode of the membrane cell.

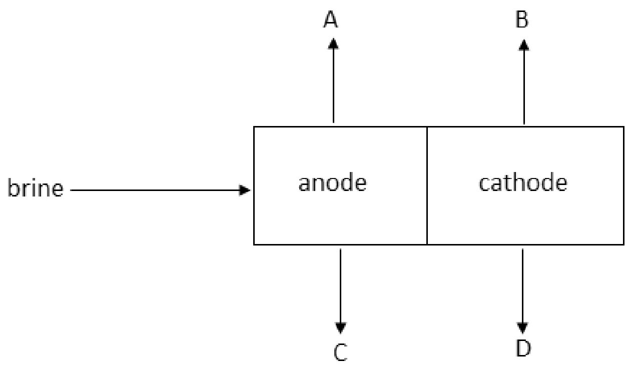
   Answer: $2H_2O_{(l)} \rightarrow H_{2\,(g)} + 2OH^-_{(aq)}$
5. Write an anode reaction for the diaphragm cell.

   Answer: $2Cl^-_{(aq)} \rightarrow Cl_{2(g)} + 2e^-$
6. Write an equation of the reaction that occurs at the cathode of a mercury cell.

   Answer: $Na^+_{(aq)} + 2e^- \rightarrow Na_{(s)}$
7. Write an equation for the production of sodium hydroxide in the mercury cell.

   Answer: $2Na_{(s)} + H_2O_{(l)} \rightarrow 2NaOH_{(aq)} + H_{2(g)}$
8. Give two reasons why is it necessary to steam the sodium hydroxide solution obtained from the diaphragm cell.

   Answer: Steaming is done in order to remove the NaCl contaminants and also to concentrate the sodium hydroxide solution.
9. The flow diagram below represents the cell membrane process.



Name the substances A, B, C and D.

Answer: A - chlorine gas, B - hydrogen gas, C- dilute sodium chloride solution, D - sodium hydroxide solution

3. Conclusion and Chalkboard summary

Activity to Re-enforce lesson (Educator revises the exercise with the learners.). [15min.]

HOMEWORK QUESTIONS/ ACTIVITY (Learners to answer questions from this topic from the prescribed text book they use.

RESOURCES USED:

Any of the prescribed text books, charts or overhead projector and transparencies for diagrams.

Reflection/Notes:

Name of Teacher		**HOD:**	
Sign:		**Sign:**	
Date:		**Date:**	

GRADE	12	SUBJECT	Physical Sciences	WEEK	27	TOPIC	Chemical Systems(Fertiliser Industry) – Time: 60 min	Lesson	2

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	

LESSON OBJECTIVES	At the end of this lesson learners should be able to: • Describe the process of fractional distillation of air • Describe the production of hydrogen gas at Sasol from coal and steam • Describe the production of ammonia by the Haber process.

TEACHING and LEARNING ACTIVITIES

1. TEACHING METHOD/S USED IN THIS LESSON:

Question and Answer; Narrative

2. LESSON DEVELOPMENT

2.1 Introduction:

Educator introduces the lesson by asking learners to state the inorganic fertilisers they know and possibly giving the chemical formula for each.

Educator writes down both the name and formula given by learners if correct. Incorrect names and formulae are corrected. [5min.]

PRE-KNOWLEDGE

A basic understanding of :

- Inorganic fertilisers
- The formulae of raw materials and products of the Haber process
- Balancing chemical equations
- Determining formulae of substances from given names
- Distillation

EDUCATOR tests pre-knowledge by using the question and answer method as indicated in the baseline assessment.

BASELINE ASSESSMENT: QUESTIONS/ ACTIVITY [15min.]

- Write the formulae for ammonium chloride, ammonium sulphate, copper (II) sulphate, phosphoric acid, zinc (II) chloride, aluminium hydroxide
- Write a balanced chemical equation for the reaction of sodium and water, a neutralisation reaction between sulphuric acid and sodium hydroxide.

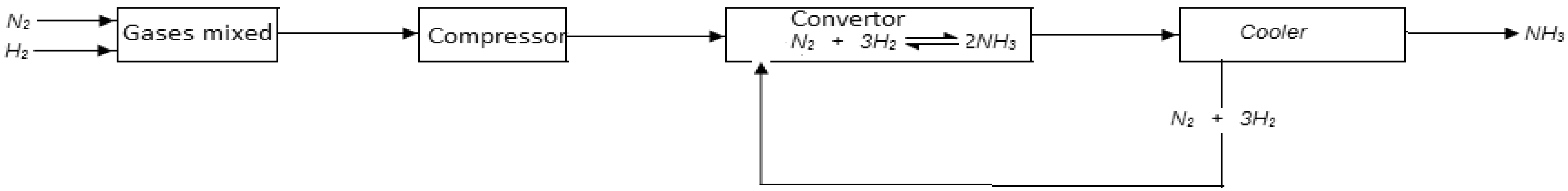
2.2 Main Body (Lesson presentation [30 min.]

- Educator starts a lesson with a discussion on simple and fractional distillation

- Simple distillation is the process in which a solution is heated to produce a vapour which is heated to produce a vapour which is then cooled to become a liquid again. This process is used to separate a pure liquid from a dissolved solid substance.
- Fractional distillation is used to separate liquids with different boiling points. The liquid with a lower boiling point is collected as a distillate.
- Artificial fertilisers: The most common artificial fertilisers are ammonium fertilisers. These are produced from ammonia. Ammonia itself is produced from a reaction between nitrogen and hydrogen.
- **Nitrogen gas**
- . Nitrogen occurs naturally in the atmosphere. It forms 78% of the air. Pure nitrogen is obtained by from the fractional distillation of liquid air. First the air is liquefied and then distilled.
- Liquifying the air
- Air is filtered to remove dust and then cooled until it reaches -200^{0}C. During the cooling process, water vapour condenses first and is removed. At -79^{0}C carbon dioxide freezes and is removed. Oxygen liquefies at -183^{0}C and nitrogen liquefies at -196^{0}C. At -200^{0}C both oxygen and nitrogen would be liquids.
- Fractional distillation of liquid air
- The liquid mixture is passed into the bottom of a fractionating column. Liquid nitrogen boils rises to the top where the gas is tapped off. As the gaseous nitrogen rises, liquid oxygen remains at the bottom.
- **Hydrogen gas**
- Hydrogen gas is produced at Sasol from steam and coal by the process of gasification. These are heated together with oxygen at very high temperatures and pressure. The following reactions occur in the process:

1. $C + H_2O \rightarrow CO + H_2$
2. $C + O_2 \rightarrow CO_2$
3. $CO + H_2O \rightarrow CO_2 + H_2$

- **Haber Process**
- N_2 and H_2 are pumped into a vessel containing iron powder. Iron acts as a catalyst for this process. The two gases react to form ammonia (NH_3) but the reaction is reversible.
  $N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g)$
- To promote the forward reaction pressure and temperature have to be controlled accordingly.
- Flow chart showing the Haber Process



From the cooler, ammonia is collected as a liquid. Unreacted nitrogen and hydrogen are sent back to the convertor.

3. Conclusion and Chalkboard summary

Activity to Re-enforce lesson (Educator gives learners an written exercise covering the main concepts of the lesson and revises the exercise with them.). [15min.]

1. What are the raw materials for the production of ammonia?

   Answer: Nitrogen and hydrogen

2. By what process is nitrogen, for the Haber process, obtained?

   Answer: Fractional distillation of liquid air.

3. How is hydrogen gas produced at Sasol?

   Answer: It is produced from the gasification of coal where coal is heated under very high temperatures and pressure in the presence of steam and oxygen.

4. Write balanced chemical equations for the reactions by which hydrogen is produced at Sasol.

$C + H_2O \rightarrow CO + H_2$

$CO + H_2O \rightarrow CO_2 + H_2$

5. Other than nitrogen and hydrogen, what other substance would you expect to find in the convertor and what is the role of this substance?

Answer: Iron powder. This substance acts as a catalyst.

HOMEWORK QUESTIONS/ ACTIVITY (Educator must divide learners into groups and allocate them the following processes to read and prepare to present to others in class: Ostwald process,Contact process, production of ammonium nitrate, production of ammonium sulphate, production of super phosphate.

RESOURCES USED:

Any of the prescribed text books and any other source of relevant information.

Reflection/Notes:

Name of Teacher		**HOD:**	
Sign:		**Sign:**	
Date:		**Date:**	

GRADE	12	SUBJECT	Physical Sciences	WEEK	27	TOPIC	Chemical Systems(Chemical Industry) – Time: 60 min	Lesson	3

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should be able to: • Describe the Ostwald's process and write equations for the relevant steps of the process. • Describe and explain the Contact process. • Write balanced chemical equations for reactions that occur in both the Ostwald process and the contact process.		

TEACHING and LEARNING ACTIVITIES

1. TEACHING METHOD/S USED IN THIS LESSON:

Question and Answer; Narrative ,

2. LESSON DEVELOPMENT

2.1 Introduction:

Educator introduces the lesson by using a diagram of a simple electrolytic cell and asks questions related to electrolysis.

Teacher draws a simple electrolytic cell on the board or uses a chart. He/she asks learners whether it is a galvanic cell or an electrolytic cell. Learners have to give a reason for their answer. .He/she then asks the learners to identify the various parts of the electrolytic cell. A short discussion is held on what happens in the cell during electrolysis. The educator has to reinforce those concepts which learners seem not to remember. [5min.]

PRE-KNOWLEDGE

A basic understanding of :

- Chemical formulae of nitric acid, sulphuric acid and ions found in aqueous solutions of these acids.
- Properties of acids and bases.

EDUCATOR tests pre-knowledge by using the question and answer method as indicated in the baseline assessment.

BASELINE ASSESSMENT: QUESTIONS/ ACTIVITY [15min.]

- Write down the chemical formulae of nitric acid and sulphuric acid.
- Write down the ions found in aqueous nitric acid and sulphuric acid.
- Write equations that represent the ionisation of these acids.

2.2 <u>Main Body (Lesson presentation)</u>

- Educator starts a lesson by explaining the role of inorganic acids in the manufacture of inorganic fertilisers. [30 min.]
- Most commonly used fertilisers are made from inorganic acids, namely nitric acid and sulphuric acid.

- Nitric acid is made from ammonia through a process called the Ostwald Process and sulphuric acid is produced from sulphur dioxide and oxygen through a process called the Contact process.
- Learners who had been given a task of reading and presenting the Ostwald process are given an opportunity to do the presentation.
- Educator then explains the process in detail as shown below.
- **Ostwald process**

1. Ammonia and oxygen are mixed and passed over a heated platinum catalyst: $4NH_{3(g)} + 5O_{2(g)} \rightarrow 4NO(g) + 6H_2O_{(l)}$
2. Nitrogen oxide is cooled and reacted with oxygen to produce nitrogen dioxide: $2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$
3. Nitrogen dioxide is then mixed with oxygen and water. The three substances react to produce nitric acid: $4NO_{(g)} + O_{2(g)} + 2H_2O_{(l)} \rightarrow 4HNO_{3(aq)}$

   Alternatively nitrogen dioxide is bubbled through water to produce nitric acid and nitrogen nitrogen monoxide: $3NO_{2(g)} + H_2O_{(l)} \rightarrow 2HNO_{3(aq)} + NO_{(g)}$

   Nitrogen oxide obtained at this stageis recycled and used in step 2.

- Learners who had been given a task of reading and presenting the Contact process are given an opportunity to do the presentation.
- Educator then explains the process in detail as shown below.
- **Contact process**
- This is a process used to produce sulphuric acid and it involves 4 steps.

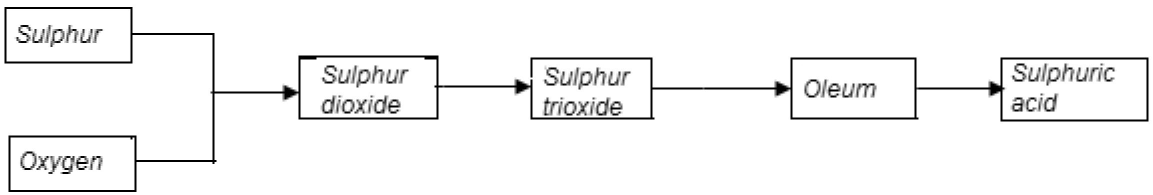
1. Sulphur is burnt in air to produce sulphur dioxide: $S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$
2. Sulphur dioxide is mixed with oxygen gas in a convertor: $2SO_{2(s)} + O_{2(g)} \rightarrow 2SO_{3(g)}$
3. Sulphur trioxide is dissolved in 98% sulphuric acid to produce oleum: $SO_{3(g)} + H_2SO_{4(l)} \rightarrow H_2S_2O_7$
4. Water is then added to oleum to produce sulphuric acid: $H_2S_2O_7 + H_2O_{(l)} \rightarrow 2H_2SO_{4(l)}$

The name "Contact " process comes from the fact that in step 2, the SO_2 and oxygen gases come into contact with a catalyst, V_2O_5 i.e. vanadium pentoxide.

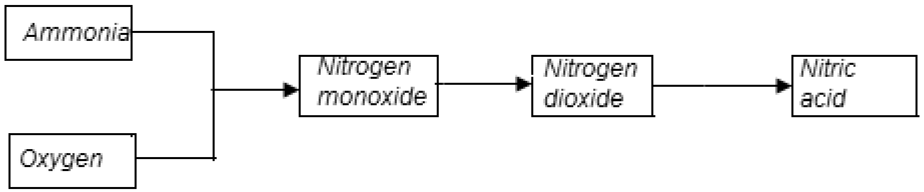
3. Conclusion and Chalkboard summary

Activity to Re-enforce lesson (Learners are given flow diagrams for the Ostwald and Contact processes and they are asked to write chemical equations for the reactions that occur at the steps represented by the arrows.). [15min.]

Flow diagram of Ostwald process



Flow diagram of Contact process



HOMEWORK QUESTIONS/ ACTIVITY (Learners have to write the uses of both nitric acid and sulphuric acid.

RESOURCES USED:

Any of the prescribed text books, charts or overhead projector and transparencies for diagrams.

Reflection/Notes:

Name of Teacher		**HOD:**	
Sign:		**Sign:**	
Date:		**Date:**	

GRADE	12	SUBJECT	Physical Sciences	WEEK	28	TOPIC	Chemical Systems(Batteries) – Time: 60 min	Lesson	1

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should be able to: • Derive half equations for galvanic cells. • Provide a net equation for a galvanic cell when given half equations • Calculate the cell voltage from the voltages of half cells • Distinguish between a primary cell and a secondary cell		

TEACHING and LEARNING ACTIVITIES

1. TEACHING METHOD/S USED IN THIS LESSON:

Question and Answer; Narrative, Demonstration

2. LESSON DEVELOPMENT

2.1 Introduction:

Educator introduces the lesson by showing learners diagrams of cells and asking them to identify whether the given cells are galvanic or electrolytic.

Learners then discuss the differences between the galvanic and electrolytic cells [5min.]

PRE-KNOWLEDGE

A basic understanding of :

- The structure of an electrolytic cell
- The structure of a galvanic cell.
- Rechargeable and non-rechargeable cells.
- Half-cell reactions

EDUCATOR tests pre-knowledge by using the question and answer method as indicated in the baseline assessment.

BASELINE ASSESSMENT: QUESTIONS/ ACTIVITY [15min.]

- Given two diagrams, an electrolytic cell and a galvanic cell learners are asked to identify the cathodes and the anodes of the two cells
- Learners are also asked to state the differences between a dry cell used in torches and a car battery. The differences are then discussed by all.
- Learners are asked to explain what half-reactions are and how they are treated to give a net equation. This is done with an example.

2.2 Main Body (Lesson presentation) [30 min.]

- Educator starts a lesson introducing primary cells.
- Primary cells

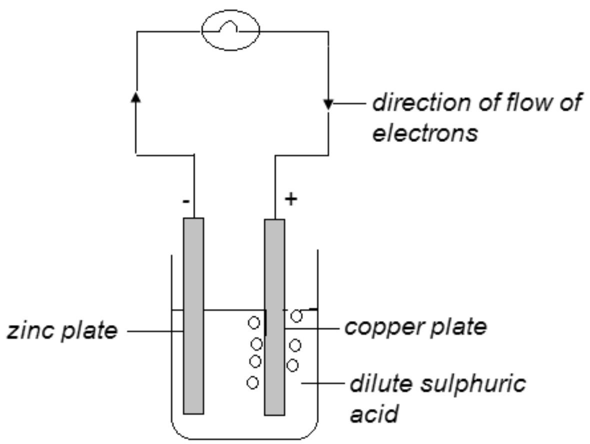
  A demonstration is carried out to show the operation of a simple cell.
- A primary cell is a galvanic cell that is not rechargeable. This cell is not rechargeable because the reaction that occurs during discharge is irreversible.
- Common primary cells are the simple cell (zinc-copper cell) and the dry cell (zinc–carbon cell).
- Chemical potential energy is converted into electrical energy through a spontaneous redox reaction.
- Cell Capacity is the ability of a fully charged battery to deliver a specific quantity of current over a specific period of time (minutes or hours)

$Q = I\Delta t$ where Q is measured in Amp. hours (A·h)

- Cell emf gives the voltage that the battery can provide and the voltage and charge together gives the amount of energy (work done) the battery can provide

$W = VQ$ or $W = VI\Delta t$ where W is the work done (energy transferred) and measured in Joules (J)

- Simple cell



- **Anode reaction:** $Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^-$ ($E^\theta_{anode} = -0.76V$)
- **Cathode reaction:** $2H^+_{(aq)} + 2e^- \rightarrow H_{2(g)}$ ($E^\theta_{cathode} = 0$)

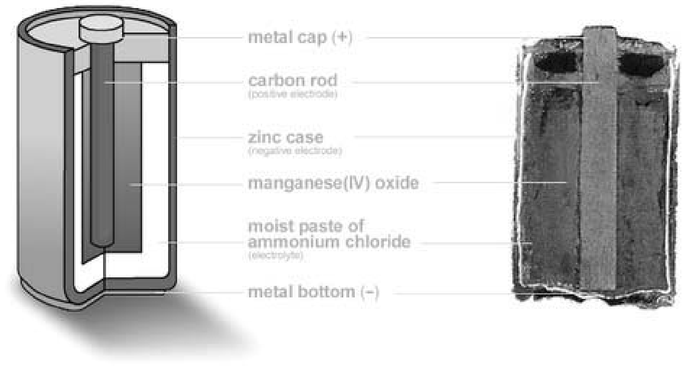
$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$

$(E^{\theta}_{cell} = 0 - (-0.76V)$

$= 0.76V$

During discharge the zinc plate decreases in size as the atoms ionise. Hydrogen ions from solution gain electrons at the cathode and they form atoms which pair to form hydrogen gas molecules. Some hydrogen gas is released but some gas bubbles accumulate around the copper cathode and insulate it. This causes a decrease in the rate of reaction hence the voltage of the cell decreases.

- A zinc-carbon cell (dry cell)



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- **Anode reaction:** $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^{-}$ [$E^{\theta}anode = -0.76$ volts]
- **Cathode reaction:** $2MnO_2(s) + 2e^{-} + 2NH_4Cl(aq) \rightarrow Mn_2O_3(s) + 2NH_3(aq) + H_2O(aq) + 2Cl^{-}$ [$e° = +0.74$ volts]
- **Overall reaction:** $Zn(s) + 2MnO_2(s) + 2NH_4Cl(aq) \rightarrow Mn_2O_3(s) + Zn(NH_3)_2Cl_2(aq) + H_2O(l)$
- $E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$

  $E^{\theta}_{cell} = +0.74V - (-0.76V)$

  $= +1,5V$

3. Conclusion and Chalkboard summary

Activity to Re-enforce lesson (Educator gives learners an written exercise covering the main concepts of the lesson and revises the exercise with them.). [15min.]

Educator revises content covered with learners by asking oral questions which also have to be answered orally.

- Definition of a primary cell
- Examples of primary cells

- Identifying anode and cathode in a galvanic cell
- Method of calculating cell voltage.

HOMEWORK QUESTIONS/ ACTIVITY (Learners could be asked to read about an alkali cell, identify the anode, cathode and electrolyte. They should also write equations for the cathode reaction, the anode reaction and net equation. They should then calculate the cell voltage of this cell.

RESOURCES USED:

Any of the prescribed text books, charts or overhead projector and transparencies for diagrams. beaker, copper plate, zinc plate, dilute sulphuric acid and light bulb.

Reflection/Notes:

Name of Teacher		**HOD:**	
Sign:		**Sign:**	
Date:		**Date:**	

GRADE	12	SUBJECT	Physical Sciences	WEEK	28	TOPIC	Chemical Systems (Batteries) – Time: 60 min	Lesson	2

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should be able to: • Define a secondary cell • Identify the cathode and the anode in a lead acid accumulator • Calculate the cell voltage of a lead acid accumulator from the half cell voltages provided • Describe a car battery • Describe the discharging and charging of a lead-acid accumulator in terms of chemical reactions • Calculate the total voltage of a car battery • Describe the impact of batteries on the environment		

TEACHING and LEARNING ACTIVITIES

1. TEACHING METHOD/S USED IN THIS LESSON:

Question and Answer; Narrative, demonstration

2. LESSON DEVELOPMENT

2.1 Introduction:

Teacher draws a diagram of a simple cell with metal electrodes and asks learners to identify the cathode and anode. Learners are further asked to use the standard electrode potentials to calculate voltage of the given cell. [5min.]

PRE-KNOWLEDGE

A basic understanding of :

- Identifying anode and cathode when given half reactions
- Calculating cell voltage when given half reactions and their voltages.

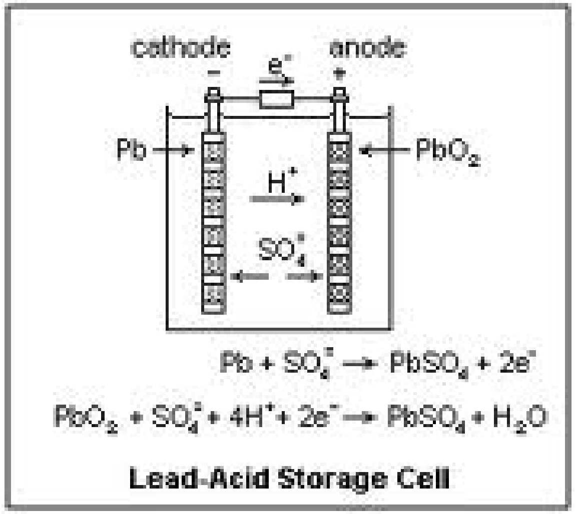
EDUCATOR tests pre-knowledge by using the question and answer method as indicated in the baseline assessment.

BASELINE ASSESSMENT: QUESTIONS/ ACTIVITY [10min.]

- Educator uses a diagram of an alkali dry cell to revise the homework with the learners.

2.2 Main Body (Lesson presentation) 35 min

- Secondary cells
- Secondary cells can be recharged because the reactions that occur during discharge are reversible. An example of a secondary cell is the lead-acid cell. This is the kind of cell found in car batteries. Lead acid cell



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Discharging

Anode reaction: $Pb(s) + SO_4^{2-}(aq) \rightarrow PbSO_{4(aq)} + 2e$ ($E^\theta = 0.356V$)

Cathode reaction: $PbO_2(s) + SO_4^{2-}{}_{(aq)} + 4H^+{}_{(aq)} + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$ ($E^\theta = 1,685V$)

Net cell reaction: $Pb(s) + PbO_2(s) + 2SO_4^{2-}{}_{(aq)} + 4H^+{}_{(aq)} \rightarrow 2PbSO_4(s) + 2H_2O(l)$ ($E^\theta = 2,041V$)

- There are 6 lead-acid cells in a 12V car battery and these cells are connected in series.

Charging

- During charging the reactions that occur at the electrodes are reversed.
- When charging the battery, the positive terminal of the battery is connected to the positive terminal of the charger.
- Impact of batteries on the environment

- Chemicals from some cells are toxic hence when discarded they may pollute the soil and water
- Batteries are made of non-biodegradable materials
- Batteries can be recycled.

CLASSWORK(Question from DOE Nov 2010 Paper 2)

Lead-acid batteries have been used in cars for the past 85 years. The equations of the half-reactions that take place in each cell of such batteries are shown below.

$Pb(s) + HSO_4^-(aq) \rightarrow PbSO_4(s) + H^+(aq) + 2e^-$

$PbO_2(s) + 3H^+(aq) + HSO_4^-(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(\ell)$

1.1 Write down the oxidation number of lead (Pb) in $PbSO_4(s)$. (1)

1.2 Write down the balanced equation for the net (overall) cell reaction. (3)

1.3 Which ONE of the reactants is the reducing agent in this cell reaction? Give a reason for the (2) answer .

One of the safety concerns related to the lead-acid battery is the dangers associated with recharging (that is reversing the net reaction) of a flat battery. Water in the battery can be electrolysed to produce hydrogen and oxygen gas during recharging.

1.4	Use the Table of Standard Reduction Potentials and write down the half-reaction which explains the formation of oxygen gas.	(2)
1.5	Why is the recharging of flat batteries a safety concern?	(1)
1.6	If the cell capacity of such a cell is 3,5 A·h, calculate the number of electrons that flow through the cell in 30 minutes. Assume the cell discharges completely during the 30 minutes. (The charge on one electron is $-1,6 \times 10^{-19}$ C.)	(5)**[14]**

ANSWERS TO CLASSWORK

1.1 (+) 2 ✓ (1)

1.2 $Pb + PbO_2 + 2H_2SO_4 \rightarrow 2PbSO_4 + 2H_2O$

OR

$Pb + PbO_2 + 2H^+ + 2HSO_4^- \rightarrow 2PbSO_4 + 2H_2O$

(reactants ✓ ; products ✓ bal ✓)

(3)

1.3 Pb / lead✓

Pb is oxidised/loses electrons. /Highest reducing ability / stronger reducing agent / smaller reduction potential (E°)✓/causes reduction.

OR The oxidation number of Pb increases (from 0 → 2) (2)

1.4 $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$ ✓✓ (2)

1.5 The gases produced during recharging (hydrogen and oxygen) may explode if sparked. ✓ (1)

16 Q = I x t ✓= 3.5 x 60 x 60 ✓= 12 600 C ✓ in 1 hour

Thus, 12 600/2 = 6 300 C ✓in 30 minutes

Number of electrons = 6300/1,6 x 10^{-9} = 3,94 x 10^{22} ✓ (5)

[14]

3. Conclusion and Chalkboard summary[15min.]

Activity to Re-enforce lesson:

Educator asks learners questions related to the lead acid cells and batteries and these questions can be answered orally.

(**HOMEWORK QUESTIONS/ ACTIVITY** (Educator must ask learners to attempt questions on this topic from their recommended Physical Sciences text book.

RESOURCES USED:

Any of the prescribed text books, charts or overhead projector and transparencies for diagrams, car battery

Reflection/Notes:

Name of Teacher		**HOD:**	
Sign:		**Sign:**	
Date:		**Date:**	