GRADE	12	SUBJECT	Physical Sciences	WEEK	12	TOPIC	Doppler Effect	Lesson	1

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should know: • The meaning of Doppler effect The following results will be the outcome of this lesson: • Learners must be able to state what the Doppler Effect is for sound and give everyday examples. • Learners must be able to explain why a sound increases in pitch when the source of the sound travels towards a listener and decreases in pitch it travels away. • Learners must be able to describe applications of the Doppler Effect with ultrasound waves in medicines, e.g. to measure the rate of blood flow or the heartbeat of foetus in the womb.		

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 • Frequency, relative velocity, pitch **BASELINE ASSESSMENT** • Baseline questions ▪ What is meant by the term frequency? ▪ Define relative velocity. ▪ What is the relationship between frequency and pitch? **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 ▪ Frequency is the number of complete waves passing a point in a second. ▪ It is a point of origin or zero point with a set of directions. ▪ The higher the frequency, the higher the pitch.	1. Learners answer the baseline questions. 2. Learners take notes from the board. 3. Learners write the classwork. **CLASSWORK** 1. What is meant by the term "Doppler Effect"? 2. a) What principle can be applied to explain what happens to the pitch of a sound as the source come closer and closer, passes you and moves away? b) Why does this happen? c) Give a real life example.	10 min 25 min 15 min	Chalkboard for notes, discussions and classwork

• Educator explains and discusses with learners the following **The Doppler Effect and sound** • The Doppler Effect is the apparent change in the frequency of a wave as a result of the relative motion between the observer (listener) and the source. • In other words, it is an alteration in the observed frequency of a sound due to motion of either the source or observer or both. • Although less familiar, this effect is easily noticed for a stationary source or observer. • The Doppler Effect is experienced whenever the speed of the object making the sound is slower than the sound waves it produces. • **The Doppler Effect and sound: car approaches observer** ▪ For example, when a car passes an observer on the ground, the observer notices that the pitch of sound is higher. ▪ The pitch of the sound is proportional to the frequency of the wave. The frequency of the wave being produced is constant. ▪ As the object approaches the observer, the distance that the wave must fit into decreases, so the wavelength becomes shorter to fit into the smaller distance. ▪ Therefore he notices that the sound waves reach him at a more frequent rate, therefore higher pitch. • **The Doppler Effect and sound: car moves away from an observer** ▪ As the object moves past the observer and distance between him and object increases, the waves spread out and reach him at a less frequent rate, therefore lower pitch. ▪ The Doppler Effect is not a result of an actual change in frequency of the source. The source puts out the same frequency, but the observer perceives it a different frequency. ▪ The Doppler Effect also occurs when the source is at rest and the observer is moving. ▪ If the observer is moving towards the source, the pitch is higher and if the observer is moving away from the source, the pitch is lower. • **The Doppler Effect and Ultrasound** ▪ Ultrasound refers to sound waves with a frequency above human hearing (greater than 20 kHz)	3. The apparent change in the frequency of a wave as a result of the relative motion between the observer and the source is called A. resonance B. Doppler Effect C. Ultrasound D. sonic boom 4. When a car approaches a stationary observer on the ground, A. the observer notices that the pitch of the sound is lower. B. the observer notices that the sound is louder. C. the observer notices that the pitch of the sound is higher. D. the observer notices that the sound is softer. **SOLUTIONS** 1. Doppler Effect is the apparent change in the frequency of a wave as a result of the relative motion between the observer (listener) and the source. 2. a) Doppler Effect principle b) If a source of sound of a constant frequency is moving towards an observer, the sound seems higher in pitch; whereas when it moves away it seems lower.		

▪ The very high frequency that ultrasound has a small wavelength. Therefore it can be reflected and refracted by very small objects. ▪ A large wavelength will pass over these small objects. ▪ Ultrasound reflects well off organs and tissue in the body. When the ultrasound is reflected off an object, the reflected wave undergoes the Doppler Effect. ▪ Sensitive instruments can determine the difference between the frequency of the outgoing waves and the reflected waves. ▪ The heartbeat and the flow of blood in an unborn baby are detected this way. ▪ This technique is also used to locate underwater objects. This is called Sonar. **2.3 Conclusion** • Ask learners about the main aspects of the lesson • Give learners classwork	c) It can be heard by an observer listening to the whistle of a train coming into a station etc. 3. B 4. C		

Reflection/note

Name of Teacher:		**HOD:**	
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GRADE	12	SUBJECT	Physical Sciences	WEEK	12	TOPIC	Doppler Effect	Lesson	2

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should know: The following results will be the outcome of this lesson: • Learners must be able to use the equation $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ to calculate the frequency of sound detected by a listener (L) when either the listener or the source (S) is moving.		

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 • Frequency, velocity, conversion of the units **BASELINE ASSESSMENT** • Baseline questions ▪ In what units is frequency measured in? ▪ Convert 20 kHz to Hz. ▪ Convert 72 km•h^{-1} to m•s^{-1} **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 ▪ Hertz (Hz) ▪ 20 kHz = 20 x 10^3 Hz ▪ 72 km•h^{-1} = 72/3,6 = 20 m•s^{-1} • 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** **Use speed of sound in air as 340 m•s^{-1}.** 1. Ambulance moving at 40 m•s^{-1} approaches a traffic light where a blind man and his dog are waiting to cross the road. The siren of the ambulance transmits waves at a frequency of 350 Hz. The pitch of the sound decreases as the ambulance moves past the man and drives further away from him. It is assumed that the speed of sound in air is 340m•s^{-1}.Determine the apparent frequency of the sound waves that the man observes as the ambulance approaches him.	5 min 20 min 25 min	Chalkboard for notes, discussions and classwork

The Doppler Effect Equation

- It is possible to calculate the frequency of the sound waves that the listener hears when the source and/or listener moves towards or away from each other by using the following equation, known as the Doppler equation.
- The Doppler equation is: $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$
- Where: f_L = frequency of sound heard by listener
- f_S = frequency of sound emitted by the sound source
- v = speed of sound in air
- v_S = speed of source
- v_L = speed of listener
- If the source and listener move towards each other: $f_L = \frac{v + v_L}{v - v_s} f_s$
- If the source and listener moves away from each other: $f_L = \frac{v - v_L}{v + v_s} f_s$

Worked Example

The siren of an ambulance emits waves at a frequency of 1000 Hz. Determine the frequency of the sound heard by a stationary listener when the ambulance is moving:

- towards the listener at a speed of 15 m•s^{-1}
- away from the listener at a speed of 15 m•s^{-1}

Solutions

2. A train moving at 180 km•h^{-1} approaches a railway crossing. It warns the pedestrians and motorists waiting at the crossing, by transmitting a siren at a frequency of 2000 Hz. Calculate the frequency at the instant the pedestrians hear the sound as the train approaches the railway crossing.
3. A racing car approaches an observer at 180 km•h^{-1}. The frequency of the sound that the car emits is 1250 Hz.

3.1 Calculate the frequency of sound waves that the observer hears when the car approaches him.

3.2 Calculate the frequency at which the observer hears the sound at the instant the car passes him.

3.3 Calculate the frequency at which the observer hears the sound when the car moves away from him.

SOLUTIONS

1. $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$

$f_L = \frac{340}{340 - 40} 350$

= 396,67 Hz

a) $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$

$f_L = \frac{340}{340 - 15} 1000$

= 1046,15 Hz

b) $f_L = \frac{v + v_L}{v - v_s} f_s$

$f_L = \frac{340}{340 + 15} 1000$

= 957,75 Hz

2.3 Conclusion

- Ask learners about the main aspects of the lesson.
- Give learners classwork

2. $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$

$f_L = \frac{340}{340 - 50} 2000$

= 2344,83 Hz

3.1

$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$

$f_L = \frac{340}{340 - 50} 1250$

= 1465.52 Hz

3.2 1250 Hz

3.3

$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$

$f_L = \frac{340}{340 + 50} 1250$

= 1089,74 Hz

Reflection/note

Name of Teacher:		**HOD:**	
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GRADE	12	SUBJECT	Physical Sciences	WEEK	12	TOPIC	Doppler Effect	Lesson	3

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	

LESSON OBJECTIVES

At the end of this lesson learners should know:

- The meaning of Doppler Effect

The following results will be the outcome of this lesson:

- Learners must be able to use the equation

$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$$

to calculate the frequency of sound detected by a listener (L) when either the listener or the source (S) is moving.

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 • Doppler Effect Equation, Doppler Effect **BASELINE ASSESSMENT** • Baseline questions ▪ Define Doppler Effect. ▪ Write the Doppler equation if the source and listener are move towards each other. ▪ Write the Doppler equation if the source and listener are move towards each other. **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 ▪ When the sound source or the listener is moving there will be a change in the frequency of the sound. We hear the sound lower or higher than the source actually is. • Educator give learners the following Consolidation exercise on Doppler Effect Equation	1. Learners answer the baseline questions. 2. Learners write the consolidation exercise **SOLUTIONS (CONSOLIDATION EXERCISE)** QUESTION 1 1.1 Doppler Effect 1.2 Car approaching $f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ $f_L = \frac{340}{340 - 16}(420)$ = 440 ,74 Hz 1.3.1 Smaller than 1.3.2 Increases	10 min 40 min	Chalkboard for notes, discussions and classwork

QUESTION 1

The siren of a police car produces a sound of frequency 420 Hz. A man sitting next to the road notices that the pitch of the sound changes as the car moves towards and then away from him.

1.1 Write down the name of the above phenomenon.

1.2 Assume that the speed of sound in air is 340 m•s^{-1}. Calculate the frequency of the sound of the siren observed by the man, when the car is moving towards him at a speed of 16 m•s^{-1}.

1.3 The police car moves away from the man at constant velocity, then slows down and finally comes to rest.

1.3.1 How will the observed frequency compare with the original frequency of the siren when the police car moves away from the man at constant velocity? Write only GREATER THAN, SMALLER THAN or EQUAL TO.

1.3.2 How will the observed frequency change as the car slows down whilst moving away? Write only INCREASES, DECREASES or REMAINS THE SAME.

QUESTION 2

The siren of a burglar alarm system has a frequency of 960 Hz. During a patrol, a security officer, travelling in his car, hears the siren of the alarm of a house and approaches the house at constant velocity. A detector in his car registers the frequency of the sound as 1000 Hz.

2.1 Name the phenomenon that explains the change in the observed frequency.

2.2 Calculate the speed at which the patrol car approaches the house. Use the speed of sound in air as 340 m•s^{-1}.

2.3 If the patrol car had approached the house at a higher speed, how would the detected frequency have compared to the first observed frequency of 1000 Hz? Write down only HIGHER THAN, LOWER THAN or EQUAL TO.

QUESTION 3

Dolphins use ultrasound to scan their environment.

When a dolphin is 100 m from a rock, it emits ultrasound waves of frequency 250 kHz whilst swimming at 20 m•s^{-1} towards the rock. Assume the speed of sound in water is 1500 m•s^{-1}.

QUESTION 2

2.1 Doppler Effect

2.2

$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$$

$$1000 = \frac{340 + v_L}{340 - 0}(960)$$

v_L = 14,17 m•s^{-1}

2.3 Higher than

QUESTION 3

3.1

$$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$$

$$f_L = \frac{1500}{1500 - 20}(250000)$$

= 253,38 x 10^3 Hz

3.2 Remains the same

The detected frequency is independent of the distance between the source and the observer.

3.1 Calculate the frequency of the sound waves detected by a detector on the rock. 3.2 When the dolphin is 50 m from the rock, another ultrasound wave of 250 kHz is emitted. How will the frequency of the detected sound waves compare with the answer calculated in QUESTION 3.1? Write down only HIGHER, LOWER or REMAINS THE SAME. QUESTION 4 An ambulance with its siren on, moves away at constant velocity from a person standing next to the road. The person measures a frequency which is 90% of the frequency of the sound emitted by the siren of the ambulance. 4.1 Name the phenomenon observed. 4.2 If the speed of sound in air is 340 m•s^{-1}, calculate the speed of the ambulance. QUESTION 5 The whistle of a train emits sound waves of frequency 2000 Hz. A stationary listener measures the frequency of these emitted sound waves as 2080 Hz. The speed of sound in air is 340 m•s^{-1}. 5.1 Name the phenomenon responsible for the observed change in frequency. 5.2 Is the train moving AWAY FROM or TOWARDS the stationary listener? 5.3 Calculate the speed of the train. 5.4 Will the frequency observed by a passenger, sitting in the train, be GREATER THAN, EQUAL TO or SMALLER THAN 2000 Hz. Explain the answer. • Educator and learners discuss the questions and answers of the Consolidation Exercise. **2.3 Conclusion** • Ask learners about the main aspects of the lesson.	QUESTION 4 4.1 Doppler Effect 4.2 $$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$$ $$90/100\, f_s = \frac{340}{340 + v_s}(f_s)$$ $\therefore v_S$ = 37,78 m•s^{-1} QUESTION 5 5.1 Doppler Effect 5.2 Towards 5.3 $$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$$ $$2080 = \frac{340}{340 - v_s}(2000)$$ $\therefore v_S$ = 13,08 m•s^{-1} 5.4 Equal The passenger moves at the same velocity as the train. / There is no difference in velocity of the passenger relative to the train.		

Reflection/note

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

GRADE	12	SUBJECT	Physical Sciences	WEEK	12	TOPIC	Doppler Effect	Lesson	4

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should know: • The meaning of "redshifts" The following results will be the outcome of this lesson: • Learners must be able to state that light from many stars is shifted towards the red, or longer wavelength/lower frequency, end of the spectrum. • Learners must be able apply the Doppler effect to these "redshifts" to conclude that most stars are moving away from Earth and therefore the universe is expanding		

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 • Spectrum of light, frequency and wavelength BASELINE ASSESSMENT • Baseline questions ▪ What is meant by "spectrum of light"? ▪ Which wavelength of light is reflected the most? ▪ Which wavelength of light is reflected the least? **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 ▪ A spectrum of light is the rainbow-like series of colours, produced by splitting light into its component colours. ▪ Violet ▪ Red • 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. How can the Doppler Effect be used to measure the motion of the Earth and a star? 2. What does it mean to say we live in an expanding universe? 3. Red shift is used as evidence of an expanding universe. How can this evidence be explained by using the spectrum lines of stars?	5 min 30 min 20 min	Chalkboard for notes, discussions and classwork

• The Doppler Effect and Light • The velocities of distant galaxies can be determined using the Doppler Effect. • Light from these galaxies has shifted towards the lower frequencies of light i.e. towards red light, because red light has the lowest frequency of all the colours of the spectrum making up white light. • This shift is called the redshift and indicates that the galaxies are moving away from us. • The greater the frequency shift, the greater the velocity with which the galaxy is moving away from us. • The further the galaxy is, the faster it is moving. • This has led to the conclusion that the universe is expanding and that at one time the universe must have been highly concentrated and then it exploded outwards. • This is called big bang. • If the star is moving towards us, then the absorption lines are shifted to higher frequencies towards the blue end of the spectrum, and we say the absorption lines are blue shifted. • If we compare the absorption spectrum of the star to the spectrum of our Sun, we can observe the shift in the frequencies of the absorption lines. • By examining the spectrum of a star we can determine whether it is moving away from or towards our solar system. • Astronomers study absorption spectra that come from stars in the galaxy, and they have recording these for many years. • In the late 1800s and early 1900s, astronomers noticed that the absorption spectra that were being recorded for many years are redshifted to lower frequencies. • This has led astronomers to conclude that the universe is expanding. **2.3 Conclusion** • Ask learners about the main aspects of the lesson. • Give learners classwork	4. A small number of galaxies have been found to be moving towards the Earth. If you were able to analyse light waves from these galaxies, what would you expect to find? Why? 5. What additional evidence is there to support the Big Bang theory? 6. How does this theory explain the evolution of the universe up to the present time? 7. One possible future of the universe is the Big Crunch. What has to happen to cause this? SOLUTIONS 1. The lines in the spectrum of a luminous body such as a star are similarly shifted towards the violet if the distance between the star and the Earth is decreasing and towards the red if the distance is increasing. By measuring the shift the relative motion of the Earth and the star can be calculated.		

	2. The spectrum observed was shifted to the red. That means all stars or galaxies are moving away from earth making the Universe bigger. 3. The absorption spectrum that is observed is red shifted. This red shifting is because of the Doppler Effect. The red indicates lower frequencies which mean these galaxies are moving away from the earth. 4. The absorption lines of these galaxies are blue shifted. The frequencies are higher. They are moving towards the earth. 5. The fact that the universe is expanding. 6. As it is expanding from nothing to something. 7. The universe will then have to contract again.		

Reflection/note

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

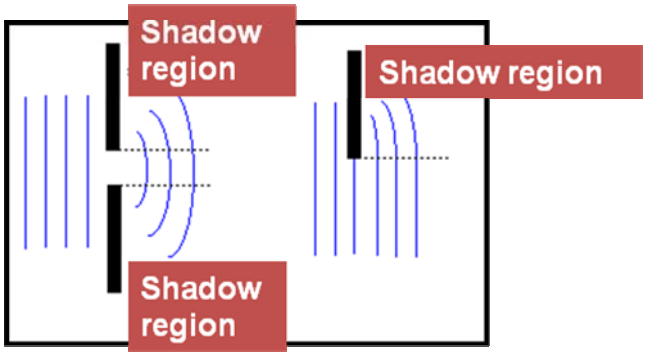
GRADE	12	SUBJECT	Physical Sciences	WEEK	13	TOPIC	2D and 3D wave fronts	Lesson	1

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should know: • The meaning of diffraction. The following results will be the outcome of this lesson: • Learners must be able to define a wavefront as an imaginary line that connects waves that are in phase. • Learners must be able to define diffraction as the ability of a wave to spread out in wavefronts as they pass through a small aperture or around a sharp edge. • Learners must be able to state Huygen's Principle.		

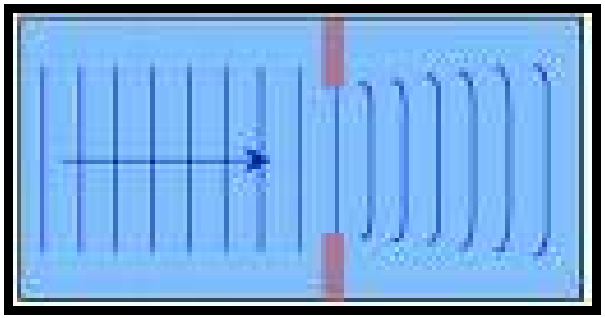
TEACHER ACTIVITIES	LEARNER ACTIVITIES	TIMING	RESOURCES NEEDED
1. TEACHING METHODS USED IN THIS LESSON Question and answer, Explanation **2. LESSON DEVELOPMENT:** **2.1 Introduction** • Introduce the lesson with the baseline questions Pre-knowledge • Frequency, waves, period, wavelength **BASELINE ASSESSMENT** • Baseline questions ▪ What is meant by the term frequency? ▪ Define period. ▪ Define wavelength. **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 ▪ Frequency: number of cycles or complete waves formed in one second. ▪ Period: time it takes for one complete wave to form. ▪ Wavelength: distance between any two consecutive points 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. One word/term a) The phenomenon observed when a wave bends around the edges of an obstacle. b) The imaginary line joining points in phase on a wave. c) The principle which states that each point on a wave front acts as a source of secondary wavelets. 2. Define diffraction. 3. State Huygen's principle.	5 min 30 min 15 min	Chalkboard for notes, discussions and classwork

Diffraction patterns

- Diffraction is the bending of the waves that pass the edge of an obstacle or the bending of waves as they go through a gap.
- This phenomenon is only found in waves and therefore any phenomenon that shows diffraction is a wave.



- The wavelength and size of the gap influences the amount of diffraction.
- The smaller the width of the gap, the greater the diffraction i.e.
- Diffraction patterns



4. Which situation will show greater diffraction and why?

a) A wavelength of 3 cm or a wave of wavelength going through the same narrow gap or

b) The same wave passing through a gap of 5 cm or 7 cm.

SOLUTIONS

1.

a) Diffraction

b) Wavefront

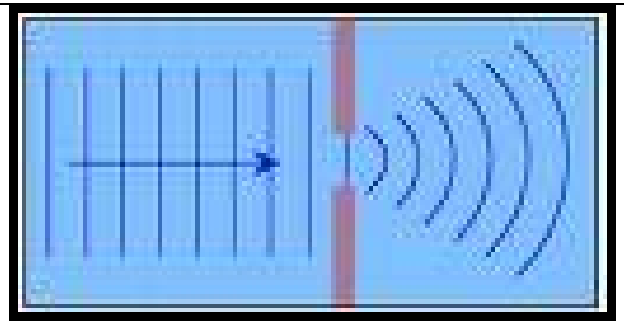
c) Huygen's Principle

1. Diffraction is the bending of the waves that pass the edge of an obstacle or the bending of waves as they go through a gap.

2. Huygen's principle states that every point on a wavefront is a source of a small wavelet that spreads out and sends out a secondary circular wavelet.

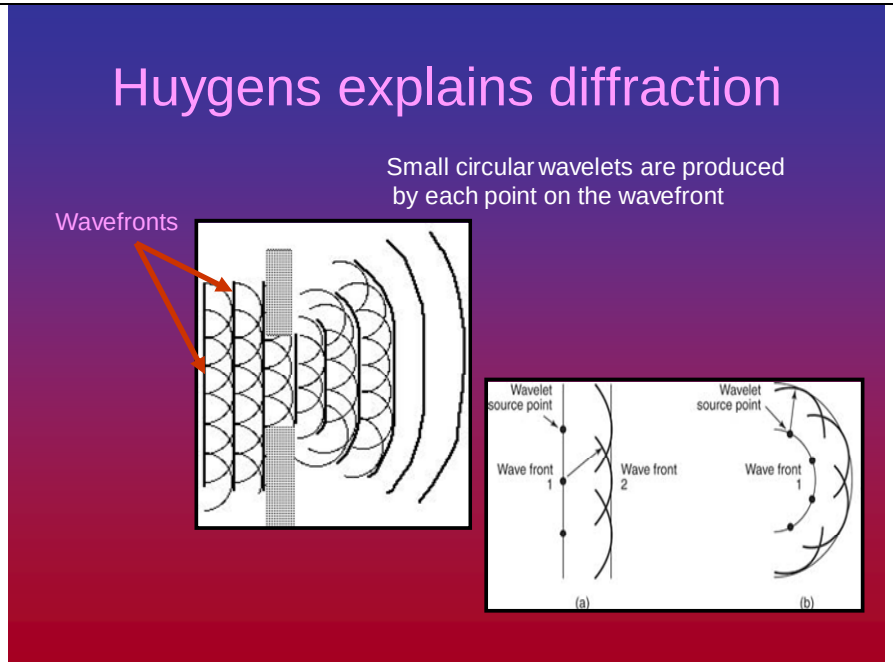
3.

a) The wave of wavelength 5 cm will show greater diffraction as it has a longer wavelength. The longer the wavelength, the greater the diffraction.

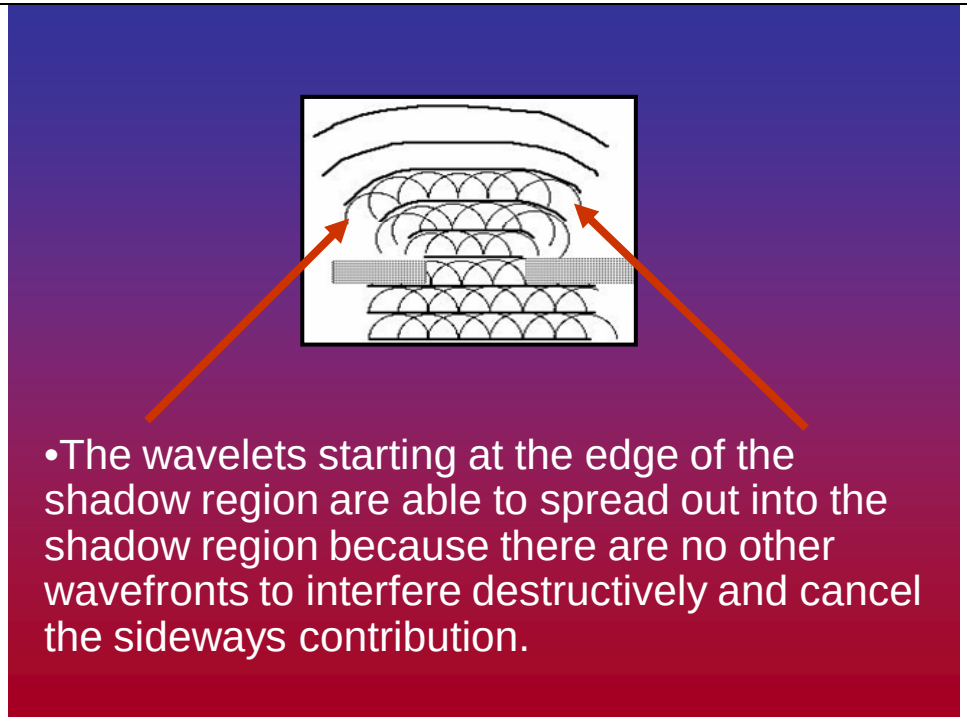


- The wavelength and size of the gap influences the amount of diffraction.
- The smaller the width of the gap, the greater the diffraction i.e. **diffraction is inversely proportional to the width**.
- The longer the wavelength of the wave, the greater the amount of diffraction i.e. diffraction is directly proportional to wavelength.
- The maximum amount of diffraction occurs when circular waves are produced after the waves pass through the gap and the wavelength is equal to the width of the gap.
- The speed of the waves, however, does not change when the wave diffracts.
- To explain why diffraction takes place, Huygen's Principle is used.
- It states that every point on a wave front is a source of a small wavelet that spreads out and sends out a secondary circular wavelet.

b) The smaller gap, 5 cm, will show greater diffraction. The smaller the gap, the greater the diffraction.



- The small wavefronts that spread out from each point on a wave front form a new wave front on the envelope of these secondary wave fronts.
- When straight wavefronts pass the edge of a boundary they continue in the forward direction.



2.3 Conclusion

- Ask learners about the main aspects of the lesson.
- Give learners classwork.

Reflection/note

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

GRADE	12	SUBJECT	Physical Sciences	WEEK	13	TOPIC	2D and 3D wave fronts	Lesson	2

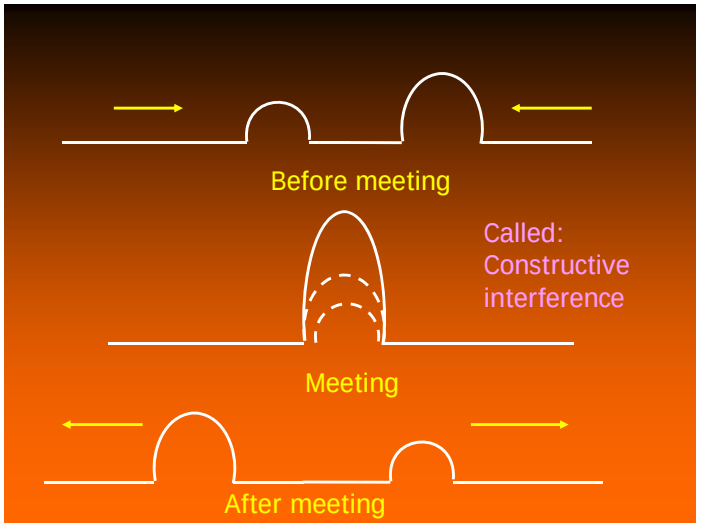
LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should know: • The meaning of interference The following results will be the outcome of this lesson: • Learners must be able to define interference as when two waves pass through the same region of space at the same time, resulting in superposition of waves. • Learners must be able to explain the concepts of constructive and destructive interference. • Learners must be able to predict areas of constructive and destructive interference from a diagram source material. • Learners must be able to investigate the interference of waves on the surface of water from two coherent sources, vibrating in phase. • Learners must be able to draw an interference pattern marking nodal lines and noting positions of maximum interference.		

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 • Interference, amplitude, wavelength, points in phase, standing waves **BASELINE ASSESSMENT** • Baseline questions ▪ Define the following terms: o Points in phase o Wavelength o Amplitude o Transverse wave o Constructive interference o Destructive interference **2.2 Main Body (Lesson presentation)** • Lesson starts with the educator asking the learners the baseline questions.	1. Learners answer the baseline questions. 2. Learners take notes from the board. 3. Learners write the classwork. **CLASSWORK** 1. Define the term interference. 2. State the principle of superposition. 3. What happens when a) a crest meets a crest b) a crest meets a trough c) a trough meets a trough 4. Define the following terms: a) Nodal lines b) Antinodal lines	10 min 30 min 10 min	Chalkboard for notes, discussions and classwork

- Educator and learners discuss the following answers of the baseline assessment
- Points in phase: the particles of the medium through which the waves move are in phase when they move simultaneously in the same direction and with the same speed.
- Wavelength: distance between any two consecutive points in phase.
- Amplitude: maximum displacements of the particles from the rest position.
- Transverse wave: a transverse wave is formed when the particles of the medium move perpendicular to the direction of propagation of the wave.
- Constructive interference: when a crest meets a crest or trough meets trough in the same medium, their amplitudes are added together to form a bigger crest or trough.
- Destructive interference: when a crest meets a trough, their amplitudes are subtracted.
- Educator explain and discuss with learners the following

Interference and superposition

- Interference occurs when pulses or waves cross each in the same space.
- The displacements of the waves combine to form a new shape.



- The **Principle of Superposition** is used to determine the size of the displacement.
- It states that when wave pulses cross, the combined displacement is equal to the algebraic sum of their displacements.

5. S_1 and S_2 are two coherent point sources which are used to generate wavefronts to produce an interference pattern.

a) What is meant by coherent sources?

b) If the distance between S_1 and S_2 is decreased, what is the effect on the nodal lines?

SOLUTION

1. Interference occurs when pulses or waves cross each other in the same space.
2. Principle of superposition: when wave pulses cross, the combined displacement is equal to the algebraic sum of their displacements.
3.

a) Constructive interference

b) Destructive interference

c) Constructive interference

4.

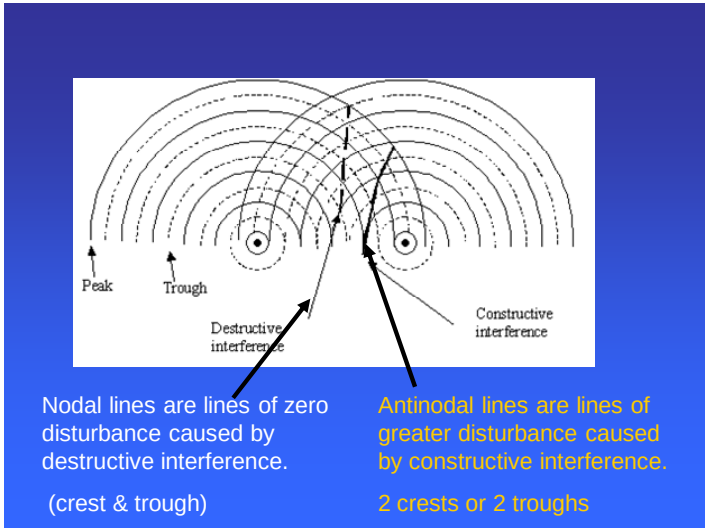
a) Nodal lines are lines of zero disturbances caused by destructive interference.

b) Antinodal lines are lines of maximum disturbance caused by constructive interference.

- Standing waves are an example of interference.
- **Nodes** in a standing wave are points of **destructive interference** i.e. points of zero displacement.
- **Antinode**s are points of **constructive interference** i.e. points of maximum displacement.
- All of the above illustrate interference in one dimension.

Interference in two dimensions

- Interference in 2D is best illustrated using water waves.
- When two circular waves are set up and these cross each other, interference takes place.
- Patterns consisting of paths of zero disturbances, called nodal lines, are seen interspersed with paths of maximum disturbance.



-

2.3 Conclusion

- Ask learners about the main aspects of the lesson.
- Give learners classwork.

5.

a) Coherent sources are sources that are in phase (same frequency)

b) The nodal lines in the pattern decrease.

Reflection/note

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

GRADE	12	SUBJECT	Physical Sciences	WEEK	13	TOPIC	2D and 3D wave fronts	Lesson	3

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	

LESSON OBJECTIVES

At the end of this lesson learners should know:

- The diffraction patterns

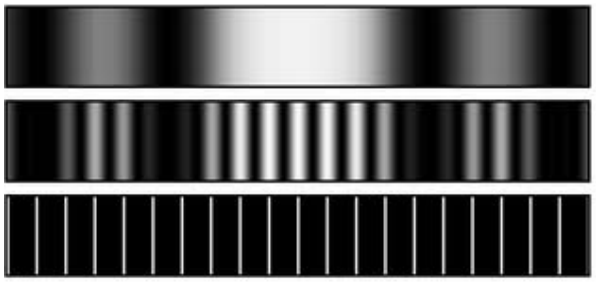
The following results will be the outcome of this lesson:

- Learners must be able to sketch the diffraction pattern for a single slit.
- Learners must be able to use $\sin\theta = \frac{m\lambda}{a}$

for a slit of width **a** to calculate the position(angle from the horizontal) of the dark bands in a single slit diffraction pattern.

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 • Diffraction, interference **BASELINE ASSESSMENT** • Baseline questions ▪ Define diffraction ▪ Define constructive interference ▪ Define destructive interference **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 ▪ Diffraction is the bending of waves around the edges of an obstacle or opening. ▪ Constructive interference occurs when two pulses or waves meet crest to crest or trough to trough.	1. Learners answer the baseline questions. 2. Learners take notes from the board. 3. Learners write the classwork. **CLASSWORK** 1. Red light is shone through a single slit onto a screen forming a diffraction pattern. Blue light is then shone through the same slit. Compare the angle of the first dark band in the red diffraction pattern compared to the position in the blue diffraction pattern. The wavelength of the red light is 700 nm, while that of the blue light is 450 nm. The width of the slit is 8 x 10^{-6}.	10 min 30 min 15 min	Chalkboard for notes, discussions and classwork

- Destructive interference occurs when two pulses or waves meet peak to trough.
- Educator explain and discuss with learners the following
- Diffraction of Light and Sound
- Sound waves are longer than light waves and therefore diffract more and are able to go around corners.
- Example: sound can be heard around corners.
- Light waves are short and do not refract much.
- That is why we are unable to see around corners.
- Nevertheless, if the gap is small enough, light does diffract.
- For example: if one looks at a light bulb through a stretched piece of cloth, the light source looks bigger than when you look at it without the cloth.
- Single slit diffraction of light
- When light passes through a single narrow slit, the pattern similar to the one shown below is seen



- When monochromatic light is used, a broad, glowing, central light band is seen flanked by darker lines.
- If a narrower slit is used, the central band is narrower, as a great amount of diffraction is produced.
- When the light is passed through the single slit, diffraction takes place at the edges of the slit and according to Huygen's Principle the edges of the slit act as point sources sending out circular waves which interfere with each other.

2. Find the position of the first dark band (first minimum) formed on the screen when blue light of wavelength 460 nm and is passed through a slit with a width of 6 μm.
3. Determine the position of the first dark band formed on the screen, when red light of 690 nm is used instead of blue light.
4. How can you distinguish between a single-slit diffraction pattern and a double slit interference pattern?
5. Monochromatic light with a wavelength of 520 nm falls perpendicular onto a single slit, of width 0,5 mm. A diffraction pattern is seen on the screen.

SOLUTIONS

1.

Red: $\sin\theta = (m\lambda)/a$

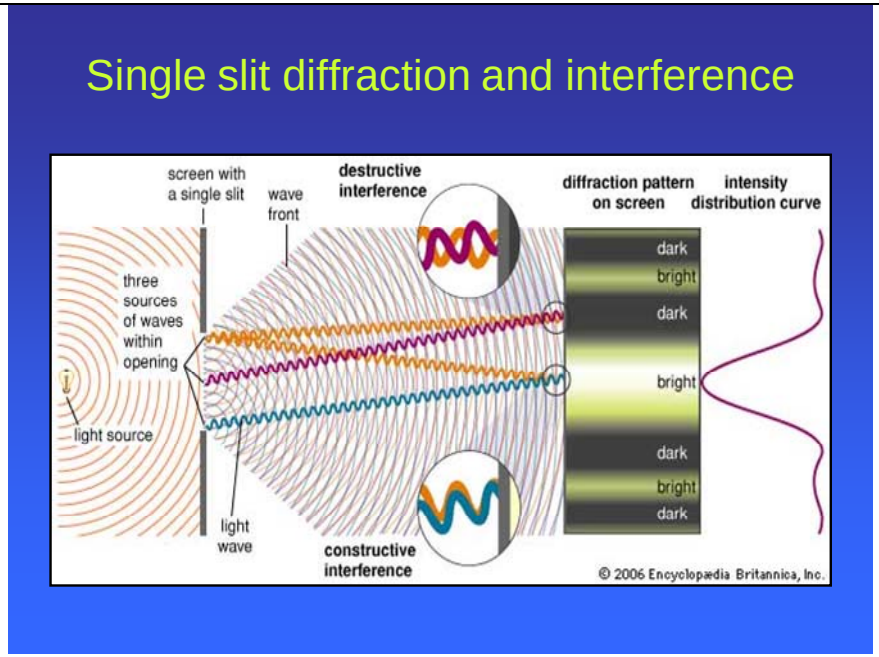
$= \frac{(1)(700 \times 10^{-9})}{8 \times 10^{-9}}$

$\therefore \theta = 5^0$

Blue: $\sin\theta = (m\lambda)/a$

$= \frac{(1)(450 \times 10^{-9})}{8 \times 10^{-6}}$

$\therefore \theta = 3{,}2^0$



- Slit diffraction pattern can be calculated by using the equation

$$\sin\theta = \frac{m\lambda}{a}$$

where a: width of the slit

λ: wavelength of the light
m: the number of dark bands from the centre.

2.3 Conclusion

- Ask learners about the main aspects of the lesson.
- Give learners classwork.

2. $\sin\theta = (m\lambda)/a$

$\sin\theta = \frac{(1)(460 \times 10^{-9})}{6 \times 10^{-6}}$

$\therefore\theta = 4{,}39^{0}$

3. $\sin\theta = (m\lambda)/a$

$\sin\theta = \frac{(1)(690 \times 10^{-9})}{6 \times 10^{-6}}$

$\therefore\theta = 6{,}6^{0}$

4. Single- slit diffraction: one broad central band with bands next to it getting narrower and getting fainter.

   Double –slit diffraction: the bands are all the same thickness and the same brightness.

5. $\sin\theta = (m\lambda)/a$

$\sin\theta = \frac{(3)(520 \times 10^{-9})}{0{,}5 \times 10^{-3}}$

$\therefore\theta = 0{,}179^{0}$

Reflection/note

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

GRADE	12	SUBJECT	Physical Sciences	WEEK	13	TOPIC	2D and 3D wave fronts	Lesson	4

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should know: • The meaning of diffraction and interference. The following results will be the outcome of this lesson: • Learners must be able to apply knowledge on 2D and 3D wave fronts.		

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 • Diffraction, interference **BASELINE ASSESSMENT** • Baseline questions ▪ Define interference. ▪ State Huygen's Principle. **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 ▪ Diffraction is the bending of the waves that pass the edge of an obstacle or the bending of waves as they go through a gap. ▪ Huygen's principle states that every point on a wave front is a source of a small wavelet that spreads out and sends out a secondary circular wavelet. • Educator give learners the following Consolidation Exercise on 2D and 3D wave fronts • Consolidation Exercise **QUESTION 1** Huygen's principle is used to explain the wave phenomena, interference and diffraction.	1. Learners answer the baseline questions. 2. Learners write the consolidation exercise. 3. Learners and educator discuss the consolidation exercise. **SOLUTIONS(CONSOLIDATION EXERCISE)** **QUESTION 1** 1.1 Each point on the wavefront acts a source of spherical secondary waves or wavelets travelling away from source. 1.2 Each point on the initial plane wavefront entering the slit acts as a source of secondary wavelets. The wavelets propagate in all directions beyond the slit causing the wave to spread into regions beyond those in line with the slit.	5 min 30 min 15 min	Chalkboard for notes, discussions and classwork

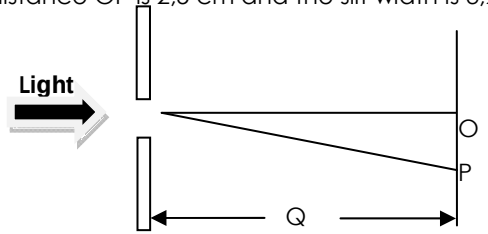
1.1 State Huygen's principle.

1.2 Use Huygen's principle to explain the diffraction of water waves in a ripple tank as they pass through a narrow opening in a barrier.

1.3 A single slit of unknown width is illuminated with red light of wavelength 650 nm. Calculate the width of the slit for which the first dark band will appear at 15^0.

QUESTION 2

Light of a single frequency pass through a single slit. The first minimum is observed at point P on a screen, as shown in the diagram below. Point O is the midpoint of the central bright band. The distance OP is 2,5 cm and the slit width is 3,2 x 10-5 m.



2.1. What can be deduced about the nature of light from this observation?

2.2. Explain how the minimum is formed at point P.

2.3. If the wavelength of the incident light is 600 nm, calculate the distance Q between the screen and the slit.

2.4. The original slit is now replaced by a second slit of different width, while the distance Q and the wavelength of the incident light remain the same. Distance OP changes to 4 cm.

2.4.1. How does the slit width of the second slit compare to that of the first slit? Only write down GREATER THAN, SMALLER THAN or EQUAL TO.

2.4.2. Explain your answer to QUESTION 2.4.1 without performing a calculation.

QUESTION 3

Learners perform an experiment with monochromatic light. They pass the light through a single slit. The distance between the screen and the slit is kept constant. The diagram below represents the pattern observed during the experiment

1.3

$$\sin\theta = \frac{m\lambda}{a}$$

$\sin 15^0 = (1)(650 \times 10^{-9})/a$

$\therefore a = 2,7 \times 10^{-6}$ m

QUESTION 2

2.1 Wave nature

2.2 Wavefronts from the slit arrive at point P out of phase and interfere destructively.

2.3

$$\sin\theta = \frac{m\lambda}{a}$$

$\sin \theta = (1)(600 \times 10\text{-}9)/3,2 \times 10\text{-}5$

$\theta = 1,07^0$

$\text{Tan } 1,07 = (2,5 \times 10\text{-}2)/Q$

$\therefore Q = 1,34$ m

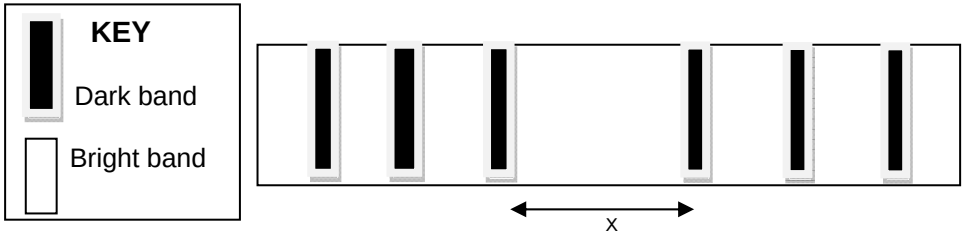
2.4.1 Smaller than

2.4.2If OP increases:

$\sin\theta$ = increases because $\sin\theta$ is inversely proportional to a.

QUESTION 3

3.1 The ability of a wave to bend/spread out as they pass through a small aperture/around a sharp edge.



The slit has a width of 0,02 mm and the SECOND dark band is formed on the screen at an angle of 3^0 from the centre of the slit.

3.1 Define the term diffraction.

3.2 Calculate the wavelength of this light.

3.3 The light is either green or red. Given that yellow light has a wavelength of 577 nm, which colour is used. Give a reason for your answer.

3.4 Using the same light as in QUESTION 3.2, write down TWO experimental changes that can be made to decrease the distance x in the diagram above.

3.5 Describe the pattern that will be observed if the single slit is now replaced with a double slit.

- Educator and learner discuss the solutions of the consolidation exercise.

2.3 Conclusion

- Ask learners about the main aspects of the lesson.
- Give learners classwork.

3.2 $\sin\theta = (m\lambda)/a$

$\sin 3^0 = (2)\lambda/0{,}02 \times 10^{-3}$

$\therefore \lambda = 5{,}23 \times 10^{-7}$ m

3.3 Green. It has a shorter wavelength than yellow light.

3.4 Increase the slit width.
Decrease the distance between the screen and the slit.

3.5 A central band of alternate bright and dark bands of equal width.

Reflection/note

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

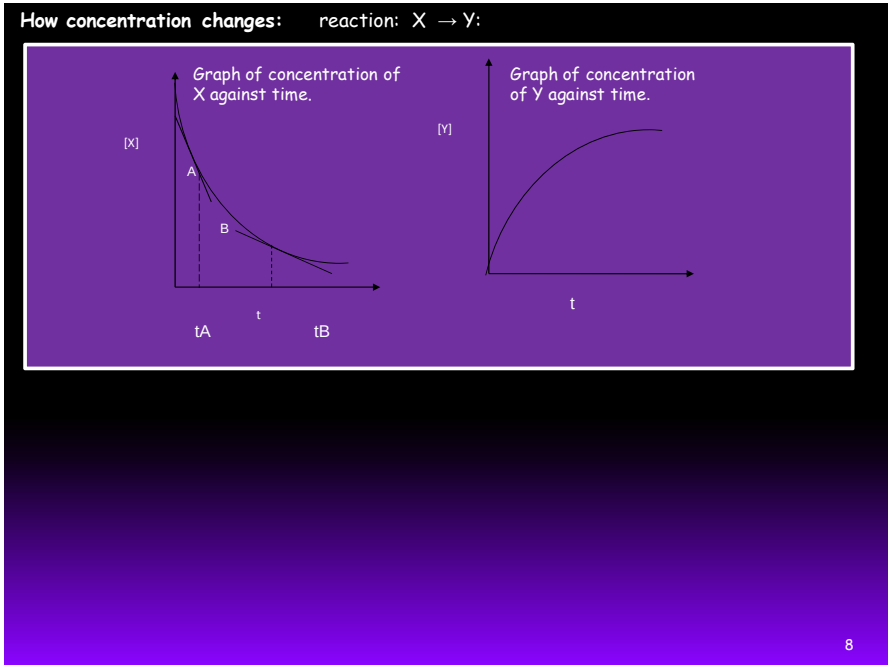
GRADE	12	SUBJECT	Physical Sciences	WEEK	15	TOPIC	Rates and Extent of Reactions	Lesson	1

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should know: • The ways of measuring rates of reaction. The following results will be the outcome of this lesson: • Learners must be able to suggest suitable experimental techniques for measuring the rate of a given reaction including the measuring of gas volumes, turbidity, change of colour and the change of the mass of the reaction vessel.		

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 • Understanding of the parts of chemical equation, the writing and balancing of chemical equations. **BASELINE ASSESSMENT** • Baseline questions ▪ Consider the hypothetical reaction: $A_{(s)} + B_{(l)} \rightarrow C_{(g)} + D_{(aq)}$ explain what all the different parts of a chemical as shown. **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 ▪ A and B: reactants ▪ C and D: products ▪ →: direction of reaction ▪ s, l, g, and aq: indicates the phase of the reactants and products • 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. 4. Learners and educator discuss the solutions to the classwork **CLASSWORK** 1. Explain what is meant by the term "rate of reaction" and how it can be measured. 2. State in each of the following reactions what change can serve as indicator of reaction rate: a) Which one boils faster, tap water or salt water? b) Different concentration of silver solutions used to electroplate a nickel bar.	5 min 25 min 15 min 15 min	Chalkboard for notes, discussions and classwork

Reaction rates

- Reaction rate: indication of the chemical change that takes place in a certain time.
- In the reaction
- $Zn_{(s)} + H_2SO_{4\,(aq)} \rightarrow ZnSO_{4\,(aq)} + H_{2\,(g)}$
- Rate of reaction can be expressed as
  - Amount of zinc used per minute (mass)
  - Amount of sulphuric acid per minute (mol)
  - Amount of zinc sulphate produced per minute (mol)
  - Volume of hydrogen produced per minute measured as reaction rate- change in the concentration of the reactants or the products in a certain time interval.
- Reaction rate = Δ[products]/Δt or Reaction rate = Δ[reactants]/Δt
- The rate of reaction is the rate at which the [reactants] or the [products] changes



c) The reaction of iron nails with tap water and saltwater.

d) Compare the reactivity of various metals with hydrochloric acid.

3. Copper shavings react with concentrated nitric acid in an exothermic reaction. Some of the products that develop, are $NO_{2(g)}$, a brown gas, and copper(II) nitrate, which is a blue solution. Name four different factors that can be used as measure of reaction rate.

SOLUTION

1. The rate of reaction is the speed of the reaction and it can be measured as follows: the amount of reactant used up per unit time or the amount of products formed per unit time.

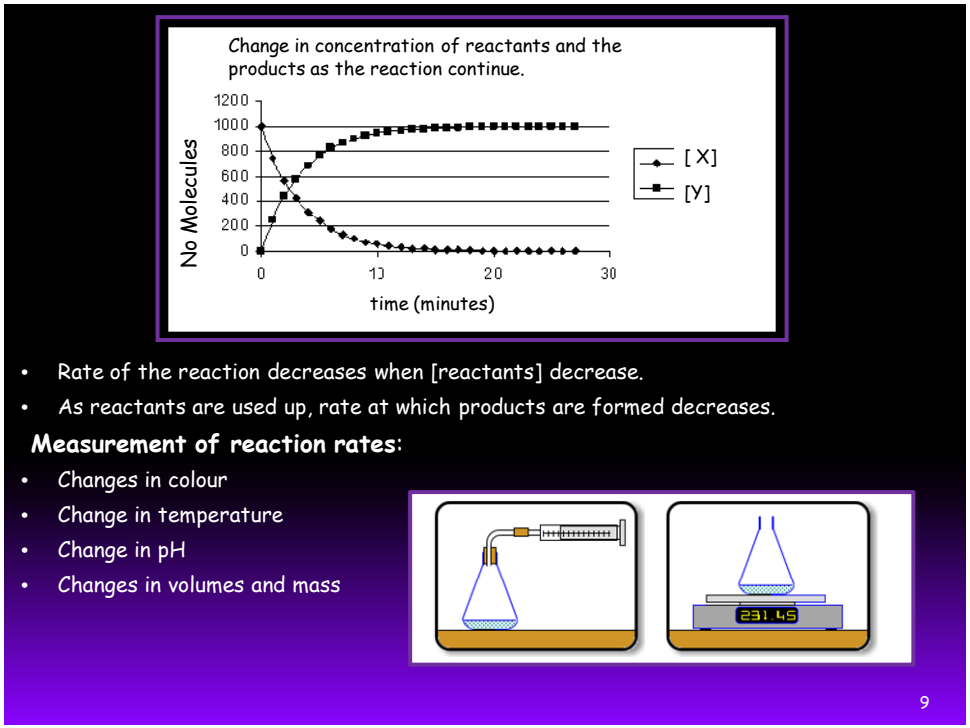
2.

a) Rate is measured as the time it takes until large bubbles are formed.

b) Rate measured as the time it takes for the object to be covered in zinc.

The curve shows:

- Reaction rate is not constant
- Rate decreases with time
- Rate of reaction = the tangent at a specific time
- Rate of reaction at A is faster than at B



2.3 Conclusion

- Ask learners about the main aspects of the lesson.
- Give learners classwork.
- Educator and learners discuss the solutions of the classwork.

c) The time it takes for the object to rust.

d) Compare the rate at which hydrogen gas is formed.

3.

a) Rate at which the brown gas is formed measured with a gas syringe which has been sealed.

b) Rate at which the mass decreases.

c) The rate at which copper is being used up.

d) Change in colour

e) Temperature increase

Reflection/note

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

GRADE	12	SUBJECT	Physical Sciences	WEEK	15	TOPIC	Rates and Extent of Reactions	Lesson	2

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should know: • The meaning of rates of reaction and factors affecting rate. The following results will be the outcome of this lesson: • Learners must be able to explain what is meant by reaction rate. • Learners must be able to list the factors which affect the rate of chemical reactions. • Learners must be able to explain in terms of the collision theory how the various factors affect the rate of chemical reactions.		

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 • Kinetic Molecular Theory **BASELINE ASSESSMENT** • Baseline questions ▪ Define the rate of reaction. **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 ▪ The reaction rate is how fast/slow a reactions is. • Educator explain and discuss with learners the following: **Factors affecting reaction rates** • There are two catergories of reactions ▪ Homogenous where reactants and products are in the same phase ▪ Heterogeneous where reactants and products are in different phases. • In the case of homogenous reactions there are four factors that affect the reaction rate	1. Learners answer the baseline questions. 2. Learners take notes from the board. 3. Learners write the classwork. **CLASSWORK** 1. The collision theory explains why chemical reactions occur and why they take place at different rates. Give one term for each of the following descriptions. 1.1 A chemical substance that speeds the rate of a chemical reaction. 1.2 A collision in which the reacting particles have sufficient kinetic energy and the correct orientation.	5 min 30 min 15 min	Chalkboard for notes, discussions and classwork

1. the nature of reactants 2. concentration 3. the temperature and 4. the presence of a catalyst • In the case of heterogeneous reactions, there is a fifth factor, the surface area (state of division) affects the reaction rate. **The Collision Theory** • For a chemical reaction to take place, atoms or molecules must get so close together that their outer electrons energy levels overlap. • Particles have to collide (come into contact with each other) • Collisions must be effective ▪ Particles must have enough kinetic energy to meet activation energy. ▪ Particles must have correct orientation. **The Collision Theory and Factors affecting the rate of reaction** **State of division or surface area** • Breaking a solid into smaller pieces allow for more vigorously mixing of particles and more freedom of movement • The greater the exposed surface area, the faster the reaction rate. • This is because the number of collision increases and therefore more effective collisions **The concentration of the reactants** • A higher concentration means a greater number of particles in a given volume. • If there are more particles, there will be more collisions and therefore more effective collisions. • Hence the rate of reaction increases. **The temperature of the reactants** • The temperature of a system is a measure of the average kinetic energy of the particles in that solution (B1 only in gases. • If the average kinetic energy is increased by increasing the temperature, more particles will have enough kinetic energy between themselves to collide successfully and react.	1.3 The factor responsible for increasing the rate of reaction when a solid is broken into smaller pieces. 1.4 A measure of the average kinetic energy of the particles in a gas. 2. The rate at which 50 mm piece of clean magnesium ribbon reacts with 20 cm^3 hydrochloric acid (concentration of 1$mol \bullet dm^{-3}$) is determined by measuring the volume of hydrogen gas released during the reaction $Mg(s) + 2\ HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$ State how the rate of this reaction will be influenced if the experiment is repeated three times altering only ONE factor at a time as follows. (Simply state INCREASE, DECREASE, or REMAIN THE SAME) 2.1 The 50 mm piece of magnesium is filed to a powder. 2.2 20 cm^3 of HCl of a 2$mol \bullet dm^{-3}$ concentration is used. 2.3 The mixture is cooled.		

• The rate of both exothermic and endothermic reactions will increase with an increase in temperature. **The presence of a catalyst** • A catalyst lowers the amount of energy needed for a successful collision. • In the presence of a catalyst more collisions are successful and the rate of both the endothermic and exothermic reactions increases. • A catalyst lowers the activation energy and therefore more particles with sufficient energy to break bonds, are available. **2.3 Conclusion** • Ask learners about the main aspects of the lesson. • Give learners classwork.	3. An iron nail will displace copper metal from a solution of copper sulphate. Give three ways in which the rate of this reaction can be increased. **SOLUTIONS** **1.** **1.1 catalyst** **1.2 effective collision** **1.3 surface area** **1.4 temperature** **2.** **2.1 increase** **2.2 decrease** **2.3 decrease** **3.** **a) Use iron powder instead of the nails.** **b) Heat the reaction mixture.** c) **Increase the concentration of the $CuSO_4$ solution.**		

Reflection/note

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

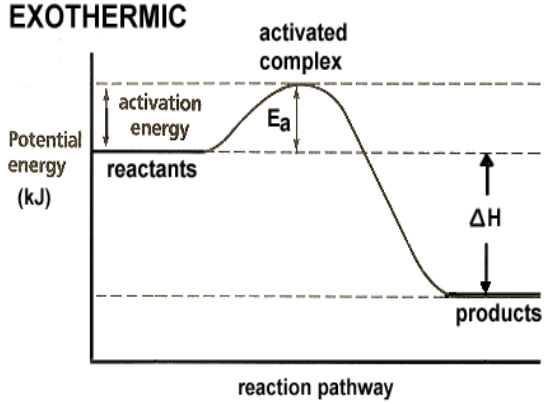
GRADE	12	SUBJECT	Physical Sciences	WEEK	15	TOPIC	Rates and Extent of Reactions	Lesson	3

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should know: • The mechanism of reaction and of catalysis. The following results will be the outcome of this lesson: • Learners must be able to define activation energy. • Learners must be able to use graph showing the distribution of molecular energies to explain why only some molecules have enough energy to react and hence how adding a catalyst and heating the reactants affects the rate. • Learners must be able to interpret the Maxwell Boltzmann curve.		

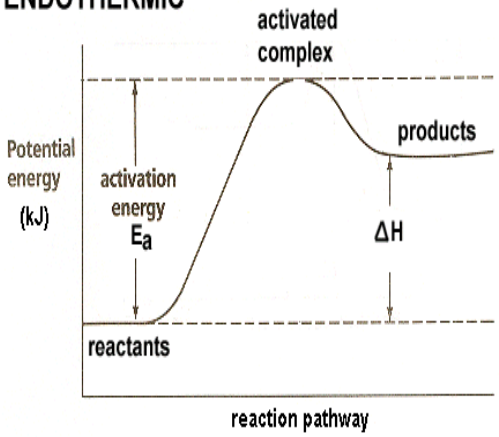
TEACHER ACTIVITIES	LEARNER ACTIVITIES	TIMING	RESOURCES NEEDED
1. TEACHING METHODS USED IN THIS LESSON Question and answer, Explanation **2. LESSON DEVELOPMENT:** **2.1 Introduction** • Introduce the lesson with the baseline questions Pre-knowledge • Exothermic and endothermic reaction, Activated complex, Concentration. **BASELINE ASSESSMENT** • Baseline questions ▪ Define exothermic reaction. ▪ Define endothermic reaction. ▪ Define activated complex. ▪ Define concentration. ▪ What is meant by ΔH and why is ΔH negative for an exothermic reaction and positive for an endothermic reaction? **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	1. Learners answer the baseline questions. 2. Learners take notes from the board. 3. Learners write the classwork. **CLASSWORK** 1. In endothermic reactions the reactants A. have more energy than the products B. have less energy than the products. C. have the same energy as the products. D. are at a lower temperature than the products 2. In an exothermic reaction A. ΔH is positive B. the activation energy is always	10 min 30 min 10 min	Chalkboard for notes, discussions and classwork

▪ Exothermic reaction: a reaction in which more energy is released than what is absorbed or in which there is a net release of energy. ▪ Endothermic reaction: a reaction in which more energy is absorbed than what is released or in which there is a net absorption of energy. ▪ Activated complex: is the energy required to initiate a chemical reaction. ▪ Concentration: is the amount of solute per unit volume of solution. ▪ ΔH: is the net amount of energy absorbed or released during a chemical reaction. It is negative for an exothermic because the energy of the products is less than the energy of the reactants. It is positive because the energy of the products is greater than the energy of the reactants. • Educator explain and discuss with learners the following: **Mechanism of reaction and catalysis** • The steps that atoms go through as their arrangement changes from reactants to products are known as the MECHANISM of the reaction. • On the microscopic level a number of steps are essential before a reaction will occur. • The model used to explain the reaction mechanism is the collision theory. • **The collision theory** ▪ Reacting atoms, molecules or ions must collide with each other. ▪ The particles must have sufficient energy and must be oriented correctly. ▪ Bonds in the original molecules must break and new bonds must form. ▪ Electrons must be re-arranged in order to form new bonds. **The activated complex** • All reactions need energy to start. The reacting atoms must pass over an "energy hill" to change from reactants to products. • The transition state that atoms must pass through is called the ACTIVATED COMPLEX. • The activated complex is an unstable structure where bonds are forming and breaking at the same time. • Energy diagrams showing the changes in the potential energy of the reacting substances during the reaction.	more than the heat of reaction C. there is a decrease in internal energy D. there is no energy change 3. A catalyst is a substance which is added to a reaction mixture to increase the reaction rate. A further characteristic of such a catalyst, is that it A. affects only endothermic reactions B. does not undergo any permanent change C. increases the reaction rate of redox reactions only D. increases the reaction rate of acid-base reactions only. 4. Use your knowledge of the collision theory to explain why chemical reactions need activation energy? 5. Explain how the activation energy influences the overall reaction rate. 6. "Catalysts lower the activation energy" Rewrite this statement to be scientifically correct. 7. How does a negative catalyst influence reaction rate. **SOLUTIONS**		

EXOTHERMIC



ENDOTHERMIC



- In an exothermic reaction the energy of products is less than the energy of the reactants
- In an endothermic reaction the energy of products is greater than the energy of the reactants.
- Activation energy (E_a): the difference in energy between the reactants and the activated complex. Unit is $kJ \bullet mol^{-1}$
- Activation energy is also referred to as the minimum amount of energy required for a molecule to react.

1. **B**
2. **C**
3. **B**
4. **Existing bonds must be broken to enable the particles to collide with the particles of the other reactants. Energy is needed to break existing bonds between atoms.**
5. **Reactions with lower activation energy occur faster than reactions with higher activation energy.**
6. **Catalysts provide alternative routes that require less energy.**
7. **Negative catalysts reduce reaction rate.**

• Heat of reaction (ΔH): the difference in energy between reactants and products. Unit: kJ•mol^{-1}. • ΔH > 0 for an endothermic reaction • ΔH < 0 for an exothermic reaction. **The mechanism of a catalyst** • The function of a catalyst is to provide an alternate route for the reaction to take place. • This route has lower activation energy and the rate of reaction increases. • A catalyst forms part of the activated complex and when this decomposes the catalyst is released unchanged. • Two kinds of catalysis ▪ Homogenous: the catalyst is the same phase as the reactants. ▪ Heterogeneous: the catalyst in different phase as the reactants. • Catalysts cannot cause a reaction to occur; they can only affect the rate of the reaction. **2.3 Conclusion** • Ask learners about the main aspects of the lesson. • Give learners classwork.			

Reflection/note

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

GRADE	12	SUBJECT	Physical Sciences	WEEK	15	TOPIC	Rates and Extent of Reactions	Lesson	4

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should know: • The factors affecting the rates of reactions. The following results will be the outcome of this lesson: • Learners must be able to compare results. • Learners must be able to draw conclusions. • Learners must be able to apply knowledge.		

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 • Factors affecting reaction rates, Collision theory **BASELINE ASSESSMENT** • Baseline questions ▪ List the factors affecting the reaction rate **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: ▪ The nature of reactants ▪ Concentration ▪ The temperature ▪ The presence of a catalyst ▪ Surface area or state of division • Educator gives learners the consolidation exercise.	1. Learners answer the baseline questions. 2. Learners write the consolidation exercise. 3. Learners and educator discuss the solutions of the consolidation exercise. **SOLUTIONS** **QUESTION 1** 1.1 Neutralisation reaction 1.2.1 What is the relationship between temperature and the reaction rate of an antacid tablet with water? 1.2.2 The reaction rate will increase with increase in temperature.	5 min 35 min 20 min	Chalkboard for notes, discussions and classwork

QUESTION 1

Antacids are used to relieve indigestion. Indigestion is the condition when the stomach produces too much acid resulting in an uncomfortable and painful feeling. A certain antacid tablet dissolves in water and reacts with the acid in the stomach to release carbon dioxide gas.

1.1. Name the type of chemical reaction that explains why antacids bring relief from indigestion.

1.2. A group of learners wants to investigate the effect of temperature on the rate of dissolution of this antacid tablet in water.

Design an investigation that the group of learners can conduct by answering the questions below.

1.2.1. State an investigative question.

1.2.2. State a hypothesis for this investigation.

1.2.3. Write down a procedure that can be followed in this investigation to test your hypothesis using some or all of the apparatus/chemicals listed below:

- Thermometer
- Stopwatch
- Hot plate
- Breaker
- Measuring cylinder
- Spatula/Teaspoon
- Water
- Antacid tablet

1.3. Is it better to take the antacid tablet with warm water or cold water? Give a reason for your answer.

QUESTION 2

A group of learners use the reaction between hydrochloric acid and magnesium powder to investigate one of the factors that influence the rate of a chemical reaction.

The reaction that takes place is:

$$Mg_{(s)} + 2\,HCl_{(aq)} \longrightarrow MgCl_{2\,(aq)} + H_{2\,(g)}$$

1.2.3

- Use the measuring and measure a fixed volume of water and transfer it to the beaker.
- Record the temperature of the water.
- Add one antacid tablet to the water and measure the time it takes to dissolve.
- Rinse the solution down the sink and repeat the experiment at two more different temperatures.
- Repeat the above steps for accuracy

1.3 Warm water. The rate at which it will bring relieve will be faster at a higher temperature.

QUESTION 2

2.1 Smaller than

2.2 Reaction rate increases with increase in concentration.

2.3 To make a fair comparison/test

2.4 When Mg is used up, the reaction will stop.

2.5.1 Remains the same

2.5.2 Increases

The learners use apparatus and follow the method shown bellow to conduct the investigation. Method –Experiment 1: Step 1: Place a spatula of magnesium powder in a conical flask and add 50 cm^3 HC l $_{(ag)}$ of known concentration. Step 2: Simultaneously start the stopwatch and close the flask with the rubber stopper containing the delivery tube. Step 3: Measure the volume of the $H_{2(g)}$ formed in the intervals of 20 seconds. Method – Experiment 2: Repeat steps 1 to 3 above, but use only 25 cm^3 of the same HC (aq) diluted to 50 cm^3 with distilled water. 2.1 How does the concentration of the acid used in Experiment 2 differ from the concentration of the acid used in Experiment 1? Write down only GREATER THAN, SMALLER THAN or EQUAL TO. 2.2 Write down a hypothesis for this investigation. 2.3 Why should the learners ensure that equal amounts of magnesium powder are used in each of two experiments? 2.4 The learners use an excess HC l $_{(aq)}$ for the two experiments. Give a reason why the excess will not influence the results 2.5 How will an increase in the temperature influence the following: 2.5.1 Final volume of gas obtained in each experiment (write down only INCREASE, DECREASE or REMAINS THE SAME) 2.5.2 Volume of gas obtained each experiment after 40 s (Write down only INCREASE, DECREASE or REMAINS THE SAME.) **QUESTION 3** Learners use hydrochloric acid and a sodium thiosulphate ($Na_2S_2O_3$) solution to investigate the relationship between rate of reaction and temperature. The reaction that takes place is represented by the following equation: $Na_2S_2O_3(aq) \rightarrow 2NaCl(aq) + S(s) + H_2O(l) + SO_2(g)$ They add 5 cm^3 dilute hydrochloric acid solution to 50 cm^3 sodium thiosulphate solution in a flask placed over a cross drawn on a sheet of white paper. The temperature of the mixture is 30 °C.	**QUESTION 3** 3.1 Reaction rate increases with an increase in temperature 3.2 Sulphur dioxide 3.3 Concentration of sodium thiosulphate 3.4 Sulphur or S 3.5 Different people have different sight abilities/reaction times.		

They measure the time it takes for the cross to become invisible. The experiment is repeated with the temperature of the mixture at 40 °C, 50 °C and 60 °C respectively. 3.1 Write down a possible hypothesis for this investigation. 3.2 Write down the NAME of the product that requires the need to work in well-ventilated room. 3.3 Apart from the volume of the reactants, state ONE other variable that must be kept constant during this investigation. 3.4 Write down the NAME or FORMULA of the product that causes the cross to become invisible. 3.5 Why is it advisable that the same learner observes the time that it takes for the cross to become invisible? **2.3 Conclusion** • Ask learners about the main aspects of the lesson. • Educator and learners discuss the solutions of the consolidation exercise.			

Reflection/note

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

GRADE	12	SUBJECT	Physical Sciences	WEEK	16	TOPIC	Chemical equilibrium	Lesson	1

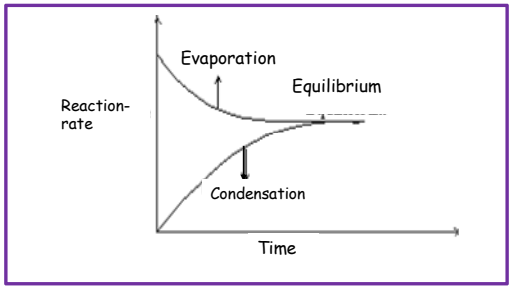
LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should know: • The meaning of chemical equilibrium and the factors affecting equilibrium The following results will be the outcome of this lesson: • Learners must be able to explain what is meant by: o Open and closed system. o A reversible reaction. o Dynamic equilibrium. • Learners must be able to list the factors which influence the position of an equilibrium.		

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 • Rates of reaction **BASELINE ASSESSMENT** • Baseline questions ▪ List the factors that affect the rate of reaction **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: ▪ Surface area ▪ Concentration or pressure ▪ Temperature	1. Learners answer the baseline questions. 2. Learners take notes from the board. 3. Learners write the classwork. **CLASSWORK** 1. What does it mean when a reaction is reversible? 2. Explain what the difference is between an open system and a close system. Which of the following reaction(s) should occur in a closed system? (i) $HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$ (ii) $NH_4Cl_{(g)} \rightleftharpoons NH_{3(g)} + HCl_{(g)}$ (iii) $2Cu_{(s)} + O_{2(g)} \rightarrow 2CuO_{(s)}$ 3. A saturated solution of sodium chloride in water is prepared. NaCl is dissolved in water until a small amount remains at the bottom. The following dynamic equilibrium reaction applies. $NaCl_{(aq)} \rightleftharpoons Na^+_{(aq)} + Cl^-_{(aq)}$ 3.1 What is the meaning of the double arrows in the reaction?	5 min 30 min 15 min	Chalkboard for notes, discussions and classwork

- Addition of a catalyst
- Nature of reactants
- Educator explain and discuss with learners the following:

Open and closed system

- Open system: matter enters or leaves the system.
- Closed system: covered, no particles enter or leave the system.
- Static equilibrium: reaction stops – no further change.
- Dynamic equilibrium: two opposing reactions occur simultaneously and at a same rate, no visible change.
- Dynamic phase equilibrium:
- Rate of evaporation = Rate of condensation
- The equilibrium is represented by ⇌
- Liquid ⇌ Vapour
- $H_2O_{(l)} \rightleftharpoons H_2O_{(g)}$
- Graph of reaction rate



- Initially evaporation rate is faster than condensation rate.
- Condensation rate picks up – evaporation rate declines
- Horizontal line indicates where evaporation and condensation occur at the same rate – dynamic phase equilibrium.

Reversible reactions

- Many chemical reactions are reversible in closed systems.

3.2 Explain what is meant by "dynamic equilibrium"?

3.3 Compare the concentration of the sodium ion and the chloride ion at equilibrium.

3.4 How do you know the equilibrium has been reached?

SOLUTIONS

1. Reversible reactions can go in both directions. This means that the products can break down and return to the starting reactants.

2. A closed system is one in which no substances in the reaction can escape, where an open system substances especially gases escape. Reaction (ii) should occur in a closed system.

3.

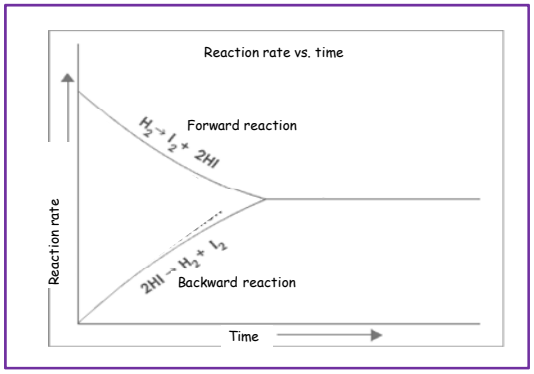
3.1 Double arrow: dynamic equilibrium has been reached.

3.2 Two opposing reactions happen simultaneously and at a same rate, thus equally so fast that no external changes can be noticed.

3.3 $[Na^+] = [Cl^-]$

3.4 The amount of NaCl not dissolved at the bottom remains the same.

- Reversible reactions that do not go to completion and occur in both the forward and reverse direction. Where the reactants form products that in turn react together to give the reactants back.
- As [reactants] decrease, the tempo forwards also decreases
- $H_{2\,(g)} + I_{2\,(g)} \rightleftharpoons 2HI_{\,(g)}$
- Hydrogen and iodine react to form hydrogen iodide.
- Hydrogen iodide is not very stable
- Dissociates back into hydrogen and iodine.
- Reversible reaction is represented by ⇌
- **The curve below: the change in reaction rate of the two reactions.**



- Forward reaction is initially fast; but slows down as more products are formed.
- The reverse reaction starts at a tempo of zero but speeds up as more products are formed.
- Two opposing reactions at the same rate – equilibrium.
- When the reaction reaches equilibrium, the rate of the forward reaction is equal to the rate of the reverse reaction.
- Also, when equilibrium is reached the concentration of the reactants and the products remain constant.
- This is called dynamic equilibrium.

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	16	TOPIC	Chemical Equilibrium	Lesson	2

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should know: • The meaning of the equilibrium constant. The following results will be the outcome of this lesson: • Learners must be able to list the factors affecting the equilibrium constant. • Learners must be able to write the expression of the equilibrium constant having been given the equation of the reaction. • Learners must be able to calculate the equilibrium constant.		

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 • Chemical equilibrium and factors affection equilibrium **BASELINE ASSESSMENT** • Baseline questions ▪ Consider the following reaction: $N_{2(g)} + 3H_{2\ (g)} \rightleftharpoons 2NH_{3\ (g)}$; $\Delta H<0$ ▪ What effect would an increase in temperature have on the above equilibrium? ▪ Which concentration (products or reactants) will increase as you effect this change? **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 ▪ The equilibrium will favour the reverse reaction. ▪ The concentration of the reactants will increase. • 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 exercise 4. Learners and educator discuss the solutions of the exercise. 5. Learners write the classwork. **CLASSWORK** 1. Consider the equation: $2NO_{2\ (g)} \rightleftharpoons N_2O_{4\ (g)}$ The concentration of NO_2 is found to be 0,013 mol•dm^{-3} and that of N_2O_4 to be 0,035 mol•dm^{-3}. When the reaction is at equilibrium calculate K_c.	5 min 15 min 15 min 5 min 20 min	Chalkboard for notes, discussions and classwork

The Equilibrium Constant (K_c)

- For hypothetical reaction

$aA + bB \rightleftharpoons cC + dD$

- The equilibrium constant for this reaction:

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

- K_c values would be higher for a reaction equilibrium that lies far to the right i.e. if the concentration of the products is higher.
- K_c values would be lower for an equilibrium that lies far to the left i.e. if the concentration of the reactants is higher.
- The value of K_c is constant at a particular temperature i.e. **temperature is the only factor that affects K_c.**
- If the temperature is increased or decreased, K_c will change depending on which side the equilibrium shifts according to Le Chatelier's principle.
- For example if a change in temperature shifts the equilibrium to the right , the value of K_c would increase.
- If the reagent is a solid or liquid, its concentration is taken to be 1 and **thus does not appear in the K_c expression.**
- K_c has no units.
- Educator gives learners the following class exercise.

Class exercise

1. Write down an expression for the equilibrium constant for each of the following reversible reactions:

1.1 $2H_2O_2\,(aq) \rightleftharpoons 2H_2O\,(l) + O_2\,(g)$

1.2 $2HCl_{(aq)} + CaCO_{3\,(s)} \rightleftharpoons CaCl_{2\,(aq)} + H_2O\,(l) + CO_{2\,(g)}$

1.3 $N_{2\,(g)} + 3H_{2\,(g)} \rightleftharpoons 2NH_{3\,(g)}$

2. In which of the following reactions will the concentration at equilibrium of the products be much higher than the reactants?

2.1 $H_{2\,(g)} + F_{2\,(g)} \rightleftharpoons 2HF_{(g)}$ $K_c = 1 \times 10^8$

2.2 $SO_{2\,(g)} + NO_{2\,(g)} \rightleftharpoons NO_{(g)} + SO_{3\,(g)}$ $K_c = 1 \times 10^2$

2. Hydrogen gas and iodine gas are mixed in a closed container and heated to 440 °C. At equilibrium it is found that the concentration of the reactants and products are as follows:

$[H_2] = 2{,}06\ mol \bullet dm^{-3}$

$[I_2] = 13{,}4\ mol \bullet dm^{-3}$

$[HI] = 36{,}98\ mol \bullet dm^{-3}$

Calculate the equilibrium constant at 440 °C

$H_{2\,(g)} + I_{2\,(g)} \rightleftharpoons 2HI_{(g)}$

3. For the reaction

$SO_{2\,(g)} + NO_{2\,(g)} \rightleftharpoons NO_{(g)} + SO_{3\,(g)}$

the value of the K_c =4. The concentrations at equilibrium are as follows:

$[SO_3] = 0{,}2\ mol \bullet dm^{-3}$

$[NO] = 0{,}4\ mol \bullet dm^{-3}$

$[NO_2] = 0{,}1\ mol \bullet dm^{-3}$

Calculate the concentration of SO_2.

4. Carbon dioxide reacts with 36 g of graphite in a $1dm^3$ container. At equilibrium it is found that there is 0,38 mol of carbon dioxide and 1,24 mol of carbon monoxide. Calculate the value of the equilibrium constant.

2.3 $H_2O_{(g)} \rightleftharpoons 2H_{2(g)} + O_{2(g)}$ $K_c = 6 \times 10^{-28}$

- Educator and learners discuss the following solutions of the class exercise.

1.

1.1 $K_c = \frac{[O_2]}{[H_2O_2]^2}$

1.2 $K_c = \frac{[CO_2][CaCl_2]}{[HCl]^2}$

1.3 $K_c = \frac{[NH_3]^2}{[N_2][H^2]^3}$

2.

2.1 [products] > [reactants]

2.2 [products] > [reactants]

2.3 [products] < [reactants]

2.3 Conclusion

- Ask learners about the main aspects of the lesson.
- Give learners classwork

$CO_{2(g)} + C_{(s)} \rightleftharpoons 2CO_{(g)}$

SOLUTIONS

1. $K_c = \frac{[N_2O_4]}{[NO_2]^2}$

$= \frac{0,035}{(0,013)^2}$

$= 207,1$

2. $K_c = \frac{[HI]^2}{[H_2][I_2]}$

$= \frac{(36,98)^2}{(2,06)(13,4)}$

$= 49,54$

3. $K_c = \frac{[NO][SO_3]}{[SO_2][NO_2]}$

$4 = \frac{(0,4)(0,2)}{[SO_2](0,1)}$

$\therefore [SO_2] = 0,2\ mol \cdot dm^{-3}$

4. $c = n/v$

$\therefore [CO] = (1,24)/(1)$

$= 1,24\ mol \cdot dm^{-3}$

$\therefore [CO_2] = (0,38)/(1)$

$= 0,38\ mol \cdot dm^{-3}$

$Kc = \frac{[CO]^2}{[CO_2]}$

$= \frac{(1,24)^2}{(0,38)}$

$= 4,046$

Reflection/note

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

GRADE	12	SUBJECT	Physical Sciences	WEEK	16	TOPIC	Chemical Equilibrium	Lesson	3

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should know: • The meaning of equilibrium constant. The following results will be the outcome of this lesson: • Learners must be able to list the factors affecting the equilibrium constant. • Learners must be able to write the expression of the equilibrium constant having been given the equation of the reaction. • Learners must be able to calculate the equilibrium constant. • Learners must be able to explain the significance of high and low values of the equilibrium constant.		

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 • Dynamic equilibrium, Le Chatelier's principle and factors affecting equilibrium, Equilibrium constant, Stochiometry. **BASELINE ASSESSMENT** • Baseline questions Consider the reaction: $2SO_{2\,(g)} + O_{2\,(g)} \rightleftharpoons 2SO_{3\,(g)}$ ▪ What is the molar ratio of SO_2 and O_2? ▪ What is the molar ration of O_2 and SO_3? **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: ▪ 2 mol of SO_2 react with 1 mol of O_2 ▪ 1 mol of O_2 produce 2 mol of SO_3	1. Learners answer the baseline questions. 2. Learners take notes from the board. 3. Learners write the classwork. **CLASSWORK** 1. The following reaction reaches equilibrium at 30 °C in a closed 1 dm^3container. $H_{2\,(g)} + I_{2\,(g)} \rightleftharpoons 2HI_{\,(g)}$ Calculate the value of Kc if 1 mol of $H_{2\,(g)}$ and 1 mol of $I_{2\,(g)}$ are placed in the container and analysis shows that 0, 8 mol of HI are present when equilibrium is reached. 2. Reaction: $PCl_{5\,(g)} \rightleftharpoons PCl_{3\,(g)} + Cl_2$ (g) 0,375 mol of $PCl_{5\,(g)}$ is heated in a closed 1 dm^3 container. The equilibrium mixture contains 0,125 mol of chlorine. Calculate the equilibrium constant for the decomposition of PCl_5.	5 min 25 min 25 min	Chalkboard for notes, discussions and classwork

- Educator explain and discuss with learners the following
- Equilibrium Constant Calculations
- Most calculations involving K_c you are given some information (usually the number of moles) and asked to calculate the information not given and eventually K_c.
- For such type of questions it helps to break the question as follows:
  - **START/INITIAL:** here you record the moles of the starting substances (most products start at 0).
  - **CHANGE** (Reacted/formed): "Reacted" applies to reactants and "formed" applies to products – molar ratios can be used in this step (not at start)
  - **EQUILIBRIUM:** For reactants, this is moles at start minus the moles reacted (change). For products, this is moles at start plus moles formed (change)
  - **EQUILIBRIUM CONCENTRATION:** If the above values are in moles, then calculate the concentration using the formula c= n/v
- Example

Reaction: $2SO_{2\,(g)} + O_{2\,(g)} \rightleftharpoons 2SO_{3\,(g)}$

7 mol SO_2 and 6 mol O_2 put in a container of volume 2 dm^3 at a temperature of 600 K. At equilibrium 4 mol SO_3 have formed. Determine the value of K_c.

Solution

	SO_2	O_2	SO_3
Initial (mol)	**7**	**6**	**0**
Change (mol)	**4**	**2**	**4**
Equilibrium (mol)	**7 -4 = 3**	**6 -2 = 4**	**4**
Concentration , c=n/v ($mol \cdot dm^{-3}$)	**3/2 = 1,5**	**4/2 = 2**	**4/2 = 2**

$K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$

$= (2)^2 / (1,5)^2(2) = 0,889$

3. Nitric oxide ($NO_{(g)}$) forms in internal combustion engines by the direct combination of nitrogen and oxygen according to the following reversible reaction

   $N_{2\,(g)} + O_{2\,(g)} \rightleftharpoons 2NO_{\,(g)}$

   During a research experiment carried out by initially adding 1 mol of N_2 and 1 mol O_2 in a 2 dm^3 closed container at 300 K, it was found that the concentration of the $NO_{\,(g)}$ present in the container at equilibrium was 0,1 $mol \cdot dm^{-3}$. Calculate the equilibrium constant for the reaction at this temperature.

SOLUTIONS

1.

	H_2	I_2	HI
Initial (mol)	**1**	**1**	**0**
Change (mol)	**0,4**	**0,4**	**0.8**
Equilibrium (mol)	**0,6**	**0,6**	**0,8**
Concentration, c = n/v ($mol \cdot dm^{-3}$)	**0,6**	**0,6**	**0,8**

$K_c = \frac{[HI]^2}{[H_2][I_2]}$

$= \frac{(0,8)^2}{(0,6)(0,6)} = 1,78$

2.3 Conclusion

- Ask learners about the main aspects of the lesson.
- Give learners classwork.

2.

	PCl_5	PCl_3	Cl_2
Initial (mol)	**0,375**	**0**	**0**
Change (mol)	**0,125**	**0,125**	**0,125**
Equilibrium (mol)	**0,25**	**0,125**	**0,125**
Concentration, c = n/v ($mol \cdot dm^{-3}$)	**0,25**	**0,125**	**0,125**

$$K_c = \frac{[PCl_3][Cl_2]}{[PCl_5]}$$

$$= \frac{(0,125)(0,125)}{(0,25)}$$

$$= 6,25 \times 10^{-2}$$

3.

	N_2	O_2	NO
Initial (mol)	**1**	**1**	**0**
Change (mol)	**0,1**	**0,1**	**0,2**
Equilibrium (mol)	**0,9**	**0,9**	**0,2**
Concentration, c = n/v ($mol \cdot dm^{-3}$)	**0,45**	**0,45**	**0,1**

First calculate moles at equilibrium.

$$n_{NO} = cv = (0,1)(2) = 0,2 \text{ mol}$$

$$K_c = \frac{[NO]^2}{[N_2][O_2]}$$

$$= \frac{(0,1)^2}{}$$

	(0,45)(0,45) **= 0,049**		
Reflection/note			

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

GRADE	12	SUBJECT	Physical Sciences	WEEK	17	TOPIC	Chemical Equilibrium	Lesson	1

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should know: • The factors affecting the chemical equilibrium. • The Le Chatelier's Principle. The following results will be the outcome of this lesson: • Learners must be able to state Le Chatelier's Principle. • Learners must be able to explain qualitatively, given appropriate data, the effects of changes of pressure, temperature, concentration and the use of a catalyst on the amount of each substance in an equilibrium mixture.		

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 • Reversible reactions, chemical equilibrium, endothermic and exothermic reactions. **BASELINE ASSESSMENT** • Baseline questions ▪ Define the terms endothermic and exothermic reactions. ▪ What does $\Delta H < 0$ mean? ▪ Consider the reaction: $N_{2\,(g)} + 3H_{2\,(g)} \rightleftharpoons 2NH_{3\,(g)} \quad \Delta H < 0$ o Is the forward reaction exothermic or endothermic? o Is the reverse reaction exothermic or endothermic? **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	1. Learners answer the baseline questions. 2. Learners take notes from the board. 3. Learners write the classwork. **CLASSWORK** 1. List the factors which affect the equilibrium. 2. State Le Chatelier's principle. 3. Study the following equation $2CO_{(g)} + O_{2\,(g)} \rightleftharpoons 2CO_{2\,(g)} \quad \Delta H < 0$ Use Le Chatelier's principle to predict what effect the following changes will have on the equilibrium. 3.1 increase in the concentration of O_2 3.2 decrease in temperature 3.3 increase in pressure	5 min 35 min 15 min	Chalkboard for notes, discussions and classwork

- Endothermic reactions are reactions that absorb heat.
- Exothermic reactions are reaction that release heat.
- $\Delta H < 0$ means the reaction is exothermic.
- Forward reaction is exothermic.
- Reverse reaction is endothermic.
- Educator explain and discuss with learners the following

Factors affecting chemical equilibrium and Le Chatelier's principle:

- Le Chatelier's principle is used to explain the effect of factors affecting chemical equilibrium.
- Le Chatelier's principle: when the equilibrium in a closed system is disturbed by changing any of the conditions i.e concentration, temperature, volume or partial pressure, the equilibrium will shift in such a way as to cancel the effect of the change.

Concentration

- Consider the following reaction in a closed system:

$CoCl_2^- + 6H_2O \rightleftharpoons Co(H_2O)_6^{2+} + 4Cl^-$

blue **red**

- If you add a little water to the blue solution, it turns red i.e. the forward reaction uses up the water.
- If you add concentrated HCl to the red solution, it turns blue i.e. the reverse reaction uses up the Cl^- ions.
- Conclusion
- When you increase the concentration of a substance on the left, the equilibrium will favour the forward reaction and;
- When you increase the concentration of a substance on the right, the equilibrium will favour the reverse reaction.

Temperature

- Consider the following reaction in a closed system

$2NO_{2\,(g)} \rightleftharpoons N_2O_{4\,(g)}$ $\Delta H < 0$

brown **yellow**

3.4 addition of a catalyst

4. Consider the reaction

$2SO_{2\,(g)} + O_2\,(g) \rightleftharpoons 2SO_{3\,(g)}$ $\Delta H<0$

What can be done to promote the formation of SO_3?

SOLUTIONS.

1. Temperature; concentration; pressure/volume.

2. When the equilibrium in a closed system is disturbed by changing any of the conditions i.e concentration, temperature, volume or partial pressure, the equilibrium will shift in such a way as to cancel the affect of the change.

2.1 The equilibrium will favour the forward reaction.

2.2 The equilibrium will favour the forward reaction.

2.3 The equilibrium will favour the forward reaction.

2.4 The equilibrium will not be affected. The catalyst will increase the rate of both the forward and reverse reactions.

3.

- **Increase the concentration of O_2, SO_2**
- **Withdraw SO_3**

• If the mixture is heated, the gas goes dark brown i.e. the equilibrium will favour the reverse reaction. • This is the direction of the endothermic reaction. • Cooling the mixture will make the colour lighter i.e. the reaction will favour the forward reaction. • This is the direction of the exothermic reaction. • Exothermic reactions release heat. • Conclusion ▪ A decrease in temperature favours the exothermic reaction and an increase in temperature favours the endothermic reaction. **Pressure** • Consider the following reaction $2SO_{2\,(g)} + O_{2\,(g)} \rightleftharpoons 2SO_{3(g)}$ **2mol 1mol 2mol** • The left hand side has 3 mol of gas and the right hand side has 2 mol. • The 3 mol of gas exerts more pressure than 2 mol, therefore an increase in pressure will make the equilibrium shift to the side that exerts the least pressure i.e. the right hand side. • Conclusion ▪ An increase in pressure favours the side with fewer molecules and a decrease in pressure favours the side with more molecules. **2.3 Conclusion** • Ask learners about the main aspects of the lesson. • Give learners classwork.	• **Increase the pressure of the system** • **Decrease the temperature**		

Reflection/note

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

GRADE	12	SUBJECT	Physical Sciences	WEEK	17	TOPIC	Chemical Equilibrium	Lesson	2

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	At the end of this lesson learners should know: • The factors affecting the chemical equilibrium. • The Le Chatelier's Principle. The following results will be the outcome of this lesson: • Learners must be able to apply the rate equilibrium principles to important industrial applications.		

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 • Reversible reactions, chemical equilibrium, endothermic and exothermic reactions. **BASELINE ASSESSMENT** • Baseline questions ▪ Consider the reaction: $N_{2\,(g)} + 3H_{2\,(g)} \rightleftharpoons 2NH_{3\,(g)}$ $\Delta H < 0$ o Is the forward reaction exothermic or endothermic? o Is the reverse reaction exothermic or endothermic? **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 ▪ Forward reaction is exothermic. ▪ Reverse reaction is endothermic. • 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** Educator to give learners an activity on the application of equilibrium.	5 min 35 min 15 min	Chalkboard for notes, discussions and classwork

Application to important industrial processes

- **The Haber process- industrial preparation of ammonia**

$N_{2\,(g)} + 3H_{2\,(g)} \rightleftharpoons 2NH_{3\,(g)}$ $\Delta H = -92{,}4\ kJ \bullet mol^{-1}$

Conditions: 150 – 250 atm ; 300 °C – 550 °C

- Problems of Haber process

❖ Rate of reaction

✓ Room temperature, reaction very slow.

✓ Increasing the temperature will speed up the reaction rate.

❖ Chemical equilibrium

✓ Reaction where ammonia forms is exothermic.

✓ Increasing temperature, decreases formation of ammonia.

✓ Less ammonia will be produced.

✓ Lower temperature will produce more ammonia but will decrease the reaction rate too much.

❖ Catalyst

✓ Catalyst can be used to increase reaction rate.

✓ Requires a temperature of 400 °C to be effective.

❖ Pressure

✓ High pressure favours forming ammonia.

✓ Extreme conditions like 200 atm pose safety risk.

✓ Cost to strengthen pipes, reaction vessels very high.

❖ Optimised yields

✓ N_2 and H_2 constantly added to vessel (concentration increased).

✓ Equilibrium is cooled, temperature between 300 °C and 500 °C.

✓ Pressurized to 20 atm.

✓ Ammonia liquefied and drained (concentration decreased).

✓ Temperature of reaction is fast enough, the yield of ammonia about 60% (You get less ammonia but you get it quickly).

• **The contact process- industrial preparation of sulphuric acid** ❖ Critical step $2SO_{2\,(g)} + O_{2\,(g)} \rightleftharpoons 2SO_{3\,(g)}$ ❖ Most economic conditions ✓ Temperature = 450 ^{o}C and a modest pressure of 1 -2 atm. ✓ Vanadium pentoxide (V_2O_5) is used as a catalyst. ✓ Catalyst has no effect on amount of SO_3 produced it only speeds up the reaction. **2.3 Conclusion** • Ask learners about the main aspects of the lesson. • Give learners classwork.			

Reflection/note

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

GRADE	12	SUBJECT	Physical Sciences	WEEK	18	TOPIC	**Electrochemical Reactions:** **1.** Definition of Cells, using oxidation and reductions (electron (e^-) transfer) and anode and cathode in terms of the mentioned aspects o The **galvanic Cell:** ▪ Self sustaining electrode reactions Conversion of electrical energy into chemical energy	LESSON	1 (a)

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	
LESSON OBJECTIVES	**1.** Learners will be **TAUGHT and LEARN** the following: • **To define the galvanic cell in terms**: o Self sustaining electrode reactions o Conversion of chemical energy to electrical energy **2.** **LESSON OUTCOMES – At the end of the lesson learners should be able to:** • define what is galvanic cell, using oxidation and reduction (electron (e^-) transfer) • explain **oxidation and reduction** in terms of electrons transfer. • describe when the substance is **oxidised** and when the substance is **reduced.** • describe galvanic cell as self sustaining electrode reactions • understand conversion of electrical energy into chemical energy		

TEACHER ACTIVITIES	LEARNER ACTIVITIES	TIMING	RESOURCES NEEDED
1. TEACHING METHODS USED IN THIS LESSON: **Explanations, illustrations, Demonstrations and questions and answer methods**	**1. Baseline Assessment:** 1. Write down and balance the reaction in which magnesium combines with oxygen. **$2Mg + O_2 \rightarrow 2MgO$**		

2. Lesson Development **2.1 Introduction** • The teacher will introduce the lesson by giving learners **baseline assessment.** **OR** • **Using question and answer method?** ✓ Define the concept oxidation? ✓ Define the concept reduction? ✓ What is the reaction in which oxidation and reduction happen simultaneously? ✓ What energy conversion takes place in galvanic cell? ✓ How does redox reaction differ with acids and bases? **Discussion and Explanation Method (the teacher will clear any misconceptions that the learners may have)** • **Facilitate group discussion/ Response from the above assessment activities.** • **Explain:** oxidation reaction in terms of **metals reacting with oxygen** – (as previously described). • **Demonstrate the process** – using the **periodic table** **Use Lewis structure to explain the transfer of electrons** **3. Lesson development** 3.1 Contextualization questions: (learners will respond to questions) • What reaction result when a metal rusts?	1.1 Which element donates electrons and the element that accepts the electrons? Refer to a periodic table in which these elements are found. **Magnesium donates electrons and Oxygen accepts electrons.** **Magnesium is found in group 2 of the periodic table and oxygen in 6.** 1.2 Write down and balance the reactions in which magnesium combine with Chlorine. **$Mg + Cl_2 \rightarrow MgCl_2$** 1.3 Which element donates electrons and which element is accepting the electrons? **Magnesium donates electrons and chlorine accepts electrons.** **2. GROUP WORK ACTIVITY** **Learners will work in groups to find solutions:** **2.1 Define each of the following expressions in terms of electron transfer:** **2.1.1** Oxidation: **is the process by which electrons are donated from one substance to another.** **2.1.2** Reduction: **is the process by which one substance accepts electrons from another substance.** **2.1.3** Oxidizing agent: **A substance that removes electrons from another reactant in a redox reaction. It is reduced.** **2.1.4** Reducing agent: **A substance that donates electrons to another reactant in a redox reaction. It is oxidized.**	**Baseline assessment:** **± (15 min)** **Feedback: provide correct answers** **± (15 min)** **Demonstration and Explanation** **± 15 minutes** **OR**	**Worksheet** **Chalkboard summary** **Charts/ or available resources**

• What is the essential difference between acid-base reactions and redox reactions? The teacher will then explain if these reactions: spontaneous or / non-spontaneous ✓ Reactions of metals combining with oxygen were **previously** called **oxidation.** ✓ The term oxidation was used to describe the process in which an element combines with oxygen. ✓ **In this reaction:** **$Mg_{(s)} + O_{2(g)} \rightarrow MgO_2$** ✓ **Magnesium oxide** is an ionic compound which is formed by each magnesium atom losing its two **valence electrons** to the oxygen atom, so forming **Mg^{2+} and O^{2-} ions.** ✓ These two oppositely charged ions now attract each other on account of the strong electrostatic force which exists between them. ✓ Use Lewis structure/ Coupers notations to describe how electrons are transferred to form metal oxide. (add two dots to complete valency) Mg: + :O: Mg^{2+} + $[:O:]^{2-} \rightarrow MgO$ ✓ During this oxidation process, magnesium was the donor of electrons, and oxygen the acceptor of electrons. ✓ **The oxidation process thus involves the transfer of electrons.** **<u>DEMONSTRATION USING PERIODIC TABLE:</u>** **Now consider the reaction of magnesium with chlorine**: $Mg^{2+} + 2[Cl^-] \rightarrow MgCl_2$	**2.1.5** Explain the concept redox reaction: **Transfer of electrons from one substance to another substance.** **<u>HOMEWORK</u>** **<u>Select the correct word from those given in brakets:</u>** 1.1 Reduction is the (**gain** / loss) of electrons 1.2 Oxidation is the (**loss** / gain) of electrons 1.3 Reduction occurs at the (anode/ **cathode)**. 1.4 Oxidation occurs at the (**anode/** cathode). 1.5 Magnesium metal is written as [**Mg**/ Mg^{2+} (aq)]. 1.6 Magnesium ion is written as [Mg/ **Mg^{2+} (aq)**]. **<u>Provide one word</u>** 1.7 What do we call a device that makes use of electrochemical reactions? **Electrochemical cell** 1.8 Write down **two half cell reactions** which occurs between Magnesium and Oxygen **$Mg_{(s)} \longrightarrow Mg^{2+}_{(aq)} + 2e^-$** **$\frac{1}{2} O_{2(aq)} + 2e^- \longrightarrow O^{2-}_{(g)}$** 1.9 Write down a total or nett cell reaction.	**Illustrations and Explanation** **± 15 – 20 minutes** **Lesson Demonstration and explanations** **± 15 minutes**	**Relevant equipments/ or other available resources.** **Chalkboard summary**

- ✓ If we were to apply the original definition, this reaction could not be classified as an oxidation reaction because it does not involve the combination of oxygen with another substance.
- ✓ Magnesium donate two electrons to the chlorine atoms
- ✓ This change can be represented as follows:

$Mg \rightarrow Mg^{2+} + 2e^-$

$O_2 + 2e^- \rightarrow O^{2-}$

- ✓ It is therefore necessary to consider oxidation not in terms of a reaction with oxygen, but rather in terms of the electrons transfer which takes place.
- ✓ An oxidation process is therefore defined as the process by which electrons are transferred from one substance to another.
- ✓ Transfer of electrons implies that one substance must donate the electrons and another must receive the electrons.
- ✓ A substance that removes electrons from another reactant in a redox reaction is reduced.
- ✓ The process is known as **oxidation**
- ✓ The substance that donates electrons to another reactant in a redox reaction is oxidized.
- ✓ The process is known as **reduction.**

4. Lesson Development:

TEACHING – ACTIVITY

Use **standard electrode potentials** (reduction potentials) to explain half cell reactions in terms of electron transfer

$Mg_{(s)} \rightarrow Mg^{2+}_{(aq)} + 2e^-$

$\frac{1}{2} O_{2\,(aq)} + 2e^- \rightarrow O^{2-}_{(g)}$

$Mg\,(s) + \frac{1}{2} O_2\,(g) \rightarrow Mg^{2+}\,(aq) + O^{2-}\,(g)$

1.9 For each of the following reactions write the oxidation and reduction half-reactions. In each case name the oxidizing agent and the reducing agent

a) $Mg + Cu^{2+} \rightarrow Mg^{2+} + Cu$

Answers: (a) Oxidation half - reaction:

$Mg\,(s) \rightarrow Mg^{2+}\,(aq) + 2e^-$

Reduction half reaction:

$Cu^{2+}\,(aq) + 2e^- \rightarrow Cu\,(s)$

Oxidizing agent: Cu^{2+} ions

Reducing agent: Mg atom

b) $2Fe^{3+}\ Pb \rightarrow 2Fe^{2+} + Pb^{2+}$

Answer: (b) Oxidation half – reaction

$Pb\,(s) \rightarrow Pb^{2+}\,(aq) + 2e^-$

Reduction half reaction:

$Fe^{3+}\,(aq) + e^- \rightarrow Fe^{2+}\,(aq)$

Oxidizing agent: Fe^{3+} ions

Reducing agent: Pb atom

$Li^+ + e^- \rightleftharpoons Li$ − 3,05 $K^+ + e^- \rightleftharpoons K$ − 2,93 $Cs^+ + e^- \rightleftharpoons Cs$ − 2,92 $Ba^{2+} + 2e^- \rightleftharpoons Ba$ − 2,90 $Sr^{2+} + 2e^- \rightleftharpoons Sr$ − 2,89 $Ca^{2+} + 2e^- \rightleftharpoons Ca$ − 2,87 $Na^+ + e^- \rightleftharpoons Na$ − 2,71 $Mg^{2+} + 2e^- \rightleftharpoons Mg$ − 2,36 $A\ell^{3+} + 3e^- \rightleftharpoons A\ell$ − 1,66 $Mn^{2+} + 2e^- \rightleftharpoons Mn$ − 1,18 $Cr^{2+} + 2e^- \rightleftharpoons Cr$ − 0,91 **LESSON SUMMARYCONCLUSION:** • Oxidation and Reduction occurs simultaneously. • The two reactions are known as half-reactions.			

Reflection/note

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

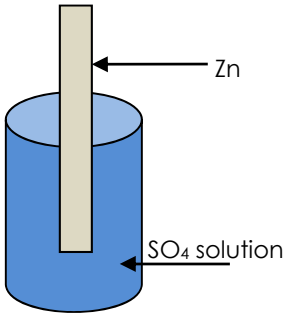
GRADE	**12**	**SUBJECT**	**Physical Sciences**	**WEEK**	**18**	**TOPIC**	**Electrochemical Reactions:** **1.** Definition of Cells, using oxidation and reductions (electron (e^-) transfer) and anode and cathode in terms of the mentioned aspects o The **galvanic Cell:** ▪ Self sustaining electrode reactions Conversion of electrical energy into chemical energy	**LESSON**	**1 (b)**

LESSON SUMMARY FOR: DATE STARTED:		**DATE COMPLETED:**	

LESSON OBJECTIVES	**1.** Learners will be **TAUGHT and LEARN** the following**:** **To define the galvanic cell in terms**: o Definition of **Redox Reaction** – in relation to electron (e^-) transfer. o The importance redox reactions in relation to **energy conversion.** o The application of these reactions in electrochemical cell of torch cells, car battery, etc. **2. LESSON OUTCOMES – At the end of the lesson learners should be able to:** • define what is galvanic cell, using oxidation and reduction (electron (e^-) transfer) • explain **oxidation and reduction** in terms of electrons transfer. • describe when the substance is **anode** and when the substance is **cathode.** • describe galvanic cell as self sustaining electrode reactions • understand conversion of electrical energy into chemical energy

TEACHER ACTIVITIES	**LEARNER ACTIVITIES**	**TIMING**	**RESOURCES NEEDED**
1. TEACHING METHODS USED IN THIS LESSON: **Explanations, illustrations, Demonstrations and questions and answer methods**	**Baseline Assessment:** **One word question:**		

2. Lesson Development **2.1 Introduction** **a) Pre-knowledge required.** • The teacher will introduce the lesson by giving learners **baseline assessment**. **OR** • **Using question and answer method recap from previous knowledge?** ✓ What do we call a process in which electrons are transferred? ✓ Why the solution of salt is called ionic? ✓ A metal rod in which oxidation takes place? ✓ What energy conversion takes place in electrolytic cell? **Discussion and Explanation Method (the teacher will clear any misconceptions that the learners may have)** • **Facilitate group discussion/ Response from the above assessment activities.** • **Explain the concepts:** - Anode and Cathode electrode - Reducing and Oxidizing agent - Galvanic cell **3. Lesson development** 3.1 Contextualization questions: **The teacher will facilitate these question with the learners allow them to discuss their solutions in class (± 10 minutes can be spend)** • What type of energy exists in the electrolyte of car battery?	**1.** The type of electrochemical cell in which chemical energy is converted to electrical energy. **Galvanic cell** **2.** An ionic solution that conducts electricity. **Electrolyte solution** **3.** The reactant that donates electrons during a redox reaction. **An anode** 4. Write down the half cell reactions in which calcium reacts with sulphur. **$Ca\ (s) \rightarrow Ca^{2+}\ (aq) + 2e^-$ - Oxidation reaction** **$S\ (s) + 2e^- \rightarrow S^{2-}\ (aq)$ - Reduction reaction** **1. GROUP WORK ACTIVITY** **Learners will work in groups to find solutions:** Identification of the precipitate formed during the discoloration of the copper sulphate solution. 1.1 Write down and balance a reaction of Hydrochloric acid reacting with zinc, liberating hydrogen. Show the phases of the substances. **$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$** 1.2 Write down the reaction of Nitric acid reacting with copper. What is the colour solution? **$3\ Cu\ (s) + 8\ HNO_3\ (aq) \rightarrow 3\ Cu(NO_3)_2 + 4\ H_2O + 2\ NO$**	**Baseline assessment:** **± (15 min)** **Feedback: provide correct answers** **± (15 min)** **Demonstration and Explanation ± 15 minutes OR**	**Worksheet** **Chalkboard summary** **Charts/ or available resources**

• Is this battery secondary cell or primary cell? Explain • Why such cells are said to be self sustaining electrode reactions? • What type of energy conversion takes place when this cell operates in a car? • What is the difference between concentrated solution and saturated solution? **<u>DEMONSTRATION: (if there is enough resources – teacher can divide learners into groups)</u>** **To investigate the reaction between zinc metal and copper ions.** Prepare a dilute solution of copper sulphate by dissolving about 6g of copper sulphate crystals ($CuSO_4.5H_2O$) in 250 cm^3 of water.  ✓ What do you think is the cause of the blue colour of the solution? ✓ **Measure** the mass of the zinc plate before is immersed in the solution. ✓ After the zinc metal is placed in a solution do you notice any change? ✓ If so, do you recognize the substance formed? ✓ Do you notice any change in the intensity of the colour of the copper sulphate solution? ✓ If so, can you explain the change? ✓ Find the new mass of the plate. ✓ What has caused the change in mass?	**1.3** From the previous section, it appears that a reaction occurs when zinc metal Zn (s) comes into contact with copper ions Cu^{2+} (aq). However, **if copper is placed in a solution containing zinc ions** 1.3.1 Is there any reaction taking place? **No reaction takes place.** 1.3.2 Write down the equation which describes your assumption. **$Cu\ (s) + Zn^{2+}\ (aq) \rightarrow$ no reaction** 1.3.3 Is this reaction spontaneous or not spontaneous explaining your answer? **Not spontaneous, having to change external factors to start the reaction.** 1.3.4 Write down the equation that indicates reaction between zinc metal when it comes in contact with copper solution. **$Zn\ (s) + Cu^{2+}\ (aq) \rightarrow Zn^{2+}\ (aq) + Cu\ (s)$** 1.3.5 Is this reaction spontaneous or non spontaneous explain your answer? **Spontaneous reaction, takes place without having to change any external factors to start the reaction** **<u>HOMEWORK</u>** Since this sort of reaction finds wide application in a study of electrochemical cells, it is important to know which reactions between metals and metal ions actually lead to spontaneous reactions. In this connection, carry out the following investigation	**Illustrations and Explanation** **± 15 – 20 minutes**	**Relevant equipments/ or other available resources.**

Discussion

- ✓ The blue colour of the solution is caused by the presence of Cu^{2+} ions.
- ✓ The increase in mass of the plate confirms that a substance (Copper) was deposited on it.
- ✓ The solution gradually becomes clear.
- ✓ The Cu^{2+} ions which were in the solution precipitate out as Cu atoms, and the blue colour of the disappears.

The reaction can be represented as follows:

Cu^{2+} (aq) + $2e^-$ → Cu (s) ---------- (1)

Zn (s) → Zn^{2+} (aq) + $2e^-$ ---------- (2)

Cu^{2+} (aq) + Zn (s) → Zn^{2+} (aq) + Cu (s) ---------- (3)

- ✓ **Half – reaction (1)** shows the **reduction process.** Copper ions receive electrons and are reduced to copper atoms which are deposited on the zinc.
- ✓ **Half – reaction (2)** shows the **oxidation process** during which zinc atoms act as electron donors, are oxidized to zinc ions and thus go into solution.
- ✓ By once again adding the two half-reactions together, equation
- ✓ **(3)** results, which represents the complete reaction.
- ✓ During the process electrons are thus transferred from the zinc atoms to the copper ions.

TEACHING – ACTIVITY

HCl – is a compound which is broken into H^+ and Cl^-

HCl (aq) → H^+ (aq) + Cl^- (aq)

Practical Investigation:

Prepare dilute solutions (of concentration approximately 0, 1 $mol.dm^{-3}$) of the following salts.

$ZnSO_4$; $FeSO_4$; $CuSO_4$; $Pb(NO_3)_2$; $MgSO_4$; $AgNO_3$

Now use the pieces of the metals Zn, Fe, Cu, Pb, Mg and Ag.

Test which metals give spontaneous reactions with the salt solutions.

Remember after each test to clean the metal, and to use a fresh portion of the salt solution for each test.

Write equations for the half – reactions and the complete reaction for each spontaneous reaction which occurs.

Learners will work in groups to find solutions:

Solutions to this practical will be presented by groups to class.

Lesson Demonstration

± 15 minutes

Chalkboard summary

REDOX REACTION **Oxidation:** $Mg\ (s) \rightarrow Mg^{2+}\ (aq) + 2\ e^-$ **Reduction:** $2\ H^+\ (aq) + 2\ e^- \rightarrow H_2\ (g)$ **CONCLUSION:** • A **reducing agent** is a substance which, during a reaction, acts as an **electron donor** and is **oxidised** in the process. • A **oxidizing agent** is a substance which, during a reaction, acts as an **electron receiver** and is **reduced** in the process. • **Redox reactions** are characterised by the transfer of electrons. • Metal elements are mostly oxidised when reacting with non-metals. The teacher will then explain if these reactions spontaneous or / non-spontaneous			

Reflection/note

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

GRADE	12	SUBJECT	Physical Sciences	WEEK	18	TOPIC	**Electrochemical Reactions: (Lesson 1C)** o The **galvanic Cell:** ▪ Self sustaining electrode reactions Conversion of electrical energy into chemical energy	LESSON	- 1 (C)

LESSON SUMMARY FOR: DATE STARTED:	Follow up from previous lesson	DATE COMPLETED:	

LESSON OBJECTIVES

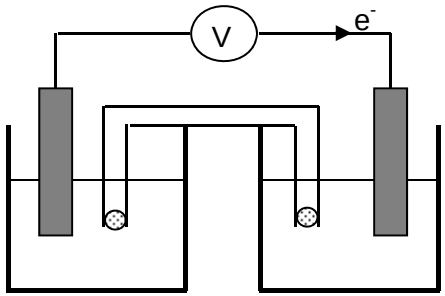
1. Learners will be **TAUGHT and LEARN** the following**:**

To define the galvanic cell in terms:

- o Definition of **Redox Reaction** – in relation to electron (e^-) transfer.
- o The importance redox reactions in relation to **energy conversion.**
- o The application of these reactions in electrochemical cell of torch cells, car battery, etc.

2. LESSON OUTCOMES – At the end of the lesson learners should be able to:

- define what is galvanic cell, using oxidation and reduction (electron (e^-) transfer)
- describe when the substance is **anode** and when the substance is **cathode.**
- describe galvanic cell as self sustaining electrode reactions
- understand conversion of electrical energy into chemical energy

TEACHER ACTIVITIES	LEARNER ACTIVITIES	TIMING	RESOURCES NEEDED
1. TEACHING METHODS USED IN THIS LESSON: **Explanations, illustrations, Demonstrations and questions and answer methods** **2. Lesson Development** **2.1 Introduction** **a) Pre-knowledge required.** • The teacher will introduce the lesson by giving learners **baseline assessment**. **OR** **RECAP QUESTION: TEST KNOWLDGE** 1.1 A standard voltaic cell is set up using a Ni | Ni^{2+} electrode as the positive electrode. The cell has emf of 2, 12 V. 1.1.1 Identify the negative electrode. Show all workings **EMF = $E^{\ominus}_{(cell)} = E^{\ominus}_{cathode} - E^{\ominus}_{anode}$** **2, 12 = - 0, 25 - $E^{\ominus}_{anode}$** **= - 2, 37 V (magnesium)** 1.1.2 Write down oxidizing agent in this cell. **$Ni^{2+}_{(aq)}$** **Discussion and Explanation Method (the teacher will clear any misconceptions that the learners may have)** • **Facilitate group discussion/ Response from the above assessment activities.**	**Baseline Assessment:** The galvanic cell represented in the diagram below consists of a Mg electrode dipped into a $Mg(NO_3)_2$ solution, and a Pb electrode dipped into a $Pb(NO_3)_2$ solution. Assume that the cell operates under standard conditions 1. State TWO standard conditions in which the cell operate. **(temperature 25 ^{0}C, Concentration 1 mol·dm^{-3})**  2. Write down the half – reaction that takes place in half- cell A. **($Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$)** 3. Write down the cell notation of this cell. **Mg(s) | Mg^{2+} (1mol·dm^{-3}) || Pb^{2+}(s) (1 mol·dm^{-3}) | Pb (s)** 4. Calculate the EMF of this cell. **EMF = $E^{\ominus}_{(cell)} = E^{\ominus}_{cathode} - E^{\ominus}_{anode}$** **= - 0, 13 – (-2, 36)** **= 2, 23 volts**	**Baseline assessment:** **± (15 min)** **Feedback: provide correct answers** **± (15 min)**	**Worksheet** **Chalkboard summary**

- **Explain the concepts:**

- In this section we investigated the indirect transfer of electrons using an electrochemical cell.

- The investigation clearly illustrates how chemical energy is converted into electrical energy.

- Galvanic cell is another type of electrochemical cells.

- We refer to this as indirect transfer of electrons.

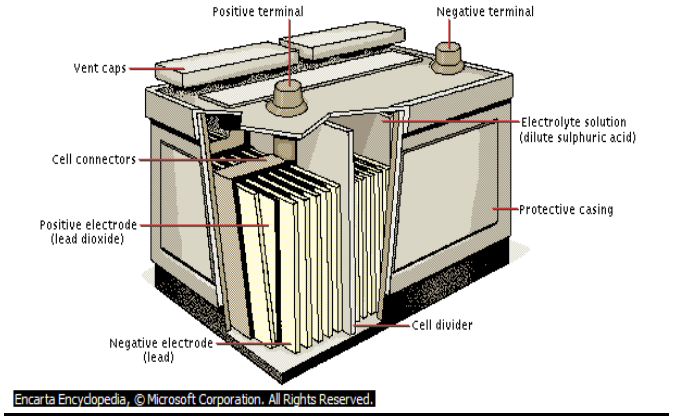
2 Lesson development

2.1 Contextualization questions:

The teacher will facilitate these question with the learners allow them to discuss their solutions in class (± 10 minutes can be spend)

- In industry, the use of electrochemical processes such as electroplating and the manufacture of certain chemicals such as liquid bleach are important.

- In our homes and offices we make use of batteries to power our radios, torches, laptops and toys.
- These batteries operate as electrochemical cell



5. How will each of the following changes influences the value EMF calculated above, WRITE only decrease increase or stays the same?

5.1 An increase in the concentration of [Mg^{2+}(aq)]

Decrease

5.2 An increase in the concentration of [Pb^{2+}(aq)]

Increase

6. In which direction from Half – Cell A to B, or Half – cell B to A do cations move within the salt bridge to maintain electrical neutrality? Explain how you arrived at your answer

Half cell A to Half cell B

Concentration of positive ions / cations / Pb^{2+} ions decreases in half-cell B. /

OR/OF

Concentration of positive ions / cations/Mg^{2+} ions increase in half- cell A.

• To prevent a build-up of positive ions in half-cell A and negative ions in half-cell B / For electrical neutrality, positive ions migrate from/through the salt bridge.

1. GROUP WORK ACTIVITY

Learners will work in groups to find solutions:

Identification of the precipitate formed during the discoloration of the copper sulphate solution.

1.2 Write down and balance a reaction of Hydrochloric acid reacting with zinc, liberating hydrogen. Show the phases of the substances.

$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

Demonstration and

Explanation

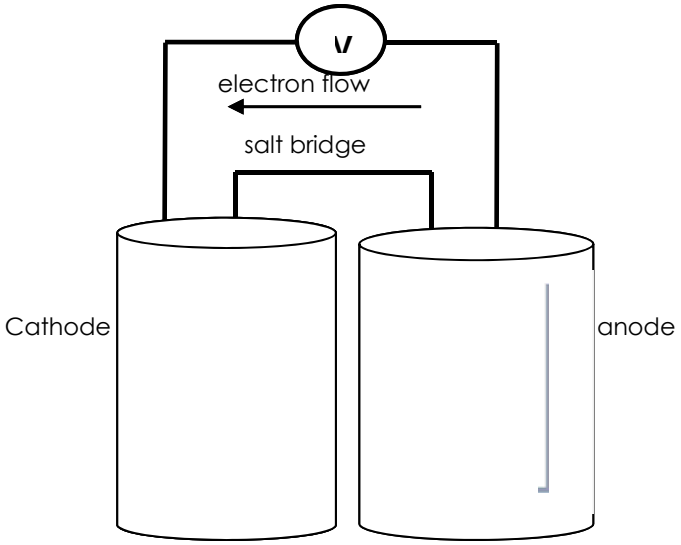
± 15 minutes

OR

Charts/ or available resources

INSTRUCTIONS AND DEMONSTRATION:

- Consider two half-cells connected by a salt bridge.
- The function of the salt bridge will be made clearer shortly.
- In the cell on the left, a silver electrode is dipping into a silver nitrate solution ($AgNO_3$ (aq).
- The cell on the right has a copper electrode dipped into a copper nitrate solution ($Cu(NO_3)_2$).
- A conducting wire connects the two electrodes to each other.
- The following reaction take place



Ag^+ (aq) + e^- → Ag (s) and Cu (s) → Cu^{2+} (aq) + $2e^-$

DISCUSSION

- The silver ions are reduced to produce silver atoms.
- The copper atoms are oxidised to copper ions.
- Electrons travel from the anode through the conducting wire to the cathode.

2. Write down the reaction of Nitric acid reacting with copper. What is the colour solution?

$3\ Cu(s) + 8\ HNO_3\ (aq) \rightarrow 3\ Cu(NO_3)_2\ (aq) + 4\ H_2O\ (l) + 2\ NO\ (g)$

11. From the previous section, it appears that a reaction occurs when zinc metal Zn (s) comes into contact with copper ions Cu^{2+} (aq). However, **if copper is placed in a solution containing zinc ions**

1.1.1 Is there any reaction taking place?

No reaction takes place.

1.1.2 Write down the equation which describes your assumption.

Cu (s) + Zn^{2+} (aq) → no reaction

1.1.3 Is this reaction spontaneous or not spontaneous explaining your answer?

Not spontaneous, having to change external factors to start the reaction.

1.1.4 Write down the equation that indicates reaction between zinc metal when it comes in contact with copper solution.

Zn (s) + Cu^{2+} (aq) → Zn^{2+} (aq) + Cu (s)

1.1.5 Is this reaction spontaneous or non spontaneous explain your answer?

Spontaneous reaction, takes place without having to change any external factors to start the reaction

Since this sort of reaction finds wide application in a study of electrochemical cells, it is important to know which reactions

Illustrations and Explanation

± 15 – 20 minutes

Relevant equipments/ or other available resources.

- These electrons are accepted by the silver ions which are then reduced to form silver atoms. **What happens in each of the solutions in each half cell** - In the copper half cell, the solution around the electrode is surrounded by Cu^{2+} ions. - To maintain the neutrality of the solution, negative ions are required. - Similarly in the silver half cell, the solution surrounding the electrode contains the negative ions (NO_3^-) - In order to maintain the neutrality in this half cell, positive ions are required. - The function of the salt bridge is to facilitate movement of negative and positive ions from solution of each half cell, thus preventing the build up of space charge around each electrode. - The construction of salt bridge is such that it allows for the movement of ions through it. - The salt bridge is filled with an electrolytic solution such as KNO_3 or KCl and is plugged at each end by porous plugs. **CONCLUSION:** • A **reducing agent** is a substance which, during a reaction, acts as an **electron donor** and is **oxidised** in the process.	between metals and metal ions actually lead to spontaneous reactions. In this connection, carry out the following investigation **Practical Investigation:** **(The practical can be done after the complete of the lesson)** **Students will perform practical experiments of Zinc/Copper electrochemical cell.** **Cell consists of two half cells each containing a solution of $CuSO_4$ and $ZnSO_4$ respectively.** - The concentration of each solution is 1 $mol.dm^{-3}$. - A salt bridge (usually KNO_3 or KCl) complete the circuit. - When the switch is closed, the ammeter registers a current, indicating electron flow through the connecting wire. **Learners will work in groups to find solutions:** **Solutions to this practical will be presented by groups to class.**	**Lesson Demonstration** **± 15 minutes**	**Chalkboard summary**

• A **oxidizing agent** is a substance which, during a reaction, acts as an **electron receiver** and is **reduced** in the process. • **Galvanic cells are self sustaining electrode cells.** • Electrodes are immersed in the electrolyte solution of separate beakers. • Salt bridge compete the external circuit of this reactions. • Energy is converted from chemical to electrical energy			

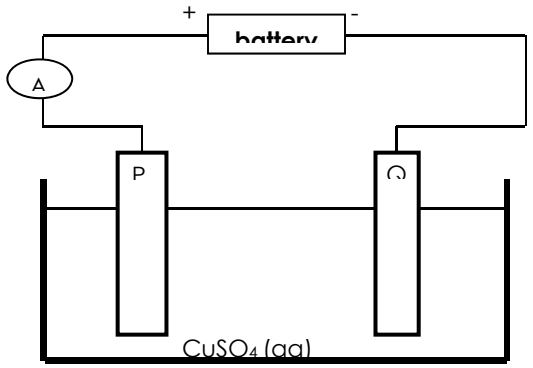
Reflection/note

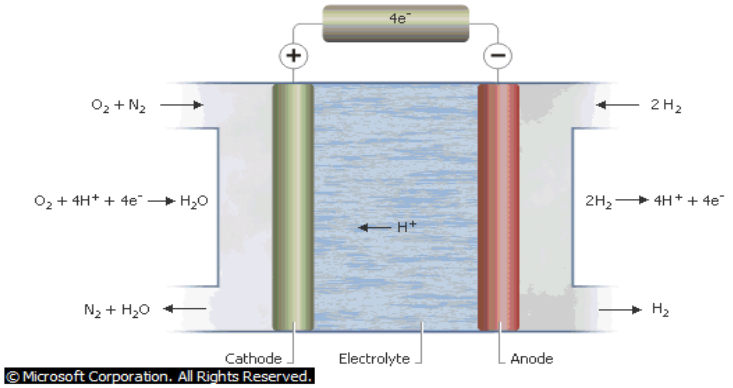
Name of Teacher		**HOD:**	
Sign:		**Sign:**	
Date:		**Date:**	

GRADE	**12**	**SUBJECT**	**Physical Sciences**	**WEEK**	**18**	**TOPIC**	**Electrochemical Reactions:** o **The electrolytic cell:** ▪ Electrode reactions that are sustained by a supply of electrical energy. Conversion of electrical energy into chemical energy	**LESSON**	**2**

LESSON SUMMARY FOR: DATE STARTED:		**DATE COMPLETED:**	
LESSON OBJECTIVES	**1.** Learners will be **TAUGHT and LEARN** the following**:** o To define the electrolytic cell in terms of ✓ Electrode reactions that are sustained by supply of electrical energy ✓ Conversion of electrical into chemical energy. o Relation of current and potential to rate and equilibrium. **2.** **LESSON OUTCOMES – At the end of the lesson learners should be able to:** • define what is an electrolytic cell in terms of electrode reactions that are sustained by supply of electrical energy. • What energy conversion takes place in this cell? • What is the relationship between current and potential to rate and equilibrium? • To write down anode half-reactions and the cathode half-reaction. • To indicate positive and negative terminal of electrode when connected to a battery		

TEACHER ACTIVITIES	**LEARNER ACTIVITIES**	**TIMING**	**RESOURCES NEEDED**
1. TEACHING METHODS USED IN THIS LESSON: **Explanations, illustrations, Demonstrations and questions and answer methods** **2. Lesson Development**	**Baseline Assessment:** a) What form of energy is found in the battery?		

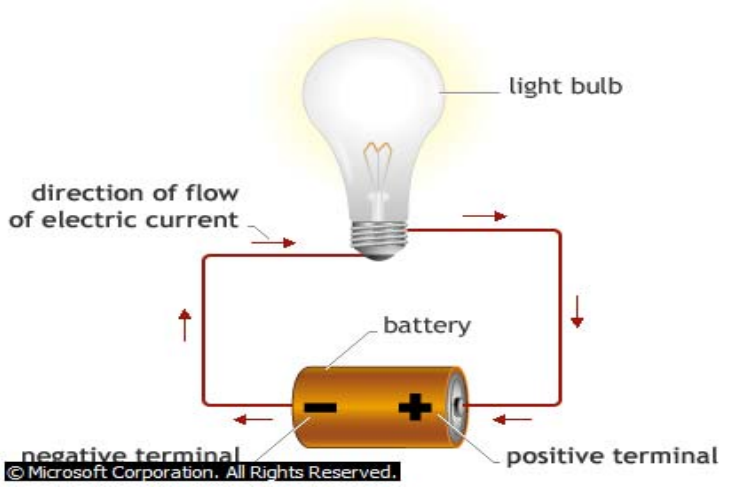
2.1 Introduction **a) Pre-knowledge required.** • The teacher will introduce the lesson by giving learners **baseline assessment**. **OR** • **Using question and answer method recap from previous knowledge?** • **Facilitate group discussion/ Response from the activity** • **Demonstration** – to introduce the **concepts** - Prepare the practical investigation of galvanic cell. • **Explanation** – Oxidation and Reduction and half cell reactions • **The teacher should ask questions**: One word item, multiple choice questions and longer questions. **Discussion and Explanation Method (the teacher will clear any misconceptions that the learners may have)** • **Facilitate group discussion/ Response from the above assessment activities.** • **Explain:** Anode and Cathode electrodes **3. Lesson development** **3.1 Contextualization questions:** • What form of energy is found in this cell?	✓ **Electrical energy** b) What form of energy is found in ionic solution? ✓ **Chemical energy** c) Mention the components of a complete external circuit. ✓ **Battery, conductors, switch, resistors and ammeter** d) What is the unit of the physical quantity potential difference of the battery? ✓ **Volts** e) Which elements will bond together in order to form table salt. ✓ **Sodium (Na) and Chlorine (Cl_2)** **1. GROUP WORK ACTIVITY** **Learners will work in groups to find solutions:** **1. GROUP WORK ACTIVITY** **Learners will work in groups**  	**Baseline assessment:** ± **(15 min)** **Feedback: provide correct answers** ± **(15 min)** **Demonstration and Explanation** **± 15 minutes**	**Worksheet** **Chalkboard summary** **Charts/ or available resources**



Fuel Cell

Fuel cells consist of an anode and a cathode, separated by an ionic conductor electrolyte. The electrons generated at the anode move through an external circuit containing the load and pass to the cathode. Fuel, commonly hydrogen, ammonia, or hydrazine, is supplied to the anode, while an oxidant, commonly air or oxygen, is
supplied to the cathode. Ions generated at the cathode are conducted by the electrolyte to the anode, where they form water by combining with hydrogen.

4. Lesson Presentation



1. Define the term electrolysis.

Decomposition reaction of molten or aqueous solution by an electric current. Electrical energy is converted into chemical energy.

2. Which electrode, P or Q, consists of the im copper? Explain how you arrived at your answer.

P = positive electrode (anode) because oxidation takes place at the positive elect anode.

3. Write down the half-reaction that takes pla electrode Q.

$Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$

4. During purification, metals such as silver an platinum form sludge at the bottom of the container.

Refer to the relative strengths of reducing a to explain why these two metals do not for during the purification process.

Pt and Ag are both weaker reducing agent copper and will not be oxidised, Copper is strong reducing agent.

OR

Illustrations and Explanation

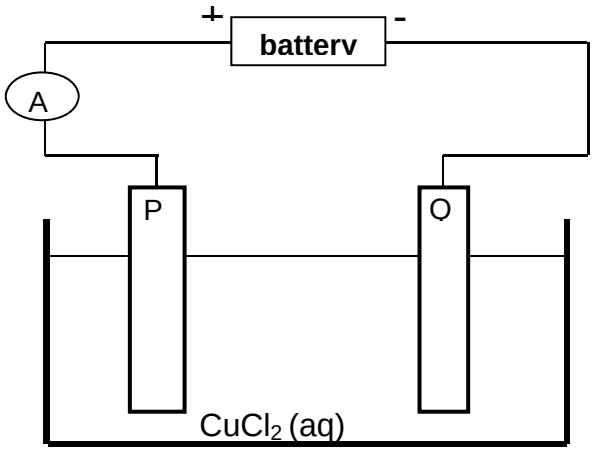
± 15 – 20 minutes

Relevant equipments/ or other available resources.

EXPLANATION:

- **Non – spontaneous** reaction is taking place.
- The chemical process happening in an electrolytic cell called **electrolysis.**
- Electricity in the form of **direct current** passes through a solution containing ions resulting in chemical changes at the electrode.
- **Metals and Non – Metals** are decomposed into two ions
- Metal ions are **positive** as metals lose **negative electrons**
- **Non-metal ions are negative as non-metals gain negative electrons**

VIDEO SHOW/ USING A CHART TO EXPLAIN ELECTROLYTIC CELLS



5. Explain why the concentration of the copper (II) sulphate solution remains constant. Assume that the only impurities in the copper are silver and platinum.

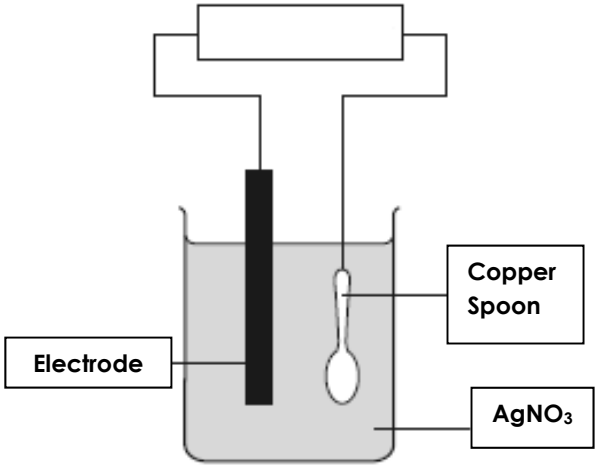
The rate at which copper is oxidised at the anode is equal to the rate at which copper ions are reduced at the cathode.

6. Why is the sludge of economic importance

Contains valuable/ expensive metals. Platinum and Silver are valuable/ expensiv metals

HOME WORK

Electroplating is one of the uses of electrolysis. The diagram below shows an electrolytic cell that can be used to plate a copper spoon with silver.



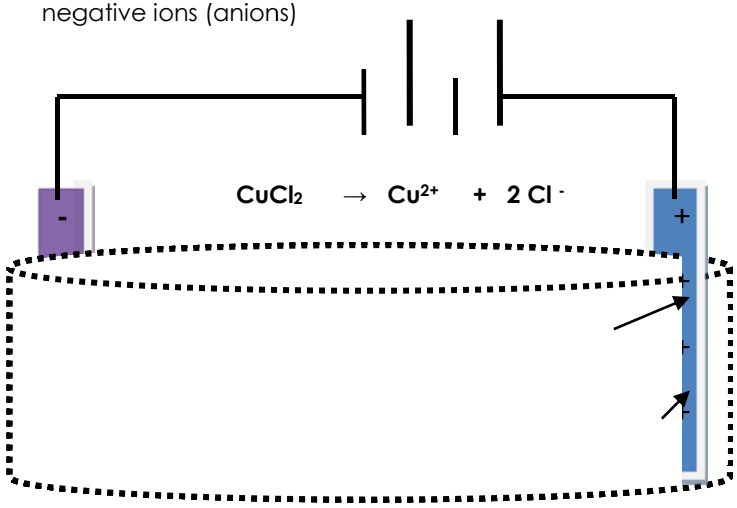
Lesson Demonstration

± 15 minutes

Chalkboard summary

DEMONSTRATION:

- An **electrode** is a **conductor** through which electrical current enters or leaves the conducting medium.
- A direct current battery is connected to two inert graphite electrodes (that do not react with the electrolyte or with the products of electrolysis).
- The electrodes are dipped into a molten copper (II)chloride electrolyte.
- The molten $CuCl_2$ decomposes or breaks up into positive ions (cations) and negative ions (anions)



$Cu^{2+} + 2e^- \rightarrow Cu$ $2Cl^- \rightarrow Cl_2 + 2e^-$

- Positive ions are attracted to the negative electrode
- and **gains electrons**
- Cathode half reaction
- **Copper metal** is **deposited** on this electrode

1. Define the term oxidation in terms of electron transfer.

   The process in which electrons are lost or given off by a substance.

2. What type of half-reaction takes place at the copper spoon? Write down only OXIDATION or REDUCTION.

   Reduction

3. Write down a half-reaction that explains the change that occurs on the surface of the copper spoon during electrolysis.

   Ag^+ (aq) + e^- → Ag (s)

4. Name the metal that is labelled 'electrode'.

   Silver/ Ag

5. Give a reason why the concentration of the $AgNO_3$(aq) remains constant during electrolysis.

   The rate of oxidation of (Ag) equals the rate of reduction (of Ag^+)

- Electrodes are reversed compared to a battery

$2Cl^-$ → Cl_2 + $2e^-$

- Negative ions are attracted to the positive electrode
- And **lose electrons**
- Anode half reactions
- **Chlorine gas** is formed at this electrode

TEACHING – ACTIVITY

1. Prepare a worksheet to describe half cell reactions of copper and chlorine.
2. Learners should describe cathode and anode in this cell.
3. Describe the direction in which electrons are moving.
4. What energy conversion would take place?
5. What do we understand by inert electrodes ?
6. What colour is the copper that is deposited onto the electrode?

CONCLUSION:

- Electrical energy is converted into chemical energy.
- Cathode is the negative electrode and anode is positive electrode.

The reaction is non- spontaneous.

BIBLIOGRAPHY

- Children Encarta – 2008 encyclopaedia
- GDE exam papers.
- Learner Work book – Watson Duncan

Reflection/note

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

GRADE	**12**	**SUBJECT**	**Physical Sciences**	**WEEK**	**18**	**TOPIC**	**Electrochemical Reactions:** o **Relation of current and potential to rate and equilibrium** ▪ Give and explain the relationship between current in an electrochemical cell and the rate of the reaction. ▪ State that the pd of the cell (V_{cell}) is related to the extend to which the spontaneous cell reaction has reached equilibrium State and use the qualitative relation between V_{cell} and the concentration of product ions and reactant ions for the spontaneous reaction.	**LESSON**	**3**

LESSON SUMMARY FOR: DATE STARTED:		**DATE COMPLETED:**	
LESSON OBJECTIVES	**1.** Learners will be **<u>TAUGHT and LEARN</u>** the following:- o Relationship between **current** in an electrochemical cell and the **rate of reaction** o State that the **pd of the cell** (V_{cell}) relate **spontaneous** reaction reached equilibrium o State relationship V_{cell} and the concentration of product ions and reactant ions o Effect of the concentration of solution on V_{cell} **2.** **<u>LESSON OUTCOMES</u> – At the end of the lesson learners should be able to:** • **Explain** how the rate of reaction affects the current that is produced by electrochemical reaction. • **What is the Pd (V_{cell})** of the cell in relation to their spontaneous reaction? • Explain how the **concentration of ions** affect reaction rate of the cell. • Explain the concept of **battery when "Flat".**		

	• Describe when battery is in equilibrium and draw the graphs. • State and use the qualitative relation between V_{cell} and the concentration of product ions and reactant ions for the spontaneous reaction.

TEACHER ACTIVITIES	LEARNER ACTIVITIES	TIMING	RESOURCES NEEDED
1. TEACHING METHODS USED IN THIS LESSON: **Explanations, illustrations, Demonstrations and questions and answer methods** **2. Lesson Development** **2.1 Introduction** **a) Pre-knowledge required.** • The teacher will introduce the lesson by giving learners **baseline assessment**. **OR** • **Using question and answer method recap from previous knowledge?** • **Facilitate group discussion/ Response from the activity** • **Demonstration** – to introduce the **concepts** - Prepare the practical investigation of galvanic cell. • **Explanation** – Oxidation and Reduction and half cell reactions • **The teacher should ask questions**: One word item, multiple choice questions and longer questions. **Discussion and Explanation Method (the teacher will clear any misconceptions that the learners may have)** • **Facilitate group discussion/ Response from the above assessment activities.** • **Explain:** Equilibrium, Potential difference, use $E^{\ominus}$ table,	**Baseline Assessment:** - Define the concept "current"? ✓ **Flow of charges/ ions in a solution** - Describe the reaction that is spontaneous? ✓ **Energy of the solution is enough to keep it working** - What instruments is used to measure the potential difference of the cell? ✓ **Voltmeter** - Explain the difference between closed and open circuit? ✓ **Closed circuit – when the current flows in a circuit by closing the switch** ✓ **Open circuit – when no current is flowing by the opening of switch** - What unit is the strength of solution measured in? ✓ **Mol· dm^{-3}**	**Baseline assessment:** **± (15 min)** **Feedback: provide correct answers** **± (15 min)**	**Worksheet** **Chalkboard summary**

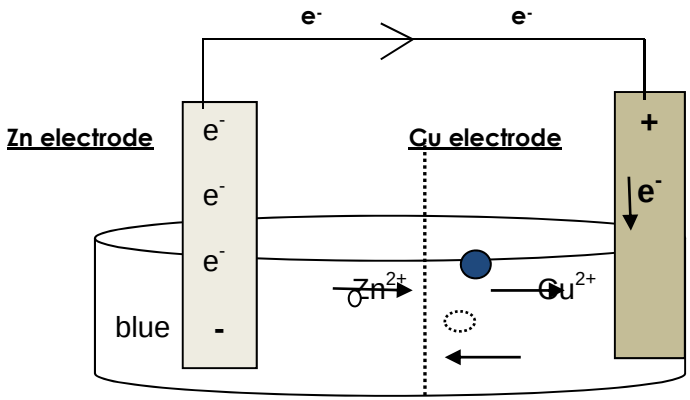
3. Lesson development

EXPLANATION:

- The rate of reaction depends upon current in the **galvanic Cell.**

- Current is maximum to begin with and **decreases** as the concentration of the reactants get used up.

- The reaction at the surface of the electrodes produce a



- Within the cell, current is carried by the **flow of ions.**

- To **maintain electrical neutrality**, positive and negative ions must be able to cross the boundary between the two half-cells.

- When the battery is fully charged, we say the battery is in **equilibrium**, there is no noticeable current through a battery.

- As reactants are used up and more products form, the increasing reverse reaction starts opposing the decreasing forward reaction, causing the EMF to decrease relative to standard conditions.

- When one of the reactants is almost used up, there is no more noticeable current and we say the battery is in equilibrium. It is "flat".

1. GROUP WORK ACTIVITY

Learners will work in groups to find solutions:

2. GROUP WORK ACTIVITY

- Predict what will happen when Zn metal is immersed in $CuSO_4$ solution.

✓ **Zinc metals will be coated with copper metal**

- What caused the blue colour of the solution?

✓ **Cu^{2+} ions in a solution**

- Judging from your observation, is the reaction spontaneous or non-spontaneous?

✓ **spontaneous**

- What is colour change of the solution as the reaction takes place?

✓ **The blue colour become clear/ disappear**

Demonstration and Explanation

± 15 minutes

OR

Illustrations and Explanation

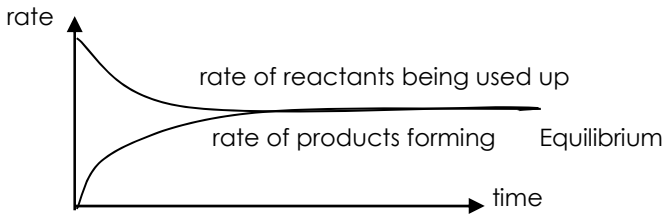
± 15 – 20 minutes

Charts/ or available resources

Relevant equipments/ or other available resources.

3. Lesson Presentation

TEACHING – ACTIVITY



REDOX REACTION

Cu^{2+} (aq) + Zn (s) $\rightleftharpoons$ Zn^{2+} (aq) + Cu (s)

Reactants Products

Use electrode potential table:

DL: Table

Practical Demonstration

- Learners will prepare a solution of copper sulphate in glass beaker

- Immerse zinc metal in the solution and observe what reaction is taking place

HOMEWORK

1.1 The Zn is (**oxidised**/ reduced) as it (gains/**loses**) electrons.

1.2 The electrons lost by Zn are transferred to the **Cu^{2+} ions**.

1.3 The Cu^{2+} is (oxidised/ **reduced**) as it (**gains**/ loses).

1.4 What gives the colour of the copper solution blue?

✓ **Cu^{2+} ions**

1.5 Write down half cell reaction that occurs on zinc.

✓ **$Zn \rightarrow Zn^{2+} + 2e^-$**

1.6 How can we get the Zinc half-reaction and the copper half-reaction to release their stored up chemical energy as thermal energy. How do we observe this?

Lesson Demonstration

± 15 minutes

Chalkboard summary

CONCLUSION: • Oxidation and Reduction occurs simultaneously • When the battery is to be "flat", reaction rate has reached equilibrium. **Electrons** flow from **negative electrode** to **positive electrode**			

Reflection/note

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

GRADE	**12**	**SUBJECT**	**Physical Sciences**	**WEEK**	**18**	**TOPIC**	**Electrochemical Reactions:** o **Understanding of the processes and redox reaction taking place in the cell.** ▪ Movement ions through the solutions. ▪ The electron flow in the external circuit of the cell and ▪ Their relation to the half reactions at the electrodes The function of the salt bridge.	**LESSON**	**4**

LESSON SUMMARY FOR: DATE STARTED:		**DATE COMPLETED:**	

LESSON OBJECTIVES

1. Learners will be **TAUGHT and LEARN** the following:

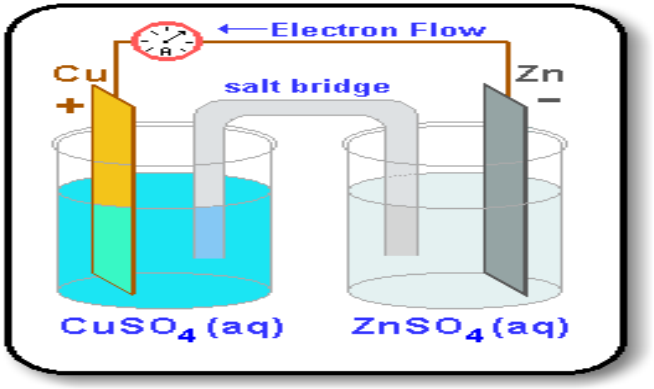
o **Understanding of the processes and redox reaction taking place in the cell.**

- Movement ions through the solutions.
- The electron flow in the external circuit of the cell and
- Their relation to the half reactions at the electrodes
- The function of the salt bridge.

2. **LESSON OUTCOMES – At the end of the lesson learners should be able to:**

- Describe movement of ions through the solutions,
- Identify cations and anions in the cell.
- State the functions of the salt bridge.
- The type of salt found in the salt bridge.
- To indicate positive and negative terminal of electrode when connected to a battery

TEACHER ACTIVITIES	LEARNER ACTIVITIES	TIMING	RESOURCES NEEDED
1. **TEACHING METHODS USED IN THIS LESSON:** **Explanations, illustrations, Demonstrations and questions and answer methods**	**Baseline Assessment:** **Individual Work:** - An ion is : **charged atom or group of**		

2. Lesson Development **2.1 Introduction** **a) Pre-knowledge required.** • The teacher will introduce the lesson by giving learners **baseline assessment**. **OR** • **Using question and answer method recap from previous knowledge?** • **Facilitate group discussion/ Response from the activity** • **Demonstration** – to introduce the **concepts** - Prepare the practical investigation of galvanic cell. • **Explanation** – movement of ions in a solution • **The teacher should ask questions**: One word item, multiple choice questions and longer questions. **Discussion and Explanation Method (the teacher will clear any misconceptions that the learners may have)** • **Facilitate group discussion/ Response from the above assessment activities.**  	**atoms** - An anion is : **A negatively charged ion** - cation is: **A positively charged ion** - OILRIG stands for: **Oxidation is the loss of electrons, reduction is the gain of electrons** - LEO stands for : **Loss of electrons is oxidation** - GER stands for : **Gain of electrons is reduction** **1. FACILITATE GROUP DISCUSSIONS** **Find the EMF of the following electrochemical cells under standard conditions** **Ba and Sn:** **$E^{\ominus}$ Sn - $E^{\ominus}$ Ba = - 0, 14 – (- 2, 9) = 2, 76 V** **Ca and Mn:** **$E^{\ominus}$ Mn - $E^{\ominus}$ Ca = - 1, 18 – (- 2,87) = 1, 69 V** **Co and Ag:**	**Baseline assessment:** **± (15 min)** **Feedback: provide correct answers** **± (15 min)** **Demonstration and Explanation** **± 15 minutes** **OR**	**Worksheet** **Chalkboard summary** **Charts/ or available resources**

Lesson development

Movement of ions through the solution:

- Positive ions (cations) will move in the same direction (from anode - negative to cathode - positive).
- The Cu^{2+} ions move towards the copper plate, attracted by the electrons that have flowed from the Zn plate
- The positive charge in the cathode solution thus gets less.
- In response to this charge imbalance, the K^{+} ions in the salt bridge migrate into the cathode solution to replace the

Missing positive charge and thus keep the solution neutral.

- The Zn dissolves and the Zn^{2+} ions entre the solution near the Zn electrode.
- This increases the concentration of Zn^{2+} ions in the anode solution and the positive charge thus build up.
- To maintain the neutrality, the excess Zn^{2+} ions migrate into the salt bridge.
- The electrons left by the dissolving zinc, remain on the Zn plate. As this negative charge builds up it repels the electrons through the wire towards the Cu electrode. These electrons then attracted the Cu^{2+} ions.
- The Cu^{2+} ions move towards the copper plate, attracted by the electrons that have flowed from the Zn plate in the external circuit.
- The positive charge in the cathode solution thus gets less. The negative sulphate ions in the cathode solution migrate into the salt bridge to get rid of the excess negative charge.

Function of the salt bridge: (symbol //)

1. The salt bridge maintains the electrical neutrality of the half cell solutions.
2. The salt bridge connects the two solutions and completes the circuit.
3. The salt bridge replace the imbalance of ions keep the two solutions neutral

$E^{\ominus}$ Ag - $E^{\ominus}$ Co = +0, 8 – (- 2, 08) = 1, 08 V

Zn and Cu:

$E^{\ominus}$ Cu - $E^{\ominus}$ Zn = + 0, 34 – (-0,76) = 1, 1 V

Mg and Pb:

$E^{\ominus}$ Pb - $E^{\ominus}$ Mg = - 0, 13 – (-2, 37) = 2, 24 V

1. GROUP WORK

The cell notation of a standard galvanic (voltaic) cell containing an unknown metal electrode X is shown below.

X(s) | X^{3+}(1 mol·dm^{-3}) || Pb^{2+}(1 mol·dm^{-3}) | Pb(s)

1.1 Name the component of the cell represented by the double vertical lines (| |) in the above cell notation.

Answer: Salt bridge

1.2 State the TWO standard conditions that are applicable to the Pb^{2+}/Pb half-cell.

Answer: Concentration of the electrolyte – 1 mol·dm^{-3} and Temperature of 25^{0}C/ 298 K

1.3 Identify the oxidising agent in the

Illustrations and Explanation

± 15 – 20 minutes

Relevant equipments/ or other available resources.

4. The voltmeter between the two will now read 1 V, the two half-cells form a full cell (battery). **<u>The standard conditions under which standard electrode potentials are determined</u>** 1. These values were measured at 25^0C (101,3 kPa) 2. Using the concentration of 1 mol·dm^{-3} These values are indicated by symbol Θ. (it used to be E$^{\ominus}$) **<u>CONCLUSION:</u>** • Positive ions from the salt bridge balance the solutions • Electron will flow from negative pole to positive of the cell • Zn dissolves and the Zn^{2+} ions enter the solution • Zn electrode loses mass as it dissolves. • Cu electrode gains mass as Cu atoms deposit on it. **<u>BIBLIOGRAPHY:</u>** - <u>Learner work book: Duncan Watson</u> - <u>Power point presentation – physical science</u>	above cell. **Answer: Pb^{2+}/ lead (II) ions** 1.4 The initial reading on a voltmeter connected across the electrodes of the above cell is 1,53 V. Identify metal X by calculating the standard reduction potential of the unknown metal X. **Answer:** **$E^{\ominus}$ cell = $E^{\ominus}_{cathode}$ - $E^{\ominus}_{anode}$** **1, 53 = (- 0, 13) - $E^{\ominus}_{anode}$** **$E^{\ominus}$ = -1, 66 V, unknown metal X is aluminium** 1.5 Write down the balanced equation for the net (overall) reaction taking place in this cell. Omit the spectator ions. **Answer: 2 Al (s) + 3 Pb^{2+} (aq) → 2Al^{3+} (aq) + 3 Pb (s)** 1.6 How will the initial voltmeter reading be affected if the concentration of the electrolyte in the X(s) | X^{3+}(aq) half-cell is increased? Write down only INCREASES, DECREASES or REMAINS THE SAME. **Answer: Decrease**	**Lesson Demonstration** **± 15 minutes**	**Chalkboard summary**

	1.7 Write down the value of the reading on the voltmeter when the cell reaction has reached equilibrium. **Answer: 0 V**		

Reflection/note

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

GRADE	12	SUBJECT	Physical Sciences	WEEK	19	TOPIC	**Electrochemical Reactions:** ▪ **Standard Electrode potential:** o Standard hydrogen electrode o Use the table of standard reduction potentials o Positive value indicates spontaneous under standard conditions	Lesson	1

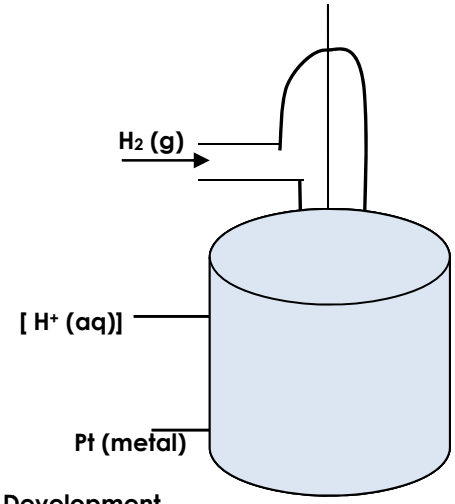
LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	

LESSON OBJECTIVES	**1.** Learners will be **TAUGHT and LEARN** the following: To describe: the standard hydrogen electrode and explain its role as the reference electrode. Explain how standard electrode potentials can be determined using the reference electrode Use the table of standard reduction potentials to deduce the emf of a standard galvanic cell Use positive value of the standard emf as an indication that the reaction is spontaneous under standard conditions. **LESSON OUTCOMES – At the end of the lesson learners should be able to:** • To describe: the standard hydrogen electrode and explain its role as the reference electrode. • Explain how standard electrode potentials can be determined using the reference electrode • Use the table of standard reduction potentials to deduce the emf of a standard galvanic cell • Use positive value of the standard emf as an indication that the reaction is spontaneous under standard conditions.

TEACHER ACTIVITIES	LEARNER ACTIVITIES	TIMING	RESOURCES NEEDED
1. TEACHING METHODS USED IN THIS LESSON: **Explanations, illustrations, Demonstrations and questions and answer methods** **2. Lesson Development** **2.1 Introduction** **a) Pre-knowledge required.**	**Baseline Assessment:** **Individual Work:** 1.1 What instruments is used to measure electrical potential? **Answer**: **voltmeter** 1.2 Define the concepts Oxidation and Reduction.	**Baseline assessment:** **± (15 min)**	**Worksheet**

• The teacher will introduce the lesson by giving learners **baseline assessment**. **OR** • **Using question and answer method recap from previous knowledge?** • **Facilitate group discussion/ Response from the activity** • **Demonstration** – to introduce the **concepts** - Prepare the practical investigation of galvanic cell. • **Explanation** – Oxidation and Reduction and half cell reactions • **The teacher should ask questions**: One word item, multiple choice questions and longer questions. **Discussion and Explanation Method (the teacher will clear any misconceptions that the learners may have)** • **Facilitate group discussion/ Response from the above assessment activities.** • **Explain:** Anode and Cathode electrode **3. Lesson development**	**Answer: Oxidation – loss of electrons by a substance** **Reduction – gain of electrons by a substance** 1.3 What is an electrolyte? **Answer**: **a pure substance that is an electrical conductor due to the movement of ions when it is in solution.** 1.4 Why is a metal electrode necessary in a half-cell? **Zn → Zn^{2+} + $2e^-$** **Answer: it acts as an electrical conductor** 1.5 Why is this anode? **Answer: Oxidation occurs at the anode** 1.6 The Zn atoms are (**oxidised**/ reduced) as it (gains/ **loses**) electrons. **GROUP WORK ACTIVITY** 1.1 Describe the external circuit of the galvanic cell. **Answer: It is the wire connecting the two electrodes plus any electrical device that is connected to this wire. A flow of electrons occurs in the external circuit from anode to cathode.** **COMPARE COPPER AND HYDROGEN ELECTRODE** **2 Learners WILL draw and label a sketch**	**Feedback: provide correct answers** **± (15 min)** **Demonstration and Explanation** **± 15 minutes** **OR**	**Chalkboard summary** **Charts/ or available resources**

A simple form of hydrogen electrode



3. Lesson Development

3.1 Contextualization questions:

- When measuring height, we usually say the ground level is zero.
- In Geography, sea level is chosen as the zero height.
- Hydrogen half- cell is chosen as the standard with **zero potential**

4. Lesson Presentation

EXPLANATION:

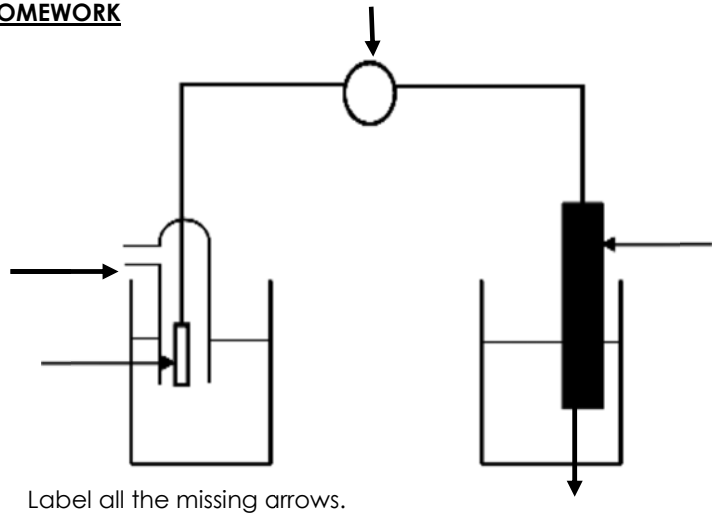
- The potential difference between a metal and a solution of the metals ions is called the **metal electrode potential.**

- Platinum shows no tendency to **dissolve.**

- It adsorbs [sic] Hydrogen onto its surface as single atoms and brings them into close contact with their dissolved ions, H^+ (aq).

- The standard electrode chosen is the **hydrogen electrode.**

HOMEWORK



1. Label all the missing arrows.
2. Name the type of electrochemical cell that converts chemical energy to electrical energy.

Answer: **Galvanic Cell**

3. If the electrochemical cell is set up as illustrated, there will be no reading on the voltmeter. Give a reason for this observation.

Answer: Incomplete circuit/ No salt bridge

4. Write down the value of the standard emf of the electrochemical cell when it is functioning.

Answer: **0, 76 V**

5. Write down the voltmeter reading when the net cell reaction in the above electrochemical cell reaches equilibrium.

Answer: **Zero**

Illustrations and Explanation

± 15 – 20 minutes

Relevant equipments/ or other available resources.

- The standard hydrogen half-cell has a **standard electrode potential, E⊖, defined as 0, 00 volts.**

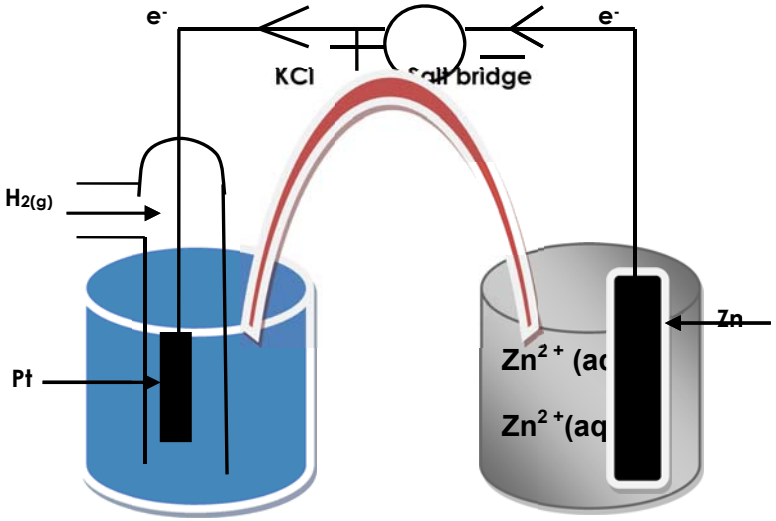
- The electrode potentials of other chemicals can be **compared to the hydrogen electrode potential.**

- A **voltmeter** is used to measure the electrode of the other metals relative to hydrogen electrode if all standard conditions are considered.

- All ionic solutions must be at a **concentration** of **1 mol ·dm^{-3}**
- Any gas involved must be at a **pressure of 101, 3 kPa (atmospheric pressure).**
- All substances must be at a **temperature of 25 ^{0} C (298 K)**
- **Platinum** must be used as the electrode when the half-cell system does not include a metal.

Comparing zinc and hydrogen electrode potential

TEACHING – ACTIVITY



6. Write down the equation for the reaction that occurs at the anode.

Answer: **Zn (s) → Zn^{2+} + $2e^{-}$**

Another electrochemical cell is set up under standard conditions by replacing the standard hydrogen half-cell with a standard magnesium half-cell.

7. Which electrode will undergo a decrease in mass? Give a reason for your answer.

Mg, because magnesium is oxidised

8. Calculate the initial emf of this electrochemical cell at standard conditions.

Answer: $E^{\ominus}$ **(cell)** = $E^{\ominus}_{(oxidising\ agent)}$ - $E^{\ominus}_{(reducing\ agent)}$
= - 0, 76 - (- 2, 6)
= + 1, 6 V

9. After a while the emf of this electrochemical cell decreases. Explain this observation by referring to the concentration of the electrolytes.

Answer:
As the cell functions, the concentration of zinc ions (reactants) decreases relative to standard conditions and the concentration of magnesium ions (products) increases relative to standard conditions . The reverse reaction starts opposing the forward reaction causing the emf to decrease relative to standard conditions.

10. Electrochemical cells such as motor car batteries with plastic casings can harm the environment if not disposed of safely. Suggest TWO ways how motor car batteries can be safely disposed of.

Answer:
Neutralise acid before disposal/ • Recycle plastic casing and lead electrodes/

Lesson Demonstration

± 15 minutes

Chalkboard summary

o 0, 000 volt assigned to the hydrogen. o **– 0, 76 V** for **$Zn^{2+}|Zn$** is called the relative standard potential. o **Cell notation**: **Pt, $H_{2\,(gas)}$	$H^{+}_{(aq)}$ || $Zn^{2+}_{(aq)}$	Zn $_{(s)}$** o **Solid double** lines indicates **salt bridge** o **Customary:** the hydrogen electrode is always written on the left o **The potential of the cell is defined as:** **$E^{\ominus}_{cell} = E^{\ominus}_{cathode} - E^{\ominus}_{anode}$ / $E^{\ominus}_{cell} = E^{\ominus}_{reduction} - E^{\ominus}_{oxidation}$** **CONCLUSION:** • The standard hydrogen electrode is used to determine the electrode potential of the other electrodes. • Positive reading, it indicates that the electrons are moving from the hydrogen electrode to the other electrode. • Negative reading, it indicates that the hydrogen electrode is now the cathode (reduction) occurs. Electrons flow from negative electrode to positive electrode			

Reflection/note

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

GRADE	**12**	**SUBJECT**	**Physical Sciences**	**WEEK**	**19**	**TOPIC**	**Electrochemical Reactions:** o **Writing of equations representing oxidation and reduction half cell reactions and redox reactions** • Predict the half-cell in which oxidation will take place. • Predict the half cell in which reduction will take place. • Write equations for reactions taking place at the anode and cathode. • Deduce the overall cell reaction by combing two half-reaction	**Lesson**	**2**

LESSON SUMMARY FOR: DATE STARTED:		**DATE COMPLETED:**	

LESSON OBJECTIVES	**1.** Learners will be **TAUGHT and LEARN** the following**:** o **Writing of equations representing oxidation and reduction half cell reactions and redox reactions** ▪ Predict the half-cell in which oxidation will take place. ▪ Predict the half cell in which reduction will take place. ▪ Write equations for reactions taking place at the anode and cathode. ▪ Deduce the overall cell reaction by combing two half-reaction **2. LESSON OUTCOMES – At the end of the lesson learners should be able to:** ▪ Predict the half-cell in which oxidation will take place. ▪ Predict the half cell in which reduction will take place. ▪ Write equations for reactions taking place at the anode and cathode. ▪ Deduce the overall cell reaction by combing two half-reaction

TEACHER ACTIVITIES	**LEARNER ACTIVITIES**	**TIMING**	**RESOURCES NEEDED**
1. TEACHING METHODS USED IN THIS LESSON: **Explanations, illustrations, Demonstrations and questions and answer methods**	**Baseline Assessment:** **One word question**		

2. Lesson Development

2.1 Introduction

a) Pre-knowledge required.

- The teacher will introduce the lesson by giving learners **baseline assessment**.

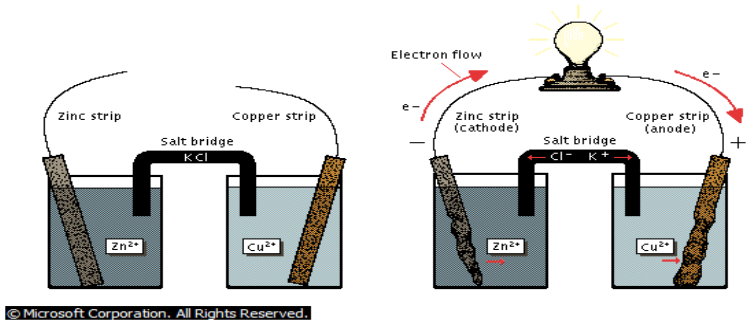
OR

- **Using question and answer method recap from previous knowledge?**
- **Facilitate group discussion/ Response from the activity**
- **Demonstration** – to introduce the **concepts**
- Prepare the practical investigation of galvanic cell.
- **Explanation** – concepts
- **The teacher should ask questions**: One word item, multiple choice questions and longer questions.

Discussion and Explanation Method (the teacher will clear any misconceptions that the learners may have)

3. Lesson development

VIDEO SHOW/ USING A CHART TO EXPLAIN GALVANIC CELLS



Voltaic Cell: A Chemical Battery

1. A substance that shows a decrease in oxidation number during chemical reaction.

Oxidizing agent

2. The electrode in an electrochemical cell where oxidation occurs.

Anode.

3. The unit in which $E^{\ominus}$ is measured. **Volts**

Multiple Choice:

1. The reactions below occur in two different electrochemical cells X and Y.

Cell X: $CuCl_{2\,(aq)} \rightarrow Cu_{(s)} + Cl_{2\,(g)}$

Cell Y: $Zn_{(s)} + CuSO_{4\,(aq)} \rightarrow Cu_{(s)} + ZnSO_{4\,(aq)}$

	Cell X	Cell Y
A	$Cl_{2\,(g)}$	$Cu_{(s)}$
B	$Cu_{(s)}$	$Cu_{(s)}$
C	$Cl_{2\,(g)}$	$ZnSO_{4\,(aq)}$
D	$Cu_{(s)}$	$ZnSO_{4\,(aq)}$

Baseline assessment:

± (15 min)

Feedback: provide correct answers

± (15 min)

Worksheet

Chalkboard summary

DEMONSTRATION AND PREDICTIONS:

- Oxidation (loss of e^-) will take place at an anode.
- Reduction (gain of e^-) will take place at a cathode.
- Anode is the negative electrode
- Cathode is the positive electrode.
- A half reaction represents either **oxidation only or reduction only.**
- **Represent**: **Zn | Zn^{2+} half cell or Cu | Cu^{2+} half cell**
- From the **$E^{\ominus}$ Table:**

Cu^{2+} + 2 e^- ⇌ Cu + 0, 34 V

Zn^{2+} + 2 e^- ⇌ Zn - 0, 76 V

Zn → Zn^{2+} + 2e^- -0, 76 V (Anode)

Cu^{2+} + 2e^- → Cu +0, 34 V (Cathode)

Zn + Cu^{2+} → Zn^{2+} + Cu

Overall Cell:
The double arrow ⇌ means each half cell could either gain or lose electrons, depending on what other half – cell it is connected to.

Half Reaction of Copper:

- Cu^{2+} is positive about gaining electrons, so the **forward reaction is favoured.**

Cu^{2+} + 2 e^- → Cu + 0, 34 V

Cu^{2+} gains 2 electrons to form Cu (s).

Cu^{2+} is **reduced** and is thus the **cathode.**

Answer: B

2. Which ONE of the following statements regarding the anode of a standard galvanic cell in operation is correct?

A. The anode accepts electrons.
B. The mass of the anode decreases.
C. The concentration of the electrolyte in the half-cell containing the anode initially decreases.
D. The anode is the positive terminal of the cell.

Answer: B

3. When the net (overall) cell reaction in a galvanic (voltaic) cell reaches equilibrium, the emf of the cell is equal to ...

A +2,00 V.

B +1,00 V.

C 0,00 V.

D -1,00 V.

Answer: C

1. GROUP WORK

The diagram below represents a galvanic (voltaic) cell functioning under standard conditions with magnesium and silver as electrodes. A voltmeter connected across the electrodes shows an initial reading of 3,17 V

Demonstration and Explanation

± 15 minutes

OR

Illustrations and Explanation

± 15 – 20 minutes

Charts/ or available resources

Relevant equipments/ or other available resources.

Half Reaction of Zinc:

- Zn^{2+} is negative about gaining electrons, so the **reverse reaction is favoured.**

$$Zn^{2+} + 2e^- \leftarrow Zn \quad -0,76\ V$$

You may not write it like this thus correctly written:

$$Zn \rightarrow Zn^{2+} + 2e^- \quad -0,76\ V$$

- Zn loses 2 electrons to form Zn^{2+} (aq)
- Zn is **oxidised** and is thus the **anode**

CONCLUSION:

- Positive ions from the salt bridge balance the solutions
- Electron will flow from negative pole to positive of the cell
- Zn dissolves and the Zn^{2+} ions enter the solution
- Zn electrode loses mass as it dissolves.
- Cu electrode gains mass as Cu atoms deposit on it.

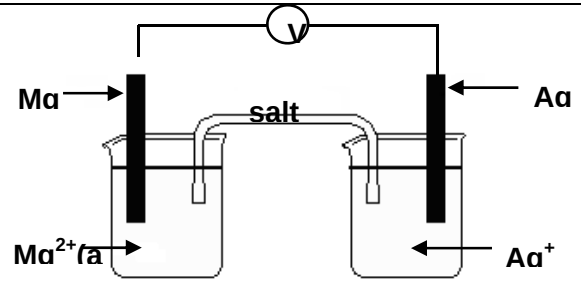
SOLUTION TO GROUP WORK ACTIVITY:

4.1 Chemical (potential) energy to electrical (potential) energy.

4.2 Temperature = 25 ^{0}C /298 K.

Concentration of electrolytes = 1 mol·dm^{-3}

4.3 Magnesium / Mg
Magnesium is a stronger reducing agent, (than Ag)
therefore Mg will be oxidised/;lose electrons.



4.1 State the energy conversion that takes place in this cell.

4.2 State TWO standard conditions under which this cell operates.

4.3 Identify the anode of this cell. Refer to the relative strength of reducing agents to explain how you arrived at the answer.

4.4 Write down the cell notation (symbolic notation) of this cell.

4.5 Write down the balanced equation for the net (overall) cell reaction that takes place in this cell. Omit the spectator ions.

Lesson Demonstration

± 15 minutes

Chalkboard summary

4.4 Mg | Mg2+ (1 mol·dm-3) || Ag+ (mol·dm-3) | Ag **OR** Mg | Mg2+ || Ag+ | Ag **OR** Mg(s) | Mg2+ (aq) || Ag+ (aq | Ag(s) 4.5 Mg + 2Ag+ Mg2+ + 2Ag bal 4.6 Increases. (Or any equivalent word) The rate of the forward reaction increases (when [Ag+] increases.) / Tendency for the reaction to proceed from left to right increases. More electrons are released per unit time. **BIBLIOGARPHY:** - Children Encarta – 2008 - GDE question paper – 2011 -	4.6 How will an increase in the concentration of the Ag^+ ions influence the current that the cell delivers? Write down only INCREASES, DECREASES or REMAINS THE SAME and explain the answer.		

Reflection/note

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

GRADE	12	SUBJECT	Physical Sciences	WEEK	19	TOPIC	**Electrolytic Reactions:** ▪ Describe, using half equations and the equation for the overall cell reaction, o The decomposition of copper chloride o A simple example of electroplating (e.g. the refining copper)	Lesson	3

LESSON SUMMARY FOR: DATE STARTED:		DATE COMPLETED:	

LESSON OBJECTIVES

1. Learners will be **TAUGHT and LEARN** the following:

- Describe, using half equations and the equation for the overall cell reaction,
  - o The decomposition of copper chloride
  - o A simple example of electroplating (e.g. the refining copper)
- The concept electr oplating of metals
- The coating a metal (eg. iron) with another metal (eg. tin) because tin has a more useful property of not rusting
- Electroplating depends on current strength, concentration, temperature, distance between electrodes and surface preparation
- The use of this technique to purify copper

2. **LESSON OUTCOMES – At the end of the lesson learners should be able to:**

- write down half cell reaction for electroplating
- give examples of metals that do not oxidise easily.
- identify the compound that must be used as the anode or the cathode during electroplating.

TEACHER ACTIVITIES	LEARNER ACTIVITIES	TIMING	RESOURCES NEEDED
1. **TEACHING METHODS USED IN THIS LESSON:** **Explanations, illustrations, Demonstrations and questions and answer methods** 2. **Lesson Development**	**Baseline Assessment:** **Individual Work:** 1. Define the concept oxidation of metals.		

2.1 Introduction

a) Pre-knowledge required.

- The teacher will introduce the lesson by giving learners **baseline assessment**.

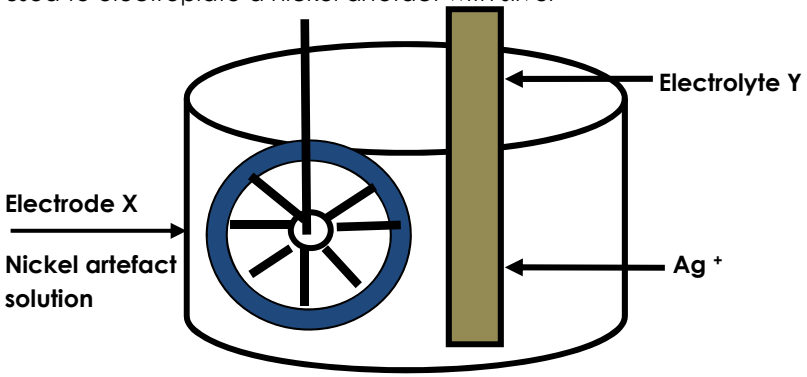
OR

- **Using question and answer method recap from previous knowledge?**
- **Facilitate group discussion/ Response from the activity**
- **Demonstration** – to introduce the **concepts**
  - Prepare the practical investigation of galvanic cell.
- **Explanation** – concepts
- **The teacher should ask questions**: One word item, multiple choice questions and longer questions.

Discussion and Explanation Method (the teacher will clear any misconceptions that the learners may have)

3. Lesson development

An attractive silver appearance can be created by electroplating artefacts made from cheaper metals, such as nickel, with silver. The simplified diagram below represents an arrangement that can be used to electroplate a nickel artefact with silver



Answer: Loss of electrons by metals

2. The properties of metals and non – metals.

Non – Metals: **Cannot conduct electricity**

Metals: **conduct electricity**

3. Chemical formula: Silver Nitrate and Potassium Cyanide

Answer: **$AgNo_3$ and KCN**

4. Mention products that are used daily in households that are plated.

Answer: **Teapot, Knife**

5. What energy conversion takes place when electroplating?

Answer: **Electrical energy is converted to chemical energy**

GROUP WORK ACTIVITY

a. Which electrode (**cathode**/anode) will the nickel artefact represent?
b. Name the metal represented by electrode Y. **(Silver)**
c. Write down the half-reaction responsible for the change that occurs at the surface of the artefact.

$Ag^+ + e^- \rightarrow Ag$

d. Give a reason why the concentration of the electrolyte remains constant during electroplating.
The rate of oxidation of silver at the anode is equal to the rate of reduction of silver ion at the cathode

e. In industry some plastic articles are sometimes electroplated. Explain why plastic must be coated with graphite before electroplating.

Plastic is a non-conductor, graphite is a conductor

Baseline assessment:

± (15 min)

Feedback: provide correct answers

± (15 min)

Worksheet

Chalkboard summary

1. Which electrode (cathode/anode) will the nickel artefact represent?
2. Name the metal represented by electrode Y.
3. Write down the half-reaction responsible for the change that occurs at the surface of the artefact.
4. Give a reason why the concentration of the electrolyte remains constant during electroplating.
5. In industry some plastic articles are sometimes electroplated. Explain why plastic must be coated with graphite before electroplating.
6. Give a reason why, from a business point of view, it is not advisable to plate platinum with silver.

3. Lesson Development

2.2 Contextualization questions:

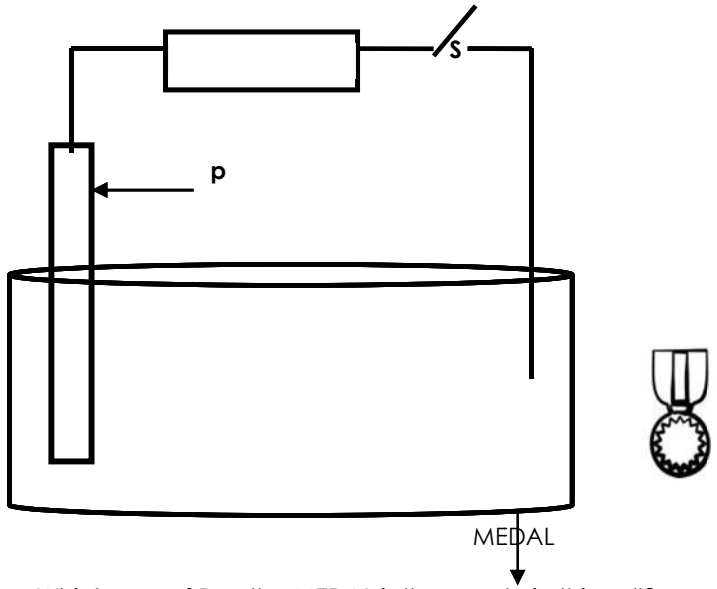
Electroplating
Teapots are electroplated with a thin layer of silver to protect them from corrosion and to give them an attractive finish. Objects that are electroplated are first cleaned, and then placed in a bath that contains ions, or positively charged atoms, of the metal that will be deposited on them. The object to be plated is connected to the negative end of an electric current source, which causes the object to attract the positive metal ions in the bath.

f. Give a reason why, from a business point of view, it is not advisable to plate platinum with silver.

Platinum is expensive, more durable than other metals.

HOMEWORK ACTIVITY

The diagram below represents a cell that can be used to electroplate a tin medal with a thin layer of silver to improve its appearance.



1. Which one of P or the MEDAL is the anode in this cell?
   Answer: P

Write down the following:

2. NAME or SYMBOL of the element of which electrode P is composed. **Answer: Ag/ Silver**

Demonstration and Explanation

± 15 minutes

OR

Illustrations and Explanation

± 15 – 20 minutes

Charts/ or available resources

3. Lesson Presentation

EXPLNATION:

- **Electroplating**: is used to protect **metals** that oxidise very easily by covering them with a thin layer of a metal that does not oxidise easily.
- The metal object that must be plated, acts as the
- **cathode** (negative electrode) and must be always be connected to the negative terminal of the electrical supply.
- It is suspended into a bath that contains a solution of a suitable salt of the metal with which it is suppose to be plated.
- The electrolyte is a mixture of silver nitrate and potassium cyanide.
- The cyanide ensures that the concentration of the silver ions, required for plating, are of good quality

ELECTROLYTE, ANODE AND CATHODE

$Ag_{(s)} \rightarrow Ag^{+}_{(aq)} + e^{-}$ (anode)

$Ag^{+}_{(aq)} + NO^{-}_{3\,(aq)} + H_2O$ (in electrolyte solution)

$Ag^{+} + e^{-} \rightarrow Ag_{(s)}$ (cathode)

- Anode is made of an impure metal and the same metal – when deposited on the cathode – is absolutely pure.
- Vast quantities of copper are purified by electrolysis with impure copper slabs as anodes and thin sheets of pure copper as cathodes.
- During the electrolysis copper (II) ions leave the anode slabs and plate out on the cathode sheets when they are discharged.

3. NAME or FORMULA of the electrolyte that has to be used to achieve the desired results.

Answer: Silver Nitrate/ $AgNO_3$ or silver ethanoate/ acetate/ CH_3COOAg

4. Switch S is now closed. Write down the visible changes that will occur at the following:

4.1 Electrode P:

Answer: Silver/metal bar becomes eroded/pitted/smaller/thinner, eaten away

4.2 The medal:

Answer: A (silver) layer forms on medal

5 Write down the equation for the half-reaction to support the answer to QUESTION

Answer: $Ag^{+} + e^{-} \rightarrow Ag$

6 How will the concentration of the electrolyte change during the electroplating process? Write down only INCREASES, DECREASES or REMAINS THE SAME.

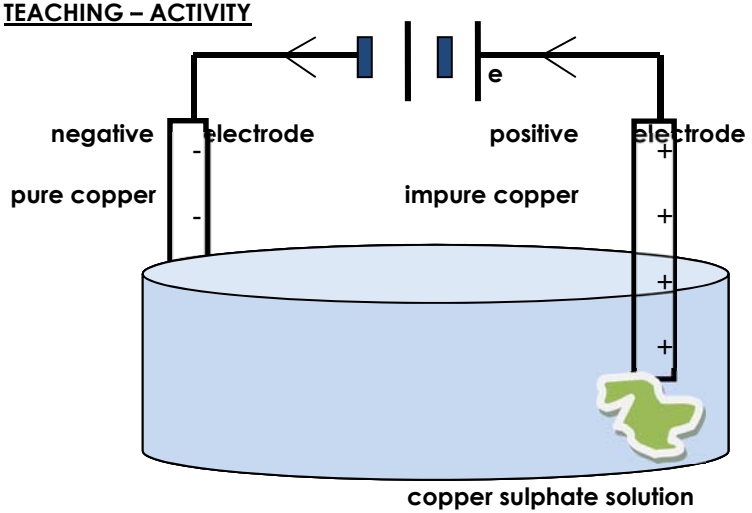
Answer: Remain the same

7 You want to coat the medal with copper instead of silver. State TWO changes that you will make to the above cell to obtain a medal coated with copper.

Answer: Replace the silver solution with copper solution/ soluble copper salt

Relevant equipments/ or other available resources.

TEACHING – ACTIVITY



- **The most important use of electroplating:**

- The anode made of an impure metal and the same metal-when deposited on the cathode – is absolutely pure.

- Vast quantities of copper are purified by electrolysis with impure copper slabs as anodes and thin sheets of pure copper as cathode.

- The electrolyte is a solution of copper sulphate $CuSO_{4\,(aq)}$

- During the electrolysis copper (II) ions leaves the anode slabs and plate out on the cathode sheets when they are discharged.

- Less reactive metals such as gold, silver and platinum form a mud under the anode and more reactive metals such as zinc remain as ions in the solution. In effect the reaction are: $Cu_{(s)} \rightarrow Cu^{2+}{}_{(aq)} \rightarrow Cu_{(s)}$

CONCLUSION:

- Electroplating is used to protect metals that oxidise very easily
- Silver nitrate and potassium cyanide are used as mixtures

BIBLIOGRAPHY

- Children Encarta – 2008 (Robert Harding picture library).
- Exam question paper – 2008
- Oxford Successful – Physical Sciences (Peter Broster et al)

Lesson Demonstration

± 15 minutes

Chalkboard summary

• Source current is required in order to conduct this process • Reduction takes place at the negative cathode • Oxidation takes place at the positive anode • Electrolytic cells use a lot of energy. Power stations burn coal to produce this energy and as a result huge quantities of carbon dioxide are produced. This contributes to an increase in the greenhouse gas emissions and thus an increase in global warming.			

Reflection/note

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