SUBJECT and GRADE	Physical Sciences Gr 12	
TERM 3	*Week 3*	
TOPIC	Optical Phenomena and Properties of Materials (This section must be read in conjunction with the CAPS, p. 132–133.)	
AIMS OF LESSONS	**Photo-electric effect** • Describe the photoelectric effect as the process whereby electrons are ejected from a metal surface when light of suitable frequency is incident on that surface. • State the significance of the photoelectric effect. • Define **threshold frequency**, f_o, as the minimum frequency of light needed to emit electrons from a certain metal surface. • Define **work function**, W_o, as the minimum energy that an electron in the metal needs to be emitted from the metal surface. • Perform calculations using the photoelectric equation: $E = W_o + E_{Kmax}$, where $E = hf$ and $W_o = hf_o$ and $E_{Kmax} = \frac{1}{2}mv^2_{max}$ • Explain the effect of intensity and frequency on the photoelectric effect.	
RESOURCES	***Paper based resources*** *You are referred to the:* • *Optical Phenomena topic in the textbook or study guides that you will have on hand.* • *Examination Guideline (page 13)* • *Mind the Gap books (pages 134 - 143)* • *Past NSC Examination papers (refer to Paper 1)*	**Digital resources** Refer to the relevant digital resources: • wcedePortal.co.za • HeyScience App for Physical Sciences • Past NSC Examination papers • You Tube videos Electromagnetic Wave: https://youtu.be/WNkB8lY-k04 Another video on Electromagnetic Waves https://youtu.be/Vwjcn4Vl2iw

	How does a Microwave Work: https://youtu.be/5DpYlnHT-0s Extra information on Electromagnetic waves: https://youtu.be/bwreHReBH2A Demonstration of Photo Electric Effect using electroscope: https://youtu.be/l-gwAs2ApPw Demonstration of Photo Electric Effect using evacuated tube: https://youtu.be/maFUYiQgwUU Calculations on Photo electric effect: https://youtu.be/253wCijyZJo Application of Photo-electric cells: https://youtu.be/tyCYxvpMQg8 How do Solar cells work: https://youtu.be/UJ8XW9AgUrw
INTRODUCTION	***Part 1 and 2*** 1. You should be able to explain what an electromagnetic wave is. 2. You should be able to list the different EM waves in order of increasing (or decreasing) wavelength (or frequency). 3. You should be able to do state some of the disadvantages of high frequency radiation. 4. Observe the following YouTube videos: Electromagnetic Wave: https://youtu.be/WNkB8lY-k04 Another video on Electromagnetic Waves: https://youtu.be/Vwjcn4Vl2iw How does a Microwave Work: https://youtu.be/5DpYlnHT-0s Extra information on Electromagnetic waves: https://youtu.be/bwreHReBH2A 5. Now attempt the following questions for Enrichment

QUESTION 1

The table below shows the arrangement of electromagnetic waves according to their frequencies.

TYPE OF RADIATION	TYPICAL FREQUENCY (Hz)
Radio Waves	$10^{5} - 10^{10}$
Microwaves	$10^{10} - 10^{11}$
Infrared (IR)	$10^{11} - 10^{14}$
Visible Light	$10^{14} - 10^{15}$
Ultraviolet (UV)	$10^{15} - 10^{16}$
X-rays	$10^{16} - 10^{18}$
Gamma rays	$10^{18} - 10^{21}$

1.1 List TWO properties of electromagnetic waves. (2)

1.2 Which radiation listed above has the highest energy? Give a reason for your answer. (2)

1.3 One of the types of waves above has energy of $1,99 \times 10^{-20}$ J. Identify this wave using suitable calculation.

HINT: use the equation you learnt in Gr 10: $E = hf$ (4)

[8]

QUESTION 2 - DBE Gr 10 Nov 2016

Different types of electromagnetic radiation have different frequencies. This can influence their properties and what each could be used for in our daily lives.

2.1 Choose the frequency from COLUMN B that matches the type of electromagnetic radiation in COLUMN A.

Write only the letter (A–C) next to the question number (2.1.1–2.1.3) in the ANSWER BOOK, for example 2.1.4 D

COLUMN A TYPE OF RADIATION		COLUMN B FREQUENCY IN Hz	
2.1.1	Ultraviolet	A	10^{23}
2.1.2	Gamma	B	10^{7}
2.1.3	Radio	C	10^{16}

(3)

2.2 Write down ONE use of each of the following types of radiation

2.2.1 Infrared (1)

2.2.2 Microwaves (1)

2.3 When doctors need to establish the seriousness of a fracture, a picture is taken of the broken bone. The picture below shows a fracture

[Source: learning radiography.com]

Write down the following:

2.3.1 Name of the type of radiation used for this procedure. (1)

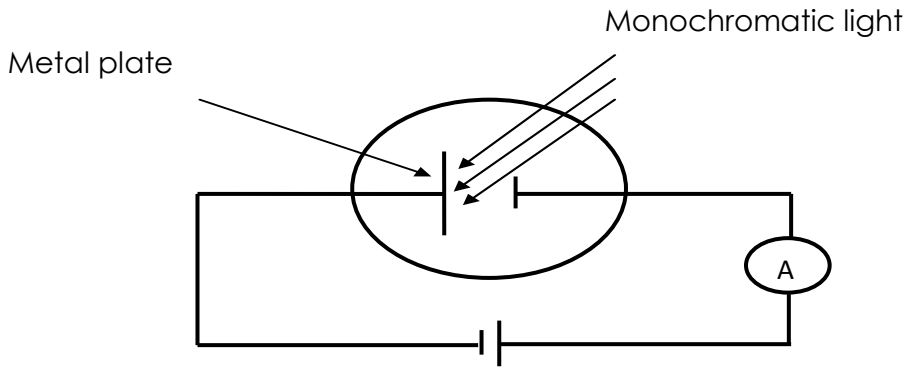
2.3.2 Property of this type of radiation which enables it to perform this procedure. (1)

2.3.2 Danger of overexposure to this type of radiation. (1)

2.4 A radio programme is transmitted in the FM band on a wavelength of 3 m.
Calculate the energy of a photon of the radio wave. (3)

[11]

CONCEPTS AND SKILLS	***Part 3*** • You should be able to explain what a "photon" is. It is light transmitted as "packages" of energy moving along as a transverse wave. The magnitude of this energy is directly proportional to the frequency of the wave. Therefore the energy of the photon can be calculated using the equation: $E = hf$ (where h = Planck's constant = $6{,}63 \times 10^{-34}$ J·s^{-1}) • You should be able to explain the concept "photo-electric effect" MTG p. 135. It is the ejection of electrons from a metal surface when light of suitable frequency is incident on that surface. • You should be able to define "threshold frequency" and "work function" **Threshold frequency f_o**, as the minimum frequency of light needed to emit electrons from a certain metal surface. **Work function**, W_o, as the minimum energy that an electron in the metal needs to be emitted from the metal surface. • Observe the following YouTube video on experiments: Demonstration of Photo Electric Effect using electroscope: https://youtu.be/l-gwAs2ApPw Demonstration of Photo Electric Effect using evacuated tube: https://youtu.be/maFUYiQgwUU	CAN YOU? • Explain what a photon is? • Calculate the energy of a photon of light? • Define "photo-electric effect" • Define "threshold frequency" and "work function" • Do calculations on the photo-electric effect.

ACTIVITIES/ASSESSMENT	***Part 4 and 5*** • Observe the following YouTube videos on Applications of the Photo-Electric Effect Application of Photo-electric cells https://youtu.be/tyCYxvpMQg8 How do Solar cells work https://youtu.be/UJ8XW9AgUrw Calculations on Photo electric effect https://youtu.be/253wCijyZJo • Thereafter work through the Examples of calculations on Photo-electric Effect from Mind the Gap pages 137 – 141 and/or any other textbook. • Now you can work through the questions under the Consolidation Heading
CONSOLIDATION	Now try the following questions as consolidation. **QUESTION 1 DBE Gr 12 Feb-March 2018** 1.1 In the diagram below, monochromatic light is incident on the metal plate of a photocell. A sensitive ammeter shows a reading. 

1.1.1 How does the energy of the photons of the incident light compare to the work function of the metal plate? Choose from GREATER THAN, LESS THAN or EQUAL TO. Give a reason for the answer. (2)

1.1.2 When a change is made to the monochromatic light, the reading on the ammeter increases. A learner makes the following statement with regard to this change:

The increase in the ammeter reading is due to an increase in the energy of the incident photons.

Give a reason why this statement is INCORRECT. (2)

1.1.3 What does the photoelectric effect tell us about the nature of light? (1)

1.2 Ultraviolet radiation is incident on the surface of sodium metal. The threshold frequency (f_0) for sodium is $5{,}73 \times 10^{14}$ Hz. The maximum speed of an electron emitted from the metal surface is $4{,}19 \times 10^5$ m·s^{-1}.

1.2.1 Define or explain the term *threshold frequency*. (2)

Calculate the:

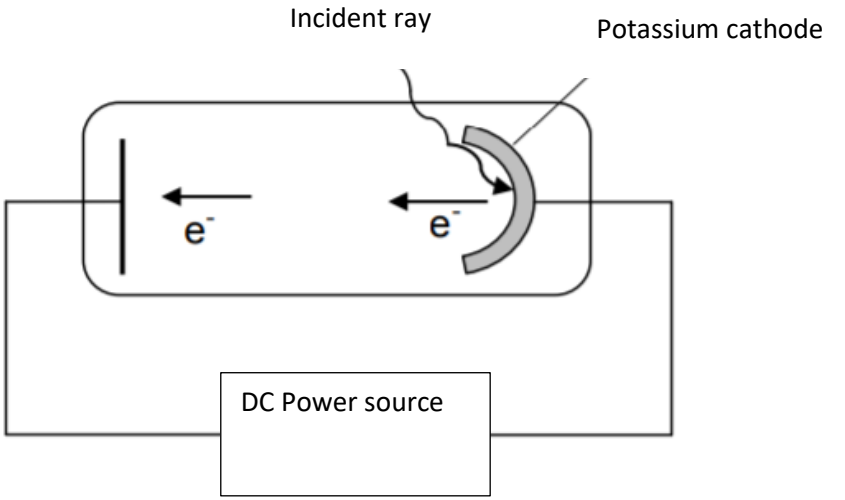
1.2.2 Work function of sodium (3)

1.2.3 Frequency of the incident photon (3)

[13]

QUESTION 2 (DBE Gr 12 Nov 2014)

Ultraviolet light is incident onto a photocell with a potassium cathode as shown below. The threshold frequency of potassium is 5,548 x 10^{14} Hz.



2.1 Define the term threshold frequency (cut-off frequency). (2)

The maximum speed of an ejected photoelectron is 5,33 x 10^5 m·s^{-1} .

2.2 Calculate the wavelength of the ultraviolet light used. (5)

The photocell is now replaced by another photocell with a rubidium cathode. The maximum speed of the ejected photoelectron is 6,10 x 10^5 m·s^{-1} when the same ultraviolet light source is used.

2.3 How does the work function of rubidium compare to that of potassium?
Write down only GREATER THAN, SMALLER THAN or EQUAL TO. (1)

2.4 Explain the answer to QUESTION 2.3. (3)

[11]

Memo

Question 1 (DBE Gr 12 Feb-March 2018)

1.1.1 Greater than/Groter as✓

Electrons are ejected from the metal plate./Elektrone word vrygestel vanaf die metaalplaat ✓

Accept: a current is registered on the ammeter. (2)

1.1.2 Increase in intensity means that (for the same frequency) the number of photons per second increases (ammeter reading increases)✓ but the energy of the photons stays the same ✓

(Therefore the statement is incorrect).

OR

An increase in the energy of the photons only increases the kinetic energy of the photoelectrons and not the number of photoelectrons, thus the ammeter reading will not change.

Toename in intensiteit beteken dat (vir dieselfde frekwensie) die aantal fotone neem toe (ammeterlesing neem toe) maar die energie van die fotone bly dieselfde. (Dus is die stelling verkeerd) (2)

1.1.3 Light has a particle nature/Lig het 'n deeltjieaard

Accept light energy is quantized/Aanvaar ligenergie is gekwantiseer✓ (1)

1.2.1 The minimum frequency needed for the emission of electrons (from a metal surface)

Die minimum energie benodig vir die vrystelling van elektrone (vanaf die metaaloppervlak) (2)

1.2.2 $W_o = hf_o$ ✓

$= (6,63 \times 10\text{-}34)(5,73 \times 1014)$ ✓

$= 3,8 \times 10^{-19}$ J ✓ [$3,799 \times 10^{-19}$ J] (3)

1.2.3 POSITIVE MARKING FROM QUESTION 11.2.2 POSITIEWE NASIE VANAF VRAAG 11.2.2

$E = W_o + Ek(max/maks)$

$hf = hf_o + Ek(max/maks)$ ✓

$hf = hf_o + \frac{1}{2} mv^2$

$(6,63 \times 10^{-34})f = 3,8 \times 10^{-19} + [\frac{1}{2}(9,11 \times 10^{-31})(4,19 \times 10^{5})^2$ ✓

$f = 6,94 \times 10^{14}$ Hz ✓ [7×10^{14} Hz] (3) [13]

	Question 2 (DBE Gr 12 Nov 2014) 2.1 The minimum frequency (of a photon/light) needed to emit electrons from (the surface of) a metal. (substance)✓✓ (2) Die minimum frekwensie (van 'n foton/lig) benodig om elektrone vanaf die (oppervlakte van)'n metaal (stof) vry te stel. 2.2 $E = W_o + Ek(max/maks)$ $hf = hf_o + Ek(max/maks)$ ✓ $hf = hf_o + \frac{1}{2} mv^2$ $hc/\lambda = hf_o + \frac{1}{2} mv^2$ $[(6,63 \times 10^{-34})(3 \times 10^8)] / \lambda$ ✓ $= (6,63 \times 10^{-34})(5,548 \times 10^{14})$ ✓ $+ \frac{1}{2} (9,11 \times 10^{-31})(5,33 \times 10^5)^2$ ✓ $\lambda = 4 \times 10^{-7}$ m ✓ (5) 2.3 Smaller (less) than ✓Kleiner (minder) as (1) 2.4 The wavelength/frequency/energy of the incident light (photon/hf) is constant ✓. Since the speed is larger, the kinetic energy of ejected electron is larger ✓ the work function/W_o /threshold frequency is smaller. ✓ (3) [11] Die golflengte/frekwensie/energie van die invallende lig (foton/hf) is konstant Aangesien die spoed vergroot, is die kinetiese energie groter, is die arbeidsfunksie / W_o / drumpel frekwensie kleiner
VALUES	• The use of Photo-electric effect in everyday usage, such as Solar Panels, Sound in Cinematography, controlling of temperature in furnaces in Industry, switching street lights on and off etc. makes us more aware of how we should decrease our reliance on fossil fuels (especially carbon) for our livelihood. In this way we will reduce the production of greenhouse gases such as CO_2