

KWV EDUCATION



KWV PHYSICS

PHOTO-ELECTRIC QUESTIONS

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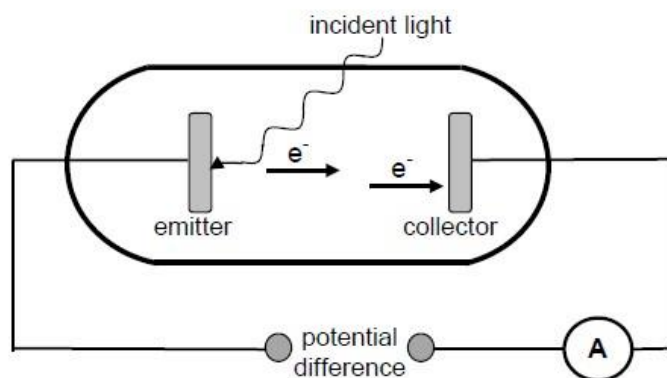
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WHERE TO START IN MATHS AND SCIENCE

KWV 01

QUESTION 11 (Start on a new page.)

11.1 The apparatus below is used to demonstrate the photoelectric effect.



11.1.1 Define, in words, the *photoelectric effect*. (2)

The incident monochromatic light transfers $1,8 \times 10^{-9} \text{ J}$ of energy in one second to a certain area of the emitter. The wavelength of a photon in the incident light is 260 nm.

If one photon releases one electron, calculate the:

11.1.2 Number of electrons released from the surface of that area of the emitter in one second (5)

11.1.3 Current produced, in amperes (4)

11.2 The sketch below shows an example of a line emission spectrum.



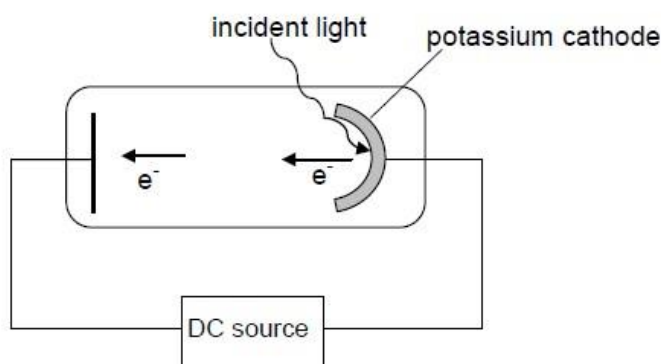
11.2.1 Briefly explain how this type of spectrum is formed by referring to electron transitions in atoms. (2)

11.2.2 Write down ONE important use of line emission spectra. (1)
[14]

KWV 02

QUESTION 10 (Start on a new page.)

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



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

The maximum speed of an ejected photoelectron is $5,33 \times 10^5 \text{ m}\cdot\text{s}^{-1}$.

10.2 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 $6,10 \times 10^5 \text{ m}\cdot\text{s}^{-1}$ when the same ultraviolet light source is used.

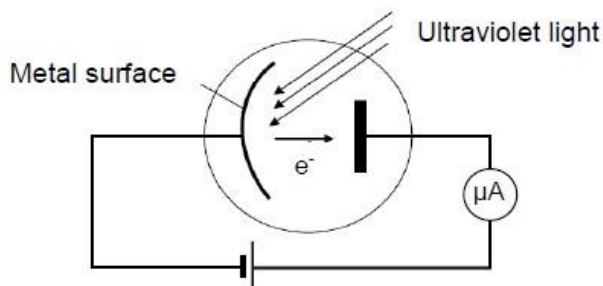
10.3 How does the work function of rubidium compare to that of potassium? Write down only GREATER THAN, SMALLER THAN or EQUAL TO. (1)

10.4 Explain the answer to QUESTION 10.3. (3)
[11]

KWV 03

QUESTION 10 (Start on a new page.)

A learner uses photocells to determine the maximum kinetic energy of ejected photoelectrons. One photocell has a caesium cathode and the other has a sodium cathode. Each photocell is radiated by ultraviolet light from the same source as shown below.



The incomplete results obtained are shown in the table below.

NAME OF THE METAL	WORK FUNCTION OF THE METAL (J)	MAXIMUM KINETIC ENERGY OF PHOTOELECTRONS (J)
Caesium	$3,36 \times 10^{-19}$	$2,32 \times 10^{-19}$
Sodium	$3,65 \times 10^{-19}$	E_K

- 10.1 Define the term *work function of a metal*. (2)
- 10.2 Use the information in the table to calculate the wavelength of the ultraviolet light used in the experiment. (4)
- 10.3 Calculate the maximum kinetic energy, E_K , of an electron ejected from the sodium metal. (4)
- 10.4 The intensity of the incident ultraviolet light was then increased.
 - 10.4.1 Give a reason why this change does NOT affect the maximum kinetic energy of the ejected photoelectrons. (1)
 - 10.4.2 How does the increased intensity affect the reading on the ammeter? Write down only INCREASES, DECREASES or REMAINS THE SAME. (1)
 - 10.4.3 Explain the answer to QUESTION 10.4.2. (2)

[14]

KWV 04

QUESTION 11 (Start on a new page.)

In an experiment to demonstrate the photoelectric effect, light of different wavelengths was shone onto a metal surface of a photoelectric cell. The maximum kinetic energy of the emitted electrons was determined for the various wavelengths and recorded in the table below.

INVERSE OF WAVELENGTH $\frac{1}{\lambda} (\times 10^6 \text{ m}^{-1})$	MAXIMUM KINETIC ENERGY $E_{k(\text{max})} (\times 10^{-19} \text{ J})$
5,00	6,60
3,30	3,30
2,50	1,70
2,00	0,70

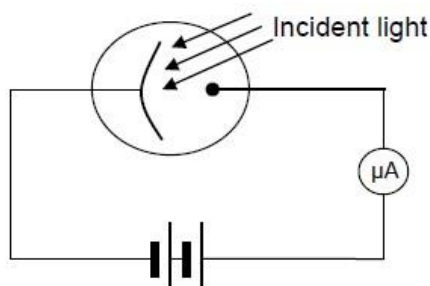
- 11.1 What is meant by the term *photoelectric effect*? (2)
- 11.2 Draw a graph of $E_{k(\text{max})}$ (y-axis) versus $\frac{1}{\lambda}$ (x-axis) ON THE ATTACHED ANSWER SHEET. (3)
- 11.3 USE THE GRAPH to determine:
- 11.3.1 The threshold frequency of the metal in the photoelectric cell (4)
- 11.3.2 Planck's constant (4)
- [13]

KWV 05

QUESTION 11 (Start on a new page.)

An investigation was conducted to determine the effects of changes in frequency AND intensity on the current generated in a photoelectric cell when light is incident on it.

The apparatus used in the investigation is shown in the simplified diagram below.



The results of the experiment are shown in the table below.

EXPERIMENT	FREQUENCY (Hz)	INTENSITY (Cd)	CURRENT (μA)
A	$4,00 \times 10^{14}$	10	0
B	$4,50 \times 10^{14}$	10	0
C	$5,00 \times 10^{14}$	10	0
D	$5,01 \times 10^{14}$	10	20
E	$5,01 \times 10^{14}$	20	40
F	$6,50 \times 10^{14}$	10	30

11.1 Define the term *work function*. (2)

11.2 Identify an independent variable. (1)

The threshold frequency for the metal used in the photocell is $5,001 \times 10^{14}$ Hz.

11.3 Define the term *threshold frequency*. (2)

11.4 Calculate the maximum speed of an emitted electron in experiment F. (5)

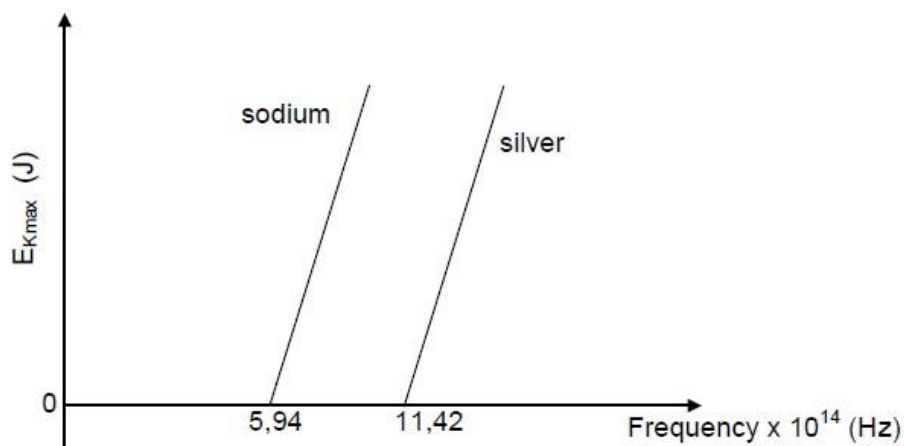
In experiments D and E, the current doubled when the intensity was doubled at the same frequency.

11.5 What conclusion can be made from this observation? (2)
[12]

KWV 06

QUESTION 10 (Start on a new page.)

- 10.1 A learner is investigating the photoelectric effect for two different metals, silver and sodium, using light of different frequencies. The maximum kinetic energy of the emitted photoelectrons is plotted against the frequency of the light for each of the metals, as shown in the graphs below.



- 10.1.1 Define the term *threshold frequency*. (2)
- 10.1.2 Which metal, sodium or silver, has the larger work function? Explain the answer. (3)
- 10.1.3 Name the physical constant represented by the slopes of the graphs. (1)
- 10.1.4 If light of the same frequency is shone on each of the metals, in which metal will the ejected photoelectrons have a larger maximum kinetic energy? (1)
- 10.2 In a different photoelectric experiment blue light obtained from a light bulb is shone onto a metal plate and electrons are released.

The wavelength of the blue light is 470×10^{-9} m and the bulb is rated at 60 mW. The bulb is only 5% efficient.

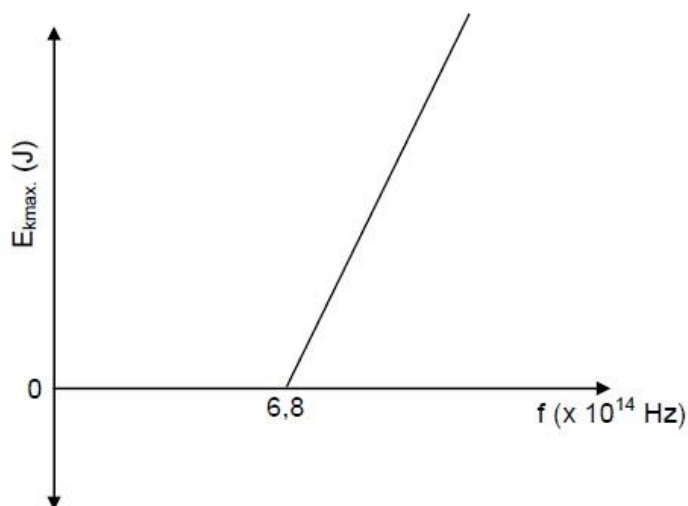
- 10.2.1 Calculate the number of photons that will be incident on the metal plate per second, assuming all the light from the bulb is incident on the metal plate. (5)
- 10.2.2 Without any further calculation, write down the number of electrons emitted per second from the metal. (1)

[13]

KWV 07

QUESTION 10 (Start on a new page.)

The graph below is obtained for an experiment on the photoelectric effect using different frequencies of light and a given metal plate.



The threshold frequency for the metal is $6,8 \times 10^{14} \text{ Hz}$.

10.1 Define the term *threshold frequency*. (2)

In the experiment, the brightness of the light incident on the metal surface is increased.

10.2 State how this change will influence the speed of the photoelectrons emitted.

Choose from INCREASES, DECREASES or REMAINS UNCHANGED. (1)

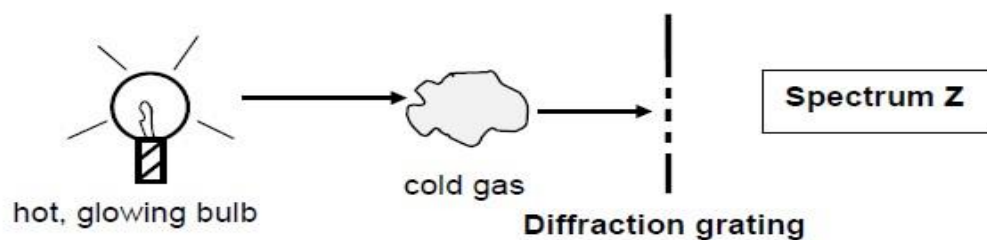
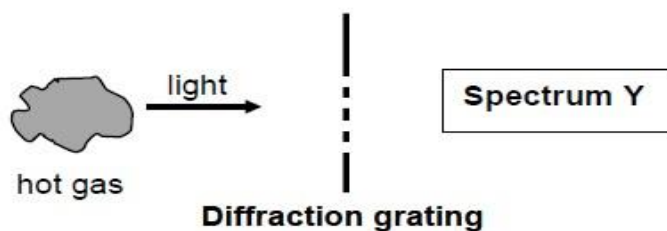
10.3 Show by means of a calculation whether the photoelectric effect will be OBSERVED or NOT OBSERVED, if monochromatic light with a wavelength of $6 \times 10^{-7} \text{ m}$ is used in this experiment. (5)

One of the radiations used in this experiment has a frequency of $7,8 \times 10^{14} \text{ Hz}$.

10.4 Calculate the maximum speed of an ejected photoelectron. (5)
[13]

QUESTION 11 (Start on a new page.)

- 11.1 A teacher in a science class explains how different types of spectra are obtained. The teacher uses the simplified diagrams shown below for the explanation.



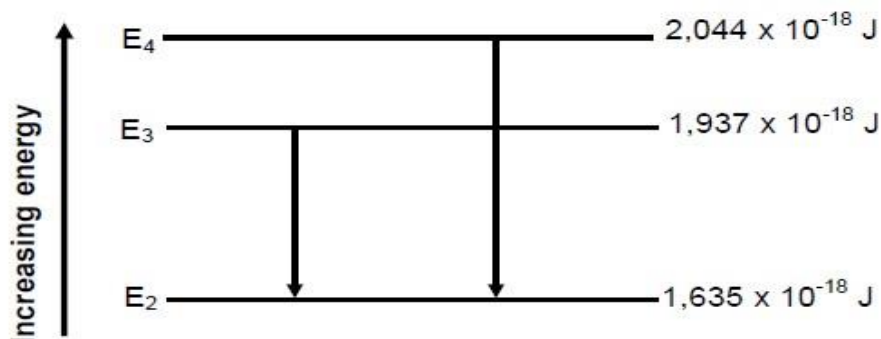
Name the type of spectrum of:

11.1.1 Y (1)

11.1.2 Z (1)

- 11.2 In an excited atom, electrons can 'jump' from lower energy levels to higher energy levels. They can also 'drop' from higher energy levels to lower energy levels.

The diagram below (not drawn to scale) shows some of the transitions for electrons in an excited atom.



- 11.2.1 Do the transitions indicated in the diagram lead to ABSORPTION or EMISSION spectra? (1)

- 11.2.2 Calculate the frequency of the photon produced when an electron in an excited atom makes a transition from E_4 to E_2 , as shown in the diagram. (4)

The threshold frequency of a metal, Q, is $4,4 \times 10^{14} \text{ Hz}$.

- 11.2.3 Calculate the kinetic energy of the most energetic electron ejected when the photon produced in QUESTION 11.2.2 is incident on the surface of metal Q. (4)

Another metal, R, has a threshold frequency of $7,5 \times 10^{14} \text{ Hz}$.

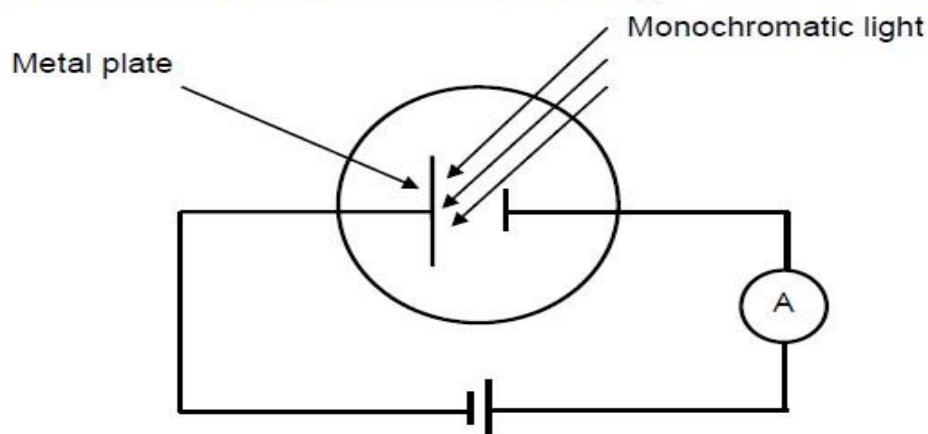
- 11.2.4 Will the photon produced in QUESTION 11.2.2 be able to eject electrons from the surface of metal R? Write down only YES or NO.

Give a reason for the answer.

(2)
[13]

QUESTION 11 (Start on a new page.)

- 11.1 In the diagram below, monochromatic light is incident on the metal plate of a photocell. A sensitive ammeter shows a reading.



- 11.1.1 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)

- 11.1.2 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)

- 11.1.3 What does the photoelectric effect tell us about the nature of light?

(1)

- 11.2 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.

- 11.2.1 Define or explain the term *threshold frequency*.

(2)

Calculate the:

- 11.2.2 Work function of sodium

(3)

- 11.2.3 Frequency of the incident photon

(3)

[13]

KWV 10

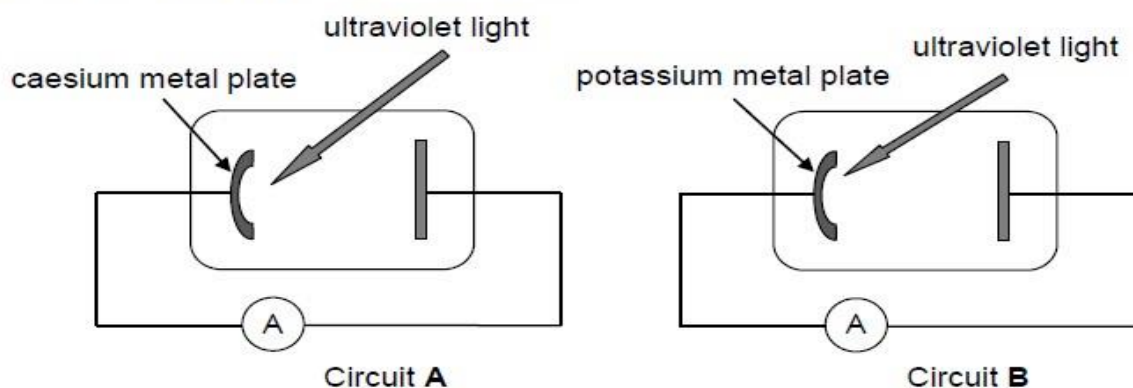
QUESTION 11 (Start on a new page.)

The threshold frequencies of caesium and potassium metals are given in the table below.

METAL	THRESHOLD FREQUENCY
Caesium	$5,07 \times 10^{14} \text{ Hz}$
Potassium	$5,55 \times 10^{14} \text{ Hz}$

- 11.1 Define the term *work function* in words. (2)
- 11.2 Which ONE of the two metals in the table has the higher work function? Give a reason for the answer by referring to the information in the table. (2)

The simplified diagrams below show two circuits, **A** and **B**, containing photocells. The photocell in circuit **A** contains a caesium metal plate, while the photocell in circuit **B** contains a potassium metal plate.



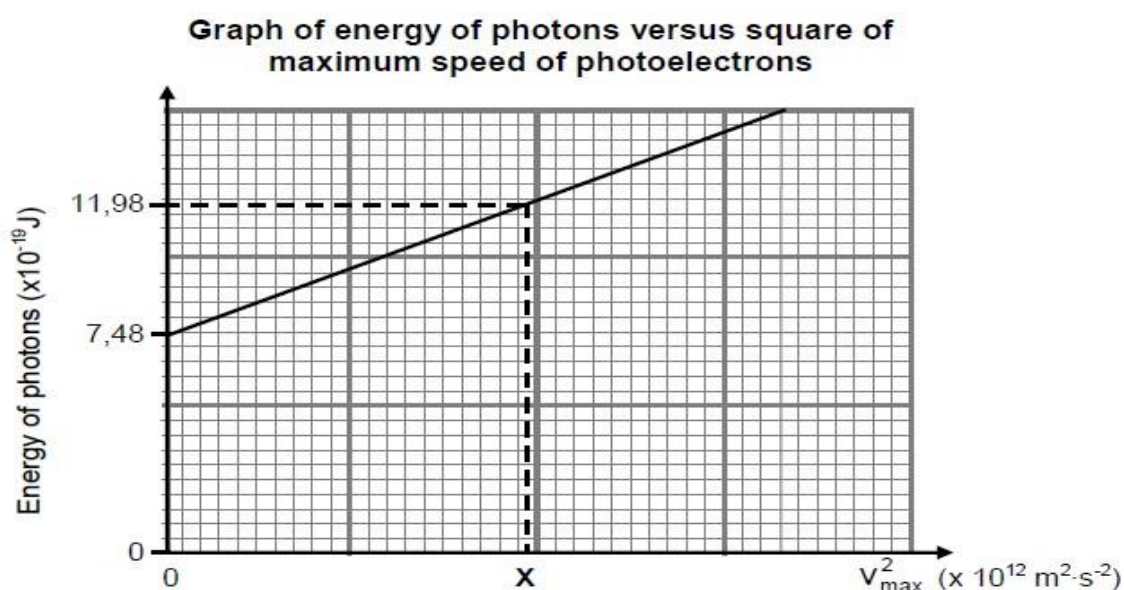
Ultraviolet light with the same intensity and wavelength of $5,5 \times 10^{-7} \text{ m}$ is incident on the metal plate in EACH of the photocells and the ammeter in circuit **A** registers a current.

- 11.3 By means of a calculation, determine whether the ammeter in circuit **B** will also register a current. (3)
- 11.4 Calculate the maximum kinetic energy of an ejected electron in circuit **A**. (5)
- 11.5 How will the maximum kinetic energy of the ejected electron, calculated in QUESTION 11.4, change when the intensity of the incident light increases? (1)
- [13]

QUESTION 10 (Start on a new page.)

During an experiment, light of different frequencies is radiated onto a silver cathode of a photocell and the corresponding maximum speed of the ejected photoelectrons are measured.

A graph of the energy of the incident photons versus the square of the maximum speed of the ejected photoelectrons is shown below.



10.1 Define the term *photoelectric effect*. (2)

Use the graph to answer the following questions.

10.2 Write down the value of the work function of silver. (3)
Use a relevant equation to justify the answer.

10.3 Which physical quantity can be determined from the gradient of the graph? (1)

10.4 Calculate the value of X as shown on the graph. (5)

The experiment above is now repeated using light of higher intensity.

10.5 How will EACH of the following be affected? Choose from INCREASES, DECREASES or REMAINS THE SAME.

10.5.1 The gradient of the graph (1)

10.5.2 The number of photoelectrons emitted per unit time (1)

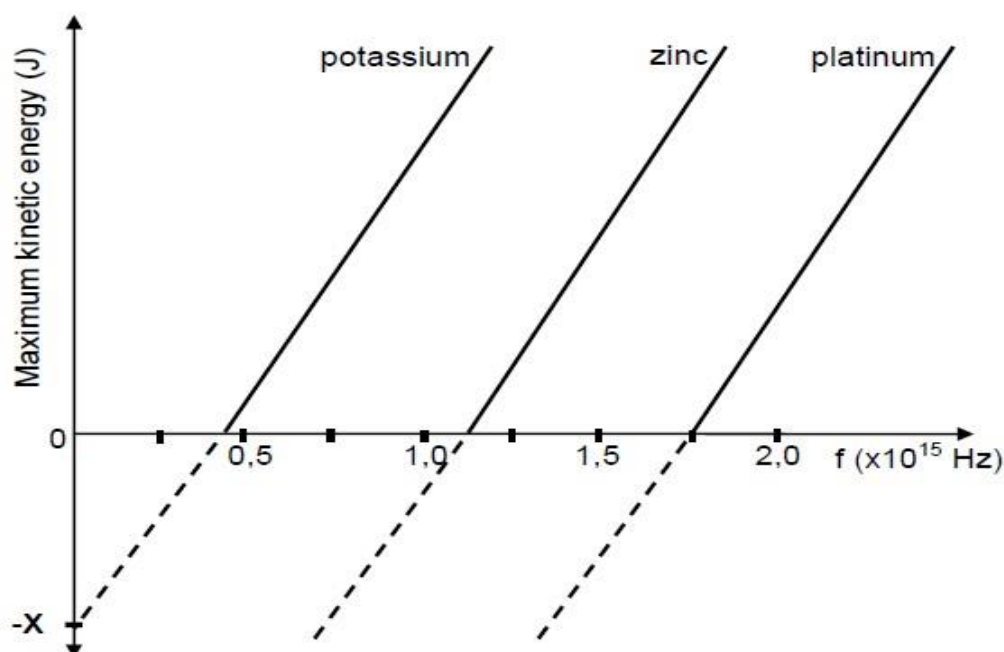
[13]

KWV 12

QUESTION 10 (Start on a new page.)

An experiment is conducted to investigate the relationship between the frequency of light incident on a metal and the maximum kinetic energy of the emitted electrons from the surface of the metal. This experiment is conducted for three different metals.

The graph below represents the results obtained.



- 10.1 Name the phenomenon on which this experiment is based. (1)
 - 10.2 Name the physical quantity represented by X on the graph. (1)
 - 10.3 Which ONE of the three metals needs incident light with the *largest wavelength* for the emission of electrons? (2)
Give a reason for the answer.
 - 10.4 Define the term *work function* in words. (2)
 - 10.5 Calculate the:
 - 10.5.1 Work function of **platinum** (3)
 - 10.5.2 Frequency of the incident light that will emit electrons from the surface of **platinum** with a maximum velocity of $5,60 \times 10^5 \text{ m}\cdot\text{s}^{-1}$ (4)
- [13]**

**DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 1 (PHYSICS)**

**GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 1 (FISIKA)**

TABLE 1: PHYSICAL CONSTANTS/TABEL 1: FISIESE KONSTANTES

NAME/NAAM	SYMBOL/SIMBOOL	VALUE/WAARDE
Acceleration due to gravity <i>Swaartekragversnelling</i>	g	$9,8 \text{ m}\cdot\text{s}^{-2}$
Universal gravitational constant <i>Universele gravitasiekonstant</i>	G	$6,67 \times 10^{-11} \text{ N}\cdot\text{m}^2\cdot\text{kg}^{-2}$
Radius of the Earth <i>Radius van die Aarde</i>	R_E	$6,38 \times 10^6 \text{ m}$
Mass of the Earth <i>Massa van die Aarde</i>	M_E	$5,98 \times 10^{24} \text{ kg}$
Speed of light in a vacuum <i>Speed van lig in 'n vakuum</i>	c	$3,0 \times 10^8 \text{ m}\cdot\text{s}^{-1}$
Planck's constant <i>Planck se konstante</i>	h	$6,63 \times 10^{-34} \text{ J}\cdot\text{s}$
Coulomb's constant <i>Coulomb se konstante</i>	k	$9,0 \times 10^9 \text{ N}\cdot\text{m}^2\cdot\text{C}^{-2}$
Charge on electron <i>Lading op elektron</i>	e	$-1,6 \times 10^{-19} \text{ C}$
Electron mass <i>Elektronmassa</i>	m_e	$9,11 \times 10^{-31} \text{ kg}$

TABLE 2: FORMULAE/TABEL 2: FORMULES**MOTION/BEWEGING**

$v_f = v_i + a \Delta t$	$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$ or/of $\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2$
$v_f^2 = v_i^2 + 2a\Delta x$ or/of $v_f^2 = v_i^2 + 2a\Delta y$	$\Delta x = \left(\frac{v_i + v_f}{2} \right) \Delta t$ or/of $\Delta y = \left(\frac{v_i + v_f}{2} \right) \Delta t$

FORCE/KRAG

$F_{\text{net}} = ma$	$p = mv$
$f_s^{\text{max}} = \mu_s N$	$f_k = \mu_k N$
$F_{\text{net}} \Delta t = \Delta p$ $\Delta p = mv_f - mv_i$	$w = mg$
$F = G \frac{m_1 m_2}{d^2}$ or/of $F = G \frac{m_1 m_2}{r^2}$	$g = G \frac{M}{d^2}$ or/of $g = G \frac{M}{r^2}$

WORK, ENERGY AND POWER/ARBEID, ENERGIE EN DRYWING

$W = F \Delta x \cos \theta$	$U = mgh$ or/of $E_p = mgh$
$K = \frac{1}{2} mv^2$ or/of $E_k = \frac{1}{2} mv^2$	$W_{\text{net}} = \Delta K$ or/of $W_{\text{net}} = \Delta E_k$ $\Delta K = K_f - K_i$ or/of $\Delta E_k = E_{kf} - E_{ki}$
$W_{\text{nc}} = \Delta K + \Delta U$ or/of $W_{\text{nc}} = \Delta E_k + \Delta E_p$	$P = \frac{W}{\Delta t}$
$P_{\text{ave}} = F v_{\text{ave}}$ / $P_{\text{gemid}} = F v_{\text{gemid}}$	

WAVES, SOUND AND LIGHT/GOLWE, KLANK EN LIG

$v = f \lambda$	$T = \frac{1}{f}$
$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ or/of $f_L = \frac{v \pm v_L}{v \pm v_b} f_b$	$E = hf$ or /of $E = \frac{hc}{\lambda}$
$E = W_0 + E_{k(\text{max})}$ or $E = W_0 + K_{\text{max}}$ where $E = hf$ and $W_0 = hf_0$ and $E_{k(\text{max})} = \frac{1}{2} mv_{\text{max}}^2$ / $K_{\text{max}} = \frac{1}{2} mv_{\text{max}}^2$	
$E = W_0 + E_{k(\text{maks})}$ of $E = W_0 + K_{\text{maks}}$ waar $E = hf$ en $W_0 = hf_0$ en $E_{k(\text{maks})} = \frac{1}{2} mv_{\text{maks}}^2$ / $K_{\text{maks}} = \frac{1}{2} mv_{\text{maks}}^2$	

ELECTROSTATICS/ELEKTROSTATIKA

$F = \frac{kQ_1Q_2}{r^2}$	$E = \frac{kQ}{r^2}$
$V = \frac{W}{q}$	$E = \frac{F}{q}$
$n = \frac{Q}{e}$ or/of $n = \frac{Q}{q_e}$	

ELECTRIC CIRCUITS/ELEKTRIESE STROOMBANE

$R = \frac{V}{I}$	emf (ε) = $I(R + r)$ emk (ε) = $I(R + r)$
$R_s = R_1 + R_2 + \dots$ $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$	$q = I\Delta t$
$W = Vq$ $W = VI\Delta t$ $W = I^2R\Delta t$ $W = \frac{V^2\Delta t}{R}$	$P = \frac{W}{\Delta t}$ $P = VI$ $P = I^2R$ $P = \frac{V^2}{R}$

ALTERNATING CURRENT/WISSELSTROOM

$I_{ms} = \frac{I_{max}}{\sqrt{2}}$ / $I_{wgk} = \frac{I_{maks}}{\sqrt{2}}$	$P_{ave} = V_{ms}I_{ms}$ / $P_{gemiddeld} = V_{wgk}I_{wgk}$
$V_{ms} = \frac{V_{max}}{\sqrt{2}}$ / $V_{wgk} = \frac{V_{maks}}{\sqrt{2}}$	$P_{ave} = I_{ms}^2 R$ / $P_{gemiddeld} = I_{wgk}^2 R$
	$P_{ave} = \frac{V_{ms}^2}{R}$ / $P_{gemiddeld} = \frac{V_{wgk}^2}{R}$