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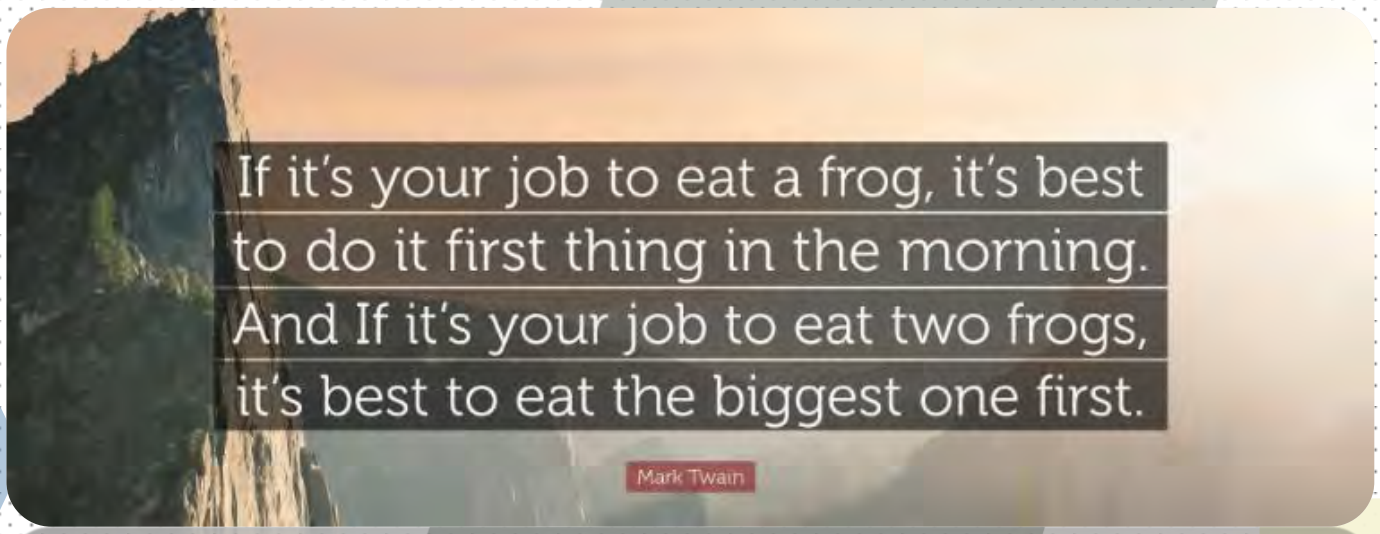


OPTION 3/*OPSIE 3*	
$I_{rms} = \frac{I_{max}}{\sqrt{2}}$ ✓ $I_{rms} = \frac{6}{\sqrt{2}}$ ✓ $I_{rms} = 4,24$ A $P_{ave} = V_{rms}I_{rms}$ $= (200)(4,24)$ $= 848$ W (848,53)	$P_{ave} = \frac{V^2_{rms}}{R}$ $848 = \frac{(200)^2}{R}$ ✓ $= 47,17\ \Omega$ ✓ **OR/*OF*** $P_{ave} = I^2_{rms}R$ $848 = (4,24)^2R$ ✓ $= 47,17\ \Omega$ ✓

(4)

9.2.2 **POSITIVE MARKING FROM QUESTION 9.2.1.**
POSITIEWE NASIEN VANAF VRAAG 9.2.1.

OPTION 1/*OPSIE 1*	**OPTION 2/*OPSIE 2***
$W = I^2R\Delta t$ ✓ $= \underline{(4,24)^2(47,17)}$ ✓(7200) ✓ $= 6,11 \times 10^6$ J ✓ ($6,10 \times 10^6$)	$W = VI\Delta t$ ✓ $= \underline{(200)(4,24)}$ ✓(7200) ✓ $= 6,11 \times 10^6$ J ✓
OPTION 3/*OPSIE 3*	**OPTION 4/*OPSIE 4***
$W = \frac{V^2\Delta t}{R}$ ✓ $= \frac{(200^2)\ ✓ (7200)✓}{47,27}$ $= 6,11 \times 10^6$ J ✓ ($6,10 \times 10^6$)	$P = \frac{W}{\Delta t}$ ✓ ✓ $848 = \frac{W}{7200}$ ✓ $= 6,11 \times 10^6$ J ✓

(4)
[13]

QUESTION 10/*VRAAG 10*

10.1 $6,63 \times 10^{-34}$ ✓ (1)

10.2

Marking criteria/*Nasienkriteria*
If any of the underlined key words/phrases in the **correct context** is omitted or extra incorrect words added, deduct 1 mark./*Indien enige van die onderstreepte sleutel woorde/frases in die **korrekte konteks** uitgelaat of inkorrekte woorde bygevoeg is, trek 1 punt af.*

The minimum energy needed to eject an electron from a (metal) surface. ✓✓
Die minimum energie benodig om 'n elektron uit 'n (metaal)oppervlak vry te stel. (2)

10.3.1 $W_o = hf_o$ ✓
$= \underline{(6,63 \times 10^{-34})(5 \times 10^{14})}$ ✓
$= 3,32 \times 10^{-19}$ J ✓ (3)

10.3.2 **POSITIVE MARKING FROM QUESTION 10.3.1./ *POSITIEWE NASIEN VANAF VRAAG 10.3.1.***

OPTION 1/*OPSIE 1*

$$\text{Gradient} = \frac{\Delta E_k}{\Delta f} \checkmark$$

$$6{,}63 \times 10^{-34} \checkmark = \frac{(X - 0)}{(12{,}54 \times 10^{14} - 5 \times 10^{14})} \checkmark$$

$$X = 5 \times 10^{-19} \text{ (J)} \checkmark$$

OPTION 2/*OPSIE 2*

$E = W_o + E_{k(max)}$

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

$h\frac{c}{} = h\frac{c}{_o} + E_{k(max)}$

✓ Any one/*Enige een*

$$\underline{(6{,}63 \times 10^{-34})(12{,}54 \times 10^{14})} \checkmark = \underline{3{,}32 \times 10^{-19} + E_{k(max)}} \checkmark$$

$$E_{k(max)} = 5 \times 10^{-19} \text{ J} \checkmark$$

$$X = 5 \times 10^{-19} \text{ (J)}$$

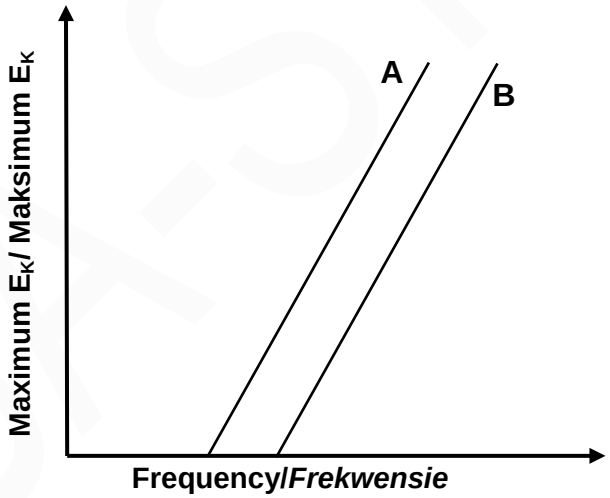
Note/*Aantekkening*:
Do not penalise learner again in 10.3.2 if (x 10^{14}) is omitted in 10.3.1/*Moenie leerder weer penaliseer in 10.3.2 indien (x 10^{14}) uitgelaat is in 10.3.1 nie.*

(4)

10.4.1 No effect/*Geen effek* ✓ (1)

10.4.2 Increases/*Toeneem* ✓ (1)

10.5



Marking criteria/*Nasienkriteria*	
Graph B to the right of graph A./ *Grafiek B aan regterkant van grafiek A.*	✓
Lines are parallel./*Lyne is parallel.*	✓
If both graphs are not labelled/*Indien beide grafieke nie benoem is nie*: $^0/_2$	
If two seperate graphs are drawn/*Indien twee aparte grafieke geteken is* : $^0/_2$	

(2)
[14]

TOTAL/*TOTAAL*: 150

QUESTION 10/*VRAAG 10*

10.1 Light has a particle nature/is quantized ✓
Lig het 'n deeltjie geaardheid/is gekwantiseerd (1)

10.2

Marking criteria/*Nasienkriteria*
If any of the underlined key words/phrases in the **correct context** is omitted deduct 1 mark./*Indien enige van die onderstreepte sleutelwoorde/frases in die **korrekte konteks** uitgelaat is, trek 1 punt af.*

The minimum energy (of incident photons) that can eject electrons from a metal/surface. ✓✓
Die minimum energie (van invallende fotone) wat elektrone kan vrystel vanuit 'n metaal/oppervlak. (2)

10.3

$E = W_0 + E_{k(max)}$
$hf = hf_0 + E_{k(max)}$
$hf = hf_0 + \frac{1}{2}mv^2_{max}$
$E = W_0 + \frac{1}{2}mv^2_{max}$
✓ Any one/ *Enige een*

$(6,63 \times 10^{-34})(5,96 \times 10^{14})$ ✓ $= 3,42 \times 10^{-19} + E_{k(max)}$ ✓
$E_{k(max)} = 5,30 \times 10^{-20}$ J ✓ $(5,32 \times 10^{-20}$ J) (4)

10.4 $q = I\Delta t$
$= (0,012)(10)$ ✓
$= 0,12$ C

$n = \frac{q}{e}$

$n = \frac{0,12}{1,6 \times 10^{-19}}$ ✓✓

$n = 7,5 \times 10^{17}$ (electrons/*elektrone*)

number of photons/*aantal fotone* = n = $7,5 \times 10^{17}$ ✓ (4)

10.5 Increases/*Verhoog* ✓

More photons strike the surface of the metal per unit time/ at a higher rate ✓ hence more (photo) electrons ejected per unit time ✓(resulting in increased current).
Meer fotone tref die oppervlak van die metaal per eenheidstyd/ teen 'n hoër tempo, gevolglik word meer (foto)elektrone per eenheidstyd vrygestel (wat tot 'n verhoogde stroom lei). (3)
[14]

TOTAL/*TOTAAL*: 150

QUESTION 10/*VRAAG 10*

10.1.1

Marking criteria/*Nasienkriteria:*
If any of the underlined key words/phrases in the correct context are omitted:
- 1 mark per word/phrase.
Indien enige van die sleutelwoorde/frases in die korrekte konteks weggelaat word: - 1 punt per word/frase.

The process whereby electrons are ejected from a (metal) surface when light of suitable frequency is incident on that surface. ✓✓
Die proses waartydens elektrone vrygestel word vanaf 'n (metaal) oppervlak wanneer lig van geskikte frekwensie invallend is op die oppervlak. (2)

10.1.2 For one photon/*Vir een foton*:

NOTE/*LET WEL*
$W_o = hf_o$ $^0/_2$

$E = hf$ ✓
$= (6{,}63 \times 10^{-34})(1{,}2 \times 10^{15})$ ✓
$= 7{,}96 \times 10^{-19}$ J

No of e = No of photons/*Hoeveelheid fotone*

$$= \frac{\text{Total energy of photons}}{\text{Energy of one photon}} \,/\, \frac{\text{Totale energie van fotone}}{\text{Energie van een foton}}$$

$$= \frac{1{,}75 \times 10^{-9}}{7{,}96 \times 10^{-19}} \checkmark$$

$= 2{,}2 \times 10^{9}$ ✓ $(2{,}198 \times 10^{9})$ (4)

10.1.3 **POSITIVE MARKING FOR E ONLY FROM QUESTION 10.1.2/ *POSITIEWE NASIEN VIR SLEGS E VANAF VRAAG 10.1.2***

$E = W_0 + K_{max}$
$hf = hf_o + \frac{1}{2}mv_{max}^2$
✓Any one/*Enige een*

$7{,}96 \times 10^{-19}$ ✓ $= (6{,}63 \times 10^{-34})(9{,}09 \times 10^{14})$ ✓ $+ \frac{1}{2}(9{,}11 \times 10^{-31})v_{max}^2$ ✓

$v_{max} = 6{,}51 \times 10^{5}$ m·s^{-1} ✓ (5)

10.2 An atom (electron) in higher (excited) energy state/level returns to a lower energy state/level. ✓
Energy is released as light (photons/frequencies of light are released). ✓
'*n Atoom (elektron) in 'n hoër (opgewekte) energie toestand/vlak keer terug na 'n laer energievlak (grondvlak).*
Energie word vrygestel as lig (fotone/frekwensies van lig word vrygestel). (2)
[13]

TOTAL/*TOTAAL*: 150

QUESTION 10/*VRAAG 10*

10.1

Marking criteria/*Nasienkriteria*
If any of the underlined key words/phrases in the **correct context** is omitted deduct 1 mark./*Indien enige van die onderstreepte sleutel woorde/frases in die korrekte konteks uitgelaat is, trek 1 punt af.*

The minimum frequency of light needed to eject electrons from a metal / surface. ✓✓
Minimum frekwensie van lig benodig om elektrone vanaf 'n metaal / oppervlak vry te stel. (2)

10.2 Greater than/*Groter as* ✓✓ (2)

10.3

OPTION 1/*OPSIE 1*
$E = W_o + E_{k(max)}$ ✓
$f_x = (\frac{1}{6,63 \times 10^{-34}})$ ✓$(23,01 \times 10^{-19})$ ✓ + $10,40 \times 10^{14}$ ✓
$= 4,51 \times 10^{15}$ (Hz)✓ $(45,1 \times 10^{14}$ Hz)

OPTION 2/*OPSIE 2*
$m = \frac{1}{h}$ ✓
$\frac{f_x - 10,4 \times 10^{14}}{23,01 \times 10^{-19} - 0}$ ✓ $= \frac{1}{6,63 \times 10^{-34}}$ ✓
$f_x = 4,51 \times 10^{15}$ (Hz) ✓ $(45,1 \times 10^{14}$ Hz)

OPTION 3/*OPSIE 3*
$E = W_o + E_{k(max)}$ ✓
$hf = hf_0 + E_{k(max)}$
$6,63 \times 10^{-34} f_x$ ✓$= (6,63 \times 10^{-34})(10,40 \times 10^{14})$✓$+ 23,01 \times 10^{-19}$ ✓
$f_x = 4,51 \times 10^{15}$ (Hz)✓ $(45,1 \times 10^{14}$ Hz) (5)

10.4

10.4.1 No effect/*Geen effek nie* ✓ (1)

10.4.2 Increases/*Verhoog* ✓ (1)

10.4.3 No effect/*Geen effek* nie ✓ (1)

[12]

TOTAL/*TOTAAL*: 150

QUESTION 10/*VRAAG 10*

10.1 $11,6 \times 10^{-19}$ J ✓

ACCEPT/*AANVAAR*
$11,6 \times 10^{-19}$ to/*tot* $11,8 \times 10^{-19}$ J ✓

(1)

10.2 As the wavelength of the incident radiation/light increases the maximum kinetic energy of the emitted electrons decreases. ✓✓/
Soos die golflengte van die invallende straling/lig toeneem verminder die maksimum kinetiese energie van die vrygestelde elektrone.

OR/*OF*
As the wavelength of the incident radiation/light decreases the maximum kinetic energy of the emitted electrons increases. /
Soos die golflengte van die invallende straling/lig afneem vermeerder die maksimum kinetiese energie van die vrygestelde elektrone.

OR/*OF*
The maximum kinetic energy is inversely proportional to the wavelength./
Die maksimum kinetiese energie is omgekeerd eweredig aan die golflengte.

OR/OF

$$E_{k(max)} \ \alpha \ \frac{1}{\lambda}$$

(2)

10.3

NOTE: -1 mark for each key word/phrase omitted in the correct context. ***LET WEL:*** *-1 punt vir elke sleutelwoord/frase weggelaat in die korrekte konteks.*

The work function of a metal/surface is the minimum energy needed to remove/release an electron from a (metal) surface. ✓✓
Die werksfunksie van „n metaal/oppervlak is die minimum energie wat benodig word om „n elektron vanaf die (metaal) oppervlak vry te stel. (2)

10.4

OPTION 1/*OPSIE 1*

$W_o = hf_o$
$E = \frac{hc}{\lambda_o}$
$E = \frac{hc}{\lambda}$
✓Any one/*Enige een*

$W_o = \frac{(6,63\times10^{-34})(3\times10^{8})}{4,9\times10^{-7}}$ ✓ ✓
$= 4,06\times10^{-19}$ J ✓ $(4,059\times10^{-19})$

OPTION 2/*OPSIE 2*

$E = W_o + E_{k(max)}$
$W_0 = \frac{hc}{\lambda_o} + 0$
✓Any one/*Enige een*

$E = \frac{hc}{\lambda_o} + 0$
$W_o = \frac{(6,63\times10^{-34})(3\times10^{8})}{4,9\times10^{-7}}$ ✓ ✓
$= 4,06\times10^{-19}$ J ✓ $(4,059\times10^{-19})$ (4)

Accept any set of co-ordinates for calculation of W_o see table below
Aanvaar enige stel ko-ordinate vir die berekening van W_o sien tabel hieronder

$E = W_o + E_{k(max)}$
$\frac{hc}{\lambda} = W_o + E_{k(max)}$
✓Any one/*Enige een*

$\frac{(6,63\times10^{-34})(3\times10^{8})}{1,5\times10^{-7}}$ ✓ $= W_o + 8 \times 10^{-19}$ ✓
$W_o = 5,26 \times 10^{-19}$ J ✓

Table of values for W_o /*Tabel van waardes vir W_o*

		Q 10.4	Q 10.5
λ	$E_{K(max)}$	W_o	$E_{K(max)}$
$4,9 \times 10^{-7}$	0	$4,06 \times 10^{-19}$	$3,572 \times 10^{-18}$
$0,75 \times 10^{-7} – 0,8 \times 10^{-7}$	$14,0 \times 10^{-19}$	$1,252 \times 10^{-18} – 1,08625 \times 10^{-18}$	$2,726 \times 10^{-18}$
$1,5 \times 10^{-7}$	8×10^{-19}	$5,26 \times 10^{-19}$	$3,452 \times 10^{-18}$
2×10^{-7}	$6,0 \times 10^{-19} - 6,2 \times 10^{-19}$	$3,745 \times 10^{-19} – 3,95 \times 10^{-19}$	$3,6035 \times 10^{-18} – 3,945 \times 10^{-18}$
3×10^{-7}	$3,6 \times 10^{-19}$	$3,03 \times 10^{-19}$	$3,675 \times 10^{-18}$
4×10^{-7}	$1,6 \times 10^{-19}$	$3,3725 \times 10^{-19}$	$3,64075 \times 10^{-18}$

10.5 **POSITIVE MARKING FROM QUESTION 10.4**
POSITIEWE NASIEN VANAF VRAAG 10.4

$E = W_o + E_{k(max)}$
$\frac{hc}{\lambda} = W_0 + E_{k(max)}$
✓Any one/*Enige een*

$\frac{(6,63\times10^{-34})(3\times10^{8})}{0,5\times10^{-7}}$ ✓ $= 4,06\times10^{-19}$ ✓ $+ E_{k(max)}$
$E_{k(max)} = 3,57 \times 10^{-18}$ J ✓ $(3,572\times10^{-18}$ or/*of* $35,72 \times 10^{-19})$ (4)

[13]

TOTAL/*TOTAAL*: 150

QUESTION 10/*VRAAG 10*

10.1 Photoelectric effect/*Fotoëlektriese effek* ✓ (1)

10.2 Work function (of potassium)/*Werksfunksie/Arbeidsfunksie (van kalium)* ✓ (1)

10.3 Potassium/*Kalium* ✓
It has the lowest work function / threshold frequency / highest threshold wavelength. ✓
Dit het die laagste arbeidsfunksie / drumpelfrekwensie / hoogste drumpel golflengte. (2)

10.4

Marking criteria/*Nasienriglyne*
If any of the underlined key words/phrases in the correct context are omitted: - 1 mark per word/phrase. *Indien enige van die sleutelwoorde/frases in die korrekte konteks weggelaat word: - 1 punt per woord/frase*

The work function of a metal is the minimum energy that an electron (in the metal) needs✓ to be emitted/ejected from the metal / surface. ✓
Die werkfunksie/arbeidsfunskie van 'n metaal is die minimum energie benodig om 'n elektron vanaf 'n oppervlak / metaal vry te stel. (2)

10.5.1 $W_o = hf_o$ ✓
$= (6{,}63 \times 10^{-34})(1{,}75 \times 10^{15})$ ✓
$= 1{,}160 \times 10^{-18}$ J ✓

OR/*OF*
$E = W_o + E_{k(max)}$
$hf = W_o + E_{k(max)}$
✓ Any one / *Enigeen*
$(6{,}63 \times 10^{-34})(1{,}75 \times 10^{15}) = W_o + 0$ ✓
$W_o = 1{,}160 \times 10^{-18}$ J ✓ (3)

10.5.2 **POSITIVE MARKING FROM QUESTION 10.5.1.**
POSITIEWE NASIEN VANAF VRAAG 10.5.1.

$E = W_0 + E_{k(max)}$
$hf = hf_o + \frac{1}{2}mv^2_{max}$
✓Any one/*Enige een*

$(6{,}63 \times 10^{-34})f$ ✓ $= 1{,}160 \times 10^{-18} + \frac{1}{2}(9{,}11 \times 10^{-31})(5{,}60 \times 10^5)^2$ ✓
$\therefore\ f = 1{,}97 \times 10^{15}$ Hz ✓ (4)
[13]

TOTAL/*TOTAAL*: 150

QUESTION 10/*VRAAG 10*

10.1

Note: -1 mark for each key word/phrase omitted in correct context. ***Let Wel:*** *-1 punt vir elke sleutel woord/frase weggelaat in die korrekte konteks.*

The process whereby electrons are ejected from a metal / surface when light (of suitable frequency) is incident on that surface. ✓✓
Die proses waarby elektrone vanaf 'n (metaal)oppervlak vrygestel word wanneer lig (van geskikte frekwensie) daarop skyn/inval. (2)

10.2 7,48 x 10^{-19} (J) ✓
E = W_o + $E_{k(max)}$ (= W_o + ½mv^2_{max}) ✓
When/*Wanneer* $E_{k(max)}$ = 0 / v = 0 / v^2 = 0 / E = W_o / W_o is the y-intercept / *is die y-afsnit* ✓ (3)

10.3 Mass (of photo-electron)/*Massa (van foto-elektron)*/m ✓

ACCEPT/*AANVAAR:*
½m (1)

10.4

OPTION 1/*OPSIE* 1
Gradient = ½m
$\frac{11,98 \times 10^{-19} \checkmark - 7,48 \times 10^{-19} \checkmark}{X - 0 \checkmark}$ = ½(9,11 x 10^{-31}) ✓
X = 0,9879 ✓ (0,99 or 0,988)

ACCEPT/*AANVAAR*
X = 0,9879 x 10^{12} ($m^2 \cdot s^{-2}$)

POSITIVE MARKING FROM 10.2/*POSITIEWE NASIEN VANAF 10.2*
OPTION 2/ *OPSIE 2*
E = W_o + $E_{k(max)}$
E = W_o + ½m$v^2_{(max)}$ } ✓Any one / *Enige een*
11,98 x 10^{-19} ✓ = 7,48 x 10^{-19}✓ + ½(9,11 x 10^{-31}) v^2✓ [or/*of* ½(9,11 x 10^{-31})X]
4,5 x 10^{-19} = 4,56 x $10^{-31}v^2$
v^2 = 0,9868 x 10^{12}
X/v^2 = 0,9868 ✓ (0,99)
Range/*gebied* (0,9868 – 0,9879 / 9,87 x 10^{11} – 9,88 x 10^{11})

ACCEPT/*AANVAAR:*
X = 0,9868 x 10^{12} ($m^2 \cdot s^{-2}$) / 9,868 x 10^{11} ($m^2 \cdot s^{-2}$) (5)

10.5.1 Remains the same /*Bly dieselfde* ✓ (1)

10.5.2 Increases / *Neem toe* ✓ (1)
[13]

TOTAL/*TOTAAL*: 150

QUESTION 10/*VRAAG 10*

10.1 The minimum frequency of light needed to eject electrons from a metal (surface)✓✓.
Minimum frekwensie van lig benodig om elektrone vanaf 'n metaal (oppervlak) vry te stel.

NOTE/*LET WEL*:
-1 for each key word/phrase omitted.
-1 vir elke sleutel woorde/frase weggelaat. (2)

10.2

OPTION 1/*OPSIE 1*	**OPTION 2/*OPSIE 2***
$E = h\frac{c}{\lambda}$ ✓ $= \frac{(6,63\times10^{-34})(3\times10^{8})}{5\times10^{-7}}$ ✓ $= 3,98 \times 10^{-19}$ J✓	$c = f\lambda$ $3 \times 10^{8} = f(5 \times 10^{-7})$ $f = 6 \times 10^{14}$ Hz $E = hf$ $= (6,63 \times 10^{-34})(6 \times 10^{14})$ ✓ $= 3,98 \times 10^{-19}$ J✓

✓Both equations
Beide vergelykings

(3)

NOTE: do not penalise if *v* is used in place of *c.*

10.3

OPTION 1/*OPSIE 2*
POSITIVE MARKING FROM QUESTION 10.2/*POSITIEWE NASIEN VANAF VRAAG 10.2*

$E = W_0 + E_{kmax}$

$hf = W_0 + \frac{1}{2}mv^2_{max}$ ✓

$h\frac{c}{\lambda} = W_0 + E_{K(max/maks)}$

$h\frac{c}{\lambda} = hf_0 + E_{K(max/maks)}$

1 mark any one/*1 punt vir enige*

$3,98 \times 10^{-19} = (6,63 \times 10^{-34})(5,55 \times 10^{14}) + E_{K(max/maks)}$ ✓
$E_{K(max/maks)} = 3,0 \times 10^{-20}$ J✓

$E_{K(max/maks} > 0$ ✓

(The electrons emitted from the metal plate have kinetic energy to move between the plates, hence the ammeter registers a reading.
Die elektrone vrygestel vanaf die metaalplaat het kinetiese energie om tussen die plate te beweeg en gevolglik registreer die ammeter 'n lesing)

OPTION 2/OPSIE 2
POSITIVE MARKING FROM QUESTION 10.2/*POSITIEWE NASIEN VANAF VRAAG 10.2*

$W_o = hf_o$ ✓
$= \underline{(6,63 \times 10^{-34})(5,55 \times 10^{14})}$ ✓
$= 3,68 \times 10^{-19}$ J

$E_{photon} > W_o$ ✓

(The energy of the incident photon is greater than the work function of potassium. From the equation $hf = W_0 + E_{Kmax}$, the ejected photoelectrons will move between the plates, ✓ hence the ammeter registers a reading.
Die energie van die invallende foton is hoër as die arbeidsfunksie van kalium. Vanaf die vergelyking $hf = hf_0 + E_{K(maks)}$, *sal die vrygestelde foto-elektrone tussen die plate te beweeg en gevolglik registreer die ammeter 'n lesing.*)

OPTION 3/*OPSIE 3*

$c = f\lambda$ ✓
$3 \times 10^8 = f(5 \times 10^{-7})$ ✓
$f = 6 \times 10^{14}$ Hz

$f > f_0$ ✓

The frequency of the incident photon is higher than the threshold frequency. From the equation $hf = hf_0 + E_{K(max)}$, the ejected photoelectrons will be able to move between the plates ✓ (for the given frequency), hence the ammeter registers a reading.
Die frekwensie van die invallende foton is hoër as die drumpelfrekwensie. Vanaf die vergelyking $hf = hf_0 + E_{K(maks)}$, *sal die vrygestelde foto-elektrone tussen die plate kan beweeg en gevolglik registreer die ammeter 'n lesing.)* (4)

10.4 The increase in intensity increases the *number* of photons per second.✓
Soos die intensiteit toeneem, neem die aantal fotone per sekonde toe.

Since each photon releases one electron✓ the number of ejected electrons per second increases.✓
Aangesien elke foton een elektron vrystel, neem die aantal vrygesteld e elektrone per sekonde toe.
ACCEPT: Flow of electrons per unit time increases ✓ (1 mark)
AANVAAR: vloei van elektrone per eenheidstyd neem toe (1 punt)

This causes the current /ammeter reading to increase.
Dit veroorsaak dat die stroom/ammeterlesing toeneem. (3)

[12]

TOTAL/*TOTAAL*: 150

OPTION 3/*OPSIE 3*

$P_{ave/gemid} = V_{rms/wgk} I_{rms/wgk}$

$1600 = (240,416)\ I_{rms/wgk}$

$I_{rms/wgk} = 6,66$ A

$R = \frac{V_{rms}}{I_{rms}}$ ✓

$= \frac{240,416}{6,66}$ ✓

$= 36,1\ \Omega\ (36,09\ \Omega)$ ✓

(Do not penalise if rms is omitted in $R = \frac{V_{rms}}{I_{rms}}$ / *Moenie penaliseer indien wgk uitgelaat is nie.)*

OPTION 4/*OPSIE 4*

$P_{ave/gemid} = \frac{V_{max/maks} I_{max/maks}}{2}$

$1600 = \frac{340 I_{max/maks}}{2}$

$I_{max/maks} = 9,412$ A

$R = \frac{V_{max}}{I_{max}}$ ✓

$= \frac{340}{9,412}$ ✓

$= 36,12\ \Omega$ ✓

(Do not penalise if max is omitted in $R = \frac{V_{max}}{I_{max}}$ / *Moenie penaliseer indien maks uitgelaat*

(3)
[11]

QUESTION 11/*VRAAG 11*

11.1 Work function of a metal is the minimum energy needed to eject an electron from the metal surface ✓✓
Arbeidsfunksie van 'n metaal is die minimum energie benodig om 'n elektron uit die oppervlakte van 'n metaal vry te stel. (2)

NOTE/*LET WEL*
If any of the underlined key words/phrases in the **correct context** is omitted deduct 1 mark.
*Indien enige van die onderstreepte sleutel woorde/frases in die **korrekte konteks** uitgelaat is, trek 1 punt af.*

11.2 Potassium / *Kalium* / K ✓

f_o for potassium is greater than f_o for caesium ✓
f_o vir kalium is groter as f_o vir sesium

OR/*OF*
Work function is directly proportional to threshold frequency ✓
Arbeidsfunksie is direk eweredig aan die drumpel frekwensie

ACCEPT/*AANVAAR*
$W_o = hf_o$
$W_o \ \alpha\ f_o$ (2)

11.3 **OPTION 1/*OPSIE 1***
$c = f\lambda$ ✓
$3 \times 10^8 = f(5,5 \times 10^{-7})$ ✓
$f = 5,45 \times 10^{14}$ Hz
$f_{uv} < f_{o\ of\ K(potassium)}$
∴Ammeter in circuit **B** will not show a reading ✓
∴*Ammeter in stroombaan B sal nie 'n lesing toon nie.*

OPTION 2/*OPSIE 2*

$E = \frac{hc}{\lambda} = \frac{(6{,}63 \times 10^{-34})(3 \times 10^{8})}{5{,}5 \times 10^{-7}}$

$= 3{,}6164 \times 10^{-19}$ J

$W_o = hf_o = (6{,}63 \times 10^{-34})(5{,}55 \times 10^{14}) = 3{,}68 \times 10^{-19}$ J

$W_o > E$ or/*of* $hf_o > hf$

∴The ammeter will not register a current /*ammeter sal nie lesing registreer*✓

Mark allocation / *Puntetoekening*

✓ both correct formulae/*beide korrekte formules*: $E = \frac{hc}{\lambda}$ and $W_o = hf_o$

✓ both substitutions/*beide vervangings*: $\frac{(6{,}63 \times 10^{-34})(3 \times 10^{8})}{5{,}5 \times 10^{-7}}$ and/*en*

$(6{,}63 \times 10^{-34})(5{,}55 \times 10^{14})$

✓ correct conclusion

OPTION 3/*OPSIE 3*

$c = f_o\lambda_o$ ✓

$3 \times 10^{8} = (5{,}55 \times 10^{14})\lambda$ ✓

$\lambda_o = 5{,}41 \times 10^{-7}$ m

λ_o (threshold wavelength) < λ (incident wavelength)

λ_o (drumpelgolflengte) < λ (invallende golflengte)

∴ the ammeter will not register a current / *ammeter sal nie lesing registreer* ✓ (3)

11.4 **OPTION 1/*OPSIE 1***

$E = W_0 + E_{k(max)}$

$hf = hf_o + \frac{1}{2}mv^2_{max}$ ✓

$h\frac{c}{\lambda} = h\frac{c}{\lambda_0} + E_{K(max)}$

NOTE: If E_K of the incorrect photocell is calculated, candidate forfeit the mark for the final answer.

***LET WEL**: Indien Ek van verkeerde fotosel bereken is, verbeur kandidaat die punt vir finale antwoord*

$\frac{(6{,}63 \times 10^{-34})(3 \times 10^{8})}{5{,}5 \times 10^{-7}}$ ✓ ✓ = $(6{,}63 \times 10^{-34})(5{,}07 \times 10^{14}) + E_{k(max)}$ ✓

$E_K = 2{,}55 \times 10^{-20}$ J ✓ (Range/*Gebied*: $2{,}52 \times 10^{-20} - 2{,}6 \times 10^{-20}$ J)

OPTION 2/*OPSIE 2*

POSITIVE MARKING FROM 11.3/POSITIEWE NASIEN VANAF 11.3

$E = W_0 + E_{k(max)}$

$hf = hf_o + \frac{1}{2}mv^2_{max}$ ✓

$h\frac{c}{\lambda} = h\frac{c}{\lambda_0} + E_{K(max)}$

NOTE: If E_K of the incorrect photocell is calculated, candidate forfeit the mark for the final answer.
***LET WEL**: Indien Ek van verkeerde fotosel bereken is, verbeur kandidaat die punt vir finale antwoord*

$(6,63 \times 10^{-34})(5,45 \times 10^{14})$ ✓✓ $= \underline{(6,63 \times 10^{-34})(5,07 \times 10^{14})} + \underline{E_{k(max)}}$ ✓

$E_K = 2,52 \times 10^{-20}$ J ✓ (Range/*Gebied*: $2,52 \times 10^{-20} – 2,6 \times 10^{-20}$ J)

(5)

11.5 Remains the same/*Bly dieselfde* ✓ (1)

[13]

TOTAL/*TOTAAL*: 150

QUESTION 11/*VRAAG 11*

11.1.1 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)

11.1.2 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)

11.1.3 Light has a particle nature/*Lig het 'n deeltjieaard*
Accept light energy is quantized/*Aanvaar ligenergie is gekwantiseer*✓ (1)

11.2.1 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)

11.2.2 $W_0 = hf_0$ ✓
$= \underline{(6{,}63 \times 10^{-34})(5{,}73 \times 10^{14})}$✓
$= 3{,}8 \times 10^{-19}$J✓ [$3{,}799 \times 10^{-19}$ J] (3)

11.2.3 **POSITIVE MARKING FROM QUESTION 11.2.2**
POSITIEWE NASIE VANAF VRAAG 11.2.2
OPTION 1/*OPSIE 1*
$E = W_0 + E_{k(max/maks)}$
$hf = hf_0 + E_{k(max/maks)}$
$hf = hf_0 + ½ mv^2$
$E = W_0 + ½ mv^2$
✓ Any one/*Enige een*

$(6{,}63 \times 10^{-34})f = 3{,}8 \times 10^{-19} + [½(9{,}11 \times 10^{-31})(4{,}19 \times 10^5)^2]$✓
$f = 6{,}94 \times 10^{14}$ Hz✓ [7×10^{14} Hz]

OPTION 2/*OPSIE 2*
$E = W_0 + E_{k(max/maks)}$
$hf = hf_0 + E_{k(max/maks)}$
$hf = hf_0 + ½ mv^2$
$E = W_0 + ½ mv^2$
✓ Any one/*Enige een*

$E = 3{,}8 \times 10^{-19} + [½(9{,}11 \times 10^{-31})(4{,}19 \times 10^5)^2]$✓
$hf = 4{,}599 \times 10^{-19}$
$(6{,}63 \times 10^{-34})f = 4{,}599 \times 10^{-19}$
$f = 6{,}94 \times 10^{14}$ Hz✓ [7×10^{14} Hz] (3)
[13]

TOTAL/*TOTAAL*: 150

POSITIVE MARKING FROM 10.2.2/ *POSITIEWE NASIEN VANAF 10.2.2.2.*

OPTION 2/*OPSIE 2*

$$P_{average} = \frac{V_{rms}^2}{R}$$
$$= \frac{226,27^2}{35} \checkmark$$
$$= 1462,80 \text{ W}$$

$P_{average} = V_{rms}I_{rms}$ ✓ $1\,462,80 = (226,27)\, I_{rms}$ ✓ $I_{rms} = 6,46$ A ✓	$P_{average} = I^2_{rms}R$ ✓ $1\,462,80 = I^2_{rms}(35)$ ✓ $I_{rms} = 6,46$ A ✓

(4)

POSITIVE MARKING FROM 10.2.2/ *POSITIEWE NASIEN VANAF 10.2.2.2*

OPTION 1/*OPSIE 1*

$$I_{rms} = \frac{V_{rms}}{R} \checkmark = \frac{226,27}{35} \checkmark = 6,46 \text{ A} \checkmark$$

(4)
[13]

QUESTION 11/*VRAAG 11*

11.1 Work function (of a metal) is the minimum energy needed to eject an electron from the metal/surface
Werksfunksie (van 'n metaal) is die minimum energie benodig om 'n elektron vanaf die metaal/oppervlak vry te stel. (2)

NOTE:/LET WEL
If any one of the underlined key words in the **correct context** is omitted deduct 1 mark.
*Indien enige van die onderstreepte woorde in die **korrekte konteks** uitgelaat is trek 1 punt af.*

11.2 (Maximum) kinetic energy of the ejected electrons✓
(*Maksimum) kinetiese energie van die vrygestelde elektrone.* (1)

11.3 Wavelength/Frequency (of light) ✓
Golflengte/frekwensie (van lig) (1)

11.4 Silver✓/*Silwer*

- According to Photoelectric equation, $hf = W_o + ½ mv^2$
(For a given constant frequency), as the work function increases the kinetic energy decreases. ✓ Silver has the smallest kinetic energy✓ and hence the highest work function./
Volgens die fotoelektriese vergelyking $hf = W_o + ½ mv^2$:
(Vir 'n gegewe konstante frekwensie) as die werksfunksie verhoog, verlaag die kinetiese energie. Silwer het die kleinste kinetiese energie en dus die hoogste werksfunksie. (3)

11.5

$hf = W_o + \frac{1}{2}mv^2_{max/maks}$
$h\frac{c}{\lambda} = W_o + E_{k(max/maks)}$ ✓

$\frac{(6,63\times10^{-34})(3\times10^{8})}{2\times10^{-8}}$ ✓ $= W_o + 9,58\times10^{-18}$ ✓

$9,945 \times 10^{-18} = W_o + 9,58 \times 10^{-18}$

$W_o = 3,65 \times 10^{-19}$ J ✓ (4)

11.6 REMAINS THE SAME✓/*BLY DIESELFDE*

Increasing intensity increases number of photons(per unit time) but frequency stays constant✓
the energy of the photon is the same ✓therefore the kinetic energy does not change.
Verhoging van die intensiteit verhoog die aantal fotone(per eenheidstyd) maar die frekwensie bly konstant
Foton se energie is dieselfde, daarom verander die kinetiese energie nie. (3)
[14]

TOTAL/*TOTAAL*: 150

10.2.2

OPTION 1/*OPSIE 1*

$I_{rms} = \frac{V_{rms}}{R}$✓ $= \frac{25}{20,5}$✓
$= 1,22\ (1,2195)\ A$

$P_{ave} = I_{rms}^2 R$ $=(1,22)^2(0,5)$ $= 0,74\ W$ $P_{ave} = \frac{V_{rms}^2}{R}$ ✓ $P_{ave} = \frac{(25)^2}{20,5}$✓ $P_{ave} = 30,49\ W$ Actual energy delivered per second(power) / *Energie aan toestel gelewer per sekonde (drywing)* $= (30,49 – 0,74)$ $= 29,75\ W$✓	$P_{ave} = I_{rms}^2 R$✓ $= (1,22)^2(20)$ ✓ $= 29,77\ W$✓ **OR/OF** $V_{rms/wgk\ device/toestel} = \frac{20}{20,5}$ ✓ $\times 25 = 24,39\ V$ $P_{ave} = V_{rms} I_{rms}$ ✓ $= (24,39)(1,22)$ $= 29,76\ W$ ✓	$W = I^2_{rms} R\Delta t$ $= (1,22)^2\ (0,5)(1)$ $= 0,74\ J$ $P_{ave} = \frac{V_{rms}^2}{R}$ ✓ $P_{ave} = \frac{(25)^2}{20,5}$ ✓ $P_{ave} = 30,49\ W$ Actual energy delivered per second(power) / *Energie aan toestel gelewer per sekonde (drywing)* $= (30,49 – 0,74)$ $= 29,75\ W$✓

OPTION 2/*OPSIE 2*

$V_{rms/wgk\ device/toestel} = \frac{20}{20,5}$ ✓ $\times 25 = 24,39\ V$

$P_{ave} = \frac{V_{rms}^2}{R}$✓ $= \frac{(24,39)^2}{20}$✓ $= 29,74\ W$✓

(5)
[9]

QUESTION 11 / *VRAAG 11*

11.1.1 (Line) emission (spectrum) / *(Lyn) emissiespektrum* ✓ (1)

11.1.2 (Line) absorption (spectrum) / *(Lyn) absorpsiespektrum* ✓ (1)

11.2.1 Emission ✓/ *Emissie* (1)

11.2.2

Energy released in the transition from E_4 to $E_2 = E_4 – E_2$
Energie vrygestel in die oorgang vanaf E_4 na $E_2 = E_4 – E_2$
$E_4 – E_2 = (2,044 \times 10^{-18} – 1,635 \times 10^{-18})$✓ $= 4,09 \times 10^{-19} J$

$E = hf$✓
$4,09 \times 10^{-19} = (6,63 \times 10^{-34})f$✓
$f = 6,17 \times 10^{14}\ Hz$✓

(4)

11.2.3

$E = W_0 + E_{k(max)}$
$hf = hf_0 + E_{k(max)}$
$hf = hf_0 + ½ m v^2_{max}$
$E = W_0 + ½ m v^2_{max}$
✓ Any one/*Enige een*

$4,09 \times 10^{-19}$ ✓ = $\underline{(6,63 \times 10^{-34})(4,4 \times 10^{14})}$✓ + $E_{k(max)}$

$E_{k(max)} = 1,17 \times 10^{-19}$ J✓

OR/OF

$E_{k(max)} = E_{light/lig} - W_o$
$= hf_{light/lig} - hf_o$
✓ Any one/*Enige een*

$= \underline{(6,63 \times 10^{-34})(6,17 \times 10^{14})}$ ✓- $\underline{(6,63 \times 10^{-34})(4,4 \times 10^{14})}$✓
$= 1,17 \times 10^{-19}$ J ✓ (4)

11.2.4

No✓ / *Nee*
The threshold frequency is greater than the frequency of the photon. ✓
Die drumpelfrekwensie is groter as die frekwensie van die foton
OR/*OF*
The frequency of the photon is less than the threshold frequency✓
Die frekwensie van die foton is minder as die drumpelfrekwensie
OR/*OF*
Energy of the photon is less than the work function of the metal✓
Energie van foton is minder as die van die arbeidsfunksie van die metaal (2)

[13]

TOTAL/*TOTAAL*: 150

QUESTION 10/*VRAAG 10*

10.1 The minimum frequency of light ✓needed to emit electrons from a certain metal surface.✓
Die minimum frekwensie van lig benodig om elektrone vanaf die oppervlak van 'n sekere metaal vry te stel.

OR/*OF*
The minimum frequency of light✓ below which electrons will not be emitted from the surface of a certain metal. ✓
Die minimum frekwensie van lig waaronder elektrone nie vanaf die oppervlak van 'n sekere metaal vrygestel sal word nie. (2)

10.2 The speed remains unchanged. ✓
Die spoed bly onveranderd. (1)

10.3

OPTION 1/*OPSIE 1*

$c = f\lambda$✓,

$3 \times 10^8 = f(6 \times 10^{-7})$ ✓

$\therefore f = 5 \times 10^{14}$ Hz✓

The value of f is less than the threshold frequency of the metal, ✓ therefore photoelectric effect is not observed.✓
Die waarde van f is laer as die drumpelfrekwensie van die metal, ✓*en gevolglik sal foto- nie waargeneem word nie.* ✓

OPTION 2/*OPSIE 2*

For the given metal/*Vir die gegewe metaal*

$W_0 = hf_0$✓

$= (6{,}63 \times 10^{-34})(6{,}8 \times 10^{14})$✓

$= 4{,}51 \times 10^{-19}$ J

For the given wavelength/*Vir die gegewe golflengte*

$E_{photon/foton} = \frac{hc}{\lambda}$

$= \frac{(6{,}63\times10^{-34})(3\times10^8)}{6\times10^{-7}}$ ✓

$= 3{,}32 \times 10^{-19}$ J

$E_{photon/foton} = hf$
$= (6{,}63 \times 10^{-34})(5 \times 10^{14})$ ✓
$= 3{,}32 \times 10^{-19}$ J

This energy is less than the work function✓ of the metal,therefore photoelectric effect is not observed.✓
Hierdie energie is minder as die werksfunksie ✓of *die metal, en gevolglik sal foto-elektriese nie waargeneeme word nie.* ✓ (5)

OPTION 3/*OPSIE 3*

$c = f_0\lambda_0$ ✓
$3 \times 10^8 = 6{,}8 \times 10^{14}(\lambda_0)$ ✓
$\lambda_0 = 4{,}41 \times 10^{-7}$ m ✓

The threshold wavelength (λ_0) is smaller than 6×10^{-7} m ✓ therefore photoelectric effect is not observed. ✓
Die drumpelgolflengte (λ_0) is kleiner *as 6×10^{-7} m* ✓*en gevolglik sal foto-elektriese effek nie waargeneem word nie.* ✓

10.4

$E = W_o + E_{k(max)}$

$E = W_o + \frac{1}{2}mv_{max}^2$

$h\frac{c}{\lambda} = hf_0 + \frac{1}{2}mv_{max}^2$

$hf = hf_0 + \frac{1}{2}mv_{max}^2$

Any one of the three/*Enige van die drie* ✓

$(6{,}63 \times 10^{-34})(7{,}8 \times 10^{14})$ ✓ = $(6{,}63 \times 10^{-34})(6{,}8 \times 10^{14})$ ✓ + $\frac{1}{2}mv_{max}^2$

$\frac{1}{2}mv_{max}^2 = 6{,}63 \times 10^{-20}$ J

$\frac{1}{2}(9{,}11 \times 10^{-31})v_{max/maks}^2$ ✓ $= 6{,}63 \times 10^{-20}$

$v_{max/maks} = 3{,}82 \times 10^5$ m·s^{-1} ✓

(5)
[13]

TOTAL/*TOTAAL*: 150

OPTION 4/*OPSIE 4*

$P_{ave} = \frac{V_{rms}^2}{R} = \frac{15^2}{45} = 5\,W$

$P_{ave} = V_{rms}I_{rms}$
$5 = (15)I_{rms}$ ✓
$I_{rms} = 0,33$ A

$I_{rms} = \frac{I_{max}}{\sqrt{2}}$

$0,33 = \frac{I_{max}}{\sqrt{2}}$ ✓

$I_{max} = 0,47$ A ✓

✓any one/*enige een*

(4)
[9]

QUESTION/*VRAAG 11*

11.1 It is the process whereby electrons are ejected from a (metal) surface when light of suitable frequency is incident on that surface. ✓✓
Dit is die proses waarby elektrone vanaf die oppervlak van 'n metaal vrygestel word wanneer lig van geskikte frekwensie daarop skyn. (2)

11.2 INCREASE /*TOENEEM* ✓

Increase in intensity means that (for the same frequency) the number of photons incident per unit time increase. ✓ Therefore the number of electrons ejected per unit time increases. ✓
Thus current increases.
Toename in intensiteit beteken dat (vir dieselfde frekwensie) die aantal fotone per eenheid tyd neem toe. Dus sal die aantal elektrone per eenheid tyd vrygestel, toeneem. (3)

11.3 **OPTION 1/*OPSIE 1***

$E = W_0 + E_{k(max)}$
$hf = hf_0 + E_{k(max)}$
$hf = hf_0 + ½\,mv^2$
$E = W_0 + ½\,mv^2$

✓Any one/*Enige een*

$(6,63 \times 10^{-34} \times 5,9 \times 10^{14})$ ✓ $= \frac{(6,63 \times 10^{-34})(3 \times 10^8)}{\lambda_0}$ ✓ $+ 2,9 \times 10^{-19}$ ✓

$39,117 \times 10^{-20} - 2,9 \times 10^{-19} = \frac{19,89 \times 10^{-26}}{\lambda_o}$

$\lambda_o = 1,97 \times 10^{-6}$ m✓

OPTION 2/*OPSIE 2*

$E = W_o + E_{k(max)}$
$hf = hf_o + E_{k(max)}$
$hf = hf_o + ½ mv^2$
$E = W_o + ½ mv^2$
✓Any one/*Enige een*

$(6,63 \times 10^{-34} \times 5,9 \times 10^{14})$ ✓ $= (6,63 \times 10^{-34})f_0 + 2,9 \times 10^{-19}$ ✓

$f_o = 1,52 \times 10^{14}$ Hz

$c = f_o\lambda_o$
$3 \times 10^8 = (1,52 \times 10^{14})\ \lambda_0$✓

$\lambda_o = 1,97 \times 10^{-6}$ m✓ (5)

OPTION 3/*OPSIE 3*

$E = W_o + E_{k(max)}$
$hf = hf_o + E_{k(max)}$
$hf = hf_o + ½ mv^2$
$E = W_o + ½ mv^2$
✓Any one/*Enige een*

$(6,63 \times 10^{-34} \times 5,9 \times 10^{14})$ ✓ $= W_0 + 2,9 \times 10^{-19}$ ✓
$W_o = 1,01 \times 10^{-19}$ J

$W_o = hf_o$
$1,01 \times 10^{-19} = (6,63 \times 10^{-34})f_o$
$f_o = 1,52 \times 10^{14}$ Hz

$c = f_o\lambda_o$
$3 \times 10^8 = (1,52 \times 10^{14})\ \lambda_0$✓

$\lambda_o = 1,97 \times 10^{-6}$ m✓

11.4 From the photo-electric equation, for a constant work function, ✓ the maximum kinetic energy of the photoelectrons is proportional to the energy of the photons.✓

Vanaf die foto-elektriese vergelyking is die maksimum kinetiese energie van die foto-elektrone eweredig aan die energie van die fotone vir 'n konstante arbeidsfunksie. (2)
[12]

OPTION 3/*OPSIE 3*

$P_{ave/gemid} = V_{rms/wgk}\ I_{rms/wgk}$ ✓ $= \frac{V_{max/maks} I_{max/maks}}{2}$

2 800✓ $= \frac{(340)\ I_{max/maks}}{2}$ ✓

$I_{max/maks}$ = 16,47 A

$I_{rms} = \frac{I_{max/maks}}{\sqrt{2}} = \frac{16,47}{\sqrt{2}}$

$I_{rms/wgk}$ = 11,65 A✓

OPTION 4/*OPSIE 4*

$P_{ave/gemid} = V_{rms/wgk}\ I_{rms/wgk}$✓

2 800 ✓$= \frac{340}{\sqrt{2}}\ I_{rms/wgk}$✓

$I_{rms/wgk}$ = 11,65 A ✓

OPTION 5/*OPSIE 5*

P_T : P_K
800 : 2 000 ✓
1 : 2,5

I_T : I_K
3,33 : 8,325 ✓

I_{rms} = 3,33 + 8,325 ✓
= 11,66 A ✓ (4)

[11]

QUESTION 10/*VRAAG 10*

10.1.1 The minimum frequency (of a photon/light) needed✓ to emit electrons from (the surface of) a metal. (substance) ✓
Die minimum frekwensie (van 'n foton/lig) benodig om elektrone vanaf die (oppervlakte van)'n metaal (stof) vry te stel

OR/OF

The frequency (of a photon/light) needed✓ to emit electrons from (the surface of) a metal. (substance) with zero kinetic energy✓
Die frekwensie (van 'n foton/lig) benodig om elektrone vanaf die (oppervlakte van)'n metaal (stof) met nul/geen kinetiese energie vry te stel (2)

10.1.2 Silver/*Silwer*✓

Threshold/cutoff frequency (of Ag) is higher/*Drumpel/afsnyfrekwensie (van Ag) is hoër*✓
W_o α f_o / $W_o = hf_o$ ✓
OR/*OF*
To eject electrons with the same kinetic energy from each metal, light of a higher frequency/energy is required for silver. ✓ Since $E = W_o + E_{k(max)}$ (and E_k is constant), the higher the frequency/energy of the photon/light required, the greater is the work function/W_o.✓
Om elektrone met dieselfde kinetiese energie van elke metal vry te stel,is lig van hoër frekwensie benodig vir silwer. Aangesien $E = W_o + E_{k(maks)}$ (en $E_{k(maks)}$ is konstant) word fotone/lig van hoër frekwensie/energie benodig, dus is arbeidsfunksie hoër (3)

10.1.3 Planck's constant /*Planck se konstante* ✓ (1)

10.1.4 Sodium/*Natrium*✓ (1)

10.2.1 Energy radiated per second by the blue light /*Energie per sekonde uitgestraal deur die bloulig* = $(\frac{5}{100})(60 \times 10^{-3})$ ✓ = 3×10^{-3} J·s^{-1}

$E_{photon/foton} = \frac{hc}{\lambda}$ ✓

$= \frac{(6{,}63 \times 10^{-34})(3 \times 10^{8})}{470 \times 10^{-9}}$ ✓

$= 4{,}232 \times 10^{-19}$J

Total number of photons incident per second/*Totale aantal fotone wat per sekonde inval* = $\frac{3 \times 10^{-3}}{4{,}232 \times 10^{-19}}$ ✓

$= 7{,}09 \times 10^{15}$ ✓ (5)

10.2.2 **POSITIVE MARKING FROM QUESTION 10.2.1**
POSITIEWE NASIEN VANAF VRAAG 10.2.1

$7{,}09 \times 10^{15}$ (electrons per second/*elektron per sekonde*) ✓

OR/*OF*
Same number as that calculated in Question 10.2.1 above/*Dieselfde as die in Vraag 10.2.1 hierbo bereken* (1)
[13]

TOTAL/*TOTAAL*: 150

QUESTION 11/*VRAAG 11*

11.1 It is the minimum energy that an electron in the metal needs to be emitted from the metal surface. ✓/*Dit is die minimum energie wat 'n elektron in die metaal benodig om elektrone uit die metaaloppervlak vry te stel.* ✓ (2)

11.2 Frequency/Intensity ✓/*Frekwensie/Intensiteit* (1)

11.3 The minimum frequency required to remove an electron from the surface of the metal✓/*Die minimum frekwensie benodig om 'n elektron vanaf die oppervlak van die metaal te verwyder*✓ (2)

11.4 **POSITIVE MARKING FROM QUESTION 11.4/**
POSITIEWE NASIEN VANAF VRAAG 11.4

$E = W_0 + E_k$
$hf = hf_0 + E_k$
✓ Any one/*Enige een*

$(6,63 \times 10^{-34})(6,50 \times 10^{14})$✓$=(6,63 \times 10^{-34})(5,001 \times 10^{14})$ ✓$+ ½(9,11 \times 10^{-31})v^2$✓
$\therefore v= 4,67 \times 10^5$ m·s^{-1}✓

OR/*OF*

$E_K = E_{light} - W_o$
$= hf_{light} - hf_o$
✓ Any one/*Enige een*

$= (6,63 \times 10^{-34})(6,50 \times 10^{14} - 5,001 \times 10^{14})$ ✓
$= 9,94 \times 10^{-20}$ J

$E_K = ½ mv^2$ ✓

$$v = \sqrt{\frac{2E_k}{m}} = \sqrt{\frac{(2)(9,94 \times 10^{-20})}{9,11 \times 10^{-31}}}$$ ✓

$v = 4,67 \times 10^5$ m·s^{-1} ✓ (5)

11.5 The photocurrent is directly proportional to the intensity of the incident light.✓✓/*Die fotostroom is direk eweredig aan die intensiteit van die invallende lig.* ✓✓ (2)

[12]

TOTAL/*TOTAAL*: 150

OPTION 3/*OPSIE 3*	**OPTION 4/*OPSIE 4***
$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓ $= \frac{430}{\sqrt{2}}$ ✓ = 304,06 V $P_{average} = \frac{V^2_{rms}}{R} = \frac{(304,06)^2}{400}$ = 231,13 W $P_{ave} = I_{rms}V_{rms}$✓ 231,13 = I_{rms} (304,06) ✓ I_{rms} = 0,76 A✓	$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ ✓ $= \frac{430}{\sqrt{2}}$ ✓ = 304,06 V $P_{average} = \frac{V^2_{rms}}{R} = \frac{(304,06)^2}{400}$ = 231,13 W $P_{ave} = I^2_{rms}R$✓ 231,13 = I^2_{rms} (400) ✓ I_{rms} = 0,76 A✓

[10]

QUESTION/*VRAAG 11*

11.1.1 It tells us that light has a particle nature.✓
Dit sê vir ons dat lig 'n deeltjie-aard het (1)

11.1.2 Remain the same. ✓
Bly dieselfde

For the same colour/ frequency/wavelength the energy of the photons will be the same✓. (The brightness causes more electrons to be released, but they will have the same maximum kinetic energy.)
Vir dieselfde kleur / frekwensie/ golflengte is die energie van die fotone dieselfde. (Die helderheid veroorsaak dat meer elektrone vrygestel word, maar hulle sal dieselfde maksimum kinetiese energie hê.)

OR/*OF*
Intensity only affects the number of ejected photo-electrons and not the maximum kinetic energy or maximum speed of the ejected photo-electrons
Intensiteit beinvloed slegs die aantal vrygestelde foto-elektrone en nie die maksimum kinetiese energie of maksimum spoed van die foto-elektrone.
OR/OF
Maximum kinetic energy of ejected photo-electrons is independent of intensity of radiation
Maksimum kinetiese energie van vrygestelde foto-elektrone is onafhanklik van die intensiteit van straling. (2)

11.1.3
$E = W_0 + E_k$
$hf = hf_0 + E_k$
$hf = hf_0 + ½ mv^2$
$E = W_0 + ½ mv^2$
✓ Any one/*Enige een*

$\frac{(6,63\times10^{-34})(3\times10^8)}{420\times10^{-9}}$ ✓ $= \frac{(6,63\times10^{-34})(3\times10^8)}{\lambda_0}$ ✓ $+ \frac{1}{2}(9,11\times10^{-31})(4,76\times10^5)^2$ ✓

$\lambda_o = 5,37 \times 10^{-7}$ m
∴ the metal is sodium / *die metaal is natrium* ✓ (5)

11.2 **Q**✓ and/*en* **S** ✓

-

Emission spectra occur when excited atoms /electrons drop from higher energy levels to lower energy levels. ✓✓
Emissiespektra ontstaan wanneer opgewekte atome/elektrone vanaf hoër energievlakke na laer energievlakke beweeg.
(Characteristic frequencies are emitted/*Kenmerkende frekwensies word vrygestel.*) (4)

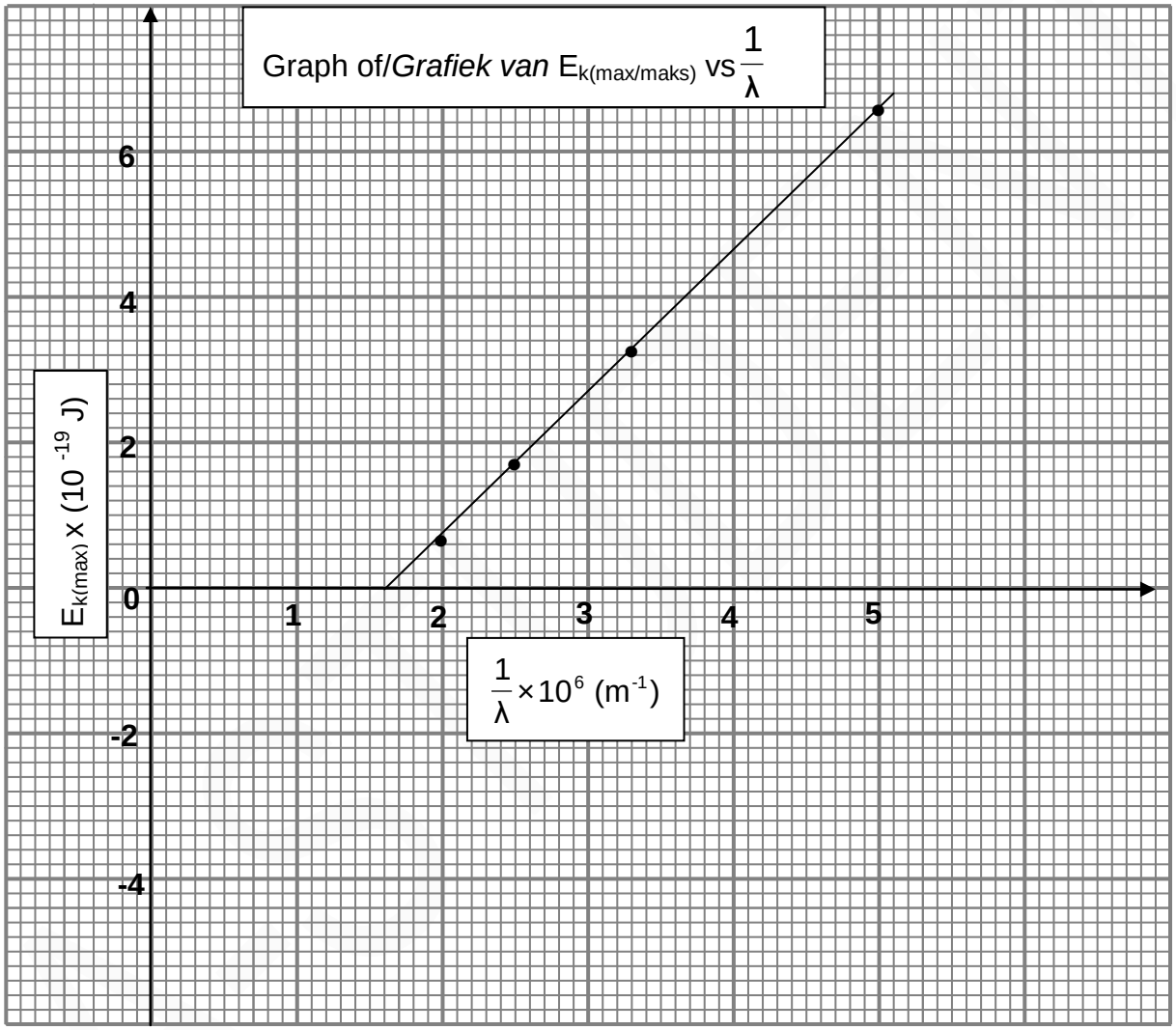
[12]

TOTAL/*TOTAAL*: 150

QUESTION 11/*VRAAG 11*

11.1 It is the process whereby electrons are ejected from a metal surface when light (of suitable frequency) is incident on it. ✓✓
Dit is die proses waartydens elektrone vanaf 'n metaaloppervlak vrygestel word wanneer van geskikte frekwensie daarop inval✓✓ (2)

11.2



11.3.1

OPTION 1/OPSIE 1

$\frac{1}{\lambda} = 1{,}6 \times 10^{6}\ m^{-1}$ ✓

$f_o = c\frac{1}{\lambda}$ ✓

$= (3 \times 10^{8})(1{,}6 \times 10^{6})$ ✓

$= 4{,}8 \times 10^{14}$ Hz✓ (**Accept/*Aanvaar*** $4{,}8 \times 10^{14}$ Hz to/*tot* $5{,}1 \times 10^{14}$ Hz) (4)

OPTION 2/OPSIE 2

By extrapolation: y-intercept = $-W_o$/*Deur ekstrapolasie : y-afsnit* = $-W_o$

$W_o = hf_o$ ✓

$3{,}2 \times 10^{-19}$✓ $= (6{,}63 \times 10^{-34})f_o$ ✓

$f_o = 4{,}8 \times 10^{14}$ Hz✓ (**Accept/*Aanvaar*** $4{,}8 \times 10^{14}$ Hz to/*tot* $4{,}83 \times 10^{14}$ Hz) (4)

OPTION 3/OPSIE 3 (Points from the graph/ *Punte vanaf grafiek***)**

$E = W_o + E_{k(max)}$

$\frac{hc}{\lambda_0} = hf_0 + E_{k(max)}$ ✓

$(6{,}63 \times 10^{-34})(3 \times 10^{8})(1{,}6 \times 10^{6})$✓ $= (6{,}63 \times 10^{-34})f_0 + 0$ ✓

$f_o = 4{,}8 \times 10^{14}$ Hz ✓

OR/*OF*

$(6{,}63 \times 10^{-34})(3 \times 10^{8})(5 \times 10^{6}) = (6{,}63 \times 10^{-34})f_0 + 6{,}6 \times 10^{-19}$

$f_o = 4{,}92 \times 10^{14}$ Hz

OR/*OF*

$(6{,}63 \times 10^{-34})(3 \times 10^{8})(3{,}3 \times 10^{6}) = (6{,}63 \times 10^{-34})f_0 + 3{,}3 \times 10^{-19}$

$f_o = 4{,}8 \times 10^{14}$ Hz

OR/OF

$(6{,}63 \times 10^{-34})(3 \times 10^{8})(2{,}5 \times 10^{6}) = (6{,}63 \times 10^{-34})f_0 + 1{,}7 \times 10^{-19}$

$f_o = 4{,}94 \times 10^{14}$ Hz

OR/OF

$(6{,}63 \times 10^{-34})(3 \times 10^{8})(2{,}2 \times 10^{6}) = (6{,}63 \times 10^{-34})f_0 + 0{,}7 \times 10^{-19}$

$f_o = 5{,}54 \times 10^{14}$ Hz (4)

11.3.2

OPTION 1/*OPSIE 1*	**OPTION 2/*OPSIE 2***
hc = Gradient/ *Helling* ✓ $= \frac{\Delta y}{\Delta x}$ $= \frac{6,6\times10^{-19}}{(5-1,6)\times10^{6}}$ ✓ = 1,941 x10^{-25} (J·m) $h = \frac{\text{gradient / helling}}{c}$ $h = \frac{1,941\times10^{-25}}{3\times10^{8}}$ ✓ = 6,47 x10^{-34} J·s ✓	W_0 = y intercept/*afsnit* = 3,2 x10^{-19} J ✓ **Accept /*Aanvaar*** 3,2 x10^{-19} J to/*tot* 3,4 x10^{-19}J) $W_o = hf_o$ 3,2 x 10^{-19}✓ = h(4,8 x 10^{14}) ✓ h = 6,66 x 10^{-34} J·s✓ **Accept /*Aanvaar*** 6,66 x10^{-34} J·s to/*tot* 7,08 x10^{-34}J·s)

(4)

OPTION 3/*OPSIE 3*
(Points from the graph
*(Punte vanaf grafiek***)**

$\frac{hc}{\lambda} = W_0 + K_{max} = 3,2\times10^{-19}$✓ $+ 6,6\times10^{-19}$ ✓

$h = \frac{9,8\times10^{-19}}{(3\times10^{8})(5\times10^{6})}$✓ $= 6,53\times10^{-34}$ J·s

OR/*OF*

$\frac{hc}{\lambda} = W_0 + K_{max} = 3,2\times10^{-19}$✓ $+ 3,3\times10^{-19}$ ✓

$h = \frac{6,5\times10^{-19}}{(3\times10^{8})(3,3\times10^{6})}$✓ $= 6,57\times10^{-34}$ J·s

OR/*OF*

$\frac{hc}{\lambda} = W_0 + K_{max} = 3,2\times10^{-19}$✓ $+ 1,7\times10^{-19}$

$h = \frac{4,7\times10^{-19}}{(3\times10^{8})(2,5\times10^{6})}$✓ $= 6,27\times10^{-34}$ J·s

OR/*OF*

$\frac{hc}{\lambda} = W_0 + K_{max} = 3,2\times10^{-19}$✓ $+ 0,7\times10^{-19}$ ✓

$h = \frac{3,9\times10^{-19}}{(3\times10^{8})(2\times10^{6})}$✓ $= 6,5\times10^{-34}$ J·s

OPTION 4/*OPSIE 4*

$W_o = \frac{hc}{\lambda_o}$ or / of $W_o = hc\frac{1}{\lambda_o}$

3,2 x 10^{-19} ✓= h(3 x 10^{8})(1,6 x 10^{6})✓

h = 6,66 x 10^{-34} J·s ✓

(4)
[13]

TOTAL/*TOTAAL*: 150

QUESTION 10/*VRAAG 10*

10.1 The minimum energy needed to emit an electron ✓ from (the surface of) a metal. ✓
Die minimum energie benodig om 'n elektron uit die (oppervlak van) 'n metaal vry te stel. (2)

10.2 $E = W_0 + \frac{1}{2}mv_{max}^2$
$h\frac{c}{\lambda} = W_0 + \frac{1}{2}mv_{max}^2$
} Any ONE OF/*ENIGE EEN van*✓

$\frac{(6{,}63\times10^{-34})(3\times10^{8})}{(\lambda)} = (3{,}36\times10^{-19}) + 2{,}32\times10^{-19}$ ✓ ✓

λ = 3,50 x 10^{-7} m✓ (4)

10.3 **POSITIVE MARKING FROM QUESTION 10.2**
POSITIEWE NASIEN VANAF VRAAG 10.2

$E = W_0 + \frac{1}{2}mv_{max}^2$
OR/*OF*
$h\frac{c}{\lambda} = W_0 + \frac{1}{2}mv_{max}^2$
} ✓ ✓

$\frac{(6{,}63\times10^{-34})(3\times10^{8})}{(3{,}50\times10^{-7})} = (3.65\times10^{-19}) + E_k$

E = 2,03 x 10^{-19} J✓ (4)

10.4.1 Increasing the intensity does not change the energy/ frequency/wavelength of the incident photons✓/The energy of a photon remains unchanged (for the same frequency).
Verhoging van die intensiteit, verander nie die energie/frekwensie/golflengte van die invallende fotone nie/Die energie van die foton bly onveranderd (vir dieselfde frekwensie). (1)

10.4.2 Increases./*Neem toe*✓ (1)

10.4.3 More photons (packets of energy) strike the surface of the metal per unit time✓ hence more (photo) electrons ejected per unit time ✓(leading to increased current).
Meer fotone (energie pakkies) tref die oppervlakte van die metaal per eenheidstyd, gevolglik word meer (foto)elektrone per eenheidstyd vrygestel (wat lei tot 'n verhoogde stroom). (2)
[14]

TOTAL/*TOTAAL*: 150

QUESTION 10/*VRAAG 10*

10.1 The minimum frequency (of a photon/light) needed to emit electrons ✓ from (the surface of) a metal. (substance) ✓
Die minimum frekwensie (van 'n foton/lig) benodig om elektrone vanaf die (oppervlakte van)'n metaal (stof) vry te stel. (2)

10.2 **OPTION 1/*OPSIE 1***

$E = W_o + E_{k(max)}$
$E = W_o + \frac{1}{2}mv^2_{max}$
$h\frac{c}{\lambda} = hf_0 + \frac{1}{2}mv^2_{max}$
✓Any one / *Enige een*

$\frac{(6{,}63 \times 10^{-34})(3 \times 10^8)}{\lambda}$ ✓$= (6{,}63 \times 10^{-34})(5{,}548 \times 10^{14})$ ✓$+ \frac{1}{2}(9{,}11 \times 10^{-31})(5{,}33 \times 10^5)^2$ ✓

$\lambda = 4 \times 10^{-7}$ m✓ (5)

OPTION 2/*OPSIE 2*

$E = W_o + E_{k(max)}$
$E = W_o + \frac{1}{2}mv^2_{max}$
$hf = hf_0 + \frac{1}{2}mv^2_{max}$
✓Any one / *Enige een*

$(6{,}63 \times 10^{-34})f = (6{,}63 \times 10^{-34})(5{,}548 \times 10^{14})$ ✓$+ \frac{1}{2}(9{,}11 \times 10^{-31})(5{,}33 \times 10^5)^2$ ✓

$f = 7{,}5 \times 10^{14}$ Hz

$c = f\lambda$
$3 \times 10^8 = (7{,}5 \times 10^{14})\lambda$✓
$\lambda = 4 \times 10^{-7}$ m ✓ (5)

10.3 Smaller (less) than ✓
Kleiner (minder) as (1)

10.4 The wavelength/frequency/energy of the incident light (photon/hf) is constant✓.
Die golflengte/frekwensie/energie van die invallende lig (foton/hf) is konstant

Since the speed is larger, the kinetic energy is larger ✓ the work function/W_0/threshold frequency smaller. ✓

Aangesien die spoed vergroot, is die kinetiese energie groter, is die arbeidsfunksie / W_0 / drumpel frekwensie kleiner (3)
[11]

GRAND TOTAL/*GROOTTOTAAL*: 150

QUESTION 11/*VRAAG 11*

11.1.1 The emission of electrons from the surface of a metal ✓ by light of an appropriate frequency. ✓/*Die vrystelling van elektrone vanaf die oppervlak van 'n metaal/Deur lig van 'n toepaslike frekwensie* (2)

11.1.2 Total energy transferred per second = 1,8 x 10^{-9} J
Totale energie oorgedra per sekonde = 1,8 x 10^{-9} J
Energy of one photon/*Energie van een foton*:

$E_{photon/foton} = hf$
$= \frac{hc}{\lambda}$ } (any one/*enige een*) ✓

$= \frac{(6,63 \times 10^{-34})(3 \times 10^{8})}{260 \times 10^{-9}}$ ✓

= 7,65 x 10^{-19} J

Number of electrons in one second = $\frac{1,8 \times 10^{-9}\ ✓}{7,65 \times 10^{-19}\ ✓}$ = 2,35 x 10^{9} ✓

OR/OF
Total energy transferred per second = 1,8 x 10^{-9} J
Totale energie oorgedra per sekonde = 1,8 x 10^{-9} J
Energy of one photon/*Energie van een foton*

$E_{photon/foton} = hf$
$= \frac{hc}{\lambda}$ } ✓any one /*enige een*

Number of electrons /*Aantal elektrone* = $\frac{1,8 \times 10^{-9}\ ✓}{hf} = \frac{1,8 \times 10^{-9} \times \lambda}{hc}$

Number of electrons ejected/*Aantal elektrone vrygestel* = $\frac{1,8 \times 10^{-9} \times 2,6 \times 10^{-7}\ ✓}{6,63 \times 10^{-34} \times 3 \times 10^{8}\ ✓}$

$\therefore N_e$ = 2,35 x 10^{9} (electrons per second) ✓ (5)

11.1.3 **POSITIVE MARKING FROM QUESTION 11.1.2.**
POSITIEWE NASIEN VANAF VRAAG 11.1.2.
q = N_e x e
= (2,35 x 10^{9})(1,6 x 10^{-19}) ✓ = 3,76 x 10^{-10} C
q = IΔt ✓

$\therefore$ I = $\frac{q}{\Delta t} = \frac{3,76 \times 10^{-10}}{1}$ ✓

I = 3,76 x 10^{-10} A ✓ (4)

11.2.1 Electrons in excited state fall back to ground state/ lower energy state. ✓
Elektrone in opgewekte toestand val terug na grondtoestand /laer energietoestand
Energy radiated as light. /*Energie uitgestraal as lig.* ✓ (2)

11.2.2 To identify elements. */Om elemente te identifiseer.* ✓
Accept / *Aanvaar:*
To determine the temperature of stars/ Fluorescent lights/ Neon signs./ (1)
Om die temperatuur van sterre te bepaal/ Fluoreserende ligte/ Neontekens **[14]**

TOTAL SECTION B/*TOTAAL AFDELING B*: 125
GRAND TOTAL/*GROOTTOTAAL*: 150

QUESTION 11/*VRAAG 11*

11.1 The minimum energy needed to remove an electron ✓
from the surface of a metal. ✓
Die minimum energie benodig om 'n elektron vanaf die oppervlak van 'n metaal te verwyder. (2)

11.2

11.2.1 $W_0 = hf_0$ ✓
$= (6{,}63 \times 10^{-34})(4 \times 10^{14})$ ✓
$= 2{,}65 \times 10^{-19}$ J ✓ (3)

11.2.2 $E = W_0 + E_k$
$hf = hf_0 + \frac{1}{2}mv^2$
} ✓ Any one/*Enige een*

$(6{,}63 \times 10^{-34})(8 \times 10^{14})$ ✓ $= 2{,}65 \times 10^{-19}$ ✓ $+ \frac{1}{2}(9{,}11 \times 10^{-31})v^2$ ✓

$\therefore v = 7{,}63 \times 10^{5}$ m·s^{-1} ✓ (5)

11.3

11.3.1 Equal to /*Gelyk aan* ✓
The gradient is Planck's constant./ *Die gradiënt is Planck se konstante.* ✓ (2)

11.3.2 8×10^{14} Hz ✓
f_0 is directly proportional to W_0. / *f_0 is direk eweredig aan W_0.* ✓ (2)
[14]

TOTAL/*TOTAAL*: 150

10.7

OPTION 1/ *OPSIE 1*

$P_{ave} = V_{rms}I_{rms}$ ✓

$= \left(\frac{V_{max}}{\sqrt{2}}\right)\left(\frac{I_{max}}{\sqrt{2}}\right)$ ✓ (1 mark for both formulae / *1 punt vir beide formules*)

$= \left(\frac{311}{\sqrt{2}}\right)$✓$\left(\frac{21{,}21}{\sqrt{2}}\right)$ ✓

= 3 298,16 W ✓ (Accept range / *Aanvaar gebied*: 3298,13 – 3299,18 W)

OPTION 2/ *OPSIE 2*

$P_{ave} = \frac{V_{max}I_{max}}{2}$ ✓✓

$= \frac{(311)(21.21)}{2}$ ✓✓

= 3298,16 W✓

OPTION 3 / *OPSIE 3*

$V_{rms} = \frac{V_{max}}{\sqrt{2}} = \frac{311}{\sqrt{2}}$ ✓✓= 219,91 V

$I_{rms} = \frac{I_{max}}{\sqrt{2}} = \frac{21{,}21}{\sqrt{2}}$ ✓= 14,998 A

$P_{ave} = V_{rms}I_{rms}$ ✓

= (219,91)(14,998)

= 3 298,21 W ✓

OPTION 4/ *OPSIE 4*

$R = \frac{V_{max}}{I_{max}}$

$= \frac{311}{21{,}21}$ ✓

= 14,66 Ω

$V_{rms} = \frac{V_{max}}{\sqrt{2}} = \frac{311}{\sqrt{2}}$ ✓= 219,91 V

$P_{ave} = \frac{V_{rms}^2}{R}$ ✓

$= \frac{(219{,}91)^2}{14{,}66}$ ✓

= 3 298,8 W✓

OPTION 6/*OPSIE 6*

$R = \frac{V_{max}}{I_{max}}$

$= \frac{311}{21{,}21}$ ✓

= 14,66 Ω

$I_{rms} = \frac{I_{max}}{\sqrt{2}} = \frac{21{,}21}{\sqrt{2}}$ ✓= 14,998 A

$P_{ave} = I_{rms}^2R$ ✓

$= (14{,}998)^2(14{,}66)$ ✓

= 3 297,62 W✓

(5)
[14]

QUESTION 11/*VRAAG 11*

11.1

11.1.1 Photo-electric effect / *Foto-elektriese effek* ✓ (1)

11.1.2

OPTION 1/*OPSIE 1*

$E = W_0 + E_k$

$hf = hf_0 + E_k$

$\frac{hc}{\lambda} = W_0 + \frac{1}{2}mv^2$

✓ Any one/*Enige een*

$\frac{(6{,}63 \times 10^{-34})(3x10^8)}{200 \times 10^{-9}}$ ✓ = 8 x 10^{-19} ✓ + ½(9,11 x 10^{-31})v^2 ✓

v= 6,53 x 10^5 m·s^{-1} ✓ (653454,89 m·s^{-1})

OPTION 2 / *OPSIE 2*

c = fλ
3 x 10^8 = f(200 x 10^{-9})
f = 1,5 x 10^{15} Hz

$hf = hf_0 + E_k$✓

(6,63 x 10^{-34})(1,5 x 10^{15}) ✓= 8 x 10^{-19} ✓ + ½(9,11 x 10^{-31})v^2 ✓

v= 6,53 x 10^5 m·s^{-1} ✓ (5)

11.1.3 Increases / *Vermeerder* ✓ (1)

11.1.4 Remains the same / *Bly dieselfde* ✓
- Intensity only affects number of photoelectrons emitted per second. ✓
Intensiteit beïnvloed slegs die getal foto-elektrone vrygestel per sekonde.

OR/*OF*

Remains the same / *Bly dieselfde* ✓
- The kinetic energy of the emitted photoelectrons remains the same.
Die kinetiese energie van die vrygestelde foto-elektrone bly dieselfde.

OR/*OF*

Remains the same / *Bly dieselfde* ✓
- Only the frequency/wavelength of the incident light affects the maximum kinetic energy.
Slegs the frekwensie/golflengte van die invallende lig beïnvloed die maksimum kinetiese energie. (2)

11.2 B ✓
Orange light has a higher frequency than red light. ✓
Oranje lig het 'n hoër frekwensie as rooi lig.

OR/*OF*

Orange light has smaller wavelength than red light.
Oranje lig het 'n kleiner golflengte as rooi lig. (2)

11.3 Line emission (spectra) / *Lyn emissie(spektrum)* ✓ (1)
[12]

TOTAL SECTION B/*TOTAAL AFDELING B*: 125
GRAND TOTAL/*GROOTTOTAAL*: 150

QUESTION 11/*VRAAG 11*

11.1 Quantum/packet of energy/*Kwantum/pakkie energie*✓
found in light/*In lig gevind* ✓ (2)

11.2

11.2.1

OPTION 1/*OPSIE 1*

$E = \frac{hc}{\lambda}$ ✓

$6,9 \times 10^{-19}$ ✓ $= \frac{(6,63 \times 10^{-34})(3 \times 10^{8})}{\lambda}$ ✓ ✓

$\therefore \lambda = 2,9 \times 10^{-7}$ m ✓

OPTION 2 / *OPSIE 2*

$E = hf$

$6,9 \times 10^{-19}$ ✓ $= 6,63 \times 10^{-34} f$ ✓

$\therefore f = 1,04 \times 10^{15}$ Hz

$c = f\lambda$

$3 \times 10^{8} = 1,04 \times 10^{15} \lambda$ ✓

$\therefore \lambda = 2,88 \times 10^{-7}$ m ✓

✓ Both formulae *Beide formules*

Notes/*Aantekeninge*
Accept/*Aanvaar:* $v = f\lambda$

(5)

11.2.2 $E = W_o + E_k$ ✓
$6,9 \times 10^{-19} = 6,4 \times 10^{-19} + E_k$ ✓
$\therefore E_k = 5 \times 10^{-20}$ J ✓ (3)

11.3

11.3.1 Increases/*Vermeerder* ✓

- More photons (packets of energy) strike the surface of the metal per unit time./*Meer fotone (pakkies energie) tref die oppervlakte van die metaal per eenheid tyd.* ✓
- More (photo)electrons ejected per unit time./*Meer (foto)elektrone vrygestel per eenheid tyd*. ✓ (3)

11.3.2 Increases/*Vermeerder* ✓

- (Photo)electrons are emitted with higher kinetic energy/move faster./ *(Foto)elektrone word vrygestel met hoër kinetiese energie/beweeg vinniger.* ✓
- Increase in rate of flow of charge./Same number of charges pass a point in a shorter time./*Toename in tempo van vloei van lading/dieselfde aantal lading beweeg verby 'n punt in 'n korter tyd.* ✓ (3)

[16]

TOTAL SECTION B/*TOTAAL AFDELING B:* 125
GRAND TOTAL/*GROOTTOTAAL*: 150

QUESTION 11/*VRAAG 11*

11.1

11.1.1 Kinetic energy /*Kinetiese energie* (E_k)✓ (1)

11.1.2 Frequency /*Frekwensie*✓(f) (1)

11.1.3 (Type of) metal✓
(Soort) metaal ✓ (1)

11.2 The minimum frequency needed to emit electrons ✓
from (the surface of) a metal. ✓
Die minimum frekwensie benodig om elektrone vry te stel vanaf (die oppervlak van) 'n metaal. (2)

11.3 9×10^{14} Hz ✓ (1)

11.4

$E = W_0 + E_k$
$hf = hf_0 + E_k$ } ✓ Any one /*Enige een*

$(6{,}63 \times 10^{-34})(14 \times 10^{14})$ ✓ $= (6{,}63 \times 10^{-34})(9 \times 10^{14})$ ✓ $+ E_k$

$\therefore E_k = 3{,}32 \times 10^{-19}$ J ✓ $(3{,}31 \times 10^{-19}$ J) (4)

11.5 Remains the same/*Bly dieselfde* ✓ (1)
[11]

TOTAL SECTION B/*TOTAAL AFDELING B*: 125
GRAND TOTAL/*GROOTTOTAAL*: 150

10.2.2

(b) $P_{ave} = V_{rms/wgk}I_{rms/wgk}$ ✓

$2\ 000 = (230)I_{rms/wgk}$ ✓

$I_{rms/wgk} = 8,70$ A ✓ (8,696 A) (3)

[12]

QUESTION 11/*VRAAG 11*

11.1 Photoelectric effect/*Foto-elektriese effek* ✓ (1)

11.2

11.2.1 $E = hf$ ✓

$= (6,63 \times 10^{-34})(6,16 \times 10^{14})$ ✓

$= 4,08 \times 10^{-19}$ J ✓ (3)

11.2.2 $E = W_0 + K$ ✓

$4,08 \times 10^{-19}$ ✓ $= (6,63 \times 10^{-34})f_0$ ✓ $+ 5,6 \times 10^{-20}$ ✓

$f_0 = 5,31 \times 10^{14}$ Hz ✓ (5)

11.3

11.3.1 Increases ✓

More photoelectrons emitted per second ✓

Vermeerder ✓

Meer foto-elektrone vrygestel per sekonde ✓ (2)

11.3.2 Remains the same ✓

Intensity does not affect energy. ✓

Bly dieselfde ✓

Intensiteit het geen effek op energie nie. ✓

OR/*OF*

Remains the same ✓

The frequency of light remains the same. ✓

Bly dieselfde ✓

Die frekwensie van die lig bly dieselfde. ✓ (2)

[13]

TOTAL SECTION B/*TOTAAL AFDELING B*: 125

GRAND TOTAL/*GROOTTOTAAL*: 150

QUESTION 12 / *VRAAG 12*

12.1 Photo-electric effect / *Foto-elektriese effek* ✓ (1)

12.2 Work function / *Werkfunksie / Arbeidsfunksie* ✓ (1)

12.3 $c = f\lambda$ ✓
3×10^8 ✓ $= f(330 \times 10^{-9})$ ✓
$\therefore f = 9{,}09 \times 10^{14}$ Hz ✓

OR/*OF*

$E = \frac{hc}{\lambda} = \frac{(6{,}63 \times 10^{-34})(3 \times 10^8)}{330 \times 10^{-9}}$ ✓ $= 6{,}03 \times 10^{-19}$ J

$E = hf$

$6{,}03 \times 10^{-19} = (6{,}63 \times 10^{-34})f$ ✓

$\therefore f = 9{,}09 \times 10^{14}$ Hz ✓

✓ for both equations
vir beide vergelykings

(4)

12.4

Option 1 / *Opsie 1*:

$E = W_o + K$
$\frac{hc}{\lambda} = W_o + K$
✓ Any one / *Enige een*

$\therefore \frac{(6{,}63 \times 10^{-34})(3 \times 10^8)}{330 \times 10^{-9}}$ ✓ $= 3{,}5 \times 10^{-19} + K$ ✓
$\therefore K = 2{,}53 \times 10^{-19}$ J ✓

Option 2 / *Opsie 2*:

$E = W_o + K$
$hf = W_o + K$
✓ Any one / *Enige een*

$\therefore (6{,}63 \times 10^{-34})(9{,}09 \times 10^{14})$ ✓ $= 3{,}5 \times 10^{-19} + K$ ✓
$\therefore K = 2{,}53 \times 10^{-19}$ J ✓

(4)

12.5

12.5.1 Remains the same / *Bly dieselfde* ✓ (1)

12.5.2 Increases / *Vermeerder* ✓ (1)

12.6

12.6.1 Ultraviolet radiation / *Ultraviolet-straling* ✓ (1)

12.6.2 High energy / high frequency ✓
Hoë energie / hoë frekwensie (1)

[14]

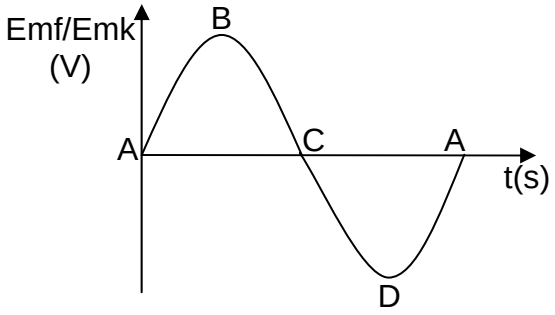
TOTAL SECTION B/TOTAAL AFDELING B: 125
GRAND TOTAL/*GROOTTOTAAL*: 150

QUESTION 13 / *VRAAG 13*

13.1 Electromagnetic induction / Faraday's law ✓
Elektromagnetiese induksie / Faraday se wet [12.2.1] (1)

13.2 Provides a (sliding) contact (between coil and conducting wires) ✓/ Ensures free rotation
Verskaf 'n (glyende) kontak (tussen die spoel en die geleidende drade)/ Verseker dat spoel vrylik roteer [12.2.1] (1)

13.3



Checklist / *Kontrolelys* Criteria for graph / *Kriteria vir grafiek*	Marks/ *Punte*
Correct shape **with full cycle (ignore if more than one cycle shown** / *Korrekte vorm* ***met volle siklus (ignoreer indien meer as een siklus getoon word)***	✓✓
Points A, B, C and D correctly indicated/Punte A, B, C en D korrek aangedui,	✓

[12.1.2] (3)

13.4 Increase the speed at which the coil rotates ✓
Verhoog die spoed waarteen die spoel roteer [12.2.3] (1)

13.5 (Splitring) commutator ✓
(Splitring)kommutator [12.2.3] (1)
[7]

QUESTION 14/*VRAAG 14*

14.1 Photoelectric effect / *Foto-elektriese effek* ✓ [12.2.1] (1)

14.2 The minimum energy of light needed to emit (photo)electrons from a metal ✓✓
Die minimum energie benodig deur lig om (foto-)elektrone uit 'n metaal vry te stel [12.2.1] (2)

14.3

Option 1 / *Opsie 1*:

$E/hf = \frac{hc}{\lambda}$ ✓ $= \frac{(6{,}63\times10^{-34})(3\times10^{8})}{555\times10^{-9}}$ ✓ $= 3{,}58 \times 10^{-19}$ J

$hf = W_0 + \frac{1}{2}mv^2$ ✓ $\therefore$ $3{,}58 \times 10^{-19} = W_0 + 0$ ✓

$\therefore\ W_0 = 3{,}58 \times 10^{-19}$ J ✓

Option 2 / *Opsie 2*:

$hf = W_0 + \frac{1}{2}mv^2$ ✓

$\frac{hc}{\lambda}$ ✓$= W_0 + \frac{1}{2}mv^2$

$\frac{(6{,}63\times10^{-34})(3\times10^{8})}{555\times10^{-9}}$ ✓ $= W_0 + 0$ ✓

$\therefore\ W_0 = 3{,}58 \times 10^{-19}$ J ✓

Option 3 / *Opsie 3*:

$f = \frac{c}{\lambda} = \frac{3\times10^{8}}{555\times10^{-9}}$ ✓ $= 5{,}41 \times 10^{14}$ Hz

$E = hf = (6{,}63 \times 10^{-34})(5{,}41 \times 10^{14})$ ✓$= 3{,}59 \times 10^{-19}$ J

$hf = W_0 + \frac{1}{2}mv^2$ ✓ $\therefore$ $3{,}59 \times 10^{-19} = W_0 + 0$ ✓

$\therefore\ W_0 = 3{,}59 \times 10^{-19}$ J ✓

Option 4 / *Opsie 4*:

$W_0 = hf_0$ ✓✓ $= \frac{(6{,}63\times10^{-34})(3\times10^{8})}{555\times10^{-9}}$ ✓ $= 3{,}58 \times 10^{-19}$ J ✓

[12.1.3] (6)

14.4 Increases / *Vermeerder* ✓

With light of higher intensity more photons strikes the metal surface per second / *Met lig van hoër intensiteit tref meer fotone die metaaloppervlak per sekonde* ✓

Thus more (photo)electrons are emitted per second, ✓resulting in a bigger current./ *Dus word meer (foto-)elektrone per sekonde vrygestel wat 'n hoër stroom tot gevolg het.* [12.2.2] (3)

14.5 Decreases / *Verminder* ✓ [12.2.2] (1)

[13]

TOTAL SECTION B / *TOTAAL AFDELING B:* 125
GRAND TOTAL / *GROOTTOTAAL:* 150