Jawapan

Bab 7

BAB 7

Fizik Kuantum
Quantum Physics

7.1 Teori Cahaya Kuantum
Quantum Theory of Light

1. (a)

Penglibatan ahli fizik dalam pencetusan idea teori fizik kuantum
The involvement of physicist in the discovery of ideas that sparked the Quantum Physics Theory

Teori Klasik / ***Classical Theory***	**Teori Kuantum** / ***Quantum Theory***
Isaac Newton	Max Planck
Thomas Young	Albert Einstein
John Dalton	Niels Bohr
J.J. Thomson	Louis de Broglie

(b) (i) tinggi, tinggi / *higher, higher*
(ii) tinggi, banyak / *higher, more*
(iii) lebih pendek, lebih tinggi / *shorter, higher*

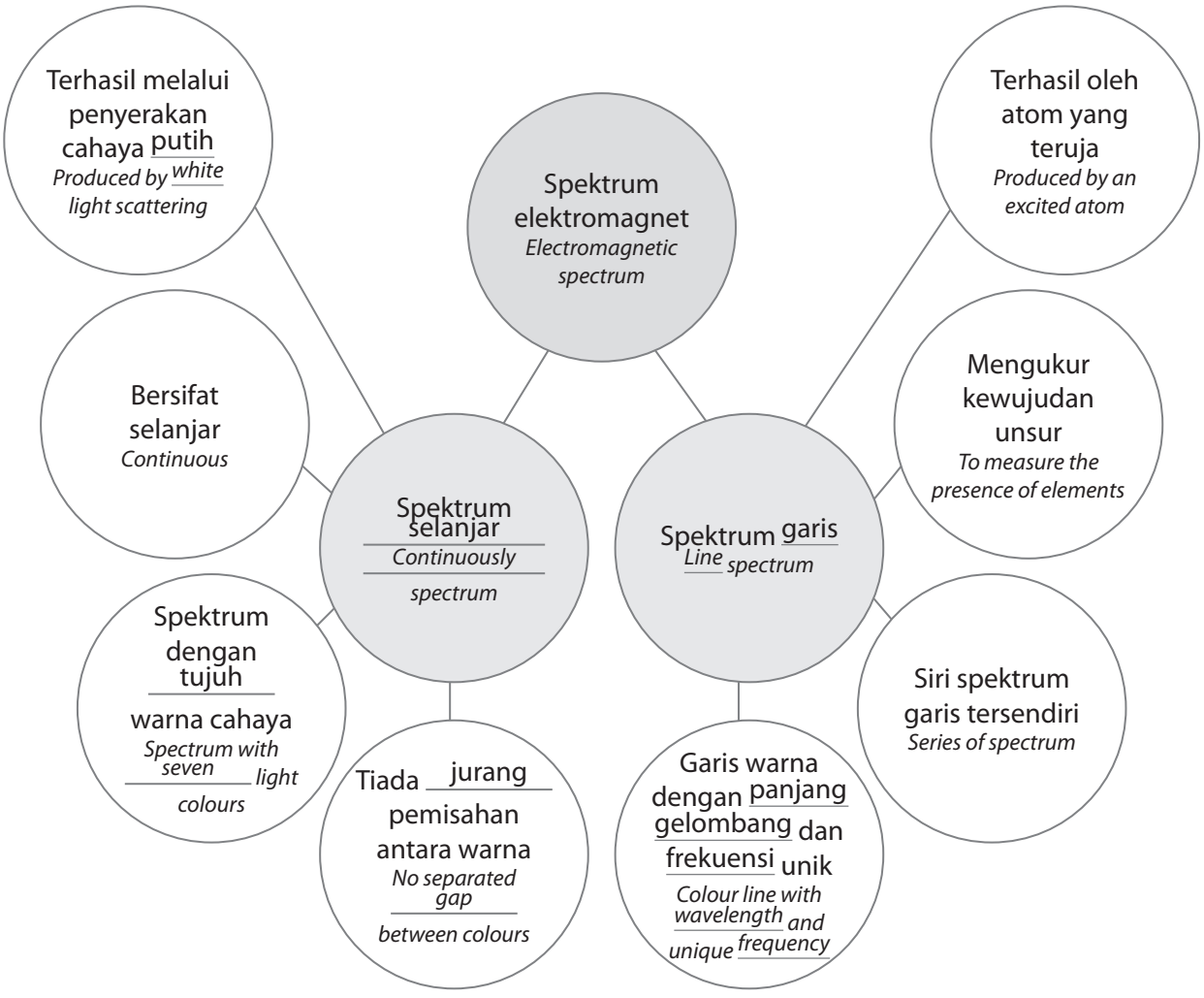
2. (a)

Nama ahli fizik ***Name of physicist***	**Penemuan utama** ***Main finding***	**Penerangan penemuan** ***Explanation of the finding***
Isaac Newton (1643 – 1727)	Sifat zarah cahaya *The particle nature of light*	• Cahaya sebagai satu aliran zarah melalui eksperimen pembiasan cahaya. *Light as a single stream of particles by refraction experiment*
Thomas Young (1773 – 1829)	Eksperimen dwicelah cahaya *Double-slit experiment*	• Membuktikan cahaya bersifat gelombang *Proved that light is a wave*
John Dalton (1766 – 1844)	Model atom dalton *Dalton atomic model*	• Atom merupakan zarah asas bagi setiap jirim. *Atom is a basic particle of each matter.*
J.J. Thomson (1856 – 1940)	Penemuan elektron *Discovery of electrons*	• Elektron ialah zarah subatom bercas negatif. *Electron is a subatom particle negatively charged.*

(b)

Nama ahli fizik ***Name of physicist***	**Penemuan utama** ***Main finding***	**Penerangan penemuan** ***Explanation of the finding***
Max Planck (1858 – 1947)	Kuantum tenaga (tenaga yang diskrit) *Quantum energy (discrete energy)*	• Jasad hitam memancarkan gelombang elektromagnet berbentuk tenaga diskrit berkadar terus dengan frekuensi getaran *The black body emits electromagnetic wave in the form of discrete energy that is directly proportional to the wave frequency.* • Keamatan sinaran berkadar songsang dengan frekuensi gelombang. *The intensity of the radiation is inversely proportional to the wave frequency.*
Albert Einstein (1879 – 1955)	Konsep foton – cahaya terdiri daripada foton *Photon concept-light consists of photon*	• Tenaga foton berkadar terus dengan frekuensi gelombang cahaya. *Photon energy is directly proportional to the light wave frequency.* • Kesan fotoelektrik diterangkan melalui teori foton Einstein. *Photoelectric effect is explained in Einstein's photon theory.*
Niels Bohr (1885 – 1962)	Penghasilan spektrum garis oleh atom hidrogen *Production of line spectrum by hydrogen atoms*	• Elektron bergerak mengelilingi atom nukleus. *Electron moves around the nucleus atom.* • Pemindahan elektron dari petala paras tenaga tinggi ke petala paras tenaga rendah memancarkan foton. *The transition of electron from higher energy level shell to lower energy level shell emits photons.*
Louis de Broglie (1892 – 1987)	Zarah bersifat gelombang *Wave nature of particles*	• Memperkenalkan hipotesis de Broglie iaitu sifat kedualan zarah-gelombang yang menunjukkan cahaya berkelakuan seperti zarah dan gelombang *Introduced Broglie's hypothesis knowns as wave-particle duality to show light behave as a particle and wave.*

3.



4.

Sifat Kedualan Gelombang-Zarah
Characteristic of Wave-Particle Duality

(a) dikenali sebagai : Hipotesis de Broglie
also known as : de Broglie's hypothesis

Cahaya bersifat gelombang
Light behaves as a wave

(b) Pembuktian hipotesis de Broglie telah dibuktikan melalui eksperimen pembelauan elektron.
The validation of de Broglie's hypothesis was confirmed through electron diffraction experiments.

(c) Corak pembelauan elektron melalui lapisan grafit nipis menyerupai corak pembelauan cahaya melalui bukaan membulat.
The diffraction patterns of electrons through a thin layer of graphite resembles the light diffraction patterns through an aperture.

(d) Panjang gelombang de Broglie suatu alur elektron ialah 1000 – 10000 kali lebih pendek berbanding dengan panjang gelombang cahaya.
The de Broglie wavelength of an electron beam is approximately 1000 – 10000 times shorter compared to the wavelength of light.

(e) Sifat panjang gelombang de Broglie merupakan ciri penting menghasilkan pembesaran lebih tinggi dalam operasi mikroskop elektron.
The property de Broglie wavelength is very important for higher magnification of electron microscope.

(f) Formula / *Formulae:*

$$\lambda = \frac{h}{mv}$$

λ = Panjang gelombang
Wavelength
h = Pemalar Planck
Planck's constant
v = Halaju zarah
Velocity of particle
m = Jisim zarah
Mass of particle

Cahaya bersifat zarah
Light behaves as a particle

(g) Louis de Broglie menyatakan bahawa:
Semua zarah boleh menunjukkan ciri-ciri gelombang.
Louis de Broglie states that: All particles can exhibit wave characteristics.

(h) Louis de Broglie telah menerbitkan persamaan gelombang bersifat zarah:
Louis de Broglie derived an equation to relate the behaviour of wave as a particle.

(i) Formula / *Formulae:*

$$\lambda = \frac{h}{p}, p = mv$$
$$\rightarrow mv = \frac{h}{\lambda}$$

(j) Semakin besar momentum zarah, semakin pendek panjang gelombang.
The greater the momentum of the particle, the shorter the wavelength.

(k) Ciri gelombang tidak dapat diperhatikan kerana nilai pemalar Planck, *h* adalah sangat kecil dan zarah yang berjisim besar mempunyai panjang gelombang de Broglie terlalu pendek untuk dikesan.
The wave characteristics cannot be observed since the Planck constant, h is very small and particles of a large masses will have de Broglie wavelength which are too short to be detected.

5.

Kuantum Tenaga
Quantum of Energy

(a) Definisi Kuantum Tenaga
Definition of Quantum Energy :
Paket tenaga yang diskrit dan bukan tenaga selanjar
Discrete energy packet and not a continuous energy

(b) Teori Kuantum Max Planck dan Albert Einstein menyatakan :
Max Planck and Albert Einstein's Quantum Theory states that :
– Foton ialah tenaga cahaya wujud dalam bentuk paket tenaga.
Light energy exists in the form of an energy packet.
– Tenaga foton berkadar terus dengan frekuensi gelombang cahaya.
Photon energy is directly proportional to the frequency of light waves.

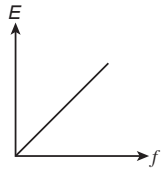
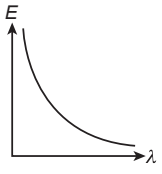
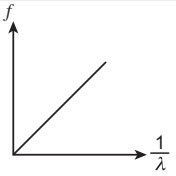
(c) Foton ialah / *Photon is :*
Kuantum tenaga cahaya yang boleh dipindahkan
Light energies transferred in a quantum of energy

(d) Formula penyelesaian masalah kuantum tenaga :
Formulae to solve problem solving on quantum of energy :
$E = hf$ atau / *or* $E = \frac{hc}{\lambda}$
laitu / *which :*
E = tenaga foton
photon energy
h = pemalar Planck
planck's constant
$(6.63 \times 10^{-34}$ Js)
f = frekuensi gelombang
frequency of wave
c = halaju cahaya / *speed of light*
$(3.0 \times 10^{8}$ ms$^{-1})$

(e) Hubungan tenaga foton, panjang gelombang dan frekuensi gelombang cahaya :
Relationship between photon energy, wavelength and frequency of light wave:
$E \propto f$
E berkadar terus dengan f
E directly proportional to f
$E \propto \frac{1}{\lambda}$
E berkadar songsang dengan λ
E inversely proportional to f

(f) Faktor-faktor mempengaruhi tenaga foton:
Factors affecting photon energy:
(i) Frekuensi gelombang, f
Wave frequency
(ii) Panjang gelombang, λ
Wavelength

(g) Lakarkan graf dan nyatakan hubungan antara kuantiti fizik dalam formula tenaga foton :
Sketch the graph and state the relationship of physical quantities in photon energy formulae :

		
E berkadar terus dengan f *E directly proportional to f*	E berkadar songsang dengan λ *E inversely proportional to λ*	f berkadar terus dengan $\frac{1}{\lambda}$ atau f berkadar songsang dengan λ *f directly proportional to* $\frac{1}{\lambda}$ *or f inversely proportional to λ*

6. $E = hf$

$E = (6.63 \times 10^{-34})\ (3.4 \times 10^{14})$

$E = 2.2542 \times 10^{-19}\text{J}$

$n = \dfrac{p}{hf}$

$n = \dfrac{(4.5 \times 10^{-3})}{2.2542 \times 10^{-19}}$

$n = 1.9963 \times 10^{16}\ \text{s}^{-1}$

7. (a) Panjang gelombang de Broglie bagi suatu zarah bergerak, $\lambda = \dfrac{h}{mv}$

De Broglie wavelength of a moving particle

Formula momentum, $p = mv$ dan tenaga kinetik, $E = \dfrac{1}{2}\text{mv}^2$

Momentum formula, p = mv and kinetic energy,

Diberi $m = 9.11 \times 10^{-31}$ kg dan E =75 *eV* (Tukar unit eV → J), maka perlu menyatakan momentum dalam sebutan *m* dan *E*

Given $m = 9.11 \times 10^{-31}$ *kg and* $E = 75$ *eV (Change unit eV → J), hence require to state the momentum in terms of m and E.*

2m $(E = \dfrac{1}{2}mv^2)$

$2mE = (mv)^2$

$\therefore mv = \sqrt{2mE}$ ------❶

Formula $\lambda = \dfrac{h}{mv}$ → gantikan dengan persamaan / *replace with equation* ❶

$\lambda = \dfrac{h}{\sqrt{2mE}}$

$\lambda = \dfrac{(6.63 \times 10^{-34})}{\sqrt{2(9.11 \times 10^{-31})(75 \times 1.60 \times 10^{-19})}}$

$\lambda = 1.4179 \times 10^{-19}\ \text{m}$

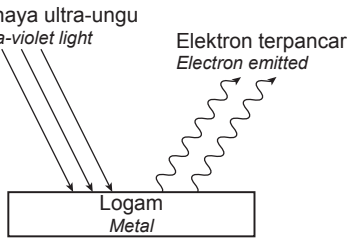
(b) Pembelauan elektron
Diffraction of electron

7.2 Kesan Fotoelektrik
Photoelectric Effect

1.

Konsep fizik ***Physics concept***	**Maksud** ***Definition***
Kesan Fotoelektrik *Photoelectric Electric*	Apabila suatu permukaan logam disinari oleh alur cahaya yang mempunyai frekuensi tertentu, elektron daripada logam itu dipancar keluar. *When a metal surface is illuminated by a beam of light at a certain frequency, electrons can be emitted from the metal.*
Fotoelektron *Photoelectron*	Elektron yang terpancar dari permukaan logam peka cahaya (katod) apabila disinari dengan alur cahaya tertentu. *Electrons which emitted from a light sensitive metal surface (cathode) when it is illuminated with a certain light beam.*
Foton *Photon*	Kuantum tenaga cahaya yang boleh dipindahkan. *Light energies transferred in a quantum of energy.*

2. (a)



(b) $E = hf$

$E = (6.63 \times 10^{-34})(5.3 \times 10^{14})$

$E = 3.5139 \times 10^{-19}\text{J}$

$n = \dfrac{P}{hf}$

$n = \dfrac{(5.0 \times 10^{-3})}{3.5139 \times 10^{-19}}$

$n = 1.4229 \times 10^{16}\ \text{s}^{-1}$

3.

Fungsi: Menerima sinaran gelombang elektromagnet dan memancarkan elektron daripada permukaannya

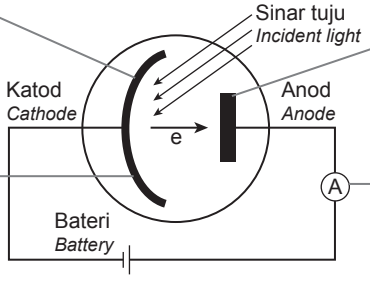
Function: Receives electromagnetic wave radiation and emits the electron from a metal surface.

Fungsi: Mengumpul atau menerima pancaran elektron daripada katod

Function: Collects or receives electron beam from the cathode.

(a) Permukaan logam
Permukaan logam

(c) Pengesan
Detector



(b) Tiub vakum
Vacuum tube

(d) Ammeter
Ammeter

(c) Fungsi: Mestilah berada dalam keadaan vakum untuk memastikan tiada ganguan kepada pancaran elektron dari katod ke anod.

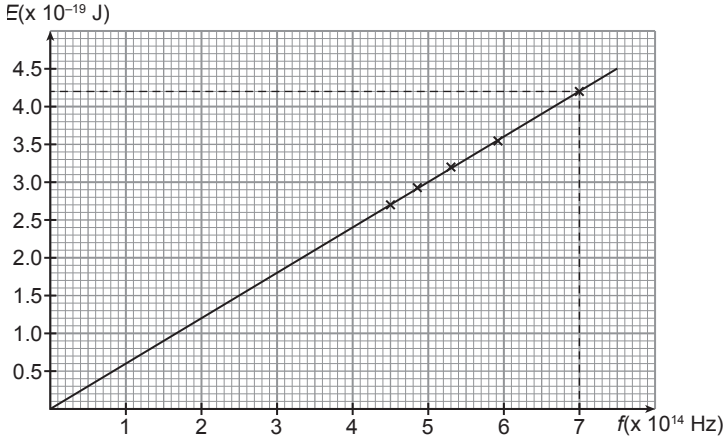
Function: Should be in vacuum state to prevent any interruption of electron when moving from cathode to anode.

Fungsi: Mengukur arus fotoelektrik dalam litar

Function: Measures the photoelectric current in the circuit

4.

Panjang gelombang LED, λ *LED wavelength, λ* **(nm)**	**Frekuensi foton** *Photon frequency* $f = \frac{c}{\lambda} = \frac{3 \times 10^8}{\lambda}$ **(Hz)**	**Voltan mula menyalakan LED** *The voltage starts to light up the LED,V(V)*	**Tenaga foton dikeluarkan** *Photon energy released* $E = eV$, **(J)**
430	6.98×10^{14}	2.75	4.40×10^{-19}
505	5.94×10^{14}	2.19	3.50×10^{-19}
560	5.36×10^{14}	2.00	3.20×10^{-19}
615	4.88×10^{14}	1.87	2.99×10^{-19}
655	4.58×10^{14}	1.75	2.80×10^{-19}



$$= \frac{(4.2 - 1.2) \times 10^{-19}}{(7 - 2) \times 10^{14}}$$

$= 0.6 \times 10^{-33}$

$= 6.0 \times 10^{-34}$ J s $\approx 6.34 \times 10^{-34}$ J s

Perbincangan / *Discussion*

1. foton /*photon*

2. voltan pengaktifan / *activation voltage*

3. Kecerunan / *The gradient*

5. (a) (i) tinggi, tinggi
higher, greater

(ii) terpancar, lebih besar
emitted, greater than

(iii) kinetik, tidak, bertambah
kinetic, does not, increase

(iv) serta-merta, rendah
instantaneous, low

(b) (i) tidak bergantung, keamatan
not depend on, light intensity

(ii) elektron, frekuensi, kinetik
electrons, frequency, kinetic

(iii) elektron
electrons

(iv) kinetik
kinetic

(v) tenaga yang cukup tinggi keamatan cahaya
a very high energy intensity of light

6. (a) logam, elektron, fotoelektron
metal, electrons, photoelectrons

(b) anod, arus fotoelektrik
anode, photoelectric current

(c) arus
current

7. (a)

Definisi / *Definition*	
Kesan fotoelektrik: / *Photoelectric effect*:	
(a) Apabila suatu permukaan logam disinari oleh alur cahaya yang mempunyai frekuensitertentu, elektron daripada logam itu dipancar keluar. *When a metal surface is illuminated by a beam of light at a certain frequancy, electrons can be emitted from the metal.*	
Frekuensi ambang ***Threshold frequency,* f_0**	**Gelombang ambang** ***Threshold wavelength,* λ_0**
(b) Frekuensi minimumdiperlukan untuk menghasilkan fotoelektrikpada logam. *The minimum frequency required to producephotoelectric effect on a metal.*	(c) Panjang gelombang maksimum cahaya yang diperlukan oleh logam untuk memancarkan elektron. *The maximum wavelength of lightneeded for a metal to emit electrons.*

Kesan Fotoelektrik
Photoelectric Effect

Kesan Fotoelektrik berdasarkan keputusan eksperimen ***Photoelectric effect based on experimental result***
(d) Semakin tinggi frekuensi foton cahaya, semakin tinggi tenaga kinetik fotoelektronyang dipancarkan daripada permukaan logam *The higher the frequency of the photon of light, the higher the kinetic energy of the phitielectrons emitted from themetal surface*
(e) Frekuensi ambang, f_0 bagi sesuatu logam ialah frekuensi minimum yang dapat mengeluarkan elektron. *The threshold frequency, f_0 of a metal is the minimum frequency needed to emit electrons.*
(f) Tenaga kinetik fotoelektron tidak bergantung pada keamatan cahaya *The kinetic energy of phototelectrons does not depend on the intensity of light*
(g) Fototelektron dipancarkan secara serta-merta apabila permukaan logam disinari cahaya *Photoelectrons are emitted instantaneously when a metal surface is illuminated by light*

Pembebasan elektron daripada logam berlaku apabila: ***Ejection of electron from metal happened when:***
$f > f_0$ (h) Frekuensi sinar gelombang lebih besar berbanding frekuensi ambang logam *The frequency of wave is bigger compared to threshold frequency of metal*
$\lambda < \lambda_0$ (i) Panjang sinar gelombang lebih kecil berbanding gelombang ambang logam *The wavelength is smaller compared to threshold wavelength of metal*
$E > W$ (j) Tenaga foton lebih besar berbanding fungsi kerja *Photon energy is bigger compared to work function*

7.3 Teori Fotoelektrik Einstein
Einstein's Photoelectric Theory

1. (a) kesan fotoelektrik
photoelectric effect

(b) foton, elektron, tenaga kinetik maksimum
photon, electron, maximum kinetic energy

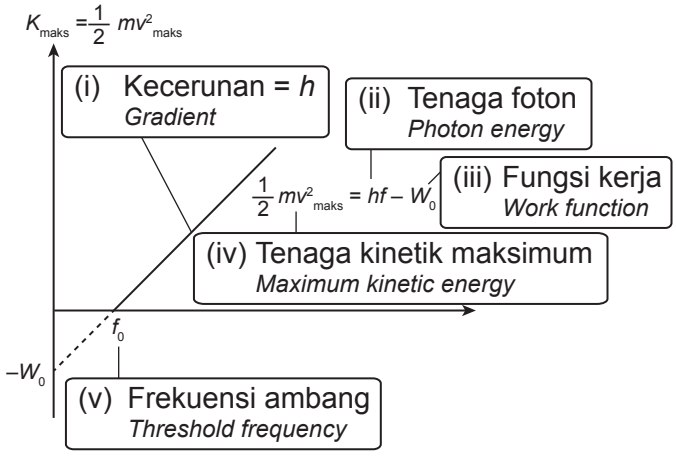
(c) tenaga kinetik maksimum + fungsi kerja
maximum kinetic energy + work function

$$hf = \frac{1}{2}mv^2_{\text{maks}} + W$$

2. (a) frekuensi minimum, kesan fotoelektrik
minimum frequency, photoelectric effect

(b) tenaga minimum
minimum energy

3.



(d) Tiada elektron dapat dibebaskan dari permukaan logam.
No electrons can be released from the metal surface.

4. (a)

Jenis logam *Type of metal*	**Panjang gelombang** *Wavelength* λ **(nm)**	**Frekuensi ambang** *Threshold frequency* $f_0 = \frac{c}{\lambda}$ **Hz**	**Fungsi kerja** *Work function* $W = \frac{hf_0}{e}$ **(eV)**
Natrium *Sodium*	541	$\frac{(3.0 \times 10^8)}{541 \times 10^{-9}}$ $= 0.55$	$\frac{(6.63 \times 10^{-34}) \times (0.55 \times 10^{15})}{1.6 \times 10^{-19}}$ $= 2.28$
Zink *Zinc*	288	$\frac{(3.0 \times 10^8)}{288 \times 10^{-9}}$ $= 1.04$	$\frac{(6.63 \times 10^{-34}) \times (1.04 \times 10^{15})}{1.6 \times 10^{-19}}$ $= 4.31$
Platinum *Platinum*	192	$\frac{(3.0 \times 10^8)}{192 \times 10^{-9}}$ $= 1.56$	$\frac{(6.63 \times 10^{-34}) \times (1.56 \times 10^{15})}{1.6 \times 10^{-19}}$ $= 6.46$

(b) (i)

Dengan / *With:*	Menyatakan hubungan / *State the relationship:*
h adalah pemalar Planck *h is the Planck's constant*	*W* dengan λ / *W with* λ *:* *W* berkadar songsang dengan λ *W inversely proportional to* λ
f_0 adalah frekuensi ambang f_0 *is the threshold frequency*	λ bertambah, *W* berkurang / λ *increases, W decreases*
c adalah halaju cahaya *c is a speed of light*	W dengan f_0 */ W with* f_0 *:* *W* berkadar terus dengan f_0 / *W directly proportional to* f_0
λ adalah panjang gelombang λ *is a wavelength*	f_0 bertambah, *W* bertambah / f_0 *increases, W increases*

5. (a) Daripada graf / *from the graph*, frekuensi ambang / *threshold frequency*
Pintasan pada paksi *f* / *intercept on f axis*
$= 3 \times 10^{14}$ Hz

(b) Daripada graf / *from graph*. Fungsi kerja / *work function*,
Pintasan pada paksi K_{maks} *intercept on* K_{max} *axis* $= W_0 = -2 \times 10^{-19}$ J

$$W_0 = \frac{1.2 \times 10^{-19}}{1.6 \times 10^{-19}\ \text{J}} = -1.25\ \text{eV}$$

(c) Kecerunan graf / *gradient of graph* $= \frac{3 \times 10^{-19}}{(8-3) \times 10^{14}} = 6 \times 10^{-34}$ Js

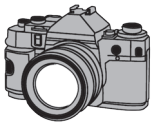
(d) Daripada graf / *From graph*, apabila / *when* $f = 8 \times 10^{14}$ Hz,
$K_{maks} = 3 \times 10^{-19}$ J

6. (a) fotoelektrik / *photoelectric*
(b) litium, cesium, divakumkan
lithium, cesium, vacuumed
(c) katod, fotoelektron
cathode, photoelectrons
(d) anod, arus / *anode, current*

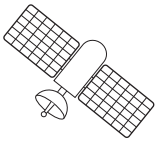
7. (a) suria, elektrik / *solar, electrical*

(b)

Pembuka pintu automatik
Automatic door opener



Pengesan imej kamera
Camera image detector



Panel suria
Satellite solar panels

Kalkulator
Calculator

Jam tangan
Watches

PRAKTIS SPM 7

KERTAS 1

1. A **2.** A **3.** B **4.** A **5.** D
6. A **7.** A **8.** A

KERTAS 2

Bahagian A

1. (a) Ya, ammeter tersebut akan menunjukkan bacaan yang kecil. Fotoarus telah terhasil kerana frekuensi bagi cahaya hijau melebihi frekuensi ambang.
Yes, the ammeter will show a small reading. Photocurrent is produced because the frequency of green light has exceeded threshold frequency.

(b) (i) $K_{maks} = hf - W$

$6.2 \times 10^{-20} = (6.63 \times 10^{-34})(6 \times 10^{14}) - W$

$W = 3.36 \times 10^{-19}$ J

(ii) $W = hf_0$

$f_0 = \frac{W}{h} = \frac{3.36 \times 10^{-19}}{6.63 \times 10^{-34}} =$

5.06×10^{14}Hz

(c) (i) Berkurang; Tiada bacaan
Decreases; No reading

(ii) Bertambah
Increases

(iii) Tiada perubahan
Unchanged

Bahagian B

2. (a) Kuantum tenaga cahaya yang boleh dipindahkan.
Light energies transferred in a quantum of energy.

(b) (i) $E = nh\frac{c}{\lambda}$

$n = \frac{E\lambda}{hc}$

$= \frac{10^{-18} \times (460 \times 10^{-9})}{6.63 \times 10^{-34}(3.00 \times 10^{8})}$

= 23.13 → bilangan minimum foton 23
Minimum number of photon is 23

(ii) – Tenaga foton
Photon energy in eV unit

$= \frac{3.94 \times 10^{-19}}{1.6 \times 10^{19}} = 2.46$ eV

– cesium (2.14 eV), kalium (2.29 eV), tenaga foton (2.46 eV), kuprum (4.7 eV), aurum (5.1 eV)
caesium (2.14 eV), potassium (2.29 eV), photon energy (2.46 eV), copper (4.7 eV), aurum (5.1 eV)

– Kalium dan cesium yang mempunyai fungsi kerja yang lebih rendah daripada tenaga foton 2.46 eV
Potassium and caesium are having a work function lower than photon energy 2.46 eV

– Kalium dan cesium akan memancarkan fotoelektron apabila cahaya tampak menyinarinya
Potossium and caesium will emit photoelectrons when light appears to illuminate them

(c) – Tenaga foton terhasil oleh cahaya merah
Photon energy carried by red light,

$E = h\left(\frac{c}{\lambda}\right)$

$= 6.63 \times 10^{-34}\left(\frac{3 \times 10^{8}}{650 \times 10^{-9}}\right)$

$= 3.06 \times 10^{-19}$ J

– Panjang gelombang ambang kalium
threshold wavelength of pottasium =

$\lambda_o = \frac{hc}{W} = \frac{6.63 \times 10^{-34} \times (3 \times 10^{8})}{3.65 \times 10^{-19}}$

$= 5.45 \times 10^{-7}$ m → 545×10^{-9} m // 545 nm

Kesan fotoelektrik tidak berlaku kerana
The photoelectric effect does not occur because :

– tenaga cahaya merah lebih rendah dari fungsi kerja logam kalium ($E < W$)
the energy of red light is lower than the work function of potassium metal ($E < W$)

– panjang gelombang cahaya merah lebih besar daripada panjang gelombang ambang kalium ($\lambda_{merah} > \lambda_o$)
the wavelength of red light is bigger than the threshold wavelength of pottasium ($\lambda_{red} > \lambda_o$)

(d)

Cadangan / ***Suggestion***	**Sebab** / ***Reason***
Sel foto semikonduktor *Semiconductor photo cells*	Jimat tenaga elektrik dan bersaiz kecil *Save electricity and small size*
Keamatan punca cahaya yang rendah *Low light source intensity*	Penggunaan tenaga yang sedikit *Low energy consumption*
Punca cahaya warna inframerah *Infrared color light source*	Lebih selamat, kurang kesan buruk berbanding ultraungu , kurang pembelauan. *Safer, less adverse effects than ultraviolet, less diffraction.*
Fungsi kerja logam yang rendah *Low metal working function*	Lebih efisien, peka, lebih cekap, boleh berfungsi apabila keamatan cahaya yang rendah *More efficient, sensitive, more efficient, can be functioning when low light intensity*
Y dipilih / Y choosen *Y selected / Y choosen*	Sel foto semikonduktor, keamatan punca cahaya rendah, inframerah dan fungsi kerja logam rendah *Semiconductor photo cell, low light source intensity, infrared and low metal working function*

Bahagian C

3. (a) Tenaga minimum yang diperlukan untuk membebaskan elektron daripada permukaan logam
The minimum energy required to release the electron from a particular metal surface

(b) – Katod disambungkan pada keupayaan negatif dalam sel foto yang disaluti dengan logam peka cahaya seperti cesium dan litium berbentuk semisilinder.
Cathode is connected to the negative potential in the photocells coated with a light-sensitive metal such as caesium and lithium in semi-cylindrical shaped.

– Anod yang disambungkan kepada keupayaan positif ialah satu rod logam yang dipasang sejajar dengan paksi semisilinder katod.
Anode which connected to the positive potential is a metal rod fixed at the axis of the semi-cylindrical cathode.

– Apabila cahaya menyinari permukaan katod, fotoelektron dibebaskan.
When a light is illuminated on the cathode, photoelectron are released.

– Fotoelektron tertarik ke anod.
The photoelectron are attracted to anode.

– Terdapat perbezaan beza keupayaan (voltan) antara anod dan katod.
There are a difference of potential difference (voltage) between anode and cathode.

– Arus fotoelektrik dihasilkan apabila terdapat pengaliran fotoelektron dalam litar.
Photoelectric current produced when photoelectron flows in the circuit

(c) – Panjang gelombang bagi cahaya hijau > cahaya biru.
The wavelength of the green light > blue light.

– Frekuensi cahaya hijau < cahaya biru.
The frequency of the green light < blue light

– Laju elektron yang dibebaskan Rajah 3.2 < Rajah 3.3.
The speed of electrons being ejected Diagram 3.2 < Diagram 3.3

– Frekuensi bertambah apabila panjang gelombang bagi cahaya berkurang.
Frequency increases as wavelength of light decrease.

– Apabila frekuensi cahaya bertambah, laju elektron yang dibebaskan daripada permukaan logam bertambah.
As frequency of light increases, speed of electron ejected from the metal surface increases.

(d)

Cadangan ***Suggestion***	**Sebab** ***Reason***
J ialah bekalan kuasa *J is power supply*	*K* dan *M* memerlukan bekalan kuasa elektrik untuk berfungsi. *K and M need electric power supply to function.*
K ialah pemancar inframerah *K is infrared transmitter*	Inframerah kurang mengalami pembelauan berbanding gelombang radio. Frekuensi inframerah melebihi frekuensi ambang logam di dalam penerima inframerah. *Infrared has less diffraction than radio wave.* *Frequency of infrared exceeds the threshold frequency of metal in the infrared receiver.*
L menuju sinar ke arah kanan *L is to direct the ray to the right*	Inframerah ditujukan kepada *M* untuk menghasilkan kesan fotoelektrik. *Infrared is incident to M in order to produce photoelectric effect.*
M ialah penerima inframerah *M is Infrared receiver*	Fungsi kerja bagi logam dalam penerima cukup rendah bagi foton inframerah membebaskan elektron daripada permukaan logam. *Work function of the metal in the receiver is low enough for the infrared photon to release electrons from the metal.*
N ialah skrin paparan *N is display screen*	Output daripada pemproses akan memaparkan hasil pengiraan di skrin. *Output of the processor will show the counting result on the screen.*