

---

UNIVERSITI SAINS MALAYSIA

Second Semester Examination  
Academic Session 2003/2004

February/March 2004

**ZCT 104E/3 - Physics IV (Modern Physics)**  
***[Fizik IV (Fizik Moden)]***

Duration: 3 hours  
*[Masa: 3 jam]*

---

Please check that the examination paper consists of **SIXTEEN** pages of printed material before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi ENAM BELAS muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]*

**Instruction:** Answer all **FOUR (4)** questions. Students are allowed to answer all questions in Bahasa Malaysia or in English.

***[Arahan:*** Jawab kesemua **EMPAT** soalan. Pelajar dibenarkan menjawab semua soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]

**Data**

speed of light in free space,  $c = 3.00 \times 10^8 \text{ m s}^{-1}$

permeability of free space,  $\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$

permittivity of free space,  $\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$

elementary charge,  $e = 1.60 \times 10^{-19} \text{ C}$

the Planck constant,  $h = 6.63 \times 10^{-34} \text{ J s}$

unified atomic mass constant,  $u = 1.66 \times 10^{-27} \text{ kg}$

rest mass of electron,  $m_e = 9.11 \times 10^{-31} \text{ kg}$

rest mass of proton,  $m_p = 1.67 \times 10^{-27} \text{ kg}$

molar gas constant,  $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

the Avogadro constant,  $N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$

gravitational constant,  $G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$

acceleration of free fall,  $g = 9.81 \text{ m s}^{-2}$

**Question 1. (25 marks)**

- 1.1 A spaceship of proper length  $L_p$  takes  $t$  seconds to pass an Earth observer. What is its speed as measured by the Earth observer according to classical physics?  
*[Sebuah kapal angkasa yang panjang proper-nya  $L_p$  mengambil masa  $t$  untuk bergerak melalui seorang pemerhati di Bumi. Mengikut fizik klasik, apakah kelajuannya yang terukur oleh pemerhati di Bumi itu?]*

A.  $L_p / t$                       B.  $\frac{cL_p / t}{\sqrt{c^2 + (L_p / t)^2}}$                       C.  $c$                       D.  $L_p$

E. Non of the above  
*[Tiada dalam pilihan di atas]*

- 1.2 In Question 1, what is its speed as measured by the Earth observer according to special relativity?  
*[Dalam soalan 1, apakah kelajuan yang terukur oleh pemerhati di Bumi mengikut teori kerelatifan khas?]*

A.  $L_p / t$                       B.  $\frac{cL_p / t}{\sqrt{c^2 + (L_p / t)^2}}$                       C.  $c$                       D.  $L_p$

E. Non of the above  
*[Tiada dalam pilihan di atas]*

- 1.3 What is the momentum of a proton if its total energy is twice its rest energy?  
*[Apakah momentum bagi suatu proton jika jumlah tenaganya adalah dua kali tenaga rehatnya?]*

A. 1620 Ns    B. 1 MeV/c    C. 938 MeV/c                      D. 2 MeV/c

E. 1620 MeV/c

- 1.4 The power output of the Sun is  $3.8 \times 10^{26}$  W. How much rest mass is converted to kinetic energy in the Sun each second?  
*[Output kuasa Matahari ialah  $3.8 \times 10^{26}$  W. Berapakah jisim rehat yang ditukarkan kepada tenaga kinetik setiap saat di dalam Matahari?]*

A.  $4.2 \times 10^9$  kg                      B.  $1.3 \times 10^{17}$  kg                      C.  $3.6 \times 10^8$  kg

D.  $6.6 \times 10^{10}$  kg                      E.  $4.2 \times 10^8$  kg

- 1.5 What is the value of  $hc/e$  in unit of  $\text{nm} \cdot \text{eV}$   
*[Apakah nilai  $hc/e$  dalam unit  $\text{nm} \cdot \text{eV}$  ?]*
- A. 1.240      B.  $1240 \times 10^{-6}$       C. 1240      D.  $1240 \times 10^{-9}$   
 E.  $1240 \times 10^{-3}$
- 1.6 By what factor is the mass of an electron accelerated to the speed of  $0.999c$  larger than its rest mass?  
*[Berapa besarnya factor jisim satu elektron yang dipecutkan kepada kelajuan  $0.999c$  berbanding dengan jisim rehatnya?]*
- A. 31.6      B. 0.03      C. 0.04      D. 22.3      E. 1.0
- 1.7 The rest mass of a photon  
*[Jisim rehat foton]*
- A. is zero  
*[ialah sifar]*  
 B. is the same as that of an electron  
*[sama dengan jisim elektron]*  
 C. depends on its frequency  
*[bergantung kepada frekuensinya]*  
 D. depends on its energy  
*[bergantung kepada tenaganya]*  
 E. Non of the above  
*[Tiada dalam pilihan di atas]*
- 1.8 Determine the vacuum wavelength corresponding to a  $\gamma$ -ray energy of  $10^{19}$  eV  
*[Tentukan jarak gelombang vakum bagi sinar  $\gamma$  yang bersepadanan dengan tenaga  $10^{19}$  eV]*
- A.  $1.24 \times 10^{-9}$  pm  
 B.  $1.24 \times 10^{-16}$  pm  
 C.  $1.24 \times 10^{-25}$  nm  
 D.  $1.24 \times 10^{-16}$  nm  
 E.  $1.24 \times 10^{-25}$  nm

- 1.9 To produce an x-ray quantum energy of  $10^{-15}$  J electrons must be accelerated through a potential difference of about  
*[Untuk menghasilkan sinar-x dengan tenaga kuantum  $10^{-15}$  J suatu elektron mesti dipecutkan melalui satu beza keupayaan yang nilainya lebih kurang]*
- A. 4 kV
  - B. 6 kV
  - C. 8 kV
  - D. 9 kV
  - E. 10 kV

**Question 1.10– 1.12**

*[Soalan 1.10-1.12]*

- A.  $10^{-4}$  m
  - B.  $10^{-7}$  m
  - C.  $10^{-10}$  m
  - D.  $10^{-12}$  m
  - E.  $10^{-15}$  m
- 1.10 Which of the values in the list above is the best estimate of the radius of an atom?  
*[Nilai yang manakah dalam senarai di atas memberikan anggaran yang paling baik untuk radius satu atom?]*
- 1.11 Which of the values in the list above is the best estimate of the wavelength of visible light?  
*[Nilai yang manakan dalam senarai di atas memberikan anggaran yang paling baik untuk jarak gelombang cahaya ternampak?]*
- 1.12 Which of the values in the list above is the best estimate of the wavelength of a 1.5 MeV electron?  
*[Nilai yang manakan dalam senarai di atas memberikan anggaran yang paling baik untuk jarak gelombang bagi elektron 1.5 MeV?]*
- 1.13 What is the momentum of a single photon of red light ( $\nu = 400 \times 10^{12}$  Hz) moving through free space?  
*[Apakah momentum foton cahaya merah ( $\nu = 400 \times 10^{12}$  Hz) yang bergerak melalui ruang bebas?]*

- A.  $8.8 \times 10^{-27}$  kg m/s
- B. 6 keV
- C. 1240 eV/c
- D. 1.65 eV/c
- E. 2.4 eV/c

- 1.14 What potential difference must be applied to stop the fastest photoelectrons emitted by a nickel surface under the action of ultraviolet light of wavelength 2000 Å? The work function of nickel is 5.00 eV.

*[Apakah beza keupayaan yang mesti dikenakan untuk menghentikan fotoelektron paling pantas yang dipancarkan dari permukaan nikel di bawah tindakan cahaya ultraungu yang jarak gelombangnya 2000 Å? Fungsi kerja nikel ialah 5.00 eV.]*

- A. 1.0 kV
- B. 1.2 kV
- C. 2.0 V
- D. 1.0 V
- E. 1.2 V

- 1.15 Which of the following statement(s) is (are) true?

*[Manakah kenyataan yang berikut adalah benar?]*

- I. The assumption of the Ether frame is inconsistent with the experimental observation  
*[Tanggapan rangka Ether adalah tidak konsisten dengan pemerhatian eksperimen]*
- II. The speed of light is constant  
*[Kelajuan cahaya adalah malar]*
- III. Maxwell theory of electromagnetic radiation is inconsistent with the notion of the Ether frame  
*[Teori sinaran keelektromagnetan Maxwell adalah tidak konsisten dengan tanggapan rangka Ether]*
- IV. Special relativity is inconsistent with the notion of the Ether frame  
*[Kerelatifan Khas adalah tidak konsisten dengan tanggapan rangka Ether]*

- A. III,IV      B. I, II, III      C. I, II, III,IV
- D. I, II      E. I, II,IV

1.16 Which of the following statements are true about light?

*[Yang manakah kenyataan berikut adalah benar berkenaan dengan cahaya?]*

- I. It propagates at the speed of  $c = 3 \times 10^8$  m/s in all medium  
*[Cahaya tersebar pada kelajuan  $c = 3 \times 10^8$  m/s dalam semua jenis medium]*
- II. It's an electromagnetic wave according to the Maxwell theory  
*[Cahaya ialah gelombang elektromagnetik mengikut teori Maxwell]*
- III. It's a photon according to Einstein  
*[Cahaya ialah foton menurut Einstein]*
- IV. It always manifests both characteristics of wave and particle simultaneously in a given experiment  
*[Cahaya sentiasa memperlihatkan kedua-dua ciri gelombang dan kezarahan secara serentak dalam sesuatu eksperimen]*

A. I,IV      B. II, III,IV      C. I, II, III,IV

D. I, II      E. II,III

1.17 Which of the following statements are true about Lorentz transformation?

*[Yang manakah kenyataan berikut adalah benar berkenaan dengan transformasi Lorentz?]*

- I. It relates the space-time coordinates of one inertial frame to the other  
*[Ia menghubungkan-kaitkan koordinat-koordinat ruang-masa suatu rangka inersia dengan koordinat-koordinat ruang-masa rangka inersia lain]*
- II. It is the generalisation of Galilean transformation  
*[Ia merupakan generalisasi transformasi Galilean]*
- III. It constitutes one of the Einstein's special relativity postulates  
*[Ia merupakan salah satu postulat teori kerelatifan khas Einstein]*
- IV. Its derivation is based on the constancy of the speed of light postulate  
*[Ia diterbitkan berdasarkan postulat kemalaran kelajuan cahaya]*

A. I,IV      B. I,II, IV      C. I, II, III,IV

D. I, II      E. II,III

- 1.18 The expression of linear momentum has to be modified in the relativistic limit in order to  
*[Ekspresi momentum linear kena dimodifikasikan pada limit relativistik supaya]*
- I. preserve the consistency between the Lorentz transformation and conservation of linear momentum  
*[konsistensi antara transformasi Lorentz dengan keabadian momentum linear terpelihara]*
  - II. preserve the consistency between the Galilean transformation and conservation of linear momentum  
*[konsistensi antara transformasi Galilean dengan keabadian momentum linear terpelihara]*
  - III. preserve the consistency between special relativity with Newtonian mechanics  
*[konsistensi antara kerelatifan khas dengan mekanik Newton terpelihara]*
  - IV. preserve the consistency between the Lorentz transformation and Galilean transformation  
*[konsistensi antara transformasi Lorentz dengan transformasi Galilean terpelihara]*
- A. I only      B. I,II, IV      C. I, III,IV      D. III,IV      E. IV only

**Question 2. (25 marks)**  
***[Soalan 2 (25 markah)]***

- 2.1 What is the kinetic energy of the fastest photoelectrons emitted by a copper surface, of work function 4.4 eV when illuminated by visible light of 700 nm?  
*[Apakah tenaga kinetik fotoelektron paling pantas yang dipancarkan oleh permukaan kuprum, yang fungsi kerjanya 4.4 eV, semasa disinari cahaya ternampak 700 nm?]*
- A. 1.17 eV
  - B. 6.17 eV
  - C. 1.17 eV
  - D. 1.0 eV
  - E. non of the above  
*[Tiada dalam pilihan di atas]*



- 2.2 Suppose that a beam of 0.2-MeV photon is scattered by the electrons in a carbon target. What is the wavelength of those photon scattered through an angle of  $90^\circ$ ?  
*[Katakan satu bim foton 0.2 MeV diserakkan oleh elektron di dalam sasaran karbon. Apakah jarak gelombang bagi foton yang diserakkan melalui satu sudut  $90^\circ$ ?]*
- A. 0.00620 nm  
 B. 0.00863 nm  
 C. 0.01106 nm  
 D. 0.00243 nm  
 E. non of the above  
*[Tiada dalam pilihan di atas]*
- 2.3 Determine the cut-off wavelength of x-rays produced by 50-keV electrons in a x-ray vacuum tube?  
*[Tentukan jarak gelombang penggal bagi sinar-x yang dihasilkan oleh elektron 50 keV dalam satu tiub sinar-x vakum.]*
- A.  $0.000248 \text{ \AA}$   
 B.  $2.48 \text{ \AA}$   
 C.  $248 \text{ \AA}$   
 D.  $0.248 \text{ \AA}$   
 E. non of the above  
*[Tiada dalam pilihan di atas]*
- 2.4 A lamp emits light of frequency  $5.0 \times 10^{15} \text{ Hz}$  at a power of 25 W. The number of photons given off per seconds is  
*[Suatu lampu memancarkan cahaya berfrekuensi  $5.0 \times 10^{15} \text{ Hz}$  pada kuasa 25 W. Bilangan foton yang dihasilkan per saat ialah]*
- A.  $1.3 \times 10^{-19}$       B.  $8.3 \times 10^{-17}$       C.  $7.5 \times 10^{18}$       D.  $1.9 \times 10^{50}$   
 E.  $2.9 \times 10^{13}$
- 2.5 Which of the following transitions in a hydrogen atom emits the photon of lowest frequency?  
*[Dalam senarai di bawah, peralihan yang manakah memancarkan foton frekuensi terendah di dalam atom hidrogen?]*

- A.  $n = 1$  to  $n = 2$       B.  $n = 2$  to  $n = 1$       C.  $n = 2$  to  $n = 6$   
 D.  $n = 6$  to  $n = 2$       E.  $n =$  infinitely large to  $n = 1$   
*[ $n =$  sebesar tak terhingga ke  $n = 1$ ]*

2.6 The speed of an electron whose de Broglie wavelength is  $1.0 \times 10^{-10}$  m is  
*[Kelajuan satu elektron yang jarak gelombang de Broglie-nya  $1.0 \times 10^{-10}$  m ialah ]*

- A.  $6.6 \times 10^{-24}$  m/s      B.  $3.8 \times 10^3$  m/s      C.  $7.3 \times 10^6$  m/s  
 D.  $1.0 \times 10^{10}$  m/s      E.  $6.6 \times 10^2$  m/s

2.7 A large value of the probability density of an atomic electron at a certain place and time signifies that the electron  
*[Nilai yang besar bagi ketumpatan kebarangkalian suatu elektron atom pada sesuatu tempat dan masa menunjukkan elektron itu]*

- A. is likely to be found there  
*[agak mungkin dijumpai di sana]*  
 B. is certain to be found there  
*[pasti dijumpai di sana]*  
 C. has a great deal of energy there  
*[mempunyai banyak tenaga di sana]*  
 D. has a great deal of charge  
*[mempunyai banyak cas]*  
 E. is unlikely to be found there  
*[tidak berapa mungkin dijumpai di sana]*

2.8 Ionisation energy of hydrogen is 13.5 eV. What is the shortest wavelength in the Lyman series of hydrogen atom?  
*[Tenaga pengionan hidrogen ialah 13.5 eV. Apakah jarak gelombang terpendek dalam siri Lyman hidrogen?]*

- A. 364 nm      B. 121 nm      C. 91 nm      D. 819 nm  
 E. 103 nm

- 2.9 If the momentum of a particle is doubled, its wavelength is multiplied \_\_\_\_\_ times  
*[Jika momentum suatu zarah digandakan dua, jarak gelombangnya digandakan \_\_\_\_\_ kali]*
- A. 1                      B. 2                      C. 1/2                      D. 8                      E. 0
- 2.10 A standing wave cannot have less than \_\_\_\_ antinode. In quantum mechanics, that fundamental mode would be called the \_\_\_\_\_.  
*[Suatu gelombang pegun tidak boleh mempunyai kurang daripada \_\_\_\_ antinod. Dalam mekanik kuantum, mod asas ini dinamakan \_\_\_\_\_. ]*
- A. 1, first excited state                      B. 1, ground state  
*[keadaan teruja pertama]                      [keadaan dasar]*
- C. 2, first excited state                      D. 2, ground state  
*[keadaan teruja pertama]                      [keadaan dasar]*
- E. 0, ground state  
*[keadaan dasar]*
- 2.11 Assume that the uncertainty in the position of a particle is equal to its de Broglie wavelength. What is the minimal uncertainty in its velocity,  $v_x$ ?  
*[Anggapkan bahawa ketidakpastian dalam kedudukan suatu zarah adalah sama dengan jarak gelombang de Broglie-nya. Apakah ketidakpastian minimum dalam halajunya  $v_x$ ?]*
- A.  $v_x/4\pi$                       B.  $v_x/2\pi$                       C.  $v_x/8\pi$                       D.  $v_x$
- E.  $v_x/\pi$
- 2.12 If the ionisation energy for a hydrogen atom is 13.6 eV, what is the energy of the level with quantum number  $n = 3$ ?  
*[Jika tenaga pengionan satu atom hidrogen ialah 13.6 eV, apakah tenaga untuk paras yang bernombor kuantum  $n = 3$ ?]*
- A. 1.51 eV                      B. 3.4 eV                      C. 12.1 eV
- D. -1.51 eV                      E. -3.4 eV

- 2.13 What is the zero-point energy of an electron trapped in an infinite potential well of size  $L = 0.5 \text{ \AA}$   
*[Apakah tenaga titik-sifar bagi elektron yang terperangkap di dalam suatu telaga keupayaan infinit yang saiznya  $L = 0.5 \text{ \AA}$ ]*
- A.  $7.5 \times 10^{-9} \text{ eV}$       B.  $11.7 \times 10^{-6} \text{ eV}$       C.  $0.30 \times 10^{-6} \text{ eV}$   
 D.  $13.6 \text{ eV}$       E.  $65 \times 10^{-6} \text{ eV}$
- 2.14 A moving body is described by the wave function  $\psi$  at a certain time and place;  $\psi^2$  is proportional to the body's  
*[Suatu jasad bergerak diperihalkan oleh fungsi gelombang  $\psi$  pada suatu masa dan tempat tertentu:  $\psi^2$  adalah berkadar dengan]*
- A. electric field  
*[medan elektrik]*  
 B. speed  
*[kelajuan]*  
 C. energy  
*[tenaga]*  
 D. probability of being found  
*[kebarangkalian untuk dijumpai]*  
 E. mass  
*[jisim]*
- 2.15 The continuous x-ray spectrum produced in an x-ray tube can be explained by  
*[Keseluruhan spektrum sinar-x yang dihasilkan dalam suatu tiub sinar-x dapat diterangkan oleh]*
- I. Classical Electromagnetic wave theory  
*[Teori klasik gelombang keelektromagnetan]*  
 II. Pair production  
*[Penghalisan pasangan]*  
 III. Bremsstrahlung  
*[Bremsstrahlung]*  
 IV. Diffraction  
*[Belauan]*
- A. I,IV      B. I,II, IV      C. I, III,IV      D. I, III  
 E. II,III

2.16 Planck constant  
[*Pemalar Planck*]

- I. is a universal constant  
[*ialah satu pemalar universal*]
- II. is the same for all metals  
[*adalah sama bagi semua jenis logam*]
- III. is different for different metals  
[*adalah tidak sama bagi logam yang berlainan*]
- IV. characterises the quantum scale  
[*mencirikan skala kuantum*]

- A. I,IV                      B. I,II, IV                      C. I, III,IV                      D. I, III  
E. II,III

2.17 A neon sign produces  
[*Suatu lampu neon menghasilkan*]

- I. a line spectrum  
[*suatu spektrum garis*]
- II. an emission spectrum  
[*suatu spektrum pancaran*]
- III. an absorption spectrum  
[*suatu spektrum penyerapan*]
- IV. photons  
[*foton*]

- A. I,IV                      B. I,II, IV                      C. I, III,IV                      D. I, III  
E. II,III

2.18 Which of the following statements are true?  
[*Kenyataan berikut yang manakah benar?*]

- I.. the ground states are states with lowest energy  
[*keadaan asas adalah keadaan dengan tenaga yang paling rendah*]
- II. ionisation energy is the energy required to raise an electron from ground state to free state  
[*tenaga pengionan adalah tenaga yang diperlukan untuk menaikkan suatu elektron dari keadaan asas ke keadaan bebas*]

III. Balmer series is the lines in the spectrum of atomic hydrogen that corresponds to the transitions to the  $n = 1$  state from higher energy states  
*[Balmer siri adalah garis-garis spectrum atom hidrogen yang bersepadanan dengan peralihan dari paras-paras tenaga yang lebih tinggi ke paras  $n = 1$ ]*

A. I,IV

B. I,II, IV

C. I, III,IV

D. I, II

E. II,III

**Question 3. (25 marks)***[Soalan 3. (25 markah)]*

- (a) Lithium, beryllium and mercury have work functions of 2.3 eV, 3.9 eV and 4.5 eV, respectively. If a 400-nm light is incident on each of these metals, determine  
*[Fungsi kerja Lithium, beryllium dan raksa adalah 2.3 eV, 3.9 eV dan 4.5 eV masing-masing. Jika cahaya 400 nm ditujukan ke atas setiap satu logam itu, tentukan]*
- (i) which metals exhibit the photoelectric effect, and  
*[logam yang manakah memperlihatkan kesan fotoelektrik, dan ]*
- (ii) the maximum kinetic energy for the photoelectron in each case (in eV)  
*[tenaga kinetik maksimum untuk fotoelektron dalam setiap kes itu (dalam unit eV)]*
- (b) Molybdenum has a work function of 4.2 eV.  
*[Fungsi kerja Molybdenum ialah 4.2 eV.]*
- (i) Find the cut-off wavelength (in nm) and threshold frequency for the photoelectric effect.  
*[Carikan jarak gelombang penggal (dalam unit nm) dan frekuensi ambang untuk kesan fotoelektrik]*
- (ii) Calculate the stopping potential if the incident radiation has a wavelength of 180 nm.  
*[Hitungkan keupayaan penghenti jika sinaran tuju mempunyai jarak gelombang 180 nm.]*

- (c) A 0.0016-nm photon scatters from a free electron. For what scattering angle of the photon do the recoiling electron and the scattered photon have the same kinetic energy?  
*[Suatu foton 0.0016 nm diserakkan oleh elektron bebas. Apakah sudut serakan foton supaya elektron yang tersentak dan foton yang terserak itu mempunyai tenaga kinetik yang sama?]*

**Question 4. (25 marks)**

**[Soalan 4. (25 markah)]**

- (a) An electron is contained in a one-dimensional box of width 0.100 nm. Using the particle-in-a-box model,  
*[Suatu elektron terkandung di dalam satu kotak satu dimensi yang lebarnya 0.100 nm. Dengan menggunakan model zarah-dalam-satu-kotak]*
- (i) Calculate the  $n = 1$  energy level and  $n = 4$  energy level for the electron in eV.  
*[Hitungkan paras tenaga  $n = 1$  dan  $n = 4$  untuk elektron itu dalam unit eV.]*
- (ii) Find the wavelength of the photon (in nm) in making transitions that will eventually get it from the the  $n = 4$  to  $n = 1$  state  
*[Hitungkan jarak gelombang foton (dalam unit nm) semasa ia membuat peralihan yang membawanya dari keadaan  $n = 4$  ke keadaan  $n = 1$  ]*
- (b) Consider a 20-GeV electron.  
*[Pertimbangkan suatu elektron 20 GeV.]*
- (i) What is its Lorentz factor  $\gamma$ ?  
*[Apakah faktor Lorentznya?]*
- (ii) What is its de Broglie wavelength?  
*[Apakah jarak gelombang de Broglie-nya?]*
- (c) A photon is emitted as a hydrogen atom undergoes a transition from the  $n = 6$  state to the  $n = 2$  state. Calculate  
*[Suatu foton dipancarkan ketika suatu atom hidrogen melakukan satu peralihan dari keadaan  $n = 6$  ke  $n = 2$ . Hitungkan]*

- (i) the energy  
*[tenaga]*
- (ii) the wavelength  
*[jarak gelombang]*
- (iii) the frequency  
*[frekuensi]*

of the emitted photon  
*[foton yang dipancarkan]*

- 000 O 000 -



**ZCT 104/3E Modern Physics**  
**Final Exam**  
**Objectives answer sheet**

**Nombor Peperiksaan:**

- |      |                       |                       |                       |                       |                       |      |                       |                       |                       |                       |                       |
|------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| 1.1  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | 2.1  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1.2  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | 2.2  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1.3  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | 2.3  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1.4  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | 2.4  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1.5  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | 2.5  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1.6  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | 2.6  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1.7  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | 2.7  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1.8  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | 2.8  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1.9  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | 2.9  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1.10 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | 2.10 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1.11 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | 2.11 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1.12 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | 2.12 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1.13 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | 2.13 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1.14 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | 2.14 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1.15 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | 2.15 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1.16 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | 2.16 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1.17 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | 2.17 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1.18 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | 2.18 | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

