ZCT 104/3E Modern Physics
Semester II, Sessi 2004/05
Test I (17 Dec 2004)

Data
Speed of light in free space, $c = 3.00 \times 10^{8}$ ms^{-1}
Elementary charge, $e = 1.60 \times 10^{-19}$ C
The Planck constant, $h = 6.63 \times 10^{-34}$ J s
Unified atomic mass constant, $u = 1.66 \times 10^{-27}$ kg
Rest mass of electron, $m_e = 9.11 \times 10^{-31}$ kg
Rest mass of proton, $m_p = 1.67 \times 10^{-27}$ kg

1. What are the major flaws in the classical model of blackbody radiation given by Rayleigh-Jeans laws?
   I Molecular energy is quantized
   II Molecules emit or absorb energy in discrete irreducible packets
   III The intensity of short wavelength radiation emitted by a blackbody approaches infinity as the wavelength decreases.
   IV Energy is continuously divisible

   A. III, IV **B. I, II,III** **C. II, III, IV** **D. I, II**
   E. Non of the above

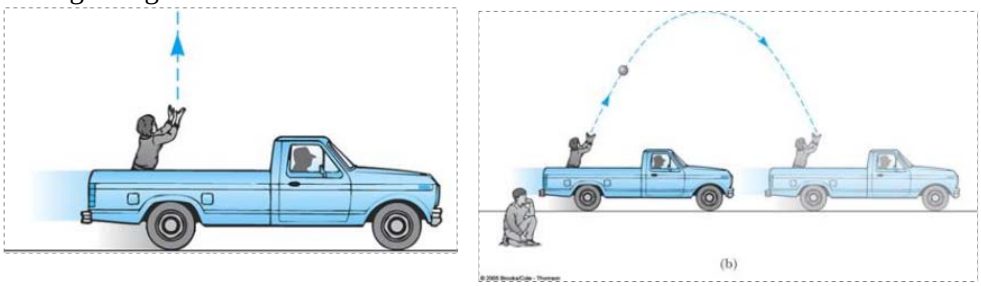
2. What are the assumptions did Planck make in dealing with the problem of radiation?
   I Molecular energy is quantized
   II Molecules emit or absorb energy in discrete irreducible packets
   III The intensity of short wavelength radiation emitted by a blackbody approaches infinity as the wavelength decreases.
   IV Energy is continuously divisible

   A. III, IV **B. I, II,III** **C. II, III, IV** **D. I, II**
   E. Non of the above

3. An unstable high-energy particle enters a detector and leaves a track of length d before it decays. Its speed relative to the detector was $v = c/2$. What is its proper lifetime? That is how long would the particle have lasted before decay had it been at rest with respect to the detector?

A. $\frac{d}{c}$ **B.** $\frac{4d}{\sqrt{3}c}$ **C.** $\frac{2d}{\sqrt{3}c}$ **D.** $\frac{\sqrt{3}d}{c}$ **E.** Non of the above

4. A ball was thrown upward by an observer in a van moving with constant speed $u << c$. He is observed by an observer in a rest frame attached to the ground, see figure below. Which of the following statement(s) is (are) true regarding the two inertial frames of reference?



   I The ball thrown follows different paths in different frames of reference
   II The kinematical laws of classical mechanics are valid only the moving frame (the van) but not to the rest frame attached to ground.
   III Classically Galilean transformation relates the trajectory of the ball in the rest frame with that in the moving frame.
   IV Since $u<<c$, Lorentz transformation will fail to relate the trajectory of the ball in the rest frame with that in the moving frame.

   A. II,III **B. I, II,III** **C. II, III, IV** **D. I Only** **E.** Non of the above

5. What measurement(s) do two observers in relative motion always agree on?
I The relativistic mass of an object
II The relativistic momentum of an object
III The relativistic energy of an object
IV $E^2 - p^2$, where p is the magnitude of relativistic momentum and E the relativistic energy the object

A. II,III **B. I, II,III** **C. II, III, IV** **D. IV Only**
E. Non of the above

6. Which of the following statement(s) is (are) true?
I The upper limit of the speed of an electron is the speed of light c.
II As more energy E is fed into an object its momentum approaches $\frac{E}{c}$.
III There is no upper limit to the relativistic momentum of an electron.
IV There is an upper limit to the relativistic momentum of an electron.

A. III **B. I, II,III** **C II, IV** **D. IV Only** **E.** Non of the above

7. The rest energy and total energy respectively, of three particles, expressed in terms of a basic amount A are (1) A, $2A$; (2) A, $3A$; (3) $3A$, $4A$. Without written calculation, rank the particles according to their kinetic energy, greatest first.

A. 2 > 1 = 3 **B.** 1 > 2 = 3 **C.** 2 > 1 > 3 **D.** 2 = 1 = 3
E. 3 > 1 = 2

8. The length of a spaceship is measured to be exactly half its rest length. By what factor do the spaceship's clocks run slow relative to clocks in the observer's frame?

A. 0.866 **B.** 0.745 **C.** 2.000 **D.** 0.366 **E.** 0.134

9. The length of a spaceship is measured to be exactly half its rest length. What is the speed parameter $\beta = v/c$ of the spaceship relative to the observer's frame?

A. 0.87 **B.** 2.00 **C.** 0.75 **D.** 2.73 **E.** 4.00

10. Consider a light pulse emitted from the origin, O, of a stationary frame S. The origin of a moving frame S', O', which overlaps with O at $t = t' = 0$ is moving with a constant speed u with respect to O. Which statement(s) correctly describe(s) the position of the wavefront of the light sphere as measured from the origins? r (r') is the distance of the wavefront from the origin O (O') at time t (t').

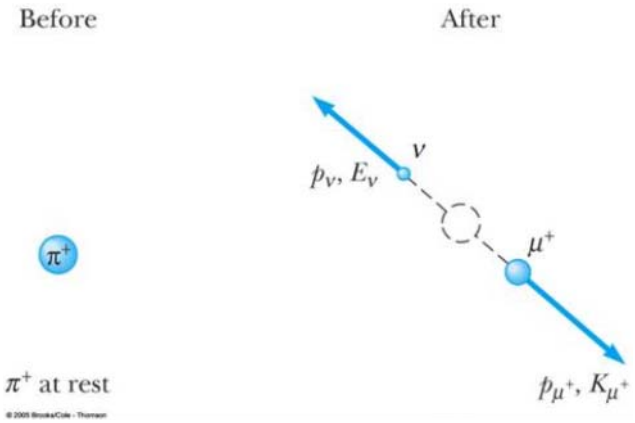
I $r = ct$ **II** $r' = ct'$ **III** $r' = r$ **IV** $r' = ut'$

A. I,II **B. I, II,III** **C. II, III, IV** **D. IV Only** **E.** Non of the above

11. Which of the following statement(s) is (are) true regarding Lorentz transformation (LT)?
I Time dilation can be recovered from LT
II Length contraction can be recovered from LT
III Absolute simultaneity is not guaranteed by LT
IV Galilean transformation is a generalisation of LT

A. II,III **B. I, II,III** **C. II, III, IV** **D. I, II** **E.** Non of the above

Question 12-13 are based on the decay of a π meson into a muon and a massless neutrino shown in figure below. The mass of the muon is known to be m_μ = 106 MeV/c^2, and the kinetic energy of the muon is measured to be K_μ = 4.6 MeV. p_μ denotes the momentum of the muon.



12. What is the momentum of the neutrino?

A. $\sqrt{\left(K_\mu + m_\mu c^2\right)^2 - m_\mu^2 c^4}$ **B.** $\left(K_\mu + m_\mu c^2\right)$

C. $\sqrt{2 m_\mu K_\mu}$ **D.** p_μ **E.** Non of the above

13. What is the total relativistic energy of the neutrino?

A. $\sqrt{\left(K_\mu + m_\mu c^2\right)^2 - m_\mu^2 c^4}$ **B.** $\left(K_\mu + m_\mu c^2\right) + \sqrt{\left(K_\mu^2 + 2K_\mu m_\mu c^2\right)}$

C. K_μ **D.** $m_\mu c^2$ **E.** Non of the above

14. What happens to the density of an object as its speed increases, as measured by an Earth observer?

A. Remain the same as it is when at rest
B. Increase by a factor of γ
C. Increase by a factor of γ^2
D. Increase by a factor of $1/\gamma$
E. Non of the above

15. What is the upper limit of the momentum of an electron?

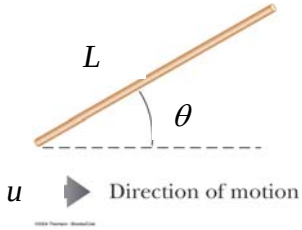
A. $m_e c$ **B.** c **C.** 0 **D.** Infinity **E.** Non of the above

16. Which of the following statement(s) is (are) true?

I Only massless particle can travel at the speed of *c*.
II Not all massless particle can travel at the speed of *c*.
III It is not necessary that a massless particle must travel at the speed of *c*.
IV All particles which are not massless must travel at the speed lower than *c*.

A. II,III **B. I, II,III** **C. I, III, IV** **D. I, IV** **E.** Non of the above

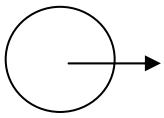
17. A moving rod is observed to have a length of *L* and to be orientated at an angle of θ = 45° with respect to the direction of motion, as shown in the figure below. The rod has a speed of $u = \frac{c}{\sqrt{2}}$.



What is the proper length of the rod?

A. $\frac{3}{2}L$ **B.** L **C.** $\sqrt{\frac{3}{2}}L$ **D.** $\frac{\sqrt{3}L}{2}$ **E.** Non of the above

18. A spaceship in the shape of a sphere moves past and observer on Earth with a speed of $v = 0.5c$ in the direction as indicated by the arrow. What shape will the observer see as the spaceship move past?



E. Non of the above

19. What is the speed of an object having relativistic momentum of magnitude p and rest mass m?

A. $\frac{p}{m}$ **B.** $\frac{c}{\sqrt{1+\left(mc/p\right)^2}}$ **C.** $\frac{mc^2}{u}$ **D.** $\frac{mu^2}{c}$ **E.** Non of the above

20. An electron with rest mass m_e moves with a speed of $\frac{\sqrt{3}}{2}c$. What is the work required to increase its speed to $\frac{2\sqrt{2}}{3}c$?

A. $m_e c^2$ **B.** $0.511 m_e c^2$ **C.** $\frac{5}{36}m_e c^2$ **D.** $\frac{\sqrt{5}}{6}m_e c^2$ **E.** Non of the above

ZCT 104/3E Modern Physics
Semester II, Sessi 2004/05
Test I (18 Feb 200b)

1. Which statements is (are) TRUE about photoelectricity according to classical physics?

I) Light beam of higher intensity is expected to eject electrons with higher kinetic energy from the metal surface
II) The energy carried by a beam of light is thought to be continuous
III) Light is wave and not comprised of quantum of energy
IV) When light is irradiated on the metal surface, some time lag is expected before photoelectrons are ejected from the surface

A. I, II **B. II, III**
C. III **D. I, II, III, IV**
E. Non of A, B, C, D

2. Let a given metal surface is irradiated with monochromatic light of intensity I_1. Then the same surface is irradiated by monochromatic light with intensity I_2 (where $I_2 > I_1$) but with a longer wavelength. Which of the following statements is (are) true?

I) The energy of the photon in the beam with intensity I_2 is larger than that in the beam with intensity I_1.
II) The saturated photocurrents will remain unchanged.
III) The maximum kinetic energy of the photoelectron will increase for the beam with intensity I_2
IV) The different intensity of light will alter the work function of the metal surface

A. I, II **B. II, III**
C. III **D. III, IV**
E. Non of A, B, C, D

3. Which of the following statements is (are) correct about Bohr's atom and a quantum particle trapped inside a simple infinite quantum well of width d?

I) The gap separating energy levels of higher quantum number becomes closer and closer in the Bohr's hydrogen atom, whereas in the case of particle in a box the gap becomes larger and larger at higher quantum levels.
II) The electron in the Bohr's atom is subjected to a non-zero potential due to Coulomb's attraction, whereas in the box the particle is subjected to zero potential.
III) The energy levels in the Bohr's atom are negative whereas they are positive for the particle in the well.
IV) In both cases the particles involved form standing waves

A. I, II, III, IV **B. II, III**
C. III **D. III, IV**
E. Non of A, B, C, D

4. Which of the following statements is (are) true?

I) A particle has a de Broglie wavelength that is related to its linear momentum
II) A particle's momentum must be quantised in all systems, bounded or unbounded
III) A particle's kinetic energy must be quantised in all systems, bounded or unbounded
IV) A particle's kinetic energy is only quantised in bounded system

A. I, II, IV **B. I, II, III**
C. I, IV **D. II, III**
E. Non of A, B, C, D

5. In order to have photoelectrons ejected from a metal surface in a typical photoelectric effect experiment,

I) the frequency of the light used must be larger than a certain cut-off value
II) the intensity of the light used must be larger than a certain cut-off value
III) the wavelength of the light used must be larger than a certain cut-off value
IV) the saturated photocurrent must be larger than a certain cut-off value

A. I, II, IV **B. I, III**
C. I **D. II, III, IV**
E. Non of A, B, C, D

6. Which of the following statements is (are) TRUE regarding photoelectric effect (PE) and Compton effect (CE)?

I) In PE light behaves like particle, whereas in CE light behave like wave

II) In PE light behaves like wave, whereas in CE light behave like particle

III) In PE only part of the photon's energy is lost to the atom, whereas in CE all of the photon's energy is lost to the free electron

IV) In PE all of the photon's energy is lost to the atom, whereas in CE only part of the photon's energy is lost to the free electron

A. I, III **B. II, III**
C. II, IV **D. IV**
E. Non of A, B, C, D

7. Which statements is (are) TRUE about photoelectric and Compton effects?

I) Compton effect experiment confirms that the energy of the quantum of light is proportional to the frequency of the wave model of light

II) Compton effect experiment confirms that the radiant energy of light is quantized into concentrated bundle

III) Photoelectric effect infers that the radiant energy of light is quantized into concentrated bundle

IV) Both Compton effect and photoelectric effect confirm that EM radiation has both wave and particle properties

A. I, III **B. II, III**
C. II, IV **D. IV**
E. Non of A, B, C, D

8. Which of the following is (are) the correct statement(s) about X-ray production in a conventional X-ray tube?

I) Part or all of the kinetic energy of the moving electron is converted into X rays photon

II) X-rays is emitted when the bombarding electrons undergo Compton scattering

III) The production of x-rays can be considered as a photoelectric process

IV) The shortest wavelength in the x-rays spectrum is the same for different material

A. II, III **B. I, IV**
C. II, IV **D. IV**
E. Non of A, B, C, D

9. Which of these statements is (are) true about blackbody radiation?

I) Rayleigh-Jeans law is behaving in a physically acceptable manner at short wavelengths

II) Rigel (the blue star) is hotter than Betelguese (red star) because of the position of the peak wavelength in their black body spectrum

III) According to Rayleigh-Jeans law the average energy of the oscillators is given by the equipartition theorem

IV) The spectral distribution of radiation from a blackbody can only be explained in terms of quantised energy levels of the oscillators

A. I, II, III, IV **B. II, III, IV**
C. II, IV **D. III, IV**
E. Non of A, B, C, D

10. Which of these statements are correct?

I) We conclude that light behave like wave when we find that the light from the sun arrives to the Earth after 8 minutes it was emitted.

II) When we consider light to behave like a particle we expect some detectable time lag for the electron to be emitted from the surface of the metal in a PE experiment.

III) When we consider light to behave like wave we expect some detectable time lag for the electron to be emitted from the surface of the metal in a PE experiment.

IV) Photoelectric effect occurs at the same energy scale as that of the x-rays production because x-rays production is the inverse of the photoelectric process.

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

11. Which of the following statements is (are) TRUE?

I) The energy levels of the atomic orbit is quantized

II) The energy associated with the orbits of the electron in a hydrogen atom is negative because it is not a bounded system

III) $E = 0$ means the electron is free from the bondage of the nucleus' potential field.
IV) Electron at very large quantum number n is tightly bounded to the nucleus by the EM force.

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

12. Which of the following statements is (are) TRUE about the Bohr's model of hydrogen-like atom?

I) It applies the Newton's second law for the atom's mechanical stability
II) The angular momentum is postulated to be quantised via $L = nh/2\pi$
III) It assumes the validity of classical electromagnetic theory for the orbiting electron
IV) The only stable orbits of radius r are those that can fit in a multiple number of standing wave of the electron, i.e $2\pi r = n\lambda$

A. I, II, III, IV **B. II, III, IV**
C. I, II, IV **D. III,IV**
E. Non of A, B, C, D

13. Which of the following statements is (are) true?

I) Thompson suggestion of the Plum Pudding Model is falsified by Rutherford's alpha particle experiment
II) Rutherford suggested the planetary model of atoms.
III) de Broglie is the first to experimentally confirm that electron manifests wave nature.
IV) Frank-Hertz experiment confirms the existence of discrete energy levels in mercury atom

A. I, II, III, IV **B. II, III, IV**
C. I, II, IV **D. III,IV**
E. Non of A, B, C, D

14. Which of the following statement is (are) true about the Plum-pudding model by Thompson and Rutherford's experiment?

I) Plum-pudding model fails to explain the emission & absorption line spectrum from atoms because it predicts only a single unique emission frequency.
II) Plum-pudding model cannot explain the 180 degree back-scattering of alpha particle seen in Rutherford's scattering experiment.
III) The planetary model of atoms is plagued by infrared catastrophe
IV) In the Rutherford's alpha particle scattering experiment, the large deflection of alpha particle is caused by a close encounter between alpha particle and the diffused distribution of the positive charge of an atom.

A. I, II, III **B. II, III, IV**
C. I, II, IV **D. III, IV**
E. Non of A, B, C, D

15. Which of the following statements is (are) true regarding the basic properties of atoms?

I) Atoms are of microscopic size, ~10^{-10} m
II) Atoms are stable
III) Atoms contain negatively charges, electrons, but are electrically neutral.
IV) Atoms never emit and absorb EM radiation.

A. I, II, III **B. II, III, IV**
C. I, II, IV **D. III, IV**
E. Non of A, B, C, D

16. Which of the following statements is (are) true about Bohr's hydrogen-like atom?

I) The increase in the quantum number n means an increase in the energy of the atomic states.
II) When n approaches infinity, the energy of the hydrogen atom become infinity.
III) Free electron is the electron which has the smallest quantum number n
IV) The zero point energy is the energy of the lowest possible quantum state

A. I, II, III **B. II, III, IV**
C. I, IV **D. III, IV**
E. Non of A, B, C, D

17. Heisenberg's uncertainty principle is a consequence of

A. the intrinsic wave nature of particle
B. the intrinsic particle nature of wave

C. the indivisible nature of particle
D. the divisible nature of particle
E. probabilistic interpretation of the wave function

18. Which of the following statements is (are) true about the spectrum from hydrogen atom?

I) Balmer series involves transitions of electron from higher orbits to the $n = 2$ orbit
II) Balmer series is the first spectral series of hydrogen atom observed
III) When electron in higher orbit is de-excited to lower orbit, photons of discrete frequency are emitted from the atom, as seen in the emission spectrum
IV) When electron in lower orbit is excited to higher orbit, photons of discrete frequency are absorbed by the atom, as seen in the absorption spectrum

A. I, II, III, IV **B. II, III, IV**
C. I, IV **D. III, IV**
E. Non of A, B, C, D

19. Which of the following statements is (are) true regarding a quantum particle trapped inside an infinite well of width L?

I) It forms stationary (standing) waves inside the well
II) The linear momentum of the particle becomes quantised
III) The minimum energy of the particle inside the well is given by $h^2/8mL^2$
IV) The energy of the particle inside the well can take on negative value

A. I, II, III, IV **B. I, II, III**
C. I, IV **D. III, IV**
E. Non of A, B, C, D

20. Which of the following statements is (are) true regarding pair production and pair annihilation of electron-positron pair?

I) Pair annihilation occurs only above the threshold energy of $2m_ec^2$
II) Pair production occurs only above the threshold energy of $2m_ec^2$
III) Energy is always conserved in both processes of pair production and pair annihilation
IV) Momentum is always conserved in both processes of pair production and pair annihilation

A. I, II, III, IV **B. I, II, III**
C. I, IV **D. II, III, IV**
E. Non of A, B, C, D

UNIVERSITI SAINS MALAYSIA

Final Exam
Academic Session 2004/2005
March 2005

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 **15** pages of printed material before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi 15 muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

Instruction: Answer all questions. Please answer the objective questions from Part A in the objective answer sheet provided. Answer both structured questions from Part B. Please submit the objective answer sheet and the answers to the structured questions separately.

Students are allowed to answer all questions in Bahasa Malaysia or in English.

*[**Arahan**: Jawab **SEMUA** soalan. Sila jawab soalan-soalan objektif daripada bahagian A dalam kertas jawapan objektif yang dibekalkan. Jawab kedua-dua soalan struktur daripada Bahagian B. Hantar kertas jawapan objektif dan jawapan kepada soalan struktur berasingan.]*

[Pelajar dibenarkan untuk menjawab samada dalam bahasa Malaysia atau bahasa Inggeris.]

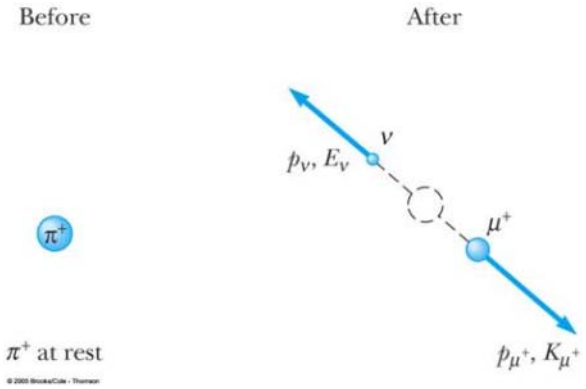
Data

speed of light in free space, $c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space, $\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space, $\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
elementary charge, $e = 1.60 \times 10^{-19}$ C
Planck constant, $h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant, $u = 1.66 \times 10^{-27}$ kg
rest mass of electron, $m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton, $m_p = 1.67 \times 10^{-27}$ kg
molar gas constant, = 8.31 J K^{-1} mol^{-1}
Avogadro constant, $N_A = 6.02 \times 10^{23}$ mol^{-1}
gravitational constant, $G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}
acceleration of free fall, $g = 9.81$ m s^{-2}

Part A: Objective
Instruction: Answer all 40 objective questions in this Part.
[Bahagian A: Objektif.]
[Arahan: Jawab kesemua 40 soalan objektif dalam Bahagian ini.]

Question 1 - 3 are based on the decay of a π meson into a muon and a massless neutrino shown in the figure below. The mass of the muon is known to be m_μ = 106 MeV/c^2, and the kinetic energy of the muon is measured to be K_μ = 4.6 MeV. p_μ denotes the momentum of the muon.

[Soalan 1-3 adalah berdasarkan pereputan satu meson π kepada satu muon dan satu neutrino tanpa jisim, sepertimana ditunjukkan dalam gambarajah di bawah. Diketahui jisim muon ialah m_μ = 106 MeV/c^2, dan tenaga kinetik muon yang terukur ialah K_μ = 46 MeV. p_μ menandakan momentum muon.]



1. How is the momentum of the muon, p_μ related to the kinetic energy of the muon? E_μ denotes the total relativistic energy of muon.
   [Bagaimanakah momentum muon p_μ dikaitkan dengan tenaga kinetik muon? E_μ menandakan tenaga keretatifan muon]

   A. $p_\mu c = \sqrt{\left(K_\mu + m_\mu c^2\right)^2 - m_\mu^2 c^4}$ **B.** $p_\mu = \sqrt{\left(K_\mu + m_\mu c^2\right)^2 - m_\mu^2 c^4}$

   C. $p_\mu = \sqrt{2 m_\mu K_\mu}$ **D.** $p_\mu c = \sqrt{\left(E_\mu^2 + m_\mu c^2\right)^2}$

   E. Non of A, B, C, D *[Jawapan tiada dalam A, B, C, D]*

2. What is the rest energy of the π meson?
   [Apakah tenaga rehat meson π ?]

   A. $K_\mu + m_\mu c^2$ **B.** $\left(K_\mu + m_\mu c^2\right) + \sqrt{\left(K_\mu^2 + 2K_\mu m_\mu c^2\right)}$

   C. K_μ **D.** $m_\mu c^2$

   E. Non of A, B, C, D *[Jawapan tiada dalam A, B, C, D]*

3. What is the kinetic energy of the neutrino?
   [Apakah tenaga kinetik neutrino?]

   A. $\sqrt{\left(K_\mu + m_\mu c^2\right)^2 - m_\mu^2 c^4}$ **B.** $\left(K_\mu + m_\mu c^2\right) + \sqrt{\left(K_\mu^2 + 2K_\mu m_\mu c^2\right)}$

   C. K_μ **D.** $m_\mu c^2$

   E. Non of A, B, C, D *[Jawapan tiada dalam A, B, C, D]*

4. Which of the following statement(s) is (are) true? *[Manakah kenyataan yang berikut adalah benar?]*

I All inertial frames are equivalent *[Semua rangka inersia adalah setara]*

II If light obeys Galilean transformation, light waves would appear stationary in an inertial frame that moves with the same speed with that of the light. *[Jika cahaya mematuhi transformasi Galilean, gelombang cahaya akan kelihatan pegun dalam satu rangka inersia yang kelajuannya sama dengan kelajuan cahaya]*

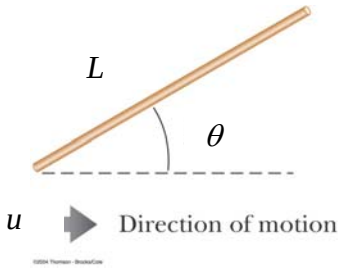
III In an inertial frame moving approximately with the speed of light, light waves would appear stationary according to the postulates of special theory of relativity *[Dalam satu rangka inersia yang bergerak dengan kelajuan hampir dengan kelajuan cahaya, gelombang cahaya akan kelihatan pegun mengikut postulat teori kerelatifan khas.]*

IV It is experimentally verified that electromagnetic waves propagate through a medium called Ether *[Telah disahkan secara eksperimen bahawa gelombang elektromagnetik merambat melalui satu jenis medium digelar Ether.]*

A. II,III **B. I, II,III** **C. II, III, IV** **D. I, II**
E. Non of A, B, C, D *[Jawapan tiada dalam A, B, C, D]*

5. A moving rod is observed to have a length of L and to be orientated at an angle of $\theta = 45°$ with respect to the direction of motion, as shown in the figure below. The rod has a speed of $u = \frac{c}{\sqrt{2}}$.

[Suatu rod bergerak diperhatikan mempunyai panjang L dan diorientasikan pada suatu sudut $\theta = 45°$ merujuk kepada arah gerakannya sepertimana ditunjukkan dalam gambarajah di bawah. Kelajuan rod ialah $u = \frac{c}{\sqrt{2}}$.]



What is the tangent of the angle in the proper frame (in terms of $\tan\theta$)?
[Apakah tangen sudutnya (dinyatakan dalam sebutan $\tan\theta$) dalam rangka `proper']

A. $\tan\theta$ **B.** $\frac{\tan\theta}{\sqrt{2}}$ **C.** $\sqrt{2}\tan\theta$ **D.** $2\tan\theta$

E. Non of A, B, C, D *[Jawapan tiada dalam A, B, C, D]*

6. What measurement(s) do two observers in relative motion always agree on?
[Apakah ukuran(-ukuran) yang sentiasa disetujui oleh dua orang pemerhati yang berada dalam pergerakan relatif]

I The speed of light c in vacuum *[Laju cahaya c dalam vakum]*
II The speed v of their relative motion *[Laju relatif v di antara mereka]*

III The momentum of an object *[Momentum suatu objek]*
IV The rest mass of an object *[Jisim rehat suatu objek]*

A. II, III **B. I, II, IV** **C. II, III, IV** **D. I, II**
E. Non of A, B, C, D *[Jawapan tiada dalam A, B, C, D]*

7. Given {*x,t*}, {*x*',*t*'} are two sets of coordinates used by two reference frames which are moving with a constant relative velocity, which statement(s) correctly describe(s) the transformation between them?
[Diberi {x,t}, {x',t'} merupakan dua set koordinat yang digunakan oleh dua rangka rujukan yang bergerak dengan halaju relatif mantap, kenyataan yang manakah memerihalkan transformasi di antara dua set koordinat tersebut dengan betul?]

I {*x,t*} is related to {*x*',*t*'} by Galilean transformation at $u << c$
[{x,t} dikaitkan dengan {x',t'} oleh transformasi Galilean pada u << c]

II {*x,t*} is related to {*x*',*t*'} by Galilean transformation at $u \rightarrow c$
[{x,t} dikaitkan dengan {x',t'} oleh transformasi Galilean pada u → c]

III {*x,t*} is related to {*x*',*t*'} by Lorentz transformation at $u << c$
[{x,t} dikaitkan dengan {x',t'} oleh transformasi Lorentz pada u << c]

IV {*x,t*} is related to {*x*',*t*'} by Lorentz transformation at $u \rightarrow c$
[{x,t} dikaitkan dengan {x',t'} oleh transformasi Lorentz pada u → c]

A. I,II **B. I, III,IV** **C. II, III, IV** **D. I, IV Only**
E. Non of A, B, C, D *[Jawapan tiada dalam A, B, C, D]*

8. What is the upper limit of the speed of an electron?
[Apakah limit atas bagi laju suatu elektron?]

A. $m_e c$ **B.** c **C.** 0 **D.** Infinity
E. Non of A, B, C, D *[Jawapan tiada dalam A, B, C, D]*

9. The units of the Planck constant *h* are those of:
[Unit bagi pemalar Planck h adalah sama dengan unit bagi …]

A. energy **B.** power **C.** momentum **D.** angular momentum
E. frequency

10. Rank following electromagnetic radiations according to the energies of their photons, from least to greatest.
[Menyusun sinaran elektromagnetik berikut mengikut tenaga foton mereka, daripada yang paling lemah kepada yang paling besar]

1. blue light 2. yellow light 3. x-rays 4. radio waves
A. 1, 2, 3, 4 **B.** 4, 2, 1, 3 **C.** 4, 1, 2, 3 **D.** 3, 2, 1, 4 **E.** 3, 1, 2, 4

11. In a photoelectric effect experiment the stopping potential is:
[Dalam eksperimen kesan fotoelektrik keupayaan penghenti adalah]

A. the energy required to remove an electron from the sample
[tenaga yang diperlukan untuk menyingkirkan satu elektron daripada sampel]

B. the kinetic energy of the most energetic electron ejected
[tenaga kenetik bagi elektron terlenting yang paling bertenaga]

C. the potential energy of the most energetic electron ejected
[tenaga keupayaan bagi elektron terlenting yang paling bertenaga]

D. the photon energy *[tenaga foton]*

E. the electric potential that causes the electron current to vanish
[keupayaan elektrik yang menyebabkan arus elektron hilang]

12. In a photoelectric effect experiment no electrons are ejected if the frequency of the incident light is less than A/h, where h is the Planck constant and A is:
[Dalam eksperimen kesan fotoelektrik tiada elektron akan terlenting jika frekuensi cahaya tuju adalah kurang daripada A/h, di mana h ialah pamalar Planck dan A ialah:]

A. the maximum energy needed to eject the least energetic electron
[tenaga maksimum yang diperlukan untuk melentingkan elektron yang paling kurang bertenaga]

B. the minimum energy needed to eject the least energetic electron
[tenaga miminum yang diperlukan untuk melentingkan elektron yang paling kurang bertenaga]

C. the maximum energy needed to eject the most energetic electron
[tenaga maksimum yang diperlukan untuk melentingkan elektron yang paling bertenaga]

D. the minimum energy needed to eject the most energetic electron
[tenaga minimum yang diperlukan untuk melentingkan elektron yang paling bertenaga]

E. the intensity of the incident light *[keamatan cahaya tuju]*

13. Consider the following: *[Pertimbangkan yang berikut]*

I. A photoelectric process in which some emitted electrons have kinetic energy greater than hf, where f is the frequency of the incident light.
[Satu proses fotoelektrik di mana sebahagian elektron terlenting mempunyai tenaga kinetik yang lebih besar daripada hf, di mana f ialah frekuensi cahaya tuju]

II. A photoelectric process in which all emitted electrons have energy less than hf.
[Satu proses fotoelektrik di mana kesemua elektron terlenting mempunyai tenaga kurang daripada hf]

III. Compton scattering from stationary electrons for which the emitted light has a frequency that is greater than that of the incident light.

[Penyerakan Compton daripada elektron-elektron rehat yang mana cahaya tertenting mempunyai frekuensi yang lebih besar daripada frekuensi cahaya tuju]

IV. Compton scattering from stationary electrons for which the emitted light has a frequency that is less than that of the incident light.
[Penyerakan Compton daripada elektron-elektron rehat yang mana cahaya tertenting mempunyai frekuensi yang lebih kecil daripada frekuensi cahaya tuju]

The only possible processe(s) is (are) *[Proses(-proses) yang mungkin ialah]*:

A. I **B. III** **C. I** and **III** **D. I** and **IV** **E. II** and **IV**

14. In Compton scattering from stationary electrons the largest change in wavelength that can occur is:
[Dalam penyerakan Compton daripada elektron-elektron rehat, perubahan paling besar yang mungkin dalam jarak gelombang adalah]

A. 2.43×10^{-15} m **B.** 2.43×10^{-12} m **C.** 4.9×10^{-12} m
D. dependent on the frequency of the incident light *[bergantung kepada frekuensi cahaya tuju]*
E. dependent on the work function *[bergantung kepada fungsi kerja]*

15. Of the following, Compton scattering from electrons is most easily observed for:
[Daripada yang berikut, penyerakan Compton daripada elektron-elektron adalah paling mudah dicerap dalam]

A. microwaves **B.** infrared light **C.** visible light
D. ultraviolet light **E.** x rays

16. In Compton scattering from stationary particles the maximum change in wavelength can be made larger by using:
[Dalam penyerkan Compton daripada zarah-zarah rehat, perubahan maksimum dalam jarak gelombang boleh dijadikan lebih besar dengan menggunakan]

A. higher frequency radiation *[sinaran yang berfrekuensi lebih tinggi]*
B. lower frequency radiation *[sinaran yang berfrekuensi lebih rendah]*
C. more massive particles *[zarah yang berjisim lebih besar]*
D. less massive particles *[zarah yang berjisim lebih kecil]*
E. particles with greater charge *[zarah yang casnya lebih besar]*

17. Evidence for the wave nature of matter is: *[Bukti untuk sifat gelombang bagi jasad ialah]*

A. Electron diffraction experiments of Davisson and Germer
[eksperimen belauan elektron oleh Davisson dan Germer]
B. Photoelectric effect *[kesan fotoelektrik]*
C. Young's double slit experiment *[eksperimen dwi-celah Young]*
D. the Compton effect *[kesan Compton]*
E. Frank-Hertz experiment *[eksperimen Frank-Hertz]*

18. Monoenergetic electrons are incident on a single slit barrier. If the energy of each incident electron is increased, the central maximum of the diffraction pattern:
[Elektron monotenaga ditujukan pada satu sawar celah tunggal. Jika tenaga setiap elektron tuju dinaikkan, maka maksimum pusat corak belauan]

A. widens *[dilebarkan]* **B.** narrows *[disempitkan]*

C. stays the same width *[kelebaran tetap tak berubah]*

D. widens for slow electrons and narrows for fast electrons
[dilebarkan untuk elektron yang lambat dan disempitkan untuk elektron yang pantas]

E. narrows for slow electrons and widens for fast electrons
[disempitkan untuk elektron yang lambat dan dilebarkan untuk elektron yang pantas]

19. Which of the following statement(s) is (are) true? *[Manakah kenyataan yang berikut adalah benar?]*

I An ideal blackbody absorbs all of the light that is incident on it. *[Jasad hitam yang ideal menyerap kesemua cahaya yang tertuju padanya]*

II The distribution of energy in the blackbody radiation depends upon the material from which the blackbody is constructed.
[Taburan tenaga dalam pancaran jasad hitam bergantung kepada jenis bahan yang membentuk dinding jasad hitam]

III A blackbody is a perfect emitter of the radiation it generates. *[Jasad hitam adalah pemancar pancaran yang sempurna.]*

IV The energy of an ultraviolet photon is more than the energy of an infrared photon.
[Tenaga suatu foton ultraungu adalah lebih tinggi daripada tenaga bagi suatu foton inframerah]

A. III, IV **B. I, II, III** **C. I, III, IV** **D. I, III**
E. Non of A, B, C, D *[Jawapan tiada dalam A, B, C, D]*

20. If the wavelength of a photon is doubled, what happens to its energy?
[Jika jarak gelombang digandakan dua kali, apa yang akan berlaku ke atas tenaganya?]

A. It is halved. *[ia diseparuhkan]*
B. It stays the same. *[tetap tak berubah]*
C. It is doubled. *[ia digandaduakan]*
D. It is quadrupled. *[ia digandakan 4 kali]*
E. Non of A, B, C, D *[Jawapan tiada dalam A, B, C, D]*

21. Light of a given wavelength is used to illuminate the surface of a metal, however, no photoelectrons are emitted. In order to cause electrons to be ejected from the surface of this metal you should
[Cahaya dengan jarak gelombang tertentu digunakan untuk memancari permukaan satu logam, tapi tiada fotoelektron yang terlentingkan. Unutk menlentingkan elektron daripada permukaan logam tersebut anda kena]

A. use light of a longer wavelength.
[menggunakan cahaya yang berjarak gelombang lebih panjang]

B. use light of a shorter wavelength.
[menggunakan cahaya yang berjarak gelombang lebih pendek]

C. use light of the same wavelength but increase its intensity.
[menggunakan cahaya yang berjarak gelombang sama tapi menambahkan keamatannya]

D. use light of the same wavelength but decrease its intensity.
[menggunakan cahaya yang berjarak gelombang sama tapi mengurangkan keamatannya]

E. Non of A, B, C, D *[Jawapan tiada dalam A, B, C, D]*

22. Protons are being accelerated in a particle accelerator at sub-relativistic energies. When the energy of the protons is doubled, their de Broglie wavelength will
[Proton dipecutkan dalam satu pemecut zarah pada tenaga sub-kerelatifan. Bila tenaga proton digandaduakan, jarak gelombang de Broglienya akan]

A. increase by a factor of 2. *[bertambah dengan satu factor 2]*
B. decrease by a factor of 2. *[berkurang dengan satu factor 2]*
C. increase by a factor of $\sqrt{2}$. *[bertambah dengan satu factor $\sqrt{2}$]*
D. decrease by a factor of $\sqrt{2}$. *[berkurang dengan satu factor $\sqrt{2}$]*
E. Non of A, B, C, D *[Jawapan tiada dalam A, B, C, D]*

23. A proton and an electron are both accelerated to the same final speed. If λ_p is the de Broglie wavelength of the proton and λ_e is the de Broglie wavelength of the electron, then
[Kedua-dua proton dan elektron dipecutkan kepada laju akhir yang sama. Jika λ_p ialah jarak gelombang de Broglie proton dan λ_e ialah jarak gelombang de Broglie elektron maka]

A. $\lambda_p > \lambda_e$. **B.** $\lambda_p = \lambda_e$. **C.** $\lambda_p < \lambda_e$.
D. Not enough data to answer this question. *[tak cukup data untuk menjawab soalan ini]*
E. Non of A, B, C, D *[Jawapan tiada dalam A, B, C, D]*

24. If the position of an electron is measured very precisely there is an uncertainty in measuring its
[Jika kedudukan suatu elektron diukur dengan sangat tepat maka akan wujud ketidakpastian dalam pengukuran …nya]
A. rest mass. **B.** momentum. **C.** potential energy.
D. charge. **E.** Non of A, B, C, D *[Jawapan tiada dalam A, B, C, D]*

25. Which of the following statement(s) is (are) true? *[Manakah kenyataan yang berikut adalah benar?]*

I A zero value for the Planck's constant would mean that the laws of classical physics would apply to quantum physics.
[Jika pemalar Planck bernilai sifar ini bermakna hukum-hukum fizik klasik akan teraplikasikan dalam fizik kuantum]

II In quantum tunneling, electrons and other quantum particles can tunnel through a region of space that would be forbidden to them if they were classical particles.
[Dalam penerowongan kuantum, elektron dan zarah-zarah kuantum lain boleh menerowongi satu rantau yang terlarang bagi mereka yang merupakan zarah-zarah klasikal.]

III A large value for the Planck's constant would mean that the laws of classical physics would apply to quantum physics.
[Jika pemalar Planck bernilai besar ini bermakna hukum-hukum fizik klasik akan teraplikasikan dalam fizik kuantum]

A. III **B. II, III** **C. I** **D. I, II**
E. Non of A, B, C, D *[Jawapan tiada dalam A, B, C, D]*

26. A major advantage of an electron microscope over a visible light microscope is that the electron microscope
[Manfaat yang major bagi satu mikroskop elektron berbanding dengan mikroskop cahaya nampak ialah bahawa mikroskop elektron]

A. has much greater magnification. *[memberikan pembesaran yang lebih tinggi]*
B. operates with much lower intensity. *[beroperasi pada keataman yang lebih rendah]*
C. can penetrate opaque samples. *[boleh menembusi sampel legap]*
D. can have much better resolution.*[memberikan leraian yang lebih baik]*
E. requires no lenses for its operation. *[tidak memerlukan kanta-kanta dalam operasinya]*

27. An important observation that led Bohr to formulate his model of the hydrogen atom was the fact that
[Salah satu pencerapan yang merangsangkan Bohr memformulasikan model atom hidrogennya ialah fakta bahawa]

A. a low density gas emitted a series of sharp spectral lines.
[gas berketumpatan rendah memancarkan pinggir-pinggir spectrum yang tajam]

B. neutrons formed a diffraction pattern when scattered from a nickel crystal.
[neutron membentuk corak belauan bila diserakkan daripada hablur nickel]

C. electrons were found to have a wave nature.
[elektron didapti mempunyai sifat gelombang]
D. the peak of the blackbody radiation moved to shorter wavelengths as the temperature was increased.
[puncak jasad hitam bergerak menghampiri jarak gelombang yang lebih pendek bila suhu bertambah]

E. the emission of light by an atom does not appear to conserve energy.
[pancanran cahaya oleh atom tidak mengabadikan tenaga]

28. The particle nature of light is best illustrated by which of the following?
[Sifat zarah cayaha adalah paling baik diilustrasikan oleh yang mana berikut?]

A. The scattering of alpha particles from gold foil. *[Serakan zarah alfa daripada foil emas]*

B. The fact that hot objects emit electromagnetic radiation.
[Fakta bahawa objek panas memancarkan pancaran elektromagnetik]

C. The diffraction pattern observed when a beam of electrons is scattered by a crystal
[Corak belauan yang dicerap bila satu bim elektron diserakkan oleh satu hablur]

D. The fact that a rainbow consists of a continuous spectrum of colors
[Fakta bahawa pelangi mengandungi satu spektrum warna yang selanjar]

E. The ejection of electrons from a metal surface illuminated by light**.**
[Pelentingan elektron daripada permukaan logam yang disinari cahaya]

29. A wave function is given by
[Satu fungsi gelombang diberikan oleh]

$\Psi(x) = 0$ for $x < 0$
$\Psi(x) = Ax$ for $0 \leqslant x \leqslant L$
$\Psi(x) = 0$ for $x > L$

The product of the normalization constant A and the quantity $L^{3/2}$ is equal to:
[Hasildarab pemalar normalisasi A dengan kuantiti $L^{3/2}$ bersamaan dengan]

A. $\sqrt{12}$ **B.** $\sqrt{15}$ **C.** $\sqrt{20}$ **D.** $\sqrt{24}$ **E.** $\sqrt{3}$

30. If a wave function ψ for a particle moving along the x axis is "normalized" then:
[Jika satu funsi gelombang ψ untuk satu zarah yang bergerak sepanjang paksi x adalah ternormalisasikan, maka

A. $\int |\psi|^2 dt = 1$ **B.** $\int |\psi|^2 dx = 1$ **C.** $\partial\psi/\partial x = 1$ **D.** $\partial\psi/\partial t = 1$
E. $|\psi|^2 = 1$

31. The energy of an electron in a hydrogen atom that is about to get ionised is
[Tenaga elektron dalam atom hidrogen yang hampir-hampir diionkan adalah]

A. -13.6 eV **B.** -3.4 eV **C.** -10.2 eV
D. -1.0 eV **E.** 0 eV

32. According to the Bohr model of hydrogen atom, the energy E_n of a hydrogen atom of a state with quantum number n is proportional to:
[Mengikut model hidrogen Bohr tenaga E_n suatu atom hidrogen pada keadaan dengan nombor kuantum n adalah berkadaran dengan]

A. n **B.** n^2 **C.** $1/n$ **D.** $1/n^2$

E. Non of A, B, C, D *[Jawapan tiada dalam A, B, C, D]*

33. The series limit for the Balmer series represents a transition $m \rightarrow n$, where (m, n) is
[Limit siri bagi siri Balmer mewakili satu peralihan $m \rightarrow n$, di mana (m, n) ialah]

A. (2,1) **B.** (3,2) **C.** (∞,0) **D.** (∞,1) **E.** (∞,2)

34. The location of a particle is measured and specified as being exactly at $x = 0$, with *zero* uncertainty in the x direction. How does this affect the uncertainty of its velocity component in the y direction?
[Lokasi suatu zarah adalah diukur dan dispesifikasikan sebagai tepat-tapat pada $x = 0$ dengan ketidakpastian sifar dalam arah x. Bagaimanakah keadaan ini mempengaruhi ketidakpastian komponen halajunya dalam arah y?]

A. It does not affect it. *[Keadaan ini tidak mempengaruhinya]*
B. It makes it infinite. *[Keadaan ini menjadikannya infinit]*
C. It makes it zero. *[Keadaan ini menjadikannya sifar]*
D. It makes it negative *[Keadaan ini menjadikannya negatif]*
E. Non of A, B, C, D *[Jawapan tiada dalam A, B, C, D]*

35. The Balmer series of hydrogen is important because it:
[Siri Balmer bagi hidrogen adalah penting kerana ia]

A. is the only one for which the Bohr theory can be used
[merupakan satu-satunya siri yang dapat diaplikasikan oleh teori Bohr]

B. is the only series which occurs for hydrogen
[merupakan satu-satunya siri yang berlaku dalam hidrogen]

C. is in the visible region
[berada dalam rantau nampak]

D. involves the lowest possible quantum number n
[melibatkan numbor kuantum yang terendah mungkin]

E. involves the highest possible quantum number n
[melibatkan numbor kuantum yang tertinggi mungkin]

36. The quantization of energy, $E = nhf$, is not important for an ordinary pendulum because:
[Pengkuantuman tenaga, $E = nhf$, adalah tidak penting bagi suatu bandul kerana]

A. the formula applies only to mass-spring oscillators
[formular hanya teraplikasikan ke atas pengayun jisim-spring]

B. the allowed energy levels are too closely spaced
[selang paras tenaga diizinkan adalah terlalu padat]

C. the allowed energy levels are too widely spaced
[selang paras tenaga diizinkan adalah terlalu lebar]

D. the formula applies only to atoms
[formular hanya teraplikasikan ke atas atom]

E. the value of *h* for a pendulum is too large
[nilai h bagi bandul terlalu besar]

37. A hydrogen atom is in its ground state. Incident on the atom are many photons each having an energy of 5 eV. The result is that
[Suatu atom hidrogen berada dalam keadaan buminya. Foton-foton bertenaga 5 eV setiap satu ditujukan pada atom itu. Hasilnya ialah]

A. the atom is excited to a higher allowed state
[atom teruja kepada keadaan dizinkan yang lebih tinggi]

B. the atom is ionized
[atom diionkan]

C. the photons pass by the atom without interaction
[foton merentasi atom tanpa berinteraksi]

D. the photons are ionised
[foton diionkan]

E. the atom is de-excited to a lower quantum state
[atom ternyah-uja kepada keadaan dizinkan yang lebih rendah]

38. A hydrogen atom makes a transition from the $n = 3$ level to the $n = 2$ level. It then makes a transition from the $n = 2$ level to the $n = 1$ level. Which transition results in emission of the longest-wavelength photon?
[Satu atom hidrogen melakukan peralihan dari paras n=3 ke paras n=2. Kemudiannya ia melakukan satu peralihan dari paras n=2 ke paras n=1. Peralihan yang manakan menghasilkan pancaran foton berjarak gelombang paling panjang?]

A. the first transition *[peralihan pertama]*
B. the second transition *[peralihan kedua]*

C. neither, because the wavelengths are the same for both transitions.
[bukan A ataupun B kerana jarak gelombang kedua-dua kes adalah sama]
D. one cannot determine the answer because data provided is not sufficient.
[jawapan tidak boleh ditentukan kerana data yang diberikan tak cukup]

E. Non of A, B, C, D *[Jawapan tiada dalam A, B, C, D]*

39. An electron and a proton are accelerated to a common relativistic energy (i.e. $E >> m_e c^2, m_p c^2$), where m_e and m_p denote the masses of the electron and proton respectively. Determine the ratio of the de Broglie wavelength of the electron to that of the proton.
[Satu elektron dan proton dipecutkan kepada satu tenaga kerelatifan E yang sama, (iaitu $E >> m_e c^2, m_p c^2$), di mana m_e dan m_p menandakan jisim elektron dan proton masing-masing. Tentukan nisbah jarak gelombang de Broglie elektron kepada proton.]

(A) $\frac{m_p}{m_e}$ (B) $\sqrt{\frac{m_p}{m_e}}$ (C) $\sqrt{\frac{m_e}{m_p}}$ (D) $\frac{m_p}{m_e}$ (E) 1

40. How is the empirical Ryberg constant, R_H, be related to the other constants of nature in the Bohr model of hydrogen atom?
[Bagaimanakah pemalar empirikal Ryberg R_H dikaitkan kepada pemalar-pemalar alam yang lain mengikut model Bohr atom hidrogen?]

A. $R_H = \frac{2\pi^2 m_e e^4}{h^2 c}\left(\frac{1}{4\pi\varepsilon_0}\right)^2$ **B.** $R_H = \frac{2\pi^2 m_e e^4}{h^3 c}\left(\frac{1}{4\pi\varepsilon_0}\right)^2$

C. $R_H = \frac{2\pi^2 m_e e^4}{h^3 c}\left(\frac{1}{4\pi\varepsilon_0}\right)$ **D.** $R_H = \frac{2\pi^2 m_e e^4}{h^3 c^3}\left(\frac{1}{4\pi\varepsilon_0}\right)^2$

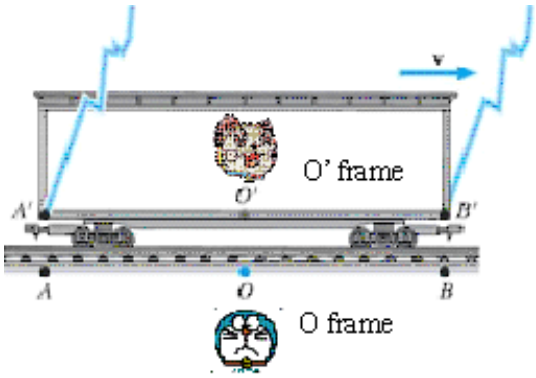
(E) Non of A, B, C, D *[Jawapan tiada dalam A, B, C, D]*

Part B: Structured Questions [60 marks]
Instruction: Answer both questions 1 and 2 in this Part.

[Bahagian B: Soalan Struktur. 60 markah]
[Arahan: Jawab kedua-dua soalan 1 dan 2 dalam Bahagian ini.]

1(a) Consider the Gedanken experiment of a moving train (the O' frame) passing by an observer called Doraemon on the ground (the O frame) with a speed of v, see figure below. The length of the train, as measured by Doraemon, is L. Another observer, Doraemiyan is seen by Doraemon to sit at the middle of the train, $L/2$, when Doraemiyan passes by Doraemon at time t=0. At that instance, two lightning bolts strike points A and B at the edges of the train such that both events appear to occur simultaneously according to Doraemon. What is the time lag between the lights from event A and event B arriving at Doraemiyan, $t_A - t_B$, as seen by Doraemon, where both t's are measured in Doraemon's frame. Express your answer in terms of v, L, and the speed of light c. [*Hint: Do you think you should apply time-dilation or length contraction formulae here?*]
[Pertimbangkan eksperimen Gedanken di mana satu tren (rangka O') bergerak melepasi seorang pemerhati Doraemon yang berada di atas bumi (rangka O) dengan laju v, rujuk gambarajah di bawah. Panjang tren sebagaimana yang diukur oleh Doeaemon ialah L. Seorang lagi pemerhati, Doraemiyan diperhatikan oleh Doraemon sebagai duduk di tengah-tengah tren, L/2, bila Doraemiyan bergerak melepasi Doraemon pada masa t =0. Pada ketika itu, dua petir menyambar titik-titik A dan B pada pinggir tren sedemikian rupa supaya kedua-dua peristiwa itu kelihatan berlaku secara serentak kepada Doraemon. Apakah masa susulan di antara cahaya dari peristiwa A dan peristiwa B yang sampai kepada Doraemiyan, $t_A - t_B$, mengikut Doraemon? Kedua-dua masa t_A, t_B adalah diukur dalam rangka Doraemon. Nyatakan jawapan anda dalam sebutan v, L dan laju cahaya c. [Hint: Adakah anda perlu mengaplikasikan formular-formular pendilatan-masa dan susutan panjang?]

[10 marks]



1(b) When a photoelectric surface is illuminated with light of wavelength 437 nm, the stopping potential is 1.67 V.
[Bila satu permukaan fotoelektrik disinari cahaya berjarak gelombang 437 nm, keupayaan penghenti ialah]

[5 + 5 marks]

(*i*) What is the work function of the metal in eV?
[Apakah fungsi kerja logam tersebut dalam unit eV?]

(*ii*) What is the maximum speed of the ejected electrons?
[Apakah laju maksimum elektron terlenting?]

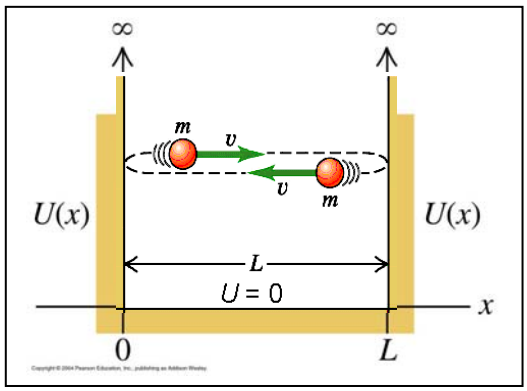
1(c) An electron has a speed of 0.95*c*. What is the the magnitude of its momentum? **[5 marks]**
[Suatu elektron berlaju 0.95c. Apakah magnitud momentumnya?]

1(d) A 29.0 pm photon is Compton scattered by a stationary electron. What is the maximum energy loss of the photon?
[Satu foton 29.0 pm diserak Compton oleh satu elektron pegun. Apakah kehilangan tenaga foton yang maksimum?]

[5 marks]

2(a) Consider a quantum particle trapped in an infinite quantum well (with width L) given by
[Pertimbangkan satu zarah kuantum yang terperangkap dalam satu telaga kuantum infinit (dengan lebar L) yang diberikan oleh]

$$U(x) = \begin{cases} \infty, & x \le 0, x \ge L \\ 0, & 0 < x < L \end{cases}$$



The behaviour of a particle inside the infinite well [i.e. the region where $U(x) = 0$ for $0 < x < L$] is governed by the 1-D time-independent Schrodinger equation $\frac{\partial^2\psi(x)}{\partial x^2} = -B^2\psi(x)$, where $B^2 = \frac{2mE}{\hbar^2}$. E is the energy of the particle.

[Kelakuan zarah dalam telaga infinit (iaitu dalam rantau $U(x) = 0$ for $0 < x < L$) diperintah oleh persamaan merdeka-masa Schrodinger 1-D $\frac{\partial^2\psi(x)}{\partial x^2} = -B^2\psi(x)$, di mana $B^2 = \frac{2mE}{\hbar^2}$. E ialah tenaga zarah.]

(*i*) Show that $\psi(x) = A\sin Bx + C\cos Bx$ is a solution to the Schrodinger equation for the particle inside the well, where *A, C* are some constants.
[Tunjukkan bahawa $\psi(x) = A\sin Bx + C\cos Bx$ merupakan penyelesaian kepada persamaan Schrodinger untuk zarah dalam telaga, di mana A dan C adalah pemalar.]

[5 marks]

(*ii*) Determine the values of *C* and *B* by applying boundary conditions that must be fulfilled by the Schrodinger equation governing the particle.
[Tentukan nilai-nilai C dan B dengan mengaplikasikan syarat-syarat sempadan yang mesti dipenuhi oleh persamaan Schrodinger yang memerintah zarah itu.]

[4 + 6 marks]

(*iii*) Hence show that the energy of the particle in the infinite well is quantized.
[Seterusnya tunjukkan bahawa tenaga zarah dalam telaga infinit adalah terkuantumkan]

[5 marks]

2(b) What is the kinetic energy of an electron at the ground state of the hydrogen atom, given that the ground state energy of the hydrogen atom is -13.6 eV? Give your answer in unit of eV.
[Apakah tenaga kinetik elektron pada keadaan bumi atom hidrogen? Diberitahu tenaga bumi atom hidrogen ialah -13.6 eV. Berikan jawapan anda dalam unit eV.]

[10 marks]