
UNIVERSITI SAINS MALAYSIA

KSCP Semester Examination
Academic Session 2007/2008

June 2008

ZCT 205/3 – Quantum Mechanics
[Mekanik Kuantum]

Duration: 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains **FIVE** printed pages before you begin the examination.

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

Instruction: Answer **ALL SIX (6)** questions. Students are allowed to answer all questions in Bahasa Malaysia or in English.

Arahan: *Jawab **SEMUA ENAM (6)** yang diberikan. Pelajar dibenarkan menjawab semua soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.*

1. (a) Explain in details the photo-electric effect. Explain clearly how quantum concepts are able to explain the experimental results of the photo-electric effect.
[Perihalkan secara terperinci kesan fotoelektrik. Terangkan secara jelas bagaimana konsep-konsep kuantum dapat menjelaskan keputusan-keputusan eksperimen kesan fotoelektri.]
 (60/100)
- (b) Give three other experiments which demonstrate the failure of Classical Physics that required Quantum Mechanics to explain the experimental results. Explain briefly on each case.
[Berikan tiga lain eksperimen yang menunjukkan kegagalan konsep Fizik Klasik yang memerlukan Mekanik Kuantum untuk menjelaskan keputusan-keputusan eksperimen. Terangkan secara ringkas tentang setiap kes.]
 (40/60)
2. (a) State the postulates of Quantum Mechanics.
[Nyatakan postulat-postulat Mekanik Kuantum]
 (35/100)
- (b) Derive the time-dependent 1-D Schrodinger Equation by assuming that the wave function of a free entity travelling along the positive x-axis is given by $\varphi = Ae^{-i(\omega t - kx)}$.
[Terbitkan Persamaan Schrodinger 1-D bersandar masa dengan menganggapkan bahawa fungsi gelombang bagi suatu entiti bebas yang bergerak ke paksi-x positif diberikan dengan $\varphi = Ae^{-i(\omega t - kx)}$.]
 (50/100)
- (c) Derive further the time-independent Schrodinger Equation.
[Terbitkan seterusnya Persamaan Schrodinger tak-bersandar masa.]
 (15/100)
3. (a) State precisely the Heissenberg Uncertainly Principle.
[Nyatakan dengan tepat Prinsip Ketakpastian Heissenberg.]
 (25/100)

- (b) Prove that the eigenvalues of a Hermitian operator are real.
[Buktikan bahwa nilai-eigen-nilai-eigen sesuatu operator Hermitian semestinya hakiki.]
 (25/100)
- (c) Starting from the Principle of conservation of probabilities and using the Continuous Theorem, $-\nabla\vec{J} = \frac{\partial\rho}{\partial t}$, derive the expression in 1-D for the probability density current, S . What is this expression, \vec{S} , in 3-D?
[Degaan menggunakan Prinsip Keabadian Kebarangkalian dan merujuk kepada Persamaan Keselantaran, $-\nabla\vec{J} = \frac{\partial\rho}{\partial t}$, terbitkan bentuk arus ketumpatan kebarangkalian, S , di dalam 1-D. Apakah bentuk \vec{S} di dalam 3-D?]
 (50/100)
4. (a) Describe in details the meanings of 'Pure State' and 'Mixed State' in Quantum Mechanics.
[Terangkan secara terperinci erti-erti 'Keadaan Tulin' dan 'Keadaan Campuran'.]
 (40/100)
- (b) The quantum state of a system is given by the expression.
[Keadaan kuantum bagi suatu sistem diberikan dengan ungkapan.]

$$\phi = 3\phi_1 + 2\phi_2 + \phi_3$$

where *[dimana]*

$$\hat{H}\phi_1 = \hbar\omega\phi_1$$

$$\hat{H}\phi_2 = 3\hbar\omega\phi_2$$

$$\hat{H}\phi_3 = 2\hbar\omega\phi_3$$

\hat{H} is the Hamiltonian (total energy) operator

[\hat{H} adalah operator Hamiltonian atau jumlah tenaga]

- (i) If measurement of total energy is made on the system, what is the probability of obtaining each eigenvalue?

[Jikalau ukuran jumlah tenaga dilakukan ke atas sistem itu, berapakah keberangkalian untuk mendapat setiap nilai eigen?]

(30/30)

- (ii) Calculate the expectation value of the total energy of the system.

[Hitungkan nilai jangkaan jumlah tenaga sistem itu.]

(30/30)

5. An entity is trapped inside a 2-D well given by –

[Suatu entiti terkurung di dalam suatu kotak 2-D seperti berikut :-]

$$V = 0 \quad 0 \leq x \leq a$$

$$V = 0 \quad 0 \leq y \leq b$$

$V = \infty$ in other region *[di kawasan lain]*

- (a) Obtain the wavefunction and energy of the entity

[Dapatkan fungsi-gelombang dan tenaga entiti itu.]

(70/100)

- (b) Draw the energy-level diagram up to the sixth excited level. How much energy is needed to excite the entity from ground state to the 4th excited state?

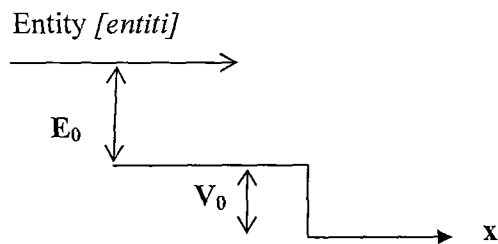
[Tuliskan rajah tenaga sampai ke paras tenaga teruja ke-enam. Berapakah tenaga yang diperlukan untuk menerujakan entiti dari paras dasar ke paras teraju ke-empat?]

Is there any degeneracy in this system?

[Adakah terdapat kedegeneratan bagi sistem itu?]

(30/100)

6.



An entity is travelling in the positive x -direction as shown in the diagram above.

[Suatu entiti bergerak ke arah positif- x seperti yang ditunjukkan di gambarajah diatas.]

- (a) Obtain the reflection coefficient, R , and the transmission coefficient, T . Discuss these results with those from the Classical Physics.
 [Dapatkan pekali pembalikan, R , dan pekali penghantaran, T . Bincangkan keputusan-keputusan yang terdapat dengan yang daripada Fizik Klasik.]
 (60/100)

- (b) Explain in details the phenomenon of Tunnelling Effect. Give two examples whereby Tunnelling Effect is observed.
 [Terangkan kesan penerowongan secara teliti dan berikan dua contoh kesan penerowongan.]
 (40/100)