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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(TAKE HOME)
SEMESTER I
SESSION 2020/2021

COURSE NAME	:	STATISTICAL PHYSICS
COURSE CODE	:	BWC 30103
PROGRAMME CODE	:	BWC
EXAMINATION DATE	:	JANUARY/FEBRUARY 2021
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS **OPEN BOOK EXAMINATION**

THIS QUESTION PAPER CONSISTS OF **FOUR (4)** PAGES

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Q1 (a) A particle absorbs a boson *M* and causing it undergoes a nuclear transmutation which raises or lowers the electrical charge of the particle and in the same time, the particle changes its flavour. State what is particle *M*, its fundamental interaction, list of particles involved and the mathematical model to describe the interaction.

(4 marks)

(b) State **FOUR (4)** differences between quarks and its superpartners.

(4 marks)

(c) In theory of quantum chromodynamics, quarks come in three colours. Justify the statement that "all baryons are colourless or white".

(4 marks)

(d) Your roommates major in chemistry. They know all about protons, neutrons, and electrons, and they see them in action every day in the laboratory. However, they may be in doubt when you tell them about positrons, quarks, muons, and neutrinos. Explain to them why none of these particles play any direct role in chemistry.

(8 marks)

Q2 (a) The boson *B* suffers a mathematical problem in general relativity. The explanation of this particle in the quantum field theory is not complete and the Standard Model works without explaining it. State what is particle *B*, its fundamental interaction, list of particles involved and the mathematical model to describe the interaction.

(4 marks)

(b) (i) Define symmetry.

(1 mark)

(ii) State what is T-symmetry.

(1 mark)

(iii) Describe how T-symmetry is violated.

(2 marks)

(c) List the first and second generations of particles.

(2 marks)

(d) State the meaning of the third and fourth lines in the Lagrangian of the Standard Model.

(2 marks)

(e) (i) State the purposes of the particle accelerators and the general concept used in the acceleration of particles.

(3 marks)

(ii) Describe what is linear accelerator and outline the important role of the radio frequency oscillator as the booster for particles to accelerate.

(2 marks)

(ii) Discuss why the chamber of the linear accelerators are in vacuum.

(3 marks)

Q3 (a) For a certain molecule, the first excited state lies at 0.2 eV above the ground state.

(i) At what temperature would the number of molecules in the ground state be exactly 10 times the number in the first excited state?

(4 marks)

(ii) What is the excitation temperature for this molecule?

(4 marks)

(b) For a nitrogen (N_2) molecule at room temperature ($m = 4.7 \times 10^{-26}$ kg, $T = 295$ K), what is its

(i) average velocity,

(3 marks)

(ii) average speed,

(3 marks)

(iii) root mean square speed,

(3 marks)

(iv) most probable speed.

(3 marks)

Q4 (a) Sketch the energy distribution function at two different temperatures for a system of free particles that is governed by Fermi-Dirac statistics. Indicate which curve corresponds to the higher temperature. Explain the graph briefly.

(8 marks)

(b) Calculate the average energy per particle, ε, for a Fermi gas at $T = 0$, given that ε_F is the Fermi energy.

(6 marks)

(c) In a white dwarf star of one solar mass the atoms are all ionized and contained in a sphere of radius 2 x 10^9cm. Find the Fermi energy of the electron in eV.

(6 marks)

Q5 (a) For a certain boson system, the density of states is constant ($g(\varepsilon) = C$), and the occupation numbers of all states are sufficiently small that we can write $n \approx e^{-\beta(\varepsilon-\mu)}$. Show that the chemical potential, μ, depends on the temperature and the total number of particles in the system according to $\mu = -kT\ln(CkT/N)$.

(8 marks)

(b) In the case of bosons, the low-lying states have larger occupation numbers than the classical prediction, so that the total internal energy of a boson system is correspondingly low. Clarify this statement.

(12 marks)

END OF QUESTIONS –