Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	RADIATION DETECTION AND MEASUREMENT
COURSE CODE	:	BWC 33303
PROGRAMME CODE	:	BWC
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER **ALL** QUESTIONS 2.THIS FINAL EXAM IS CONDUCTED VIA ☐ Open book ☒ Closed book 3. STUDENTS ARE PROHIBITED TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

Q1 (a) Describe the sources of ionising radiation used in laboratory.

(5 marks)

(b) Differentiate the interaction between heavy charge particles and fast electrons when they are impinged into matter.

(4 marks)

(c) A 10-minute count of a radioactive source and background gives a total of 846 counts. The background alone counted for 10 minutes gives a total of 73 counts. Determine the net counting rate due to the source alone, and its associated standard deviation.

(6 marks)

(d) Explain the following terms:

(i) Photoelectric absorption

(ii) Compton scattering

(iii) Pair production

(6 marks)

(e) Charged particles that are impinged onto an absorber material would undergo a series of interactions with the material to transfer its energy. Determine the number of alpha particles with energy 5 MeV required to deposit a total energy of 1 Joule [J]. 1 MeV of energy is equivalent to 160 femto Joule [fJ].

(4 marks)

Q2 (a) Explain the following terms:

(i) Radiation exposure

(ii) Absorbed dose

(iii) Effective dose

(iv) Equivalent dose

(8 marks)

(b) **Table Q2.1** shows the value of energy dissipation per ion pair (the *W*-value) for different gases.

Table Q2.1

Value of energy dissipation per ion pair (the *W*-Value) for different gases		
	W-value in eV/ion pair	
Gas	Fast electrons	Alphas
A	27.0	25.9
He	32.5	31.7
H_2	38.0	37.0
N_2	35.8	36.0
Air	35.0	35.2
O_2	32.2	32.2
CH_4	30.2	29.0

(i) Differentiate the *W*-value for electrons and for alpha particles.

(2 marks)

(ii) Choose a gas that is most suitable for measuring low energy ionizing radiation.

(2 marks)

(iii) Estimate the number of ion pairs created by an incident of 5.5 MeV alpha particle when it is fully stopped within helium gas.

(2 marks)

(iv) Determine the corresponding saturated current if 300 alpha particles per second enter a helium-filled ion chamber (given the elementary charge = 1.602×10^{-19} C).

(3 marks)

(c) In considering a gas-filled detector, charged species produced due to ionisation will interact with each other as well as with the neutral gas atoms or molecules. Explain the diffusion, charge transfer, electron attachment and recombination process involved.

(8 marks)

Q3 (a) **Figure Q3.1** shows different operation regions labelled A, B, C, D and E of a gas-filled detector. The observed pulses amplitude are plotted versus the applied voltage to create the electric field, for two events depositing two different amounts of energy of 1 MeV and 2 MeV within the gas inside the detector.

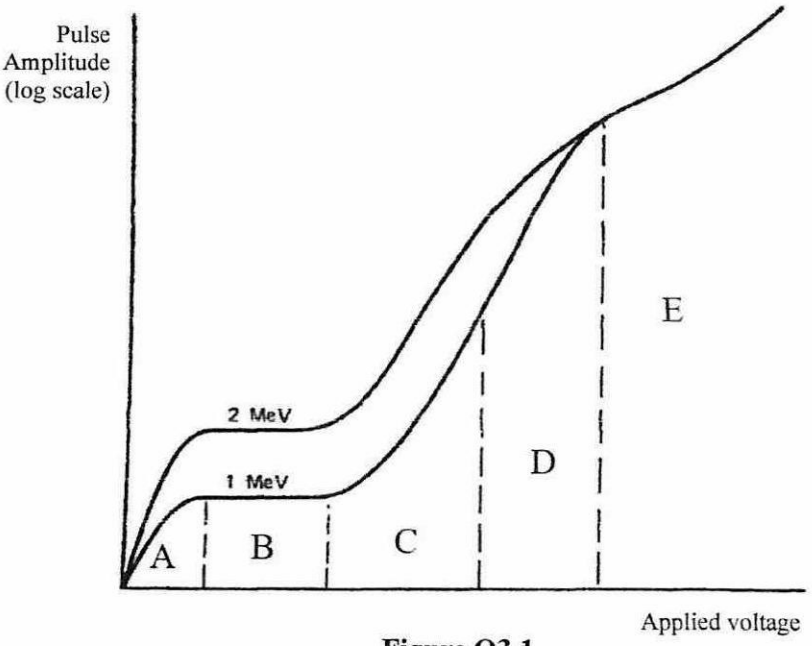

Figure Q3.1

(i) Name the regions B, C and E.

(3 marks)

(ii) Predict what would happen to the formed ion pairs if the applied voltage is very low (region A).

(3 marks)

(iii) Differentiate the region of C and E regarding to their gas multiplication and charge collection process.

(5 marks)

(b) A scintillation detector comprises of scintillation material, photocathode and dynode as the basic structures. Draw a simplified diagram of the detector and explain the function of each of these structures.

(6 marks)

(c) **Figure Q3.2** shows a spectrum of a homogenueous radionuclide, obtained using a NaI(Tl) scintilaltion detector. Determine the photopeaks energy and the name of the radionuclide.

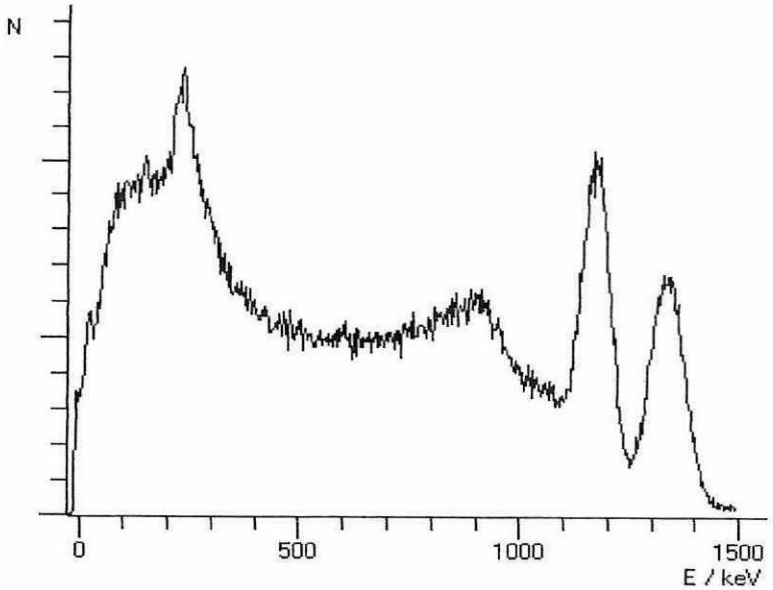

Figure Q3.2

(4 marks)

(d) Monoenergetic 450 keV gamma ray is absorbed in a NaI(Tl) crystal with efficiency of 11%. If the output scintillation photon having an average energy of 2.6 eV reached the cathode of a photomultiplier (PM) tube, calculate the average number of scintillation photons produced per absorb gamma photon.

(4 marks)

Q4 (a) Differentiate the donor level and acceptor level created in energy band gap in semiconductor material due to the effect of dopant. Provide appropriate sketches to support your points.

(5 marks)

(b) Boron based detector, Lithium based detector and Helium based detector are the types of practically used neutron detector. Explain the basic working principle of these detectors.

(6 marks)

(c) Briefly describe the application of the portable handheld type radiation detector and the laboratory-based high energy resolution detector.

(4 marks)

(d) Differentiate the charge collection process in solid-state detector and in gas-filled detector.

(4 marks)

(d) Briefly explain the ideal situation to use a radiation survey meter that displays:

(i) CPM

(ii) mR/h

(iii) mSv/h

(6 marks)

– END OF QUESTIONS –