TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MEDICAL ENGINEERING

UNIVERSITY EXAMINATION FOR:

BACHELOR OF SCIENCE IN MEDICAL ENGINEERING

TMD 4101: MEDICAL PHYSICS

SPECIAL SUPPLEMENTARY EXAMINATION

SERIES: AUGUST2016

TIME: 2HOURS

DATE: 19Sep2017

Instructions to Candidates

You should have the following for this examination
-Answer Booklet, examination pass and student ID
This paper consists of **FIVE** questions.
Attemptquestion ONE (Compulsory) and any other TWO questions.
Do not write on the question paper.

Question ONE (COMPULSORY)

a) Explain the following :

   a) Annihilation quantum
   b) Internal conversion
   c) Auger electron (8 Marks)

b) Figure Q1 shows the planetary model of a nitrogen atom.

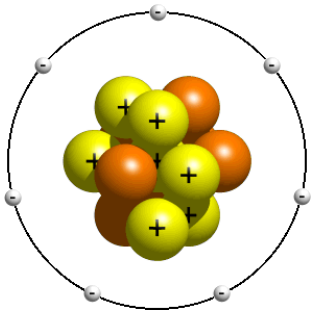


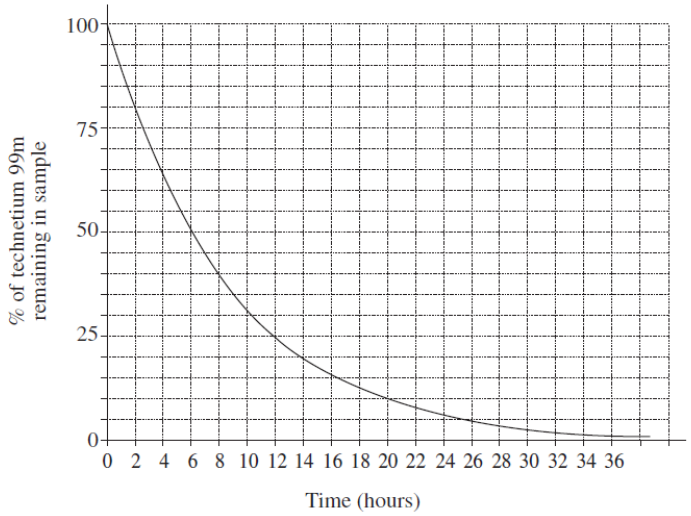
Fig. Q1

i). Describe two things about the model that fit accurately with the modern understanding of an atom.

ii). Describe one aspect of the model that does not accurately portray the modern understanding of an atom. How would you change this feature to make it reflect the modern understanding of an atom? Sketch a picture to describe your change. (8 Marks)

c) Technetium 99m is an artificial isotope which is frequently used to obtain a scan of the human body.

i). Using the graph, determine the half-life of technetium 99m.



ii). A patient is given an injection containing 6.0×10^{-18} kg of technetium 99m. The scan is taken four hours after the injection. How much technetium 99m remains undecayed when the scan is taken? (Give your answer in kilograms.) (5 marks)

d) With the aid of a well labelled diagram, describe the Rutherford Gold foil experiment. (9 marks)

Question TWO

a) State two factors that determine the value of the acoustic impedance. (2 Marks)

b) An ultrasound investigation was used to identify a small volume of substance in a patient. It is suspected that this substance is either blood or muscle. During the ultrasound investigation, an ultrasound pulse of frequency of 3.5×10^6 Hz passed through soft tissue and then into the small volume of unidentified substance. A pulse of ultrasound reflected from the front surface of the volume was detected 26.5 μs later. The ratio of the reflected intensity to the incident intensity, for the ultrasound pulse reflected at this boundary was found to be 4.42×10^{-4}. The table below shows data for the acoustic impedances of various materials found in a human body.

medium	acoustic impedance Z/ kg m^{-2} s^{-1}
air	4.29×10^2
blood	1.59×10^6
water	1.50×10^6

brain tissue	1.58×10^6
soft tissue	1.63×10^6
bone	7.78×10^6
muscle	1.70×10^6

i). Use appropriate data from the table above to identify the unknown medium. You must show your reasoning.

ii). Calculate the depth at which the ultrasound pulse was reflected if the speed of ultrasound in soft tissue is 1.54 km s^{-1}.

iii). Calculate the wavelength of the ultrasound in the soft tissue. (10 Marks)

c) Describe the principles of the production of a short pulse of ultrasound using a piezoelectric transducer. (8 Marks)

Question THREE

(a) Explain what is meant by the term, "half-life of a radioactive nuclide". (1 mark)

(b) Enumerate FIVE stages in the use of radioisotopes which define their use in clinical diagnosis. (5 marks)

(c) Describe an example of use of a radioisotope for clinical diagnosis. (5 marks)

(d) A Geiger counter is an instrument used to detect radiation. A Geiger counter detects 40 counts per second from a sample of iodine-131. The half-life of iodine-131 is 8 days.

i). Using the graph paper provided, sketch a graph showing the count rate from the sample of iodine-131 over a period of 24 days.

ii). From the graph, deduce the activity of the sample of iodine-131 over a period of 20 days. (9 marks).

Question FOUR

Write short notes on each of the following:

a) the Photoelectric effect

b) Compton effect

c) Beta decay

d) Electron capture (20 marks)

Question FIVE

a) The figure Q5 below shows a simplified X-ray tube

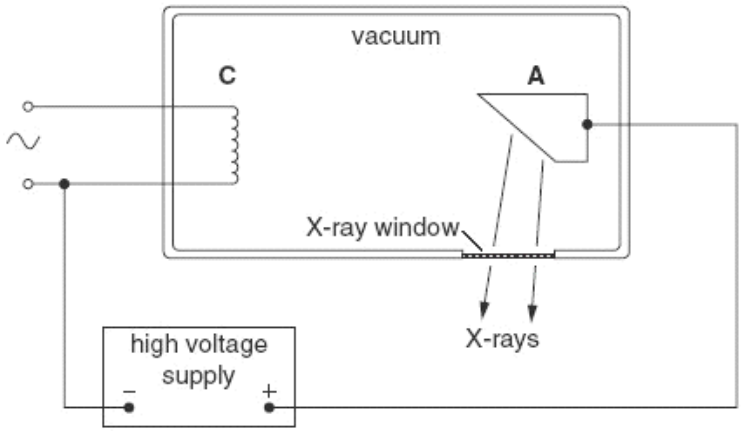


Figure Q5

Explain briefly, with reference to the parts labelled C and A,

i). how X-rays are generated

ii). the energy conversions that occur. (6 marks)

b) In order to take an X-ray photograph, the X-ray beam is passed through an Aluminium filter to safely remove low energy X-ray photons before reaching the patient. Suggest why it is necessary to remove these low energy X-rays. (1 mark)

c) The average linear attenuation coefficient for X-rays that penetrate the Aluminium is 250 m^{-1}. The intensity of an X-ray beam after travelling through 2.5 cm of Aluminium is 347 W m^{-2}. Show that the intensity incident on the Aluminium is about 2×10^5 W m^{-2}. (3 marks)

d) The X-ray beam at the filter has a circular cross-section of diameter 0.20 cm. Calculate the power of the X-ray beam from the Aluminium filter. Assume that the beam penetrates the Aluminium filter as a parallel beam. (2 marks)

e) Table Q5 shows data for the intensity of a parallel beam of X-rays after penetration through varying thicknesses of a material.

Table Q5

intensity / MW m^{-2}	thickness / mm
0.91	0.40
0.69	0.80
0.52	1.20
0.40	1.60
0.30	2.00
0.23	2.40
0.17	2.80

i). Plot a graph of transmitted X-ray intensity against thickness of absorber.

ii). Find the thickness that reduces the intensity of the incident beam by one half.

iii). Use your answer to (e)(ii) to calculate the linear attenuation coefficient μ. Give the unit for your answer (8 marks)