RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
Third Year - Semester II Examination – October/November 2017

PHY 3212 – MEDICAL PHYSICS II

Time: Two (02) hour

Answer All Questions

Plank constant (h) $= 4.14 \times 10^{-15}$ eV s
Speed of light in vacuum (c) $= 3 \times 10^{8}$ m s^{-1}
Speed of sound in soft tissue = 1540 m s^{-1}

Part I *(20 marks for each question)*

1. (i) Draw a labelled diagram of an X-ray tube.

(ii) Indicate the functions of the major components of above tube.

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(iii) What factor determines
(a) the rate of emission of X-ray photons?.....

(b) the energy of X-ray photons? .....

(iv) What is the supply voltage required to produce X-rays of maximum energy of 120 keV?

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(v) How are characteristic X-rays produced?

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(vi) An X-ray photon of wavelength 2.2 Å collides with an electron in the *K* shell of a *Ca* atom and gives all its energy to it, the electron is ejected with a kinetic energy of 3.75 keV. Calculate
(a) the minimum energy required to remove an electron from the *K* shell of a *Ca* atom,

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(b) the threshold wavelength of incident X-rays to remove an electron from the *K* shell of a *Ca* atom.

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(vii) Why pair production interaction is **not** predominant with diagnostic X rays?

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2. Give short answers for the followings.

(i) What is meant by *isomeric transition* in radioactivity?

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(ii) What is a *Positronium*?

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(iii) During a PET scan how does the instrument identify that the two photons came from the same positron annihilation?

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(iv) Give one basic **similarity** and one basic **difference** between CT imaging and PET imaging.

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(v) What is radiopharmaceutical?

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(vi) How is Technetium-99m produced for imaging purpose?

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(vii) Incorporating a new PET scanner into the diagnostic stream of a hospital is not that easy task. Give two reasons for this difficulty.

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Part II *(30 marks for each question)*

3. (i) What are the functions of a transducer used in ultrasound diagnostic technique?

(ii) Selection of pulse repetition rate in ultrasound pulse-echo technique is very important for better imaging. If a pulse rate of 1 kHz is selected, show by calculation whether this rate is sufficient for imaging an average adult.

(iii) Draw a block diagram of a simple apparatus that uses Doppler shift of ultrasound to examine blood flow.

(iv) What is the Doppler frequency-shift of ultrasound reflected from the blood flowing at 0.85 ms^{-1}? The frequency of the ultrasound is 4 MHz and the blood is flowing at an angle of 40° to the direction of the ultrasound. Assume the speed of sound to be 1540 ms^{-1}.

(v) Cardiologist uses an ultrasound scanner with an operating frequency of 3.5 MHz that can detect Doppler frequency shifts as small as 0.1 kHz. What is the smallest flow velocity detectable with this device?

(vi) Calculate the remaining intensity of a 100 mW ultrasound pulse that loses 30 dB while travelling through tissue.

4. (i) Distinguish among physical, biological and effective half lives, and state the relationship among them.

(ii) Explain what will be the effective half-life when

(a) the biological half-life is much higher than physical half-life,

(b) the physical half-life is much higher than biological half-life.

(iii) A worker is preparing a radiopharmaceutical containing a radioactive isotope of iodine to be used in a procedure requiring a source activity of 2.0 MBq. If the procedure will be performed approximately after 2 days, what source activity should initially be prepared if the isotope is

(a) iodine-123 with a half life of 13 hours,

(b) iodine-131 with a half life of 8.05 days?

(iv) Iodine-131 is cleared biologically with a half-life of 130 days. For treating thyroid disease, a Medical Physicist has to compute how long the body should be exposed to radiation. What value of half-life does he use in this calculation?

(v) The effective half-life for strontium-90 in the bones is roughly 17 years. Can the physical half-life of strontium be greater than 17 years? Explain your answer.

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