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RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree in Applied Sciences
Third Year – Semester I Examination – October/ November 2015

PHY 3211 –MEDICAL PHYSICS I

Answer **all** questions Time allowed: **2 hour**

Instructions: **Index No:** .....

1. Answers should be written in the **space given**.
2. Only the calculators provided by the university are allowed to be used.

Values of constants

speed of light in a vacuum	$c = 3.00 \times 10^{8}\ \mathrm{ms}^{-1}$
electron charge	$e = 1.60 \times 10^{-19}\ \mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$
mass of electron	$\mathrm{m}_e = 9.11 \times 10^{-31}\ \mathrm{kg}$
mass of proton	$\mathrm{m}_p = 1.67 \times 10^{-27}\ \mathrm{kg}$
acceleration of free fall on the Earth's surface	$g = 9.81\ \mathrm{m\,s}^{-1}$
electron volt	$1\ \mathrm{eV} = 1.60 \times 10^{-19}\ \mathrm{J}$
Rydberg constant	$R_H = 1.097 \times 10^{7}\ \mathrm{m}^{-1}$
Atomic mass unit	$1\ \mathrm{u} = 931.6\ \mathrm{MeV}$
Angstrom	$1\text{Å} = 1 \times 10^{-10}\ \mathrm{m}$

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1. (a) Isotopes of a given element have different properties, such as mass, but the same chemical properties. Explain the reasons? [2 marks]

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Index No: .....

(b) Why do heavier elements require more neutrons in order to maintain stability? [3 marks]

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(c) Various processes can cause electrons to eject from an electron shell. Briefly explain 3 of these processes. [6 marks]

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(d) The *K, L* and *M* energy levels for Cu, Ni, and Co are given in the following Table. It is desired to filter the K_β line from the K_α and K_β radiation emitted from Cu. Which will be the better filter, Ni or Co? [4 marks]

Element	Z	E_K, keV	E_L, keV	E_M, keV
Cu	29	-8.979	-0.931	-0.074
Ni	28	-8.333	-0.855	-0.068
Co	27	-7.709	-0.779	-0.060

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Index No: .....

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2. (a) Explain the difference between ***fission*** and ***fusion*** reactions and why each process produces energy. [3 marks]

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(b) What is ***mass defect***? What is the relationship between mass defect and binding energy? [3 marks]

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Index No: .....

(c) Rutherford identified 3 types of radiation using electric field. Briefly explain these 3 types using examples. **[5 marks]**

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(d) A pair of nuclei for which $Z_1 = N_2$ and $Z_2 = N_1$ are called *mirror isobars* (The atomic and neutron numbers are interchangeable). Binding energy measurements on such pairs can be used to obtain evidence of the charge independence means that the proton-proton, proton-neutron and neutron-neutron forces are approximately equal. Calculate the difference in binding energy for the two mirror nuclei ${}^{15}_{8}\mathrm{O}$ and ${}^{15}_{7}\mathrm{N}$. (Mass of ${}^{1}_{0}\mathrm{n} = 1.00867\ \mathrm{u}, 1\mathrm{u} = 1.66\times10^{-27}\mathrm{kg}$).

[4 marks]

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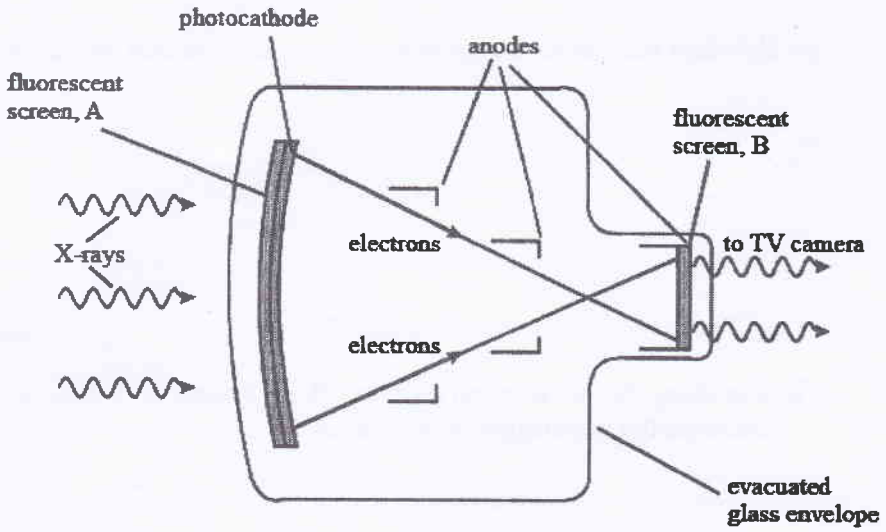
Index No: .....

3. (a) The diagram shows a fluoroscopic image intensifier.



Explain the purpose of:

(i) the fluorescent screen, *A* [2 marks]

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(ii) the photocathode [2 marks]

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(iii) the anodes [2 marks]

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(iv) the fluorescent screen, *B* [2 marks]

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Index No: .....

(b) In an x-ray tube, electrons are accelerated from rest through a potential difference of 74.2 kV before they hit the target anode.

(i) Calculate the kinetic energy of an electron as it reaches the anode. [2 marks]

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(ii) Assuming that the electron gives up all this energy to form an x-ray photon, calculate the wavelength of the photon. [2 marks]

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(c) X-rays are used in a CT scanner. Describe briefly how a CT scanner produces an image. [3 marks]

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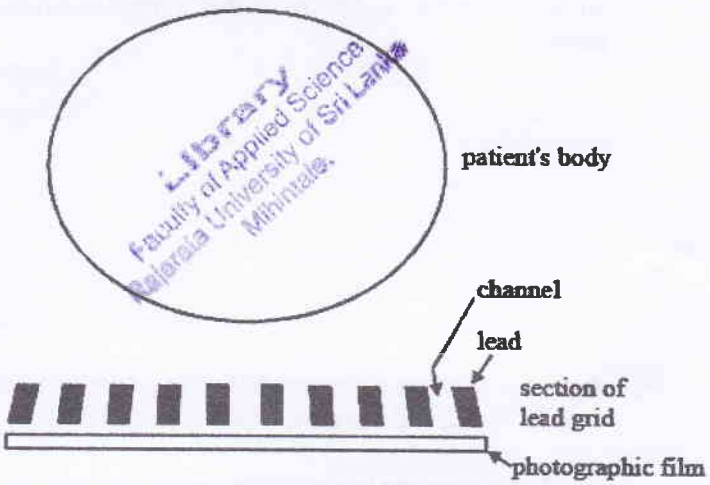
Index No: .....

4. (a) When using an x-ray source to produce an image of part of a patient, a lead grid is sometimes placed between the patient and the photographic film, as shown in the diagram. The channels in the grid diverge from the x-ray source.



(i) Why is the grid made of lead? [2 marks]

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(ii) By drawing the paths of about 10 rays from the x-ray source to illustrate your answer, explain how the use of the grid improves the clarity of the x-ray image. [3 marks]

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Index No: .....

(iii) Explain why is it important to use a *point source* of x-rays for imaging purposes. [2 marks]

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(b) (i) Two different types of radiation have the same radiation biological effectiveness (RBE). Does this mean that each type delivers the same amount of energy to the tissue that it irradiates (exposed to)? Justify your answer. [2 marks]

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(ii) A person receives a single whole-body dose of α particles. The absorbed dose is 38rad, and the RBE of the α particles is 12.

(I) Determine the biologically equivalent dose received by this person. [2 marks]

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(II) With this dose, which one of the following would you expect to happen: no short-term ill effects, the onset of radiation sickness, a 50% chance of dying, or almost certain death? [1 mark]

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Index No: .....

(iii) A 2.0 kg tumor is being irradiated by a radioactive source. The tumor received an absorbed dose of 12 Gy in a time of 850 s. Each disintegration of the radioactive source produces a particle that enters the tumor and delivers energy of 0.40 MeV. What is the **activity** $\Delta N/\Delta t$ of the radioactive source?

[3 marks]

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