00187

The Open University of Sri Lanka
Department of Physics
BSc Degree Programme – Level 5
Final Examination - 2019/2020

Course Code:	**PHU5300 / PYU3160 / PYE5160**
Course Title:	**Nuclear and Particle Physics**
Date:	**1st February 2021**
Time:	**01:30 pm to 03:30 pm**
Duration:	**2 Hours**

GENERAL INSTRUCTIONS TO CANDIDATES

- Read all instructions carefully before answering the questions.
- Unless specified, standard symbols have their usual meanings.
- This question paper consists of **06 Essay type questions** in 03 pages.
- Answer **only ANY FOUR (04)** questions.
- Non-programmable calculators are allowed.
- Write your answers in the answer book / single sheets provided at the examination hall. Question / section numbers should be written against relevant answers.
- Write your **Index Number** in the spaces provided in the answer book / single sheets. Also write all other details requested in the answer book.
- Having any form of unauthorized documents / mobile phones in your possession is a punishable offense.

(01) (a) Explain the similarities between a 'liquid drop' and an 'atomic nucleus'.

(b) Based on semi-empirical mass formula, binding energy of a nucleus can be expressed as:

$$E_B(A,Z) = a_V A - a_S A^{2/3} - a_c \frac{Z(Z-1)}{A^{1/3}} - a_{asy} \frac{(A-2Z)^2}{A} \pm \delta(A,Z)$$

Identify each and every term in the above formula.

(c) Describe the contribution of the following terms in the above formula,

i. Surface energy term
ii. Volume energy term
iii. Asymmetric energy term

(02) (a) Using Heisenberg's uncertainty principle, justify that existence of electrons inside a nucleus is impossible?

(b) Calculate the minimum kinetic energy required for an electron to stay inside the nucleus of an atom with mass number $A = 112$. (The radius, r, of the nucleus is given by the empirical radius formula, $r = r_0 A^{1/3}$ and $r_0 \approx 1.25$ fm.)

(c) What are (i) mirror nuclei and (ii) isotopes? Briefly describe their properties.

(03) (a) State the conservation laws applicable to nuclear reaction and briefly describe them.

(b) When a nucleus of mass M_x is bombarded with a particle of mass m_x, the product particle of mass m_y is ejected at an angle of 90° with the direction of bombarding particle.

Show that the Q-value can be expressed as,

$$Q = K_y\left(1 + \frac{m_y}{M_y}\right) - K_x\left(1 - \frac{m_x}{M_x}\right)$$

where, M_y is mass of the product nucleus, K_x is kinetic energy of the nucleus and K_y is kinetic energy of the product nucleus.

(04) (a) Briefly discuss the following processes with suitable examples.

(i) nuclear fission, and

(ii) nuclear fusion

(b) A nuclear power plant is generating power at the rate of 2 GW.

(i) How many U^{235} atoms undergo fission per second?

(ii) How many kilograms of U^{235} would be required to operate the power plant for one year?

(Consider: 1 MeV = 1.602×10^{-13} J and on an average 200 MeV energy is released per fission. Avogadro's number is 6.022×10^{23} mol^{-1}).

(05) (a) What are the three generations of leptons in standard model? Briefly describe each of them.

(b) What are the three generations of quarks in standard model? Briefly describe each of them.

(c) Compare and contrast **weak interactions** and **strong interactions** of quarks.

(06) (a) Explain the principle and working of a Betatron, with the help of suitable sketches.

(b) Derive the following *Betatron condition* for a stable orbit of constant radius r in a magnetic induction B caused by the magnetic flux ϕ.

$$\emptyset = 2\pi r^2 B$$

(c) Discuss the different functions of the time varying magnetic field in the Betatron.

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