00150

The Open University of Sri Lanka
BSc Degree Programme – Level 5
Final Examination - 2025/2026
Nuclear and Particle Physics – PHU5300

Date: 09th May 2025 Time: 02.00 pm – 04.00 pm

Useful Physical Constants / Conversions

1 amu	=	931.5 MeV/c^2	Mass of $^{14}_{7}N$	=	14.003074 amu
Mass of $^{1}_{1}H^{+}$	=	1.007277 amu	Mass of $^{17}_{8}O$	=	16.999132 amu
Mass of $^{4}_{2}He^{++}$	=	4.001506 amu			

Note: Standard symbols have their usual meanings.

Answer Any Four (04) Questions Only

(01) (a) Briefly explain the 'liquid drop' model of the atomic nucleus.

(b) State **five** key assumptions made in developing the liquid drop model of the nucleus.

(c) Describe the **successes** and **limitations** of the liquid drop model of the nucleus.

(d) Briefly describe the Semiempirical Mass Formula.

(02) (a) Define the terms "half-life" and "mean-life" of a radioactive substance

(b) Derive an expression for half-life ($T_{1/2}$) of a radioactive element.

(c) Establish the relationship between the "half-life" and "mean-life".

(d) The activity of a radioisotope is found to decrease to one-eighth ($^{1}/_{8}$) of the initial activity in 36 hours. Calculate the following:

(i) Half-life

(ii) Disintegration constant

(03) (a) State two major differences between a chemical reaction and a nuclear reaction.

(b) The nuclear reaction between an alpha particle and a stationery nitrogen ($^{14}_{7}N$) atom results in the transmutation of nitrogen into an oxygen isotope ($^{17}_{8}O$), with the emission of a proton.

(i) Write the equation for the above nuclear reaction (use standard symbols).

(ii) Compute the **minimum** kinetic energy of the alpha particle for the above reaction to happen (state your answer in MeV).

(iii) State assumptions (if any) made in computing the above **minimum** kinetic energy.

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(04) (a) Name three (03) types of radiation detection devices.

(b) Briefly describe the working principle of **anyone (01)** of the three radiation detection devices listed by you above in part (a).

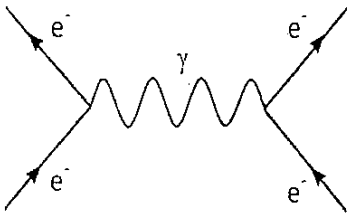
(c) Discuss the strengths and weaknesses of the device described by you above in part (b).

(05) (a) Briefly describe the conservation laws for elementary particle reactions.

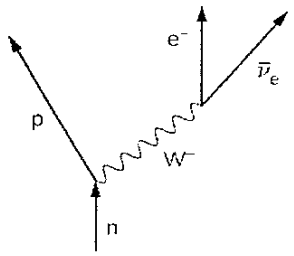
(b) Feynman diagrams are graphical representations that show how elementary particles interact. Briefly describe **important rules** followed in constructing a Feynman diagram.

(c) Describe the elementary particle interactions represented by the following two Feynman diagrams.

(i)



(ii)



(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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