

Tutorial 4:

- Violation of parity in beta decay;
- Gamma decay and internal conversion; Elementary ideas about Mossbauer spectroscopy
- Q-value of nuclear reactions; Nuclear fission and fusion, energy production in stars; Nuclear reactors.

Section A: Radioactivity, Mossbauer spectroscopy

Q1:

Explain parity violation in β -decay. Describe how parity violation was experimentally detected in the decay of ^{60}Co . Mention any other decay process in which the parity violation has been demonstrated. 20

2013

Q2:

It is possible to estimate the nuclear radius from the study of alpha decay ? Explain how. 10

2014

Q3:

Describe briefly how parity violation in β -decay was experimentally observed ? What do you understand by the statement, 'neutrinos are left-handed' ? 10

2017

Q4:

Explain the various methods of finding the size of the nucleus. How will you determine the nuclear radius from the observation of beta rays resulting from nuclear transition when the initial and final nuclei are mirror nuclei? 5+15

2019

Q5:

Why is it not possible to detect the parity violation in weak interaction by observing only the beta decay rate? Justify your answer. 15

2019

Q6:

Natural uranium found in the earth's crust contains the isotopes $^{235}_{92}\text{U}$ and $^{238}_{92}\text{U}$ in the atomic ratio 7.3×10^{-3} to 1. Assuming that at the time of formation these two isotopes were produced equally, estimate the time since formation.

Given that the mean lives of both the isotopes are 1.03×10^9 years and 6.49×10^9 years, respectively. 10

2020

Q7:

Write down the basic weak interaction processes in the nuclei. Also illustrate the beta decays of (i) neutron and (ii) proton. 15

2020

Q8:

Explain the Mössbauer effect. 10

2020

Q9:

Explain the phenomenon of internal conversion and define the internal conversion coefficient. Discuss under what conditions the internal conversion process becomes important. 20

2021

Q10:

What is the age of a fossil that contains 6 g of carbon ^{14}C and has a decay rate of 27 decays per minute ?

Given : Ratio $\frac{^{14}\text{C}}{^{12}\text{C}} = 1.3 \times 10^{-13}$, Half life ($T_{1/2}$) of $^{14}\text{C} = 5730$ yrs. 10

2023

Q11

What is nuclear resonance absorption of gamma rays ? Describe the working and applications of Mossbauer spectrometer. 15

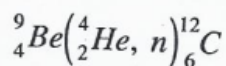
2024

Section B: Q Value of Nuclear Reactions, Nuclear Reactors

Q1:

Calculate the Q -value of the reaction :

10



Given :

$$\text{Mass}({}_4^9\text{Be}) = 9.01283 \text{ u}$$

$$\text{Mass}({}_2^4\text{He}) = 4.002603 \text{ u}$$

$$\text{Mass}({}_6^{12}\text{C}) = 12.000 \text{ u}$$

$$\text{Mass}(n) = 1.0086652 \text{ u}$$

2013, 2015, 2024

Q2:

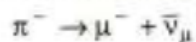
The maximum energy of a positron (e^+) released in the decay of ${}_6\text{C}^{13}$ atom into a ${}_7\text{N}^{13}$ atom is 1.202 MeV. If the mass of the ${}_6\text{C}^{13}$ atom is 13.003354 u, calculate the mass of the ${}_7\text{N}^{13}$ atom.

10

2018

Q3:

A π^- -meson at rest decays into a μ^- -meson :



Calculate the kinetic energy of the μ^- -meson emitted in the reaction.

15

2018

Q4:

- (i) List the main reactions in the pp chain leading from hydrogen to helium during stellar nucleosynthesis. Also mention the net effect of the reactions.

10

2020

Q5:

What are chain reactions ? What do you mean by critical size of the core in which chain reaction takes place ?

10

2021

Q6:

A neutron and a proton can undergo radiative capture at rest :



Find the energy of the photon emitted in this capture. Is the recoil of the deuteron important ?

15

2022

Q7:

What do you understand by the critical size of a reactor ? Explain the main features of nuclear reactors.

5+15=20

2023

Q8.

Consider a uranium nucleus (${}_{92}\text{U}^{236}$) breaking up spontaneously into two equal parts. Estimate the reduction of electrostatic energy of the nucleus considering uniform charge distribution.

[Assume that nuclear radius is $1.2 \times 10^{-13} A^{1/3} \text{ cm}$]

15

2025

Q9.

Is it possible for a photon to transfer all its energy to a free electron? Give reasons.

5

2025