Tutorial 5:

- Classification of elementary particles and their interactions;
- Conservation laws
- Quark structure of hadrons; Field quanta of electroweak and strong interactions;
- Elementary ideas about unification of forces;
- Physics of neutrinos.

Q1:

(c) In the following reactions indicate with an explanation, whether they proceed by strong, electromagnetic or weak interaction or they are forbidden : 15

(i) $\pi^+ \rightarrow \mu^+ + \nu_\mu$

(ii) $p \rightarrow n + e^+ + \nu_e$

(iii) $p + \pi^- \rightarrow K^+ + \Sigma^-$ 15

2013

Q2:

(c) State the quantum numbers I_z, Y and S for the $u\ d\ s$ quarks and antiquarks. Which combination of these leads to the formation of (i) proton and (ii) neutron ? 10 10

2013

Q3:

(b) What is the role of neutrino in the weak interaction of radioactive nuclides ? Explain the experimental detection of neutrino. 20 15

2013

Q4:

How are elementary particles classified on the basis of their participation in fundamental interaction ? 10

2014

Q5:

State the quantum numbers I_z, Y and S for uds quarks and antiquarks. Which combination of these leads to the formation of a (i) proton and (ii) neutron ? 10

2015

Q6:

Describe grand unification theories (GUT). 20

2015

Q7:

How many types of neutrinos exist ? How do they differ in their masses ? 15

2015

Q8:

Write down the following decays in terms of quarks :

(i) $\Omega^- \rightarrow \wedge^\circ + K^-$

(ii) $\wedge^\circ \rightarrow p + \pi^-$

(iii) $K^- \rightarrow \mu^- + \upsilon_\mu$. 15

2015

Q9:

Write down the quark structure of the following hadrons :

$\Delta^{++}, \Omega^-, \Sigma^-$ and $\wedge^\circ$

Write down the following decays in terms of quarks : *6+9=15*

(i) $n \rightarrow p^+ + e^- + \bar{\nu}_e$

(ii) $\Delta^+ \rightarrow \pi^+ + n$

(iii) $\Sigma^+ \rightarrow p^+ + \pi^0$

2016

Q10:

Explain unification of electromagnetic and weak interactions. What is Z°-boson ? What is its relevance in electroweak unification ? *10*

2016

Q11:

What are elementary particles and how are they classified ? Describe in brief the different types of interactions that can occur between the elementary particles. ***6+4=10***

2016

Q12:

Explain the various leptonic family members. What is leptonic number conservation ? Based on this conservation law, state whether the following reactions are possible or not : ***10+5+5+5=25***

(i) $\pi^- \rightarrow \mu^- + \bar{\nu}_\tau$

(ii) $n \rightarrow p^+ + e^- + \bar{\nu}_e$

2016

Q13:

(i) State the three characteristic properties of strong, weak and electromagnetic forces distinguishing one from the other.

(ii) Point out the interactions in which the following conservation laws are obeyed or violated

(a) Isotopic spin

(b) Hyper charge

(c) Lepton number

(d) Charge conjugation

(iii) Write down the quark constituents of each of the following :

(a) π^+, (b) K^+, (c) Δ^{++}, (d) Σ^o, (e) Ω^- 5+10+5=20

2017

Q14:

Which of the following elementary particle reactions/decays are allowed under various conservation laws? If allowed, write down the type of interaction and the characteristic time by which it would proceed :

(i) $p + n \rightarrow \Lambda^0 + \Sigma^+$

(ii) $\pi^+ + n \rightarrow \Lambda^0 + K^+$

(iii) $p + n \rightarrow K^+ + \Sigma^+$

(iv) $\pi^0 \rightarrow \gamma + \gamma$

(v) $\bar{n} \rightarrow \bar{p} + e^+ + \nu_e$ 10

2018

Q15:

Assuming equal masses for up (u) and down (d) quarks, find the ratio (μ_n / μ_p) of the magnetic moments of neutron and proton. 10

2019

Q16:

(ii) List in two separate columns, the quantities that are conserved and not conserved in the weak interaction of particles. 10

2020

Q17:

ρ° and K° mesons both decay mostly to π^+ and π^-. Explain why the mean lifetime of ρ° is shorter ($\backsim 10^{-23}$s) compared to the mean lifetime of K°($\backsim 10^{-10}$s). 10

2021

Q18:

What are the properties of the particles made up of the following quarks ?
(a) $u\bar{d}$ (b) $\bar{u}d$ (c) dds (d) uss 10

2021

Q19:

How many types of neutrinos exist ? How do they differ in their masses ? 15

2021

Q20:

Explain why each of the following particles cannot exist according to the quark model.
(i) A Baryon of spin 1 and
(ii) An anti-Baryon of electric charge +2 10

2022

Q21:

Which of the following decays are allowed and which are forbidden ? If the decay is allowed, state which interaction is responsible. If it is forbidden, state which conservation law its occurrence would violate.

(a) $n \longrightarrow p + e^- + \bar{\nu}_e$

(b) $\wedge^\circ \longrightarrow \pi^+ + \pi^-$

(c) $\pi^- \longrightarrow e^- + \gamma$

(d) $\pi^\circ \longrightarrow e^- + e^+ + \nu_e + \bar{\nu}_e$

(e) $\pi^+ \longrightarrow e^- + e^+ + \mu^+ + \nu_\mu$ 15

2022

Q22:

How could you establish that ν_e and $\bar{\nu}_e$ are two different particles ? 10

2023

Q23:

(i) $K^+ \longrightarrow \Pi^+ + \Pi^+ + \Pi^-$

(ii) $\Pi^+ + \rho \longrightarrow \Pi^+ + \Pi^+ + n$

(iii) $\Pi^+ + \rho \longrightarrow \Delta^{++} \longrightarrow \Pi^+ + \rho$

(iv) $\sum^\circ \longrightarrow \lambda^\circ + \gamma$

(v) $\sum^+ \longrightarrow \lambda^\circ + e^+ + \nu_e$

(vi) $K^- + \rho \longrightarrow K^+ + K^\circ + \Omega^-$

(vii) $\Pi^\circ \longrightarrow \gamma + e^+ + e^-$

(viii) $\sum^- \longrightarrow n + e^- + \bar{\nu}_e$

(ix) $\lambda^\circ \longrightarrow \rho + e^- + \bar{\nu}_e$

(x) $e^+ + e^- \longrightarrow \gamma + \gamma$

Name the interactions via which the above nuclear decays occur : 1×10=10

2023

Q24.

What is meant by strength of the interactions of elementary particles ? Classify the different forces on the basis of this strength of interaction. *10*

2024

Q25.

What are the various conservation laws for elementary particles ? Apply these conservation laws to confirm whether the following reactions are possible or not : *15*

(i) $\pi^+ + n^0 \rightarrow K^0 + K^+$

(ii) $\bar{\nu}_e + p^+ \rightarrow n^0 + e^-$

2024

Q26.

Explain the various leptonic family members. What is leptonic number conservation? Based on this conservation law, tell whether the following reactions are possible or not :

(i) $\pi^- \rightarrow \mu^- + \bar{\nu}_\tau$

(ii) $n \rightarrow p^+ + e^- + \bar{\nu}_e$ 15

2025