D 132059 **(Pages : 2)** **Name.....**

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, NOVEMBER 2025

(CBCSS)

Physics

PHY 3C 10—NUCLEAR AND PARTICLE PHYSICS

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

Answer the questions as per the instructions given in each section.

Section A

Answer **all** *questions.*
Each question carries 1 *weightage.*

1. Define the binding energy of a nucleus. How is it related to the mass defect ?
2. What is internal conversion in gamma decay ?
3. What is meant by magic numbers in the nuclear shell model ?
4. State the physical significance of spin-orbit coupling in nuclei.
5. What is Scintillation ? Give one example of a scintillator material.
6. What is counting statistics ? State the distribution governing radiation counting.
7. What are the four fundamental forces of nature ?
8. Define baryon number and lepton number.

(8 × 1 = 8 weightage)

Section B

Answer any **two** *questions.*
Each question carries 5 *weightage.*

9. Explain the concept of singlet and triplet potentials. How do they account for the difference in binding of the *np*, *pp*, and *nn* systems ?
10. Describe nuclear lifetimes and discuss the factors determining the lifetime in α, β, and γ decay processes.

Turn over

11. Describe the collective model of nuclei with nuclear vibrations and rotations. Explain the role of deformation in determining nuclear energy spectra.

12. Describe the classification of elementary particles based on internal symmetries, including baryons, mesons, leptons, and gauge bosons. Explain the role of SU(3) symmetry and the eightfold way.

(2 × 5 = 10 weightage)

Section C

Answer any **four** *questions.*
Each question carries 3 *weightage.*

13. Explain why the deuteron has only the triplet state ($^3S_1$) bound but not the singlet state ($^1S_0$).

14. An α-particle of energy 5 MeV is emitted in a radioactive decay. Calculate the Q-value, given that the recoil kinetic energy of the daughter nucleus is 0.12 MeV.

15. Explain the role of valence nucleons in determining nuclear magnetic dipole moments.

16. Using the semi-empirical mass formula, explain how the binding energy varies with mass number and identify the term responsible for pairing effects.

17. Describe the construction and operation of a photomultiplier tube (PMT).

18. Explain Yukawa's theory of the strong interaction and the role of the pion.

19. Discuss the conservation of isospin and its components in strong interactions.

(4 × 3 = 12 weightage)

D 111207 (**Pages : 2**) **Name**.....

Reg. No.....

THIRD SEMESTER M.Sc. (CBCSS) [REGULAR / SUPPLEMENTARY] EXAMINATION, NOVEMBER 2024

Physics

PHY 3C 10—NUCLEAR AND PARTICLE PHYSICS

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

Section A

Answer **all** *questions.*

Each question carries 1 *weightage.*

1. Name some experiments to determine the distribution of nuclear charge.
2. Define Tensor Potential.
3. List three properties of the nuclear force.
4. Write down deuterium-deuterium or reactions.
5. Give examples for thermonuclear weapons.
6. Define and explain Graviton.
7. Explain the distinct features of strong nuclear forces.
8. What is the use of conservation principles ?

(8 × 1 = 8 weightage)

Section B

Answer any **two** *questions.*

Each question carries 5 *weightage.*

9. Explain in detail N-N scattering. Solve the interaction problem.
10. Explain the fermi theory of β decay.
11. With figure explain the structure, constituents and working of nuclear reactor.
12. With suitable examples and figures, explain eight fold way of symmetry.

(2 × 5 = 10 weightage)

Turn over

Section C

Answer any **four** *questions.*

Each question carries 3 *weightage.*

13. Explain nuclear angular momentum and parity.
14. The binding energy of the neon isotope $_{20}Ne^{10}$ is 160.647 MeV. Find its atomic mass.
15. Illustrate the two principal arguments in support of the presence of exchange forces in nuclei.
16. Write a note on the mass of nutrino.
17. Explain inverse β decay.
18. Why nuclear fission ? Explain
19. With figure write a note on the possible arrangements of quarks in Barions and Mesons.

(4 × 3 = 12 weightage)

D 51329 **(Pages : 2)** **Name.....**

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, NOVEMBER 2023

(CBCSS)

Physics

PHY 3C 10—NUCLEAR AND PARTICLE PHYSICS

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

Section A

Answer **all** *questions.*
Each question carries weightage 1.

1. Write a note on electric dipole moment.
2. What are the allowed and forbidden beta decay.
3. State the three components of total angular momentum Z of the deuteron.
4. Explain Scattering cross sections.
5. What are gauge bosons ?
6. List the particles affected and not affected by Strong force.
7. Explain symmetric and antisymmetric functions.
8. What are the features of a photo multiplier tube.

(8 × 1 = 8 weightage)

Section B

Answer any **two** *questions.*
Each question carries weightage 5.

9. With figure explain the structure, constituents and working of nuclear reactor.
10. With figure explain the energy level diagram of Shell model of nucleus.

Turn over

11. With details of quantum numbers and other properties of various elementary particles, explain Sakata model.

12. With suitable examples and figures explain eight fold way of symmetry.

(2 × 5 = 10 weightage)

Section C

Answer any **four** *questions.*
Each question carries weightage 3.

13. Explain proton and neutron separation energies.

14. Compute the total binding energy for (a) $_{7}Li$; (b) $_{20}Ne$; (c) $_{56}Fe$; (d) $_{235}U$.

15. Explain how The Nucleon - Nucleon Force Is charge symmetric and Nearly Charge Independent

16. Briefly explain forbidden decays.

17. What is a Moderator ? Explain its working with example.

18. Write a note on Proportional counter.

19. Write a note on coloured quarks.

(4 × 3 = 12 weightage)

D 31198 **(Pages : 2)** **Name.....**

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, NOVEMBER 2022

(CBCSS)

Physics

PHY 3C 10—NUCLEAR AND PARTICLE PHYSICS

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

Section A

Answer **all** *questions.*
Each question carries weightage 1.

1. Sketch and explain the salient features of binding energy curve.
2. How the singlet and triplet potential existed in a nucleus ?
3. How did neutrino help in understanding of beta decay ?
4. Illustrate nuclear fusion process with example.
5. Explain the term quadrupole moment of a nucleus.
6. What is dead time in the GM counter ?
7. Classify particle based on interaction.
8. Briefly explain Grand Unified Theory.

(8 × 1 = 8 weightage)

Section B

Answer any **two** *questions.*
Each question carry weightage 5.

9. Outline the simple theory of deuteron structure using a square well potential of finite width and depth. Obtain the relation between the well parameters and binding energy. Show that the deuteron wave function is an admixture of S and D state.
10. Explain briefly the energetics of β decay reaction. Discuss the Fermi theory of β decay.
11. With a neat block diagram explain the working of a GM counter.
12. Discuss the fabrication and working of a controlled fusion reactor. State the application.

(2 × 5 = 10 weightage)

Turn over

Section C

Answer any **four** *questions.*
Each question carry weightage 3.

13. Determine the mass difference between two mirror nuclei which have N and Z differing by one unit and the same odd value of A.

14. Using semi empirical mass formula, find the most stable isobar for a nucleus having A = 43. Give coulomb energy coefficient a_c = 0.583 MeV and asymmetry energy coefficient a_{sym} = 19.3MeV.

15. Briefly compare the different type of gas detectors.

16. Explain Quark model for Spin Zero and Spin 3/2 hadrons.

17. Give an account of nuclear rotational energy levels.

18. Consider the following decay $^{17}\mathrm{F} \rightarrow {}^{17}\mathrm{O} + \beta^+ + \upsilon_e$ .Find the maximum kinetic energy of positron if the atomic masses of ^{17}F and ^{17}O are 17.0076 u and 17.0045 u respectively.

19. Draw a schematic diagram of nuclear fission reactor. Explain briefly a) Moderator b) Control rod.

(4 × 3 = 12 weightage)

D 11689 **(Pages : 2)** **Name.....**

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, NOVEMBER 2021

(CBCSS)

Physics

PHY 3C 10—NUCLEAR AND PARTICLE PHYSICS

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
3. *The instruction if any, to attend a minimum number of questions from each sub section / sub part / sub division may be ignored.*
4. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

Section A

Answer **all** *questions.*
Each question carries weightage 1.

1. Give the theory of force between a proton and neutron in deuterium for the ground state.
2. What is the basic assumption of a single particle shell model ?
3. What is the concept of fission to explain the stability of nucleus ?
4. What are allowed and forbidden beta decay ?
5. What is the kinetic energy of alpha particles in terms of Q value ?
6. What was the necessity of introducing color quantum number ?
7. Write a note on semiconductor detectors.
8. Explain about the four fundamental forces in nature.

(8 × 1 = 8 weightage)

Turn over

Section B

Answer any **two** *questions.*
Each question carries weightage 5.

9. Explain the term mass and binding energy of a nucleus. Give two method for determining the mass and binding energy of nucleus.

10. Explain the quark model for hadrons. What are the experimental evidences for confined quark.

11. Give a brief description of Nuclear Model Explain the single particle shell model with one of its application.

12. Explain the theory of alpha particle emission. Also discuss the angular momentum and parity selection rule for alpha decay.

(2 × 5 = 10 weightage)

Section C

Answer any **four** *questions.*
Each question carries weightage 3.

13. From the known masses of ^{15}O and ^{15}N, compute the difference in binding energy. Assuming this difference to arise from the difference in coulomb energy, Compute the nuclear radius of ^{15}O and ^{15}N. (Mass of proton = 1.00727647 a.m.u., Mass of neutron = 1.0086654 a.m.u., Mass of ^{15}O = 15.0030654 a.m.u. Mass of ^{15}N = 15.004890a.m.u)

14. Show that the mixing of S and D states accounts for the magnetic moment of the deuteron.

15. Discuss about the classical electromagnetic radiation.

16. Discuss the theory of controlled fission reactions.

17. Explain what are single channel and multichannel analyser.

18. Illustrate with an example the conservation laws obeyed in elementary particle reaction.

19. Distinguish between Leptons and Hadrons.

(4 × 3 = 12 weightage)

D 91052 (Pages : 2) Name.....

Reg. No.....

THIRD SEMESTER M.A./M.Sc./M.Com. DEGREE (REGULAR) EXAMINATION, NOVEMBER 2020

(CBCSS)

Physics

PHY 3C 10—NUCLEAR AND PARTICLE PHYSICS

(2019 Syllabus Year)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each Section / Part.*
2. *The minimum number of questions to be attended from the Section / Part shall remain same.*
3. *There will be an overall ceiling for each Section / Part that is equivalent to maximum weightage of the Section / Part.*

Section A

Answer **all** *questions.*

Each question carries weightage 1.

1. Show that the D state probability in Deuteron is roughly 4%.
2. What are magic numbers ? Why there are no magic numbers that are odd.
3. What is neutron and proton separation energy ?
4. What you meant by sub criticality and supercriticality condition in a fission reactor ?
5. Briefly explain the multipole moments.
6. Write the semi empirical mass formula. Briefly explain each term in semi empirical mass formula.
7. Parity is conserved in all strong or electromagnetic interactions, but is violated in week interactions. Justify the statement.
8. What are single channel and multichannel analyser ?

(8 × 1 = 8 weightage)

Turn over

Section B

Answer any **two** *questions.*
Each question carries weightage 5.

9. Starting from the *n-p* scattering explain the characteristics of a nuclear force.

10. Derive an expression for the total magnetic moment of the nucleus and explain with the help of Schmidt diagram.

11. With a neat block diagram explain the working of a Scintillation detector.

12. Explain the conservation laws of elementary particles reaction.

(2 × 5 = 10 weightage)

Section C

Answer any **four** *questions.*
Each question carries weightage 3.

13. Using the Shell model predict the ground state spin and parity of $^{17}_{8}O$ and $_{20}{}^{40}Ca$.

14. Bring out the angular momentum and parity selection rules in β decay.

15. Discuss the vibrational energy state of nucleus.

16. Discuss the strange behaviour of elementary particles. Calculate the strangeness of K^+, 'Ω^-.

17. What is the principle of operation of ionisation chamber ?

18. Describe any *two* methods for the determination of nuclear mass.

19. Briefly explain nucleon-nucleon scattering.

(4 × 3 = 12 weightage)

D 90745 (Pages : 2) Name.....

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE (SUPPLEMENTARY) EXAMINATION, NOVEMBER 2020

(CUCSS)

Physics

PHY 3C 10—NUCLEAR AND PARTICLE PHYSICS

(2017 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions.*

Each question carries 1 *weightage.*

1. Briefly explain a particle decay process in the quark model.
2. What are magic numbers, singly magic and doubly magic nuclei ? Which nuclear model explain the stability of magic nuclei ?
3. Mention the condition of requirement for a thermo nuclear fusion reactor.
4. What is deuteron ? Mention its properties.
5. Briefly explain magnetic moment of the nuclei.
6. Briefly explain the saturation property of nuclear forces.
7. Correlate Binding Energy per nucleon and fission reaction.
8. What are the limitations of a GM counter ?
9. What is the difference between internal conversion and electron capture?
10. Explain the Lawson criterion for nuclear fusion.
11. Why solid-state detectors are preferred over scintillation detectors?
12. Classify the various interactions types interactions in relation to elementary particles.

(12 × 1 = 12 weightage)

Turn over

Section B

Answer any **two** *questions.*
Each question carries 6 *weightage.*

13. Describe partial wave analysis of nuclear reaction and deduce the formula for the reaction cross-section.

14. Give the quantum mechanical theory to explain the α-decay process.

15. Explain the shell model of the nucleus. What are its merits and demerits ?

16. Discuss the conservation laws in particle physics. How are the conservation laws related to the symmetry properties ?

(2 × 6 = 12 weightage)

Section C

Answer any **four** *of the following questions.*
Each question carries 3 *weightage.*

17. Calculate the energy released by fission of 1 kg. of U^{235} in kWh. The energy released per fission is 200 MeV and Avogadro number are 6.023×10^{23}.

18. A 0.01 mm thick $^{7}_{3}Li$ target is bombarded with a beam of flux of 10^{13} particles /cm^2-s. as a result 10^8 neutrons/s are produced. Calculate the cross-section for this reaction. Density of lithium is 500 kg/m^3.

19. The activity of a certain nuclide decreases to 25 % of its original value in 20 days. Find its half-life.

20. The radius of the central wire of a proportional counter is 0.1 mm. and the radius of the cylinder tube is 2 cm. Calculate the electric field developed at the surface of the wire, when the potential difference of 1,500 volts is applied between the two.

21. A positive pion collides with a proton, two protons plus other particles are created. What is the other particle ?

22. A GM counter with a dead time of 2×10^{-4} seconds register 30.000 counts per minute. Find the intensity of the incoming beam of particles in terms of the particles received per second.

(4 × 3 = 12 weightage)

D 70980 (Pages : 2)

Name.....

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE (REGULAR) EXAMINATION

NOVEMBER 2019

Physics

PHY 3C 10—NUCLEAR AND PARTICLE PHYSICS

(2012 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions.*

Each question has weightage 1.

1. With suitable example explain the nuclear radius determination on the basis of mass distribution of nuclei.
2. Nuclei do not exhibit electric dipole moment and magnetic quadrupole moment. Explain.
3. Explain laser isotope separation.
4. What are mirror nuclei ? Why are they significant ?
5. Explain how the spin orbit interaction affect the heirarchy of nuclear levels.
6. Give any 2 draw backs of extreme single particle shell model for nuclei.
7. Explain parity violation in beta decay.
8. Explain internal conversion. Give an example.
9. Define isospin. What is its significance in nuclear reactions ?
10. Define stripping reaction with an example.
11. Name the field particles for the fundamental interactions.
12. State and explain CPT theorem.

(12 × 1 = 12 weightage)

Section B

Answer any **two** *questions.*

Each question has weightage 6.

13. Derive Weizsacker's semi empirical mass formula and hence arrive at mass parabola.
14. Give an account of Fermi theory of beta decay. How does it explain the experimental observations ?

Turn over

15. Explain nuclear fission. Discuss the characteristics of fission.

16. Define quarks and quark model of hadrons.

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions.*
Each question has weightage 3.

17. Determine the binding energy and neutron separation energy of the following nuclei :

    (a) $^{7}_{3}Li$,

    (b) $^{20}_{10}Ne$.

    Given, m(^{7} Li) = 7.016003 u, m(^{6} Li) = 6.015121u, m (^{1}H) = 1.007825u, m(^{0}n) = 939.565346 MeV, m(^{20}Ne) = 19.999981u, m(^{19}Ne) = 19.001880u

18. Explain the origin of low lying levels of ^{120}Te by the addition of 2quadrupole phonons to the 0^+ state.

19. A sample of RaE ($^{210}_{83}Bi$) containing 4.0 mgm shows beta activity and radiates energy at the rate of 1 watt. Find the average energy of beta particles emitted assuming half life of the sample is 5 days.

20. Determine the spin parity of the ground gtate and fist excited state of the following Nuclei :

    (a) $^{45}_{21}Sc$,

    (b) $^{11}_{6}C$,

    (c) $^{236}_{92}U$.

21. The reaction ^{23} Na(n α) ^{20}F has a Q value of –5.4 MeV. Find the threshold energy of the neutron for the reaction. Given mass of neutron = 1.008665 u, m(^{20} Na) = 22.9898u.

22. State with reasons which of the processes are allowed and which are forbidden :

    (a) $p + p \rightarrow K^{+} + p + A^{0}$.

    (b) $\Sigma^{-} \rightarrow \pi^{-} + p$.

    (c) $\Sigma^{-} \rightarrow \pi^{-} + n$.

    (d) $\pi^{-} + p \rightarrow K^{0} + \Sigma^{0}$.

    (e) $\pi^{-} + p \rightarrow \pi^{0} + A^{0}$.

    (f) $\pi^{-} + p \rightarrow n + \gamma$.

(4 × 3 = 12 weightage)

D 70985 (Pages : 2)

Name.....

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE (REGULAR) EXAMINATION
NOVEMBER 2019

Physics

PHY 3C 10—NUCLEAR AND PARTICLE PHYSICS

(2017 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions.*
Each question carries 1 *weightage.*

1. What are the limits on the phase shifts for an elastic scattering and a nuclear reaction process ?
2. What are singlet and triplet potentials ?
3. Express the Gell-mann-Nishijima formula.
4. Explain the origin of stellar energy.
5. What are baryon and lepton conservation laws ?
6. Give the Gamow Teller selection rules for beta decay.
7. How does binding energy of the odd-odd differ from the even-even nuclei.
8. What is the principle of Ionization chamber ?
9. What are the assumptions on which shell model is based ?
10. What is Solar Fusion ?
11. Explain the concept of charge conjugation.
12. What do you mean by pair production and annihilation of matter ?

(12 × 1 = 12 weightage)

Section B

Answer any **two** *questions.*
Each question carries 6 *weightage.*

13. With necessary theory explain in detail the low energy n-p scattering and obtain the expression for cross-section.
14. Give the main assumptions of liquid drop model of the nucleus. Obtain the expression for the binding energy of a nucleus based on liquid drop model. State the semi-empirical formula of Weizacker.

Turn over

15. Give an account of :

(i) Semiconductor detector.

(ii) Discuss the working of a scintillation detector.

16 What are Quarks ? Outline the basic properties of quarks. Explain the quark model of baryons.

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions.*
Each question carries 3 *weightage.*

17. Some nuclear reactions involving elementary particles is given below. Among them which reaction are possible ?

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

(ii) $\bar{\upsilon}_e + p \rightarrow n + e^+$.

(iii) $\pi^+ + \pi \rightarrow \Lambda^0 + K^+$.

18. It is required to operate a proportional counter with a maximum radial field of 10^6 Vm^{-1}. What is the applied voltage required if the radii of the wire and tube are 0.01 cm and 1 cm respectively

19. A radioactive substance has a half life period of 30 days. Calculate the time taken for $\frac{3}{4}$ original numbers of atoms to disintegrate

20. Calculate the binding energy and average binding energy per nucleon of $_{15}P^{31}$ of mass $_{15}P^{31} = 30.9737634$.

21. The activity of certain radio nuclide decreases to 15% of its original value in 10 days. Find its half life.

22. Show that for a most stable isobar of a nucleus having odd mass number A , the atomic number Z is given by, $\left[\frac{A}{\left(0.015A^{\frac{2}{3}} + 2\right)}\right]$ the constants in the semiempirical mass formula $a_3 = 0.58$Mev, $a_4 = 19.3$ Mev.

(4 × 3 = 12 weightage)

D 70980 (Pages : 2)

Name.....

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE (REGULAR) EXAMINATION

NOVEMBER 2019

Physics

PHY 3C 10—NUCLEAR AND PARTICLE PHYSICS

(2012 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions.*

Each question has weightage 1.

1. With suitable example explain the nuclear radius determination on the basis of mass distribution of nuclei.
2. Nuclei do not exhibit electric dipole moment and magnetic quadrupole moment. Explain.
3. Explain laser isotope separation.
4. What are mirror nuclei ? Why are they significant ?
5. Explain how the spin orbit interaction affect the heirarchy of nuclear levels.
6. Give any 2 draw backs of extreme single particle shell model for nuclei.
7. Explain parity violation in beta decay.
8. Explain internal conversion. Give an example.
9. Define isospin. What is its significance in nuclear reactions ?
10. Define stripping reaction with an example.
11. Name the field particles for the fundamental interactions.
12. State and explain CPT theorem.

(12 × 1 = 12 weightage)

Section B

Answer any **two** *questions.*

Each question has weightage 6.

13. Derive Weizsacker's semi empirical mass formula and hence arrive at mass parabola.
14. Give an account of Fermi theory of beta decay. How does it explain the experimental observations ?

Turn over

15. Explain nuclear fission. Discuss the characteristics of fission.

16. Define quarks and quark model of hadrons.

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions.*
Each question has weightage 3.

17. Determine the binding energy and neutron separation energy of the following nuclei :

    (a) $^{7}_{3}Li$,

    (b) $^{20}_{10}Ne$.

    Given, m(^{7} Li) = 7.016003 u, m(^{6} Li) = 6.015121u, m (^{1}H) = 1.007825u, m(^{0}n) = 939.565346 MeV, m(^{20}Ne) = 19.999981u, m(^{19}Ne) = 19.001880u

18. Explain the origin of low lying levels of ^{120}Te by the addition of 2quadrupole phonons to the 0^+ state.

19. A sample of RaE ($^{210}_{83}Bi$) containing 4.0 mgm shows beta activity and radiates energy at the rate of 1 watt. Find the average energy of beta particles emitted assuming half life of the sample is 5 days.

20. Determine the spin parity of the ground gtate and fist excited state of the following Nuclei :

    (a) $^{45}_{21}Sc$,

    (b) $^{11}_{6}C$,

    (c) $^{236}_{92}U$.

21. The reaction ^{23} Na(n α) ^{20}F has a Q value of –5.4 MeV. Find the threshold energy of the neutron for the reaction. Given mass of neutron = 1.008665 u, m(^{20} Na) = 22.9898u.

22. State with reasons which of the processes are allowed and which are forbidden :

    (a) $p + p \rightarrow K^{+} + p + A^{0}$.

    (b) $\Sigma^{-} \rightarrow \pi^{-} + p$.

    (c) $\Sigma^{-} \rightarrow \pi^{-} + n$.

    (d) $\pi^{-} + p \rightarrow K^{0} + \Sigma^{0}$.

    (e) $\pi^{-} + p \rightarrow \pi^{0} + A^{0}$.

    (f) $\pi^{-} + p \rightarrow n + \gamma$.

(4 × 3 = 12 weightage)

D 52333 (Pages : 2) Name.....

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE EXAMINATION, DECEMBER 2018

(CUCSS—PG)

Physics

PHY 3C 10—NUCLEAR AND PARTICLE PHYSICS

(2012 Syllabus Year)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions.*

Each question has weightage 1.

1. Show that nuclear density is a constant irrespective of the mass number(A) of nuclei.
2. Explain the significance of deuteron in the study of nuclear forces.
3. Explain scattering length and comment on its sign.
4. Sketch the energy level diagram for a nucleus with harmonic oscillator potential.
5. What are Schmidt lines ?
6. Give beta transition selection rules.
7. Explain the gamma ray energetics.
8. Give the characteristics of compound nuclei in nuclear reactions.
9. Give the CNQ cycle in solar fusion.
10. Name the fundamental forces of nature and compare them.
11. Discuss the conservation of isospin for elementary particles.
12. What is a quark? What are the different quark flavours ?

(12 × 1 = 12 weightage)

Section B

Answer any **two** *questions.*

Each question has weightage 6.

13. Discuss the characteristics of low energy *n-p* scattering. Give the theory and correlate it with the experimental observations.
14. Give the characteristics of collective model of nuclei. Explain with an example how the vibrational motion of the nuclei can account for the low energy excitations.

Turn over

15. Explain the concept of non-conservation of parity in beta decay. Explain the Wu experiment to verify it.

16. Discuss the various conservation laws and quantum numbers for elementary particles.

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions.*
Each question has weightage 3.

17. Using semi-empirical mass formula find an expression for the most stable isobar in beta decay. Hence find the most stable nucleus for A = 77. Given a_c = 0.72 MeV and a_{sym} = 23 MeV.

18. Find the possible beta transitions (electron emission, positron emission and electron capture) between $^{7}_{4}$Be and $^{7}_{3}$Li. Given ($^{7}_{4}$Be) = 7.0116004 u and m ($^{7}_{3}$Li) = 7.01929 u. 1 u = 931 MeV.

19. For the nuclide $I^{\pi} = ½^{+}$ in the ground state excited states are $(9/2)^{+}$, $(3/2)^{+}$, $(1/2)^{+}$ $(5/2)^{+}$ in order of ascending energy. Draw an energy level diagram and indicate the most likely gamma ray transitions.

20. Neutron capture of slow neutrons by ^{235}U shows a resonance peak of excitation energy 0.29 eV. The compound nucleus may de-excite either through gamma emission or by fission into larger nuclear fragments. The mean life of compound nucleus was found to be 4.7×10^{-15} s and the partial width for gamma emission is 3.4×10^{-2} eV. Find the partial width for fission.

21. Estimate the temperature required for the fusion reaction of 2 Deuterons to form a ^{4}He. Given radius of Deuteron = 2 Fermi.

22. State with reasons which elementary particle reactions among the following are possible. Among the possible ones explain the type of interaction with reasons :

    (a) $p + p \rightarrow K^{+} + \Sigma^{+}$.

    (b) $\pi^{\circ} \rightarrow \gamma + \gamma$.

    (c) $p + n \rightarrow \Lambda^{\circ} + K^{+}$.

    (d) $\pi^{+} + p \rightarrow \Sigma^{+} + K^{+}$.

    (e) $\pi^{+} + n \rightarrow K^{\circ} + K^{+}$.

    (f) $\Lambda^{\circ} \rightarrow n + \lambda$.

(4 × 3 = 12 weightage)

D 52341 (Pages : 2) Name.....

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE EXAMINATION, DECEMBER 2018

(CUCSS—PG)

Physics

PHY 3C 10—NUCLEAR AND PARTICLE PHYSICS

(2017 Syllabus Year)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions.*
Each question carries 1 *weightage.*

1. What is the CP violation in particle physics ?
2. Why are even -even nuclei are most stable ?
3. What are the advantages of semiconductor detector ?
4. Why is β-ray spectrum being continuous ?
5. What are the similarities between a nucleus and liquid drop ?
6. What is the importance of asymmetric term in semiempirical mass formula ?
7. How does the *np* and *pp* scattering cross section compare ?
8. What is internal conversion process ?
9. What is difference between π-mesons and K-mesons ?
10. What is a quarks ? Are they colored ?
11. Give short note on the general features of a nuclear fission reactor ?
12. Give the properties of a good quality photomultiplier tube.

(12 × 1 = 12 weightage)

Section B

Answer any **two** *questions.*
Each question carries 6 *weightage.*

13. Describe the effective range theory of *p-p* scattering.
14. Write an essay on the nuclear fusion reaction undergoing at the interior of the sun. What are the various fusion reactors and describe in detail about any *two* fusion reactors ?

Turn over

15. Explain the working of Proportional and GM counters.

16. Explain in detail about charge conjugation, parity and time reversal and the combination of them with suitable examples.

(2 × 6 = 12 weightage)

Section C

Answer any **four** *of the following questions.*
Each question carries 3 *weightage.*

17. The maximum energy of β - particles from $^{32}_{15}P$ is 1.71 MeV. What magnetic field perpendicular to the beam of β - particles from $^{32}_{15}P$ would bend it to give a radius of 100 mm. ? Given

$$m = m_0\left(1-\frac{v^2}{c^2}\right)^{-\frac{1}{2}}.$$

18. If the energy of the α-particle emitted by ^{231}Au is 5.48 MeV, find the closest distance it can approach a Au nucleus.

19. Using the liquid drop model, find the most stable isobars for A = 118.

20. An α-particle of energy 5.48 MeV is completely stopped in an ionization chamber. What is the pulse height in an external resistance of 1 MΩ ? Energy required to produce an ion pair is 35 eV and the capacitance of the chamber is 50 pF.

21. Calculate the height of the potential barrier faced by an α-particle inside the $^{226}_{88}Ra$ $^{226}_{88}$ Ra nucleus.

22. Determine whether the following reactions are allowed or forbidden :

(a) $p + p \rightarrow K^+ + \Sigma^+$.

(b) $\overline{\upsilon}_e + p \rightarrow n + \mu^+$.

(c) $p + \pi^- \rightarrow \Sigma^0 + \eta^0$.

(4 × 3 = 12 weightage)

C 31290 (Pages : 3) Name.....

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE EXAMINATION, DECEMBER 2017

(CUCSS)

Physics

PHY 3C 10—NUCLEAR AND PARTICLE PHYSICS

(2012 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions.*
Each has weightage 1.

1. If stable nuclei have equal number of proton and neutron whereas the heavy nuclei have excess of neuron. Explain why ?
2. Explain the general nature of the nucleon-nucleon potential.
3. Explain briefly the electron scattering technique used for nuclear radius determination.
4. What is asymmetry energy in the semi empirical mass formula ?
5. Explain CPT theorem.
6. Briefly explain why deuteron has a ground state S state and cannot have any excited S state.
7. Describe the magic numbers. How the magic number can be explained with the help of the shell model for a nucleus ?
8. Derive an expression for Q-value of a nuclear reaction. Show that an exothermic reaction is possible even when the reacting nuclei have no energy.
9. Describe about the source of energy in the core of our sun.
10. Briefly explain the characteristic nature of energy spectrum of beta particles.
11. Describe the quarks and their properties.
12. Mention the interacting and mediating particles in each of the basic forces of nature. What is the spin of the mediating particles ?

(12 × 1 = 12 weightage)

Turn over

Section B

Answer any **two** *questions.*
Each has weightage 6.

13. Discuss the Effective range theory of n-p scattering and obtain a relation between scattering length, effective range and deuteron binding energy.

14. Describe Gamow's theory of alpha decay. Discuss how the theory explain Geiger Nuttal law.

15. Give an evidence in favour of a shell structure in a nuclei. State main assumptions in the shell model of the nuclei and describe its success.

16. (a) Give detail information about the formation of mesons or baryons with the help of quark model.

    (b) Describe the eight color gluons and their matrices.

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions.*
Each has weightage 3.

17. Using the harmonic-oscillator shell model, describe the expected configurations for the ground states of the light stable nuclei with $A \leq 4$, specify also their total L, S, J and T quantum numbers and parity.

18. The simplest model for low lying states of nuclei with N and Z between 20 and 28 involves only $f_{7/2}$ nucleons. Using this model predict the magnetic dipole moment of $^{41}_{20}Ca_{21}$ and $^{41}_{21}Sc_{20}$.

19. Consider the following high energy reactions or particle decays :

    (i) $\pi^- + p \rightarrow \pi^0 + n$.

    (ii) $\pi^0 \rightarrow \gamma + \gamma + \gamma$.

    (iii) $\pi^0 \rightarrow \gamma + \gamma$.

    (iv) $p + \bar{p} \rightarrow \gamma$. Indicate for each case :

    (a) Allowed or forbidden.

    (b) Reason if forbidden.

    (c) Type of interaction if allowed.

20. The half life of $_{13}Al^{28}$ is 2.3 min and that of $_{11}Na^{23}$ is 15 hrs. Obtain a value for the ratio of the number of aluminium atoms to sodium atoms remaining after 12 min. At what time will this ratio be unity ?

21. Explain why a baryon of spin 1 and antibaryon of electric charge +2 cannot exist according to quark model.

22. In the scattering experiment using alpha particles of energy 7.68 MeV and the target materials are gold and aluminium. Calculate the distance of the closest approach in both cases.

(4 × 3 = 12 weightage)

D 71336 (Pages : 2) Name.....

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE EXAMINATION, DECEMBER 2014

(CUCSS)

Physics

PHY 3C 10—NUCLEAR AND PARTICLE PHYSICS

(2012 Admission onwards)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions.*
Each question carries 1 weightage.

1. What is mass defect and how will you correlate it with packing fraction ?
2. Write down semi-emperical mass formula and explain the different terms in it.
3. Explain Electric quadrapole moment of a nucleus.
4. What are the predictions of shell model ?
5. Explain how collective model explains nuclear vibrations.
6. Explain Kuril plot.
7. Define internal conversion coefficient and explain its significance.
8. Briefly explain the various conservation laws in nuclear reactions.
9. Explain the terms spontaneous fission and induced fission.
10. What is a thermonuclear reaction ? Illustrate it with an example.
11. Briefly explain Quark flavours and colours.
12. Write a note on quantum chromo dynamics.

(12 × 1 = 12 weightage)

Section B

Answer any **two** *questions.*
Each question carries 6 weightage.

13. Discuss the deutron system in detail considering it as a rectangular square well potential and deduce an expression for the radius of the deutron.
14. Derive an expression for the total magnetics moment of the nucleus and explain it with the help of Schmidt diagram.

Turn over

15. Using Fermi's theory of β-decay explain allowed and forbidden β–transitions.

16. Discuss the various conservation laws in particle interaction.

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions.*
Each question carries 3 weightage.

17. Compute the mass defects of :

    (a) ^{32}S ; (b) ^{20}F ; (c) ^{238}U.

18. Determine the harmonic oscillator frequencies w appropriate to the nuclei ^{17}O and ^{60}Ni.

19. Prove that for $E_m << m_e c^2$, the mean kinetic energy of the 13-particle is equal to $E_m/3$.

20. For the following endoergic reactions, find the Q value and the threshold kinetic energy, assuming in each case that the lighter particle is incident on the heavier particle at rest.

    (a) $^{7}Li + P \rightarrow {}^{7}Be + n$.

    (b) $^{12}C + P \rightarrow n + {}^{12}N$.

    (c) $^{35}Cl + \alpha \rightarrow n + {}^{38}K$.

21. Consider a typical reaction during the neutron induced fission of $^{235}_{92}U$, namely

$$n + {}^{235}_{92}U \rightarrow {}^{236}_{92}U^* \rightarrow {}^{98}_{40}Z_r + {}^{136}_{52}T_e + 2n$$

The following fission fragments are far from stability region and decay into stable end products $^{98}_{42}M_o$ and $^{136}_{52}X_e$ by successive emission of β-particles calculate total energy that will be released in this fission reaction.

22. Analyse the following decays or reactions for possible violation of the basic conversation laws :

    (a) $\pi^+ + n \rightarrow \wedge^\circ + K^+$.

    (b) $\pi^+ + n \rightarrow K^\circ + K^+$.

    (c) $\bar{v}_e + p \rightarrow n + \mu^+$.

    (d) $\bar{v}_e + p \rightarrow n + e^+$.

    (e) $\wedge^\circ + \rightarrow p + K^-$.

(4 × 3 = 12 weightage)

D 91603 (Pages : 2) Name.....

Reg. No.....

THIRD SEMESTER M.Sc. PROGRAMME DEGREE EXAMINATION DECEMBER 2015

(CUCSS)

Physics

PHY 3C 10—NUCLEAR AND PARTICLE PHYSICS

(2012 Admission onwards)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions.*
Each has weightage 1.

1. Draw the binding fraction curve and explain its features.
2. What is parity ? Explain its significance.
3. Nucleon-Nucleon force is charge independent. Justify the statement.
4. What are magic numbers ? How will you account it with the help of shell model ?
5. Explain how collective model explain nuclear rotations.
6. Explain Kurie plot.
7. Explain different types of nuclear reactions.
8. Distinguish between exoergic and endoergic nuclear reactions. Define Q value of a nuclear reaction.
9. What are the characteristics of nuclear fission ?
10. Illustrate nuclear fusion process with an example.
11. What is strangeness ? Explain conservation of strangeness.
12. Briefly explain Quarks flavours and colours.

(12 × 1 = 12 weightage)

Section B

Answer any **two** *questions.*
Each has weightage 6.

13. Discuss in detail Proton-Proton Scattering at low energies.
14. Derive an expression for the total magnetic moment of the nucleus and explain it with the help of Schmidt diagram.
15. Account parity violation in β decay and describe an experiment to verify it.
16. What is an endoergic reaction ? Derive an expression for the Threshold energy of an endoergic reaction.

(2 × 6 = 12 weightage)

Turn over

Section C

Answer any **four** *questions.*
Each has weightage 3.

17. Compute the total binding energy and binding energy per nucleon for :

    (a) $^{7}\alpha_i$.

    (b) ^{20}Ne.

    (c) ^{56}Fe.

    (d) ^{235}u.

18. Predict angular momenta and parities for the ground state of ^{12}C, ^{11}B, ^{17}O and ^{16}N using shell model of nucleus.

19. Show that in the β transformation $^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y + \bar{\beta} + \bar{\upsilon}$ the Kinetic energy of the recoil nucleus is given by $E_y = \dfrac{(Q + 2m_0 C^2) E_m}{2M_y C^2}$.

20. Calculate threshold energy required to initiate the reaction $^{31}P(n, p)\,^{31}Si$. Also calculate the maximum energy of β-decay of ^{31}Si + ^{31}P. Given M_p = 1.00814 *amu* Mu = 1.00898 *amu*, Mp = 30.98356 and Msi = 30.98515 *amu*.

21. Analyse the following decays or reactions for possible Violation of the basic conservation laws.

    (a) $K^+ \rightarrow \pi^+ + \pi^+ + \pi^0 + \pi^-$.

    (b) $K^+ \rightarrow \pi^+ + e^+ + \mu^-$.

    (c) $\wedge^0_+ p \rightarrow \Sigma^+ + n$

    (d) $\wedge^0 \rightarrow p + k^-$.

    (e) $\Sigma^+ \rightarrow n + e + \upsilon_e$.

22. Analyse the following decays according to their quark content.

    (a) $\Omega^- \rightarrow \wedge^0 + k^-$.

    (b) $k^+ \rightarrow \pi^+ + \pi^0$.

    (c) $\equiv^- \rightarrow \wedge^0 + \pi^-$.

    (d) $\wedge^+_c \rightarrow p + \bar{k}^0$.

(4 × 3 = 12 weightage)

D 6724 (Pages : 2) Name.....

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE EXAMINATION, DECEMBER 2016

(CUCSS)

Physics

PHY 3C 10—NUCLEAR AND PARTICLE PHYSICS

(2012 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions.*
Each has weightage 1.

1. Explain the meson exchange theory of nuclear force.
2. Explain the collective model of the nucleus.
3. Sketch and explain the salient features of binding energy curve.
4. What is meant by parity of a nuclear state ?
5. Explain the role of neutrino in beta decay.
6. Briefly discuss the colour quantum numbers
7. What is Fermi-Kurie Plot ? What information does it provide ?
8. Explain the main features of a resonance nuclear reaction.
9. Define Q-value and threshold energy for a nuclear reaction.
10. What is CPT Theorem ?
11. What are quarks ? How do these interact with each other to form particles ?
12. What are hadrons ? Discuss their SU(3) classification and its success in predicting new particles.

(12 × 1 = 12 weightage)

Section B

Answer any **two** *questions.*
Each question has weightage 6.

13. Explain the semi-empirical mass formula and obtain an expression for the number of protons (Z) in a nucleus.
14. Give the quantum mechanical treatment of the deuteron. Show that the mixing of the S and D sates accounts for the magnetic moment of the deuteron.

Turn over

15. Discuss the Fermi theory of beta decay. Illustrate how the continuous beta spectrum is explained and what are allowed and forbidden beta transitions ?

16. Discuss in detail various conservation laws and symmetry operations for elementary Particles.

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions.*
Each question has weightage 3.

17. Calculate the binding energy of the following isobars and their binding energies per nucleons, $_{28}Ni^{64}$ = 63.9280 amu $_{29}Cu^{64}$ = 63.9298 amu.

Which of these would you expect to be β-active and how would it decay ?

18. The difference in the Coulomb energy between the mirror nuclei $^{49}_{24}Cr$, $^{49}_{25}Mn$ is 6.0 MeV.

Assuming that the nuclei have a spherically symmetric charge distribution and that e^2 is approximately 1.0 MeV-fm. Calculate the radius of the If $^{49}_{25}Mn$ nucleus.

19. Calculate the Q-value for the reactions Al^{27} (d, α) Mg^{25} and Mg^{25} (α, d) Al^{27}. Given, masses of all nuclei are determined accurately with the help of mass spectrometer as : mAl = 26.9901 amu, mMg = 24.9936 amu, mα = 4.0039 amu, m_d = 2.0147 amu.

20. In the fission of $_{92}U^{235}$ by a thermal neutron, the fragments found are $_{42}Mo^{98}$ and $_{54}Xe^{136}$. How many electrons are released in the reaction. Calculate the amount of energy released in the reaction when the masses of $_{92}U^{235}$, $_{42}Mo^{98}$ and $_{54}Xe^{136}$ and neutron in amu are respectively, 235.044, 97.906, 135.907 and 1.009.

21. According to the shell model find the spin, parity of $^{40}_{20}Ca$, $^{89}_{38}Sr$, $^{27}_{13}Al$, $^{125}_{51}Sb$, $^{61}_{28}Ni$ in their ground state.

22. Which of the following processes are absolutely forbidden and why ?

(i) $p \rightarrow e^+ + \overline{Y}$.

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

(iii) $\overline{n} + n \rightarrow \pi^0 + \pi^+ + \pi^-$.

(iv) $\pi^+ + n \rightarrow \pi^- + p$.

(v) $\pi^0 + n \rightarrow \pi^- + \overline{p}$.

(vi) $\pi^0 + \pi^- \rightarrow \overline{n} + p$.

(4 × 3 = 12 weightage)