8. Explain the physical process occurring in a proportional counter due to the passage of a charged particle of low specific ionization and hence obtain an expression for the multiplication factor. 7+3=10

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M.Sc. PHYSICS
THIRD SEMESTER
NUCLEAR PHYSICS
MSP-303

(Use separate answer scripts for Objective & Descriptive)

Duration: 3 hrs. **Full Marks: 70**

[PART-A: Objective]

Time: 20 min. **Marks: 20**

Choose the correct answer from the following: ***1×20=20***

1. Which of the following reaction is possible?
   a. $^{14}N_7 \rightarrow {}^{13}C_6 + \beta^+ + \nu_e$
   b. $^{13}N_7 \rightarrow {}^{13}C_6 + \beta^+ + \nu_e$
   c. $^{13}N_7 \rightarrow {}^{13}C_6 + \beta^+$
   d. $^{13}N_7 \rightarrow {}^{13}C_7 + \beta^+ + \nu_e$

2. The non conservation of parity in beta decay was first hinted by:
   a. Yang and Lee
   b. Frank and Condon
   c. Bohr and Wheeler
   d. Wu and co-workers

3. The term neutrino oscillation refers to the phenomena of:
   a. Vibration of a neutrino
   b. Neutrino flavor change
   c. Generation of a neutrino
   d. None of the above

4. Half life of a radioactive material is 4 days. After 20 days, the fraction remaining un-decayed will be:
   a. 1/32 b. 1/20 c. 1/16 d. 1/8

5. The decay chain of the nucleus $^{238}U_{92}$ involves 8 alpha decays and 6 beta decays. The final nucleus at the end of the process will have:
   a. Z=82, A=206
   b. Z=84, A=224
   c. Z=88, A=206
   d. Z=76, A=200

6. The contribution of the coulomb energy in the semi-empirical mass formula of a nucleus of mass number A and the atomic number Z is of the form (a=constant):
   a. $aZA^{2/3}$
   b. $\frac{aZ(Z-1)}{A^{1/3}}$
   c. $\frac{aZ(Z+1)}{A}$
   d. $\frac{aZ^2}{A^{2/3}}$

7. Which isobars of A=75, does the liquid drop model suggests the most stable Nucleus?
   a. Z=35 b. Z=33 c. Z=36 d. Z=32

8. The magnetic moment ($\mu = J + 2.29$) of $^{20}_{10}Ne_{10}$ is:
   a. 2.39 Nuclear Magneton
   b. 2.30 Nuclear Magneton
   c. 4.79 Nuclear Magneton
   d. 2.29 Nuclear Magneton

9. The multiplication factor (k) for a super critical chain reaction is:
   a. $k = 1$ b. $k > 1$ c. $k < 1$ d. $k \geq 1$

10. Nuclear fusion of proton is possible due to:
    a. C-C cycle b. C-N cycle
    c. N-N cycle d. None of these

11. What is the approximate mass number of a nucleus whose radius is measured to be $6.0 \times 10^{-15}\ m$?
    a. 110 b. 90 c. 82 d. 125

12. The total angular momentum of a nucleus with even-A nuclei is:
    a. even multiple of $\hbar$ only b. integral multiple of $\hbar$
    c. half-integral multiple of $\hbar$ d. none of the above

13. Which of the following about the nuclear force is true?
    a. It is an attractive force between electrons and protons in an atom.
    b. It is much weaker than the gravitational force.
    c. It is much weaker than the electromagnetic force.
    d. It is a strong, short-range, attractive force between the nucleons.

14. In natural unit system ($\hbar = c = 1$), 1 sec is equivalent to:
    a. $1.52 \times 10^{24}\ GeV^{-1}$ b. $5.07 \times 10^{15}\ GeV^{-1}$
    c. $1.52 \times 10^{24}\ GeV$ d. $5.07 \times 10^{15}\ GeV$

15. The fundamental gauge boson which mediates the strong interaction between two quarks is:
    a. photon (γ) b. Z^0 boson
    c. gluon (g) d. Higgs boson (H)

16. The quark content of the Λ^- particle is:
    a. uds b. dss c. ddd d. sss

17. A gamma ray of energy 0.9 MeV loses energy by:
    a. Pair production only.
    b. Photoelectric effect only.
    c. Photoelectric effect and Compton effect.
    d. Photoelectric effect, Compton effect and pair production.

18. Critical energy of electron in air is:
    a. 200 MeV b. 50 MeV c. 20 MeV d.84 MeV

19. An electron of energy 150 MeV in air loses energy only by:
    a. Ionization only b. Ionization and excitation only
    c. Bremsstrahlung d. Compton scattering only

20. For application of GM counter in cosmic ray studies, the operating point must be:
    a. At the starting of the plateau region b. At the end of the plateau region
    c. At the middle of the plateau region d. Outside the plateau region

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(PART-B :Descriptive)

Time: 2 hrs. 40min. **Marks: 50**

[Answer question no.1 & any four (4) from the rest]

1. a. Derive and sketch the energy level scheme due to spin-orbit interaction on a central potential in a nucleus. 6+4=10
   b. Using the shell model, predict the ground state spin-parity of $^{15}_{8}O$, $^{39}_{19}Kr$, $^{20}_{10}Ne$ and $^{63}_{29}Cu$.

2. a. Explain Fermi theory of beta decay. 5+3+2=10
   b. Sketch the Kurie Plot for allowed beta decay and give reason for the deviation in a straight line Kurie plot.
   c. Write a note on the neutrino less double beta decay.

3. a. Using the Liquid drop model, obtain an expression for the semi-empirical mass formula and explain the term associated with it. 5+3+2=10
   b. Calculate the atomic number of the most stable nucleus for a given mass number A on the liquid drop model. Hence explain why out of $_2He^6$, $_4Be^6$ and $_3Li^6$ only the last one is stable.
   c. Write the demerits of the Liquid drop Model.

4. a. Explain the different types of Nuclear reactions. 5+4+1=10
   b. Define Nuclear Fission reaction. Calculate the energy released by 1 kg of $_{92}U^{235}$.
   c. Calculate the energy released when a Helium nucleus is formed by the fusion of two deuterium nuclei.

5. a. Define nuclear binding energy. Compute the binding energy per nucleon of $^{24}_{12}Mg$. Given mass of proton, $m_p = 1.007275\ u$ and mass of neutron, $m_n = 1.008665\ u$ and mass of magnesium, $m_{mg} = 24.305\ u$. 5+3+2=10
   b. If nuclear force is charge independent and a neutron and a proton forms a bound state, then why is there no bound state for two neutrons? What information does it provide on the nucleon-nucleon force?
   c. If the mass defect of $^{240}_{94}Pu = +50.123$, find its corresponding atomic mass.

6. Analyze the properties of ground state deuteron considering square well potential of the nucleus. 10

7. a. What do you mean by elementary or fundamental particle? List all the fundamental entities of the standard model of particle physics with their symbols. Also mention their charge and spin. 7+3=10
   b. Construct the baryon octet putting the symbols of the baryons in appropriate places in the octet according to their charge and strangeness.

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