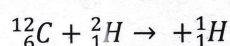
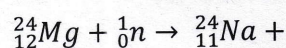


B.Sc. 6th Semester (Honours) Examination, 2023 (CBCS)**Subject : Physics****Course : DSE-3:(6)****(Nuclear and Particle Physics)****Time: 3 Hours****Full Marks: 60***The figures in the margin indicate full marks.**Candidates are required to give their answers in their own words**as far as applicable.***1. Answer any ten of the following questions:****2×10=20**

- (a) Find the density of nucleons in $^{12}_6\text{C}$ nucleus.
- (b) What will be the quadrupole moment of a system containing two dipoles of dipole moment \vec{p} placed in opposite direction and separated by a distance d ? What can you say about quadrupole moment of a spherical nucleus?
- (c) Explain the term 'saturation and charge independence of nuclear force'.
- (d) What is long range α -particle and fine structure of α -ray spectrum?
- (e) What is internal conversion ? How does it differ from β^- decay?
- (f) What do you mean by non-conservation of parity in β decay?
- (g) Define nuclear reaction cross-section. What is its unit?
- (h) Complete the following reactions:



- (i) Which of the following materials (work function of each material is given within bracket) can be used for designing photocell operable in visible light?

Tungsten ($\phi = 4.5 \text{ eV}$) and Lithium ($\phi = 2.3 \text{ eV}$).

- (j) What is Compton wavelength? Find the Compton shift at the scattering angle 180° .
- (k) Briefly explain the role of dynodes in scintillation detector.
- (l) Mention the positions of π^+ and π^- in $Y - I_3$ plot ($Y =$ Hypercharge, $I_3 =$ z-component of isospin).
- (m) A proton accelerating cyclotron having the applied voltage frequency as 2.2×10^7 cycles/sec. Calculate the magnetic field strength for resonance.
- (n) What is pair production? Obtain the minimum energy of photon required for pair production.
- (o) Write down the charge and strangeness of up and strange quark.
2. Answer *any four* of the following questions: 5×4=20
- (a) (i) Express the Q-value in orbital electron capture and β^+ decay in terms of atomic masses.
- (ii) Determine the energy of the neutrino that is produced when ${}^7_4\text{Be}$ undergoes electron capture at rest. 3+2
- (b) (i) For odd- A nuclei the nuclear mass can be expressed as $M(z, A) = \alpha A + \beta Z + \gamma Z^2$, where α , β and γ are constants. Here, Z and A correspond to the atomic number and mass number of the nucleus. Show that odd- A nuclides on either side of the mass parabola decay to a stable state having greatest binding energy.
- (ii) Why are two parabolas obtained for even- A nuclides? 3+2
- (c) (i) What are magic numbers? Using the shell model explain the presence of magic nuclei.
- (ii) Calculate the spin-parity of ${}^{41}_{19}\text{K}$ and ${}^{45}_{20}\text{Ca}$ nuclei using shell model. (1+2)+2
- (d) (i) Draw graphs of observed photoelectric current with retarding potential for two different frequencies of incident light. Explain the graph using Einstein's quantum theory of light.
- (ii) Light of wavelength 2000\AA falls on aluminium surface which has work function of 4.2 eV . Calculate the maximum kinetic energy of photoelectrons. (1+2)+2

(e) Discuss the construction and working of a semiconductor detector. Mention one advantage and one disadvantage of such detector. 3+2

(f) Obtain the expression of threshold energy for endoergic reaction. Calculate the energy required to remove the least tightly bound neutron from ${}_{20}^{45}\text{Ca}$. 3+2

3. Answer *any two* of the following questions: 10×2=20

(a) (i) What is binding energy of a nucleus? Draw the curve of binding energy per nucleon with mass number. Why is there a peak at $A=4$?

(ii) Using the curve, explain the release of energy in fusion of light nuclei and fission of heavy nuclei.

(iii) Calculate the binding energy (in MeV) of deuteron. (1+2+1)+(2+2)+2

(b) (i) What is the Q-value in disintegration process? Show that the Q-value in α -disintegration can be expressed in terms of kinetic energy of α -particle and mass number of disintegrating nucleus.

(ii) Obtain the expression of Geiger-Nuttall law using Gamow's theory of α -decay.

(iii) Calculate the height of the potential barrier between daughter nucleus and the α -particle in α -decay of ${}_{92}^{238}\text{U}$. (1+2)+5+2

(c) (i) Mention the nature of interaction of the following processes:

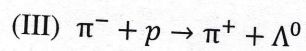
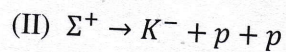
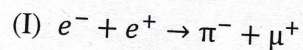
(I) Beta decay of nucleus

(II) Binding of nucleons to form a nucleus

(III) Confinement of quarks in neutron.

(IV) Friction of a ball rolling on the ground

(ii) Why are the following reactions forbidden?



(iii) Write down the quark content of Ξ^- , Σ^0 and K^0 .

4+3+3

(d) (i) Obtain the Rutherford scattering formula.

(ii) Describe the working principle of a linear accelerator with a proper diagram.

6+4

[Useful Data:

$$R_0 = 1.2 \text{ fm}$$

$$\text{Planck's Constant (h)} = 6.626 \times 10^{-34} \text{ J-s}$$

$$1 \text{ u} = 1.661 \times 10^{-27} \text{ kg} = 931.5 \text{ MeV}$$

$$\text{Mass of proton} = 1.00727647 \text{ u}$$

$$\text{Mass of neutron} = 1.008665 \text{ u}$$

$$\text{Mass of electron} = 0.00054858 \text{ u}$$

$$\text{Mass of deuteron} = 2.01355321 \text{ u}$$

$$\text{Charge of proton} = 1.6 \times 10^{-19} \text{ C}$$

$$\text{Mass of } {}_4^7\text{Be} = 7.01693 \text{ u}$$

(5)

SH-VI/PHSH/DSE-3/23

Mass of ${}^7_3\text{Li} = 7.016 \text{ u}$

Mass of ${}^{40}\text{Ca} = 39.962589 \text{ u}$

Mass of ${}^{39}\text{Ca} = 38.970691 \text{ u]$
