বিদ্যাসাগর বিশ্ববিদ্যালয়
VIDYASAGAR UNIVERSITY

Question Paper

B.Sc. Honours Examinations 2020
(Under CBCS Pattern)
Semester - V
Subject: PHYSICS
Paper: DSE2T

Full Marks : 60
Time : 3 Hours

Candiates are required to give their answer in their own words as far as practicable.
The figures in the margin indicate full marks.

NUCLEAR AND PARTICLE PHYSICS

Answer any ***three*** from the following questions : 3×20

1. Answer any ***ten*** questions : 10×2=20

   (a) The measured mass of deuteron atom $\left({}_1H^2\right)$, Hydrogen atom $\left({}_1H^1\right)$, proton and neutron are 2.01649*u*, 1.00782*u*, 1.00727*u* and 1.00866*u*. Find the binding energy of the deuteron nucleus.

   (b) By using single particle shell model predict the gound state spin and parity of ${}_{29}Cu^{63}$.

(c) Consider the particle reaction $P + n \rightarrow \Xi^- + k^+ + \Sigma^+$

Find the change in strangeness quantum number.

(d) Using the liquid drop model find the most stable isobar for $A = 27$.

(e) Find out whether the following reaction is exoergic or endoergic

$${}_3Li^6 + {}_0n^1 \rightarrow {}_2He^4 + {}_1H^3$$

$$M\left({}_3Li^6\right) \rightarrow 6.0151234\ amu$$

$$M\left({}_0n^1\right) \rightarrow 1.0086654\ amu$$

$$M\left({}_2He^4\right) \rightarrow 4.0026034\ amu$$

$$M\left({}_1H^3\right) \rightarrow 3.0160294\ amu$$

(f) Describe 'Hyper charge' in connection with elementary particles.

(g) The dead time of a GM counter is $400\mu s$. What is the true count rate of 1100 counts per minute ?

(h) Write down Geiger Nuttal law and explain it.

(i) State C.P.T. theorem for elementary particles.

(j) Calculate the ionisation current produced by a beam of α particles of 5Mev energy entering an ionisation chamber at the rate of one particle per second. Given that one ion pair consumes 35 ev energy.

(k) What is the difference between electron capture and positron emission.

(l) A 0.01 mm thick ${}_3Li^7$ target is bombarded with a beam of intensity 10^{13} protons/sec. As a result 10^8 neutrons produced. Calculate the cross section of the reaction given density of lithuim = 500 kg/m^3.

(m) Show that the nuclear density of ${}_1H^1$ is about is about 1014 times greater than atomic density. Assume the atom to have the radius of first Bohr orbit.

(n) Using single particle shelll model calculate quadrapole moment of ${}_{13}Al^{27}$.

(o) A cyclotron has a magnetic field of 10^4 gram and radius of 80cm. Calculate the frequency of the alternating electric field that must be applied and to what energy deuterons can be accelerated ? Mass of deuteron = 2 amu.

2. (a) What are mirror nuclei ? Calculate the β disintegration energy of mirror nbuclei.

(b) Describe Rutherford's experiment on the scattering of α - particles and state some of the improtant conclusions drawn from the experiment.

(c) Explain nuclear binding energy and packing fraction. Discuss graphically the variation of average binding energy per nucleon with A.

(d) Explain liquid drop model. Give any two achievements of the model. 5×4

3. (a) Determine whether the following relations are allowed or forbidden ?

(i) $\pi^+ + n \rightarrow \Lambda^o + K^+$

(ii) $p + \pi^- \rightarrow \Sigma^o + \eta^o$

(iii) $\bar{\nu}_e + p \rightarrow n + \mu^+$

A prticle consists of u quark, d quark and s quark. What is its charge ? What is a charmed quark ? 3+1+1

(b) Explain the working principle of cyclotron and derive the expression for the maximum kinetic energy achieved by a particle.

Can a cyclotron be used to accelerate electrons ? If not why ? 3+2

(c) (i) It is found that 20 cm thick sheet of aluminium placed in the path of 1.1 Mev radiation beam reduces the intensity to 2%. Calculate the mass absorption coefficient of aluminium for the radition. (Density of Aluminium = 2700 kg/m^3).

(ii) A photon of frequency ν is scattered by an electron initially at rest. Derive an expression for kinetic energy of recoil electron. Prove that maximum energy of recoil is

$$E_{\max} = \frac{h\nu}{1 + \frac{m_o c^2}{2h\nu}}$$ 2+3

(d) (i) Discuss the origin of asymmetry energy and coulomb energy in semi empirical mass formula.

(ii) Using semi empirical binding energy formula calculate binding energy of $_{20}Ca^{40}$

Given : $a_v = 14$ MeV; $a_s = 13$ MeV; $a_c = 0.6$ MeV; $a_a = 19$ MeV;

$a_p = (\pm 34.0)$ MeV. 3+2

4. (a) What do you mean by internal coversion ? Define internal conversion coefficient.

Explain the processs :

(i) β decay

(ii) positron emission

(iii) Electron capture.

Why α spectra is discrete but β spectra is continous ? 2+2+4+2

(b) (i) Draw the characteristics curve of GM Counter. Define threshold voltage. An Organic quenched GM tube , operates at 1000 volt and has a wine having diameter 0.2 mm. The radius of the cathode is 2 cm. What is the maximum radial field ? Why can't a GM counter measure the energy of the incident particle ? 2+1+3

(ii) What is the implication of Geiger-Nuttal law in the relation with α decay ? Given that the range in standard air of the α particles from radium (half life = 1622 years) is 3.3.6 cm, where as from polonium (half life = 138 days) this range is 3.85 cm. Calculate the half life of Rac for which the α particle range is 6.97 cm.. 2+2

5. (a) Why are the most stable nuclei found in the region near $A = 60$? Find the energy release, if two H^2 nuclei fuse together to form He^4 nucles. The binding energy per nucleon of H and He is 1.1 MeV and 7.0 Me V respectively. 2+3

(b) What are magic number ? What is the evidence for shell structure of the nucleus ? Sketching the main assumption, explain the shell model of the nucleus. 1+2+2

(c) (i) What is meant by isospin ? Give the value of the isospin and the z component of the isospin for (i) pions and (ii) nucleons.

(ii) Explain why the following reaction not allowed under the conservation of baryon number and strangeness number $\Pi^+ + n \rightarrow K^0 + K^+$. 3+2

(d) What is thereshold energy in nuclear reaction ? Obtain an expression for thershold energy. 2+3

6. (a) A singly changed positive ion is accelerated through a potential difference of 1000 V in a mass spectrograph. It then passes through a uniform magnetic field B = 1500 gauss, and then deflected into a circular path of radius 0.122 m.

(i) What is the speed of the ion ? 2

(ii) What is the mass of the ion ? 2

(iii) What is the mass number of the ion ? 1

(b) One milligram of a radioactive material with half-life of 1600 years is kept for 2000 years. Calculate the mass, which would have decyaed by this time. 5

(c) (i) Describe the Fermi's Theory of allowed β decay.

(ii) Discuss relative merits and demerits of various nuclear models. What is the importance of magic numbers ? 6+4=10

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ASTRONOMY AND ASTROPHYSICS

Answer any ***three*** from the following questions : 3×20

1. (a) What are the advantages and disadvantages of the optical telescope ?

   (b) Mention different types of detectors and their detection limit. 10+10

2. (a) What do you mean by brightness, luminosity, magnitude and temperature of a star ?

   (b) Describe the H-R diagram in details. Show the position of red giants in this diagram. 10+8+2

3. (a) What are the different types of galaxies ? Give examples.

   (b) Mention the location of the solar system in the universe.

   (c) Define bulges, discs and halo of a galaxy.

   (d) Write down Hubble's Law. 8+2+9+1

4. (a) What is spectroscopic parallax ? Where it is used ?

   (b) Describe how to determine temperature and radius of a star.

   (c) Differentiate white dwarf and brown dwarf. 6+10+4

5. (a) Describe solar photosphere and solar atmosphere.

   (b) What is solar corona and solar flare ?

   (c) Describe the "end" of sun like stars. 10+4+6

6. (a) What do you mean by binary stars and pulser ?

   (b) What is active galactic nuclei ? Mention the properties around the galactic nucleus.

   (c) Write a short note on dark matter. 8+6+6

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PHYSICS OF EARTH

Answer any ***three*** from the following questions : 3×20

1. (a) Describe the origin of magnetic field in earth.

   (b) Explain the source of geo-thermal energy. 10+10

2. (a) What are the origins of oceans, continents, mountains and rift valleys ?

   (b) Describe earth quake and earth quake belts. 10+10

3. (a) Write a brief description on ocean current system and effect of Coriolis forces on it.

   (b) Explain the origin of tides and Tsunamis. 10+10

4. (a) Write a short note on green house effect.

   (b) Write a short note on Indian monsoon system. 10+10

5. (a) Describe water cycle, carbon cycle, nitrogen cycle and phosphorous cycle.

   (b) Explain the role of cycles in maintaining a steady state. 4×4+4

6. (a) What are geochronological methods ? Mention their application in varioius geological studies ?

   (b) Describe the history of development in concepts of uniformitarianism, catastrophism and Neptuinsm. 10+10

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ADVANCED MATHEMATICAL PHYSICS 2

Answer any ***three*** from the following questions : 3×20

1. Derive the Euler-Lagrange's equation of motion. Establish Hamilton's principle and Lagrange's equation from the Euler-Lagrange's equation.

2. Discuss briefly about Canonical transformation and Legendre transformation. Show that the following transformation is Canonical

$$P = \left(qp^2\right), Q = \frac{1}{p}$$

3. Establish Hamilton's canonical equation of motion in Poission's bracket form. Show that

$$\left[q_k, q_l\right] = \left[p_k, p_l\right] = 0$$

and $\left[q_k, p_l\right] = \delta_{kl}$

4. Write down the properties that should be hold for forming a group. Show that the symmetry transformations of a square form a group.

5. Consider four-element Abelian group consisting of the set $\{1, i, -1, -i\}$ under ordinary multiplication, choose the basis vector as $(1\ i)^{\mathrm{T}}$. Find the two dimensional representative matrices corresponding to each elements. Now, change the basis vector $u = \left(1\ i\right)^T$ to $u_Q = \left(3-i\quad 2i-5\right)^T$. Find the real transformation matrix Q. Also find the transformed representative matrix $[D_{QT}(i)]$ corresponding to the element i.

6. Find the mean and standard deviation of the Poission's distribution. The probability distribution function of the Poission's distribution is given by

$$f\left(x\right) = e^{-m}\frac{m^x}{x!}$$

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