CENTRAL UNIVERSITY OF HARYANA

End Semester Examinations June 2023

Programme: Integrated B.Sc. M.Sc. (Physics)

Semester: IV **Session: 2022-23**

Course Title: Elements of Modern Physics **Max. Time: 3 Hours**

Course Code: SBS PHY 03 402 CC 4004 **Max. Marks: 70**

Instructions:

- Question no. 1 has seven parts and students need to answer any four. Each part carries three and half marks.
- Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks.
- The use of a personal non-programmable calculator is allowed.

Q1. (a) Planck's constant (h), the speed of light in vacuum (c) and Newton's gravitational constant (G) are three fundamental constants of nature. Which of the following combinations has the dimension of length?
(i) $\sqrt{hG}/c^{3/2}$ (ii) $\sqrt{hG}/c^{5/2}$ (iii) $\sqrt{hc/G}$ (iv) $\sqrt{Gc}/h^{3/2}$

(b) Find kinetic energy of a proton whose de Broglie wavelength is 1.00 fm.

(c) Draw $Re[\Psi(x)]$ and $\Psi(x)(\Psi(x)^*$ for incident wave, reflected wave and transmitted wave of particles having energy less than the height of a step potential V_0. Here, $\Psi(x)$ is wave function of particle, Re represents real part, $V(x) = 0$ for $x < 0$ and $V(x) = V_0$ for $x \geq 0$.

(d) Explain why atomic magic numbers are not the same as the nuclear magic numbers?

(e) If Planck's constant were smaller or larger than it is, what change would you expect in quantum phenomenons?

(f) A 1.00 kW radio transmitter operates at a frequency of 880 kHz. How many photons per second does it emit?

(g) Explain why pair production can not happen in empty space?

$(4 \times 3.5 = 14)$

Q2. (a) Write point-wise about what is expected in the results of the photoelectric effect experiment if we assume that light behaves like a wave. Discuss how these expected outcomes are defied by Einstein's theory of light which also agrees with the experimental results.

(b) Show that in Compton Scattering the kinetic energy of the recoiled electron is given by

$$K = h\nu\left[\frac{\alpha(1-\cos\phi)}{1+\alpha(1-\cos\phi)}\right].$$

Here, h is Planck's constant, $\alpha = h/m_0c\lambda$. m_0 is rest mass of the electron, and ϕ is the photon's scattering angle.

(c) Write properties of a well-behaved wave-function in quantum mechanics. Also discuss the physical interpretation of such wave-function.

$(2 \times 7 = 14)$

Q3. (a) What do you mean by phase velocity (v_p) and group velocity (v_g) of a particle in quantum mechanics. Discuss how the group velocity of a relativistic quantum particle can be equal to, smaller than or greater than its phase velocity.

(b) Discuss double slit interference experiment with photons.

(c) Set up a non-relativistic Schrödinger wave equation. Find the time independent and time dependent part of it.

$(2 \times 7 = 14)$

Q4. (a) A particle of mass m is confined in a one-dimensional box of unit length. At time $t = 0$, the wavefunction of the particle is $\Psi(x, 0) = A \sin 2\pi x \cos \pi x$, where A is the normalization constant. Find the expectation values of momentum and energy at $t = 0$. Also, write the wavefunction $\Psi(x, t)$ at a later time t.

(b) Solve Schrödinger wave equation to find wavefunctions and energies for a particle of mass m in a symmetric infinite square well having width a.

(c) Find the expressions of Einstein's A and B coefficients. Show that at optical frequencies the emission from a hot body (T=1000 K) is predominantly due to spontaneous transitions and hence the light from usual light sources is incoherent.

$(2 \times 7 = 14)$

Q5. (a) Discuss Liquid Drop Model of nucleus structure and semi-empirical mass formula.

(b) Define activity and half-life of a radioactive sample. Find the activity of 1.00 mg of radon $^{222}_{86}$Rn, whose half-life is 3.8 days. What will be activity of the this sample be exactly one week later?

(c) What are nuclear fission and fusion processes. Write a short note on the working of Breeder reactor.

$(2 \times 7 = 14)$

CENTRAL UNIVERSITY OF HARYANA

Fourth Semester Term End Examinations June 2023

Programme: Integrated B.Sc. - M.Sc. (Physics) **Session: 2022-23**

Semester: Fourth **Max. Time: 3 Hours**

Course Title: Digital Systems and Applications **Max. Marks: 70**

Course Code: SBS PHY 03 403 CC 4004

Instructions:

1. Question no. 1 has seven parts and students are required to answer any four. Each part carries three and half marks.

2. Question no. 2 to 5 have three parts and students are required to answer any two parts of each question. Each part carries seven marks.

Q 1. (4 x 3.5 = 14)

a) The vertical gain control of a CRO is set at a deflection sensitivity of 5 V/cm. An unknown ac voltage (sinusoidal) is applied to the Y-input. A 10 cm long straight line trace is observed on the screen. Determine the ac voltage.

b) Show how basic gates are realized using NAND gates. Also, give the boolean expression for each circuit.

c) What is half adder? Write its truth table and develop its logic circuit.

d) Explain the difference between the volatile and non-volatile memories.

e) A monostable multivibrator is to be used as a divide-by-5 circuit. The frequency of the input trigger is 2 kHz. Determine the value of R_A if the capacitor is of 0.02 μF.

f) Write a note on flags in the Microprocessor 8085.

g) Compare the combinational and sequential circuits.

Q 2. (2 x 7 = 14)

a) State and prove DeMorgan's Theorems.

b) Discuss all the laws and rules of boolean algebra.

c) Using a Karnaugh map, convert the following standard POS expression into a minimum POS expression, a standard SOP expression, and a minimum SOP expression:

$$(\overline{A} + \overline{B} + C + D)(A + \overline{B} + C + D)(A + B + C + \overline{D})(A + B + \overline{C} + \overline{D})(\overline{A} + B + C + \overline{D})(A + B + \overline{C} + D)$$

Q3. (2 x 7 = 14)

a) Explain the operation of full adder. Implement a 4-bit parallel adder using full adder.

b) How can you realize the edge triggered J-K flip flop from an S-R flip flop? Write the truth table of J-K flip flop and explain how race-around problem can be solved in it.

c) What is Multiplexer? Discuss the working of multiplexers with the logic diagram. In a 4-input multiplexer, what will be the output for $D_0 = 1$, $D_1 = 0$, $D_2 = 1$, $D_3 = 0$, $S_0 = 1$, and $S_1 = 0$?

Q 4. (2 x 7 = 14)

a) Explain the working of IC 555 timer as an astable multivibrator and prove that frequency of oscillations is independent of the collector supply voltage.

b) Discuss serial in/serial out shift registers in detail.

c) Why is a parallel counter faster than a ripple counter? Explain the working of up synchronous counter.

Q 5. (2 x 7 = 14)

a) Draw the architecture of Microprocessor 8085 and write a note on various registers used in Microprocessor 8085.

b) Using a neat pin diagram, explain the various signals of the Microprocessor 8085.

c) Write a note on the bus structure of the Microprocessor 8085.

CENTRAL UNIVERSITY OF HARYANA

Jant-Pali, Mahendergarh, Haryana

Name of Programme : M.Sc. Physics Year & Semester : June 2023, Fourth Semester Course Name : Cosmology Course Code : SBSPHY01403DCEC3104 Maximum Marks : 70 Duration : 3 Hrs	Note: All Questions are compulsory. Use of basic calculator is allowed. Attempt any Four parts in Question No. 1, each part carries 3.5 marks. Attempt any two out of three parts from Question 2 to 5. Each part carries 7 marks.

Q1.

A. What do you understand by an event and coordinate system in special relativity.

B. Describe the proper time. What is the relation between coordinate time interval and the proper time interval.

C. Explain the meaning of homogeneity and isotropy of the universe.

D. How do we infer that the present universe is accelerating and not decelerating.

E. How do you define a black hole with the help of Schwarzschild's line element.

F. What are the similarities between electromagnetic radiation and gravitational radiation.

G. What is the meaning of anisotropies in the Cosmic microwave background (CMB).

Q2.

A. Define the space time interval in Special relativity. Show that it is an invariant quantity.

B. Why do we call velocity (v^{μ}) and acceleration (a_{μ}), 4 vectors . Find their product.

C. Define and describe the weak and strong equivalence principle that connect special relativity to general relativity.

Q3.

A. Find the equation of motion of a particle in the space time of a massive object.

B. What is Einstein's equation of General relativity. What are the physical meaning of different terms present in it.

C. Describe the spacetime (metric) formed by a charged spherically symmetric system of mass m, assuming that the energy density of the system (as a function of distance from center) is $\epsilon(r)$.

Q4.

A. What is line element ? In Newtonian cosmology find the expression for Robertson Walker Metric.

B. Derive the Friedmann's equation for acceleration of the universe, given that the scale factor evolves with time according to $\frac{\dot{a}^2}{a^2}+\frac{kc^2}{a^2}=\frac{8\pi G}{3c^2}\rho$. Here the symbols have their usual meaning.

C. Solve the Friedmann equation for scale factor (a(t)) for a flat universe that is dominated by matter and radiation at different times.

Q5.

A. Explain the term Cosmic Microwave background radiation. How was it formed ?

B. What is the meaning of the term nucleosynthesis. Explain the decoupling of radiation and matter in the early universe.

C. What is horizon problem ? How can inflation help us resolve the horizon problem ?

CENTRAL UNIVERSITY OF HARYANA

Term End Semester Examinations June-July 2023

Programme: M.Sc. Physics **Session: 2022-23**

Semester: IV (2nd Year) **Max. Time: 3 Hours**

Course Title: Advanced Nuclear Physics **Max. Marks: 70**

Course Code: SBS PHY 01 401 DCEC 3104

Instructions:

1. Question no. 1 has seven parts and students are required to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and students are required to answer any two parts of each question. Each part carries seven marks.

Q 1. (4X3.5=14)

a) Express the surface of a pure quadrupole deformed nucleus in Cartesian coordinates.

b) Differentiate between neutron skin and bubble structure. Explain with examples.

c) Show that the shape parameter $\alpha_{\lambda\mu}$ transforms under rotation like a spherical tensor with angular momentum λ.

d) Discuss the atomic nucleus as an asymmetric rotor.

e) Describe the isotope separation online (ISOL) technique to produce radioactive ion beams.

f) Discuss the salient features of relativistic heavy ion collision.

g) Differentiate between s-process and r-process. Draw the s-process path from ^{56}Fe to ^{64}Zn.

Q 2. (2X7=14)

a) Explain in detail the nuclear orientation effects.

b) Discuss the effect of deformation on magic shells.

c) Explain characteristics properties of halo nuclei. How the small binding energy leads to the formation of halo structure?

Q3. (2X7=14)

a) Show that the deformation parameter α_{00} can be used to cancel the overall density change present as a side effect in the other multipole deformation.

b) Show that the kinetic energy of a vibrating charged liquid drop with a sharp surface is given by $T = \frac{1}{2}\rho_m R_0^5 \sum_{\lambda,\mu} \frac{1}{\lambda} |\dot{\alpha_{\lambda,\mu}}|^2$.

c) Describe Nilsson model of nuclei and its uses to explain nuclear properties.

Q 4. (2X7=14)

a) Explain the scattering of deformed nuclei during ion-ion collision.

b) Describe the nuclear reactions which occurs when a radioactive ion beam is incident onto some heavy target. How the fusion induced by loosely bound nuclei differs from that induced by tightly bound nuclei?

c) Compare the dynamics of nuclear reactions at intermediate and high energies.

Q 5. (2X7=14)

a) Explain in detail the hot big bang cosmology.

b) Discuss nucleosynthesis mechanisms for the formation of elements with $A \leq 60$ in stars.

c) Write a note on recent trends in nuclear structure physics and related important applications.

CENTRAL UNIVERSITY OF HARYANA

End Semester Examination (June 2023)

Programme: M.Sc. (Physics)

Semester: IV | **Session: 2022-23**

Course Title: Particle Physics | **Max. Time: 3 Hours**

Course Code: SBS PHY 01 402 DCEC 3104 | **Max. Marks: 70**

Instructions:

- Question No. 1 has seven parts and the student needs to answer any four. Each part carries three and a half marks.
- Questions No. 2–5 have three parts each and the student needs to answer any two parts of each question. Each part carries seven marks.
- A personal, non-programmable, and non-communicating calculator may be allowed to use.

Q1. (a) What is hypercharge? Write Gell-Mann-Nishijima formula.

(b) What is the need for high energy in particle physics studies?

(c) The α-spectrum is discrete, whereas the β-spectrum is continuous. Why?

(d) Write the parities of neutral and charged pions. Justify your answer.

(e) "Electric charge and color charge are always conserved in fundamental interactions, whereas flavor is approximately conserved." Justify the statement in your words.

(f) In how many ways, the weak interactions can be classified? Discuss.

(g) What do you mean by colored quarks? Write the reasons that led to the color hypothesis.

$(4 \times 3.5 = 14)$

Q2. (a) How elementary particles can be classified on the basis of (i) mass, (ii) interactions, and (iii) spin statistics? Discuss in detail.

(b) Compare the features of fundamental interactions and write a note on the unification of these interactions.

(c) Write a note on the Standard Model of Particle Physics. Also, write down the loopholes of this model.

$(2 \times 7 = 14)$

Q3. (a) Using the conservation laws, discuss whether the following processes are feasible or not. Also, write the dominating type of interaction, if the process is feasible.

i. $n \rightarrow p^+ + e^-$

ii. $\mu^- \rightarrow e^- + \nu_e + \nu_\mu$

iii. $\Lambda^o \rightarrow p + \pi^-$

iv. $\pi^o \rightarrow \gamma + \gamma$

(b) The ψ-meson has anomalously long lifetime. Why?

(c) Write a note on the (i) charge conjugation operator, (ii) time reversal operator, and (iii) TCP theorem.

$(2 \times 7 = 14)$

Q4. (a) Prove that the total cross-section of the $\pi^+ p$ scattering is three times the total cross-section of the $\pi^- p$ scattering in the pion-nucleon scattering.

(b) Justify the following statements with appropriate reasons:

i. A neutral pion can decay into two photons, but it can't decay into three photons.

ii. A ρ-meson can decay into two pions, but it can't decay into three pions.

iii. A φ-meson can decay into three pions, but it can't decay into two pions.

(c) Show that, in a nucleon-nucleon scattering, the cross-section of the process $(p + p \rightarrow d + \pi^+)$ is twice the cross-section of the process $(p + n \rightarrow d + \pi^o)$.

$(2 \times 7 = 14)$

Q5. (a) What is the eightfold way? Draw (i) baryon octet, and (ii) baryon decuplet. Also, write the quark content, charge, and strangeness of each particle in these multiplets in tabular form.

(b) Discuss the parity non-conservation in weak interactions using appropriate experimental observations.

(c) Using the neutral kaon system, explain the concept of CP violation along with experimental evidence.

$(2 \times 7 = 14)$

CENTRAL UNIVERSITY OF HARYANA

Fourth Semester Term End Examinations June 2023

Programme: M.Sc. (Physics) **Session: 2022-23**

Semester: Fourth **Max. Time: 3 Hours**

Course Title: Experimental Techniques in Nuclear and Particle Physics **Max. Marks: 70**

Course Code: SBS PHY 01 406 DCEC 3104

Instructions:

1. Question no. 1 has seven parts and students are required to answer any four. Each part carries three and half marks.

2. Question no. 2 to 5 have three parts and students are required to answer any two parts of each question. Each part carries seven marks.

Q 1. (4 x 3.5 = 14)

a) What is radioactivity? Write the units of radioactivity.

b) Discuss Bremsstrahlung process.

c) Define energy resolution and detection efficiency of detectors.

d) Explain the difference between the slow and fast neutrons.

e) A radioactive element has a half life of 25 hours. After what time will $1/8^{th}$ of the initial number of its atoms disintegrate?

f) What are NIM and CAMAC standards?

g) Write a short note on the HIRA facility.

Q 2. (2 x 7 = 14)

a) Explain Compton Scattering. What is the minimum energy of a gamma ray photon after Compton scattering, if original incident photon energy is 0.611 MeV?

b) Prove that the maximum energy that can be transferred from a charged particle of mass m with kinetic energy E to an electron of mass m_0 in a single collision is $4Em_0/m$.

c) Discuss interactions of fast electrons with matter.

Q3. (2 x 7 = 14)

a) Explain principle, construction, working and limitations of Proportional Counter.

b) Discuss the working principle and different types of semiconductor detectors.

c) What is Cherenkov radiation? Discuss classical theory for production of Cherenkov radiation in the Cherenkov detector.

Q 4. (2 x 7 = 14)

a) Describe different methods of pulse shaping.

b) Explain analog-to-digital converters.

c) What are preamplifiers and linear amplifiers? Discuss types of preamplifiers.

Q 5. (2 x 7 = 14)

a) What are various detector systems for heavy-ion reactions? Discuss in detail about the large neutron detector array.

b) Discuss the key elements of a particle collider. Also, write the detector requirements for a high-energy collider.

c) Discuss in detail about the CMS detector and its detection mechanism.

Central University of Haryana

Reappear Term End Examinations, June 2023

Programme: M.Sc. Physics | **Session: 2022-23**

Semester : IV | **Max. Time: 3 Hours**

Course Title: Nuclear Physics: Interaction & Detection | **Max. Marks: 70**

Course Code: SBS PHY 01 401 DCEC3104

Instructions:

1. **Question no. 1 has seven sub parts and students need to answer any four. Each sub part carries three and half Marks.**

2. **Question no. 2 to 5 have three sub parts and students need to answer any two sub parts of each question. Each sub part carries seven marks.**

Question No. 1. (4X3.5=14)

a) Write the configuration of protons for the nuclei $^{16}_{8}O$.

b) What are nuclear isomers?

c) Draw different shapes for deformed nuclei.

d) What do you mean by proton form factor?

e) What is dead time for a GM counter?

f) What are the characteristics of a ion source?

g) Write a note on quark structure of nucleon.

Question No. 2. (2X7=14)

a) Explain the concept of probing charge distribution with electron.

b) Explain the nuclear polarization in NN scattering.

c) Explain meson theoretical potential.

Question No. 3. (2X7=14)

a) Explain the single particle model for a nucleus.

b) Elaborate the various features of Nilsson model.

c) Explain the behavior of nucleus at high spin states.

Question No. 4. (2X7=14)

a) How radiations interact with matter? Elaborate

b) Explain the working of a semiconductor detector.

c) Discuss the working of a Cherenkov detector.

Question No. 5. (2X7=14)

a) Explain the working of a charge particle accelerator.

b) Write a note on Higgs boson.

c) Explain the working of a cockroft-walton accelerator.

CENTRAL UNIVERSITY OF HARYANA

End Semester Examinations June 2023

Programme: Integrated B.Sc. M.Sc. (Physics)

Semester: IV | **Session: 2022-23**

Course Title: Mathematical Physics III | **Max. Time: 3 Hours**

Course Code: SBS PHY03 401 CC 4004 | **Max. Marks: 70**

Instructions:

- Question no. 1 has seven parts and students need to answer any four. Each part carries three and half marks.
- Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks.

Q1. (a) Find the smallest positive integer n for which

$$\left[\frac{1+\iota}{1-\iota}\right]^n = 1$$

(b) Solve $x^4 + \iota = 0$

(c) Derive C-R equation in polar form?

(d) Show that the function e^z has an isolated essential singularity at $z = \infty$.

(e) What is Fourier transform of Dirac- Delta function.

(f) Find the Laplace transform of $(1 + \sin 2t)$.

(g) Discuss the change of scale property of Laplace transform.

$(4 \times 3.5 = 14)$

Q2. (a) If ω is cube root of unity, prove that $(1 - \omega)^6 = -27$

(b) Find the sum of residues of function

$$f(z) = \frac{\sin z}{z \cos z}$$

at its poles inside the circle $|z| = 2$

(c) If $w = \phi + \iota\, \psi$ represents the complex potential for an electric field and

$$\psi = x^2 - y^2 + \frac{x}{x^2 + y^2}$$

determine the function ϕ?

$(2 \times 7 = 14)$

Q3. (a) Explain Cauchy Integral formula. Also find out Cauchy Integral formula for derivative of an analytic function.

(b) Use residue calculus to evaluate the following integral

$$\int_0^{2\pi} \frac{d\theta}{5 - 3cos\theta}$$

(c) Using Cauchy Integral formula to evaluate

$$\int_c \frac{z}{(z^2 - 3z + 2)}$$

$(2 \times 7 = 14)$

Q4. (a) What is Modulation and Convolution theorem on Fourier transform?

(b) Find the Fourier cosine transform of

$$e^{-a^2x^2}$$

and hence evaluate Fourier sine transform of

$$xe^{-a^2x^2}$$

(c) Discuss the solution of Heat conduction problem by Fourier sine transform.

$(2 \times 7 = 14)$

Q5. (a) Find the Laplace transform of

$$\frac{(1 - \cos t)}{t^2}$$

(b) If $L[f(t)] = F(s)$ then prove that

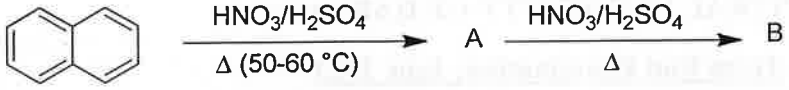
(b.1) $L[f(t-a).u(t-a)] = e^{-as}F(s)$

(b.2) $L[f(t).u(t-a)] = e^{-as}L[f(t+a)]$

(c) Using the Convolution theorem, find

$$L^{-1}\frac{s^2}{(s^2 + a^2)(s^2 + b^2)}$$

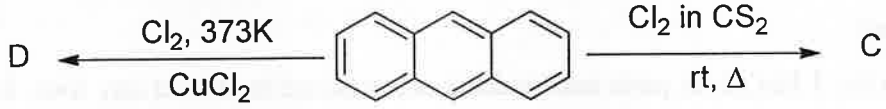
$(2 \times 7 = 14)$



(6)

b) What are Polynuclear hydrocarbons? Write down any two chemical reactions of Antracene. (6)

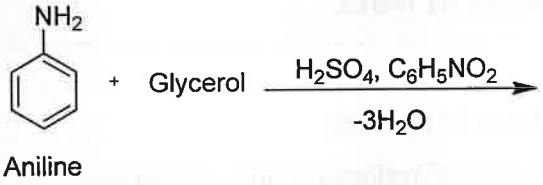
c) Identify the product **C** and **D** in the following conversions



(6)

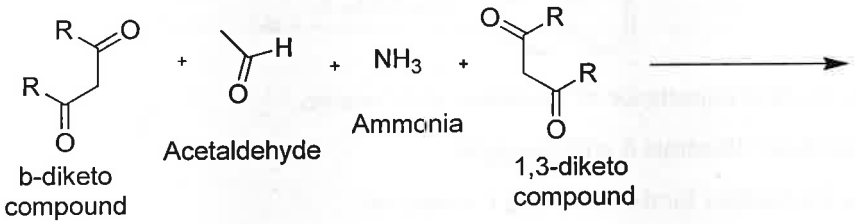
Question no. 4

a) Identify **A** and write a detailed mechanism of the given reaction. (6)



b) i) How will you prepare Quinoline from α-aminoaldehyde/ketone and another aldehyde/ ketone with at least one methylene carbon to the carbonyl. (3)

ii) Write down the mechanism for the following conversion



(3)

c) i) What is Doebner- Miller synthesis? Write down its mechanism. (3)

ii) Illustrate the mechanism of Pictet-Spengler reaction. (3)

Question no. 5

a) i) Write down an explanatory note on Hoffmann's exhaustive methylation. (3)

ii) Medicinal importance of Reserpine. (3)

b) i) Write down an explanatory note on Emde's modification. (3)

ii) Write down the structure elucidation of Nicotine. (3)

c) Write down the physiological action Quinine. (6)

Question no. 6

a) Write down the procedure of structure elucidation and synthesis of Citral. (6)

b) What is α-Terpineol? How its structure can be elucidated? (6)

c) Describe the occurrence and classification of Terpenes. How the structure of Neral was elucidated? (6)

CENTRAL UNIVERSITY OF HARYANA

Term End Examination, June 2023

Programme: Integrated B.Sc - M.Sc. Chemistry; Semester: IV **Session: June-July 2023**

Course Title: Organic Chemistry III – Heterocyclic Chemistry **Max. Time: 3 Hours**

Course Code: SBS CH 020402 C 4004 **Max. Marks: 70**

Instructions:

1. Question no. **1** has seven parts and students are required to answer any four. Each part carries two Marks.
2. Question no. **2** to **5** have three parts and student are required to answer any two parts of each question. Each part carries six marks.

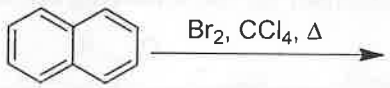
Question no. 1

a) Write down a short note on Dye Test.

b) Describe any one method of synthesis of nitro compounds.

c) Write down an explanatory note on basicity order and reactivity order of Furan, Thiophene and Oxazole.

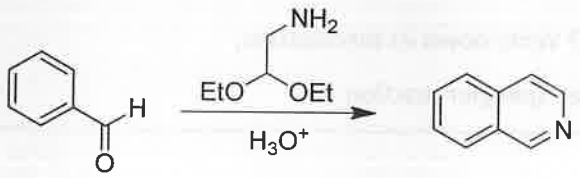
d) Complete the following reaction



e) Write down the medical importance of Morphine and Cocaine.

f) What is Isoprene Rule? Illustrate it with example.

g) Write down the mechanism for the following Conversion



(2 X 7)

Question no. 2

a) How will you differentiate primary, secondary tertiary and quaternary amines? (6)

b) Discuss the following with mechanism

i) Carbylamine Reaction ii) Mannich Reaction (3X2)

c) Describe any two important reactions of nitriles. (3X2)

Question no. 3

a) Identify **A** and **B** in the following conversion including mechanism.

CENTRAL UNIVERSITY OF HARYANA

Second Semester Term End Examinations July-2023

Programme: M.SC (Physics) **Session: 2022-23**

Semester: Second Semester **Max. Time: 3 Hours**

Course Title: Statistical Mechanics **Max. Marks: 70**

Course Code: SBS PHY 01 201 CC 3104

Instructions:

1. Question no. 1 has seven parts and students are required to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and students are required to answer any two parts of each question. Each part carries seven marks.

Q 1. (4X3.5=14)

a) Write short notes on:

(i) Postulate of equal a priori probability

(ii) Entropy of mixing of two samples of the same gas.

b) Explain second order phase transitions.

c) Derive the Sacker-tetrode equation for the entropy of a perfect gas.

d) Write short on:

(i) Partition Function

(ii) Phase Space.

e) Differentiate Between Microstates and Macrostates with examples.

f) Write Maxwell's Boltzmann's, Bose-Einstein and Fermi Dirac distribution laws. Under what condition Bose-Einstein and Fermi Dirac distribution laws reduce to classical -Maxwell's Boltzmann's distribution law?

g) What is the difference between a Boson and Fermion?

Q 2. (2X7=14)

a) Define various thermodynamic potentials, stating the conditions under which each is specially useful, and derive the four thermodynamic relations of Maxwell from the thermodynamic potentials U, F, H and G.

b) Show that for a homogeneous fluid

$$C_P - C_V = T\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial V}{\partial T}\right)_P$$

Hence prove that for a perfect gas $C_P - C_V = R$.

c) For silver, the molar specific heat at constant pressure in the range 50 to 100 K is given by $C_P = 0.076T - 0.00026T^2 - 0.15\ cal/K$, where T is the Kelvin temperature. If 2 moles of silver are heated from 50 to 100 K. calculate (i) heat required (ii) change in entropy.

Q3. (2X7=14)

a) Derive Liouville's theorem for the change of density of distribution with time and show that the density of phase points is conserved.

b) Explain probability. Give the physical interpretations for probability of a system as a function of its entropy.

c) State the law of equipartition of energy. Use the classical distribution law to prove that the average energy for each degree of freedom of a perfect gas molecule is $\frac{1}{2}kT$.

Q 4. (2X7=14)

a) The number of molecules in energy rangy range ε and $\varepsilon + d\varepsilon$ is given by

$$2\pi n\left(\frac{1}{\pi kT}\right)^{3/2} \varepsilon^{1/2} e^{-\varepsilon/kT} d\varepsilon$$

Deduce the expressions for the following:

(i) The most probable energy

(ii) The number of molecules containing most probable energy

(iii) The mean energy

b) How one may extend the treatment for a canonical ensemble to a Grand Canonical ensemble? Deduce the grand partition function and related thermodynamic parameters for an assembly of different kinds or molecules.

c) Explain the concept of an ensemble. Distinguish clearly between canonical, micro-canonical and grand canonical ensembles.

Q 5. (2X7=14)

a) What is Fermi energy? Derive an expression for Fermi energy at temperature T. Establish a relation between mean energy of electron and Fermi energy.

b) Deduce Bose-Einstein distribution formula and explain the phenomenon of Bose-Einstein condensation.

c) On the basis of quantum theory calculate (i) translational, (ii) vibrational and (iii) rotational partition functions for a single diatomic molecule and hence for a gas consisting of n diatomic molecules.

CENTRAL UNIVERSITY OF HARYANA

Term End Examinations July- 2023

Programme: Integrated BSc-MSc Physics **Session: 2022-23**

Semester: 2nd **Max. Time: 3 Hours**

Course Title: Waves and Optics **Max. Marks: 70**

Course Code: SBS PHY 03 202 CC 4004

Instructions:

1. Question no. 1 has seven parts and students are required to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and students are required to answer any two parts of each question. Each part carries seven marks.

Q 1. (4X3.5=14)

a) A simple harmonic oscillator is characterized by $y = a\cos wt$, calculate the displacement at which kinetic energy is equal to its potential energy.

b) Discuss why two independent sources of light can never be coherent?

c) A string 1.3 meter in length is divided into three segments such that their frequencies are in the ratio 2:3:4. Find the length of each segment.

d) Briefly explain Fresnel biprism?

e) A wave of frequency 400 Hz is travelling with a velocity 800 m/s. How far are two points situated whose displacement differ in phase by $\pi/4$?

f) Differentiate between transverse and longitudinal waves.

g) The ratio of intensities of two waves that produce interference pattern is 16:1. Deduce the ratio of maximum to minimum intensities in fringe system.

Q 2. (2X7=14)

a) Define forced oscillations. Derive and solve the differential equation of a forced harmonic oscillator. Obtain the condition of resonance.

b) Explain logarithmic decrement and relaxation time in damped harmonic system.

c) Discuss the composition of simple harmonic motions acting upon a particle simultaneously at right angles to each other with same time period but different in phase.

Q3. (2X7=14)

a) Discuss the energy transport in a plane progressive wave and derive an expression for energy density

b) Derive an expression for the velocity of longitudinal waves in gaseous medium.

c) What is organ pipe? Discuss the formation of standing waves in a pipe which is closed at one end.

Q 4. (2X7=14)

a) Describe the arrangement to observe Newton's ring by reflected light. Obtain an expression for the wavelength of light.

b) What are necessary conditions for the interference of light to be observable? Explain interference using Young's double slit experiment.

c) Describe the principal and working of Michelson's interferometer.

Q 5. (2X7=14)

a) Discuss Fraunhofer diffraction at a single slit and find the intensity of first order maxima and second order maxima.

b) Explain clearly the differences between Fresnel and Fraunhofer diffraction with neat diagrams. What are Fresnel's half period Zones?

c) Define resolving power and dispersing power of a grating. Obtain expressions for these in case of plane transmission grating.

CENTRAL UNIVERSITY OF HARYANA

Even Semester Term End Examinations June 2022

Programme: M.Sc. Physics **Session: 2021-22**

Semester: IV **Max. Time: 3 Hours**

Course Title: Thin Film and Integrated Device **Max. Marks: 70**

Course Code: SPMS PHY 01 405 DCEC 3104

Instructions:

1. Question no. 1 has seven parts and students are required to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student are required to answer any two parts of each question. Each part carries seven marks.

Q 1. (4X3.5=14)

a) What is an IC? Classify IC on behalf of fabrication technique, and chip size.

b) Explain float zone crystal growth method.

c) How many aspects of film quality can you name?

d) Working of rotary and sorption pump.

e) What are the different methods for melting the charge, and their advantages and disadvantages?

f) Differentiate between electron beam lithography and x-ray beam lithography?

g) How is film thickness controlled in evaporation systems?

Q 2. (2X7=14)

a) Draw the block diagram of any 16 pin IC. Name the pins or terminals in the IC to which DC power supply and ground have to be connected.

b) Describe CMOS process overview. Why do we use n-well in p-substrate for CMOS technology instead of using p-well in n-substrate?

c) Why Si is the most important semiconductor for the microelectronics industry? Write the basic steps in the formation of electronic grade silicon.

Q3. (2X7=14)

a) What is the principle, working and application of turbo molecular pump?

b) What is the principle, working and advantages of sputtering for thin film deposition? Distinguish sputtering versus thermal evaporation.

c) Classify CVD technique? Why is heterogeneous CVD preferred over homogeneous CVD? Explain metal organic chemical vapor deposition (MOCVD).

Q 4. (2X7=14)

a) What are the basic steps in lithography process? What is the purpose of a soft and post-apply bake?

b) What are the ingredients of a lithography process? What are the advantages and disadvantages of contact printing and proximity printing?

c) What is electron beam lithography? Explain its procedure, advantages, and drawbacks.

Q 5. (2X7=14)

a) Define density of states (DOS) for electrons. What information is provided by DOS about the structure of materials?

b) Illustrate ideal condition for the formation of p-n junction and metal semiconductor barrier.

c) What is Ohmic contact formation, and contact resistance?

CENTRAL UNIVERSITY OF HARYANA

Reappear, July 2023

Programme: M.Sc. Physics | **Session: 2022-23**

Semester : III | **Max. Time: 3 Hours**

Course Title: Nuclear Physics | **Max. Marks: 70**

Course Code: SBS PHY 01 302 CC 3104

Instructions:

1. Question no. 1 has seven sub parts and students need to answer any four. Each sub part carries three and half Marks.

2, Question no. 2 to 5 have three sub parts and students need to answer any two sub parts of each question. Each sub part carries seven marks.

Question No. 1. (4X3.5=14)

a) Write the configuration of protons for the $^{40}_{20}Ca$.

b) Write a note on Electromagnetic interactions.

c) List the assumptions of Fermi gas model.

d) What do you mean by Higgs field?

e) Write a note on scattering length

f) Why deuteron nucleus exhibits positive quadrupole moment?

g) Calculate radius of $^{56}_{28}Fe$ nucleus using Ngo parametrization.

Question No. 2. (2X7=14)

a) Discuss the properties of neutrinos.

b) What do you mean by nuclear disintegration? List different decay chains.

c) Discuss the electron capture phenomena.

Question No. 3. (2X7=14)

a) Discuss nucleon-nucleon scattering at low energy.

b) Derive expression for deuteron nuclear potential.

c) Show that nuclear forces are charge independent.

Question No. 4. (2X7=14)

a) Describe the semi-empirical mass formula.

b) Draw energy level diagram based on Shell model for proton configuration.

c) How spin-orbit coupling improved the Shell model?

Question No. 5. (2X7=14)

a) Discuss the CP and CPT invariance with suitable examples.

b) What are strange particle? Write a note on strangeness quantum number.

c) Discuss Strong interactions.

CENTRAL UNIVERSITY OF HARYANA
Jant-Pali, Mahendergarh, Haryana
Term End Examination July-2023

Name of Programme	: **M.Sc. Physics**	
Year & Semester	: **July 2023, Second Semester**	
Course Name	: **Mathematical Methods in Physics - II**	
Course Code	: **SBS PHY 01 203 CC 3104**	
Maximum Marks	: **70**	**Duration : 3 Hrs**

Note:
Attempt any Four parts in Question No. 1, each part carries 3.5 marks.
Attempt any 2 parts from each of the remaining questions. Each part carries 7 marks.

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1. (a) What are singular points in a second order linear differential equation. Describe your answer with the help of Laguerre equation.

   (b) Convert the Laplace partial differential equation (written in rectangular coordinates) into a set of ordinary differential equation using method of separation of variables.

   (c) What do you understand by spherical harmonics ? Describe their usefuleness.

   (d) The solutions of the linear oscillator equation $\frac{\partial^2 x}{\partial t^2} + \omega^2 t = 0$, are $x_1 = \sin\omega t$ and $x_2 = \cos\omega t$. Find the wronskian and comment whether the solutions are independent ?

   (e) Explain a real life example of the use of Laplace transformation.

   (f) Write the fourier series expansion of $f(x) = x^2$ for $-1 < x < 1$ and $f(x+2) = f(x)$.

   (g) Write the integral representation of dirac delta function using Fourier and inverse Fourier transformation.

2. a. Let $u(x,t)$ denote the temperature at position x and time t in a long, thin rod of length l that runs from $x = 0$ to $x = l$. Then the heat equation is given by

$$\frac{\partial}{\partial t}u(x,t) = \alpha^2 \frac{\partial^2}{\partial x^2}u(x,t)$$

   Assuming the boundary condition to be $u(0,t) = 0 = u(l,t)$ and the initial condition to be $u(x,0) = f(x)$, find the solution of heat equation using the method of separation of variables.

   b. Find the solution $L_n(x)$ of Laguerre equation using power series method.

   c. Show that $P_n(x)$, defined by $\frac{1}{\sqrt{1-2xt+t^2}} = \sum_{n=0}^{\infty} t^n P_n(x)$, satisfies Legendre's differential equation.

3. a. Prove that for the Associated Legendre polynomial we have

$$(n+1-m)P_{n+1}^m(x) = (2n+1)xP_n^m(x) - (n+m)P_{n-1}^m(x)$$

b. Change the Hermite ordinary differential equation into a Sturm Liouville form. Show that Hermite function follow the orthogonality relation with a weight factor equal to $exp(-x^2)$.

c. Show, by means of the Wronskian, that a linear, second-order, homogeneous ordinary differential equation of the form $y''(x) + P(x)y'(x) + Q(x)y(x) = 0$ cannot have three independent solutions.

4. a. Find the Fourier integral of

$$f(t) = \begin{cases} t & 0 < t < a, \\ 0 & t > a \end{cases}$$

b. If $\tilde{f}(k) = F\{f(x)\}$ represents the Fourier transform of $f(x)$ then show that

$$F\{(-ix)^n f(x)\} = \frac{d^n}{dk^n}\tilde{f}(k)$$

c. Use Fourier transform of $exp(-|t|)$ and the Parseval's theorem to show that

$$\int_{-\infty}^{\infty} \frac{d\omega}{(1+\omega^2)^2} = \frac{\pi}{2}$$

5. a. If $L[f(t)] = F(s)$ represents the Laplace transformation of $f(t)$, show that

$$L[t\cos(at)] = \frac{1}{s^2+a^2} - \frac{2a^2}{(s^2+a^2)^2}$$

b. Using the convolution theorem of Laplace transformations, prove that

$$\int_0^1 y^n(1-y)^m dy = \frac{n!m!}{(n+m+1)!}$$

c. Use the Laplace transform to solve the following differential equation

$$y'' + 2y' + y = 1$$

with the initial condition $y(0) = 2$ and $y'(0) = -2$

Remember

1. Associated Legendre equation : $(1-x^2)\frac{d^2}{dx^2}P_n^m(x) - 2x\frac{d}{dx}P_n^m(x) + \left[n(n+1) - \frac{m^2}{1-x^2}\right]P_n^m(x) = 0$
2. Bessel Equation : $x^2\frac{d^2}{dx^2}J_n(x) + x\frac{d}{dx}J_n(x) + (x^2-n^2)J_n(x) = 0$
3. Hermite Equation : $\frac{d^2}{dx^2}H_n(x) - 2x\frac{d}{dx}H_n(x) + 2nH_n(x) = 0$
4. Laguerre Equation : $x\frac{d^2}{dx^2}L_n(x) + (1-x)\frac{d}{dx}L_n(x) + nL_n(x) = 0$

CENTRAL UNIVERSITY OF HARYANA

Second Semester Term End Examinations July 2023

Programme: Integrated B.SC. - M.SC (Physics) **Session: 2022-23**

Semester: Second Semester **Max. Time: 3 Hours**

Course Title: Electricity and Magnetism **Max. Marks: 70**

Course Code: SBS PHY 03 201 CC 4004

Instructions:

1. Question no. 1 has seven parts and students are required to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and students are required to answer any two parts of each question. Each part carries seven marks.

Q 1. (4X3.5=14)

a) Use Coulomb's force to define the dielectric constant of a substance. The dielectric constant of pure water is 81. What will be the absolute permittivity of water?

b) Define electric lines of force. Do the two electric lines of force intersect each other? Give reason for your answer.

c) What do you mean by an equipotential surface? What is the direction of electric lines of force with respect to an equipotential surface?

d) Prove the relation E = - grad $\emptyset$, where the symbols have their used meanings.

e) State Gauss's law in magnetostatics. Does it have any concern with Maxwell's equations?

f) What is the relationship between permittivity (ϵ_0) and permeability (μ_0) of free space.

g) Prove that the magnetic field induction (B) can be represented by a vector potential.

Q 2. (2X7=14)

a) The electric potential at any point in the X- Y plane is given by
$\emptyset = 5x(x^2 + y^2)^{1/2} + y(x^2 + y^2)^{-1/2}$.
Find the Cartesian components of the electric field intensity at that point.

b) If 10 coulomb charge is placed at the centre of a cube of side 10 cm, calculate the flux coming out of any face of the cube.

c) A spherical charge distribution of radius a is given by

$$\rho = \rho_0\left(1 - \frac{r}{a}\right) = 0 \qquad for\ r \leq a$$

$$= 0 \qquad for\ r > a$$

Calculate

(i) The electric field strength at a point distance r from the centre (I) outside and (II) inside the charge distribution.

(ii) The value of r for which the field is maximum.

Q3. (2X7=14)

a) Show that $\emptyset = \frac{1}{r}$ satisfies Laplace's equation.

b) Three equal charges of $+6\times10^{-9}$ coulomb are located at the corners of an equilateral triangle, whose sides are 12 cm long. Find the potential at the centre of the base of the triangle.

c) Derive the expression for energy stored in a capacitor.

Q 4. (2X7=14)

a) Explain Biot-Savart law. Obtain the expression for magnetic field induction on the axis of a current carrying circular loop.

b) Explain the phenomenon of hysteresis in magnetic material using an example.

c) Derive the relationship between **H, B** and **M.**

Q 5. (2X7=14)

a) State and explain Faraday's laws of electromagnetic induction.

b) State and explain Norton's Theorem.

c) Derive the expression for energy stored in magnetic field

CENTRAL UNIVERSITY OF HARYANA
Jant-Pali, Mahendergarh, Haryana
Term End Examination July -2023

Name of Programme	:	**M.Sc. Physics**	
Year & Semester	:	**July 2023, Third Semester (Reappear)**	
Course Name	:	**General Theory of Relativity**	
Course Code	:	**SBS PHY 01 305 DCEC 3104**	
Maximum Marks	:	**70**	**Duration : 3Hrs**

Note:
(1) All Questions are compulsory. .
(2) Attempt any Four parts in Question No. 1, each part carries 3.5 marks.
(3) Attempt any two parts from each of the questions 2 to 5. Every part carries 7 marks.

Q1
a) Define the covariant derivative of a tensor.
b) Define the weak and strong equivalence principle.
c) Describe the phenomenon of bending of light in gravitational field.
d). Define a black hole based on the definition of Schwarzschild radius.
e). Define Killing vectors in General Relativity. What is their significance ?
f). Show that the spacetime volume $d^4x = dt\ d^3x$ is a Lorentz invariant quantity.
g). Consider a scalar quantity ϕ. Show that, the quantity $(\frac{\partial \phi}{\partial x^a})$ transforms as a tensor.

Q2.
a) Derive the expression for Lorentz transformation in General relativity.
b) Discuss the length contraction and time dilation in Special relativity.
c) Describe the thought experiment that prompted Einstein to move from Special relativity to General Relativity.
Q3. Establish the following identities for a general metric tensor $g_{\mu\nu}$:
a) $g^{\mu\nu}\Gamma^{\alpha}_{\mu\nu} = -(1/\sqrt{-g})(\sqrt{-g}g^{\alpha\beta})_{,\beta}$
b) $(g^{\mu\nu}g_{\nu\alpha,\beta}) = -(g^{\mu\nu}{}_{,\beta}g_{\nu\alpha})$
c) $g^{\mu\nu}_{,\alpha} = -\left(g^{\beta\nu}\Gamma^{\mu}_{\alpha\beta} + g^{\mu\beta}\Gamma^{\nu}_{\alpha\beta}\right)$
Q4.
a). Derive geodesic equation of motion of a particle in the presence of gravitation.
b). Derive the expression $g_{00} = 1 + 2\phi$ in the newtonian approximation of geodesic equation.
c). Define the Schwarzschild metric. What is the physical significance of this metric ?

Q5.
a) Write down the generic form of Einstein's equation in General Relativity. Prove that Einstein equations can also be written as : $R_{\mu\nu} = -\kappa[T_{\mu\nu} - \frac{1}{2}g_{\mu\nu}T]$
b) Write a short note on Gravitational Waves.
c) Describe the similarities between Electromagnetic theory and gneral theory of relativity on the basis of action principle.

End note :
$\Gamma^{\alpha}_{\mu\nu} = \frac{1}{2}g^{\alpha\beta}(g_{\beta\mu,\nu} + g_{\beta\nu,\mu} - g_{\mu\nu,\beta})$; $R^{a}_{bcd} = \partial_c\Gamma^{a}_{bd} - \partial_d\Gamma^{a}_{bc} + \Gamma^{e}_{bd}\Gamma^{a}_{ec} - \Gamma^{e}_{bc}\Gamma^{a}_{ed}$; $R_{ab} = R^{c}_{acb}$;
$R = g^{ab}R_{ab}$;

CENTRAL UNIVERSITY OF HARYANA

Second Semester Term End Examinations July 2023

Programme: M.Sc. Physics | **Session: 2022-23**

Semester: II | **Max. Time: 3 Hours**

Course Title: Quantum Mechanics-II | **Max. Marks: 70**

Course Code: SBS PHY 01 201 DCEC 3104

Instructions:

1. Question number 1 has seven sub parts and students need to answer any four. Each sub part carries three and half marks.
2. Question number 2 to 5 have three sub parts and students need to answer any two sub parts of each question. Each sub part carries seven marks.

Question Number 1. (4X3.5=14)

a) "Conservation of momentum is a consequence of translational symmetry". Prove this statement.

b) Find the operator $\hat{x}'$ obtained by applying a translation through a distance a to the operator $\hat{x}$.

c) Find the ground state energy and wavefunction of a system of four distinguishable spinless particles placed in an infinite potential well of size a.

d) Use the WKB approximation to calculate the energy levels of a spinless particle of mass m moving in a one-dimensional box with walls at x = 0 and x = L.

e) Prove the optical theorem, which relates the total cross-section to the imaginary part of the forward scattering amplitude: $\sigma = \frac{4\pi}{k} Im[f(0)]$.

f) The second-order correction to the energy of the ground state is always negative. Why?

g) Calculate the bound on the ground state energy of the Hamiltonian with an attractive delta function potential, namely, $H = -\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2} - \alpha\delta(x)$ using the variational principle with the trial wavefunction $\Psi(x) = A\exp(-bx^2)$.

Question Number 2. (2X7=14)

a) A particle of mass m is in a potential $V = \frac{1}{2}m\omega^2x^2$, where ω is a constant. Let $\hat{a} = \sqrt{\frac{m\omega}{2\hbar}}\left(\hat{x} + \frac{i\hat{p}}{m\omega}\right)$. Calculate $\frac{d\hat{a}}{dt}$ in the Heisenberg picture.

b) Determine the momentum operator $\hat{P}_H(t)$ in the Heisenberg picture for a one-dimensional harmonic oscillator.

c) Explain Schrodinger picture and Heisenberg picture in detail.

Question Number 3. (2X7=14)

a) A particle of charge Q and mass M, which is moving in a one-dimensional harmonic potential of frequency ω, is subjected to a weak electric field E in the X-direction. Determine the first-order and second-order correction to the energies.

b) Suppose we put a delta-function bump in the center of the infinite square well: $H' = \alpha\delta(x - a/2)$, where α is a constant. Find the first-order correction to the allowed energies. Explain why the energies are not perturbed for even n.

c) Estimate the ground state energy of the hydrogen atom using the trial wavefunction $\Psi(r, \theta, \Phi) = e^{-r/a}$ through the variational method.

Question Number 4. (2X7=14)

a) Calculate the differential cross section in the first-Born approximation for a Coulomb potential V(r) = $Z_1Z_2e^2$/r, where Z_1e and Z_2e are the charges of the projectile and target particles, respectively.

b) Consider the potential $V(\vec{r}) = \sum_i V_0 a^3 \delta^{(3)}(\vec{r} - \vec{r}_i)$, where $\vec{r}_i$ are the position vectors of the vertices of a cube of length a centered at the origin and V_0 is a constant. If $V_0 a^2 \ll \frac{\hbar^2}{m}$ then calculate the total scattering cross-section in the low-energy limit.

c) The differential cross-section for scattering by a target is given by, $\frac{d\sigma(\theta,\Phi)}{d\Omega} = a^2 + b^2 cos^2\theta$. If N is the flux of the incoming particles, then calculate the number of particles scattered per unit time.

Question Number 5. (2X7=14)

a) A particle, which is initially (t = 0) in the ground state of an infinite, one-dimensional potential box with walls at x = 0 and x = a, is subjected for $0 \leq t \leq \infty$ to a perturbation $\hat{V}(t) = \hat{x}^2 e^{-t/\tau}$. Calculate to first order the probability of finding the particle in its first excited state for $t \geq 0$.

b) For a Dirac Particle moving in a central potential, show that the orbital angular momentum is not a constant of motion.

c) Consider a spinless particle of mass $\boldsymbol{m}$, which is moving in a one-dimensional infinite potential well with walls at $x = 0$ and $x = a$. Find $\hat{X}_H(t)$ and $\hat{P}_H(t)$ in the Heisenberg picture.

CENTRAL UNIVERSITY OF HARYANA

End Semester Examination (June 2023)

Programme: Integrated B.Sc.-M.Sc. (Chemistry/Mathematics)

Semester: IV **Session: 2022-23**

Course Title: Modern Physics [GE] **Max. Time: 3 Hours**

Course Code: SBS PHY 03 401 GE 4004 **Max. Marks: 70**

Instructions:

- Question No. 1 has seven parts and the student needs to answer any four. Each part carries three and a half marks.
- Questions No. 2–5 have three parts each and the student needs to answer any two parts of each question. Each part carries seven marks.
- A personal, non-programmable, and non-communicating calculator may be allowed to use.

Q1. (a) Find the de Broglie wavelength of:

i. a ball of mass 66.3 g moving with velocity 100 m/s

ii. an electron moving with velocity 6.63×10^6 m/s.

(b) Mention the phenomenons that are in favour of:

i. the wave nature of radiation,

ii. particle nature of radiation
and hence explain wave-particle duality.

(c) Explain the meaning of linearity and superposition principle in the context of quantum mechanics.

(d) Calculate nuclear radii and nuclear densities of (i) ${}^{16}_{8}O$, and (ii) ${}^{56}_{26}Fe$ nuclei.

(e) The half life time of ${}^{222}Rn$ nucleus is 3.8 days. Find the mean lifetime, decay constant and activity of 1 mg of radon.

(f) Compare nuclear fission with nuclear fusion using adequate examples.

(g) What is NZ graph? Which of the following nuclei is expected to be more stable: ${}^{7}_{3}Li$ or ${}^{8}_{3}Li$?

$(4 \times 3.5 = 14)$

Q2. (a) Write a note on Compton effect and derive the expression for Compton shift. How does it favour the quantum theory of radiation?

(b) Explain photoelectric effect with the help of a labelled diagram. Also discuss the experimental findings of the photoelectric effect.

(c) State uncertainty principle and use it to explain that electron can not exist inside the nucleus.

$(2 \times 7 = 14)$

Q3. (a) Consider a particle trapped inside a one dimensional box of length L.

i. Find the probabilities to find the particle between 0.4 L and 0.6 L for the ground state and the first excited state.

ii. Calculate the expectation value of the position of the particle.

(b) Derive the expression for time-dependent Schrödinger' equation in three dimensions for a non-relativistic particle having mass 'm' and momentum 'p'.

(c) Derive the quantum mechanical operators associated with momentum and energy. Also write the expression to calculate the associated expectation values.

$(2 \times 7 = 14)$

Q4. (a) Consider a particle of mass 'm' confined in a field free region between two walls at x=0 and x=L. Assuming that the particle does not loose energy in collisions with the walls:

i. Obtain the expression for normalized wave-function.

ii. Draw the wave-functions and probabilities for ground and first excited states.

iii. Show that stationary energy levels of the particle are given by $\frac{n^2h^2}{8mL^2}$

(b) Discuss the motion of a particle across a rectangular potential barrier and show that there is finite probability that a particle with energy less than barrier can cross the barrier.

(c) What do you mean by binding energy per nucleon? Draw the binding energy per nucleon as a function of mass number. Also write the semi-empirical formula for binding energy and explain the meaning of each term.

$(2 \times 7 = 14)$

Q5. (a) Write a note on radioactive decay. Discuss in detail about the different kind of radioactive decays with examples and possible reasons of the decay.

(b) Draw a schematic diagram of a nuclear reactor depicting its general features. Also write the role of moderator and control rods.

(c) Write the fundamental β-decay and inverse β-decay processes. Explain why β-spectrum is continuous, whereas α-spectrum is continuous.

$(2 \times 7 = 14)$

CENTRAL UNIVERSITY OF HARYANA

End Semester Examinations July 2023

Programme: Integrated B.Sc. M.Sc. (Chemistry/Mathematics)

Semester: II **Session: 2022-23**

Course Title: Electricity and Magnetism (GE) **Max. Time: 3 Hours**

Course Code: SBS PHY 03 205 GEC 4004 **Max. Marks: 70**

Instructions:

- Question no. 1 has seven parts and students need to answer any four. Each part carries three and half marks.
- Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks.

Q1. (a) Find the expression for capacitance of a parallel plate capacitor having large plate area A and gap between them as d.

(b) Three equal charges of magnitude 'Q' are placed equispaced along the positive x-axis such that the distance between first and third charge is 4 m. Find the electric field at a height 1 m above the top of middle charge.

(c) Show that electric field can not exist inside a perfect conductor.

(d) Find the integral form of Ampere's law from the following expression $\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}$, where $\vec{B}$ is magnetic field, $\vec{J}$ is volume current density and μ_0 is magnetic permeability of the free-space.

(e) Justify why magnetic forces do no work.

(f) Find divergence of vector function $\vec{A} = \vec{r}/r^3$, where $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$.

(g) Why it is advised to necessarily wear rubber gloves and shoes when dealing with electrical appliances.

$(4 \times 3.5 = 14)$

Q2. (a) Find the expression for $\vec{C} = (\vec{a}_1 - \vec{a}_2) \times (\vec{a}_1 + \vec{a}_2)$. Given that $\vec{a}_1 = 6\hat{i} - 4\hat{j} + 4\hat{k}$ and $\vec{a}_2 = -7\hat{i} + \hat{j} - 2\hat{k}$.

(b) A vector function is given by $\vec{v} = v_x\hat{i} + v_y j + v_z\hat{k}$. Derive the expressions for $\vec{\nabla}.\vec{v}$ and $\vec{\nabla} \times \vec{v}$. Also, discuss the geometrical interpretation of $\vec{\nabla}.\vec{v}$ and $\vec{\nabla} \times \vec{v}$.

(c) Find curl of the following vector function: $\vec{A} = \hat{r}/r^2$. Given that $\hat{r} = \vec{r}/|r|$ and $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$.

$(2 \times 7 = 14)$

Q3. (a) Discuss Gauss's law in presence of dielectrics and show that the displacement field is given by $\vec{D} = \epsilon\vec{E}$, where ϵ is permittivity of the material.

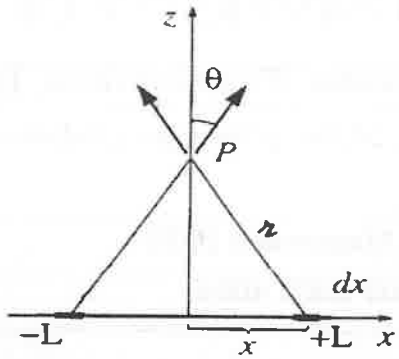

Figure 1: A wire of segment $2L$ having uniform charge density λ

(b) Prove that the electric field at a height z above the midpoint of a straight wire shown in Figure 1 is given by

$$\vec{E} = \frac{1}{4\pi\epsilon_0} \frac{2\lambda L}{z\sqrt{z^2 + L^2}} \hat{z} \tag{1}$$

(c) Show that the electric field due to an infinite straight wire carrying uniform charge density λ can be derived from Eq. (1). Also verify it by solving Gauss Law.

$(2 \times 7 = 14)$

Q4. (a) Find the expression for magnetic field due to a thin sheet current having uniform surface current density K.

(b) Discuss Ampere's law in magnetised matter. Establish the relation: $\mu = \mu_0(1 + \chi_m)$.

(c) Discuss briefly about the origin of magnetic field in matter. Compare dia, para and ferromagnetic materials on the basis of this discussion.

$(2 \times 7 = 14)$

Q5. (a) Explain Ampere's Maxwell law. Discuss it is in the case of charging of a capacitor for non-steady currents.

(b) Define the following: Electromagnetic wave, Poynting vector, Electromagnetic energy and Electromagnetic intensity.

(c) Represented below is an electromagnetic wave propagating in vacuum, whose electric field component is given by $\vec{E} = 4\sin(kx - \omega t)\hat{j}$, where $\omega = 8\pi$ radian/s. Find E, B, magnetic field $\vec{B}$, average value of energy (u), Poynting vector $(\vec{S})$, and intensity (I).

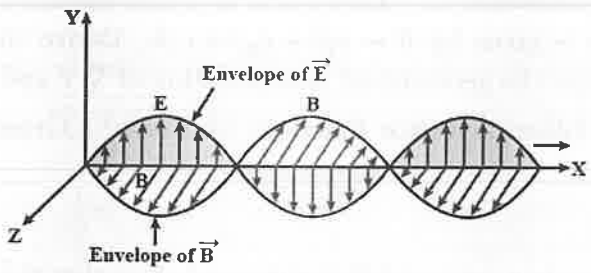

Figure 2: An electromagnetic wave propagating in free space

$(2 \times 7 = 14)$

CENTRAL UNIVERSITY OF HARYANA

End Semester Examination (June 2023)

Programme: Integrated B.Sc.-M.Sc. (Chemistry/Mathematics)

Semester: IV **Session: 2022-23**

Course Title: Modern Physics [GE] **Max. Time: 3 Hours**

Course Code: SBS PHY 03 401 GE 4004 **Max. Marks: 70**

Instructions:

- Question No. 1 has seven parts and the student needs to answer any four. Each part carries three and a half marks.
- Questions No. 2–5 have three parts each and the student needs to answer any two parts of each question. Each part carries seven marks.
- A personal, non-programmable, and non-communicating calculator may be allowed to use.

Q1. (a) Find the de Broglie wavelength of:

i. a ball of mass 66.3 g moving with velocity 100 m/s

ii. an electron moving with velocity 6.63×10^6 m/s.

(b) Mention the phenomenons that are in favour of:

i. the wave nature of radiation,

ii. particle nature of radiation
and hence explain wave-particle duality.

(c) Explain the meaning of linearity and superposition principle in the context of quantum mechanics.

(d) Calculate nuclear radii and nuclear densities of (i) ${}^{16}_{8}O$, and (ii) ${}^{56}_{26}Fe$ nuclei.

(e) The half life time of ${}^{222}Rn$ nucleus is 3.8 days. Find the mean lifetime, decay constant and activity of 1 mg of radon.

(f) Compare nuclear fission with nuclear fusion using adequate examples.

(g) What is NZ graph? Which of the following nuclei is expected to be more stable: ${}^{7}_{3}Li$ or ${}^{8}_{3}Li$?

$(4 \times 3.5 = 14)$

Q2. (a) Write a note on Compton effect and derive the expression for Compton shift. How does it favour the quantum theory of radiation?

(b) Explain photoelectric effect with the help of a labelled diagram. Also discuss the experimental findings of the photoelectric effect.

(c) State uncertainty principle and use it to explain that electron can not exist inside the nucleus.

$(2 \times 7 = 14)$

Q3. (a) Consider a particle trapped inside a one dimensional box of length L.

i. Find the probabilities to find the particle between 0.4 L and 0.6 L for the ground state and the first excited state.

ii. Calculate the expectation value of the position of the particle.

(b) Derive the expression for time-dependent Schrödinger' equation in three dimensions for a non-relativistic particle having mass 'm' and momentum 'p'.

(c) Derive the quantum mechanical operators associated with momentum and energy. Also write the expression to calculate the associated expectation values.

$(2 \times 7 = 14)$

Q4. (a) Consider a particle of mass 'm' confined in a field free region between two walls at x=0 and x=L. Assuming that the particle does not loose energy in collisions with the walls:

i. Obtain the expression for normalized wave-function.

ii. Draw the wave-functions and probabilities for ground and first excited states.

iii. Show that stationary energy levels of the particle are given by $\frac{n^2h^2}{8mL^2}$.

(b) Discuss the motion of a particle across a rectangular potential barrier and show that there is finite probability that a particle with energy less than barrier can cross the barrier.

(c) What do you mean by binding energy per nucleon? Draw the binding energy per nucleon as a function of mass number. Also write the semi-empirical formula for binding energy and explain the meaning of each term.

$(2 \times 7 = 14)$

Q5. (a) Write a note on radioactive decay. Discuss in detail about the different kind of radioactive decays with examples and possible reasons of the decay.

(b) Draw a schematic diagram of a nuclear reactor depicting its general features. Also write the role of moderator and control rods.

(c) Write the fundamental β-decay and inverse β-decay processes. Explain why β-spectrum is continuous, whereas α-spectrum is continuous.

$(2 \times 7 = 14)$

MSc (Physics} IInd Semester Exam July, 2023

SBS PHY01 202CC 3104 CLASSICAL ELECTRODYNAMICS

Max. Marks: 70 **Time: 3 Hrs.**

Instructions:

1. Question no. 1 has seven parts and students are required to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and students are required to answer any two parts of each question. Each part carries seven marks.

I Answer any 4 of the following briefly and to the point: **(3.5 X 4)**

(a) Show that the scalar potential satisfies Poisson's equation.

(b) What is the significance and usefulness of Green's function technique?

(c) What is the origin of Fermi Contact term? When does it contribute significantly?

(d) What is function of Coulomb Gauge?

(e) Bring out the differences between induced polarization and orientational Polarization. What is the effect of temperature on them?

(f) What are Stoke's parameters?

(g) How do scalar and vector potentials get modified when the charge density and current density are dependent on time?

II (a) Derive a relationship between polarizability of the molecule and the macroscopic electric susceptibility of a polar material. Hence, obtain the Clausius Mosotti relation.

(b) Starting from the electrostatic potential energy of a system of charges, drive expression for energy density of electric field and hence show that regions of higher electric field will have greater energy density.

(c) A charge distribution with spherical symmetry has density $\rho_v = \begin{pmatrix} \rho_0, & 0 \le r \le R \\ 0, & r > R \end{pmatrix}$.

Determine V everywhere and energy stored in region r < R. (7,7)

III (a) Starting from the expression of dipole field, calculate the energy of interaction of two permanent magnetic dipoles and hence define the Fermi contact term.

(b) Derive law of conservation of energy for em field and hence define the Poynting vector.

(c) A proton of mass m is projected into a uniform field B = B_0 a_z with an initial velocity $\alpha a_x + \beta a_z$. Find differential equation that the position vector $r = xa_x + ya_y + za_z$ must satisfy. Show that its solution describes a circular helix in space. (7,7)

IV (a) Starting from plane progressive solution of electromagnetic wave equation, show that the electromagnetic wave is transverse in nature. Also show that in an unbounded homogeneous medium, a plane monochromatic wave ravels with a phase velocity $c/\sqrt{\mu\epsilon}$.

(b) What are electromagnetic waveguides? Write corresponding Maxwell's equation in component form.

(c) Starting from electromagnetic wave equation in a homogeneous isotropic medium free of charges, show that the skin depth is a function of frequency of wave. What is the ratio of skin depth for copper at 10^4 Hz to that of 10^{10} Hz? Calculate the skin depth for copper at 10^{10} Hz, given that $\sigma \cong 5\ X\ 10^{17} s^{-1}$. (7,7)

V (a) Show by direct substitution that the retarded potential

$A(x,t) = \frac{1}{c}\int_{all\ space} \frac{f(x', t-\frac{|x-x'|}{c})}{|x-x'|} d^3x'$ satisfy the differential equation

$$\left(\nabla^2 - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}\right) A(x,t) = -\frac{4\pi}{c} J(x,t).$$

(b) Show that for a charge oscillating according to harmonic law $x = x_0 \cos(\omega_0 t + \alpha)$, the total mean intensity of radiation emitted is $p = \frac{e^2 \omega_0^4 x_0^2}{3c^3}$.

(c) In a transverse uniform electric field, show that the relativistically moving charged particle traverse a Catenary path. (7,7)