[This question paper contains 4 printed pages]

Your Roll No.....

G

Sr. No. of Question Paper : 1769

Unique Paper Code : 2222512301

Name of the Paper : Heat and Thermodynamics

Name of the Course : **B.Sc. (Prog.) Physical Science–NEP- UGCF**

Semester : III

Duration : 2 Hours Maximum Marks : 60

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Question no. **1** is compulsory.
3. Attempt any **five** questions including Question no. **1**.
4. **All** questions carry equal marks.
5. Use of non-programmable scientific calculators is allowed.

1. Attempt all parts. Each part carries equal marks.

(a) Explain the concept of temperature using the zeroth law of thermodynamics.

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(b) Calculate the change in entropy when 1 mole of an ideal gas expands isothermally to three times its original volume.

(c) Calculate the most probable velocity of a Maxwellian gas molecule of mass 5.31×10^{-26} kg at 300K.

(d) Determine the wavelength corresponding to the maximum emissivity of a black body at a temperature T equal to 3 K and 5000 K. In what spectral region will the wavelengths be found?

(12)

2. (a) Using the first law of thermodynamics, prove that,

(i) For one mole of an ideal gas, $C_P - C_V = R$

(ii) If E_S and E_T are adiabatic and isothermal elasticity respectively, then

$$E_S/E_T = C_P/C_V = \gamma$$

(4,4)

(b) 1 mole of a perfect gas initially at 27°C is compressed adiabatically such that its pressure becomes 10 times its initial value. Calculate,

(i) Its temperature after compression

(ii) Work done during the process

Given : $\gamma = 1.4$

(4)

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3. (a) What are Kelvin-Planck statement and Clausius statement of second law of thermodynamics? Show that both the statements are equivalent. Hence derive the mathematical expression of second law of thermodynamics in terms of entropy. (8)

(b) The efficiency of Carnot's engine is 1/5. By decreasing the temperature of the sink by 50K while keeping the source at the same temperature, it increases to 1/3. Find the temperatures of the source and the sink. (4)

4. (a) Define the four thermodynamic potentials? Deduce Maxwell's thermodynamic relations using fundamental equations of thermodynamic potentials. (9)

(b) Prove the following, (symbols have their usual meaning)

$$\left(\frac{\partial H}{\partial P}\right)_T = V - T\left(\frac{\partial V}{\partial T}\right)_P$$ (3)

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5. (a) Define mean free path λ of the molecules of a gas. If d is the diameter of each molecule and n is the no. of molecules per unit volume, derive expression for λ assuming that all the molecules except the one under consideration are at rest. (8)

(b) Write the expression for the coefficient of viscosity η of an ideal gas in terms of mean free path. How does it vary with absolute temperature of the gas? (4)

6. (a) Describe the spectral distribution of the black body radiation. How does Planck's radiation law lead to Rayleigh's radiation law? (9)

(b) Determine the temperature and the power radiated from 1 cm^2 of stellar surface of the sun with λ_{max} = 5100 Å considering the stellar surface to be a blackbody. (3)

7. (a) What are the salient features of Maxwell Boltzmann statistics? Describe qualitatively how these features are different from Bose-Einstein and Fermi Dirac statistics. (8)

(b) Calculate and show the number of ways of arranging four Bosons in seven different states. (4)

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Values of Constants:

Boltzmann's constant, $k = 1.38 \times 10^{-23} JK^{-1}$

Universal gas constant, $R = 8.31\ Jmol^{-1}K^{-1}$

Wien's constant, $b = 2.898 \times 10^{-3}$ mK

[This question paper contains 8 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 1784 5 G

Unique Paper Code : 2353572003

Name of the Paper : Theory of Equations and Symmetries

Name of the Course : **B.Sc. (Phys. Sci. and Math. Sci.) with Operational Research**

Semester : III

Duration : 3 Hours Maximum Marks : 90

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.

2. Attempt **all** questions by selecting any **three** parts from each question.

3. Part of the questions to be attempted together.

4. Each question carries equal marks.

5. Use of Calculator not allowed.

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P.T.O.

1. Solve any **three** of the following :

(a) Without actual division find the remainde with $x^3 - 3x^2 + 6x - 5$ is divided by $x - 3$.

(b) Find a quartic equation having the root 2 a ro triple root 1.

(c) Prove that every equation of n degrees at m roots, counting multiplicity.

(d) What is the condition that $ax^2 + bx + c = 0$ sl have a double root?

2. Solve any **three** of the following :

(a) Using synthetic division divide $2x^5 - x^3 + 2x -$ by $x + 2$.

b) Prove that every equation of an even degree with positive leading coefficient, whose zero degree term is negative, has at least two real roots, one positive and the other negative.

(c) Show that if an equation is complete, the number of continuations of sign in f(x) is same as the number of variations of sign in f(−x).

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d) Using Newton's method find all the integral roots of $x^4 - 9x^3 + 24x^2 - 23x + 15 = 0$.

3. Solve any **three** of the following :

(a) Find the equation whose roots are recipro the roots of

$$x^4 - 3x^3 + 7x^2 + 5x - 2 = 0.$$

(b) Find the equation whose roots are roots of

$$x^5 + 4x^3 - x^2 + 11 = 0,$$

each diminished by 3.

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(c) Explain the Cardan's method for the solution cubic equations.

(d) Find the five fifth roots of 1.

4. Solve any **three** of the following :

(a) Remove the fractional coefficients from the equation $x^3 - \frac{5}{2}x^2 - \frac{7}{18}x + \frac{1}{108} = 0$.

(b) Transform the equation $x^4 - 4x^3 - 18x^2 - 3x + 2 = 0$ into one which shall want the second degree term.

(c) Solve the equation $x^3 - 18x - 35 = 0$ by using Cardan method.

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(d) Solve the equation using relations between roots and coefficients;

$$x^3 - 9x^2 + 23x - 15 = 0,$$

given that the roots are in arithmetical progression.

5. Solve any **three** of the following :

(a) If α, β, γ are the roots of $x^3 + px^2 + qx + r = 0$, so that $\Sigma\alpha = -p$, $\Sigma\alpha\beta = q$, and $\alpha\beta\gamma = -r$. Prove that

$$\Sigma\alpha \,.\, \Sigma\alpha\beta = \Sigma\alpha^2\beta + 3\alpha\beta\gamma$$

where $\Sigma\alpha^2\beta = 3r - pq$.

(b) If α, β, γ are the roots of $x^3 + px^2 + qx + r = 0$, find $\sum \frac{\beta^2 + \gamma^2}{\beta\gamma}$.

(c) For the cubic equation $x^3 + px^2 + qx + r = 0$ find the value of $\Sigma\alpha^2$.

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(d) Given the cubic equation $x^3 + c_1x^2 + c_2x + c_3 = 0$ with roots $\alpha_1, \alpha_2, \alpha_3, \alpha_4$, show that

$$\sum_{i=1}^{4} \alpha_i^4 = c_1^4 - 4c_1^2c_2 + 4c_1c_3 + 2c_2^2 .$$

6. Solve any **three** of the following :

(a) If $\alpha, \beta, \gamma, \delta$ are the roots of $x^4 + px^3 + qx^2 + rx + s = 0$, find $\sum \frac{\beta\gamma + \gamma\delta + \beta\delta}{\beta + \gamma + \delta - 3}$.

(b) Eliminate the second degree term from the equation $x^3 + 6x^2 - 7x - 4 = 0$.

(c) Find the equation whose roots are the squares of the root of $x^4 + x^3 + 2x^2 + x + 1 = 0$.

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(d) If α, β, γ are the roots of $x^3 + px^2 + qx + r = 0$, find the equation whose roots are

$$\beta^2 + \beta\gamma + \gamma^2,\ \gamma^2 + \gamma\alpha + \alpha^2,\ \alpha^2 + \alpha\beta + \beta^2.$$

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[This question paper contains 8 printed pages.]

Your Roll No.....

13

Sr. No. of Question Paper : 831 G

Unique Paper Code : 2352572301

Name of the Paper : Differential Equations

Name of the Course : **B.Sc. (Physical Science and Mathematical Science) with Operational Research and Bachelor of Arts**

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Semester : III

Duration : 3 Hours Maximum Marks : 90

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.

2. Attempt **all** questions by selecting **two** parts form each question.

3. **All** questions carry equal marks.

1. (a) Show that the homogeneous equation

$$(Ax^2 + Bxy + Cy^2)dx + (Dx^2 + Exy + Fy^2) = 0$$

is exact if and only if $B = 2D$ and $E = 2C$. Also solve the initial value problem

$$(2x^2y^2 - y^3 + 2x)dx + (2x^3y - 3xy^2 + 1)dy = 0,$$
$$y(-2) = 1.$$

(7½)

(b) Show that $y = 4e^{2x} + 2e^{-3x}$ is a solution of the initial value problem

$$\frac{d^2y}{dx^2} + \frac{dy}{dx} - 6y = 0 \quad y(0) = 6, \quad y'(0) = 2.$$

Is $y = 2e^{2x} + 4e^{-3x}$ also a solution of this problem? Explain why or why not.

(7½)

(c) Consider the equation $a\left(\frac{dy}{dx}\right) + by = ke^{-\lambda x}$, where a, b and k are positive constants and λ is nonnegative constant.

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(i) Solve this equation.

(ii) Show that if $\lambda = 0$ every solution approaches $\frac{k}{b}$ as $x \to \infty$, but if $\lambda > 0$ every solution approaches 0 as $x \to \infty$.

(7½)

2. (a) Find the orthogonal trajectories of the family of circles $x^2 + y^2 = 100$ and family of Parabolas $y = 10x^2$. (7½)

(b) The population x of a certain city satisfies the logistic law

$$\frac{dx}{dt} = \frac{1}{100x} - \frac{1}{(10)^8}x^2$$

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where time t is measured in years. Given that the population of this city is 100,000 in 1980, determine

the population as a function of time for $t > 1980$. In particular answer the following questions :

(i) What will be the population in 2000?

(ii) In what year the does the 1980 population double? (7½)

(c) Solve the Homogeneous differential equation

$2r(s^2 + 1)dr + (r^4 + 1)ds = 0.$ (7½)

3. (a) Find the general solution of

$$\left(x^2+2x\right)\frac{d^2y}{dx^2}-\frac{2(x+1)dy}{dx}+2y=1$$

Given that $y = (x + 1)$ and $y = (x + 1)^2$ are linearly independent solutions of the corresponding homogeneous equation. (7½)

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(b) Find the general solution of the differential equation

$$x^2\frac{d^2y}{dx^2}+x\frac{dy}{dx}+4y=2x\ln x, \qquad x>0 \qquad (7\tfrac{1}{2})$$

(c) Define Quasi–linear, Semi–linear and linear first order partial differential equation and give one example each. Also show that a family of spheres $x^2 + y^2 + (z-c)^2 = r^2$ satisfies the first order linear partial differential equation $y\frac{dz}{dx}-x\frac{dz}{dy}=0$. (7½)

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4. (a) Use the method of variation of parameter to find a particular solution of the differential equation :

$$\frac{d^2y}{dx^2}+6\frac{dy}{dx}+9y=\frac{e^{-3x}}{x^3}. \qquad (7\tfrac{1}{2})$$

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(b) Use the method of undetermined coefficients to find the particular solution of the differential equation :

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$$\frac{d^2y}{dx^2} - 3\frac{dy}{dx} - 4y = 16x - 12e^{2x}.$$ (7½)

(c) Given that $y = e^{2x}$ is a solution of

$$(2x+1)\frac{d^2y}{dx^2} + 4(x+1)\frac{dy}{dx} + 4y = 0.$$

Find a linearly independent solution by reducing the order. Write the general solution. (7½)

5. (a) Find the solution of Cauchy problem for first order PDE.

$$2\frac{\partial u}{\partial x} + 3\frac{\partial u}{\partial y} + z = 0 \text{ with } u(x, 0) = \sin x$$ (7½)

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(b) Find the Solution of characteristic equation for the first order PDE.

$$\frac{\partial u}{\partial x} + 2x\frac{\partial u}{\partial y} = 2xu \text{ with } u(x, 0) = x^2 \qquad (7\tfrac{1}{2})$$

(c) Find the general solution of the equation :

$$(cy - bz)zx + (az - cz)zy = bx - ay \qquad (7\tfrac{1}{2})$$

(a) Solution general solution of Cauchy problem for first order PDE.

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$$\frac{\partial u}{\partial x} + x\frac{\partial u}{\partial y} = \left(\frac{y-1}{2x^2}\right)^2 \text{ with } u(0, y) = \exp(y) \qquad (7\tfrac{1}{2})$$

(b) Find the general solution of the partial differential equation :

$$x^2(y - u)u_x + y^2(u - x)u_y = u^2(x - y) \qquad (7\tfrac{1}{2})$$

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(c) Reduce the equation :

$$y^2 u_{xx} + x^2 u_{yy} = 0, \; x \neq 0, \; y \neq 0,$$ find the general solution. (7½)

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[This question paper contains 4 printed pages.]

Your Roll No.....

21

Sr. No. of Question Paper : 851 G

Unique Paper Code : 2352572301

Name of the Paper : Differential Equations

Name of the Course : **B.Sc. (Physical Science and Mathematical Science) with Operational Research and Bachelor of Arts**

Semester : III

Duration : 3 Hours Maximum Marks : 90

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **all** questions by selecting **two** parts form each question.
3. **All** questions carry equal marks.

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1. (a) Find the general solution of the Bernoulli equation given by $\frac{dy}{dx}+\frac{y}{2x}=\frac{x}{y^3}$ with initial condition $y(1)=2$. Also find an integrating factor for the linear differential equation

$$\frac{dy}{dx}+\left(\frac{2x+1}{x}\right)y=e^{-2x}.$$ (7½)

P.T.O.

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(b) Find the general solution of the differential equation $(x^2 - 3y^2)dx + 2xy\,dy = 0$ by showing it's a homogeneous equation. Also show that $M(tx, ty) = tM(x, y)$ for $M = y + \sqrt{x^2 + y^2}$. (7½)

(c) Determine the most general $N(x,y)$ for the equation $(x^{-2}y^{-2} + xy^{-3})dx + N(x, y)dy = 0$ such that the equation is exact and solve the resulting exact equation. (7½)

2. (a) Assume that the population of a certain city increase at a rate proportional to the number of inhabitants at any time, if the population doubles in 40 years, in how many years will it triple? (7½)

(b) Show that the relation $x^2 + y^2 - 25 = 0$ is an implicit solution of the differential equation $x + y\frac{dy}{dx} = 0$ on the interval $-5 < x < 5$. Explain whether the relation $x^2 + y^2 + 25$ is also an implicit solution of $x + y\frac{dy}{dx} = 0$. (7½)

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(c) Find the particular solution of the linear system that satisfies the stated initial conditions :

$$\frac{dy_1}{dt} = y_1 + y_2, \quad y_1(0) = 1$$

$$\frac{dy_2}{dt} = 4y_1 + y_2, \quad y_2(0) = 6.$$ (7½)

3. (a) Solve the initial value problem :

$$x^2y'' + 3xy' + y = 0, \; y(1) = 4, \; y'(1) = -1.$$ (7½)

(b) Find a homogeneous linear ordinary differential equation for which two functions x^{-3} and $x^{-3} \ln x \; (x > 0)$ are solutions. Show also linear independence by considering their Wronskian. (7½)

(c) Consider the initial value problem :

$$\frac{dy}{dx} = 1 + y^2, \; y(0) = 0.$$

Examine the existence and uniqueness of solution in the rectangle : $|x| < 5, \; |y| < 3$. (7½)

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4. (a) Find a general solution of the following nonhomogeneous differential equation :

$$y'' + 4y' + 4y = e^{-2x} \sin 2x.$$ (7½)

(b) Use the method of undetermined coefficients to find the particular solution of the differential equation :

$$y'' - 2y' + y = x^2 + e^x.$$ (7½)

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(c) Use the method of variation of parameters to find a particular solution of the differential equation : $y'' + y = \tan x \sec x$. (7½)

5. (a) Find the general solution of the equation.

$$(x-y)y^2u_x + (x-y)x^2u_y = (x^2+y^2)u$$ (7½)

(b) Eliminate the constants a and b from the equation

$$2z = (ax+y)^2 + b$$ (7½)

(c) Solve the initial value problem :

$$u_t + uu_t = x, \quad u(x, 0) = 1$$ (7½)

6. (a) Find the general solution of the linear partial differential equation.

$$x(y^2-z^2)u_x + y(z^2-x^2)u_y + z(x^2-y^2)u_z = 0$$

(7½)

(b) Use $v = \ln u$ and $v = f(x) + g(y)$ to solve the equation.

$$x^2 u_x^2 + y^2u_y^2 = u^2$$ (7½)

(c) Reduce the equation: $x^2 u_{xx} + 2x\, u_{xy} + y^2 u_{yy} = 0$ to canonical form and hence find the general solution. (7½)

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[This question paper contains 4 printed pages.]

Your Roll No.....

25

G

Sr. No. of Question Paper : 4875

Unique Paper Code : 42227929

Name of the Paper : Elements of Modern Physics

Name of the Course : **B.Sc. (Prog.) Physical Science : DSE**

Semester : V

Duration : 3 Hours

Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all.
3. Question No. **1** is compulsory.
4. **All** questions carry equal marks.
5. Non-programmable scientific calculators are allowed.

1. All parts are compulsory : (3×5=15)

(a) If the time lapse between the excitation of atom and emission of radiation by it is 10^{-8} s, then determine the uncertainty in the frequency of emitted photon.

(b) What value of n is associated with the Lyman series line in hydrogen whose wavelength is 102.6 nm?

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P.T.O.

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(c) Explain the physical significance of wavefunction. What are the conditions that the wave function of a particle must obey?

(d) What is the maximum percentage change in the wavelength of a 2.00 Å photon scattered by an electron?

(e) Plot and explain the variation of binding energy per nucleon with atomic mass number.

2. (a) A beam of monochromatic X rays of wavelength λ is scattered by a free electron. Derive an expression for the wavelength of scattered radiation. Discuss the significance of this effect. Explain why this effect cannot be observed with visible light.

(b) The work function of potassium is found to be 2.1 eV. Calculate the threshold wavelength. What should be wavelength of incident radiation if the stopping potential for electrons is 0.43 V?

(10,5)

3. (a) Enlist two shortcomings of Rutherford's atomic model and explain how Bohr's model overcome these discrepancies.

(b) Give de-Broglie's explanation of energy quantization which was postulated in Bohr's model. Draw the de Broglie waves corresponding to n=3 energy state of Bohr theory.

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(c) The energy of an excited hydrogen atom is -0.85 eV. Calculate the angular momentum of the electron according to Bohr's theory. (5,5,5)

4. (a) Establish the time dependent Schrodinger's wave equation for a non relativistic particle. Using this equation, obtain an expression for time independent Schrodinger's wave equation.

(b) Normalize the following wave function :

$\psi(x) = e^{-|x|} \sin \alpha x$, where α is constant.

(10,5)

(a) A particle of mass m and energy $E > V_0$ travelling along x direction has a potential barrier defined as :

$$V(x) = \begin{cases} 0 & \text{for} \quad x < 0 \\ V_0 & \text{for} \quad x > 0 \end{cases}$$

Derive an expression for transmission and reflection coefficient.

(b) Calculate the ratio E/V_0 so that the probability of transmission is 80%? (10,5)

(a) What conservation laws were apparently violated due to the continuous energy distribution of the β-decay electrons? How did Pauli's proposal of new particle overcome these violations?

(b) What is meant by activity of a radioactive sample? The half-life of $_{92}U^{238}$ is 4.5×10^9 y. Calculate the activity of 1 gm of $_{92}U^{238}$.

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P.T.O

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(c) Calculate the minimum energy required to break a $^{4}_{2}He$ nucleus into free protons and neutrons? Given that the mass of $^{4}_{2}He$ atom, proton and neutron is 4.002603 u, 1.007276 u and 1.008665 u respectively. (5,5,5)

7. (a) Using Heisenberg Uncertainty principle, show that an electron cannot be a constituent of the atomic nucleus.

(b) Write the semi-empirical mass formula for calculation of the binding energy of a nucleus. Calculate the binding energy per nucleon for $^{91}Zr_{40}$. The values of coefficients are :

a1 = 14.1 MeV, a2 = 13.0 MeV, a3 = 0.595 MeV, a4 = 19.0 MeV, a5 = 33.5 MeV.

(c) Calculate the total energy released when 1.0 kg of $^{235}_{92}U$ undergoes fission completely, assuming energy released per fission to be 200 MeV. (5,5,5)

Constants

$m_e = 9.1 \times 10^{-31}$ kg

$h = 6.626 \times 10^{-34}$ Js

$c = 3 \times 10^{8}$ ms^{-1}

$R = 1.097 \times 10^{7}$ m^{-1}

$N_A = 6.023 \times 10^{23}$ atoms/mol

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[This question paper contains 8 printed pages.]

29 **Your Roll No.....**

Sr. No. of Question Paper : 4979 **G**

Unique Paper Code : 42227929

Name of the Paper : Elements of Modern Physics

Name of the Course : **B.Sc. (Prog.) Physical Science – (DSE)**

Semester : V

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.

2. Attempt **five** questions in all.

3. Question No. **1** is compulsory.

4. **All** questions carry equal marks.

5. Non-programmable scientific calculators are allowed.

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1. All parts are compulsory : (3×5=15)

(a) A metal whose work function is 4.2 eV is irradiated by radiation of 2000 Å wavelength. Find the maximum kinetic energy of emitted electrons.

(b) Estimate the minimum uncertainty in the velocity of a proton confined in a nucleus of radius 10^{-14} m.

(c) A wave function of a particle is given by $\psi(x) = Ae^{-kx}$ over the domain $0 \le x \le \infty$ (Assume $\psi(x) = 0$ outside this domain.), where A and k are constants. Find the normalization constant A in terms of k.

(d) The wavefunction associated with a particle is given as $\psi(x) = \sqrt{\frac{2}{L}} \sin\left(\frac{3\pi x}{L}\right)$ in region $0 \le x \le L$, and $\psi(x) = 0$ otherwise. Calculate the probability of finding the particle in interval $\frac{L}{3} \le x \le \frac{2L}{3}$.

(e) Write salient features of nuclear forces.

(a) Show that the de Broglie wavelength associated with electron which is accelerated from rest through a potential difference V volt (non-relativistic case) is

$$\lambda = \frac{12.3}{\sqrt{V}} \text{Å} .$$

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(b) A photon of energy 3 keV collides with an electron initially at rest. If the photon emerges at an angle 60°, calculate the angle at which the electron recoils.

(c) In a typical Davisson-Germer experiment, the first maxima in the diffraction pattern of 54 eV electrons was observed at $\phi = 60°$ from an unknown target, where ϕ is the angle between the incident and scattered beams. Determine the lattice constant D of the target. (5,5,5)

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3. (a) What is energy-time uncertainty principle? Discuss the gamma ray microscope thought experiment and explain how it validates Heisenberg's uncertainty principle.

(b) Calculate series limit wavelengths corresponding to Balmer and Paschen series of hydrogen spectra.

(10,5)

(a) A particle of mass m is confined in a one dimensional infinitely rigid box having potential

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$$V(x) = \begin{cases} \infty & x < -L/2 \\ 0 & -L/2 \le x \le L/2 \\ \infty & x > L/2 \end{cases}$$

Find the wave functions associated with the particle and its energy E.

(b) When light of given wavelength is incident on a metallic surface, the stopping potential for the photoelectrons is 3.2 V. If a second light source

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whose wavelength is double that of the first is used, the stopping potential drops to 0.8 V. Calculate the work function and the cut-off frequency of the metal. (10,5)

5. (a) A particle of mass m and energy $E < V_0$ travelling along x-axis has a potential barrier defined by

$$V(x) = \begin{cases} 0 & x < 0 \\ V_0 & 0 < x < L \\ 0 & x > 0 \end{cases}$$

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Write Schrodinger equations and their solutions for three regions, explain each term of the solutions.

(b) The transmission probability of an electron across a potential barrier of 10 eV is equal to 0.8%. If the width of the potential barrier is 0.6 nm, calculate the energy of incident electron using the approximate formula.

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(c) Calculate the de Broglie wavelength for a proton of kinetic energy 70 MeV. (5,5,5)

6. (a) For following wavefunction

$$\psi(x, t) = A(\sin kx + iB\cos kx)e^{-i\omega t}$$

where A, B, k, ω are real constants. Calculate probability density and probability current density.

(b) The time-independent wave function of a particle of mass m moving in a potential $V(x) = \alpha^2 x^2$ is

$\psi(x) = \exp\left(-\sqrt{\frac{m\alpha^2}{2\hbar^2}}x^2\right)$, α being a constant. Find the energy of the system. (10,5)

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7. (a) What is positive beta decay and negative beta decay? Explain giving examples.

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(b) One gram of ^{226}Ra has an activity of 1 curie. From this fact determine the half life of ^{226}Ra. How much time will it take to decay 0.75 g of ^{226}Ra?

(c) The nucleus $^{23}_{10}Ne$ decays by negative beta-emission. Determine the maximum kinetic energy (in Joule) of the electrons emitted. Given that :

$m(^{23}_{10}Ne) = 22.994466\,u$

$m(^{23}_{11}Na) = 22.089770\,u.$

(5,5,5

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Constants :

$h = 6.62 \times 10^{-34}$ J.s

$c = 3 \times 10^{8}$ m/s

$e = 1.6 \times 10^{-19}$ C

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$m_e = 9.1 \times 10^{-31}$ kg

$m_n = 1.6749 \times 10^{-27}$ kg $= 1.00866$ u

$m_p = 1.6726 \times 10^{-27}$ kg $= 1.00728$ u

$R = 1.097 \times 10^{7}\ m^{-1}$

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