[This question paper contains 8 printed pages.]

Your Roll No..............

Sr. No. of Question Paper : 1593 **G**

Unique Paper Code : 2222011102

Name of the Paper : Mechanics

Name of the Course : **B.Sc. Hons. (Physics)**

Semester : I

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. **All** Questions carry equal marks.
3. Q. No. **1** is compulsory.
4. Answer **any four** of the remaining five questions.
5. Use of non-programmable scientific calculators are allowed.

1. Attempt all parts of this question.

   (i) A block of mass 2 kg is placed on a frictionless platform and the coefficient of static friction

P.T.O.

between theblock and the platform is 0.6. The platform is subjected to an acceleration a. Determine the maximum acceleration of the platform such that the block does not slip on it. (3)

(ii) Find the work done in moving a particle from the point A(–2, 1, 3) to B(1, –2, –1) in the force field

$$\vec{F} = \left(y^2z^3 - 6xz^2\right)\hat{i} + 2xyz^3\hat{j} + \left(3xy^2z^2 - 6x^2z\right)\hat{k}.$$

(3)

(iii) A cosmic ray proton with energy 10^{20} eV crosses our galaxy, which has diameter of about 10^5 light years. How long does it take the proton to traverse the galaxy, in its own rest frame? Use the following : 1 eV = 1.6×10^{-19} J, mass of proton is about $m_p = 1.67 \times 10^{-27}$ kg. (3)

(iv) The centre of mass of three particles of masses 10 gm, 20 gm and 30 gm is at (1, –2, 3). Where should the fourth particle of mass 40 gm be placed so that the centre of mass of the combined system is at (1,1,1)? (3)

P.T.O.

(v) A particle of mass m moves in a central force field defined by $\vec{F} = -\frac{k}{r^4}\vec{r}$. If E is the total energy of the particle then find the speed of the particle. (3)

(vi) A particle of mass 10 kg is moving in a circle of radius 4 m with a constant speed of 5 ms^{-1}. What is its angular momentum about a point on the axis passing through the centre of the circle and perpendicular to its plane, at a distance of 3 m from its centre? (3)

2. (i) Explain the principle of rocket propulsion. Formulate the equation of motion of a rocket and hence deduce an expression for the instantaneous velocity of the rocket that takes off vertically upwards from rest under the influence of gravity. (6)

(ii) A rocket launched vertically expels mass at a constant rate equal to 0.05 m_0 kg ms^{-1}, where m_0 is its initial mass. The exhaust velocity of the gases relative to the rocket is 5 km s^{-1}. Find the velocity & the height of the rocket after 10 s. (6)

P.T.O.

(iii) Determine the centre of mass of a circular plate of uniform thickness t and diameter 2R. If a circular hole of diameter R is drilled into the plate at its boundary, will the centre of mass of the remaining portion of the plate change? If yes, then determine the centre of mass of the remaining portion of the plate. (6)

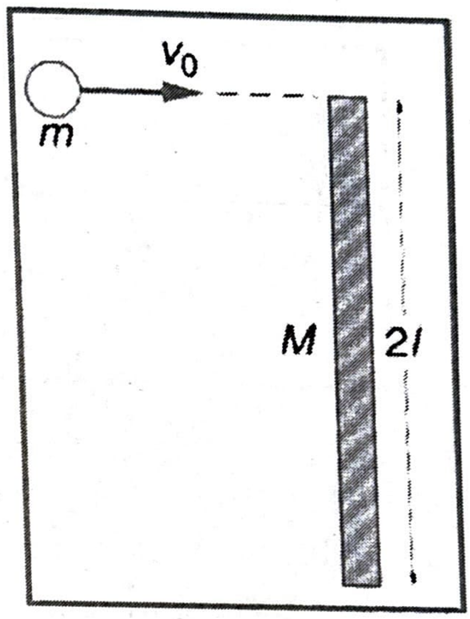
3. (i) State and derive an expression for Work-Energy Theorem. (6)

(ii) A commonly used potential energy function to describe the interaction between two atoms is the Lennard-Jones potential defined as

$$U(r)=\varepsilon\left[\left(\frac{r_0}{r}\right)^{12}-2\left(\frac{r_0}{r}\right)^{6}\right],$$ where r is the

separation between the two atoms. Are the two atoms interacting with each other by a central force? Show that the radius at the potential minimum is r_0 and that the depth of the potential is ε. Find the frequency of small oscillations about equilibrium for two identical atoms of mass m bound to each other by the Lennard-Jones interaction. (6)

(iii) A plank of length $2l$ and mass M lies on a frictionless table. A ball of mass m and speed v_0 strikes its end as shown in the figure. Find the final velocity of the ball, v_f, assuming that mechanical energy is conserved and that v_f is along the original line of motion.



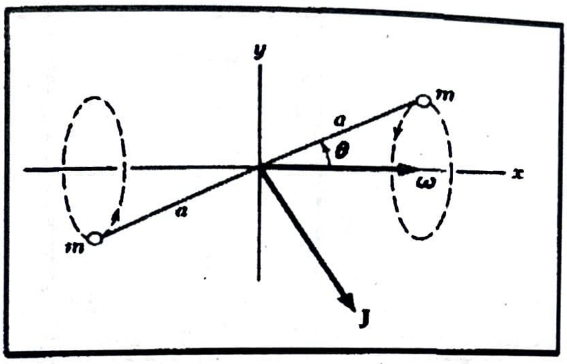
(6)

4. (i) Derive an expressions for Moment of Inertia of a uniform mass distribution in the form of a spherical shell about one of its tangential axis. (6)

(ii) Consider a rigid body consisting of two equal masses m joined by a massless rod of length 2a. The rod is made to rotate about a fixed axis through the Centre of Mass (CM) and oriented

P.T.O.

at angle θ with the length of the rod as shown in the figure. Derive an expression for the angular momentum $\vec{J}$ of the rod and hence show that $\vec{J}$ rotates with the rod always inclined at a fixed angle relative to the rod and to the axis of rotation. (6)



(iii) A bowling ball is thrown down the alley with speed v_0. Initially it slides without rolling, but due to friction it begins to roll. What is its speed when it rolls without sliding. (6)

5. (i) Using the radial and tangential equation of motion, show that the angular momentum l and the energy E of a particle of mass m moving in a potential U(r) can be expressed as $l = mr^2\dot{\theta}$ and $E = \frac{1}{2}m\dot{r}^2 + \frac{l^2}{2mr^2} + U(r)$. Hence, obtain the effective force acting on the particle. (6)

(ii) A planet of mass m and angular momentum l moves in a circular orbit in a central potential $U(r) = -kr^{n+1}$, where k is a constant and r is the distance of the particle from the origin. Find the angular frequency of radial oscillations if the particle is slightly perturbed radially. Determine the value of n for which the orbit can be stable. (6)

(iii) A particle of mass 50 g moves under an attractive central force of magnitude $4r^3$ dynes. The angular momentum is equal to 1000 g cm^2s^{-1}. Find the effective potential energy of the particle. If the radius of the particle's orbit varies between r_0 and $2r_0$ then determine r_0. (6)

6. (i) A frame of reference is rotating relative to an inertial frame with a constant angular speed ω. Determine expressions for the Centrifugal and the Coriolis forces acting on a particle of mass *m*, observed to move in the rotating frame of reference. (6)

(ii) Two particles of rest mass m_0 approach each other with equal and opposite velocity v. What is the total energy of one particle as measured in the rest frame of the other? (6)

(iii) Muons are unstable particles that spontaneously decay into an electron and two neutrinos. If the number of muons at time t = 0 is N_0, the number at time t is given by $N = N_0 e^{-t/r}$ where $\tau = 2.2\mu s$ is the mean lifetime of a muon in a frame of reference in which the muon is at rest. If a bunch of muons are moving at speed 0.95c, what is the observed mean lifetime? What fraction of muons remain after the bunch has travelled a distance of 10.0 km? (6)

(500)

[This question paper contains 8 printed pages.]

Your Roll No..............

Sr. No. of Question Paper : 1574 **G**

Unique Paper Code : 2222012302

Name of the Paper : Thermal Physics

Name of the Course : **B.Sc. (H) Physics - UGCF**

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 **five** questions in all.

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

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

5. Use of Non-programmable **Scientific calculator** is allowed.

P.T.O.

1\. (a) Calculate adiabatic lapse rate if the molecular weight of air is 0.029 Kg mol^{-1} and γ for air is 1.4.

(b) Calculate the critical constants of a gas, given $a=10^{-5}$, the unit of pressure being 1 atm and $b=10^{-3}$, the unit of volume being Ig molecular volume at NTP.

(c) Show diagrammatically how first order phase transition is different from second order phase transition.

(d) 50 g of water at 40° C is converted into ice at -10° C at constant atmospheric pressure. If the specific heat of ice at constant pressure is 0.5 cal $g^{-1}K^{-1}$, calculate the total change in entropy of the system. Latent heat of ice = 80 cal/g.

(e) Give any two differences between reversible and irreversible processes with one example for each process.

(f) At what temperature will the average speed of molecules of H_2 gas be four times the average speed of O_2 molecules. (6x3)

2. (a) Show that for an adiabatic change in a perfect gas $TP^{\left(\frac{1-\gamma}{\gamma}\right)} = constant.$ (7)

(b) Show that for an adiabatic reversible process:

$$\frac{\partial T}{\partial v} = \frac{C_v - C_p}{\alpha v C_v}$$

where C_v, and C_p are the specific heat at constant volume and pressure respectively, v is the specific volume and α is the volume coefficient of expansion. (6)

(c) Prove that adiabatic elasticity of a gas is γ times the isothermal elasticity. (5)

3. (a) Give Kelvin-Planck and Clausius statements for second law of thermodynamics. Show that both the statements are equivalent to each other. (6)

(b) Show that the efficiency of a Carnot engine is dependent only on the temperatures of the source and sink by explaining the various cycles it undergoes. (8)

(c) A reversible engine converts one-fourth of heat into work. When the temperature of the sink is reduced by 50° C, it converts one half of heat input into work. Calculate the temperatures of the source and sink. (4)

4. (a) Starting from the Maxwell's thermodynamical relation prove that $C_P - C_v = \dfrac{T\alpha^2 v}{\beta_T}$

where C_v, and C_p are the specific heat at constant volume and pressure respectively, T is the absolute temperature, β_T is the isothermal compressibility, α is the coefficient of volume expansion and v is the specific volume. (5)

(b) Derive Clausius-Clapeyron's equation

$$dP/dT = L/T(V_2 - V_1)$$

from Maxwell's the thermodynamical relations & also explain the effect of pressure on

(i) Boiling point of liquids and

(ii) Melting point of solids (6)

(c) Discuss in detail the concept of Clausius inequality and hence show that the difference in entropy for an irreversible process is greater than zero. (7)

P.T.O.

5. (a) What do you mean by magneto-caloric effect? Giving a brief description of the experimental procedure, derive the expression for the fall in temperature of the specimen. Under what conditions will the fall in temperature would be more? (9)

(b) Show that when two phases of a one component system are in equilibrium, then specific Gibb's energies have the same value in both the phases. Hence, derive Ehrenfest's equations for the second order phase transitions. (9)

6. (a) Derive an expression for the mean free path and discuss its dependence on temperature and pressure. (6)

(b) Derive an expression for the coefficient of thermal conductivity using kinetic theory of gases. (9)

(c) Calculate the root mean square velocity of neutrons and electrons at 400K, taking the mass of neutron and electron as 1.675×10^{-27} kg and 9.11×10^{-31} kg respectively. (3)

7. (a) Discuss the results of Andrew's experiments on carbon dioxide. Hence, give a comparison of van der Waals' and Andrew's isotherms. (6)

(b) What do you mean by throttling process? Explain by giving a brief discussion of the experiment. Derive an expression for Joule-Thomson coefficient for ideal gases. (8)

(c) Calculate the drop in temperature when carbon dioxide gas suffers Joule-Thomson expansion at 30°C. The pressures on the two sides of the porous plug are given as 40 atm and 1 atm respectively. The van der Waals' constants of the gas are a =

36.5 x 10^{-2} Nm^4 mol^{-2}, b=5.28 x 10^{-5} m^3mol^{-1}.

(C_p=36.575 JK^{-1} mol^{-1} and R = 8.31 $JK^{-1}mol^{-1}$)

(4)

Values of Constants:

Boltzmann's constant, k = 1.38 × 10^{-23} JK^{-1} Universal gas constant, R = 8.31 $Jmol^{-1}K^{-1}$

(1000)

(3)

[This question paper contains 4 printed pages.]

Your Roll No..............

Sr. No. of Question Paper : 1612 **G**

Unique Paper Code : 2222012303

Name of the Paper : Light and Matter

Name of the Course : **B.Sc. Hons. Physics (Core)**

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. Answer any **Four** questions in all.
3. Question No. **1** is compulsory.
4. **All** questions carry equal marks.
5. Use of non-programmable calculators is allowed.

1. Attempt all of the following : (5×3=15)

 (a) What are coherent sources? What are the methods to obtain coherent sources?

P.T.O.

(b) State and explain Stokes' treatment of phase change on reflection.

(c) Give three advantages of electron microscopy over optical microscopy.

(d) What is the radius of the first half period zone in a zone plate behaving like a convex lens of focal length 50 cm for a light of wavelength 5000 Å?

(e) The threshold frequency for photoelectric emission in a certain metal is 1.4×10^{15} Hz. Find the maximum energy of the photoelectrons when light of frequency 2×10^{15} Hz is incident on the metal surface.

2. (a) What do you understand by wave-particle duality? Explain a fundamental experiment used to explain the wave nature of a particle. (10)

(b) A light beam of wavelength 4000 Å falls on a metallic surface used in an experiment to study the photoelectric effect. If the stopping voltage is 1.5 V, calculate :

(i) the work function of the surface.

(ii) the maximum wavelength of light that will cause photoelectric emission. (5)

3. (a) What are the conditions for obtaining sustained interference? Find the conditions for bright and dark fringes formed due to interference. Graphically show and explain the intensity distribution of the interference pattern. (10)

(b) Newton's rings formed by a monochromatic light between a flat glass plate and a convex lens are viewed normally. Calculate the order of the dark ring which will have double the diameter of that of the 40th dark ring. (5)

4. (a) Explain the theory of Fresnel's half-period zone. Discuss the Fresnel's diffraction at a straight edge with the help of half-period zones. (10)

(b) Monochromatic light of wavelength 7.14×10^{-5} cm falls normally on a grating consisting of parallel wires equidistant from one another. The first-order spectrum is observed at 30° from the zero position. Find the value of the grating constant. (5)

5. (a) What is a plane diffraction grating? Show that the resolving power of a grating is proportional to the number of opaque rulings per metre. (10)

(b) Calculate the number of lines that a grating must have to resolve D1 & D2 lines of sodium in second order, given $\lambda 1$ = 5890 Å and $\lambda 2$ = 5896 Å. (5)

[This question paper contains 4 printed pages.]

Your Roll No..............

Sr. No. of Question Paper : 4406 **G**

Unique Paper Code : 32221302

Name of the Paper : Thermal Physics

Name of the Course : **B.Sc. (Hons.) Physics – CBCS_Core**

Semester : III

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. Answer any **four** of the remaining **six**.

1. (a) Prove that efficiency of a reversible engine is always higher than efficiency of an irreversible engine working between same limits of temperatures of source and sink.

P.T.O.

(b) A cyclic heat engine does 50 KJ of work per cycle. If efficiency of engine is 75%, what will be the heat rejected per cycle?

(c) Using Maxwells thermodynamic relation, calculate

$\left(\frac{\partial Cv}{\partial V}\right)_T$ for a van der Waals gas.

(d) On the basis of third law of thermodynamics prove the unattainability of absolute zero.

(e) Calculate relative magnitude of average speed, root mean square speed and most probable speed. How do these speeds vary with temperature?

(3×5=15)

2. (a) Using first law show that for a gaseous system, the ratio of adiabatic elasticity to isothermal elasticity is equal to the ratio of two heat capacities.

(b) Calculate work done during adiabatic process.

(c) Apply Zeroth's law of thermodynamics to thermal systems to arrive at the conclusion that at equilibrium the systems are at the same temperature.

(7,3,5)

3. (a) What do you understand by thermodynamic scale of temperature? Define absolute zero temperature.

(b) Prove that thermodynamic scale of temperature is equivalent to perfect gas scale.

(c) Prove that if Clausius statement is not true, the same holds for Kelvin-Planck statement.

(7,3,5)

4. (a) Obtain the Clausius inequality and discuss its significance.

(b) Using the TS diagram derive the expression for efficiency of a Carnot cycle.

(c) Calculate the total entropy change when 20 g water at 0°C is mixed with an equal amount of water at. 80°C. (Given : Specific heat of water = 1 cal g^{-1} K^{-1}) (7,3,5)

5. (a) Describe how the process of adiabatic demagnetisation leads to cooling in paramagnetic salt.

(b) From the TdS equations calculate the amount of heat transferred when one mole of van der Waals gas undergoes a reversible isothermal expansion from volume v_i to v_f.

(c) Prove the thermodynamical equations below, using Maxwell relations

(i) $dU = (C_p - pV\alpha_p)dT + V(\beta_T p - \alpha_p T)dp$

(ii) $dH = C_p dT + V(1 - \alpha_p T)dp$

Here α and β denotes coefficient of volume expansion and compressibility, respectively.

(7,3,5)

6. (a) What are transport phenomena? Derive an expression for coefficient of viscosity of a gas in terms of mean free path of its molecules.

(b) Discuss the effect of pressure and temperature on coefficient of viscosity.

(c) The mean free path of the molecules of a gas is 2×10^{-7} meters at pressure p and temperature 200 K. Calculate its value at (i) p, 400 K (ii) 2p, 200 K (iii) ½ p, 400K. (7,3,5)

7. (a) Derive and discuss the Van der Waals gas equation of state of a gas. Mention its defects.

(b) Show that for a gas obeying Van der Waals' equation

$$RT_c/P_cV_c = 8/3$$

(c) Calculate Van der Waals' constants for dry air using the following data: $T_c = 132$ K, $P_c = 37.2$ atm., and $R = 82.07$ cm³ atm K⁻¹. (7,3,5)

(5)

[This question paper contains 4 printed pages.]

Your Roll No..............

Sr. No. of Question Paper : 4520 **G**

Unique Paper Code : 32221303

Name of the Paper : Digital Systems and Applications

Name of the Course : **B.Sc. (Hons) Physics**

Semester : III

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 **any five** questions in all.
3. **Question No.1** is compulsory.
4. All questions carry **equal** marks.

1. Attempt **any five** parts (all parts carry equal marks): (5x3=15)

(a) Represent $(-56)_{10}$ in signed magnitude and 1's complement representation limited to 8-bits

P.T.O.

(b) Define deflection sensitivity in Cathode Ray Oscilloscope?

(c) The accumulator of 8085 microprocessor contains AAH and carry is set. What will accumulator and carry contain after the execution of 'XRA A' instruction?

(d) Realize OR gate using diodes and resistors.

(e) Why is D Flip-flop referred to as transparent latch?

2. (a) Draw the labelled block diagram of a Cathode Ray Tube (CRT)? Explain the role of the following:

(i) AquaDag coating

(ii) Control Grid (8)

(b) Minimize the following logic expression using K - map and realize it using NAND gates only

$F(A, B, C, D) = \Sigma m(1, 3, 7, 11, 15) + d(0, 2, 5)$ (7)

3. (a) Draw the circuit diagram of Serial Shift Register and hence describe its working in serial in serial out (SISO) and serial in parallel out (SIPO) modes. (8)

(b) Distinguish between a 4-bit multiplexer and an encoder using appropriate diagrams. Using block diagrams realise 8 x 1 multiplexer using two 4 x 1 multiplexers and an OR gate and explain its functioning? (7)

4. (a) Write an assembly language program to multiply two 8 bit numbers, one of which is stored in memory location 2050H and other one in memory location 2051H. Store the product in memory locations 2053H and 2054H. (8)

(b) Explain the working of a 2's complement 4-bit adder - subtractor with an appropriate logic circuit diagram. (7)

5. (a) Describe the phenomena of racing in JK flip-flop. Hence explain how this condition can be avoided with the use of master-slave JK flip-flop. (8)

P.T.O.

(b) Describe the working of a decade counter (MOD-10) with a suitable diagram? (7)

6. (a) Draw the circuit diagram of 555 timer IC in Astable configuration and hence explain its working in terms of the charging and discharging of its timing capacitor by drawing the relevant wave diagrams. (8)

(b) Write an assembly language programme to divide two hexadecimal numbers. (7)

7. (a) Draw the logic pin out diagram of 8085 microprocessor wherein all the different signals are depicted and classified in different groups. (8)

(b) What are flags? Describe various flags (in detail) for 8085 microprocessor. (7)

[This question paper contains 8 printed pages.]

Your Roll No..............

Sr. No. of Question Paper : 4334 **G**

Unique Paper Code : 32221501

Name of the Paper : Quantum Mechanics and Applications

Name of the Course : **B.Sc. (Hons)- Physics CBCS**

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 calculators allowed

1. Attempt **any five** of the following

(a) Verify whether the following operators are Hermitian:

P.T.O.

(i) $-i\hbar\frac{d}{dx}$

(ii) Hamiltonian of free particle

(iii) Hamiltonian of a particle in a I-d harmonic oscillator potential.

(b) Evaluate the following commutators : if $[\hat{x}, \hat{p}_x] = i\hbar$

(i) $[\hat{P}_x, \hat{L}_x]$

(ii) $[\hat{L}_i, \hat{L}^2]; i = x, y, z$

(iii) $[\hat{H}, \hat{L}^2]$

(c) What are the stationary states? Why they are so called?

(d) Find the momentum space wave function corresponding to $e^{-\alpha x}$.

(e) A particle is represented by the wave function $\psi(x, 0) = A(a^2 - x^2)$ if $-a \leq x \leq a$ and $\psi(x, 0) = 0$, otherwise. Find the uncertainty in p.

(f) Assume that a magnetic dipole, whose moment has magnitude μ_1, is aligned parallel to external magnetic field whose strength has magnitude B. Take $\mu_1 = 1$ Bohr magneton and $B = 1T$. Calculate the energy required to turn the magnetic dipole so that it is aligned antiparallel to the field.

(5×3=15)

2. (a) Consider a one-dimentional infinite potential well of width L. The wave function is given by

$$\Psi(x,0) = \begin{cases} 3\phi_1(x) + 4\phi_2(x) & \textit{inside the well} \\ 0 & \textit{outside the well} \end{cases}$$

where $\phi_1(x)$ and $\phi_2(x)$ are normalized wavefunctions of the ground state and first excited state.

(i) Normalize $\psi(x, 0)$.

(ii) Find the average energy of the particle.

(iii) Write down $\psi(x, t)$.

(iv) Find the probability of finding the particle in the interval [0, L/2] at two different times,

$$t = \frac{\hbar}{3E_1} \cdot \frac{\pi}{2} \text{ and } t = \frac{\hbar}{3E_1} \cdot \pi . 4$$

(b) A particle of mass m, which moves freely inside an infinite potential well of length 'a', is initially in the state: $\Psi(x,0) = \sqrt{\frac{1}{5a}} \sin(\frac{\pi x}{a}) + \sqrt{\frac{3}{5a}} \sin(\frac{3\pi x}{a})$

(a) Find $\psi(x, t)$ at any later time t.

(b) If the energy is measured, what are the possible values of energies with what probabilities? (9, 6)

3. (a) Solve the Schrodinger equation for a Linear Harmonic Oscillator. Obtain and plot first three eigenfunctions. Calculate the number of node in first three eigen functions. Also explain why they are symmetric and antisymmetric.

(b) Calculate the uncertainty in momentum and position for the ground state eigenfunction of linear Harmonic Oscillator and hence obtain uncertainty relation. (8, 7)

4. (a) Write the Schrodinger equation for a 3D hydrogen atom in spherical polar coordinates. Derive three separate equations for r, θ, ϕ using the method of separation of variables. Solve the equation for ϕ to obtain the normalized eigenfunctions and show that they are orhogonal.

(b) Show that the fractional difference in the energy between adjacent eigenvalues $\frac{\Delta E_n}{E_n}$ proportional

P.T.O.

to $\frac{1}{n^3}$ for a large value of n . Explain the meaning of degeneracy. Show that degree of degeneracy of nth energy level is given by $2n^2$ in hydrogen atom.

(9, 6)

5. (a) The ground state wave function of hydrogen atom is : $\psi(r) = \frac{1}{\sqrt{\pi a_0^3}} \exp(-r/a_0)$

(i) Calculate the expectation value $<r>$ and $<\frac{1}{r}>$ in the ground state of Hydrogen atom.

(ii) Calculate the probability of finding the particle at a distance less than a_0.

(iii) Write the wave function $\psi(r)$ and energy eigen value E_n for hydrogenic atom having at Z charge and principle quantum n.

(b) Apply L_z on the wave function ψ_{21-1} for the hydrogen atom and find the eigen value of L_z and corresponding eigen function.

Given : $\psi_{21-1} = \frac{1}{8\sqrt{\pi}} \cdot (\frac{1}{a_0})^{3/2} \frac{r}{a_0} \cdot e^{-r/2a_0} \cdot \sin\theta e^{-i\phi}$

(9, 6)

6. (a) Draw the energy level diagram to show the Zeeman splitting of the ground and first excited states of sodium in a week magnetic field. Also show the transitions allowed by the selection rules.

(b) Describe Stern Gerlach Experiment with necessary theory. What does it demonstrate? (7, 8)

7. (a) Find the terms for 3p4d configuration system in LS Coupling. Show them in diagram. (5)

(b) Is $^2D_{1/2}$ a possible term? Calculate the angle between vector I and vector s in the $^2P_{3/2}$ state of a one electron atom. (5)

P.T.O.

(c) What is space quantization? Calculate the possible orientations of the total angular momentum vector J corresponding to j=3/2 with respect to a magnetic field along the z axis. (5)

Useful integral

$$\int_{-\infty}^{+\infty} dx\; exp(-\alpha x^2 + \beta x) = \sqrt{\frac{\pi}{\alpha}}\, \exp(\beta^2/4\alpha)$$

$$\int_{0}^{+\infty} dx x^n\; exp(-\alpha x) = \frac{n!}{\alpha^{n+1}}$$

[This question paper contains 4 printed pages.]

Your Roll No..............

Sr. No. of Question Paper : 4388 **G**

Unique Paper Code : 32221502

Name of the Paper : Solid State Physics

Name of the Course : **B.Sc. (Hons.) Physics**

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 any **five** of the following questions.
3. Question no. **1** is compulsory.

1. Attempt any **Five** of the following : (3×5=15)

(a) What are point groups. Mention which are the two symmetry operations permissible in 2-D lattice? How many point groups are possible in 2-D lattice?

(b) What type of lattice and basis do the following structures have: (a) Sodium Chloride (b) Diamond Cubic (c) Zinc sulphide?

P.T.O.

(c) What is Ewald's construction? Give its significance

(d) For Cu, Einstein's temperature is 230°K. Calculate Einstein's frequencies of atoms in the solids. Given that $h = 6.6 \times 10^{-34}$Js and $k_B = 1.38 \times 10^{-23}$ J/K.

(e) What are phonons? Mention one experimental fact which suggests the existence of phonons.

(f) How does the Debye model differ from the Einsteins model of specific heat?

(g) What are the shortcomings of the free electron theory? Does this theory account for the validity of ohm's law?

(h) What is ferroelectricity? Draw the graph showing variation of polarization with electric field in the ferroelectric materials. Give one example of compound /element which show ferroelectricity.

2. (a) The primitive translation lattice vectors of a crystal are :

$\vec{a} = \frac{a}{2}(\hat{\imath} + \hat{\jmath} - \hat{k}), \vec{b} = \frac{a}{2}(-\hat{\imath} + \hat{\jmath} + \hat{k})$ and

$\vec{c} = \frac{a}{2}(\hat{\imath} - \hat{\jmath} + \hat{k})$

Determine the reciprocal lattice vectors and name the structure obtained. (5)

(b) What are Miller Indices? What is the purpose of taking reciprocal of intercepts in order to find out Miller indices? (5)

(c) Sketch (120), (101) and [100] in a cubic crystal. (5)

3. (a) Derive an expression for the dispersion relation for a mono-atomic lattice vibration in one dimension. Draw the dispersion curve for wave vector k lying between $-\pi/a$ to $+\pi/a$. (5)

(b) Show that for very long wavelength limit, crystal behave as a continuous medium. (5)

(c) Prove that crystal medium behave as low pass filter. (5)

4. (a) Derive Clausius-Mossotti relation between polarizability and dielectric constant of the dielectric material and discuss the significance of this relation. (8)

(b) Draw a diagram showing variation of total polarizability with frequency ranging from static to ultraviolet and explain why the dielectric constant of water is 81 at zero frequency while it is 1.8 at optical frequencies. (7)

5. (a) Discuss difference between Type I and Type II superconductors using Meissner's effect. (5)

P.T.O.

(b) Write short notes on (i) Critical temperature (ii) Critical magnetic field and its variation with temperature. (5)

(c) The penetration depth for lead is 396Å and 1730Å at 3K and 7.1 K respectively. Calculate the critical temperature for lead. (5)

6. (a) Discuss the Langevin's theory of para-magnetism. How does the quantum theory remove the shortcomings of classical Langevin's theory. (8)

(b) A paramagnetic salt contains 10^{28} ions/m^3 with magnetic moment of one Bohr magneton. Calculate the paramagnetic susceptibility and the magnetization produced in a uniform magnetic field of 10^6 A/m at room temperature (Given 1 bohr magneton = 9.27×10^{-24}A/m^2. (7)

7. (a) Discuss the formation of allowed and forbidden energy band gap on the basis of Kronig-Penny model. (10)

(b) The energy near the valence band edge of a crystal is given by: $E = -A K^2$ where $A = 10^{-39} Jm^2$. An electron with wave vector $k = 10^{10} \hat{i}\ m^{-1}$ is removed from an orbital in a completely filled valence band. Determine the effective mass and energy of the electron. (5)

(2000)

[This question paper contains 4 printed pages.]

Your Roll No...............

Sr. No. of Question Paper : 1708 **G**

Unique Paper Code : 2223012001

Name of the Paper : Numerical Analysis (DSE)

Name of the Course : **B.Sc. (Hons.) Physics**

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. Attempt total **four** questions in all with question no. **1** being compulsory.

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

4. Scientific non-programmable calculators are allowed.

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

(a) Find the relative error in

$$u = \frac{5xy^2}{z^3}$$

P.T.O.

at $x = y = z = 1$ when the relative error in each of x, y, z is 0.01.

(b) Given a vector A = [−1, 4, 2] calculate the 1-norm, 2-norm and the ∞-norm.

(c) Find the eigen values and corresponding normalised eigen vectors of the matrix :

$$\begin{pmatrix} 2 & \sqrt{2} \\ \sqrt{2} & 1 \end{pmatrix}$$

(d) Evaluate the following integral using Trapezoidal Rule with n = 4 correct to three decimal places.

$$\int_0^1 x^2 dx$$

(e) Given $\frac{dy}{dx} = x^2$ with y(0) = 1.

Find the value of y(1) using Euler's method with h = 0.5.

2. (a) Using Gauss Elimination method, solve the following system of equations :

$$2x + 2y + z = 6$$

$$4x + 2y + 3z = 4$$

$$x - y + z = 0$$ (8)

(b) Using power method determine the largest eigenvalue and the corresponding eigenvector of the matrix

$$A = \begin{bmatrix} 1 & 6 & 1 \\ 1 & 2 & 0 \\ 0 & 0 & 3 \end{bmatrix}$$

Let the initial eigenvector be

$$X^0 = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}.$$

Perform 3 iterations. (7)

3. (a) Find the value of f(8) using Newton's *Divided Difference Method* for the following dataset.

x	4	5	7	10	11	13
f(x)	48	100	294	900	1210	2028

(10)

(b) Prove the recurrence relation :

$$T_{n+1}(x) = 2xT_n(x) - T_{n-1}(x)$$

for the *Chebyshev polynomials.* (5)

4. (a) Decompose the matrix $A = \begin{bmatrix} 5 & -2 & 1 \\ 7 & 1 & -5 \\ 3 & 7 & 4 \end{bmatrix}$ into the form LU where L is a unit lower triangular and U is an upper triangular matrix. (10)

(b) Use the factors obtained above to solve the system $AX = B$ where $B = \begin{bmatrix} 4 \\ 8 \\ 10 \end{bmatrix}$. (5)

5. (a) Given

$$\frac{dy}{dx} = y - x$$

Where y(0) = 2. Find y(0.2) with h = 0.1 using Runge-Kutta second order formula up to three decimal places. (8)

(b) Solve the boundary value problem $y''(x) = y(x)$; $y(0) = 0$, $y(1) = 1.1752$ by the shooting method,, taking the two initial approximations for $y'(0)$ as 0.7 and 0.8 and $h = 0.5$. Perform only first iteration. (7)

(300)

[This question paper contains 4 printed pages.]

Your Roll No..............

Sr. No. of Question Paper : 4477 **G**

Unique Paper Code : 32227502

Name of the Paper : Advanced Mathematical Physics – I (DSE)

Name of the Course : **B.Sc. (Hons.) Physics**

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 taking at least **two** questions from each section.

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

Section-A

1. (a) Prove that the set Q_{-1} of all rational numbers other than -1 with the binary operation * defined by $a * b = a + b + ab$ form a group. (5)

P.T.O.

(b) If V be the set of all ordered triples of reals, with addition and scalar multiplication defined as follows :–

$(x_1,y_1,z_1) + (x_2,y_2,z_2) = (3y_1 + 3y_2, -x_1 - x_2, z_1 + z_2)$ and $\alpha(x_1, y_1, z_1) = (3\alpha y_1, -\alpha x_1, \alpha z_1) \forall \alpha \in R$ then show that V is not a vector space. (5)

(c) Determine whether or not the vector $\xi = (2,-5,3)$ belonging to the subspace of R^3 spanned by $\alpha_1 = (1,-3,2)$, $\alpha_2 = (2,-4,1)$ and $\alpha_3 = (1,-5,7)$. (5)

2. (a) Verify that the vectors (1,3,2), (1,–7,–8), (2,1,–1) of v_3 space are linearly dependent. (5)

(b) Consider $T : R^3 \rightarrow R^2$ defined by $T(x,y,z) = (2x + 7y, 5y - 3z)$. Determine whether T is a linear transform or not. (5)

(c) If H is a Hermitian matrix, prove that e^{iH} is a unitary matrix $\left(i = \sqrt{-1}\right)$. (5)

3. (a) Find the eigenvalues and eigenvectors of the matrix

$$A = \begin{pmatrix} 1 & 0 & 1 \\ 0 & 3 & 2 \\ 0 & 0 & 2 \end{pmatrix}$$

Can A be diagonalized? If yes, find a diagonalizing matrix P and verify that P diagonalizes A. (10)

(b) Write Cayley-Hamilton theorem and verify it for the matrix

$$A = \begin{pmatrix} 3 & -4 \\ 1 & 5 \end{pmatrix}$$ (1,4)

4. (a) Solve the following system of differential equations using matrix method

$$y_1' = -y_1 + 4y_2$$
$$y_2' = 3y_1 - 2y_2$$

subject to $y_1(0) = 3$, $y_2(0) = 4$. (10)

(b) Find e^A for the matrix $A = \begin{pmatrix} 3 & -1 \\ 4 & -2 \end{pmatrix}$. (5)

Section-B

5. (a) Obtain an expression of pure stress tensor and prove that it is symmetric tensor of order (rank) two. (6)

(b) Show that $\vec{A} = \vec{B} \times \vec{C}$ transforms like a tensor of order (rank) one. (6)

(c) Prove that ε_{ijk} (in Cartesian Co-ordinates) is an isotopic tensor of order three. (3)

6. (a) Using Cartesian tensors, prove that

$$\nabla \cdot (\vec{A} \times \vec{B}) = (\nabla \times \vec{A}) \cdot \vec{B} - (\nabla \times \vec{B}) \cdot \vec{A}$$ (7)

P.T.O.

(b) Show that $u_i\, v_j$ (in Cartesian Co-ordinates) is a tensor of order (rank) two. (3)

(c) By using the expression of Moment of Inertia of an asymmetric object

$$I_{ik} = \sum_{\text{all particles}} m\left(r^2\delta_{ik} - r_i r_k\right),$$

from a matrix of all components. What is the all meaning of I_{xy}? (4,1)

7. (a) A covariant tensor has components xy, $2y - z^2$, xz in Cartesian Co-ordinates. Find its covariant components in cylindrical co-ordinates. (12)

(b) Determine the metric tensor in Spherical Co-ordinates. (3)

8. (a) If A^{ij}_{k} and B^{p}_{q} are general tensors, show that $A^{ij}_{k}\, B^{i}_{q}$ is not a tensor. (6)

(b) Show that the outer product of two contravariant vectors A^{μ} and B^{ν} results in a contavariant tensor of rank two. (4)

(c) Show that every covariant tensor of order two can be expressed as the sum of two tensors, one of which is symmetric and the other skew-symmetric. (5)

(1000)

(10)

[This question paper contains 4 printed pages.]

Your Roll No..............

G

Sr. No. of Question Paper : 1773

Unique Paper Code : 2222511101

Name of the Paper : Mechanics

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

Semester : I

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. Attempt **four** questions in all.
3. **All** questions carry equal marks.
4. Question No. **1** is compulsory.
5. Non-programmable calculator is allowed.

1. Attempt all : (5×3)

(a) If position vector is $\vec{r} = x\hat{\imath} + y\hat{\jmath} + z\hat{k}$, then find the value of $\vec{\nabla}(\ln r)$.

P.T.O.

(b) What are conservative and non-conservative forces?

(c) Define moment of inertia. Why does the moment of inertia of a given body depend on the axis of rotation about which it rotates? Explain.

(d) State the Kepler's law of planetary motion.

(e) What are the basic postulates of special theory of relativity?

2. (a) Explain gradient, divergence and curl. What is the significance of divergence and curl of a vector? (7)

(b) Find the solution of the differential equation :

$y'' - 5y' + 6y = 0$; $y(0) = 1$ and $y'(0) = 2$. (5)

(c) What are central forces? Give two examples. (3)

3. (a) Determine the moment of inertia of a circular disc of mass M and radius R about an axis passing through its centre and perpendicular to its plane. (7)

(b) An empty freight car of mass $m_1 = 10{,}000$ kg rolls at $v_1 = 2$m/sec on a level road and collides with a loaded car of mass $m_2 = 20{,}000$ kg standing at rest. If the cars couple together, find their speed v' after the collision, and also the loss in kinetic energy. (5)

(c) Derive the expression of time dilation in relativistic motion. Why do we not observe the effect of time-dilation in everyday life? (3)

4. (a) Explain the failure of Galilean transformation equations and derive the length contraction expression by using Lorentz transformation equation. (7)

(b) A body of mass 0.5 kg is moving in a circle of radius 0.3 m with constant speed of 0.2 m/s. Find out its angular momentum about (i) the centre of the circle, (ii) a point on the axis of the circle and at a distance of 0.4 m from its centre. (5)

(c) We observe two galaxies A and B moving in opposite directions with speeds 0.5c and 0.4c respectively. What is the velocity of galaxy B as seen from galaxy A. (3)

5. (a) Deduce the differential equation of a damped harmonic oscillator. Obtain a solution and discuss in detail the case of under damping. (7)

(b) Centre of mass is at A (2,2,2) when system consists of particles of masses 2,4 and 5 kg. If the centre of mass shift to B (4,4,4) on removing 5kg, what was its position? (5)

(c) A particle is moving in one-dimensional with x(t)=A cosωt + B sin ωt. Show that motion is simple harmonic. (3)

[Symbols:

C: speed of light.

ω: angular frequency]

[This question paper contains 4 printed pages.]

Your Roll No..............

Sr. No. of Question Paper : 1769 **G**

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.

(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

$$E_S/E_T = C_P/C_V = \gamma \qquad (4,4)$$

(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)

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)

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

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)

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

(2000)

(12)

[This question paper contains 8 printed pages.]

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.

P.T.O.

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.

2. (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

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

(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)

P.T.O.

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)

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

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

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 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

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

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.

P.T.O.

(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)

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

(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)

Constants :

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

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

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

P.T.O.

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

(500)