2017-20

Full Marks : 60

Time : 3 hours

Answer any **five** questions in which **Q. No. 1.** is compulsory.

The figures in the right-hand margin indicate marks

Candidates are required to give their answers in their own words as far as practicable.

1. Answer any *three* of the following questions : 4×3

(*a*) What do you mean by Taylor series ?

(*b*) What are scalar and vectors fields ?

(*c*) Define Polar and Axial vectors.

(*d*) Find the divergence of gradient of a scalar function ϕ.

(*e*) Prove that

$$(\vec{A}\times\vec{B}).(\vec{C}\times\vec{D}) = (\vec{A}.\vec{C})\,(\vec{B}.\vec{D}) - (\vec{B}.\vec{C})\,(\vec{A}.\vec{D})$$

(*f*) Define Green Theorem.

2. Define and explain flux of a vector field. 12

3. What do you mean by the gradient of Scalar function ? Give its physical significance. 12

4. Find the expression for curl of a vector field in terms of cartesian co-ordinates. 12

5. Show that $\nabla.(\phi\vec{A}) = (\nabla\phi).\vec{A} + \phi(\nabla.\vec{A})$ where ϕ is a scalar function. 12

6. State and prove Gauss's divergence theorem. 12

7. Find the expression for Grad., Divergence and Curl in terms of cylindrical co-ordinates. 12

8. Explain the orthogonal curvilinear co-ordinates and find out expression for divergence in terms of curvilinear co-ordinates. 12

9. Explain : 4 + 4 + 4

   (*i*) Line integral of a vector field

   (*ii*) Surface integral of a vector field

   (*iii*) Volume integral of a vector field.

2017-20

Time : 3 hours

Full Marks : 60

Candidates are required to give their answers in their own words as far as practicable.

The figures in the margin indicate full marks.

Answer from both the Groups as directed.

Group – A

(Short-answer Type Questions)

Answer any **three** questions of the following : $4 \times 3 = 12$

1. (a) An electron of rest mass $9{\cdot}1 \times 10^{-31}$ kg moves with velocity 0·8 times the speed of light in vacuum. Calculate increase in mass and total energy of moving electron.

   (b) A spherical soap bubble of radius r_1 comes in contact with another spherical bubble of radius r_2. What is the radius of curvature of their common surface ?

(c) Why are soldiers asked to break steps while crossing a bridge ?

(d) Define geometrical moment of inertia. Write down its dimension and S. I. unit.

(e) Show that time period of SHM is independent of amplitude.

(f) Explain relativistic addition of velocities.

Group – B

(Long-answer Type Questions)

Answer any **four** questions : 12×4 = 48

2. Describe, with theory, Searle's method for measuring elastic constants of a wire.

3. (a) Establish a relation between Y, K and σ.

   (b) Find an expression for bending moment of a beam.

4. Define coefficient of viscosity. Give its unit and dimension. Derive Poiseulle's formula for flow of a liquid through a narrow tube.

5. Define central force with two examples. Discuss the motion of a particle moving in central orbit. Find the equation of orbit in polar form.

6. Give a analytical treatment of damped oscillations. At what condition does it oscillatory ? Discuss the result.

7. Deduce Lorentz transformation equations.

8. (a) State Kepler's laws of planetary motion.

   (b) Explain two fundamental postulates of special theory of relativity.

   (c) Discuss the effect of damping on resonance.

9. Write notes on any two of the following :

   (a) Relativistic Doppler effect

   (b) Time dilation

   (c) Coriolis and Centrifugal force

   (d) Light cantilever

   (e) Quality factor

2017-20

Time : 3 hours

Full Marks : 60

Candidates are required to give their answers in their own words as far as practicable.

The questions are of equal value.

*Answer any **five** questions.*

1. State and Prove Gauss's Law for an Electrostatic Field. Use it to find the electric field due to a uniformly charged sphere.

2. (a) Define Electrostatic Potential and Potential Gradient. Establish the relations, $\vec{E} = -\vec{\nabla} V$ and $\vec{\nabla} \times \vec{E} = 0$.

   (b) Derive Laplace's and Poisson's equations.

3. What do you mean by 'Dielectric Polarisation' ? Deduce a relation between Electric Field Strength 'E', Polarisation vector 'P' and Electric displacement 'D'.

4. Describe with relevant theory, "Anderson's Bridge" for finding the self inductance of the coil.

5. Explain Hysteresis and Hysteresis Loss from B-H curve. Derive an expression for energy dissipated in Hysteresis cycle.

6. Discuss the behaviour of a series LCR circuit with circuit diagram. Explain the depandence of the sharpness of resonance on the quality factor "Q" in the circuit.

7. Give the theory and working of a Ballistic Galvanometer. Under what conditions does a moving coil Galvanometer behave as ballistic ?

8. State and prove maximum Power Transfer Theorem, for two terminal network. What are the limitations of Thevenin's and Norton's theorem ?

9. Write short notes on the following :

   (a) Electric dipole

   (b) Dielectric strength

(c) Electric Susceptibility and Permittivity

(d) Uniqueness theorem

10. (a) Deduce an expression for Torques on a current coil in Uniform magnetic field.

(b) A condenser of capacity 0.2 μF charged to 2 Volts when discharged through a Ballistic Galvanometer gives a deflection of 9.6 cms. Calculate the current sensitivity of the Glavanometer if its periodic time be 12 seconds.

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2017-20

Full Marks : 60

Time : 3 hours

Answer from both the Groups as directed.

The figures in the right-hand margin indicate marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP—A

(Short Answer Type Questions)

1. Answer any *three* of the following : 4 × 3

(*a*) Give a brief account of Newton's formula for velocity of sound.

(*b*) What is the difference between phase velocity and group velocity ?

(*c*) Why a thin film of oil on water appears to be coloured ?

(*d*) Explain division of amplitude and division of wavefront.

(*e*) Why is the central spot in the Newton's ring system dark ?

(*f*) Discuss about the temporal and spatial coherence.

GROUP—B

(Long Answer Type Questions)

Answer any *four* of the following questions : 12 × 4

2. Set up equation for plane-progressive wave. Also set up differential equation and solve it.

3. Define standing wave, give the analytical treatment for string fixed at both ends. Also explain nodes and antinodes.

4. Describe with theory the construction and working of Michelson interferometer and method to determine the wavelength of sodium light.

5. Give the theory, experimental arrangement and method to determine the wavelength of light by Newton's ring apparatus.

6. Give an account of Young's double slit experiment and its importance.

7. What is Rayleigh's criterion for the limit of resolution ? Obtain expression for resolving power of a telescope.

8. Discuss Fraunhofer diffraction at a double slit. Derive expression for intensity distribution and find the positions of maxima and minima.

9. Write notes on any *two* of the following :

   (*a*) Zone plate

   (*b*) Electromagnetic nature of light

   (*c*) Expression for pressure variation of longitudinal wave

   (*d*) Diffraction at circular aperture

2018

Time : 3 hours

Full Marks : 60

Candidates are required to give their answers in their own words as far as practicable.

The questions are of equal value.

*Answer **five** questions in which Q. No. 1 is compulsory.*

1. Answer **all** questions of the following :

   (a) What is Brownian Motion ?

   (b) Explain Virial's theorem.

   (c) Write down expressions for mean velocity and r. m. s. velocity. Hence establish a relation between them.

   (d) What is inversion temperature ?

(e) Write down the wave equation for square wave.

(f) Explain Maxwell's law of distribution of velocity by drawing a graph.

2. (a) Define mean free path for gaseous molecules. Show that Mean free path

$$\lambda = \frac{1}{n\pi\sigma^2},$$

Where $n \rightarrow$ number of molecules per C. C.

$\sigma \rightarrow$ diameter of each molecule.

(b) Find an expression for critical volume of real gas obeying van der Waal's equation of state.

(c) Define mean velocity of molecules of a gas. Show mathematically the mean velocity varies as square root of absolute temperature.

3. (a) Find the fraction of the molecules that move with energy values between $\in$ and $\in + d\in$.

(b) Show that the enthalpy remains constant during throatling process.

(c) Set up Stern's experiment for verification of Maxwell's law for velocities of perfect gas.

4. State and explain Fourier's theorem. Also find Fourier's coefficient. Using this theorem analyse Sawtooth wave or triangular wave.

5. Derive Maxwell's law of distribution of velocities of a perfect gas.

6. Explain how kinetic theory accounts for the viscosity of gas. Derive an expression for coefficient of viscosity of a gas.

7. State and prove the law of equipartion of energy. Use this law to calculate the ratio of two specific heats of a gas and hence find this ratio for diatomic and monoatomic gases.

8. Find an expression for thermal conductivity using transport of energy.

9. Write short notes on any **two** of the following :

(a) Andrew's experiment.

(b) Translational Brownian motion

(c) Show that roof mean square velocity of gaseous molecules is directly proportional to absolute temperature.

(d) Establish a relation between T_c, V_c and P_c.

2018

Time : 3 hours

Full Marks : 60

Candidates are required to give their answers in their own words as far as practicable.

The figures in the margin indicate full marks.

*Answer **five** questions in which Q. No. 1 is compulsory.*

1. Answer the following short-answer type questions : 2×6 = 12

   (a) Write two extensive and two intensive thermodynamic variables.

   (b) Two mole of an ideal gas expands to twice of its volume isothermally at 27°C. The work done by the gas is _____ (Given Universal gas constant R = 8.3 Joule $mol^{-1} K^{-1}$)

   (c) Define specific heat.

(d) Plot temperature-entropy diagrams for Carnot's Cycle.

(e) Define Coefficient of performance of a refrigerator.

(f) Give one example of first order and second order phase transection each.

2. (a) Derive the expression for work done by an ideal gas during an adiabatic process. 4

(b) Compare the slopes of isothermal and adiabatic curves in p-v diagram. 4

(c) Define Joule-Kelvin coefficient and show that it is zero for ideal gases. 4

3. (a) Prove that for real gas $C_P - C_V \approx R\left(1 + \frac{2a}{RTV}\right)$, where the symbols have usual meanings. 6

(b) A Carnot engine operates with efficiency of 40%. How much must the temperature of the hot reservoir should increase, so that the efficiency increases to 50% ? The temperature of the cold reservoir remains at 9°C. 6

4. Give the Kelvin-Planck and Clausius statements of second law the of thermodynamics. Illustrate equivalence of these two statements. 12

5. Obtain the formula for efficiency of Carnot cycle in terms of temperatures of hot and cold reservoirs. How would you increase its efficiency ? 12

6. Show how the second law of thermodynamics leads to the concept of entropy ? Prove that (i) for any reversible cyclic change of a system the total change of entropy is zero and (ii) entropy increases in an irreversible process. 12

7. What do you understand by Kelvin's thermodynamic scale of temperature ? Show that it is identical with perfect gas scale. Is negative temperature possible on this scale ? Explain. 12

8. State and explain with example the third law of thermodynamics. Prove that it is impossible to obtain absolute zero temperature. 12

OR

State and prove Carnot's theorem.

8. Define the four thermodynamic potentials and derive Maxwell's thermodynamic relations using them. Apply it to deduce Clausius-Clapeyron's equation. 12

2018

Time : 3 hours

Full Marks : 60

Candidates are required to give their answers in their own words as far as practicable.

The figures in the margin indicate full marks.

*Answer **five** questions in which Q. No. 1 is compulsory.*

1. Pick the correct answer from the following objective type questions : 1×12 = 12

(a) Intrinsic semiconductor material at temperature 0K behaves as :

(i) Conductor

(ii) Superconductor

(iii) A power source

(iv) An insulator

(b) In a p-type semiconductor, there are :

(i) No minority carriers

(ii) Immobile negative ion

(iii) Immobile positive ion

(iv) Electron as majority carriers

(c) Potential barrier at a P-N junction is due to :

(i) Majority carriers

(ii) Minority carriers

(iii) Both (i) and (ii)

(iv) Fixed donor and acceptor ions

(d) A zener diode :

(i) Is always forward bias

(ii) Is connected in series

(iii) Has a sharp breakdown at low reverse voltage

(iv) Has a negative resistance

(e) The potential-barrier in the depletion layer is due to :

(i) Ions

(ii) Holes

(iii) Electrons

(iv) Forbidden gap

(f) For a transistor, the current gain relation between CB current gain α and CE current gain β is :

(i) $\alpha = \beta (1 - \alpha)$

(ii) $\alpha = \frac{\beta}{1-\alpha}$

(iii) $\alpha = \beta(1 + \alpha)$

(iv) $\beta = \alpha(1 + \alpha)$

(g) A load line is a graph between :

(i) I_C and V_{CC}

(ii) I_C and V_{BE}

(iii) I_E and V_{BE}

(iv) I_C and V_{BE}

(h) Ge transistors are rarely used above the temperature of :

(i) 50^oC

(ii) 75^oC

(iii) $100^{\circ}C$

(iv) $175^{\circ}C$

(i) Current flow through the base of either a P-N-P or N-P-N transistor by :

(i) Electrons

(ii) Diffusion

(iii) Holes

(iv) Majority carriers

(j) A p-n junction has a thickness of the order of :

(i) 1cm

(ii) 1mm

(iii) 10^{-6}cm

(iv) 10^{-12}cm

(k) Zenor diode (voltage regulation) is always used :

(i) With a forward biased

(ii) With a reverse biased

(iii) As a rectifier

(iv) As a switch

(l) The net charge of doped semiconductor is :

(i) Zero

(ii) Positive

(iii) Negative

(iv) Infinity

2. Answer any **two** short answer type questions of the following : 6×2 = 12

(a) Discuss the dependence of mobility on doping concentration and temperature.

(b) What is ripple factor ? Find out its equation and value for half wave rectifier.

(c) Define hybrid parameter. What is the singificane of hybrid parameter ?

(d) Discuss frequency response curve of R-C coupled amplifier.

(Long-answer Type Questions)

3. Explain the forward-and reversed-bias conditions of a semiconductor diode. Explain I-V characteristics. 6+6 = 12

4. What is potential barrier and how it developes at the junction of the diode ? Draw the energy level diagram for p-n junction under zero bias. How does it change when (a) forward bias and (b) reverse bias is applied ? 5+2+5 = 12

5. Draw the circuit diagram of a half-wave rectifier using semiconductor diodes and also explain its working. Derive the relation $n = \frac{40.6}{1 + R_L / V_d}$.

3+6+3 = 12

6. Describe Hartley Oscillater and find its frequency. 5+7 = 12

7. Explain, with the help of experimental circuit diagram, the input and output characteristic of CB transistor. 2+5+5 = 12

8. (a) Explain Barkhausen conditions required in order for sinusoidal oscillations to be sustained.

(b) Draw and explain CE amplifier. Find its current gain. 6+6 = 12

9. What is phase shift oscillator ? Sketch and explain the circuit of RC phase shift oscillator find its frequency of oscillators. 4+4+4 = 12

2019

Time : 3 hours

Full Marks : 60

Candidates are required to give their answers in their own words as far as practicable.

The figures in the margin indicate full marks.

*Answer any **five** questions in which Q. No. 1 is compulsory.*

1. Answer the following : 2×6 = 12

   (a) Represent the following complex numbers on the Argand diagram:

   (i) $3 - 4i$

   (ii) $2e^{i\pi/3}$

   (b) Find the complex conjugate of $\frac{2+3i}{1-i}$.

   (c) Show that $f(z) = \bar{z}$ is not an analytic function.

   (d) Write Euler's formula.

(e) Prove that $L(e^{at}) = \frac{1}{s-a}$.

(f) Show that $L[af_1(t) + bf_1(t)] = aL[f_1(t)] + bL[f_1(t)]$.

2. (a) Show that cube root of unity constructs vertics of an equilateral triangle on Argand diagram.

(b) Find the complex number z if $\arg(z+1) = \frac{\pi}{6}$ and $\arg(z-1) = \frac{2\pi}{3}$.

(c) If $(a_1 + ib_1) \cdot (a_2 + ib_2) \ldots (a_n + ib_n) = A + iB$, then prove that :

$$\tan^{-1}\frac{b_1}{a_1} + \tan^{-1}\frac{b_2}{a_2} + \ldots + \tan^{-1}\frac{b_n}{a_n} = \tan^{-1}\frac{B}{A}.$$

4×3 = 12

3. (a) Find Fourier sine transform of $f(x) = e^{-ax}$

(b) Find L[sin(at)]

(c) Find L[Cosh(at)]

4×3 = 12

4. (a) State and prove Cauchy integral formula.

(b) Evaluate $\int_C \frac{e^{2z}}{z^3} dz$, where C is the circle $|z| = 1$ 6×2 = 12

5. What are analytic functions ? What are zeros and singularity of a complex function ? State and prove Cauchy-Riemann conditions for a complex function to be analytic. 2+2+8 = 12

6. If $u(x, y) = x^2 - y^2 - 2xy - 2x + 3y$ then find a function $v(x, y)$ such that $f(z) = u + iv$ is analytic. Express $f(z)$ in terms of z. 9+3 = 12

7. (a) If F (s) is the Fourier transform of f(x), then prove that Fourier transform of $\{f(x) \cos(ax)\}$ $= \frac{1}{2}[F(s + a) + F(s - a)]$.

(b) If $L[f(t)] = F(s)$ represents the Laplace transform of f(t) and

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

then show that $L[g(t)] = e^{-as} F(s)$. 6×2 = 12

8. State and prove Fourier integral theorem. 12

9. Write short notes on any **two** of the following : $6 \times 2 = 12$

(a) De Moiver's theorem

(b) Dirac delta function and its properties

(c) Convolution of two functions

(d) Fourier transform of Gaussian function

2019

Time : 3 hours

Full Marks : 60

Candidates are required to give their answers in their own words as far as practicable.

The questions are of equal value.

*Answer any **five** questions in which Q. No. 1 is compulsory.*

1. Answer **all** questions of the following :

   (a) What is work function ? Calculate work function in e.v. if threshold wave length is 6000A°.

   (b) Explain Quantum mechanical tunnelling in one dimension across rectangular potential barrier.

   (c) Explain what do you understand by Laser. What are the basic differences between a laser emission and an ordinary light ?

(d) What do you mean by half life of a radioactive material ? On what factors does it depend ?

(e) Calculate the change in wavelength of photon for 90° scattering from a neutron of mass 1.67×10^{-27} kg.

(f) Electrons of an atom can't exist within the nucleus of the atom. Explain it useing uncertainty principle.

2. (a) Establish a relation between Group and Phase velocities.

(b) What is Heisenberg uncertainty principle ? Write down Time-Energy uncertainty relation Radius of H-atom is 5.3×10^{-11} m. Use uncertaintly principle to estimate minimum momentum an electron can have in this atom.

(c) Explain physical interpretation of a wave function. The wave function of a particle is given by $\psi(x) = Ne^{-\alpha x^2}$. Normalize the wave function if N and α are constants in the region $-\leq x \leq +\infty$.

3. (a) Derive Einstein's photoelectric equation.

(b) The half life of a radio active substance is 15 hours. Calculate the period in which 12.5% of the initial quantity of the substance will be left over.

(c) An electron has energy of 5000 eV. Calculate its de-Broglie wave length. ($h = 6.62 \times 10^{-34}$ J.S, $me = 9.1 \times 10^{-31}$ kg, $1eV = 1.6 \times 10^{-19}$J).

4. Derive Schrodinger equation for non-relativistic particles. Assume wave function is independent of time.

5. What is compton scattering ? Obtain an expression for compton shift. Discuss the result.

6. Describe Davisson and Germer's experiment and show the existence of electron wave and the validity of de-Broglie equation.

7. What are Einstein's A and B coefficients ? Establish a relation between them.

8. Using Liquid drop model derive the semi-empirical mass formula along with different energy terms.

9. Write short notes on any **two** of the following :

(a) Ruby Laser

(b) Succesive radioactive disintegration

(c) He-Ne Laser

(d) Show that half life of radiactive element is 0.693 times mean life

2019

Time : 3 hours

Full Marks : 60

Candidates are required to give their answers in their own words as far as practicable.

The questions are of equal value.

*Answer any **five** questions in which Q. Nos. 1 is compulsory.*

1. Answer any **three** questions of the following : 4×3 = 12

   (a) What are BCD (binary-coded decimal) numbers ? Find the BCD equivalent of decimal numbers $(48)_{10}$ and $(132)_{10}$.

   (b) State De-Morgan's Theorems and draw Logic circuits representing the same

   (c) How will you realize AND and OR gates using Diodes and Transistors ?

(d) (i) For a gate with 'n' inputs how many combinations of inputs are possible ?

(ii) Construct Truth Table for a 3-Input NOR gate.

(e) How will you represent the output of Exclusive OR gate (X-OR) using Boolean Algebra ? Also, show the logic circuit and form the Truth Table.

2. Describe the construction of CRO and explain how to make the following measurements using a CRO : (a) Voltage (b) current (c) frequency (d) Phase difference. 12

3. Give the circuit diagram of Half-adder and Full-adder and explain their working with Truth Tables. 12

4. A 3-variable Truth Table has a High output for these input conditions; 000, 010, 100, 110 : 12

(a) What is the sum of products circuit and write the Corresponding Boolean Equation.

(b) Construct Karnaugh Map for the above table and encircle all the 'octets', 'quads' and 'pairs' you find ?

5. (a) What are Decoders and Encoders ?

(b) Explain the principle of the Successive Approximation A/D converter with necessary circuit diagram. 4+8 = 12

6. Give the construction and working of an Astable Multivibrator using IC555 and sketch the relevant wave forms. 12

7. Find expressions for electrostatic deflection sensitivity and magnetic deflection sensitivity in case of CRO. 12

8. Draw the logic circuits for the following Boolean equations and simplify both the equations and the logic circuits using Boolean algebra : 12

(a) $Y = A\bar{B}C + ABC$

(b) $Y = (\bar{A} + B + C)(A + B + \bar{C})$

9. (a) Represent $(+8)_{10}$ and $(-8)_{10}$ in 1's complement form and 2's complement form.

(b) Perform the operation 48 – (–23) using 2's complement method.

(c) Convert $(6327.4051)_8$ into decimal number.

(d) Obtain the decimal equivalent of Hexadecimal number (3A.2F) $\sqrt{16}$. 12

2020

Time : 3 hours

Full Marks : 60

Candidates are required to give their answers in their own words as far as practicable.

The figures in the margin indicate full marks.

*Answer any **five** questions in which Q. No. is 1 compulsory.*

1. Choose the correct answer of the following : 1×12 = 12

(a) The operator corresponding to the total energy E is :

(i) $\hat{E} = i\hbar \frac{\partial}{\partial t}$

(ii) $\hat{E} = \frac{\hbar}{i} \frac{\partial}{\partial t}$

(iii) $\hat{E} = -i\hbar \frac{\partial}{\partial t}$

(iv) $\hat{E} = -\frac{\partial}{\partial t}$

(b) If the wave function $\psi(x)$ is normalized then

$\int_{-\infty}^{+\infty} |\psi(x)|^2 dx$ is equal to :

(i) 0

(ii) 1

(iii) $-i\hbar$

(iv) -1

(c) We say that two operators $\hat{A}$ and $\hat{B}$ do not commute if :

(i) $\hat{A}\hat{B} \neq \hat{B}\hat{A}$

(ii) $\hat{A}\hat{B} = \hat{B}\hat{A}$

(iii) $\hat{A} + \hat{B} \neq \hat{B} + \hat{A}$

(iv) $\hat{A} + \hat{B} = \hat{B} + \hat{A}$

(d) The existence of electron spin is shown by :

(i) Franck-Hertz experiment

(ii) Thompson's experiment

(iii) Michelson-Morely experiment

(iv) Stern Gerlach experiment

(e) The uncertainty principle tells us that :

(i) A particle can have only position but no momentum

(ii) A particle can have only momentum but no position

(iii) One can determine simultaneously the position and momentum of a particle

(iv) One can not determine simultaneously the position and momentum of a particle

(f) Zeeman effect is splitting of spectral lines due to :

(i) Electric field

(ii) Magnetic field

(iii) Both electric and magnetic field

(iv) None of these

(g) The value of $[\hat{p}_x, \hat{x}]$ is :

(i) $\frac{\hbar}{i}$

(ii) 0

(iii) $i\hbar$

(iv) 1

(h) Stationary states are those states for which the probability density $\rho = |\psi|^2$ is :

(i) Time-dependent

(ii) Time-independent

(iii) Space-dependent

(iv) Space-independent

(i) In Quantum Mechanics a particle is free if it moves in a region where P. E. is :

(i) Constant

(ii) Varies with distance

(iii) Varies with time

(iv) None of these

(j) A system of electrons is described by a wave function which should be :

(i) Anti-symmetric

(ii) Symmetric

(iii) Both symmetric and anti-symmetric

(iv) None of these

(k) Let $\phi(x)$ be an eigen function of an operator $\hat{A}$ with eigen value a_0. Consider the function :

$$\psi(x) = \frac{1+i}{\sqrt{2}}\,\phi(x)$$

(i) $\psi(x)$ is not an eigen function of $\hat{A}$

(ii) $\psi(x)$ is not an eigen function of $\hat{A}$ with eigen value $\frac{1+i}{\sqrt{2}}\,a_0$

(iii) $\psi(x)$ is not an eigen function of $\hat{A}$ with eigen value a_0

(iv) $\psi(x)$ is an eigen function of $\hat{A}$ with eigen value $\frac{1-i}{\sqrt{2}}\,a_0$

(l) The momentum of a free particle is :

(i) $\hbar k$

(ii) hk

(iii) $\frac{k}{h}$

(iv) $\frac{\hbar}{k}$

2. Answer any **three** of the following : $4 \times 3 = 12$

(a) What do you mean by eigen operator, eigen functions and eigen values ? Explain with examples.

(b) Normalize the wave function $\psi(x, t) = e^{-ax^2/2} e^{-iEt/\hbar}$ from $-\infty$ to $+\infty$.

(c) Find the Lande's g factors for the level $^3D_3$.

(d) A beam of short wavelength gives accurately the position of a particle. Justify.

(e) Explain Hund's rule in brief.

(f) Give reason for the similarity between spectra of alkali atoms and those of hydrogen.

3. Deduce Schrödinger's time dependent equation for a particle in a field characterised by the potential energy $V(\vec{r}, t)$. Give the physical interpretation of wave function. 12

4. Show that the Schrödinger equation has a solution of the form $\phi(\vec{r})\, U(t)$, if the potential energy of the particle associated with wave function is independent of time. Show that the most general solution of Schrödinger equation for such a particle can be written as :

$$\Psi_n(\vec{r}, t) = \sum_{n=1}^{\infty} a_n \phi_n(\vec{r}) e^{-i\frac{E_n t}{\hbar}}$$

Where a_n are constant and in particular, do not depend on time. 12

5. What is Zeeman effect ? Explain normal Zeeman effect using vector model of an atom and also derive the expression for Zeeman Shift. 12

6. Derive an expression for transmission coefficient of one dimensional square well potential. Also explain its significance. 12

7. Explain L. S. Coupling and J-J Coupling. When are these coupling's effective ? Explain how do they originate. 12

8. State and prove Larmor's theorem. Discuss the experimental evidence in support of electron spin. 12

9. Write short notes on any **two** of the following : 6×2 = 12

(a) Expectation values of position and momentum

(b) Space quantization

(c) Vector model of atom

(d) Gaussian wave packet

(e) Gyromagnetic ratio and Bohr magneton

(f) Anomalous Zeeman Effect

2020

Time : 3 hours

Full Marks : 60

Candidates are required to give their answers in their own words as far as practicable.

The figures in the margin indicate full marks.

*Answer any **five** questions in which Q. No.1 is compulsory.*

1. Choose the correct answer of the following : $1 \times 12 = 12$

(a) The unit cell with dimensions $\alpha = \beta = \gamma = 90^{\circ}$, $a = b \neq c$ is :

(i) Cubic

(ii) Triclinic

(iii) Hexagonal

(iv) Tetragonal

(b) The Miller indices of the plane parallel to the X and Y axes are :

(i) (100)

(ii) (010)

(iii) (001)

(iv) (111)

(c) A Phonon is :

(i) A photon

(ii) Cation

(iii) A quanta of energy of lattice vibration

(iv) Anion

(d) In acoustic branch :

(i) Two consecutive atoms displace in same direction

(ii) All the particles are at rest

(iii) Two consecutive atoms displace in opposite direction

(iv) None of these

(e) Curie-Weiss law is :

(i) $\chi_m = \frac{C}{T}$

(ii) $\chi_m = \frac{C}{T - \theta}$

(iii) $\chi_m = \frac{C}{\theta}$

(iv) $\chi_m = \frac{T - \theta}{C}$

(f) The relation between magnetic susceptibility and relative permeability is :

(i) $\chi = 1 - \mu_r$

(ii) $\mu_r = 1 - \chi$

(iii) $\chi = 1 + \mu_r$

(iv) $\mu_r = 1 + \chi$

(g) Kronig-Penny model of solids is :

(i) Parabolic types interactions potential for valence electron

(ii) An improvement upon the free electron model

(iii) Square well type periodic potential for valence electron

(iv) None of these

(h) Hall voltage is directly proportional to :

(i) Current

(ii) Magnetic flux density

(iii) Electric field

(iv) None of these

(i) Electronic polarizability of an atom is proportional to :

(i) Radius

(ii) $(\text{Radius})^3$

(iii) $(\text{Radius})^2$

(iv) $\sqrt{\text{Radius}}$

(j) BCC lattice is reciprocal lattice of :

(i) SC lattice

(ii) BCC lattice

(iii) FCC lattice

(iv) Hexagonal lattice

(k) The first Brillouin zone of fcc lattice is :

(i) sc

(ii) Truncated octahedron

(iii) Rhombic dodecahedron

(iv) None of these

(l) Lorentz field equation is :

(i) $E = E_0 + \frac{P}{3\varepsilon_0}$

(ii) $E = E_0 + \frac{3P}{\varepsilon_0}$

(iii) $E = E_0 - \frac{3P}{\varepsilon_0}$

(iv) $E = E_0 - \frac{P}{3\varepsilon_0}$

2. (a) Prove that every reciprocal lattice vector is normal to lattice plane of crystal lattice.

(b) Show that for magnetic susceptibility of a paramagnetic material leads to Curie's law.

(c) The dielectric constant of Argon at $0^{\circ}C$ and at one atmosphere is 1.000435. Calculate polarizability of the atom. 4×3 = 12

3. What are Bravais lattices ? Discuss the different possible Bravais lattices in two and three dimensions. 3+4+5 = 12

4. Describe the lattice vibrations of monoatomic linear lattice and obtain an expression for the dispersion relation for lattice vibrations of monoatomic linear chain. 12

5. What are the assumptions of Einstein's theory of specific heat of solids ? Derive an expression for lattice heat capacity following Einstein theory. Discuss the relation at very high and at very low temperatures. Give the predictions of this theory and compare with experimental observations. 4+8 = 12

6. Discuss Langevin's theory of diamagnetism and obtain the expression for diamagnetic susceptibility. 12

7. Explain the term hysteresis and prove that hysteresis loss per cycle of magnetisation is equal to the area of the B-H loop. 2+10 = 12

8. What is Hall effect ? Give an expression in for the Hall coefficient of semiconductor on two band model of carriers and uses of it. 2+8+2 = 12

9. Write notes on any **two** of the following : 6×2 = 12

   (a) Laue's equation for diffraction of x-rays

   (b) Conductivity and mobility of semiconductor

   (c) Langevin-Debye Equation

   (d) Clausius Mosotti Equation

2020

Time : 3 hours

Full Marks : 60

Candidates are required to give their answers in their own words as far as practicable.

The figures in the margin indicate full marks.

*Answer any **five** questions in which Q. No. is 1 compulsory.*

1. Fill up the blanks using suitable words from the following : 2×6 = 12

(Voltage, current, enhancement, depletion, astable, monostable, forward, reverse, off, on, increases, decreases, high, low, active, passive)

(a) In a transistor emitter to base junction is _____ biased while base to collector junction is _____ biased.

(b) UJT has a high-impedence _____ state and low-impedance _____ state.

(c) JFET is a _____ controlled device and its input impedance is _____.

(d) An n-channel MOSFET with a negative threshold voltage is called _____ type MOSFET and that with a positive threshold voltage is called _____ type MOSFET.

(e) _____ filters usage op-amp. The gain of a low pass filter _____ as frequency of the signal increases.

(f) _____ multivibrator is known as one shot multivibrator and _____ multivibrator has application in oscillators.

2. (a) Draw the circuit of a band pass filter and plot its frequency response.

(b) What is CMOS ? Mention its advantages.

(c) What is the different between line and load regulation ? 4×3 = 12

3. (a) Draw the circuit of a diode detector. How it is used for demodulation of AM wave ?

(b) What is tunnel diode ? How it is constructed ? Give its I-V characteristics. 6×2 = 12

4. What are the differences between active and passive filters ? Explain the active and passive low pass and high pass filters giving their circuits. 4+8 = 12

5. Describe with a circuit diagram, the working of an astable multivibrator. Why it is called a free running multivibrator ? 10+2 = 12

6. Differentiate between n-channel and p-channel JFET. Why JFET is called unipolar device ? Explain with the help of neat diagram construction, working and I-V characteristics of n-channel JFET. 2+1+9 = 12

7. With the help of neat diagram explain the operation of n-channel depletion type MOSFET. Draw and explain its drain characteristics. 8+4 = 12

8. (a) What is modulation and demodulation ? Explain amplitude modulation, frequency modulation and phase modulation. 2+6 = 8

(b) A modulating signal $m(t) = 10\cos(2\pi \times 10^3 t)$ is amplitude modulated with a carrier signal $c(t) = 50\cos(2\pi \times 10^5 t)$. Find the modulation index 4

9. What are ASK, FSK and PSK ? Explain how they are used as techniques for digital modulation ? 12

2020

Time : 3 hours

Full Marks : 60

Candidates are required to give their answers in their own words as far as practicable.

The figures in the margin indicate full marks.

*Answer any **five** questions in which Q. No. is 1 compulsory.*

1. Answer any three of the following questions : 4×3 = 12

   (a) Define Vector Space. How will you represent vectors in n-space(vectors in R^n) ? Also, state the properties to vectors in R^n.

   (b) What is "Inner Product" and the "Norm" and deduce the relationship between them ?

   (c) Find whether the set of vectors A = (1, 2, 1); B = (3, 1, 5); C = (3, – 4, 7) is linearly independent or dependent ?

(d) If $S = \{u_1, u_2, u_3\}$ is the basis of the vector space V(f), then show that every element u of V can be uniquekly expressed as a linear combination of elements of S.

(e) What is unitary matrix ? Prove that a real matrix is unitary if it is orthogonal.

(f) A covariant tensor has components xy, $2y - z^2$, xz in rectangular co-ordinates. Find its covarient components is spherical coordinates.

2. State and prove Cauchy-Schwarz Inequality. 12

3. (a) Give the properties of Hermitian operators and explain their significance in quantum mechanics.

(b) Show that if two Hermitian Operators commute then their product is also Hermitian Operator. 12

4. Define symmetric and asymmetric tensors, Prove that a symmetric tensor of rank two has at

most $\frac{N(N+1)}{2}$ different components in N-dimensional space V_N. 12

5. Write notes on any **three** of the following : $4\times3 = 12$

   (a) Linear transformations

   (b) Minkowski space

   (c) Similarity transformation

   (d) Covariant and contravariant tensors

   (e) Vector subspaces.

6. State Hamilton's variational principle for conservative systems and obtain Euler-Lagrange differential equations. 12

7. What is Electromagnetic field Tensor ? Use tensor transformation rules to show how the components of electromagnetic field tensor transform under a Lorentz transformation. 12

8. (a) Show that Hermitian Operators have real eigen values.

(b) If $|a>$ is the eigen vector of a Hermitian Operator A with eigen value 'a' then show that, $A^{-1} = \sum_a \left| a > \frac{1}{a} < a \right|$. 12

9. (a) Discuss Isomorphisms.

(b) Explain functions of Hermitian matrices. 12

 UG — Phy (C – 601)

2020

Time : 2 hours

Full Marks : 60

Candidates are required to give their answers in their own words as far as practicable.

The figures in the margin indicate full marks.

*Answer any **three** questions in which Q. No. 1 is compulsory.*

All symbols have their usual meaing.

($\epsilon_0 = 8.85 \times 10^{-12}$ F/m, $\mu_0 = 4\pi \times 10^{-7}$ H/m, $C = 3 \times 10^8$ m/s)

1. Answer any **three** questions of the following : 4×3 = 12

   (a) Discuss Poynting Vector and its physical significance. Give the dimension of poynting vector.

(b) Show that electromagnetic waves move with a speed $C = \sqrt{\frac{1}{\mu_0 \epsilon_0}}$ in free space.

(c) The relative permittivity of distilled water is 81. Calculate the refractive index and speed of electromagnetic waves in it.

(d) Define Brewster's angle. Why is it called polarising angle ?

(e) Explain double refraction in uniaxial crystals.

(f) A sugar solution in a tube of 20 cm produces optical rotation of 13°. If the specific rotation of sugar is $65^{\circ}\ dm^{-1}g^{-1}\ cm^3$, determine the strength of the solution.

2. (a) Deduce the Maxwell's field equations for $\vec{D}, \vec{B}, \vec{E}$ and $\vec{H}$ vectors and explain the physical significance of each equation. 12

(b) If the magnitude of $\vec{H}$ in a plane electromagnetic wave is 1A/m, find the magnitude of $\vec{E}$ for this plane wave in free space. 5

(c) Using Maxwell's equation :

$$\vec{\nabla} \times \vec{E} = \frac{-\partial \vec{B}}{\partial t} \text{ and } \vec{\nabla} \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$$

show that $\vec{\nabla} \cdot \vec{B} = 0$ and $\vec{\nabla} \cdot \vec{D} = \rho$. 7

3. (a) Discuss the propagation of electromagnetic waves in isotropic dielectric medium. Why do these waves are regarded as transverse ? 12

(b) Discuss the reflection and refraction of electromagnetic waves at the interface of two dielectric media. Hence define refraction index. 12

4. (a) Describe the construction of Nicol Prism and explain how it can be used as polariser and analyser. 12

(b) Use the equation of superposition of two plane polarised waves vibrating in two mutually perpendicular planes to determine the conditions for getting plane polarised, circularly polarised and ellipically polarised lights. 12

5. (a) Describe the construction and theory of Babinet's compensator. How is it used to analyse elliptically polarised light ? 12

(b) Explain optical activity and specific rotation. Give the Fresnel's theory of optical rotation. How will you verify it experimentally. 12

 UG — Phy (C – 602)

2020

Time : 2 hours

Full Marks : 60

Candidates are required to give their answers in their own words as far as practicable.

The figures in the margin indicate full marks.

*Answer any **three** questions in which Q. No. 1 is compulsory.*

1. Answer any **two** of the following questions : 6×2 = 12

   (a) What is degenerate fermi gas ?

   (b) Entropy is a measure of disorder – Explain.

   (c) State explain law of equipartition of energy.

   (d) What do you mean by thermodynamic probability ?

   (e) Mention properties of liquid helium.

2. Derive expressions for thermodynamic functions of degenerate fermi gas. 24

3. Deduce Wien's displacement law for distribution of energy in black body spectrum. 24

4. Discuss Bose-Einstein condensation. Give comparison between Maxwell-Boltzmann, Statistics and Bose-Einstein statistics. 24

5. Derive Maxwell-Boltzmann Law of distribution of speeds and calculate r. m. s. velocity using the relation. 24

2020

Time : 2 hours

Full Marks : 80

Candidates are required to give their answers in their own words as far as practicable.

The figures in the margin indicate full marks.

*Answer any **three** questions in which Q. No. 1 is compulsory.*

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

   (a) What is Hamiltonian ? Explain its physical significance.

   (b) What do you understand by retarded potential ? Explain.

   (c) What are the postulates of special theory of relativity ? Discuss Length Contraction.

   (d) Explain twin paradox.

   (e) Explain generalised co-ordinates.

2. (a) Derive the expression of Oscillation of a double pendulum using Lagrangian equation of motion. 15

(b) What is Poisson Bracket ? Describe five properties of it. 15

3. Obtain the Linard-Wichart potential for moving charge from retarded potential. Write Maxwell's equation in four tensor form. 20+10 = 30

4. Obtain the electric field and magnetic field at a point due to uniformally moving charge. What is electromagnetic field tensor ? 22+8 = 30

5. Write notes on any **two** of the following : 15×2 = 30

(a) Hamiltonian equation of motion

(b) Canonical transformation

(c) Lorentz transformation equation of special theory of relativity.

(d) Equation of charged particle in external magnetic field.

2020

Time : 2 hours

Full Marks : 80

Candidates are required to give their answers in their own words as far as practicable.

The figures in the margin indicate full marks.

*Answer any **three** questions in which Q. No. 1 is compulsory.*

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

   (a) Define binding energy per nucleon and explain its variation with mass number of the nuclei.

   (b) Explain the difference between nuclear fission and nuclear fusion.

   (c) Give the difference between ionisation chamber and G. M. Counter.

   (d) Discuss neutrino hypothesis.

(e) How do the nuclear forces differ from gravitational and electrostatic forces ?

(f) Explain Gamow factor.

2. Discuss proton-electron theory of neclear composition. Why it was thought ? Give at least two causes for the failure of this hypothesis. 30

3. What is a nuclear reaction ? Explain briefly the various types of nuclear reactions which may occur when a high energy particle approaches a nucleur reactions. 30

4. Describe the principle, construction and working of Linear accelerator. 30

5. Describe the principles, construction and working of an ionisation chamber. 30