2017

PHYSICS

(Major)

Paper : 5.1

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

GROUP—A

(Mathematical Methods)

(*Marks* : 30)

1. Answer the following questions : 1×4=4

(a) Give the Euler's formula.

(b) For the complex number $z = 3 - 4i$, find z^4, given that $\tan^{-1}\frac{4}{3} = 53 \cdot 13°$.

(c) Plot the number $e^{(1+\frac{\pi}{4}i)}$.

(d) What is Argand plane or complex plane?

2. *(a)* State De Moivre's theorem. 2

(b) Using De Moivre's theorem, show that $e^{in\theta} = \cos n\theta + i \sin n\theta$. 2

3. *(a)* Examine whether the function $f(z) = (x+iy)^3$ is an analytic function or not. 3

(b) Prove that $\overline{z_1 \cdot z_2} = \overline{z_1} \cdot \overline{z_2}$. 2

Or

Check the analyticity of the function $f(z) = \ln z$ and hence find its derivative. 5

4. *(a)* State and prove Cauchy's integral theorem. 6

(b) Using Cauchy's integral formula, evaluate $\oint \frac{z-1}{z^2+1} dz$ around the contours—

(i) $|z-i| = 1$

(ii) $|z| = 2$ 2+2=4

5. Answer either *(a)* and *(b)* or *(c)* and *(d)* :

(a) State and prove Taylor's theorem. 5

(b) Evaluate $\oint_C \frac{dz}{z}$, where c is a circle of unit radius. 2

(Continued)

(c) Obtain the residu

$f(z) = \frac{e^{iz}}{x^2+a^2}$ at $z =$

(d) Evaluate the given

the calculus of resi

GROUP—

(Classical Mec

(*Marks* : 3

6. Answer the following que

(a) What do you mean

(b) What is a central fo

(c) What do you me coordinate?

(d) What is areal velocity

7. Answer any *three* of the foll

(a) What are generalized

(b) Define virtual displace its significance.

(c) Distinguish between Lagrangian and Hamiltonian formalisms.

(d) Define reduced mass in the context of two-body central force problem.

(e) Show that angular momentum is a constant of central force motion.

8. (a) State and establish d'Alembert's principle. 1+3=4

Or

Define Hamiltonian of a system. Under what conditions is it equivalent to energy? 1+3=4

(b) Show that a two-body central force problem can be reduced to one-body problem. 4

(c) Establish the Hamiltonian and hence the equation of motion of a simple pendulum. 5

Or

Establish the differential equation for the orbit under central force. 5

9. Find the equation of m
pendulum by using
Hence find an expre
oscillation for the pend

Or

Derive Lagrange's equa
Hamilton's principle
system.

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2017

PHYSICS

(Major)

Paper : 5.2

(Atomic Physics)

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct option : 1×7=7

(a) The electron of H-atom is excited to the n-th orbit. Then the total number of emission lines in the spectrum will be

(i) $\frac{1}{2}n(n-1)$

(ii) $\frac{1}{2}n(n+1)$

(iii) $n(n-1)$

(iv) $n(n+1)$

(b) According to vector atom model, the angular momentum (l) of an electron is conserved and quantized. Quantum mechanics therefore predicts that

(i) its magnitude is $\hbar$

(ii) its magnitude is $\sqrt{l(l+1)}\,\hbar$

(iii) its orientation with magnetic field is $\cos^{-1}\left[\frac{m}{\sqrt{l(l+1)}}\right]$

(iv) its orientation with magnetic field is $\cos^{-1}\left[\frac{l}{l\sqrt{l+1}}\right]$

(c) Zeeman shift of wavelength $d\lambda$ is

(i) $d\lambda = \pm\frac{Be}{4\pi m}$

(ii) $d\lambda = \pm\frac{Be\lambda}{4\pi mc}$

(iii) $d\lambda = \pm\frac{Be\lambda^2}{4\pi mc}$

(iv) $d\lambda = \pm\frac{Be\lambda^2}{4\pi mc^2}$

(Continued)

(d) The maximum f
produced by electr
potential differenc

(i) $\frac{hc}{eV}$

(ii) $\frac{eV}{h}$

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

(iv) eV

(e) Rutherford's α-
experiment ga
information about

(i) the charge of

(ii) the size of the

(iii) the size of the

(iv) None of the ab

(f) Frequency of Rama
the

(i) frequency of in

(ii) scattering subs

(iii) intensity of inc

(iv) strength of ma

(g) Which quantum number takes $(2l+1)$ different values?

(i) Orbital quantum number

(ii) Magnetic orbital quantum number

(iii) Spin quantum number

(iv) Magnetic spin quantum number

2. Answer any *four* of the following : 2×4=8

(a) What velocity will an electron acquire in moving through a potential difference of 1 volt? Assume the values of the charge and mass of the electron.

(b) Calculate what will be the approximate quantum number n for an electron in an orbit of radius 0·1 nm.

(c) An X-ray tube operated at 40 kV emits a continuous X-ray spectrum with a short wavelength $\lambda_m = 0 \cdot 310$ Å. Calculate the Planck's constant. ($e = 1 \cdot 6 \times 10^{-19}$ coulomb and $c = 3 \times 10^8$ m/sec).

(d) The energy of a hydrogen atom in its ground state is $-13 \cdot 6$ eV. What is the energy corresponding to the first excited state?

(Continued)

(e) A beam of electrons velocity of $1 \cdot 58 \times 10^7$ circle of radius 2 cm of flux density 4 Compute the value of of the electron.

(f) Find the critical volt applied to an X-ray K-series of copper. K-absorption limit is

3. Answer *(a)* and any *two* fro

(a) What do you und structure of the spec three contributory fac of spectral lines.

(b) Show that the radii of hydrogen like atom a n^2/z where n is the p number and z is the

(c) Define and illustrate taking the case of H-a

(i) Resonance potenti

(ii) Excitation potentia

(iii) Ionization potentia

(d) Write any *one* explanatory note on the following :

(i) Franck-Hertz experiment

(ii) Ritz's combination principle

(iii) X-ray spectra

4. Answer *(a)* and *(b)*, and any *one* from *(c)* and *(d)* : 10×3=30

(a) In a Bainbridge mass spectrograph, show that the radius r of the ion-path is linearly proportional to the ion mass M for the same ionic charge q. Mention three very important parameters on the Bainbridge spectrometer.

Singly ionised atoms of ^{20}Ne pass into the deflection chamber of a Bainbridge mass spectrograph with a velocity 10^5 m/s. They are deflected by a magnetic field of 0·07 tesla. What are the radii of their path? Where would ^{22}Ne ion fall if they possessed the same velocity initially? 4+2+4=10

Or

State the fundamental postulates of Bohr on which he based his theory of the spectrum of atomic hydrogen. What

interpretation do y
negative sign of th
Explain the physical
series limit.

A hydrogen atom is in
What is the quantum
it will be excited abs
energy 12·75 eV?

(b) What is Mosley's law
law on the basis of
discuss its importanc

What is the minimu
X-rays emitted by X-r
at 50 kV?

Or

Explain the meani
quantum numbers w
state of an electron i
Pauli's exclusion prin
at any state of pr
number n, the maxi
electrons which can b
is $2n^2$.

Write down the electro
of Cu ($z = 29$).

(c) Write any *two* explanatory notes of the following : 5×2=10

(i) Compton effect

(ii) *L-S* and *J-J* coupling

(iii) Bohr magneton

(iv) Sommerfeld's correction of Bohr's atom model

(d) Draw a neat diagram of the experimental arrange of Stern and Gerlach. What effect the magnetic field would have produced had it been uniform? Show how two traces are produced by the atomic beam. 3+1+2+4=10

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2017

PHYSICS

(Major)

Paper : 5.3

(Quantum Mechanics and Astrophysics)

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

Write the answers to the two Groups in separate books

GROUP—A

(Quantum Mechanics)

(*Marks* : 40)

1. Answer any *four* questions as directed : 1×4=4

(a) Select the correct answer :

Quantum nature of light emerged in an attempt to explain

(i) radioactivity

(ii) interference

(iii) blackbody radiation

(iv) pair production

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

(c) What is the probability of finding a particle represented by $\psi(r, t)$ in unit volume?

(d) Select the correct answer :

In view of uncertainty principle, the radiation emitted by an atom can have

(i) a definite frequency

(ii) a band of frequencies

(iii) a definite phase

(iv) a definite wavelength

(e) Show that expectation value of H is the total energy E of the system.

(f) What is the expectation value of momentum $\langle p \rangle$ of a particle trapped in a one-dimensional box of length a?

2. Answer any *three* questions : 2×3=6

(a) A beam of monoenergetic neutrons corresponding to 27 °C is allowed to fall on a crystal. A first-order reflection is observed at a glancing angle 30°. Calculate the interplanar spacing of the crystal.

Given, Planck's constant $h = 6 \cdot 62 \times 10^{-34}$ Js, mass of the electron $m = 1 \cdot 67 \times 10^{-27}$ kg and Boltzmann constant $k = 1 \cdot 38 \times 10^{-23}$ J/K.

(Continued)

(b) On the average, a system remains

What is minimum energy of an excite

(c) Distinguish betwe quantum harmonic

(d) What do you m coefficient and t particle incident at t potential?

(e) The lowest energ entrapped in a box the next three hi particle can have?

3. Answer any *four* questio

(a) The work function 4·2 eV. Calculate th the fastest and slow the stopping pote wavelength when li 2000 Å falls on a surface. [Given : $c = 3 \times 10^8$ m/s, 1 eV $1 \text{Å} = 10^{-8}$ m]

(b) An incident X-ray photon of frequency ν_0 is scattered by a free electron at rest through an angle ϕ. Using relativistic expression of electron energy, show that the change in the wavelength of the photon is given by

$$\Delta\lambda = \frac{h}{m_0 c}\{1 - \cos\phi\}$$

where m_0 = rest mass of electron, h is the Planck's constant and c is the velocity of light. 5

(c) Using uncertainty relation, show that an electron cannot reside inside a nucleus.

The maximum uncertainty in the position of an electron in a nucleus is 2×10^{-14} m. Find the minimum uncertainty in its momentum. 2+3=5

(d) In what respect does the Schrödinger equation differ from classical wave equation? Explain the term 'stationary state of a quantum mechanics' system. In a stationary state E, what is the form of time-dependent part of the wave function? 2+1+2=5

(Continued)

(e) What are the proper
physical wave functi

wave function $\psi(x) = A$
domain $x \in [-\alpha, \alpha]$, h
$\Gamma\frac{1}{2} = \sqrt{\pi}$.

Or

State and prove Ehre

(f) Describe briefly
experiment. What in
draw from this exper

4. Answer any *two* questions

(a) Write down the Sch
for a linear harmoni
are the eigenvalues a
of the Hamiltonian of
oscillator? Explain t
zero-point energy of

(b) Derive the continuity
time dependent Schrö
a particle moving in
Give the physical int
continuity equation y

(c) What are the conju
quantum mechanics?
of conjugate variable
commutation relation

GROUP—B

(Astrophysics)

(*Marks* : 20)

5. Answer any *three* from the following : 2×3=6

(a) What is the difference between solar time and sidereal time? What is the right ascension (α) and the declination (δ) of the point of vernal equinox? 1+1=2

(b) What is zodiac? State the relation among right ascension, local sidereal time and hour angle. 1+1=2

(c) The blue magnitudes of star 1 and star 2 are $B_1 = 5 \cdot 2$ m and $B_2 = 6 \cdot 7$ m respectively. The visual magnitude v for both the stars is observed as 5 m. Derive the colour index (CI) of each star. 2

(d) Luminosity of Regal Star in Orion constellation is 17000 that of our Sun. If the surface temperature of the Sun is 6000 K, calculate the temperature of the Regal Star. 2

(e) What is the apparent and absolute magnitude of a star? The sun has an apparent magnitude 26·5 m, calculate its absolute magnitude. 1+1=2

(Continued)

6. Answer any *two* of the fo

(a) Draw a neat HR dia main sequence, red giant and the white the evolutionary trac in the HR diagram.

(b) What is the en mechanism inside th stars? Which reactio in the Sun like stars nitrogen-oxygen (CNO

(c) Show how the parall for determination of Why is it not possibl distant object by this

7. Write short notes on following :

(a) Mass-luminosity relat

(b) Chandrasekhar limit

(c) Protostar

(d) Supernova

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2017

PHYSICS

(Major)

Paper : 5.4

(Electronics)

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Answer the following questions very briefly : 1×7=7

(a) A positive feedback amplifier will oscillate when it satisfies a certain criterion. What is this criterion?

(b) What will be the output voltage when equal voltages are applied to the input terminals of an ideal operational amplifier?

(c) What is ripple factor?

(d) Mention one important merit and one important demerit of RC-coupled amplifier.

(e) What is the main advantage of *CE* mode over *CB* mode of transistor?

(f) What represents by 00K in binary transmission process?

(g) How is photodiode connected in a circuit?

2. Answer the following questions : 2×4=8

(a) How is varactor diode realised? Where is it used?

(b) There are two basic conditions for oscillation in a feedback amplifier. What are these?

(c) The band gap of a specimen of gallium arsenide phosphide is 1·98 eV. Determine the wavelength of the electromagnetic radiation that is emitted upon direct recombination of electrons and holes in this sample. What is the colour of the emitted radiation?

(d) Draw a TTL NAND gate with totem pole.

3. Draw the circuit diagram of a full-wave rectifier using two *P-N* junction diodes. Find out the different components present in the output voltage applying Fourier analysis. Draw output voltage pattern when shunt capacitor is used. 2+2+1=5

(Continued)

Or

Draw the circuit diagram oscillator along with circuit. Give a brief anal

4. Transform the following Thevenin's equivalent cir the value of *(a)* The impedance, *(b)* Thevenin's source and *(c)* load curre

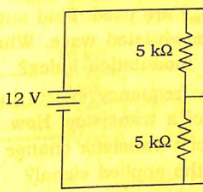

Fig. 1

5. State De Morgan's laws. S and bubbled AND gate are other. Give their truth ta

Or

Describe various current flow across the forwa junction and the revers junction of transistor.

6. Answer any *two* questions from the following : 5×2=10

(a) *(i)* Convert the binary number $1010 \cdot 01_2$ to its decimal equivalent.

(ii) Convert the decimal number $27 \cdot 375_{10}$ to its binary equivalent.

(iii) Subtract $10010 \cdot 01_2$ from $111000 \cdot 00_2$ using 2's complement. 1+2+2=5

(b) For frequency modulation carrier wave, $v_c = V_c \cos \omega_c t$ and modulating signal $v_m = V_m \cos \omega_m t$ are used. Find out the frequency of modulated wave. What is the frequency modulation index? 4+1=5

(c) There is high frequency effects in the performance of a transistor. How does performance of a transistor change with frequency of the applied signal? 5

(d) Draw the circuit for square-law diode detection. Describe how information is extracted from the received signal. 2+3=5

7. Answer any *two* questions from the following : 5×2=10

(a) What are the different modes of propagation of radio waves? Which of them determines critical frequency? What frequency range of electromagnetic wave is allotted for TV broadcasting? 3+1+1=5

(Continued)

(b) Draw the circuit d
flip-flop using NAND
and clear inputs
Explain the operation
and symbol.

(c) Find out the output
three-input weighted
circuit (Fig. 2). If
permissible output
OP-AMP is 20 mA, v
value of the load res

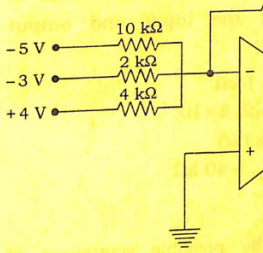

Fig. 2

(d) Draw the circuit of a p
amplifier. With the
analysis, show that m
is nearly 78·5%.

8. Answer any *two* questions from the following : 5×2=10

(a) Describe the method by which phase angle between two signals or variable voltages measured by producing Lissajous figures in CRO. 5

(b) A transistor amplifier in CE configuration couples a source of internal resistance 1 kΩ to a load of 20 kΩ. Find the input and output resistances if

$h_{ie} = 1\ k\Omega$
$h_{re} = 2 \cdot 5 \times 10^{-4}$
$h_{fe} = 150$
$1 / h_{oe} = 40\ k\Omega$ 5

(c) What are the possible sequences of binary digits used in M-ary communication? If a high frequency carrier wave is used for ASK, FSK and PSK, then what will be the pattern of modulated signal if a particular digital modulating signal is assumed? 2+3=5

(Continued)

(d) Write a short note o following :

(i) Astable multivibra

(ii) Barkhausen crite

(iii) Maximum power and mixed combi cells in circuit

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