P - III (1+1+1) H / 18 (N)

2018

PHYSICS (Honours)

Paper Code : VII-A

[New Syllabus]

Full Marks : 20 Time : Thirty Minutes

Important Instructions for OMR Sheet

1. Write / Fill your correct Subject Name, Subject Code & Paper Code in the space provided on the top of the OMR sheet (Subject Codes are given on the back of the OMR sheet & Paper Code in the Question Paper.)
2. Write / Fill your Name, Roll number, Registration number, Regn. Session, Exam Date and Exam Session in the space provided on the OMR Sheet.
3. Each item has four alternative responses marked (A), (B), (C) and (D). You have to darken the circle as indicated below on the correct response against each item.
4. Your responses to the items are to be indicated in the **OMR Sheet given inside the Paper Booklet only.** If you mark at any place other than in the circle in the OMR Sheet, it will not be evaluated.
5. If you write your Phone Number in the OMR Sheet or use abusive language or employ any other unfair means, you will render yourself liable to disqualification.
6. You have to return the OMR Sheet to the invigilators at the end of the examination compulsorily and must not carry it with you outside the Examination Hall.
7. **Use only Blue/Black Ball point pen. Use of any mobile phone, calculator or log table etc. in examination hall, is prohibited.**

OMR Sheet-এর জন্য জরুরী নির্দেশাবলী

১। OMR Sheet এর নির্দেশিত স্থানে সঠিক Subject Name, Subject Code এবং Paper Code লিখতে/পূরণ করতে হবে। OMR Sheet এর পিছনের পাতায় Subject Code গুলি দেওয়া আছে এবং Paper Code টি প্রশ্নপত্রে উল্লেখ আছে।

২। OMR Sheet এর নির্দেশিত স্থানে Name, Roll number, Registration number, Regn. Session, Exam date এবং Exam Session লিখতে/পূরণ করতে হবে।

৩। প্রতিটি প্রশ্নে চারটি করে সম্ভাব্য উত্তর, যথাক্রমে (A), (B), (C) এবং (D) করে দেওয়া আছে। পরীক্ষার্থীকে সঠিক উত্তরের গোল ঘরটি নীল/কালো কালিতে পূরণ করতে হবে।

৪। সঠিক উত্তর কেবলমাত্র উত্তর পত্র অর্থাৎ OMR Sheet-এর নির্দিষ্ট স্থানে গোল ঘর পূরণ করেই দিতে হবে। অন্য কোনো উপায়ে দেওয়া উত্তরের মূল্যায়ন হবে না।

৫। পরীক্ষার্থীর ফোন নম্বর OMR Sheet এর কোনো অংশে লেখা যাবে না। কোনোরূপ অবাঞ্ছিত শব্দ লেখা বা দুর্নীতির আশ্রয় নিলে পরীক্ষার্থী নিজেই তার জন্য দায়ী থাকবে।

৬। পরীক্ষা শেষে উত্তর পত্র (OMR Sheet) সংশ্লিষ্ট তত্ত্বাবধায়কের নিকট জমা দিয়ে পরীক্ষা কেন্দ্রের বাইরে বেরোতে হবে এবং কোনোভাবেই পরীক্ষা কেন্দ্রের বাইরে OMR Sheet টি আনা যাবে না।

৭। **শুধুমাত্র নীল/কালো বল পয়েন্ট কলম ব্যবহার করতে হবে। পরীক্ষাকক্ষে মোবাইল ফোন, ক্যালকুলেটর অথবা লগ-টেবিল ইত্যাদি ব্যবহার নিষিদ্ধ।**

Answer *all* the questions in OMR sheet.

Choose the correct answer.

Each question carries 2 marks.

1. If a generalised position co-ordinate (q_i) is cyclic with respect to the Lagrangian (L) of a system, the conjugate generalised momentum (p_i) must satisfy the relation :

   (A) p_i is a function of time (t) only.

   (B) p_i does not change with time.

   (C) p_i is always zero.

   (D) p_i may sometimes become zero, but not always.

Turn Over

2. If P_i and P_j represent the probabilities of occupation of two energy states E_i and E_j $\left(E_j > E_i\right)$ by a system, the equilibrium temperature (T) of the system in terms of E_i, E_j, P_i, P_j and the Boltzmann's constant k, is given by :

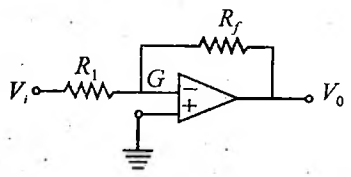
   (A) $T = \dfrac{E_j - E_i}{k \ln\left(P_i/P_j\right)}$

   (B) $T = \dfrac{E_j - E_i}{k}$

   (C) $T = \dfrac{E_i - E_j}{k \ln\left(P_i/P_j\right)}$

   (D) $\dfrac{1}{k}\left(\dfrac{E_j}{P_j} - \dfrac{E_i}{P_i}\right)$

3. Consider the following Op Amp circuit where the circuit elements are usual.



If $R_1 = 20\,k\Omega$, $R_f = 100\,k\Omega$ and $V_i = 1.0$ volt, $|V_0|$ will be :

(A) 0.2 volt

(B) 1.2 volt

(C) 6.0 volt

(D) 5.0 volt

4. Consider the following transformation :

$Q = q\cos\alpha - p\sin\alpha$ and $P = q\sin\alpha + p\cos\alpha$, where q and p are the generalised position and the conjugate generalised momentum of the system respectively. For any value of α, the Poisson bracket $[Q, P]$ has the value :

(A) 0

(B) –1

(C) 1

(D) $\cos^2\alpha - \sin^2\alpha$

Turn Over

5. A system has two energy levels of energy zero and $100\,k$ (where k = Boltzmann's constant) with degeneracies of 2 and 3 respectively. The partition function (Z) for the system at a temperature of $100\,k$ has a value :

(A) $Z = 5.0$

(B) $Z = 2.0$

(C) $Z = 2.33$

(D) $Z = 3.104$

6. An n-channel JFET has $I_{DSS} = 12.0\,\text{mA}$. If the 'pinch-off' voltage $V_P = -4.0V$, the drain current (I_D) for $V_{GS} = -2.0V$ has a value :

(A) $I_D = 3.0\,\text{mA}$

(B) $I_D = 27.0\,\text{mA}$

(C) $I_D = 4.0\,\text{mA}$

(D) $I_D = 12.0\,\text{mA}$

7. The Lagrangian of a moving particle is given by :

$$L=\frac{1}{2}m\left(\dot{r}^2+r^2\dot{\theta}^2\right)-V(r),$$

where the terms bear usual significance. The Hamiltonian (H) of the particle is given by :

(A) $H=\frac{1}{2}m\left(\dot{r}^2+r^2\dot{\theta}^2\right)$

(B) $H=\frac{1}{2}m\left(\dot{r}^2+r^2\dot{\theta}^2\right)+V(r)$

(C) $H=m\left(\dot{r}^2+r^2\dot{\theta}^2\right)+V(r)$

(D) $H=\frac{1}{2}m\left(\dot{r}^2-r^2\dot{\theta}^2\right)+V(r)$.

8. A particle falls freely under gravity. The nature of its locus in the phase space is :

(A) an ellipse

(B) a circle

(C) a parabola

(D) a straight line

Turn Over

9. The binary equivalent of the octal number $(365)_8$ is given by :

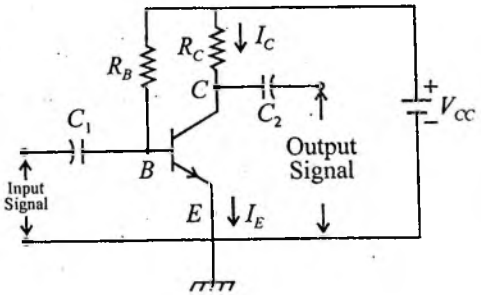
(A) $(11110101)_2$

(B) $(10110101)_2$

(C) $(11111001)_2$

(D) $(10101001)_2$

10. Consider the n-p-n transistor circuit with fixed bias arrangement. Assuming $\beta=100$ and $V_{CC}=10.0\,V$, and taking $I_B \gg I_{CBO}$, the required values of R_C and R_B to set up the Q-point at $I_C=5.0$ mA, $V_{CE}=5.0$ V will be :



Take : $V_{BE}=0.7$ V.

(A) $R_C=1.0\,k\Omega$, $R_B=100\,k\Omega$

(B) $R_C=1.0\,k\Omega$, $R_B=186\,k\Omega$

(C) $R_C=10.0\,k\Omega$, $R_B=18.6\,k\Omega$

(D) $R_C=10.0\,k\Omega$, $R_B=100\,k\Omega$

2018

PHYSICS (Honours)

Paper Code : VII-B

[New Syllabus]

Full Marks : 70 Time : Three Hours Thirty Minutes

The figures in the margin indicate full marks.

Answer *five* questions, taking at least *one* from Group - A, *one* from Group - B, *two* from Group - C and the remaining *one* from any group.

Group - A

(Classical Mechanics - II and Fluid Mechanics)

1. (a) State and explain the principle of virtual work. Write down the advantages of this principle to solve the equation of a dynamical system. 1+2+1

(b) Derive Lagrange's equations from D'Alembert's principle. 6

(c) The Lagrangian of a system is given by

$L=\frac{1}{2}e^{at}\left(\dot{x}^2-p^2x^2\right)$, where a and p are constants. Prove that the equation of motion of the system is given by

$\ddot{x}+a\dot{x}+p^2x=0$. 4

2. (a) Define Hamiltonian of a system.

Show that a generalised co-ordinate which is ignorable in the Lagrangian is also ignorable in the Hamiltonian. 1+2

Turn Over

(b) If the Lagrangian of a conservative system does not depend on time explicitly, show that its Hamiltonian is identical with its total energy and remains conserved. 4

(c) A particle of mass 'm' is constrained to move on the surface $xy=c$ under the action of gravity, 'c' being a constant. Show that the Lagrange's equation for the particle is

$m\left(x^5+c^2x\right)\ddot{x}-2mc^2\dot{x}^2-mgcx^3=0$. 5

(d) Show that the Poisson bracket $\left[q_i,\ p_j\right]_{q,\,p}=\delta_{ij}$, where δ_{ij} is a Krönecker delta. 2

3. (a) State Bernoulli's theorem for the streamline flow of an incompressible non-viscous fluid. Deduce Bernoulli's equation in this case from energy consideration. From Bernoulli's theorem arrive at Torricelli's theorem. 1+5+2

(b) The Lagrangian for a coupled harmonic oscillator is given by :

$L=\frac{1}{2}\left(\dot{q}_1^2+\dot{q}_2^2\right)-\frac{1}{2}\left(w_1^2q_1^2+w_2^2q_2^2\right)+\alpha q_1q_2$,

where α, w_1 and w_2 are constants, and q_1 and q_2 are suitable co-ordinates.

Find the Hamiltonian of the system. 3

(c) Show that the transformation defined by

$q=\sqrt{2P}\sin Q$, $p=\sqrt{2P}\cos Q$ is canonical. 3

Group - B

(Statistical Mechanics)

4. (a) Explain the postulate of equal a priori probability. 2

   (b) State and deduce Stirling's formula. 1+2

   (c) Mentioning the necessary postulates of Fermi-Dirac Statistics, obtain the Fermi-Dirac distribution formula for an ensemble of fermions. 5

   (d) Obtain an expression for the Fermi energy of electrons in a metal at OK in terms of electron density. 4

5. (a) Consider a macroscopic system with its microstates designated as 1, 2, 3, ..., r, ... If P_r be the probability of the system to be found in state 'r', prove that the entropy of the system is given by

   $$S = -k\sum_r P_r \ln P_r .$$ 4

   (b) Write down Bose-Einstein distribution formula and using it deduce Planck's law of radiation. 2+5

   (c) Consider an ensemble of two particles A and B. Each of them can occupy any one of three non-degenerate energy states. Find the possible number of microstates according to MB, BE and FD statistics. 3

Group - C

(Electronics - II)

6. (a) What do you mean by coupling of amplifiers ? When two stages of amplifiers are used in cascade, what will be the overall voltage gain ? What are the advantages of an R-C coupled transistor amplifier ? Draw its frequency response curve. 1+1+3+2

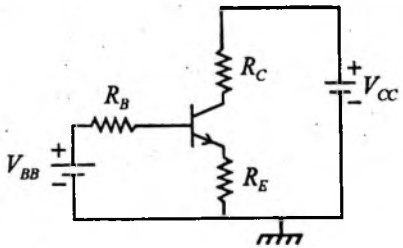
Turn Over

   (b) Describe the procedure for the construction of an enhancement-type MOSFET and explain its operation. 5

   (c) A silicon transistor is to be operated as a CE amplifier with base-resistor method of biasing. The transistor operates at the signal collector current $I_C = 1.0$ mA and $V_{CC} = 4.0$ V. The load resistance in the collector circuit is 2.0 $k\Omega$. Assuming $V_{BE} = 0.7$ volt, calculate the value of R_B. Take $\beta = 100$. 2

7. (a) What do you mean by voltage and current feedbacks in an amplifier ? List the advantages of negative feedback in a transistor amplifier. Explain how non-linear distortion can be reduced by negative feedback. 2+3+3

   (b) What do you understand by biasing of a transistor ? Show that the bias current stability factor $S = \partial I_C / \partial I_{CBO}$ is controlled by the ratio $\left(\frac{R_B}{R_E}\right)$ for the biasing scheme shown below.



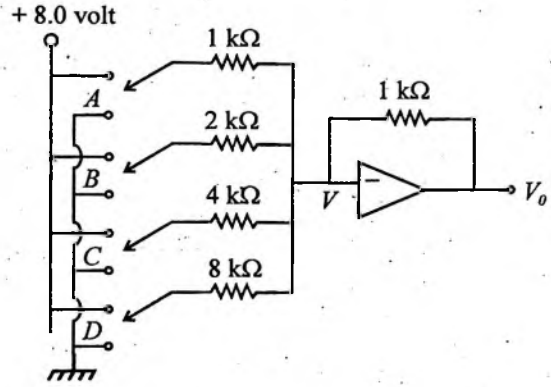
2+4

8. (a) What are the essential components of a CRO ? Define electrostatic deflection sensitivity of a cathode ray tube and obtain an expression for the same. 2+4

   (b) In a CRT, the deflection plates are 2.0 cm long and have a uniform spacing of 4.0 mm between them. The fluorescent screen is 25.0 cm away

from the centre of the deflection plates. If the final anode voltage is 2.0 kV, find the deflection sensitivity in mm/volt. 2

(c) What is meant by virtual ground of an Op Amp ? If the switches ABCD are in states 0110 in the following diagram, find the output voltage V_0.



2+4

9. (a) How many half adders are required to make a full adder ? Explain it with a block diagram. 1+3

(b) Draw the block diagram of a ROM having n input lines and m output lines. Explain its working. 2+2

(c) Draw the basic circuit of a NOR gate using two transistors. 2

(d) Name the various registers of 8085A and explain briefly their functions. 4

P - III (1+1+1) H / 18 (N)

2018

PHYSICS (Honours)

Paper Code : VIII-A

[New Syllabus]

Full Marks : 20 Time : Thirty Minutes

Important Instructions for OMR Sheet

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OMR Sheet-এর জন্য জরুরী নির্দেশাবলী

১। OMR Sheet এর নির্দেশিত স্থানে সঠিক Subject Name, Subject Code এবং Paper Code লিখতে/পূরণ করতে হবে। OMR Sheet এর পিছনের পাতায় Subject Code গুলি দেওয়া আছে এবং Paper Code টি প্রশ্নপত্রে উল্লেখ আছে।

২। OMR Sheet এর নির্দেশিত স্থানে Name, Roll number, Registration number, Regn. Session, Exam date এবং Exam Session লিখতে/পূরণ করতে হবে।

৩। প্রতিটি প্রশ্নে চারটি করে সম্ভাব্য উত্তর, যথাক্রমে (A), (B), (C) এবং (D) করে দেওয়া আছে। পরীক্ষার্থীকে সঠিক উত্তরের গোল ঘরটি নীল/কালো কালিতে পূরণ করতে হবে।

৪। সঠিক উত্তর কেবলমাত্র উত্তর পত্র অর্থাৎ OMR Sheet-এর নির্দিষ্ট স্থানে গোল ঘর পূরণ করেই দিতে হবে। অন্য কোনো উপায়ে দেওয়া উত্তরের মূল্যায়ন হবে না।

৫। পরীক্ষার্থীর ফোন নম্বর OMR Sheet এর কোনো অংশে লেখা যাবে না। কোনোরূপ অবাঞ্ছিত শব্দ লেখা বা দুর্নীতির আশ্রয় নিলে পরীক্ষার্থী নিজেই তার জন্য দায়ী থাকবে।

৬। পরীক্ষা শেষে উত্তর পত্র (OMR Sheet) সংশ্লিষ্ট তত্ত্বাবধায়কের নিকট জমা দিয়ে পরীক্ষা কেন্দ্রের বাইরে বেরোতে হবে এবং কোনোভাবেই পরীক্ষা কেন্দ্রের বাইরে OMR Sheet টি আনা যাবে না।

৭। **শুধুমাত্র নীল/কালো বল পয়েন্ট কলম ব্যবহার করতে হবে। পরীক্ষাকক্ষে মোবাইল ফোন, ক্যালকুলেটর অথবা লগ-টেবিল ইত্যাদি ব্যবহার নিষিদ্ধ।**

Answer *all* the questions in OMR sheet.

Choose the correct answer.

Each question carries 2 marks.

1. When light is incident at an angle of 30° with the surface of a slab, the reflected ray is plane polarised. Then, the refractive index (n) of the reflecting medium and the corresponding angle of refraction (r) are respectively :

   (A) $n = 1.73$; $r = 30°$

   (B) $n = 1.73$; $r = 60°$

   (C) $n = 1.50$; $r = 30°$

   (D) $n = 1.50$; $r = 60°$

2. If a 500W laser beam is concentrated by a lens into a cross-sectional area of 10^{-10} m^2, the value of the Poynting vector(s) and the amplitude of the electric field (E_0) are respectively equal to :

   (A) $S = 5\times10^{12}$ Wm^{-2} ; $E_0 = 4.314\times10^{7}$ Vm^{-1}

   (B) $S = 4.314\times10^{12}$ Wm^{-2} ; $E_0 = 5.0\times10^{7}$ Vm^{-1}

   (C) $S = 5\times10^{-8}$ Wm^{-2} ; $E_0 = 6.1\times10^{7}$ Vm^{-1}

   (D) $S = 5\times10^{12}$ Wm^{-2} ; $E_0 = 6.1\times10^{7}$ Vm^{-1}

Turn Over

3. With what velocity should a rocket move with respect to the earth so that every year spent on it corresponds to 4 years on the earth ? The invariant speed of light in free space is 'c'.

   (A) c

   (B) 0.25 c

   (C) 0.968 c

   (D) 0.5 c

4. The glancing angle for the first order reflection from a cubic crystal, using X-rays of wavelength 1.54Å, is 18°. Then, the separation between the reflecting planes of the crystal is :

   (A) 4.98Å

   (B) 2.49Å

   (C) 1.54Å

   (D) 3.08Å

5. A light wave has the x- and y-components of the electric field vector as —

   $$E_x = E_0\cos(wt+kz) \text{ and } E_y = \frac{E_0}{\sqrt{2}}\cos(wt+kz+\pi),$$

   where the terms are usual. Which of the following statements is true for the said light wave ?

   (A) It is unpolarised

   (B) It is elliptically polarised

   (C) It is circularly polarised

   (D) It is linearly polarised

6. Show that when light is incident normally on the air-glass interface, and the refractive index of glass is 1.5, the amount of light reflected back is approximately :

(A) 4%

(B) 15%

(C) 50%

(D) 100%

7. For silver the conductivity $\sigma = 3\times10^{7}$ mho.m^{-1}. The skin depth of silver for an electromagnetic wave of frequency 10 GHz is :

(A) $4.6\times10^{-6}m$

(B) $5.0\times10^{-7}m$

(C) $9.2\times10^{-7}m$

(D) $10.2\times10^{-7}m$

8. An unpolarised plane light wave of intensity 100 W/m^2 passes through two Nicols with their principal sections at 30° to each other. The intensity of the final transmitted wave would be :

(A) 75.0 W/m^2

(B) 37.5 W/m^2

(C) 12.5 W/m^2

(D) zero

Turn Over

9. The length of a rod, when at rest, is L_0. If now the rod begins to move with a uniform relative speed 'v' with respect to a stationary observer, its length was measured by him as $\frac{1}{2}L_0$. Then, 'v' has a value :

(A) c

(B) 0.433 c

(C) 0.5 c

(D) 0.866 c

10. An intrinsic sample of Ge crystal has a hole density of 10^{19} per m^3 at room temperature. When doped with Sb, the hole density decreases to 10^{17} per m^3 at the same temperature. Then, the majority carrier density will have a value :

(A) 10^{21} per m^3

(B) 10^{18} per m^3

(C) 99×10^{17} per m^3

(D) 10^{19} per m^3

P - III (1+1+1) H / 18 (N)

2018

PHYSICS (Honours)

Paper Code : VIII-B

[New Syllabus]

Full Marks : 70 Time : Three Hours Thirty Minutes

The figures in the margin indicate full marks.

Answer *five* questions, taking at least *one* from each group.

Group - A

(Physical Optics - II)

1. (a) Explain the difference between spontaneous and stimulated emissions. What is population inversion ? 2+1

   (b) Obtain a relation between Einstein's A and B coefficients. 4

   (c) Describe briefly with suitable diagrams the principle and working of a ruby laser. 5

   (d) Write briefly the basic principle of 'holography'. 2

2. (a) Discuss the principle of production of elliptically and circularly polarised light from a plane polarised light by using a doubly refracting crystal plate. Hence, define a quarter-wave plate and a half-wave plate. 4+2

   (b) A right circularly polarised beam of light $(\lambda = 525 \text{ nm})$ is incident normally on a doubly refracting crystal plate with optic axis parallel to the surface. The thickness of the plate is 0.003 nm. It is given that $n_0 - n_e = 0.175$. Find the state of polarisation of the emergent beam. 2

   (c) What is optical rotation ? Give Fresnel's explanation of optical rotation. Define specific rotation. 1+4+1

Turn Over

3. (a) Describe briefly the construction of a Babinet's compensator. Explain how it can produce any amount of phase difference between the O-ray and the E-ray emerging from the instrument. 3+3

   (b) What is a graded-index fibre ? Discuss its superiority over a step-index fibre. 1+2

   (c) A step-index fibre has a core of refractive index 1.55 and cladding of refractive index 1.53. Determine its numerical aperture and aceptance angle. 3

   (d) What is a polaroid ? What is dichroism ? 2

Group - B

(Electromagnetic theory and special theory of relativity)

4. (a) Deduce the following electromagnetic field equation :

   $\vec{\nabla} \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$, where the terms are usual.

   How the equation is reduced when the electromagnetic wave travels through a pure dielectric medium ? 4+1

   (b) An electromagnetic wave is incident on the interface between two dielectric media. What are the boundary conditions that must be satisfied by the field vectors ? Show that the frequency of the incident wave remains unchanged by reflection and transmission. 2+2

   (c) What do you mean by scattering cross-section ? Distinguish between Thompson scattering and Rayleigh scattering. How would you explain the blue colour of the sky ? 1+2+2

5. (a) State and prove Poynting's theorem. Define Poynting's vector. 5+1

   (b) Consider the propagation of plane electromagnetic waves through an isotropic dielectric medium. Find a relation between the amplitudes of the electric and magnetic field vectors. Also show that the electric field, the magnetic field and the direction of propagation are mutually orthogonal. 3+2

(c) What is a four vector ? Define spacelike and timelike four vectors with one example of each. 3

6. (a) What do you mean by 'proper time' in special theory of relativity ? 1

(b) Two photons are approaching each other with the same speed 'c'. What is the relative speed of one with respect to the other ? 2

(c) Deduce the relation $E = mc^2$, terms being usual. Hence, obtain an expression for the kinetic energy of a relativistically free particle. Show that the expression reduces to the classical formula under the condition $\frac{v}{c} \ll 1$. 4+2+1

(d) Explain stellar aberration in the light of special theory of relativity. 4

Group - C

(Solid State Physics and Electric and Magnetic Properties of Matter)

7. (a) What are Miller indices ?

Derive an expression for the interplanar spacing between two parallel planes with Miller indices (hkl) and show that for a simple cubic lattice of lattice constant 'a',

$$d_{hkl} = \frac{a}{\sqrt{h^2 + k^2 + l^2}}.$$ 2+4

(b) What is a reciprocal lattice ?

A two-dimensional lattice has the basis vectors $\vec{a} = 2\hat{x}$; $\vec{b} = \hat{x} + 2\hat{y}$. Find the reciprocal lattice vectors. 2+3

(c) What is Hall effect ? Define Hall constant. Mention two important applications of Hall effect. 1+1+1

Turn Over

8. (a) What is meant by 'hysteresis' of a ferromagnetic specimen ? Prove that the energy loss per unit volume per cyclic magnetisation of a ferromagnetic material is equal to the area of the corresponding B-H loop. 1+4

(b) A specimen of iron of density 7700 kg/m^3 and specific heat 462 J.kg^{-1}K^{-1} is magnetised by an a.c. field of frequency 50 Hz. Assuming no loss of heat, prove that the rise in temperature of the specimen per minute would be 4.22°C, if the B-H loop of the specimen has an area of 5000 J.m^{-3}.cycle^{-1}. 3

(c) Define Peltier coefficient (π) of a thermocouple comprised by two dissimilar metals A and B. Give its SI unit. Show that $\pi = T\frac{dE}{dT}$, terms being usual. 2+4

9. (a) What are the basic differences between a paramagnetic substance and a diamagnetic substance ?.

Show that when a magnetic field $\vec{B}$ is applied on a diamagnetic material, the change in magnetic moment of an orbiting electron is given by $\frac{-Be^2r^2}{4m}$, where the symbols have their usual meanings. Hence, obtain an expression for the susceptibility of a diamagnetic material. 2+5+3

(b) How does the diamagnetic susceptibility depend on temperature ? Explain with reasons. 2

(c) Briefly explain the origin of anti-ferromagnetism. 2

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P - III (1+1+1) H / 18 (N)

2018

PHYSICS (Honours)

Paper Code : IX-A

[New Syllabus]

Full Marks : 20 Time : Thirty Minutes

Important Instructions for OMR Sheet

1. Write / Fill your correct Subject Name, Subject Code & Paper Code in the space provided on the top of the OMR sheet (Subject Codes are given on the back of the OMR sheet & Paper Code in the Question Paper.)
2. Write / Fill your Name, Roll number, Registration number, Regn. Session, Exam Date and Exam Session in the space provided on the OMR Sheet.
3. Each item has four alternative responses marked (A), (B), (C) and (D). You have to darken the circle as indicated below on the correct response against each item.
4. Your responses to the items are to be indicated in the **OMR Sheet given inside the Paper Booklet only.** If you mark at any place other than in the circle in the OMR Sheet, it will not be evaluated.
5. If you write your Phone Number in the OMR Sheet or use abusive language or employ any other unfair means, you will render yourself liable to disqualification.
6. You have to return the OMR Sheet to the invigilators at the end of the examination compulsorily and must not carry it with you outside the Examination Hall.
7. **Use only Blue/Black Ball point pen. Use of any mobile phone, calculator or log table etc. in examination hall, is prohibited.**

OMR Sheet-এর জন্য জরুরী নির্দেশাবলী

১। OMR Sheet এর নির্দেশিত স্থানে সঠিক Subject Name, Subject Code এবং Paper Code লিখতে/পূরণ করতে হবে। OMR Sheet এর পিছনের পাতায় Subject Code গুলি দেওয়া আছে এবং Paper Code টি প্রশ্নপত্রে উল্লেখ আছে।

২। OMR Sheet এর নির্দেশিত স্থানে Name, Roll number, Registration number, Regn. Session, Exam date এবং Exam Session লিখতে/পূরণ করতে হবে।

৩। প্রতিটি প্রশ্নে চারটি করে সম্ভাব্য উত্তর, যথাক্রমে (A), (B), (C) এবং (D) করে দেওয়া আছে। পরীক্ষার্থীকে সঠিক উত্তরের গোল ঘরটি নীল/কালো কালিতে পূরণ করতে হবে।

৪। সঠিক উত্তর কেবলমাত্র উত্তর পত্র অর্থাৎ OMR Sheet-এর নির্দিষ্ট স্থানে গোল ঘর পূরণ করেই দিতে হবে। অন্য কোনো উপায়ে দেওয়া উত্তরের মূল্যায়ন হবে না।

৫। পরীক্ষার্থীর ফোন নম্বর OMR Sheet এর কোনো অংশে লেখা যাবে না। কোনোরূপ অবাঞ্ছিত শব্দ লেখা বা দুর্নীতির আশ্রয় নিলে পরীক্ষার্থী নিজেই তার জন্য দায়ী থাকবে।

৬। পরীক্ষা শেষে উত্তর পত্র (OMR Sheet) সংশ্লিষ্ট তত্ত্বাবধায়কের নিকট জমা দিয়ে পরীক্ষা কেন্দ্রের বাইরে বেরোতে হবে এবং কোনোভাবেই পরীক্ষা কেন্দ্রের বাইরে OMR Sheet টি আনা যাবে না।

৭। **শুধুমাত্র নীল/কালো বল পয়েন্ট কলম ব্যবহার করতে হবে। পরীক্ষাকক্ষে মোবাইল ফোন, ক্যালকুলেটর অথবা লগ-টেবিল ইত্যাদি ব্যবহার নিষিদ্ধ।**

Answer *all* the questions in OMR sheet.

Choose the correct answer.

Each question carries 2 marks.

1. An electron is trapped in a one-dimensional infinite potential well of width 1.0Å. Taking $h = 6.626 \times 10^{-34}$ J.S. and assuming the necessary formula, prove that the lowest energy of the electron will be (taking mass of an electron = 9.1×10^{-31} kg) :

   (A) 36.0 eV

   (B) 37.5 eV

   (C) 38.5 eV

   (D) 40.0 eV

2. What is the dimension of the wavefunction $\psi(\vec{r}, t)$?

   (A) L^{-3}

   (B) $L^{3/2}$

   (C) $L^{-1/2}$

   (D) $L^{-3/2}$

3. The nuclear radius of Be^8 is 2.4 F; that of Al^{27} will be :

   (A) 3.6 F

   (B) 7.2 F

   (C) 1.2 F

   (D) 2.4 F

Turn Over

4. A μ^- particle decays as :

   $\mu^- = e^- + \gamma_\mu + \bar{\gamma}_e + E$, where E = energy. Given : $m_\mu = 207 m_e$ and the rest mass of an electron is $m_e = 0.51$ MeV. Then, the maximum available energy for the process is :

   (A) 35.0 MeV

   (B) 70.0 MeV

   (C) 105.0 MeV

   (D) 105.51 MeV

5. The energy of an excited state of hydrogen atom is – 3.4 eV. If the first ionisation energy of hydrogen is 13.6 eV, the angular momentum of the electron, according to Bohr's theory, in the said excited state will be :

   (A) 2.11×10^{-34} J.S.

   (B) 3.15×10^{-34} J.S.

   (C) 1.05×10^{-34} J.S.

   (D) Zero

6. A spectral term has $S = \frac{1}{2}$, $J = \frac{5}{2}$ and $g = \frac{6}{7}$, terms being usual. The spectroscopic notation of the said term is :

   (A) $^1D_{5/2}$

   (B) $^2D_{5/2}$

   (C) $^1F_{5/2}$

   (D) $^2F_{5/2}$

7. If a system has two eigenstates ψ_1 and ψ_2 with eigenvalues E_1 and E_2, a linear combination $(a_1\psi_1 + a_2\psi_2)$ will also be an eigenstate, if :

(A) $E_2 \neq E_1$

(B) $E_2 = E_1$

(C) $E_2 = 2E_1$

(D) None of the above

8. A nucleus with A = 235 splits into two fragments with mass numbers in the ratio 3 : 2. Taking $r_0 = 1.4\ F$, prove that the separation between the fragments at the moment of splitting would be :

(A) 7.28 F

(B) 6.36 F

(C) 13.65 F

(D) 2.80 F

9. Consider the following reactions :

(1) $^{238}_{92}U \rightarrow {}^{206}_{82}Pb + 10p + 22n$

(2) $^{238}_{92}U \rightarrow {}^{206}_{82}Pb + 8\ {}^{4}_{2}He + 6e^-$

Which one of the following statements is true for the given decay modes of $^{238}_{92}U$?

(A) 1 is allowed and 2 is forbidden

(B) 1 is forbidden and 2 is allowed

(C) Both 1 and 2 are allowed

(D) Both 1 and 2 are forbidden

Turn Over

10. A radioactive substance has a half life period of 30 days. The time taken for $\frac{3}{4}$ of the original number of atoms to disintegrate, is :

(A) 120 days

(B) 90 days

(C) 80 days

(D) 60 days

P - III (1+1+1) H / 18 (N)

2018

PHYSICS (Honours)

Paper Code : IX-B

[New Syllabus]

Full Marks : 70 Time : Three Hours Thirty Minutes

The figures in the margin indicate full marks.

Answer *five* questions, taking at least *one* from each group.

Group - A

(Atomic Physics)

1. (a) Describe briefly Millikan's oil-drop method of measuring the electronic charge. What corrections did Millikan apply to Stokes' formula and why ? 5+2

   (b) Without going into mathematical detail, describe briefly with a schematic diagram the construction and the principle of operation of an Aston's mass spectrograph. 5

   (c) State Moseley's law of X-ray characteristic lines. Mention one important application of the law. 1+1

2. (a) Explain the significance of Lande's g-factor. Show that

$$g = 1 + \frac{J(J+1) + S(S+1) - L(L+1)}{2J(J+1)},$$

where the terms bear usual significance. 1+4

Turn Over

   (b) Show the space quantisation of the orbital angular momentum of the hydrogen atom in ^2p state. Consider both the old quantum theory model and the new quantum theory (that is, wave mechanical) model. 2+2

   (c) Write the spectral term with $S = \frac{1}{2}$, $J = \frac{5}{2}$ and $g = \frac{6}{7}$. 3

   (d) Explain whether the level $^4D_{1/2}$ can exhibit Zeeman splitting. 2

3. (a) What is Larmor precession ? Find the Larmor frequency of an electron orbit when placed in a magnetic field of 0.5 tesla. Assume the formula you need. 2+2

   (b) Why are rotational spectra not observed for all molecular specimens ? 2

   (c) What is Raman effect ? How is the effect experimentally studied ? Explain the origin of Stokes and anti-Stokes lines on the basis of quantum theory. 1+3+4

Group - B

(Quantum Mechanics)

4. (a) A high-energy radiation suffers compton scattering through an angle ϕ. Find an expression for the Compton shift. Discuss whether this shift depends on the energy of the incident ratiation. 4+1

   (b) A beam of X-rays of wavelength 0.2nm is incident on a free electron and gets scattered in a direction with respect to the direction of the incident radiation resulting in maximum wavelength shift. Prove that the percentage energy loss of the incident radiation is 2.36%.

   Take $\lambda_C = 0.002426$ nm., where λ_C = Compton wavelength. 4

   (c) For any function $f(x)$, calculate $\left[\hat{x}, \frac{d}{dx}\right] f(x)$. Show that the identification $\hat{p}_x = -i\hbar\frac{\partial}{\partial x}$ gives the fundamental commutator of quantum mechanics. 2+3

5. (a) What is a Hermitian operator ? Prove that $\hat{p}_x$ is Hermitian. 1+2

(b) A three-level quantum system has energy eigenvalues 0, 1 and 2 MeV. If the probabilities for the system, at time t, to be in the first two eigenstates are 49% and 36% respectively, write down the wavefunction for the system. 3

(c) Prove that $\left[\hat{L}_x,\ \hat{z}\right] = -i\hbar\hat{y}$, where L_x denotes the x-component of the angular momentum of a particle. 3

(d) Consider a linear harmonic oscillator for which the total energy is

$E = \frac{p_n^2}{2m} + \frac{1}{2}mw^2x^2$, terms being usual. The particle is assumed to be confined to a region $\sim a$. Use the uncertainty principle to obtain the ground state energy of the oscillator. 4

(e) State Bohr's principle of complementarity. 1

6. (a) The operator $\left(x + \frac{d}{dx}\right)$ has an eigenvalue 'α'. Find the corresponding eigenfunction ψ. Given : $\psi = \psi_0$ at $x = 0$. 2

(b) A particle of energy E moving in one dimension encounters a potential barrier

$$V(x) = 0 \text{ for } x < 0$$

$$= v_0 \text{ for } x > 0.$$

If $E > V_0$, calculate the reflection and the transmission coefficients. Which aspect of the result is a deviation from classical Physics ? 6

(c) The ground state wavefunction of the electron in a hydrogen atom is $\psi_0 = \frac{1}{\sqrt{\pi a_0^3}} e^{-r/a_0}$, where a_0 = radius of the first Bohr orbit.

Turn Over

Prove that $\langle r \rangle = 1.5a_0$. The most probable value of r is found to be a_0. Explain the anomaly.

Given : $\int_0^\infty e^{-\alpha r} r^n dr = \frac{n!}{\alpha^{n+1}}$ 4+2

Group - C

(Nuclear and Elementary Particle Physics)

7. (a) What is meant by 'packing fraction' of a nucleus ? How is it related to the binding energy of the nucleus ? 1+2

(b) Discuss the salient aspects of a β-ray spectrum. How would you explain the continuous and the characteristic line portions of the spectrum ? What is meant by K-capture of an atomic nucleus ? 2+4+1

(c) Show, from the semi-empirical mass formula, that $A \simeq 2Z$ for light nuclei.

Take $\frac{a_c}{a_a} = 0.030$. 3

(d) State Geiger-Nuttall law. 1

8. (a) Define cross-section of a nuclear reaction. What is its unit ? 1+1

(b) Consider the nuclear reaction :

$X + x \rightarrow Y + x + y$.

Find an expression for the separation energy of the reaction. 2

(c) Explain nuclear fission on the basis of the liquid drop model. What are 'thermal neutrons' ? 3+1

(d) The half-lives of radium (atomic weight 226) and radon gas are respectively 1622 years and 3.825 days. What is the volume of radon gas at N.T.P. equivalent to an activity of 1.0 curie ? 4

(e) What is meant by nuclear isomerism ? Give one example. 2

9. (a) Discuss briefly the origin of cosmic rays. Write down the percentage composition of primary cosmic rays. Give the cascade theory of cosmic ray showers. What are 'Van Allen radiation belts' ? 2+1+3+2

(b) How many leptons are there ? Write their names. Why a muon is a lepton ? 1+2+1

(c) On the basis of extreme single particle shell model, find the ground state spin and parity of $^{13}_{6}C$. 2
