2021

PHYSICS (Honours)

Paper Code : IX - A & B

[New Syllabus]

Important Instructions for Multiple Choice Question (MCQ)

- Write Subject Name and Code, Registration number, Session and Roll number in the space provided on the Answer Script.

  Example : Such as for Paper III-A (MCQ) and III-B (Descriptive).

  Subject Code : | III | A | & | B |

  Subject Name : | |

- Candidates are required to attempt all questions (MCQ). Below each question, four alternatives are given [i.e. (A), (B), (C), (D)]. Only one of these alternatives is 'CORRECT' answer. The candidate has to write the Correct Alternative [i.e. (A)/(B)/(C)/(D)] against each Question No. in the Answer Script.

  Example — If alternative A of 1 is correct, then write :
  1. — A

- There is no negative marking for wrong answer.

মাল্টিপল চয়েস প্রশ্নের (MCQ) জন্য জরুরী নির্দেশাবলী

- উত্তরপত্রে নির্দেশিত স্থানে বিষয়ের (Subject) নাম এবং কোড, রেজিস্ট্রেশন নম্বর, সেশন এবং রোল নম্বর লিখতে হবে।

  উদাহরণ — যেমন Paper III-A (MCQ) এবং III-B (Descriptive)।

  Subject Code : | III | A | & | B |

  Subject Name : | |

- পরীক্ষার্থীদের সবগুলি প্রশ্নের (MCQ) উত্তর দিতে হবে। প্রতিটি প্রশ্নে চারটি করে সম্ভাব্য উত্তর, যথাক্রমে (A), (B), (C) এবং (D) করে দেওয়া আছে। পরীক্ষার্থীকে তার উত্তরের স্বপক্ষে (A) / (B) / (C) / (D) সঠিক বিকল্পটিকে প্রশ্ন নম্বর উল্লেখসহ উত্তরপত্রে লিখতে হবে।

  উদাহরণ — যদি 1 নম্বর প্রশ্নের সঠিক উত্তর **A** হয় তবে লিখতে হবে :

  1. — A

- ভুল উত্তরের জন্য কোন নেগেটিভ মার্কিং নেই।

Paper Code : IX - A

Full Marks : 20 Time : Thirty Minutes

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. The lowest energy of the electron (take $h = 6.626\times10^{-34}$ J-s and mass of electron = 9.1×10^{-31} kg) is —

   (A) 36.0 eV

   (B) 37.5 eV

   (C) 38.5 eV

   (D) 40.0 eV

2. A nucleus with $A = 235$ splits into two fragments with numbers in the ratio 3:2. If $r_0 = 1.4F$, the separation between the fragments at the moment of splitting would be —

   (A) $7.28F$

   (B) $6.36F$

   (C) $13.65F$

   (D) $2.80F$

3. The energy of an excited state of hydrogen atom is $-3.4eV$. If the first ionization energy of hydrogen is $13.6eV$, the angular momentum of 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

4. The normal Zeeman splitting of the mercury 4916Å line in a magnetic field of 0.3 T is —

(A) 3.4×10^{-1}Å

(B) 1.7×10^{-2}Å

(C) 3.4×10^{-2}Å

(D) 1.7×10^{-1}Å

5. What should be the minimum energy of a photon to split an α^- particle at rest into a tritium and a proton? (The masses ${}_2He^4$, ${}_1H^3$ and ${}_1H^1$ are 4.0026 *amu*, 3.0161 *amu* and 1.0073 *amu*, respectively, and 1 *amu* $\approx$ 983 *MeV*) —

(A) 32.2 *MeV*

(B) 3.0 *MeV*

(C) 19.3 *MeV*

(D) 931.5 *MeV*

6. What is the value of the commutator $\left[x^3, P_x\right]$ where x and P_x are position and momentum operator, respectively?

(A) $3i\hbar x^3$

(B) $2i\hbar x^2$

(C) $3i\hbar x^2$

(D) $3i\hbar P_x^{\,2}$

7. What is the value of *Lande g-factor* of the state ${}^2P_{3/2}$ —

(A) 3/2

(B) 2/3

(C) 3/4

(D) 4/3

8. Which of the following wave functions can be solutions of Schrodinger's equation for $-\infty < x < +\infty$ —

(A) $\psi(x) = A\sec x$

(B) $\psi(x) = A\tan x$

(C) $\psi(x) = Ae^{x^2}$

(D) $\psi(x) = Ae^{-x^2}$

9. For the reaction $\mu^- \rightarrow e^- + \nu_e + \nu_\mu$, which of the following is correct?

(A) Parity is conserved

(B) Baryon number is conserved

(C) Neither muon lepton nor electron lepton number is conserved

(D) Both muon and electron lepton numbers are conserved

10. The electron emitted in continuous β-decay originates from —

(A) Free electrons in nucleus

(B) Inner orbits of atoms

(C) The decay of a neutron in nuclei

(D) Photon escaping from the nucleus

2021

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

Group - A

(Atomic Physics)

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

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

   (c) Without going into mathematical details, describe briefly with a schematic diagram the construction and principle of operation of a Bainbridge mass spectrograph. 5

2. (a) In Stern-Gerlach experiment, why should one use a beam of neutral atoms but not ions? If one performs the experiment with an atom of total angular momentum J, how many lines will be obtained? 3+1

   (b) The quantum numbers of two electrons in a two-valence electron atom are $n_1 = 6, l_1 = 3, s_1 = \frac{1}{2}$ and $n_2 = 5, l_2 = 1, s_2 = \frac{1}{2}$.

   (i) Assuming $L - S$ coupling, find the possible value of L and hence J.

   (ii) Assuming $j - j$ coupling, find the possible value of J. 5+5

3. (a) For normal Zeeman effect in hydrogen, explain how the Lorenz triplet occurs. How are the π and σ lines polarized? 3+2

(b) What is Raman effect? How is it different from Compton effect? Why are the Stokes lines brighter than the anti-Stokes lines? 2+2+2

(c) The series limit for the Balmer series of hydrogen atom is 3646Å. Calculate the atomic number of the element which gives X-ray wavelength down to 1.0Å. 3

Group - B

(Quantum Mechanics)

4. (a) Prove that $\frac{d < x >}{dt} = \frac{< p_x >}{m}$, where symbols have their usual meanings. 4

(b) Show that Fourier transformation of Gaussian wave packet is also Gaussian. Find the uncertainty product $\Delta x \, \Delta p_x$ in this situation. Comment on the result you obtained. 3+3+1

(c) For the wave function $\Psi = A \exp\{i(ax - \omega t)\}$, find the probability current density. (A = *const.*) 3

5. (a) Describe briefly Davisson-Germer Experiment. What information can you get from this experiment? 5+1

(b) Obtain the expression for the Broglie wavelength of a relativistic electron accelerated through high potential difference V volt. 4

(c) Write down the Hamiltonian of the electron in the hydrogen atom. The wave function of the ground state of the hydrogen atom is given by $\Psi(r) = \frac{1}{\sqrt{4\pi}} \frac{2}{a_0^{\frac{3}{2}}} e^{-\frac{r}{a_0}}$, $a_0 =$ Bohr radius. What is the most probable value of the electron position r in this state? 1+3

6. (a) A particle of mass m and energy E is moving in a one-dimensional potential given by —

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

$$V(x) = V_0 \text{ for } x \geq 0$$

If $E > V_0$, then calculate the coefficient of reflection and transmission. 6

(b) Why 3 quantum numbers are needed for an electron apart from its spin? The azimuthal wave function for the hydrogen atom is $\Phi(\phi) = Ae^{im\phi}$. Find the value A by normalizing the wave function. 2+2

(c) Establish that relations $\left[\hat{L}_z, \hat{x}\right] = i\hbar\hat{y}, \left[\hat{L}_z, \hat{y}\right] = i\hbar\hat{x}$ and $\left[\hat{L}_z, \hat{z}\right] = 0$. 4

Group - C

(Nuclear and Elementary Particle Physics)

7. (a) State the advantages and disadvantages of a GM counter. A GM counter cannot detect neutron. Why? 4+2

(b) You have at your disposal two GM counters, one has a long and flat plateau and the other has a short and steep plateau. Explain with reasons which would you prefer. 4

(c) The nuclei are approximately spherical and have an average radius R given by $R = r_0 A^{\frac{1}{3}}$ where A is the mass number and r_0 = 1.2 × 10^{-15}m. If the mass of a nucleon is 1.6 × 10^{-27}kg, estimate the nuclear density. 4

8. (a) How are the ions introduced into the dees near the centre of cyclotron? Show that in synchro-cyclotron, the angular velocity of the particle decreases with the increase in its kinetic energy. 3+3

(b) What are the design parameters of cyclotron that would accelerate α particles to a maximum energy of 20 *MeV*? The dees should have a diameter of 1*m*. 3

(c) Explain fission on the basis of liquid drop model. What is thermal neutron? 4+1

9. (a) Explain with reason whether the following reactions are allowed or forbidden : 3

(i) $p \rightarrow \pi^+ + \pi^- + e^-$;

(ii) $\pi^+ + n \rightarrow \pi^0 + k^+$;

(iii) $p + \pi^- \rightarrow n + \pi^0$.

(b) What are the relative strength and mediators of different kinds of interactions found in nature? 2+2

(c) What will be the final atomic number and mass number when an element (A, Z) emits electron, positron and α-particle in succession? 2

(d) Discuss briefly the origin of cosmic rays. Write down the percentage of composition of primary cosmic rays. 3+2

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