FEDERAL PUBLIC SERVICE COMMISSION
SPECIAL COMPETITIVE EXAMINATION-2023 FOR RECRUITMENT TO POSTS IN BS-17 UNDER THE FEDERAL GOVERNMENT

Roll Number

PHYSICS, PAPER-II

TIME ALLOWED: THREE HOURS	**(PART-I MCQs) MAXIMUM MARKS: 20**
PART-I (MCQs) : MAXIMUM 30 MINUTES	**(PART-II) MAXIMUM MARKS: 80**

NOTE: (i) First attempt **PART-I (MCQs)** on separate **OMR Answer Sheet** which shall be taken back after **30 minutes.**
(ii) Overwriting/cutting of the options/answers will not be given credit.
(iii) There is **no negative** marking. All MCQs must be attempted.

PART-I (MCQs)(COMPULSORY)

Q.1. (i) Select the best option/answer and fill in the appropriate Box ■ on the **OMR Answer Sheet.(20x1=20)**
(ii) Answers given anywhere else, other than OMR Answer Sheet, will not be considered.

1. Charge is distributed uniformly on the surface of a large flat plate. The electric field 2 cm from the plate is 30N/C. The electric field 4 cm from the plate is:
(A) 120N/C (B) 80N/C (C) 30N/C (D) 15N/C

2. A point particle with charge q is at the center of a Gaussian surface in the form of a cube. The electric flux through any one face of the cube is:
(A) q/ε_0 (B) $q/4\pi\varepsilon_0$ (C) $q/3\varepsilon_0$ (D) $q/6\varepsilon_0$

3. A hollow metal sphere is charged to a potential V. The potential at its center is:
(A) V (B) 0 (C) –V (D) 2V

4. If the plate separation of an isolated charged parallel-plate capacitor is doubled:
(A) The electric field is doubled (B) The potential difference is halved
(C) The charge on each plate is halved (D) None of these

5. A uniform magnetic field is in the positive z direction. A positively charged particle is moving in the positive x direction through the field. The net force on the particle can be made zero by applying an electric field in what direction?
(A) Positive y (B) Negative y (C) Positive x (D) Negative x

6. A constant current is sent through a helical coil. The coil:
(A) Tends to get longer (B) Tends to get shorter
(C) Tends to rotate about its axis (D) Produces zero magnetic field at its center

7. You push a permanent magnet with its north pole away from you toward a loop of conducting wire in front of you. Before the north pole enters the loop the current in the loop is:
(A) Zero (B) Clockwise (C) Counterclockwise (D) To your left

8. An electron traveling with speed v around a circle of radius r is equivalent to a current of:
(A) evr/2 (B) ev/r (C) $ev/2\pi r$ (D) $2\pi er/v$

9. The Fermi energy of a metal depends primarily on:
(A) The temperature (B) the volume of the sample
(C) The mass density of the metal (D) The number density of conduction electrons

10. In an unbiased p-n junction:
(A) The electric potential vanishes everywhere (B) The drift current vanishes everywhere
(C) The diffusion current vanishes everywhere (D) The diffusion and drift currents cancel each other

11. The Fermi-Dirac occupancy probability P(E) varies between:
(A) 0 and 1 (B) 0 and infinity (C) 1 and infinity (D) −1 and 1

12. The binding energy per nucleon:
(A) Remains the same for some fusion events (B) Increases for some, but not all, fusion events
(C) Increases for all fusion events (D) Decreases for all fusion events

13. The sievert is the correct unit to use in reporting the measurement of:
(A) The rate of decay of a radioactive source (B) The biological effect of radiation
(C) The energy delivered by radiation to a target
(D) The ability of a beam of gamma ray photons to produce ions in a target

14. Two protons are separated by 10^{-16} m. The nuclear (N), electrostatic (E), and gravitational (G) forces between these protons, in order of increasing strength, are:
(A) E, N, G (B) N, G, E (C) G, E, N (D) G, N, E

15. Which of the following particles is stable?
(A) Neutron (B) Proton (C) Pion (D) Muon

16. Some alpha emitters have longer half-lives than others because:
(A) Their decays include the emission of a photon (B) Their alpha particles have less mass
(C) Their barriers to decay are higher and wider (D) Their barriers to decay are lower and narrower

17. The force exerted on a magnetic dipole as it moves with velocity v through a Stern-Gerlach apparatus is:
(A) Troportional to v (B) Zero (C) Independent of v (D) Proportional to v^2

18. Evidence for the wave nature of matter is:
(A) Electron diffraction experiments of Davisson and Germer (B) The Compton effect
(C) Young's double slit experiment (D) Thompson's measurement of e/m

19. The units of the Planck constant h are those of:
(A) Energy (B) Power (C) Momentum (D) Angular momentum

20. The quantization of energy, E = nhf, is not important for an ordinary pendulum because:
(A) The formula applies only to mass-spring oscillators (B) The allowed energy levels are too closely spaced
(C) The allowed energy levels are too widely spaced (D) The value of h for a pendulum is too large

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PART-II

TIME ALLOWED: THREE HOURS **PART-I(MCQS): MAXIMUM 30 MINUTES**	**PART-I (MCQS) MAXIMUM MARKS = 20** **PART-II MAXIMUM MARKS = 80**

NOTE: (i) **Part-II** is to be attempted on the separate **Answer Book.**
(ii) Attempt **ONLY FOUR** questions from **PART-II** by selecting **TWO** questions from **EACH SECTION**. **ALL** questions carry **EQUAL** marks.
(iii) All the parts (if any) of each Question must be attempted at one place instead of at different places.
(iv) Write Q. No. in the Answer Book in accordance with Q. No. in the Q.Paper.
(v) No Page/Space be left blank between the answers. All the blank pages of Answer Book must be crossed.
(vi) Extra attempt of any question or any part of the question will not be considered.

Q. 2. **(a)** An infinitely long insulating cylinder of radius R has a volume charge density that varies with the radius as $\rho = \rho_0 \left(a - \frac{r}{b}\right)$ where ρ_0, a, and b are positive constants and r is the distance from the axis of the cylinder. Use Gauss's law to determine the magnitude of the electric field at radial distances (i) r < R and (ii) r > R. **(10)**

(b) A 40 cm diameter circular loop is rotated in a uniform electric field until the position of maximum electric flux is found. The flux in this position is measured to be 5.20×10^5 Nm^2/C. What is the magnitude of the electric field? **(07)**

(c) A circular ring of charge with radius b has total charge q uniformly distributed around it. What is the magnitude of the electric field at the center of the ring? **(03)** **(20)**

Q. 3. **(a)** The time independent Schrödinger equation for a particle of mass m and frequency ω is given by **(10)**

$$-\frac{\hbar^2}{2m}\frac{d^2\psi}{dx^2} + \frac{1}{2}m\omega^2 x^2 \psi = E\psi$$

Using the algebraic method solve this equation to find the expression for the energy eigenvalues.

(b) Find the expression for ground state wavefunction of harmonic oscillator in position space i.e., $\psi_0(x)$ **(07)**

(c) What we mean by square integrability in case of function spaces? **(03)** **(20)**

Q. 4. **(a)** Describe inadequacy of Classical Physics to explain the Photoelectric effect. Derive the photoelectric equation and comment how quantum physics was successful in explanation of photoelectric effect. **(10)**

(b) The stopping potential for electrons emitted from a surface illuminated by light of wavelength 491 nm is 0.710 V. When the incident wavelength is changed to a new value, the stopping potential is 143 V. What is this new wavelength? **(07)**

(c) What is the difference between ionization energy and work function? **(03)** **(20)**

Q. 5.	**(a)**	Discuss in detail the electron dynamics when an electric field is applied to a crystal.	**(10)**	
	(b)	For BCC iron, compute **(i)** the interplanar spacing and **(ii)** the diffraction angle for the (220) set of planes. The lattice parameter for Fe is 0.2866 nm. Assume that monochromatic radiation having a wavelength of 0.1790 nm is used, and the order of reflection is 1.	**(07)**	
	(c)	Calculate the volume of an FCC unit cell in terms of the atomic radius R.	**(03)**	**(20)**
Q. 6.	**(a)**	Calculate Magnetic vector potential due to a current carrying loop. Evaluate this potential for a dipole.	**(10)**	
	(b)	A certain magnetic field has a zero z-component. Show that one of the components of potential is in z direction.	**(07)**	
	(c)	What is the physical significance of $\nabla . B = 0$	**(03)**	**(20)**
Q. 7.	**(a)**	As we know that $\hat{L}^2$ and $\hat{L}_z$ do commute with each other, so they can have a joint set of eigenstates. Find the eigenvalues and eigenvectors of $\hat{L}^2$ and $\hat{L}_z$.	**(12)**	
	(b)	Find the eigenvalues and eigenvectors of Pauli spin matrix σ_x.	**(05)**	
	(c)	For a particle with spin $\frac{1}{2}$, find the quantum number m_s and also write its possible states.	**(03)**	**(20)**
Q. 8.	**(a)**	What is meant by Compton Effect? Derive an expression for Compton shift in wavelength.	**(10)**	
	(b)	X rays of wavelength 22 pm (photon energy 56 keV) are scattered from a carbon target, and the scattered rays are detected at 85° to the incident beam. What percentage of the initial x-ray photon energy is transferred to an electron in such scattering?	**(07)**	
	(c)	Is the Compton Effect more supportive of the photon theory of light than is the photoelectric effect? Explain your answer.	**(03)**	**(20)**

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