FEDERAL PUBLIC SERVICE COMMISSION
COMPETITIVE EXAMINATION-2022
FOR RECRUITMENT TO POSTS IN BS-17
UNDER THE FEDERAL GOVERNMENT

Roll Number

PHYSICS, PAPER-I

TIME ALLOWED: THREE HOURS	**PART-I (MCQS) MAXIMUM MARKS = 20**
PART-I(MCQS): MAXIMUM 30 MINUTES	**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**. **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.
(vii) **Use of Calculator is allowed.**

PART – II

Q. 2. **(a)** A particle of unit mass moves in potential $V(x) = ax^2 + b/x^2$ where a & b are positive constants. Find the angular frequency of small oscillations? (08)

(b) A hollow spherical shell carries charge density $\rho = {}^{k}/_{r^2}$ in region $a \leq r \leq b$. Find the electric field in three regions (i) $r < b$ (ii) $a < r < b$ (iii) $r > b$. (07)

(c) A projectile is fired in such a way that its horizontal range is equal to three times its maximum height. Determine its angle of projection. (05) **(20)**

Q. 3. **(a)** Assume that a star has uniform density. Show that the gravitational pressure P is proportional to V-3/4 where V is volume. (08)

(b) Derive expressions for potential and electric field associated with point charge q located near an infinite grounded conducting plane. (07)

(c) Determine equation of motion of masses attached to the string of at-wood machine by Lagrangian methods. (05) **(20)**

Q. 4. **(a)** Q cm^3 of water flows per second through a horizontal tube of uniform bore of radius r & of length L. Another tube of half the length but radius 2r is connected in parallal to same pressure head. What will be the total quantity of water flowing / sec through these two tubes? (08)

(b) A linear quadruple is an arrangement of a system of charges which consist of $-2Q$ at the origin and $+Q$ at the two point$(\pm d, 0,0)$. Show that at distances much greater than$(i.e.\ r \gg d)$, the potential may be written in the approximate form (07)

$$V = \frac{Qd^2}{4\pi\varepsilon_0 r^3}(3\cos^2\theta - 1), r^2 \gg d^2$$

(c) Two soap bubbles with radii r1 and r2 coalescs to form a bigger bubble of radii r. Show that $r = (r1^2 + r2^2)1/2$. (05) **(20)**

Q. 5. **(a)** Explain wave function. Derive wave formula and explain phase and group velocity. (08)

(b) Two semi-infinite grounded metal plates parallel to each other and to the xz-plane are located at $y = 0$ and $y = a$ planes, respectively. The left ends of these two plates at $x = 0$, are closed off by a strip of width a and extend to infinity in the z-direction. The strip is insulated from both the plates and is maintained at a specific potential $V_0(y)$. Find the potential distribution in the slot. (07)

(c) A two level system has energies 0& E. The level with zero energy is non-degenerate while the level with energy E is triply degenerate. Find the mean energy of a classical particle in this system at temperature T. (05) **(20)**

Q. 6. **(a)** Explain the particle in finite potential well with all possible cases and solutions and make a comparison with infinite potential well. (08)

(b) The potential $V_0(\theta)$ is specified on the surface of a hollow sphere, of radius R. Find potential inside the sphere. (07)

(c) A particle is confined to region x>0 by a potential which increases linearly as $u(x) = u_0x$. Find the mean position of particle at temperature T. (05) **(20)**

Q. 7. **(a)** When a gas expands adiabatically its volume is doubled while its absolute temperature is decreased by a factor 1.32. Compute number of degree of freedom of gas molecule? (08)

(b) State and prove Ampere's Law. (07)

(c) Find the rms speed of oxygen molecules at O^0c? (05) **(20)**

Q. 8. **(a)** An ensemble of non-interacting spin -1/2 particles is in contact with a heat bath at temperature T & is subjected to an external magnetic field. Each particle can be in one of the two quantum states of energies ε0. If the mean energy per particle is –ε0/2, then find free energy per particle? (08)

(b) Derive the electromagnetic wave equation in vacuum and also describe the properties of monochromatic electromagnetic waves. (07)

(c) Discuss adiabatic demagnetization using TDS equations mathematically in detail? (05) **(20)**

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COMPETITIVE EXAMINATION-2022 FOR RECRUITMENT TO POSTS IN BS-17 UNDER THE FEDERAL GOVERNMENT
PHYSICS, PAPER-II

Roll Number

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

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(vii) **Use of Calculator is allowed.**

PART – II

Q. 2. **(a)** An electric dipole, comprising a positive charge q and a negative charge $-q$, is placed on the *x*-axis. Each charge is at the same distance from the origin. The total separation between the charges is $2a$.Calculate the electric field E due to these charges along the *y*-axis at the point P, which is at a distance *y* from the origin. Assume $y \gg a$ ($\varepsilon_o = 8.85\times10^{-12}\ C^2N^{-1}m^{-2}$). (10)

(b) Write down a mathematical expression to evaluate electric field E at a distance r from the source charge Q in vector form. Sketch the graph of E as a function of r. (6)

(c) Define electric field and a dipole. (4) **(20)**

Q. 3. **(a)** Discuss photoelectric effect and establish Einstein's equation for the photoelectric effect. (10)

(b) Describe the inadequacy of the wave theory of light to explain the effect. (6)

(c) A photon of energy 12 eV falls on a certain metal plate whose work function is 4.15 eV. Find the stopping potential. The mass and charge of electron are $9.11\times10^{-31}kg$ and $1.6\times10^{-18}C$ respectively and the value of Planck's constant is $6.64\times10^{-34}\ J\times$ s. (4) **(20)**

Q. 4. **(a)** Discuss intrinsic and extrinsic semiconductors. (10)

(b) Describe the properties of diamagnetic, paramagnetic and ferromagnetic materials. (6)

(c) Briefly discuss the Landé g factor. (4) **(20)**

Q. 5. **(a)** Four charged particles of charge q, $2q$, $3q$ and $4p$ are at the corners of a square of side 'a' arranged in counter clockwise direction. Determine **(i)** the electric field at the location of charge q and **(ii)** the total electric force exerted on q. (8)

(b) A parallel plate capacitor has a plate separation of 1 *mm*. Calculate the surface area of each plate of the capacitor to obtain a capacitance of 1F. Is it possible to produce such a capacitor in the lab? Comment. ($\varepsilon_o = 8.85\times10^{-12}\ C^2N^{-1}m^{-2}$). (6)

(c) Define (6) **(20)**
(i) Capacitance **(ii)** The unit of capacitance **(iii)** Surface charge density

Q. 6. **(a)** Set up the Schrodinger wave equation for a particle of mass m confined in a one-dimensional box which has perfectly rigid walls at $x = 0$ and $x = L$. Solve the differential equation to find the expressions for energy and the eigen wave functions of the particle. (10)

(b) Sketch the graphs for the first three eigen wave functions ψ_1, ψ_2 and ψ_3. (5)

(c) Plot the graphs for the probability densities corresponding to ψ_1, ψ_2 and ψ_3. (5) **(20)**

Q. 7. **(a)** Discuss the motion of a charged particle of mass m, charge q and velocity $\boldsymbol{v}$ in a magnetic field B which is directed into the plane of paper. (8)

(b) Discuss atomic description of dielectrics. (6)

(c) Let x be the separation between the parallel plates of a capacitor of capacitance C in the absence of a dielectric material. A slab of a material of dielectric constant γ and thickness $\frac{1}{3}x$ is placed between the plates. Calculate the capacitance in the presence of the dielectric material. (6) **(20)**

Q. 8. **(a)** Discuss the properties of three subatomic particles and their corresponding antiparticles. (10)

(b) Explain in detail, how γ- radiation can be detected? (5)

(c) How can we prove that an electron does not exist in the nucleus of an atom? (5) **(20)**

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