Entrance Examinati

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(1) This booklet includes th
Problem sheets (inclu
Answer sheets
Memo sheet

(2) There are five problems
boxes ☐ .

(3) Solve three problems ou

(4) One answer sheet shoul
and its category name a
The backside of the shee

(5) Write your identificatio

(6) Return all received mat

(7) Write the numbers of t

Entrance Examination for April 2012 Enrollment
Graduate School of Advanced Sciences of Matter, Hiroshima University

Department of Quantum Matter (Engineering Field)

[1] Electromagnetism

1. Consider a solid conducting sphere A with ra[illegible]
B with inner radius b (Fig. 1). The center of [illegible]
of A is fixed at a positive value and that of B [illegible]
dielectric constant of vacuum is ϵ_0. r is the [illegible]
system.

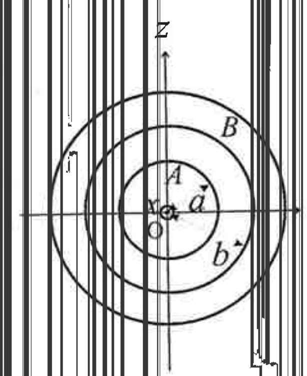
   (1) Give the direction and the magnitude [illegible] electric potential $V(r)$ at a point betw[illegible] density on the surface of A is σ.

   (2) Draw a graph of the magnitude of the [illegible] as a function of r.

   (3) Give σ, when the electric potential of [illegible] field $\boldsymbol{E}(r)$ and the electric potential V[illegible] specific value of V_1.

   (4) Give the capacitance C for A and B.

   (5) Show that the electric potential $V(r)$ [illegible] isfies Laplace's equation. Since the sy[illegible] Laplacian in the spherical polar coor[illegible] $\nabla^2 = \frac{1}{r^2}\frac{\partial}{\partial r}(r^2\frac{\partial}{\partial r})$.



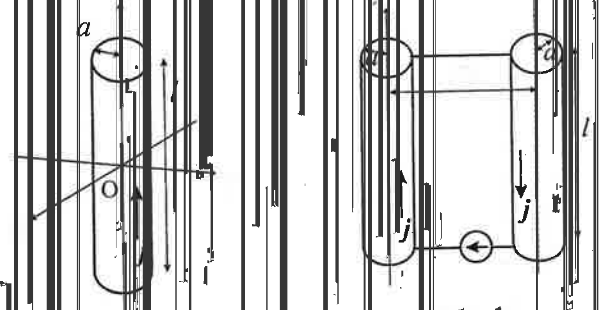
2. Consider a cylindrical conductor placed on [illegible]
is l. A current with a current density $\boldsymbol{j}$ = [illegible]
sufficiently long and the effect of both end[illegible]
vacuum is μ_0.

   (1) Give the magnitudes and the directio[illegible] conductor and the field $\boldsymbol{H}_o(r)$ outsid[illegible] the z axis.

Another conductor having the same diamet[illegible] the first one to make a circuit as shown in [illegible] magnetic field inside of the conductors an[illegible] neglected.

   (2) Give the magnetic flux Φ through th[illegible] sisting of these conductors.

   (3) Give the self inductance L of the circ[illegible]



[2] Quantum Mechanics

Consider the ground state of a
mass m in a potential $V(x)$ tha
at $x < 0$, zero for $0 < x < L$
constant value of U for $x > L$,

$$V(x) = \begin{cases} +\infty & \text{for} \quad x < \\ 0 & \text{for} \quad 0 < x \\ U & \text{for} \quad x > \end{cases}$$

0

The ground state energy E has
tween zero and the potential U

1. Write down the time indepen
   $\psi(x)$ with energy eigenvalue E
2. Give the boundary condition a
3. Find a wavefunction $\psi_1(x)$ that
   $x = 0$ and $x = L$ and satisfies
4. Give the boundary condition f
5. Find a wavefunction $\psi_2(x)$ th
   $E < U$ and satisfies the bound
6. Give the boundary conditions
7. For a specific value of $U = U_0$
   at $E = U_0/2$. Use the bounda
   is given by

[3] Semiconductor E

Consider the drift motion of electrons in a [illegible] of motion for the drift velocity $v(t)$ at time t [illegible]

$$\frac{dv(t)}{dt} \quad \frac{eF}{m^*} \quad \frac{v(t)}{\tau} \qquad \text{(a)}$$

Here, e and m^* are the elementary charge an[illegible] is a constant. Let F be a non-zero constant [illegible]

1. Find $v(t)$ for $t \geq 0$ by solving equati[illegible]
2. For large t, $v(t)$ approaches an asym[illegible]
3. Draw a graph of $v(t)$ for $t \geq 0$. In th[illegible]
4. Express the electron mobility μ usin[illegible]
5. Give the relation between the electric[illegible] with an electron density of n.
6. Explain the physical meaning of the [illegible]

Quantum mechanically, the wave nature of electrons must be considered. Let us assume the following relation between the wavenumber k and the eigenenergy E of electrons;

$$E = E_0 + \frac{\hbar^2}{2m^*}(k - k_0)^2 \qquad \text{(b)}.$$

Here, $\hbar = h/(2\pi)$ with h being the Planck constant and E_0 and k_0 are a constant of energy and a constant of wavenumber, respectively.

7. Give the relation between E and the [illegible]
8. The particle-like motion described [illegible] the wavepacket of the electron. In [illegible] wavenumber k_C is given by $v = d$[illegible] frequency ω and the wavenumber [illegible] relation between the central wavenu[illegible] graph of v as a function of k_C.
9. Using the equation $dk_C/dt = G/\hbar$ fo[illegible] external force G, derive the first ter[illegible]

En[illegible]

Graduate Sch[illegible]

[4] Thermo[illegible] nam[illegible]

1. Explain brief[illegible] can[illegible]nica[illegible] distributi[illegible] numerical ex[illegible]ions [illegible] th[illegible] Use al[illegible] the symbols [illegible] Keywords: t[illegible]al bat[illegible], p[illegible]ability, [illegible]

2. Consider a sy[illegible] of N at[illegible] in a line[illegible] State 2, who[illegible] ergies are [illegible]

   respectively, [illegible] > [illegible]. W[illegible]ssume [illegible]

   (1) Find the [illegible] cas[illegible] which [illegible]

   (2) For the [illegible]escri[illegible]ed [illegible] give [illegible] value. A[illegible] N [illegible] 1, [illegible] 1 an[illegible]

   $$\ln n! [illegible]$$

3. Consider the [illegible] the [illegible] des[illegible] of absolute t[illegible] T.

   (1) Find the [illegible] N [illegible] in S[illegible]

   (2) Find the [illegible] of [illegible] the ent[illegible] high tem[illegible] limit [illegible] $\to \infty$.

   (3) Explain [illegible]ults [illegible] in (2) [illegible] the relati[illegible] the [illegible]

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[5] Materials Science

1 . Solve the following questions cor
adsorption on a solid surface.

(1) Write down the rate equation foi
adsorption and desorption are k_a

(2) Write down the equilibrium con
equilibrium condition. Here, K is

(3) The table shows data for a gas ac
surface at a constant temperature
satisfy the Langmuir isotherm.
which was defined in question (2)
the volume $V(p)$ gives the value

2 . Answer the following questions c

(1) Give the standard cell potential
reaction is ΔG^0, and the Faraday

(2) Give the logarithmic value of th
a temperature of 300K. Here, f
considered to be $F = 1 \times 10^5$[C

(3) Explain the nature of the equilib

3 . Answer the following questions c
techniques.

(1) As shown in the figure, a diffra
wave length λ is observed at tl
which corresponds to the diffra
plane of a cubic crystal. Express
the unit cell using λ and θ

(2) The C-H bond length of Sucro
determined to be 0.110 nm by l
was obtained in these techniques