D-GT-M-QIB

# PHYSICS

## Paper II

Time Allowed : Three Hours | Maximum Marks : 200

### INSTRUCTIONS

*Candidates should attempt questions 1 and 5 which are compulsory and any THREE of the remaining questions, selecting at least ONE question from each Section.*

*All questions carry equal marks.*

*Marks apportioned to each part of a question are indicated against each.*

*Answers must be written in ENGLISH only.*

*Assume suitable data, if considered necessary, and indicate the same clearly.*

*Neat sketches may be drawn, wherever required.*

*Symbols have their usual meaning attached to them, unless otherwise indicated.*

*Important Note : All parts/sub-parts of a question must be attempted contiguously. That is, candidates must finish attempting all the parts/sub-parts of each question they are answering in the answer-book before moving on to the next question.*

*Pages left blank must be clearly struck out. Answers that follow any pages left blank may not be given credit.*

## Section – A

1. (a) What do you understand by expectation value ? Prove that

$$\frac{d}{dt} <x> = \frac{1}{m} <p_x>$$  10

   (b) A lead ball of mass 0·1 g is thrown with a velocity of $10^3$ cm/sec through a hole 1 cm in radius. Calculate the uncertainty in the angle of emergence.  10

   (c) (i) Explain 'term symbol' for a particular atomic state.

   (ii) Show that the spectral lines of alkali metals are doublets.  10

   (d) Calculate the two longest wavelengths of the Balmer series of triply ionized beryllium ($z = 4$).  10

2. (a) Starting from Schrödinger equation obtain an expression for the probability current density. Hence give an interpretation to the wave function.  10

   (b) Solve the Schrödinger equation to obtain the energy levels and eigenfunctions of a particle in a one dimensional infinitely deep potential well given by

   $V(x) = 0$ for $0 < x < a$

   $= \infty$ for $x < 0$ and for $x > a$

   Show that they form an orthonormal set of functions. What do you understand by completeness condition ? Show that they form a complete set of functions.  20+10

3. (a) Solve the Schrödinger equation for a gas of non interacting electrons enclosed in a cube of volume $L^3$. What do you mean by density of states ? Calculate the density of states and Fermi energy for the above system.    20

   (b) (i) Show that the orientation of the spin angular momentum vector of an electron with respect to the z-axis is less than one radian for spin up electron.

   (ii) When the orbital angular momentum vector $\vec{L}$ has the magnitude $\sqrt{6}\hbar$, calculate the $L_z$ components. What angles does the $\vec{L}$ vector make with the z-axis ?    20

4. (a) Discuss the pure rotational Raman spectra of symmetric top molecules. What are $R$ and $S$ branches ?    20

   (b) Derive the rotational-vibrational energy levels of a diatomic molecule. Give the analysis of the spectral lines.    20

## Section – B

5. (a) On the basis of binding energy curve explain why energy is released both in Fission and Fusion.    10

   (b) (i) Explain how the helicity of neutrino can be measured.    6

   (ii) What are 'strange particles' and what is 'strangeness number' ?    4

(c) A type $I$ superconductor with $T_c = 7\,K$ has slope $\dfrac{dB_c}{dT} = -25\ mT/K$ at transition temperature $T_c$. Estimate its critical field at $6\,K$. **10**

(d) A power supply using a full-wave rectifier is to provide 100 mA at 20 V with no more than 1% ripple. Calculate the minimum value of smoothing capacitor used. Consider the diode resistance and the resistance of the secondary of the transformer as negligible. Also take ripple frequency as 50 cycles per second. **10**

6. (a) What is $Q$ value of a nuclear reaction ? Obtain an expression for the Q-value in terms of mass and energy of the particles. **20**

(b) Discuss the four basic types of fundamental interactions in nature and compare them. **20**

7. (a) What is Meissner effect ? Determine the magnetic susceptibility of a superconductor. Explain whether a superconductor exhibits perfect ferromagnetism, paramagnetism or diamagnetism. **20**

(b) For a simple cubic, a face centered cubic and a body centered cubic crystal, determine the atomic packing factor.

How many atoms per $mm^2$ surface area are there in (100) plane for leads which has f.c.c. structure. The radius of the atoms is 0·174 nm. **20**

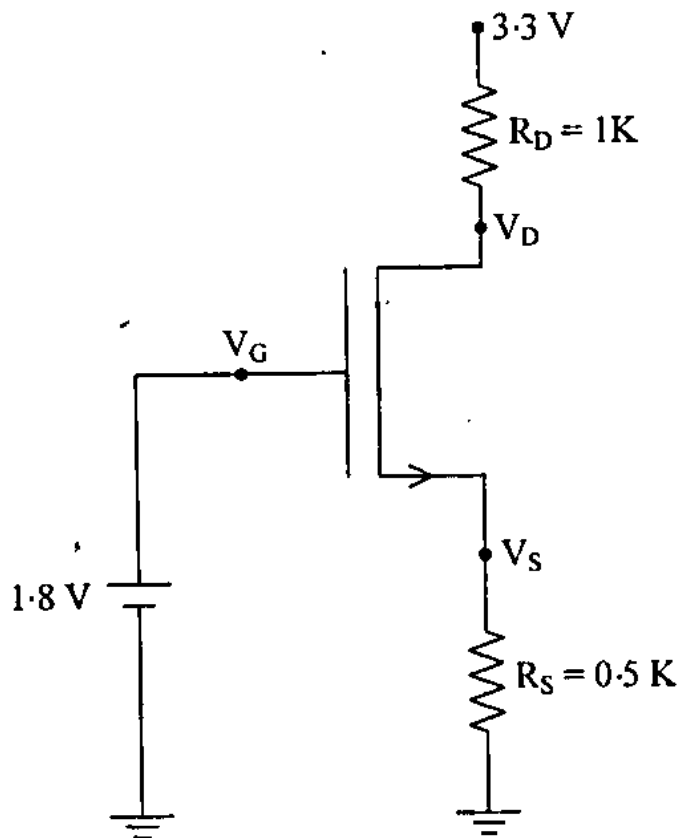.8. (a) (i) What is De Morgan's law ?

(ii) Simplify the Boolean expression

$A + AB + ABC + ABCD$                    20

(b)



The above circuit exhibits a MOSFET with a source resistor. It has $V_T = 1$ $V$ and $\mu_n C_{ox}(W/L)$ = $2mA/V^2$. Calculate the drain voltage. Also determine whether the transistor is in saturation or in the triode region.                    20

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