B.Sc. Part-II Honours Examination,2020

Sub.-PHSA PAPER-IV A FULL MARKS-25

Modalities

1. An examinee shall not attend her/his college in person to sit for the examination of a practical paper. Examinee shall

   (a) write her/his answer with BLUE/BLACK INK only.

   (b) must attach a scanned copy of her/his registration certificate at the end of the answer script. She/he may attach a scenned copy of the admit card of current examinations, if available.

   (c) scan the whole answer script in a single .pdf file. If it is instructed to use separate answer scripts for different modules/units, if any, examinee must do accordingly, but she/he shall create a single .pdf file for the answer script. There will be exactly one .pdf file for each examinee.

   (d) upload her/his answer script through proper web portal to submit.

2. The full marks and duration of examination of a paper shall be in accord with those specified by the University of Calcutta.

3. For examinations of a practical paper, examinees need not submit their laboratory work book, neither they have to face any viva. Examinees shall have to answer the questions following the instructions given in the question paper. Examinees shall use her/his own graph-papers to draw graphs(if any) in practical papers and attach them at proper positions of the answer script. Examinees shall draw circuits and graphs with BLUE/BLACK INK only.

2020

PHYSICS-HONOURS

PAPER –IVA

FULL MARKS-25

Answer ***Question No.1*** and ***any two*** from the rest

Symbols have their usual meaning everywhere

Given $h=6.626X10^{-34}$ J-sec.

$m_e=9.1X10^{-31}$ Kg.

$c=3X10^{8}$ m/sec

1. Answer ***any five*** of the following: 1X5=5

a) Find the no. of photons emitted per sec.by a 40Wsource of light of wavelength 6000 A^0.

b) What is the implication of the relation $\left[\widehat{H},\widehat{L}\right]=0$

c) Show that if ψ be an eigen function of the operator $\hat{A}$ with eigen value λ, then it is also eigenfunction of e^A with eigen value e^{λ}.

d) Show that $C_V=-T\left(\frac{\partial^2 F}{\partial T^2}\right)_V$

e) Show that in an Isobaric process, the change in enthalpy is equal to the heat transferred between the system and the surrounding.

f) What do you mean by quasi static process? All the reversible process are quasi static process but not all quasi static processes are reversible– Explain.

2. a) What is momentum representation of the position operator $\hat{x}$? Show that this representation satisfies the position -momentum commutation relation.

b) Examine whether the operator $\hat{B}$ is linear or not, where $\hat{B}f\left(x\right)=f^*\left(x\right)$

c) Show that the $\widehat{Q}=\frac{1}{2}\left[xp_x+p_xx\right]$ *is Hermitian*

d) Show that if F is Hermitian, $U = e^{iF}$ is unitary.

(2+2)+2+3+1

3. a) Show that $Compton\ shift=\frac{h}{m_ec}\left(1-\cos\theta\right)$.Discuss the appearance of two peaks in the scattered spectra.

b) Show that the de Broglie wavelength of an electron is equal to its Compton wavelength when its speed is $\frac{c}{\sqrt{2}}$.

c) For any operator $\hat{A}$ which has no explicit time dependence,

$Given\ \frac{d}{dt}\langle \hat{A} \rangle_t = \frac{i}{\hbar}\langle [\hat{H}, \hat{A}] \rangle$ .Show that $\frac{d}{dt}\langle \hat{p}_x \rangle = -\left\langle \frac{\partial V}{\partial x} \right\rangle$ (4+1)+2+3

4. a) $\psi_1(x)$ and $\psi_2(x)$ are eigenstates of the Hamiltonian with eigenvalues E_1 and E_2. Is $\psi(x,t) = C_1\psi_1(x)e^{i\left(\frac{-E_1 t}{\hbar}\right)} + C_2\psi_2(x)e^{i\left(\frac{-E_2 t}{\hbar}\right)}$ a stationary state?

b) For free particle ,show that Each positive energy eigenvalue is doubly degenerate.

c) Show that the momentum operator is a Herm itian operator.

d)Show that if H is Hermitian then e^{iH} is unitary. 2+3+2+3

5. a) Show that for a thermodynamic system $C_P - C_V = T\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial V}{\partial T}\right)_P$ and

hence prove that $C_P - C_V = \alpha^2 \beta_T TV$.

b) Show that for a thermodynamic system

$$TdS = C_V dT + \frac{\beta T}{K_T} dV$$

3+3+4

6. a) If E_S and E_T are the adiabatic and isothermal elasticity constants of a gas and γ is the ratio of two specific heats then prove that $\frac{E_S}{E_T} = \gamma$

b) Prove the following relations

i) $\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial p}{\partial S}\right)_V$

ii) $\frac{\gamma}{\gamma - 1} = \frac{\left(\frac{\partial p}{\partial T}\right)_S}{\left(\frac{\partial p}{\partial T}\right)_V}$

c) “An infinitesimal work cannot be represented by exact differential.”- Explain.

4+(2+2)+2

7. a) What is free expansion ? Show that Joule's coefficient for a gas is given by

$$\mu = \frac{1}{C_P}\left\{T\left(\frac{\partial V}{\partial T}\right)_P - V\right\}_H$$

Using this expression, prove that $\mu = 0$ for an ideal gas.

b) Starting from Gibb's free energy (G), show that

$$H = -T^2\left[\frac{\partial}{\partial T}\left(\frac{G}{T}\right)\right]_p$$

c) Prove the following relations

i) $$\left(\frac{\partial C_V}{\partial V}\right)_T = T\left(\frac{\partial^2 P}{\partial T^2}\right)_V$$

ii) $$\left(\frac{\partial C_P}{\partial P}\right)_T = -T\left(\frac{\partial^2 V}{\partial T^2}\right)_P$$

5+2+3