Total No. of Printed Pages—12

**HS/XII/Sc/Ph/OC/21**

**2021**

# PHYSICS

## ( Theory )

( Old Course )

*Full Marks* : 70

*Time* : 3 hours

*The figures in the margin indicate full marks for the questions*

*General Instructions* :

(i) All questions are compulsory.

(ii) All the answers are to be written in the Answer Script.

(iii) Internal choices have been provided for one question of 1 mark, five questions of *2* marks, five questions of *3* marks and all questions of *5* marks.

(iv) Use of non-programmable ordinary scientific calculator and/or logarithmic table is allowed.

(v) Use of Mobile Phones, Pagers and such other electronic gadgets is not allowed in the Examination Hall.

(vi) Use the following values of physical constants, wherever necessary :

Speed of light in vacuum, $c = 3 \times 10^8$ m $s^{-1}$

Planck's constant, $h = 6 \cdot 63 \times 10^{-34}$ J s

Permittivity of free space,
$\varepsilon_0 = 8 \cdot 86 \times 10^{-12}$ $C^2$ $N^{-1}$ $m^{-2}$

Permeability of free space, $\mu_0 = 4\pi \times 10^{-7}$ T m $A^{-1}$

Mass of electron, $m_e = 9 \cdot 11 \times 10^{-31}$ kg

Mass of proton, $m_p = 1 \cdot 67 \times 10^{-27}$ kg

Electronic charge, $e = 1 \cdot 6 \times 10^{-19}$ C

## GROUP—A

( Multiple choice type questions )

Choose and write the correct option for the following : ½×8=4

**1.** Force between two stationary charges, when placed in free space is 10 N. If they are placed in a medium of relative permittivity 5, the force between them is

(A) 50 N

(B) 2 N

(C) 0·5 N

(D) 10 N

**2.** A 900 pF capacitor is charged by a 100 V battery. How much electrostatic energy is stored by the capacitor?

(A) $9 \times 10^{-8}$ J

(B) $4 \cdot 5 \times 10^{-6}$ J

(C) $2 \cdot 2 \times 10^{-6}$ J

(D) $9 \times 10^{-10}$ J

**3.** At the poles, the angle of dip is

(A) 45°

(B) 30°

(C) 0°

(D) 90°

**4.** An example of ferromagnetic material is

(A) aluminium

(B) nickel

(C) gold

(D) copper

**5.** The fringe width ($\beta$) in a typical Young's double-slit experiment varies with the wavelength of light ($\lambda$) as

(A) $\beta \propto \lambda$

(B) $\beta \propto \lambda^2$

(C) $\beta \propto \frac{1}{\lambda}$

(D) $\beta \propto \frac{1}{\lambda^2}$

**6.** Which of the following phenomena is used in optical fibres?

(A) Total internal reflection

(B) Scattering

(C) Diffraction

(D) Dispersion

**7.** In an LCR-circuit, capacitance is changed from $C$ to $2C$. For the resonant frequency to remain unchanged, the inductance should be changed from $L$ to

(A) $4L$

(B) $2L$

(C) $\frac{L}{2}$

(D) $\frac{L}{4}$

**8.** In an a.c. circuit, the voltage applied is $E = E_0 \sin \omega t$. The resulting current in the circuit is $I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$. The power consumption in the circuit is given by

(A) $p = \sqrt{2} E_0 I_0$

(B) $p = \frac{I_0 E_0}{\sqrt{2}}$

(C) $p = 0$

(D) $p = \frac{I_0 E_0}{2}$

## GROUP—B

( Very short answer type questions )

Answer the following questions in *one* sentence/step each : 1×8=8

**9.** *Either*

For a cell, the terminal potential difference is 2·2 V when the circuit is open and reduces to 1·8 V when the cell is connected to a resistor of resistance 5Ω. What is the internal resistance of the cell? 1

*Or*

A current of 3·0 A flows through a 5Ω resistor. What is the rate at which heat is produced in the resistor? 1

**10.** State the principle of a Wheatstone bridge. 1

**11.** What is dark current? 1

**12.** Name the device used for data transmission from one computer to another. 1

**13.** Write two uses of optical fibres. 1

**14.** Mention two advantages of optical communication. 1

**15.** Distinguish between analog and digital signals. 1

**16.** Define work function of a metal. 1

## GROUP—C

( Short answer type–I questions )

Answer the following questions within *30* words each, wherever applicable : 2×8=16

**17.** *Either*

What is copper loss in a transformer? How can you minimize copper loss? 1+1=2

*Or*

State Faraday's laws of electromagnetic induction. 2

**18.** *Either*

If the rate of change of current of 4 A/s induces an e.m.f of 20 mV in a solenoid, what is self-inductance of the solenoid? 2

*Or*

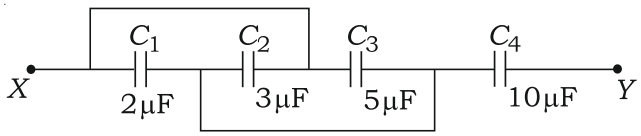
What is the self-inductance of an air-core solenoid, 50 cm long and of 2 cm radius if it has 500 turns? 2

**19.** *Either*

Two point charges of $-5\times10^{-19}$C and $+20\times10^{-19}$C are separated by a distance of 2 m. Find the point on the line joining them at which the electric field intensity is zero. 2

*Or*

Four capacitors are connected as shown in the figure :




Calculate the equivalent capacitance between the points *X* and *Y*. 2

**20.** *Either*

Show that the volume of a nucleus is directly proportional to its mass number. 2

*Or*

Find the binding energy of an α-particle in MeV. (take, 1 a.m.u. = 931·5 MeV);
Given that—

mass of $_2He^4$ = 4·00150 a.m.u.

mass of proton = 1·00728 a.m.u.

mass of neutron = 1·00867 a.m.u. 2

**21.** What is magnetic moment? Write the expression for the magnetic moment when an electron revolves at a speed $v$ around an orbit of radius $r$ in hydrogen atom. 1+1=2

**22.** Write the truth table of NOR gate. 2

**23.** *Either*

What is amplitude modulation? Represent the same graphically. 1+1=2

*Or*

Explain briefly any two reasons that make modulation necessary for communication. 1+1=2

**24.** Draw a circuit diagram of a common-emitter transistor amplifier. 2

## GROUP—D

( Short answer type–II questions )

Answer the following questions within *30* to *40* words each, wherever applicable : 3×9=27

**25.** *Either*

State the two Kirchhoff's laws. With the help of a neat diagram, deduce the condition for balance in a Wheatstone's bridge by applying Kirchhoff's laws. 1+2=3

*Or*

State the principle of potentiometer. With the help of a neat diagram, explain how a potentiometer is used to find the internal resistance of a cell. 1+2=3

**26.** *(a)* Using the expression of drift velocity $(v_d)$, and current $(I)$, show that $R = \frac{me}{ne^2 A\tau}$, where the symbols have their usual meanings. 2

*(b)* How does conductivity vary with relaxation time? 1

**27.** *Either*

*(a)* What are electromagnetic waves? 1

*(b)* How are electromagnetic waves produced? 1

*(c)* Write one important characteristic of electromagnetic waves. 1

*Or*

*(a)* Write the expression of the speed of electromagnetic waves in free space. 1

*(b)* Using the expression of the speed of electromagnetic waves, show that it is equal to the speed of light in vacuum. 1

*(c)* Write two uses of X-rays. 1

**28.** *Either*

Write down the condition of resonance in a series *L-C-R* circuit and hence find an expression for the resonant frequency. Also draw the resonance curve in *L-C-R* circuit for two values of *R*. 1+1+1=3

*Or*

Explain the principle and working theory of A.C. generator. 3

**29.** *Either*

In Young's double-slit experiment, show that the fringe width $\beta$ for interference fringes is $\beta = \frac{\lambda D}{d}$, where the symbols have their usual meanings. 3

*Or*

Draw a labelled diagram to show the image formation at the least distance of distinct vision due to a compound microscope and hence calculate its magnifying power. 1+2=3

**30.** *(a)* Show that the de Broglie wavelength of an electron of kinetic energy $E$ is given by

$$\lambda = \frac{h}{\sqrt{2mE}},$$

where $m$ is the mass of the electron and $h$ is Planck's constant. 2

*(b)* You are given a proton and an electron with same kinetic energy $E$. Which one has more de Broglie wavelength? 1

**31.** *Either*

*(a)* Define the terms 'depletion layer' and 'potential barrier' of a $p$-$n$ junction diode. ½+½=1

*(b)* With the help of a circuit diagram, explain how a Zener diode can be used as a voltage regulator. 2

*Or*

*(a)* What is a rectifier? What is the principle of a rectifier? ½+½=1

*(b)* With the help of a circuit diagram, explain the working of a $p$-$n$ junction diode as a half-wave rectifier. 2

**32.** Obtain an expression for the radius of the $n$th orbit of a revolving electron from Bohr's theory. 3

**33.** Write a mathematical expression for radioactive decay law. Hence derive an expression for number of nuclei in a radioactive sample at a time $t$ in terms of the original number at time, $t = 0$. 1+2=3

## GROUP—E

( Long answer type questions )

Answer the following questions in *70* to *80* words each, wherever applicable : 5×3=15

**34.** *Either*

Applying Gauss's law in electrostatics, obtain an expression for the electric field intensity at a point near an infinitely large plane sheet. Use the same to derive an expression for the capacitance of a parallel-plate capacitor. 3+2=5

*Or*

Derive an expression for the electric potential due to a dipole at a point on the line making an angle θ with the electric dipole moment $\vec{p}$. Hence, find the potential if the point lies on—

*(a)* axial line;

*(b)* equatorial line. 4+½+½=5

**35.** *Either*

Write Biot-Savart law in scalar form. Use this law to find the magnitude of the magnetic field due to a circular coil carrying current ($I$) at a point along its axis. How does a circular loop carrying current ($I$) behave as a magnet? 1+3+1=5

*Or*

State Ampere's circuital law. Use the law to find the magnitude of the magnetic field inside a long, straight, air-cored solenoid. Also write the expressions for the magnitude of magnetic field *(a)* at the points near the ends of the solenoid and *(b)* inside the solenoid when it is iron-cored. 1+3+1=5

**36.** *Either*

Using the relation for refraction at a single spherical refracting surface, derive the lense-maker's formula. 5

*Or*

Given that $i$ and $e$ are the angles of incidence and emergence respectively for rays refracted through a prism of angle $A$, obtain the condition for minimum deviation in terms of $i$ and $e$. Using the same, show that the refractive index $\mu$ of the material of the prism is given by

$$\mu = \frac{\sin\left(\frac{A + \delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

where $\delta_m$ is the angle of minimum deviation. 5

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