HS/XII/Sc/Ph/13

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PHYSICS

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) Write the answers of a particular Group in one place.

 (iv) Marks allotted for each question are indicated against it.

 (v) There is no overall choice. However, internal choices have been provided in two questions in Group—C, two questions in Group—D and one question in Group—E.

 (vi) For the purpose of calculation, use of non-programmable scientific calculator and/or logarithmic tables are allowed.

 (vii) Use of Mobile Phones and Pagers are not allowed in the Examination Hall.

(viii) The following values of physical constants are to be used wherever necessary :

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

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

Permittivity of free space, ε_0
$$= 8 \cdot 854 \times 10^{-12} \, \text{C}^2 \, \text{N}^{-1} \, \text{m}^{-2}$$

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

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

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

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

GROUP—A

(Multiple choice type questions)

Choose and write the correct option for the following :

½×8=4

1. The electrostatic force between two electrons separated by a distance of $4 \cdot 8 \times 10^{-15} \, \text{m}$ in vacuum is

(a) $9 \times 10^9 \, \text{N}$

(b) $4 \cdot 8 \, \text{N}$

(c) $10 \, \text{N}$

(d) $1 \cdot 6 \times 10^{-19} \, \text{N}$

2. A dipole of electric dipole moment p is placed in a uniform electric field of strength E. If is the angle between positive direction of p and E, then the potential energy of the electric dipole is minimum when is

(a) 90°

(b) 0°

(c) 45°

(d) 180°

3. The magnetic flux density at a point inside a long straight solenoid carrying a constant current is B. If the number of turns and the length of the solenoid are doubled and the current is decreased to half its initial value, what is the magnitude of the magnetic flux density now?

(a) $8B$

(b) $4B$

(c) $B/2$

(d) $B/4$

4. The force per unit length between two long straight parallel current-carrying wires is directly proportional to

(a) r

(b) r^{-1}

(c) r^{-2}

(d) r^2

(here r is the distance of separation between the two wires)

5. A series *L-C-R* circuit having inductive reactance X_L and capacitive reactance X_C is tuned to resonance. The impedance of the circuit now is

(a) R

(b) $[R^2 + (X_L - X_C)^2]^{1/2}$

(c) $[R^2 + X_L^2 + X_C^2]^{1/2}$

(d) $X_L + X_C + R$

6. The ratio of the peak and the r.m.s. voltage at any instant for an AC source is

(a) $1:2$

(b) $2:1$

(c) $1:\sqrt{2}$

(d) $\sqrt{2}:1$

7. Radio waves and visible light in vacuum have

(a) same velocity, same wavelength

(b) different velocity, different wavelength

(c) same wavelength, different velocity

(d) same velocity, different wavelength

8. Which of the following sequences is not correct in relation to the wavelength of electromagnetic waves?

(a) gamma X ray ultraviolet

(b) X ray ultraviolet visible

(c) ultraviolet infrared visible

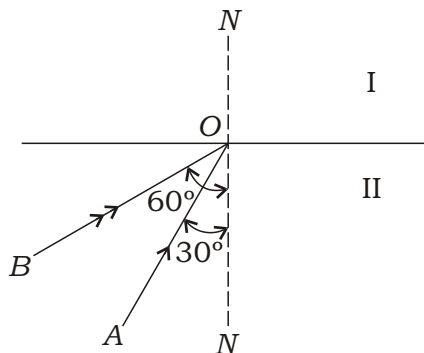*(d)* visible infrared microwave

GROUP—B

(Very short answer type questions)

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

9. Write the mathematical expression and SI unit of electric flux. ½+½=1

10. Three equal capacitors of capacitance 3 F each are combined to give an equivalent capacitance of 9 F. Draw a circuit diagram to represent the combination.

11. Define one ampere of current in terms of the force between two infinitely long parallel current-carrying conductors.

12. Given the critical angle of medium II w.r.t. I to be 45°, complete the following ray diagram for the incident rays *AO* and *BO* :

13. Write an expression for the magnifying power of an astronomical telescope for normal adjustment.

14. Name the experiment that was designed and performed to verify de Broglie's hypothesis of matter waves.

15. Write an expression for the mass defect of a nucleus having atomic number *Z* and atomic mass number *A* respectively.

16. What is a photodiode?

(7)

GROUP—C

(Short answer type–I questions)

Answer the following questions within *30* words each :

$$2 \times 8 = 16$$

17. Using Gauss's theorem in electrostatics, obtain an expression for the electric field at a point outside a uniformly charged spherical shell.

18. Find the resistance of a wire of length 10 m having a diameter of $1 \cdot 3 \times 10^{-3}$ m. (Assume the resistivity of the material of the wire to be $4 \cdot 5 \times 10^{-7}$ Ω m)

19. When the current through a coil changes at the rate of 1 A/s, it induces a voltage of 1 mV. What is the coefficient of self-induction of the coil?

20.   *Either*

State and explain Lenz's law.

Or

What are eddy currents? How are eddy current losses minimized in a transformer?

21. Using supplied values of ϵ_0 and μ_0, find the speed of electromagnetic waves in vacuum.

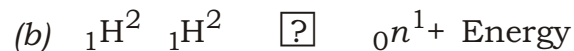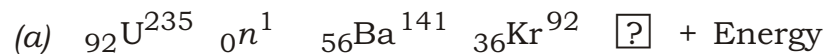**22.**   *Either*

What are isotones? Give example.   1+1=2

Or

Represent the spectral series of H-atom by a neat energy-level diagram.   2

23. Complete the following reactions and name the type of reaction :   1+1=2

(a) $_{92}U^{235} + {}_0n^1 \rightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + \boxed{?} +$ Energy

(b) $_1H^2 + {}_1H^2 \rightarrow \boxed{?} + {}_0n^1 +$ Energy

24. Draw a circuit diagram showing an *N-P-N* transistor as an amplifier in CE configuration.

GROUP—D

(Short answer type–II questions)

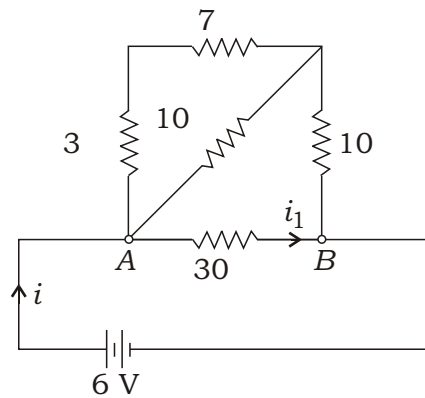Answer the following questions within *30* to *40* words each :   3×9=27

25. Show that the magnitude of the electric field at an axial point far away from a short electric dipole is inversely proportional to the cube of its distance from the centre of the dipole.
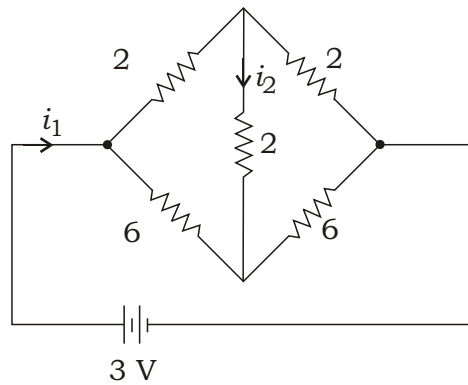
26.   *Either*

Find the values of R_{AB}, i and i_1 in the electrical circuit shown below (assume the internal resistance of the battery and the resistance of the connecting wires to be negligibly small) :

Or

Find i_1 and i_2 in the following circuit :

(Assume the internal resistance of the battery and the resistance of the connecting wires to be negligibly small.)

27. Using Biot-Savart law, show that the magnitude of the magnetic field B at the centre of a current-carrying circular coil of n turns and radius r is

$$B = \frac{\mu_0 nI}{2r}$$

where I represents the current flowing through the circular coil.

28. With a neat circuit diagram, explain how the internal resistance of a cell can be determined by using a potentiometer.

29. Describe the working of a moving-coil galvanometer and hence show that the deflection of the coil is directly proportional to the current flowing through it. $1+2=3$

30. Discuss the construction of an AC generator with the help of a simple diagram. $2+1=3$

31. *Either*

Using Huygens' principle, establish the laws of reflection. 3

Or

What is meant by interference of light? Give any two conditions for obtaining sustained interference pattern of light. Why two separate light bulbs cannot produce a sustained interference pattern of light? $1+1+1=3$

32. State the decay law for radioactive substances and hence show that $N = N_0 e^{-\lambda t}$. (Symbols have their usual meanings.) 1+2=3

33. What is photoelectric effect? Explain the variation of photoelectric current with the—

(a) intensity of the incident light;

(b) frequency of the incident light. 1+1+1=3

GROUP—E

(Long answer type questions)

Answer the following questions in *70* to *80* words each :

5×3=15

34. *Either*

Show that the refractive index of the material of a prism is given by

$$\frac{\sin \dfrac{\mu_m + A}{2}}{\sin \dfrac{A}{2}}$$

where A and μ_m represent the angle of the prism and the angle of minimum deviation through the prism respectively.

Or

Establish the relation $\dfrac{\mu_2}{v} - \dfrac{\mu_1}{u} = \dfrac{\mu_2 - \mu_1}{R}$ for refraction at a convex spherical surface of absolute refractive index μ_2 placed in a rarer medium of absolute refractive index μ_1, where u and v denote the object and the image (real) distance from the pole of the convex spherical surface.

35. *(a)* What are semiconductors? Discuss the formation of depletion layer and potential barrier in an unbiased *p-n* junction diode. 1+2=3

(b) Draw the *I-V* characteristics of a *p-n* junction diode in forward and reverse bias. 1

(c) Write the truth table of an OR gate having two inputs. 1

36. *(a)* What is sky-wave propagation? Obtain an expression for the coverage range in space-wave propagation in terms of the height of the antenna. 1+2=3

(b) Discuss two factors responsible for the need for modulation in communication. 2

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