PHYSICS (Theory)

Time allowed: 3 Hours   Maximum Marks: 70

General Instructions:

(i) All questions are compulsory.

(ii) There are 30 questions in total. Questions 1 to 8 carry one mark each, questions 9 to 18 carry two marks each, questions 19 to 27 carry three marks each and questions 28 to 30 carry five marks each.

(iii) There is no overall choice. However, an internal choice has been provided in one question of two marks, one question of three marks and all three questions of five marks each. You have to attempt only one of the choices in such questions.

(iv) Use of calculators is not permitted.

(v) You may use the following values of physical constants wherever necessary:

$c = 3 \times 10^{8}\ ms^{-1}$

$h = 6.626 \times 10^{-34} Js$

$e = 1.602 \times 10^{-19}\ C$

$\mu_0 = 4\pi \times 10^{-7}\ T\ m\ A^{-1}$

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^{9}\ N\ m^{2}\ C^{-2}$

Mass of neutron $m_n = 1.675 \times 10^{-27}$ kg

Boltzmann's constant $k = 1.381 \times 10^{-23}\ J\ K^{-1}$

Avogadro's number $N_A = 6.022 \times 10^{23}$ / mol^{-1}

1. What is the geometrical shape of the wavefront when a plane wave passes through a convex lens?

2. What is the stopping potential of a photocell, in which electrons with maximum kinetic energy of 6 eV are emitted?

3. Draw an equipotential surface for a system consisting of two charges Q, -Q separated by a distance 'r' in air.

4. Identify the part of the electromagnetic spectrum to which the following wavelengths belong: (i) 1 mm (ii) 10^{-11} m.

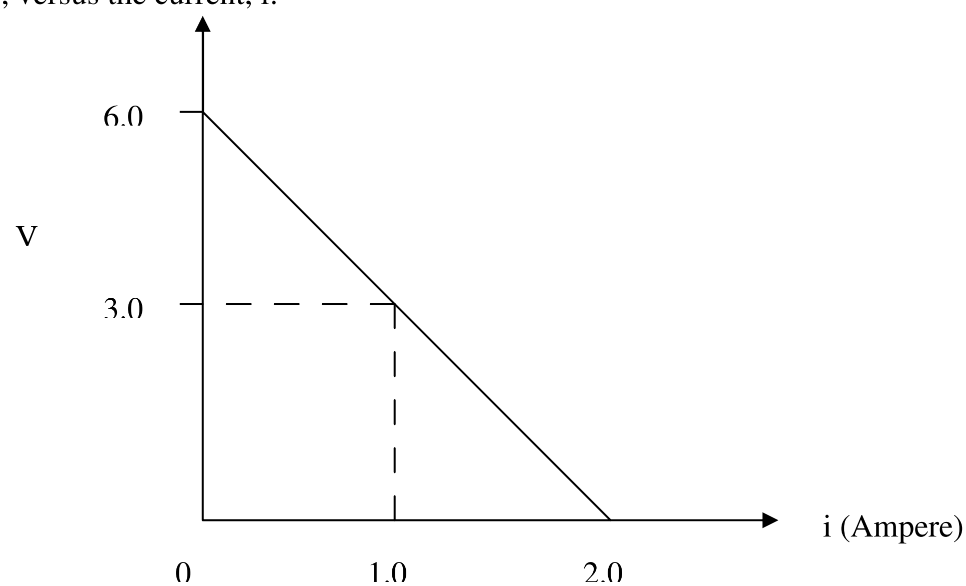
5. State the reason, why a photodiode is usually operated at reverse bias?

6. What is the nuclear radius of ^{125}Fe, if that of ^{27}Al is 3.6 fermi?

7. When current in a coil changes with time, how is the back emf induced in the coil related to it?

8. An object is held at the principal focus of a concave lens of focal length F. Where is the image formed?

9. The following graph shows the variation of terminal potential difference V, across a combination of three cells in series to a resistor, versus the current, i:



(i) Calculate the emf of each cell.

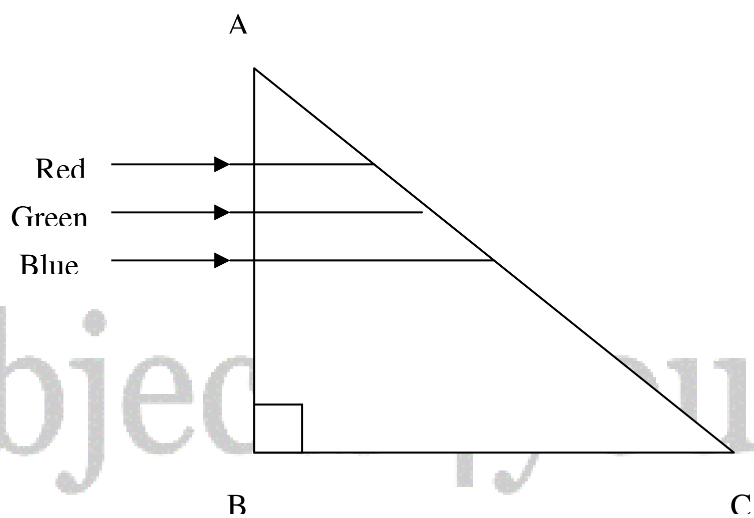
(ii) For what current I, will the power dissipation of the current be maximum?

10. State the law of radioactive decay. If N_0 is the number of radioactive nuclei in the sample at some initial time t_0, find out the relation to determine the number N present at a subsequent time. Draw a plot of N as a function of time.

OR

Draw a plot of the binding energy per nucleon as a function of mass number for a large number of nuclei. Explain the energy release in the process of nuclear fission from the above plot. Write a typical nuclear relation in which a large amount of energy is released in the process of nuclear fission.

11. In the figure given below, light rays of blue, green, red wavelengths are incident on an isosceles right-angled prism. Explain with reason, which ray of light will be transmitted through the face AC. The refractive index of the prism for red, green, blue light ate 1.39, 1,424, and 1.476 respectively.



12. Two wires X, Y have the same resistivity, but their cross-sectional areas in the ratio 2:3 and lengths in the ratio 1:2. They are first connected in series and then in parallel to a d.c source. Find out the ratio of the drift speeds of the electrons in the two wires for the two cases.

13. Using Ampere's circuital law, derive an expression for the magnetic field along the axis of a toroidal solenoid.

14. How will the angular separation and visibility the fringes in Young,s double slit experiment change when (i) Screen is moved away from the plane of the slits, and (ii) width of the source slit is increased?

15. A jet plane is traveling west at 450 ms^{-1}. If the horizontal component of earth's magnetic field at that place is 4 x 10^{-4} Tesla and the angle of dip is 30°, find the emf induced between the ends of wings having a span of 30 m.

16. What is meant by the transverse nature of electromagnetic waves? Draw a diagram showing the propagation of an electromagnetic wave along the x-direction, indicating clearly the directions of the oscillating electric and magnetic fields associated with it.

17. Why do we need carrier waves of vary high frequency in the modulation of signals? A carrier wave of peak voltage 20 V is used to transmit a message signal. What should be the peak voltage of the modulating signal, in order to have a modulation index of 80%.

18. Derive an expression for the torque acting on an electric dipole, which is held in a uniform electric field, when the axis of the dipole makes an angle θ with the electric field.

19. Draw a plot showing the variation of power of a lens with the wavelength of the incident light.

A diverging lens of refractive index 1.5 and of focal length 20 cm in air has the same radii of curvature for both sides. If it is immersed in a liquid of refractive index 1.7, calculate the focal length of the lens in the liquid.

20. If a particle of charge q is moving with velocity v along the z-axis and the magnetic field B is acting along the x-axis, use the expression F = q (v x B) to find the direction of the force F acting on it.
A beam of proton passes undeflected with a horizontal velocity v, through a region of electric and magnetic fields, mutually perpendicular to each other and normal to the direction of the beam. If the magnitudes of the electric and magnetic fields are 50 KV/m and 50 m T respectively, calculate

(i) Velocity v of the beam

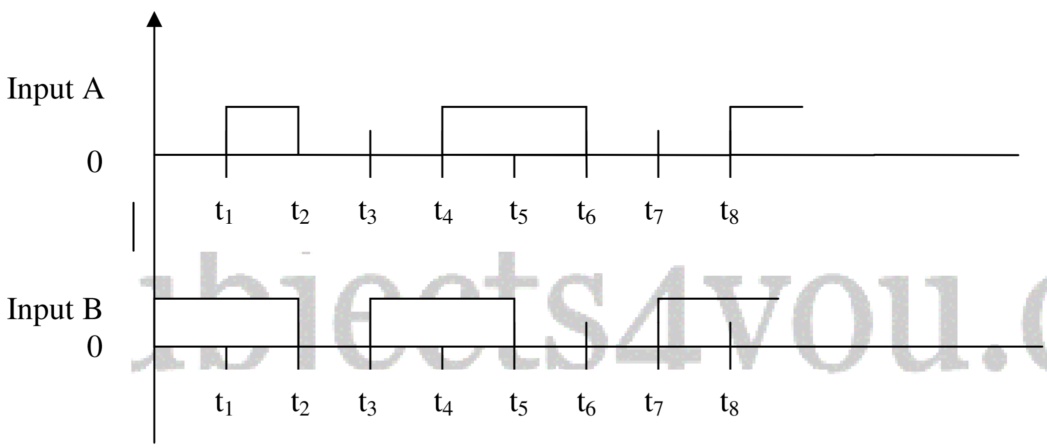
(ii) Force with which it strikes a target on a screen, if the proton beam current is equal to 0.80 m A.

21. Show that Bohr's second postulate, 'the electron revolves around the nucleus only in certain fixed orbits without radiating energy' can be explained on the basis of de Broglie hypothesis of wave nature of electron.

22. What are permanent magnets? What is an efficient way of preparing a permanent magnet? Write two characteristics properties of materials which are required to select them for permanent magnets.

23. Distinguish between isotopes and isobars. Give one example for each species. A radioactive isotope has a half-life of 5 years. How long will it take the activity to reduce to 3.125%?

24. Two signals A, B as given below, are applied as input to (i) AND (ii) NOR (iii) NAND gates. Draw the output wave-form in each case.



25. What does the term 'LOS communication' mean? Name the types of waves that are used for this communication. Give typical examples, with the help of a suitable figure, of communication systems that use space mode propagation.

26. A resistance R = 5Ω is connected to one of the gaps in a meter bridge, which uses a wire of length 1 m. An unknown resistance X > 5 Ω is connected in the other gap as shown in the figure. The balance point is notices at 'l' cm from the positive end of the battery. On interchanging R and X, it was found that the balance point shifts by 20 cm away from end A. Neglecting the end correction; calculate the value of unknown resistance X used.

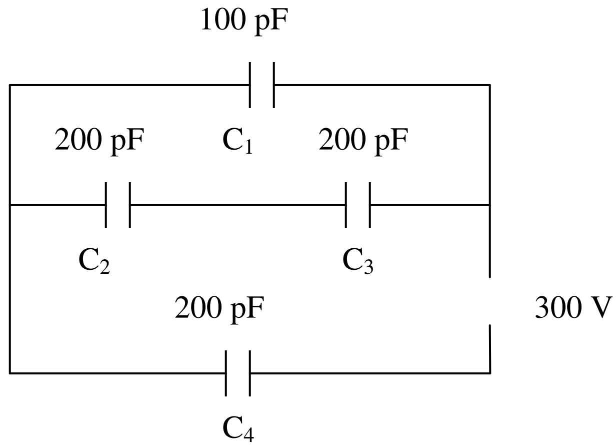
27. Draw a labeled circuit diagram of a full wave rectifier and briefly explain its working principle.

OR

Draw a labeled circuit diagram of a transistor amplifier in the common-emitter configuration. Briefly explain, how the input/output signals differ in phase by 180°.

28. (a) Derive an expression for the energy stored in a parallel plate capacitor C, charged to a potential difference V.

(b) Obtain the equivalent capacitance of the network given below. For a supply of 300 V, determine the charge and voltage across C_4.

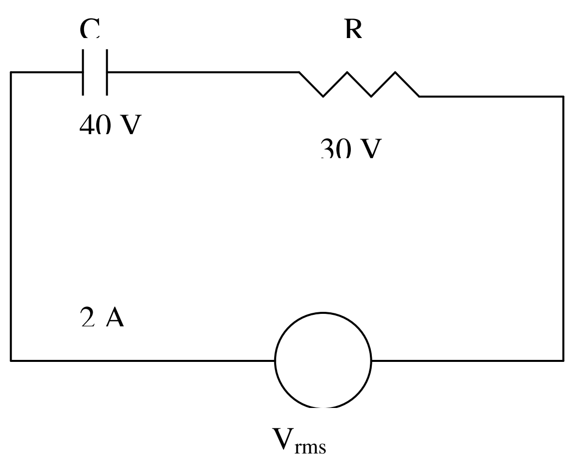


OR

Explain the principle on which Van-de-Graaff generator operates. Draw a labeled schematic sketch and write briefly its working.
A Van-de-Graaff type generator is capable of building up potential difference of 15 x 10^6V. The dielectric strength of the gas surrounding the electrode is 5 x 10^7 V m^{-1}. What is the minimum radius of the spherical shell required?
29. Draw a labeled ray diagram of a compound microscope and write an expression for its magnifying power.
the focal lengths of the objective and eye-lens of a compound microscope are 2 cm, 6.25 cm respectively. The distance between the lenses is 15 cm. (i) How far from the objective lens will the object be kept, so as to obtain the final image at the near point of the aye? (ii) Also calculate its magnifying power.

OR

Draw a labeled ray diagram of an astronomical telescope, in the normal adjustment position and write the expression for its magnifying power.
An astronomical telescope uses an objective lens of focal length 15 cm and eye-lens of focal length 1 cm. What is the angular magnification of the telescope?
If this telescope is used to view Moon, what is the diameter of the image of Moon formed by the objectives lens? (Diameter of Moon = 3.5 x 10^6 m and Radius of lunar orbit = 3.8 x 10^8 m)
30. State the condition for resonance to occur in a series LCR a.c circuit and drive an expression for the resonant frequency.
Draw a plot showing the variation of the peak current (i_m) with frequency of the a.c source used. Define the quality factor, Q of the circuit.
Calculate the (i) impendence, (ii) wattles current of the given a.c circuit.



Draw a labeled circuit arrangement showing the windings of primary and secondary coil in a transformer. Explain the underlying principle and working of a step-up transformer. Write any two major sources of energy loss in this device.
How much current is drawn by the primary coil of a transformer which steps down 220 V to 22 V to operate device with an impendence of 220 ohm?