Series : XYW1Z

रोल नं.
Roll No.

1	4	7	3	6	7	0	4

SET ~ 3

कोड नं.
Code No. **55/1/3**

परीक्षार्थी प्रश्न-पत्र कोड को उत्तर-पुस्तिका के मुख-पृष्ठ पर अवश्य लिखें ।
Candidates must write the Q.P. Code on the title page of the answer-book.

भौतिक विज्ञान (सैद्धान्तिक)
PHYSICS (Theory)

निर्धारित समय : 3 घण्टे
Time allowed : 3 hours

अधिकतम अंक : 70
Maximum Marks : 70

नोट / NOTE

(I) कृपया जाँच कर लें कि इस प्रश्न-पत्र में मुद्रित पृष्ठ 23 हैं ।
Please check that this question paper contains **23** printed pages.

(II) कृपया जाँच कर लें कि इस प्रश्न-पत्र में **33** प्रश्न हैं ।
Please check that this question paper contains **33** questions.

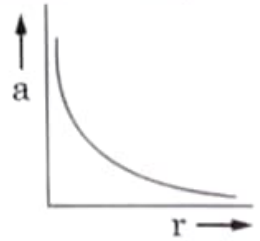
(III) प्रश्न-पत्र में दाहिने हाथ की ओर दिए गए प्रश्न-पत्र कोड को परीक्षार्थी उत्तर-पुस्तिका के मुख-पृष्ठ पर लिखें ।
Q.P. Code given on the right hand side of the question paper should be written on the title page of the answer-book by the candidate.

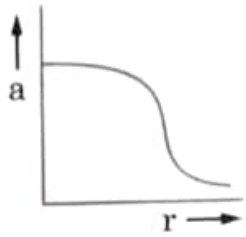
(IV) **कृपया प्रश्न का उत्तर लिखना शुरू करने से पहले, उत्तर-पुस्तिका में यथा स्थान पर प्रश्न का क्रमांक अवश्य लिखें ।**
Please write down the serial number of the question in the answer-book at the given place before attempting it.

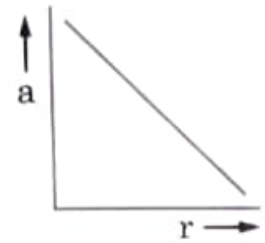
(V) इस प्रश्न-पत्र को पढ़ने के लिए 15 मिनट का समय दिया गया है । प्रश्न-पत्र का वितरण पूर्वाह्न में 10.15 बजे किया जाएगा । 10.15 बजे से 10.30 बजे तक परीक्षार्थी केवल प्रश्न-पत्र को पढ़ेंगे और इस अवधि के दौरान वे उत्तर-पुस्तिका पर कोई उत्तर नहीं लिखेंगे ।
15 minute time has been allotted to read this question paper. The question paper will be distributed at 10.15 a.m. From 10.15 a.m. to 10.30 a.m., the candidates will read the question paper only and will not write any answer on the answer-book during this period.

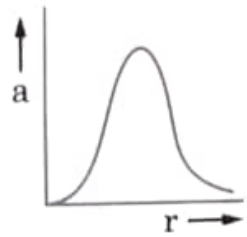
SECTION – A

1. A charge Q is fixed in position. Another charge q is brought near charge Q and released from rest. Which of the following graphs is the correct representation of the acceleration of the charge q as a function of its distance r from charge Q ? 1

(A) 

(B) 

(C) 

(D) 

2. Two conductors A and B of the same material have their lengths in the ratio 1:2 and radii in the ratio 2:3. If they are connected in parallel across a battery, the ratio $\frac{v_A}{v_B}$ of the drift velocities of electrons in them will be - 1

(A) 2 (B) $\frac{1}{2}$

(C) $\frac{3}{2}$ (D) $\frac{8}{9}$

3. A 1 cm segment of a wire lying along x-axis carries current of 0.5 A along +x direction. A magnetic field $\vec{B} = (0.4\ mT)\,\hat{j} + (0.6\ mT)\,\hat{k}$ is switched on, in the region. The force acting on the segment is 1

(A) $(2\hat{j} + 3\hat{k})$ mN (B) $(-3\hat{j} + 2\hat{k})$ μN

(C) $(6\hat{j} + 4\hat{k})$ mN (D) $(-4\hat{j} + 6\hat{k})$ μN

4. The ratio of the number of turns of the primary to the secondary coils in an ideal transformer is 20 : 1. If 240 V ac is applied from a source to the primary coil of transformer and a 6.0 Ω resistor is connected across the output terminals, then current drawn by the transformer from the source will be - 1

(A) 4.0 A (B) 3.8 A

(C) 0.97 A (D) 0.10 A

5. You are required to design an air-filled solenoid of inductance 0.016 H having a length 0.81 m and radius 0.02 m. The number of turns in the solenoid should be 1

(A) 2592
(B) 2866
(C) 2976
(D) 3140

6. A voltage $v = v_0 \sin \omega t$ applied to a circuit drives a current $i = i_0 \sin (\omega t + \phi)$ in the circuit. The average power consumed in the circuit over a cycle is 1

(A) Zero
(B) $i_0 v_0 \cos \phi$
(C) $\frac{i_0 v_0}{2}$
(D) $\frac{i_0 v_0}{2} \cos \phi$

7. X-rays are more harmful to human beings than ultraviolet radiations because X-rays - 1

(A) have frequency lower than that of ultraviolet radiations.
(B) have wavelength smaller than that of ultraviolet radiations.
(C) move faster than ultraviolet radiations in air.
(D) are mechanical waves but ultraviolet radiations are electro-magnetic waves.

8. A point source is placed at the bottom of a tank containing a transparent liquid (refractive index n) to a depth H. The area of the surface of the liquid through which light from the source can emerge out is 1

(A) $\frac{\pi H^2}{(n-1)}$
(B) $\frac{\pi H^2}{(n^2-1)}$
(C) $\frac{\pi H^2}{\sqrt{n^2-1}}$
(D) $\frac{\pi H^2}{(n^2+1)}$

9. In a photoelectric experiment with a material of work function 2.1 eV, the stopping potential is found to be 2.5 V. The maximum kinetic energy of ejected photoelectrons is 1

(A) 0.4 eV
(B) 2.1 eV
(C) 2.5 eV
(D) 4.6 eV

10. When a p-n junction diode is forward biased 1

(A) the barrier height and the depletion layer width both increase.
(B) the barrier height increases and the depletion layer width decreases.
(C) the barrier height and the depletion layer width both decrease.
(D) the barrier height decreases and the depletion layer width increases.

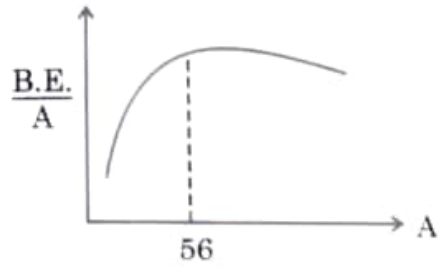
11. Let λ_e, λ_p and λ_d be the wavelengths associated with an electron, a proton and a deuteron, all moving with the same speed. Then the correct relation between them is 1

(A) $\lambda_d > \lambda_p > \lambda_e$ (B) $\lambda_e > \lambda_p > \lambda_d$

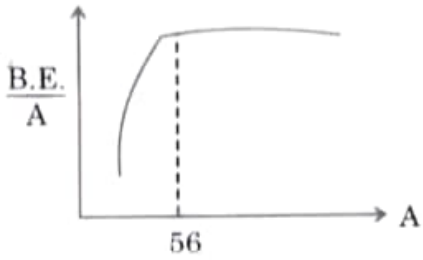
(C) $\lambda_p > \lambda_e > \lambda_d$ (D) $\lambda_e = \lambda_p = \lambda_d$

12. Which of the following figures correctly represent the shape of curve of binding energy per nucleon as a function of mass number ? 1

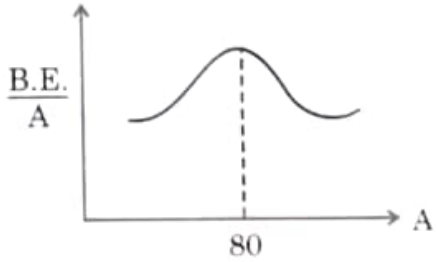
(A)



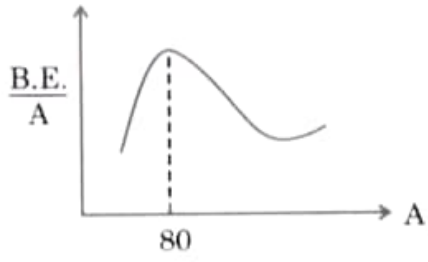
(B)



(C)



(D)



Note : Question numbers **13** to **16** are Assertion (A) and Reason (R) type questions. Two statements are given – one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (A), (B), (C) and (D) as given below.

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false and Reason (R) is also false.

13. **Assertion (A)** : We cannot form a p-n junction diode by taking a slab of a p-type semiconductor and physically joining it to another slab of a n-type semiconductor. 1

Reason (R) : In a p-type semiconductor $\eta_e >> \eta_h$ while in a n-type semiconductor $\eta_h >> \eta_e$.

14. **Assertion (A)** : The potential energy of an electron revolving in any stationary orbit in a hydrogen atom is positive. 1

Reason (R) : The total energy of a charged particle is always positive.

15. **Assertion (A)** : It is difficult to move a magnet into a coil of large number of turns when the circuit of the coil is closed. 1

Reason (R) : The direction of induced current in a coil with its circuit closed, due to motion of a magnet, is such that it opposes the cause.

16. **Assertion (A)** : The deflection in a galvanometer is directly proportional to the current passing through it. 1

Reason (R) : The coil of a galvanometer is suspended in a uniform radial magnetic field.

SECTION – B

17. n identical cells, each of e.m.f. E and internal resistance r, are connected in series. Later on it was found out that two cells 'X' and 'Y' are connected in reverse polarities. Calculate the potential difference across the cell 'X'. 2

18. (a) In a diffraction experiment, the slit is illuminated by light of wavelength 600 nm. The first minimum of the pattern falls at $\theta = 30^\circ$. Calculate the width of the slit. 2

OR

(b) In a Young's double-slit experiment, two light waves, each of intensity I_o, interfere at a point, having a path difference $\frac{\lambda}{8}$ on the screen. Find the intensity at this point.

19. A double convex lens of glass has both faces of the same radius of curvature 17 cm. Find its focal length if it is immersed in water. The refractive indices of glass and water are 1.5 and 1.33 respectively. 2

20. An electron in Bohr model of hydrogen atom makes a transition from energy level –1.51 eV to –3.40 eV. Calculate the change in the radius of its orbit. The radius of orbit of electron in its ground state is 0.53 Å. 2

21. A p-type Si semiconductor is made by doping an average of one dopant atom per 5×10^7 silicon atoms. If the number density of silicon atoms in the specimen is 5×10^{28} atoms m^{-3}, find the number of holes created per cubic centimetre in the specimen due to doping. Also give one example of such dopants. 2

SECTION – C

22. (a) Two batteries of emf's 3V & 6V and internal resistances 0.2 Ω & 0.4 Ω are connected in parallel. This combination is connected to a 4 Ω resistor. Find : 3

(i) the equivalent emf of the combination

(ii) the equivalent internal resistance of the combination

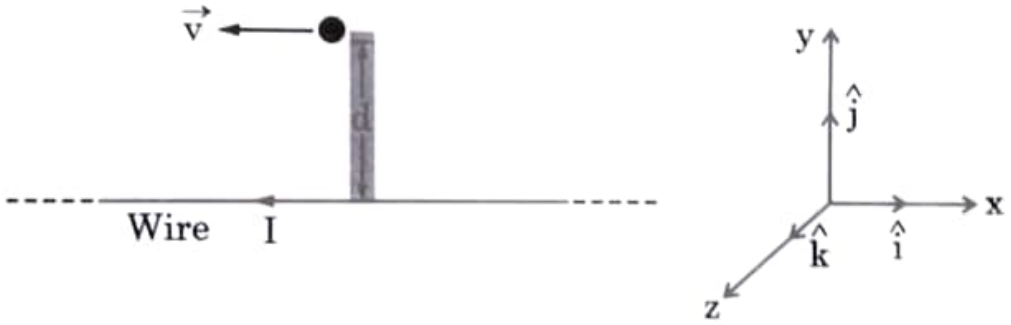
(iii) the current drawn from the combination

OR

(b) (i) A conductor of length l is connected across an ideal cell of emf E. Keeping the cell connected, the length of the conductor is increased to $2l$ by gradually stretching it. If R and R′ are initial and final values of resistance and v_d and v_d' are initial and final values of drift velocity, find the relation between (i) R′ and R and (ii) v_d' and v_d.

(ii) When electrons drift in a conductor from lower to higher potential, does it mean that all the 'free electrons' of the conductor are moving in the same direction ?

23. A particle of charge q is moving with a velocity $\vec{v}$ at a distance 'd' from a long straight wire carrying a current 'I' as shown in figure. At this instant, it is subjected to a uniform electric field $\vec{E}$ such that the particle keeps moving undeviated. In terms of unit vectors $\hat{i}$, $\hat{j}$ and $\hat{k}$, find – 3



(a) the magnetic field $\vec{B}$,

(b) the magnetic force $\vec{F}_m$, and

(c) the electric field $\vec{E}$, acting on the charge.

24. An ac source of voltage $v = v_m \sin \omega t$ is connected to a series combination of LCR circuit. Draw the phasor diagram. Using it obtain an expression for the impedance of the circuit and the phase difference between applied voltage and the current. 3

25. (a) A parallel plate capacitor is charged by an ac source. Show that the sum of conduction current (I_c) and the displacement current (I_d) has the same value at all points of the circuit. 3

(b) In case (a) above, is Kirchhoff's first rule (junction rule) valid at each plate of the capacitor ? Explain.

26. (a) Mention any three features of results of experiment on photoelectric effect which cannot be explained using the wave theory of light. 3

(b) In his experiment on photoelectric effect, Robert A. Millikan found the slope of the cut-off voltage versus frequency of incident light plot to be 4.12×10^{-15} Vs. Calculate the value of Planck's constant from it.

27. (a) Draw circuit arrangement for studying V-I characteristics of a p-n junction diode. 3

(b) Show the shape of the characteristics of a diode.

(c) Mention two information that you can get from these characteristics.

28. (a) Define 'Mass defect' and 'Binding energy' of a nucleus. Describe 'Fission process' on the basis of binding energy per nucleon. 3

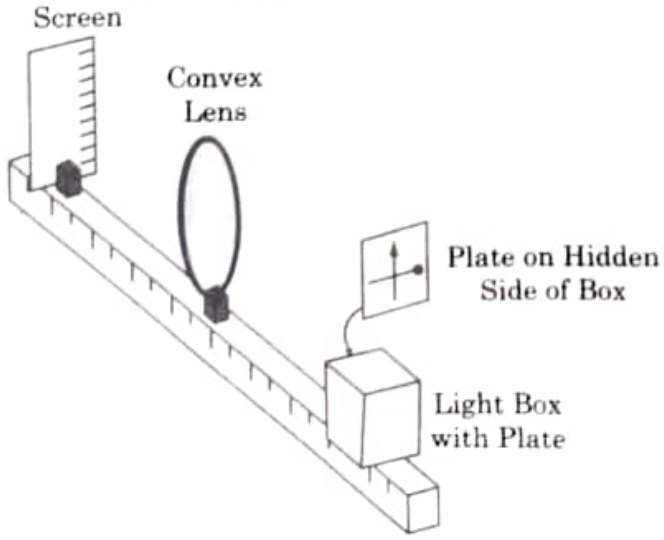
(b) A deuteron contains a proton and a neutron and has a mass of 2.013553 u. Calculate the mass defect for it in u and its energy equivalence in MeV. (m_p = 1.007277 u, m_n = 1.008665 u, 1u = 931.5 MeV/c^2)

SECTION – D

Question numbers **29** and **30** are case study based questions. Read the following paragraphs and answer the questions that follow.

29. A thin lens is a transparent optical medium bounded by two surfaces, at least one of which should be spherical. Applying the formula for image formation by a single spherical surface successively at the two surfaces of a lens, one can obtain the 'lens maker formula' and then the 'lens formula'. A lens has two foci – called 'first focal point' and 'second focal point' of the lens, one on each side. **4 × 1 = 4**

(i)



Consider the arrangement shown in figure. A black vertical arrow and a horizontal thick line with a ball are painted on a glass plate. It serves as the object. When the plate is illuminated, its real image is formed on the screen.

Which of the following correctly represents the image formed on the screen ?

(A) (B) (C) (D)

(ii) Which of the following statements is incorrect ?

(A) For a convex mirror magnification is always negative.

(B) For all virtual images formed by a mirror magnification is positive.

(C) For a concave lens magnification is always positive.

(D) For real and inverted images, magnification is always negative.

(iii) A convex lens of focal length 'f' is cut into two equal parts perpendicular to the principal axis. The focal length of each part will be :

(A) f (B) 2 f

(C) $\frac{f}{2}$ (D) $\frac{f}{4}$

OR

(iii) If an object in case (i) above is 20 cm from the lens and the screen is 50 cm away from the object, the focal length of the lens used is

(A) 10 cm (B) 12 cm

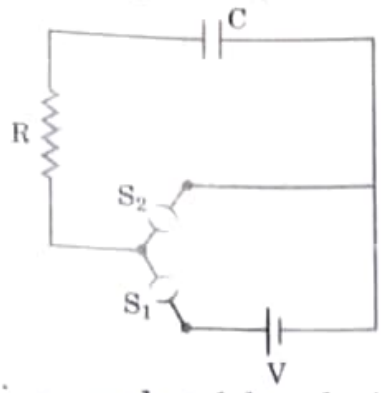
(C) 16 cm (D) 20 cm

(iv) The distance of an object from first focal point of a biconvex lens is X_1 and distance of the image from second focal point is X_2. The focal length of the lens is

(A) $X_1 X_2$ (B) $\sqrt{X_1 + X_2}$

(C) $\sqrt{X_1 X_2}$ (D) $\sqrt{\frac{X_2}{X_1}}$

30. A circuit consisting of a capacitor C, a resistor of resistance R and an ideal battery of emf V, as shown in figure is known as RC series circuit. $4 \times 1 = 4$



As soon as the circuit is completed by closing key S_1 (keeping S_2 open) charges begin to flow between the capacitor plates and the battery terminals. The charge on the capacitor increases and consequently the potential difference V_c (= q/C) across the capacitor also increases with time. When this potential difference equals the potential difference across the battery, the capacitor is fully charged (Q = *V*C). During this process of charging, the charge q on the capacitor changes with time t as $q = Q[1 - e^{-t/RC}]$

The charging current can be obtained by differentiating it and using $\frac{d}{dx}(e^{mx}) = me^{mx}$.

Consider the case when R = 20 kΩ, C = 500 μF and *V* = 10 V.

(i) The final charge on the capacitor, when key S_1 is closed and S_2 is open, is

(A) 5 μC (B) 5 mC
(C) 25 mC (D) 0.1 C

(ii) For sufficient time the key S_1 is closed and S_2 is open. Now key S_2 is closed and S_1 is open. What is the final charge on the capacitor ?

(A) Zero (B) 5 mC
(C) 2.5 mC (D) 5 μC

(iii) The dimensional formula for RC is

(A) $[M\,L^2\,T^{-3}\,A^{-2}]$ (B) $[M^0\,L^0\,T^{-1}\,A^0]$
(C) $[M^{-1}\,L^{-2}\,T^4\,A^2]$ (D) $[M^0\,L^0\,T\,A^0]$

(iv) The key S_1 is closed and S_2 is open. The value of current in the resistor after 5 seconds, is

(A) $\frac{1}{2\sqrt{e}}$ mA (B) $\sqrt{e}$ mA (C) $\frac{1}{\sqrt{e}}$ mA (D) $\frac{1}{2e}$ mA

OR

(iv) The key S_1 is closed and S_2 is open. The initial value of charging current in the resistor, is

(A) 5 mA (B) 0.5 mA (C) 2 mA (D) 1 mA

SECTION – E

31. (a) (i) (1) What are coherent sources ? Why are they necessary for observing a sustained interference pattern ? 5

(2) Lights from two independent sources are not coherent. Explain.

(ii) Two slits 0.1 mm apart are arranged 1.20 m from a screen. Light of wavelength 600 nm from a distant source is incident on the slits.

(1) How far apart will adjacent bright interference fringes be on the screen ?

(2) Find the angular width (in degree) of the first bright fringe.

OR

(b) (i) Define a wavefront. An incident plane wave falls on a convex lens and gets refracted through it. Draw a diagram to show the incident and refracted wavefront.

(ii) A beam of light coming from a distant source is refracted by a spherical glass ball (refractive index 1.5) of radius 15 cm. Draw the ray diagram and obtain the position of the final image formed.

32. (a) (i) Two point charges 5 μC and –1 μC are placed at points (–3 cm, 0, 0) and (3 cm, 0, 0) respectively. An external electric field $\vec{E} = \frac{A}{r^2}\hat{r}$ where $A = 3 \times 10^5$ Vm is switched on in the region. Calculate the change in electrostatic energy of the system due to the electric field. 5

(ii) A system of two conductors is placed in air and they have net charge of +80μC and –80μC which causes a potential difference of 16 V between them.

(1) Find the capacitance of the system.

(2) If the air between the capacitor is replaced by a dielectric medium of dielectric constant 3, what will be the potential difference between the two conductors ?

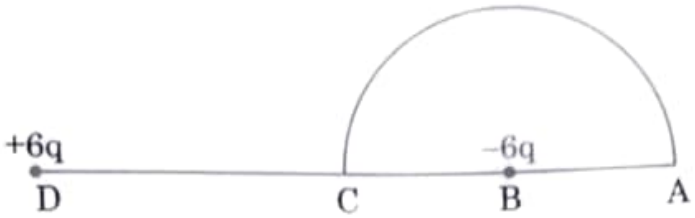
(3) If the charges on two conductors are changed to +160 μC and –160 μC, will the capacitance of the system change ? Give reason for your answer.

OR

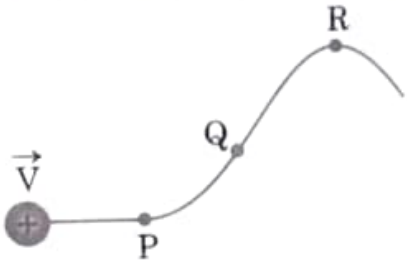
(b) (i) Consider three metal spherical shells A, B and C, each of radius R. Each shell is having a concentric metal ball of radius R/10. The spherical shells A, B and C are given charges +6q, –4q, and 14q respectively. Their inner metal balls are also given charges –2q, +8q and –10q respectively. Compare the magnitude of the electric fields due to shells A, B and C at a distance 3R from their centres.

P.T.O.

(ii) A charge $-6\ \mu C$ is placed at the centre B of a semicircle of radius 5 cm, as shown in the figure. An equal and opposite charge is placed at point D at a distance of 10 cm from B. A charge $+5\ \mu C$ is moved from point 'C' to point 'A' along the circumference. Calculate the work done on the charge.



13. (a) (i) A proton moving with velocity $\vec{V}$ in a non-uniform magnetic field traces a path as shown in the figure. 5



The path followed by the proton is always in the plane of the paper. What is the direction of the magnetic field in the region near points P, Q and R ? What can you say about relative magnitude of magnetic fields at these points ?

(ii) A current carrying circular loop of area A produces a magnetic field B at its centre. Show that the magnetic moment of the loop is $\frac{2BA}{\mu_0}\sqrt{\frac{A}{\pi}}$.

OR

(b) (i) Derive an expression for the torque acting on a rectangular current loop suspended in a uniform magnetic field.

(ii) A charged particle is moving in a circular path with velocity $\vec{V}$ in a uniform magnetic field $\vec{B}$. It is made to pass through a sheet of lead and as a consequence, it looses one half of its kinetic energy without change in its direction. How will (1) the radius of its path (2) its time period of revolution change ?
