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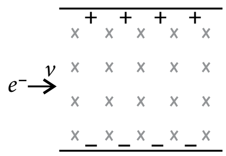
PRACTICE PAPER

Time : 3 Hours **Max. Marks :** 720

PHYSICS

SECTION-A

1. An electron enters the space between the plates of a charged parallel plate capacitor as shown in the figure. The charge density on the plate is σ. Electric intensity in the space between the plates is E. A uniform magnetic field B also exists in the space perpendicular to the direction of E. The electron moves perpendicular to both E and B without any change in direction. The time taken by the electron to travel a distance L in the space is



(a) $\frac{\sigma L}{\varepsilon_0 B}$ (b) $\frac{\sigma B}{\varepsilon_0 L}$ (c) $\frac{\varepsilon_0 LB}{\sigma}$ (d) $\frac{\varepsilon_0 L}{\sigma B}$

2. Two capacitors of capacitance 2 μF and 4 μF respectively are connected in series. The combination is connected across a potential difference of 10 V. The ratio of energies stored by capacitors will be
(a) $1:\sqrt{2}$ (b) 2 : 1 (c) 1 : 4 (d) 4 : 1

3. An unknown resistance R_1 is connected in series with a resistance of 10 Ω. This combination is connected to one gap of meter bridge while, a resistance R_2 is connected in the other gap. The balance point is at 50 cm. Now, when the 10 Ω resistance is removed the balance point shifts to 40 cm. The value of R_1 (in ohm) is
(a) 20 (b) 10 (c) 60 (d) 40

4. A magnet of length 14 cm and magnetic moment M is broken into two parts of lengths 6 cm and 8 cm. They are put at right angle to each other with opposite poles together. The magnetic moment of the combination is
(a) $\frac{M}{10}$ (b) M (c) $\frac{M}{1.4}$ (d) $2.8M$

5. A circuit area 0.01 m^2 is kept inside a magnetic field which is normal to its plane. The magnetic field changes from 2 T to 1 T in 1 ms. If the resistance of the circuit is 2 Ω, the amount of heat evolved is
(a) 0.05 J (b) 50 J (c) 0.50 J (d) 500 J

6. An LC circuit contains a 20 mH inductor and a 50 μF capacitor with an initial charge of 10 mC. The resistance of the circuit is negligible. Let the instant the circuit is closed be $t = 0$. At what time is the energy stored completely magnetic?
(a) $t = 0$ (b) $t = 1.57$ ms
(c) $t = 3.14$ ms (d) $t = 6.28$ ms

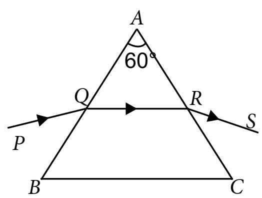
7. An alternating voltage $e = 200 \sin 100t$ V is applied to a series combination $R = 30\ \Omega$ and an inductor of 400 mH. The power factor of the circuit is
(a) 0.01 (b) 0.2
(c) 0.05 (d) 0.6

8. A particle of mass 1×10^{-26} kg and charge 1.6×10^{-19} C travelling with a velocity 1.28×10^6 m s^{-1} along the positive X-axis enters a region in which a uniform electric field E and a uniform magnetic field of induction B are present. If $E = -102.4 \times 10^3\ \hat{k}$ N C^{-1} and $B = 8 \times 10^{-2}\ \hat{j}$ Wb m^{-2}, the direction of motion of the particle is
(a) along the positive X-axis
(b) along the negative X-axis
(c) at 45° to the positive X-axis
(d) at 135° to the positive X-axis

9. An object is placed at a distance of 40 cm in front of a concave mirror of focal length 20 cm. The nature of image is
(a) real, inverted and of same size
(b) virtual, erect and of same size
(c) real, erect and of same size
(d) virtual, inverted and of same size

10. A ray of light falls on a transparent glass slab of refractive index 1.62. If the reflected ray and the refracted ray are mutually perpendicular, the angle of incidence is
(a) $\tan^{-1}(1.62)$ (b) $\tan^{-1}\left(\frac{1}{1.62}\right)$
(c) $\tan^{-1}(1.33)$ (d) $\tan^{-1}\left(\frac{1}{1.33}\right)$

11. A ray PQ incident on the refracting face BA is refracted in the prism BAC as shown in the figure and emerges from the other refracting face AC as RS, such that $AQ = AR$. If the angle of prism $A = 60°$ and the refractive index of the material of prism is $\sqrt{3}$, then the angle of deviation of the ray is



(a) 60° (b) 45°
(c) 30° (d) None of these

12. The head lights of a car are 1.2 m apart. If the pupil of the eye of an observer has a diameter of 2 mm and light of wavelength 5896 Å is used, what should be the maximum distance of the car from the observer if the two head lights are just separated?
(a) 33.9 km (b) 33.9 m
(c) 3.34 km (d) 3.39 m

13. In a Young's double slit experiment, the two slits act as coherent sources of waves of equal amplitude A and wavelength λ. In another experiment with the same arrangement the two slits are made to act as incoherent sources of waves of same amplitude and wavelength. If the intensity at the middle point of the screen in the first case is I_1 and in the second case I_2, then the ratio $\frac{I_1}{I_2}$ is

(a) 4 (b) 2 (c) 1 (d) 0.5

14. In a Young's double slit experiment, $\frac{I_1}{I_2} = \frac{16}{9}$. Ratio of maximum to minimum intensity is

(a) 1 : 49 (b) 9 : 16 (c) 16 : 9 (d) 49 : 1

15. Two polaroids are placed in the path of unpolarized beam of intensity I_0 such that no light is emitted from the second polaroid. If a third polaroid whose polarization axis makes an angle θ with the polarization axis of first polaroid, is placed between these polaroids, then the intensity of light emerging from the last polaroid will be

(a) $\left(\frac{I_0}{8}\right)\sin^2 2\theta$ (b) $\left(\frac{I_0}{4}\right)\sin^2 \theta$

(c) $\left(\frac{I_0}{2}\right)\cos^4 \theta$ (d) $I_0\cos^4\theta$

16. The energy that should be added to an electron to reduce its de-Broglie wavelength from 1 nm to 0.5 nm is

(a) four times the initial energy
(b) equal to the initial energy
(c) twice the initial energy
(d) thrice the initial energy

17. An electron and a neutron have same momentum. Which of the following statements is correct?

(a) Both neutron and electron have same kinetic energy
(b) Both neutron and electron have same de-Brolie wavelength.
(c) Both neutron and electron have same speed.
(d) Both neutron and electron have different de-Broglie wavelength.

18. The energy of a photon is equal to the kinetic energy of a proton. The energy of the photon is E. Let λ_1 be the de-Broglie wavelength of the proton and λ_2 be the wavelength of the photon. The ratio (λ_1/λ_2) is proportional to

(a) E^0 (b) $\sqrt{E}$ (c) E^{-1} (d) E^{-2}

19. The product of linear momentum and angular momentum of an electron of the hydrogen atom is proportional to n^x, where x is

(a) 0 (b) 1 (c) –2 (d) 2

20. A nucleus disintegrates into two nuclear parts which have their velocities in the ratio 2 : 1. The ratio of their nuclear sizes will be

(a) $2^{1/3} : 1$ (b) $1 : 3^{1/2}$ (c) $3^{1/2} : 1$ (d) $1 : 2^{1/3}$

21. A radioactive material decays by simultaneous emission of two particles with half-lives 1620 yr and 810 yr respectively. The time in year after which one-fourth of the material remains, is

(a) 4860 (b) 3240 (c) 2340 (d) 1080

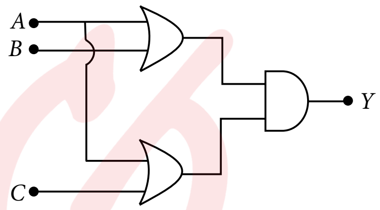
22. A radioactive sample S_1 having an activity of 5 μCi has twice the number of nuclei as another sample S_2 which has an activity of 10 μCi. The half lives of S_1 and S_2 can be

(a) 20 yr and 5 yr, respectively
(b) 20 yr and 10 yr, respectively
(c) 10 yr each
(d) 5 yr each

23. A common emitter amplifier gives an output of 3 V for an input of 0.01 V. If β of the transistor is 100 and the input resistance is 1 kΩ, then the collector resistance is

(a) 1 kΩ (b) 3 kΩ (c) 10 kΩ (d) 30 kΩ

24. The output of given logic circuit is



(a) $A + B + C$ (b) $(A + B)\cdot(A + C)$
(c) $A\cdot(B \cdot C)$ (d) $A\cdot(B + C)$

25. A small spherical ball falling through a viscous medium of negligible density has terminal velocity v. Another ball of the same mass but of radius twice that of the earlier falling through the same viscous medium will have terminal velocity

(a) v (b) $\frac{v}{4}$ (c) $\frac{v}{2}$ (d) $2v$

26. The excess pressure inside one soap bubble is three times that inside a second soap bubble, then the ratio of their surface areas is

(a) 1 : 9 (b) 1 : 3
(c) 3 : 1 (d) 1 : 27

27. Two rods of different materials having coefficients of thermal expansions α_1 and α_2 and Young's moduli Y_1 and Y_2 respectively are fixed between two rigid walls. The rods are heated, such that they undergo the same increase in temperature. There is no bending of rods. If $\frac{\alpha_1}{\alpha_2} = \frac{2}{3}$ and stresses developed in the two rods are equal, then $\frac{Y_1}{Y_2}$ is

(a) $\frac{3}{2}$ (b) 1 (c) $\frac{2}{3}$ (d) $\frac{1}{2}$

28. 1 g of steam at 100 °C and equal mass of ice at 0°C are mixed. The temperature of the mixture in steady state will be (latent heat of steam = 540 cal g^{-1}, latent heat of ice = 80 cal g^{-1})

(a) 50°C (b) 100°C (c) 67°C (d) 33°C

29. A black body emits radiations of maximum intensity for the wavelength of 5000 Å when the temperature of the body is 1227 °C. If the temperature of the body is increased by 1000 °C, the maximum intensity would be observed at

(a) 1000 Å (b) 2000 Å (c) 5000 Å (d) 3000 Å

30. Two solid spheres A and B made of the same material have radii r_A and r_B respectively. Both the spheres are cooled from the same temperature under the conditions valid for Newton's law of cooling. The ratio of the rate of cooling of A and B is

(a) $\frac{r_A}{r_B}$ (b) $\frac{r_B}{r_A}$ (c) $\frac{r_A^2}{r_B^2}$ (d) $\frac{r_B^2}{r_A^2}$

31. A gas is suddenly expanded such that its final volume becomes 3 times its initial volume. If the specific heat at constant volume of the gas is $2R$, then the ratio of initial to final pressure is nearly equal to

(a) 5 (b) 6.5 (c) 7 (d) 3.5

32. An ideal refrigerator has a freezer at a temperature of –13 °C. The coefficient of performance of the engine is 5. The temperature of the air (to which heat is rejected) will be

(a) 325°C (b) 325 K (c) 39°C (d) 320°C

33. In a Carnot engine, when T_2 = 0 °C and T_1 = 200 °C, its efficiency is η_1 and when T_1 = 0°C and T_2 = –200 °C, its efficiency is η_2, then what is $\frac{\eta_1}{\eta_2}$?

(a) 0.577 (b) 0.733 (c) 0.638 (d) 0.95

34. A container with insulating walls is divided into two equal parts by a partition fitted with a valve. One part is filled with an ideal gas at a pressure p and temperature T, whereas the other part is completely evacuated. If the valve is suddenly opened, the pressure and temperature of the gas will be

(a) $\frac{p}{2}, T$ (b) $\frac{p}{2}, \frac{T}{2}$ (c) p, T (d) $p, \frac{T}{2}$

35. If universal gas constant is R, the essential heat to increase the temperature of 4 mol monoatomic ideal gas from 273 K to 473 K at constant volume is

(a) $200R$ (b) $400R$ (c) $800R$ (d) $1200R$

SECTION-B

Attempt any 10 questions out of 15.

36. A particle at the end of a spring executes SHM with a period t_1 while the corresponding period for another spring is t_2. If the period of oscillation with the two springs in series is T, then

(a) $T = t_1 + t_2$ (b) $T^2 = t_1^2 + t_2^2$

(c) $T^{-1} = t_1^{-1} + t_2^{-1}$ (d) $T^{-2} = t_1^{-2} + t_2^{-2}$

37. A hollow pipe of length 0.8 m is closed at one end. At its open end a 0.5 m long uniform string is vibrating in its second harmonic and it resonates with the fundamental frequency of the pipe. If the tension in the wire is 50 N and the speed of sound is 320 m s^{-1}, the mass of the string is

(a) 5 g (b) 10 g (c) 20 g (d) 40 g

38. Ultraviolet light of wavelength 300 nm and intensity 1.0 W m^{-2} falls on the surface of photoelectric metal. If one percent of incident photons produce photoelectrons, then the number of photoelectrons emitted from an area of 1.0 cm^2 of the surface is nearly

(a) 2.13×10^{11} s^{-1} (b) 1.5×10^{12} s^{-1}

(c) 3.02×10^{12} s^{-1} (d) none of these

39. According to Bohr's theory of hydrogen atom, for the electron in the n^{th} allowed orbit, the

(i) linear momentum is proportional to $1/n$

(ii) radius is proportional to n

(iii) kinetic energy is proportional to $\frac{1}{n^2}$

(iv) angular momentum is proportional to n

Choose the correct option from the codes given below.

(a) (i), (iii), (iv) are correct (b) (i) is correct

(c) (i), (ii) are correct (d) (iii) is correct

40. Consider the nuclear reaction $X^{200} \rightarrow A^{120} + B^{80}$. If the binding energy per nucleon for X, A and B are 7.4 MeV, 8.2 MeV and 8.3 MeV respectively, then the energy released in the reaction is

(a) 168 MeV (b) 200 MeV

(c) 190 MeV (d) 188 MeV

41. An atomic power nuclear reactor can deliver 300 MW. The energy released due to fission of each nucleus of uranium atom U^{238} is 170 MeV. The number of uranium atoms fissioned per hour will be

(a) 30×10^{25} (b) 4×10^{22}

(c) 10×10^{20} (d) 5×10^{15}

42. The equation of a wave on a string of linear mass density 0.04 kg m^{-1} is given by

$$y = 0.02\,(\text{m})\sin\left[2\pi\left(\frac{t}{0.04\,(\text{s})} - \frac{x}{0.50\,(\text{m})}\right)\right].$$

The tension in the string is

(a) 1.25 N (b) 0.5 N (c) 6.25 N (d) 4.0 N

43. Two strings A and B are slightly out of tune and produce beats of frequency 5 Hz. Increasing the tension in B reduces the beat frequency to 3 Hz. If the frequency of string A is 450 Hz, calculate the frequency of string B.

(a) 460 Hz (b) 455 Hz (c) 445 Hz (d) 440 Hz

44. If a source emitting waves of frequency υ moves towards an observer with a velocity $v/4$ and the observer moves away from the source with a velocity $v/6$, the apparent frequency as heard by the observer will be (v = velocity of sound)

(a) $\frac{14}{15}\upsilon$ (b) $\frac{14}{9}\upsilon$ (c) $\frac{10}{9}\upsilon$ (d) $\frac{2}{3}\upsilon$

45. Two bodies are in equilibrium when suspended in water from the arms of a balance. The mass of one body is 36 g and its density is 9 g cm^{-3}. If the mass of the other is 48 g, its density in g cm^{-3} is

(a) $\frac{4}{3}$ (b) $\frac{3}{2}$ (c) 3 (d) 5

46. Mark the incorrect statement.

When a potential difference is applied across, the current passing through

(a) an insulator at 0 K is zero

(b) a semiconductor 0 K is zero

(c) a metal at 0 K is zero

(d) a p-n junction diode at 300 K is finite, if it is reverse biased

47. A circular platform is mounted on a vertical frictionless axle. Its radius is $r = 2$ m and its moment of inertia $I = 200$ kg m^2. It is initially at rest. A 70 kg man stands on the edge of the platform and begins to walk along the edge at speed $v_0 = 1$ m s^{-1} relative to the ground. The angular velocity of the platform is

(a) 1.2 rad s^{-1} (b) 0.4 rad s^{-1}
(c) 0.7 rad s^{-1} (d) 2 rad s^{-1}

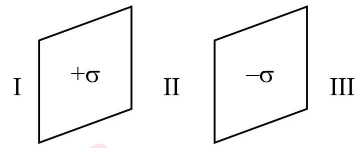
48. Assuming an electron is confined to a 1 nm wide region. Find the uncertainty in momentum. (Take $h = 6.63 \times 10^{-34}$ J s)

(a) 1.05×10^{-25} kg m s^{-1}
(b) 2.03×10^{-31} kg m s^{-1}
(c) 3.05×10^{-34} kg m s^{-1}
(d) 2.49×10^{-32} kg m s^{-1}

49. When water is heated from 0°C to 10°C , its volume

(a) increase
(b) decrease
(c) does not change
(d) first decreases and then increases

50. Two large thin metal plates are parallel and close to each other. On their inner faces, the plates have surface charge densities of opposite signs and magnitude 27×10^{-22} C m^{-2}. The electric field $\vec{E}$ in region II in between the plates is



(a) 4.25×10^{-8} N C^{-1} (b) 6.28×10^{-10} N C^{-1}
(c) 3.05×10^{-10} N C^{-1} (d) 5.03×10^{-10} N C^{-1}

Explanations

PHYSICS

1. **(c)** : For no change in the velocity of electron, magnetic force = electrostatic force

$qvB = qE$

$$v = \frac{E}{B} = \frac{\sigma}{\varepsilon_0 B}$$

The time taken by electron to travel a distance L in that space with uniform motion

$$t = \frac{L}{v} = \frac{L}{\sigma/\varepsilon_0 B} = \frac{\varepsilon_0 LB}{\sigma}$$

2. **(b)** : $U = \frac{q^2}{2C}$

For series combination of the capacitors, q = constant

$$\Rightarrow \quad U \propto \frac{1}{C}$$

$$\frac{U_1}{U_2} = \frac{C_2}{C_1} = \frac{4}{2} = 2$$

3. **(a)** : The balance condition of a meter bridge experiment

$$\frac{R}{X} = \frac{l}{100 - l}$$

Case (i) : $\frac{R_1 + 10}{R_2} = \frac{50}{50}$ ... (i)

Case (ii) : $\frac{R_1}{R_2} = \frac{40}{60}$ ... (ii)

Using R_2 from eqn. (ii) in (i), we get

$$\frac{R_1 + 10}{\frac{60}{40}R_1} = 1 \;\Rightarrow\; R_1 + 10 = \frac{3}{2}R_1 \;\Rightarrow\; R_1 = 20\ \Omega$$

4. **(c)** : Pole strength of original magnet, $m = \frac{M}{14}$

$$\therefore \quad M_1 = \frac{M}{14}.6 \quad \text{and} \quad M_2 = \frac{M}{14}.8$$

Magnetic moment of the combination,

$$M = \sqrt{M_1^2 + M_2^2} = \frac{M}{14}\sqrt{6^2 + 8^2} = \frac{10M}{14} = \frac{M}{1.4}$$

5. **(a)** : Induced emf in coil

$$\therefore \quad |e| = A\frac{dB}{dt} = 0.01 \times \frac{1}{1 \times 10^{-3}} = 10\ \text{V}$$

Current produced in coil,

$$i = \frac{|e|}{R} = \frac{10}{2} = 5\ \text{A}$$

Heat evolved = i^2Rt

$= (5)^2 \times (2) \times 1 \times 10^{-3} = 0.05$ J

6. **(b)** : For LC circuit, the time period is

$$T = 2\pi\sqrt{LC}$$

At time $t = \frac{T}{4}$, energy stored is completely magnetic.

So the time, $t = \frac{2\pi\sqrt{LC}}{4}$

or $\quad t = \frac{2\pi\sqrt{20 \times 10^{-3} \times 50 \times 10^{-6}}}{4} = 1.57$ ms

7. **(d)** : Power factor, $\cos\phi = \frac{R}{\sqrt{R^2 + \omega^2 L^2}}$

$$= \frac{30}{\sqrt{(30)^2 + (100)^2 \times (400 \times 10^{-3})^2}}$$

$$= \frac{30}{\sqrt{900 + 1600}} = \frac{30}{50} = 0.6$$

8. **(a)** : Here, $m = 1 \times 10^{-26}$ kg

$q = 1.6 \times 10^{-19}$ C

$\vec{v} = 1.28 \times 10^6 \hat{i}$ m s^{-1}

$\vec{E} = -102.4 \times 10^3 \hat{k}$ N C^{-1}

$\vec{B} = 8 \times 10^{-2} \hat{j}$ Wb m^{-2}

Force on a charged particle in a uniform electric and magnetic field is

$$\vec{F} = q\vec{E} + q(\vec{v} \times \vec{B}) = q(\vec{E} + \vec{v} \times \vec{B})$$

$$= (1.6 \times 10^{-19})[(-102.4 \times 10^3 \hat{k}) + (1.28 \times 10^6 \hat{i} \times 8 \times 10^{-2} \hat{j})]$$

$$= (1.6 \times 10^{-19})[(-102.4 \times 10^3 \hat{k} + 102.4 \times 10^3 \hat{k})] = 0$$

Acceleration of the particle, $a = \frac{F}{m} = 0$

Hence, the particle will move along positive X-axis.

9. **(a)** : From mirror formula

$$\frac{1}{v} = \frac{1}{-20} - \frac{1}{(-40)} = -\frac{1}{40}$$

$v = -40$ cm

The image is on the same side of the object.

Now, magnification $m = -\frac{v}{u} = -\frac{(-40)}{(-40)} = -1$

i.e., the image is real, inverted and of same size.

10. **(a)** : Brewster's law, $\mu = \tan\theta_p$

$\theta_p = \theta_i = \tan^{-1}(1.62)$

11. **(a)** : Ray QR travels parallel to base BC, this is the case of

minimum deviation thus

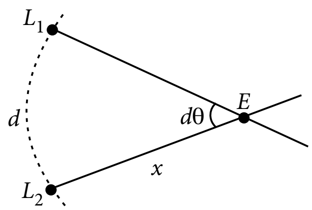
$$\mu = \frac{\sin\left(\frac{A+\delta_{min}}{2}\right)}{\sin\left(\frac{A}{2}\right)} \Rightarrow \sqrt{3} = \frac{\sin\left(\frac{60^\circ+\delta_{min}}{2}\right)}{\sin\left(\frac{60^\circ}{2}\right)}$$

$$\Rightarrow \frac{\sqrt{3}}{2} = \sin\left(\frac{60^\circ+\delta_{min}}{2}\right) \quad \therefore \delta_{min} = 60^\circ$$

12. (c) : x = distance of car from eye

D = diameter of eye lens,

d = separation between sources.



$$d\theta = \frac{d}{x} = \frac{1.22\lambda}{D}$$

$$\Rightarrow x = \frac{D \times d}{1.22\lambda} = \frac{2\times10^{-3}\times1.2}{1.22\times5896\times10^{-10}} = 3337 \text{ m}$$

$x = 3.34$ km

13. (b) : $I = I_a + I_b + 2\sqrt{I_a}\sqrt{I_b}\cos\phi$

For incoherent sources, $(\cos\phi)_{av} = 0$

$\Rightarrow I_{ics} = I_a + I_b = I_2$

I is maximum for coherent sources

$$I_{cs} = I_a + I_b + 2\sqrt{I_a}\sqrt{I_b} = I_1$$

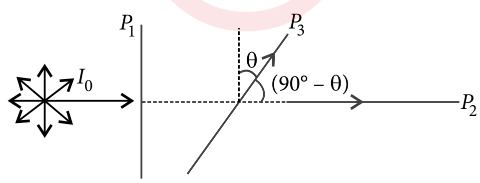
For $I_a = I_b = I_0$

$I_1 = 4I_0$ and $I_2 = 2I_0$

So, $\frac{I_1}{I_2} = 2$

14. (d) : $$\frac{I_{max}}{I_{min}} = \frac{\left(\frac{A_1}{A_2}+1\right)^2}{\left(\frac{A_1}{A_2}-1\right)^2} = \frac{\left(\frac{4}{3}+1\right)^2}{\left(\frac{4}{3}-1\right)^2} = \frac{49}{1}$$

15. (a) : For P_1, $I = (I_0)(\cos^2\theta)_{av} = \frac{I_0}{2}$



For P_3, $I = \left(\frac{I_0}{2}\right)\cos^2\theta$

For P_2, $I = \left(\frac{I_0}{2}\cos^2\theta\right)\cos^2(90^\circ - \theta)$

$$= \frac{I_0}{2}(\cos\theta\sin\theta)^2 = \frac{I_0}{8}(2\cos\theta\sin\theta)^2 = \frac{I_0}{8}\sin^2 2\theta$$

16. (d) : de-Broglie wavelength, $\lambda = \frac{h}{\sqrt{2mE}}$

$$\therefore \frac{\lambda_1}{\lambda_2} = \sqrt{\frac{E_2}{E_1}} \Rightarrow \frac{1\times10^{-9}}{0.5\times10^{-9}} = \sqrt{\frac{E_2}{E_1}}$$

$$\Rightarrow 2 = \sqrt{\frac{E_2}{E_1}} \Rightarrow \frac{E_2}{E_1} = 4 \quad \therefore E_2 = 4E_1$$

$\therefore$ Energy to be added $= E_2 - E_1$

$= 4E_1 - E_1 = 3E_1$

17. (b) : de-Broglie wavelength, $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}} = \frac{h}{mv}$

18. (b) : Required ratio, $\frac{\lambda_1}{\lambda_2} = \frac{h/\sqrt{2mE}}{hc/E}$ or $\frac{\lambda_1}{\lambda_2} \propto E^{1/2}$

19. (a) : Linear momentum, $mv = \frac{mcZ}{137n}$

Angular momentum $= \frac{nh}{2\pi}$

Linear momentum $\times$ angular momentum $\propto n^x$

$$\therefore \frac{mcZ}{137n} \times \frac{nh}{2\pi} \propto n^x$$

$n^0 \propto n^x \Rightarrow x = 0$

20. (d) : Using law of conservation of momentum

$m_1v_1 = m_2v_2$

$$\Rightarrow \frac{m_1}{m_2} = \frac{v_2}{v_1}$$

$m \propto r^3$ for a spherical nucleus of uniform density

$$\therefore \frac{m_1}{m_2} = \frac{r_1^3}{r_2^3} = \frac{v_2}{v_1} \Rightarrow \frac{r_1}{r_2} = \left(\frac{1}{2}\right)^{1/3}$$

21. (d) : Effective half-life

$$\frac{1}{T} = \frac{1}{T_1} + \frac{1}{T_2} = \frac{1}{1620} + \frac{1}{810}$$

$\Rightarrow T = 540$ yr

Fraction left after n half lives is $\left(\frac{1}{2}\right)^n$, $n = \frac{t}{540}$

According to question,

$$\frac{1}{4} = \left(\frac{1}{2}\right)^n \Rightarrow n = 2 \;\therefore\; 2 = \frac{t}{540} \Rightarrow t = 1080 \text{ yr}$$

22. (a) : Activity of $S_1 = \frac{1}{2}$ (Activity of S_2)

or $\lambda_1 N_1 = \frac{1}{2}(\lambda_2 N_2)$ or $\frac{\lambda_1}{\lambda_2} = \frac{N_2}{2N_1}$

or $\frac{T_1}{T_2} = \frac{2N_1}{N_2}$ $\left[\text{As } T = \frac{0.693}{\lambda}\right]$

Given $N_1 = 2N_2$ $\therefore$ $\frac{T_1}{T_2} = 4$

23. (b) : Voltage gain = current gain × resistance gain

or $A_V = \beta \times \frac{R_0}{R_i}$ or $\frac{V_0}{V_i} = \beta \frac{R_0}{R_i}$

or $\frac{3}{0.01} = 100 \times \frac{R_0}{1\times 10^3}$ or $R_0 = \frac{30}{0.01} = 3\,\text{k}\Omega$

24. (b) : Here $A + B = G_1$ (OR)
$A + C = G_2$ (OR)
and $G_1 \cdot G_2 = Y$ (AND)

25. (c) : Terminal velocity of the ball falling through a viscous medium of negligible density ($\sigma \approx 0$) is

$$v = \frac{2}{9\eta} r^2 \rho g$$

$$v = \frac{2}{9\eta} r^2 \left(\frac{m}{\frac{4}{3}\pi r^3} \right) g$$

For constant m, η and g

$v \propto \frac{1}{r}$

Because radius of second ball is twice that of the first ball

$\therefore \quad v_2 = \frac{v_1}{2}$

26. (a) : Given, $\frac{4T}{r_1} = 3 \times \frac{4T}{r_2} \Rightarrow \frac{r_1}{r_2} = \frac{1}{3}$

Ratio of surface areas will be

$$\frac{A_1}{A_2} = \frac{4\pi r_1^2}{4\pi r_2^2} = \frac{1}{9}$$

27. (a) : Thermal stress = $Y\alpha\Delta T$

where Y is Young's modulus, a the coefficient of linear expansion and ΔT the change in temperature.

For no bending, thermal stress in each rod should be equal so as to cancel other.

Since, $\Delta T_1 = \Delta T_2$

$$\frac{Y_1}{Y_2} = \frac{\alpha_2}{\alpha_1} = \frac{3}{2}$$

28. (b) : Heat taken by ice to raise its temperature to 100°C

$Q_1 = 1 \times 80 + 1 \times 1 \times 100 = 180$ cal

Heat given by steam when condensed

$Q_2 = m_2 L_2 = 1 \times 540 = 540$ cal

As $Q_2 > Q_1$, hence, temperature of mixture will remain 100°C.

29. (d) : According to Wien's displacement law,

$$\lambda_m \propto \frac{1}{T} \Rightarrow \frac{(\lambda_m)_1}{(\lambda_m)_2} = \frac{T_2}{T_1}$$

$$\therefore \frac{5000}{(\lambda_m)_2} = \frac{2227+273}{1227+273} \Rightarrow (\lambda_m)_2 = 3000\ \text{Å}$$

30. (b) : Rate of cooling,

$$-\frac{dT}{dt} = \frac{4eA\sigma T_S^3}{mc}(T - T_S) \propto \frac{\text{area}}{\text{mass}}$$

For given surrounding and object temperature

$$-\frac{dT}{dt} \propto \frac{R^2}{R^3} = \frac{1}{R}$$

Ratio of rates of cooling, $\frac{H_A}{H_B} = \frac{r_B}{r_A}$

31. (a) : Suddenly expanded ⇒ adiabatic process,

i.e., pV^γ = constant

$p_1 V_1^\gamma = p_2 (3V)^\gamma$

$$\gamma = \frac{C_p}{C_V} = \frac{3R}{2R} = 1.5 \Rightarrow \frac{p_1}{p_2} = 3^\gamma = 3^{1.5} \approx 5$$

32. (c) : Given that, the temperature of freezer,

$T_2 = -13$ °C

$T_2 = -13 + 273 = 260$ K

Coefficient of performance, $\beta = 5$

$$\beta = \frac{T_2}{T_1 - T_2} \quad \text{or} \quad 5 = \frac{260}{T_1 - 260}$$

$$\therefore \quad T_1 - 260 = \frac{260}{5}$$

or $T_1 - 260 = 52$ or $T_1 = (52 + 260)$ K = 312 K

or $T_1 = (312 - 273)$°C = 39°C

33. (a) : Take temperature in Kelvin

$$\eta_1 = 1 - \frac{273}{473} = \frac{200}{473} = 0.423 \quad \text{... (i)}$$

$$\eta_2 = 1 - \frac{T_2}{T_1} = 1 - \frac{73}{273} = \frac{200}{273} = 0.732 \quad \text{... (ii)}$$

Dividing eqn. (i) by (ii),

$$\frac{\eta_1}{\eta_2} = \frac{0.423}{0.732} = 0.577$$

34. (a) : Internal energy of the gas remains constant, hence

$T_2 = T$

Using $p_1 V_1 = p_2 V_2$

$$p \cdot \frac{V}{2} = p_2 V \Rightarrow p_2 = \frac{p}{2}$$

35. (d) : Specific heat for a monoatomic gas

$$C_V = \frac{fR}{2} = \frac{3R}{2}$$

Required heat is $\Delta H = nC_V \Delta T$

$$= 4 \times \frac{3}{2} R \times 200 = 1200R$$

36. (b) : For series springs, equivalent spring constant is given by, $\frac{1}{k_s} = \frac{1}{k_1} + \frac{1}{k_2}$. Also $\frac{1}{m}\left(\frac{T}{2\pi}\right)^2 = \frac{1}{k}$

$$\frac{1}{m}\left(\frac{T}{2\pi}\right)^2 = \frac{1}{m}\left(\frac{t_1}{2\pi}\right)^2 + \frac{1}{m}\left(\frac{t_2}{2\pi}\right)^2$$

$T^2 = t_1^2 + t_2^2$

37. (b) : According to question, 2 × fundamental frequency of string = fundamental frequency of pipe

$$2\left(\frac{v_1}{2L_1}\right)=\frac{v_2}{4L_2} \Rightarrow \frac{\sqrt{T/\mu}}{L_1}=\frac{320}{4L_2}$$

(μ = mass per unit length of wire)

or $\frac{\sqrt{50/\mu}}{0.5}=\frac{320}{4\times0.8}$ or, $\mu = 0.02$ kg m^{-1}

∵ length of string, $l = 0.5$ m

∴ Mass of string = $\mu \times l = 0.02 \times 0.5$
$= 10 \times 10^{-3}$ kg = 10 g

38. (b) : Energy of each photon, $E = \frac{hc}{\lambda}$

$$=\frac{6.6\times10^{-34}\times3\times10^8}{300\times10^{-9}}=6.6\times10^{-19}\text{ J}$$

Power of source is,

P = intensity × area = $1.0 \times 1.0 \times 10^{-4} = 10^{-4}$ W

Number of photons per second (N) fall on the surface,

$$=\frac{P}{E}=\frac{10^{-4}}{6.6\times10^{-19}}$$

Now number of electrons emitted = 1 % of N

$$=\frac{1}{100}\times\frac{10^{-4}}{6.6\times10^{-19}}=1.5\times10^{12}\text{ per second}$$

39. (a) : Angular momentum, $L = n\frac{h}{2\pi}$

Radius of the orbit, $r = 0.52\frac{n^2}{Z}$

Kinetic energy = $-E = +13.6\frac{Z^2}{n^2}$ eV

40. (a) : For X, binding energy = 200 × 7.4 = 1480 MeV

For A, binding energy = 120 × 8.2 = 984 MeV

For B, binding energy = 80 × 8.3 = 664 MeV

Therefore, energy released

= (984 + 664) – 1480 = 168 MeV

41. (b) : Power $=\frac{\text{energy}}{\text{time}}=300\times10^6$ W $= 3 \times 10^8$ J s^{-1}

170 MeV = $170 \times 1.6 \times 10^{-13}$ J = 27.2×10^{-12} J

Number of atoms fissioned per second (N)

$$=\frac{3\times10^8}{27.2\times10^{-12}}$$

Number of atoms fissioned per hour

$$= N\times3600 = \frac{3\times10^8\times3600}{27.2\times10^{-12}} = 4\times10^{22}$$

42. (c) : Compare given equation with

$y = A\sin(\omega t - kx)$

$$\Rightarrow \omega=\frac{2\pi}{0.04}\text{ and } k=\frac{2\pi}{0.50}$$

$$\therefore v=\frac{\omega}{k}=\frac{0.5}{0.04}=12.5\text{ m s}^{-1}$$

But $v=\sqrt{\frac{T}{\mu}} \Rightarrow T = v^2\mu$

∴ $T = (12.5)^2 \times 0.04 = 6.25$ N

43. (c) :

$\upsilon(A)$	$\upsilon(B)$	beat frequency
(i) 450	υ	5
(ii) 450	υ' (> υ)	3

(i) υ = 455 Hz or 445 Hz

(ii) $\upsilon' - 450 = \pm3$

(iii) Also $\upsilon' > \upsilon'$ (slightly)

Only 445 Hz satisfies condition (ii) and (iii)

44. (c) : When source and observer both are moving in the same direction and observer is ahead of source, then apparent frequency is given by

$$\upsilon'=\left(\frac{v-v_o}{v-v_s}\right)\upsilon=\frac{v-\frac{v}{6}}{v-\frac{v}{4}}\times\upsilon=\frac{10}{9}\upsilon$$

45. (c) : For equilibrium F_{net} (Apparent weight) on each pan should be same.

$F_{net} = W - U = mg - sVg$

or $m-\frac{\sigma m}{\rho}=\text{constant}$

$$\Rightarrow 36-1\times\frac{36}{9}=48-1\times\frac{48}{\rho} \Rightarrow \frac{2}{3}=1-\frac{1}{\rho} \Rightarrow \rho=3$$

46. (c)

47. (c) : As the system is initially at rest, therefore, initial angular momentum, $L_i = 0$.

According to the law of conservation of angular momentum, final angular momentum, $L_f = 0$

∴ Angular momentum of man = angular momentum of platform in opposite direction

i.e., $mv_0r = I\omega$

or $\omega=\frac{mv_0r}{I}=\frac{70\,(1.0)(2)}{200}=0.7\text{ rad s}^{-1}$

48. (a)

49. (d) : When water is heated from 0°C to 10°C, its volume decreases upto 4°C.

Since density of water is maximum at 4°C.

From 4°C to 10°C, density of water decreases.

Therefore volume of water increases.

50. (c) : The value of $\vec{E}$ in the region II, in between the plates,

$$=\frac{\sigma}{\varepsilon_0}=\frac{27\times10^{-22}}{8.85\times10^{-12}}=3.05\times10^{-10}\text{ N C}^{-1}$$