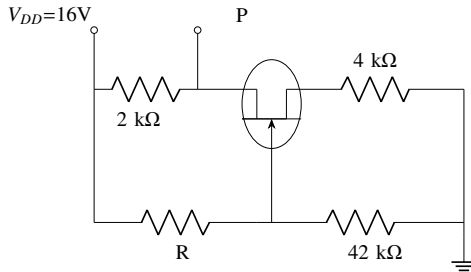


AI24BTECH11034 Tanush Sri Sai Petla

- 69) In the circuit shown, the voltage at test point P is 12 V and the voltage between gate and source is -2 V. The value of R (in $k\Omega$) is



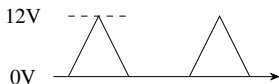
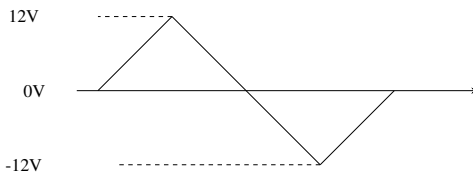
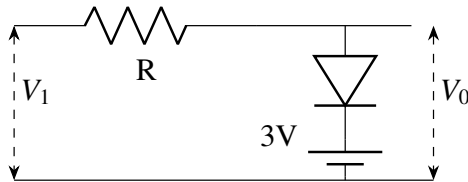
a) 42

b) 48

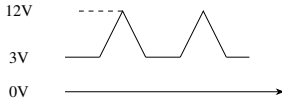
c) 56

d) 70

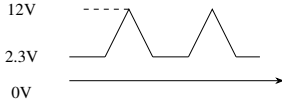
- 70) When an input voltage V_i , of the form shown, is applied to the circuit given below, the output voltage V_o is of the form:



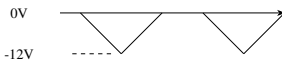
a)



b)



c)



d)

Common Data Questions

Common Data for Questions 71, 72, 73:

A particle of mass m is confined in the ground state of a one-dimensional box, extending from $x = -2L$ to $x = +2L$. The wavefunction of the particle in this state is

$$\psi(x) = \psi_0 \cos\left(\frac{\pi x}{4L}\right)$$

where ψ_0 is a constant.

71) The normalization factor ψ_0 of this wavefunction is

- a) $\frac{\sqrt{2}}{L}$ b) $\frac{1}{4L}$ c) $\frac{1}{\sqrt{2}L}$ d) $\frac{1}{L}$

72) The energy eigenvalue corresponding to this state is

- a) $\frac{\hbar^2 \pi^2}{2mL^2}$ b) $\frac{\hbar^2 \pi^2}{4mL^2}$ c) $\frac{\hbar^2 \pi^2}{16mL^2}$ d) $\frac{\hbar^2 \pi^2}{32mL^2}$

73) The expectation value of p^2 (p is the momentum operator) in this state is

- a) 0 b) $\frac{\hbar^2 \pi^2}{32L^2}$ c) $\frac{\hbar^2 \pi^2}{16L^2}$ d) $\frac{\hbar^2 \pi^2}{8L^2}$

Common Data for Questions 74, 75:

The Fresnel relations between the amplitudes of incident and reflected electromagnetic waves at an interface between air and a dielectric of refractive index μ_r are:

$$\frac{E_{\parallel}^{\text{reflected}}}{E_{\parallel}^{\text{incident}}} = \frac{\mu_r \cos r - \cos i}{\mu_r \cos r + \cos i} \quad \text{and} \quad \frac{E_{\perp}^{\text{reflected}}}{E_{\perp}^{\text{incident}}} = \frac{\cos i - \mu_r \cos r}{\cos i + \mu_r \cos r}$$

The subscripts \parallel and \perp refer to polarization, parallel and normal to the plane of incidence respectively. Here, i and r are the angles of incidence and refraction respectively.

74) The condition for the reflected ray to be completely polarized is

- a) $\mu \cos i = \cos r$ b) $\cos i = \mu \cos r$ c) $\mu \cos i = -\cos r$ d) $\cos i = -\mu \cos r$

75) For normal incidence at an air-glass interface with $\mu = 1.5$, the fraction of energy reflected is given by

- a) 0.40 b) 0.20 c) 0.16 d) 0.04

Linked Answer Questions: Q.76 to Q.85 carry two marks each.

Statement for Linked Answer Questions 76 and 77:

In the laboratory frame, a particle P of rest mass m_e is moving in the positive x direction with a speed of $\frac{5c}{19}$. It approaches an identical particle Q, moving in the negative x direction with a speed of $\frac{2c}{5}$.

76) The speed of the particle P in the rest frame of the particle Q is

- a) $\frac{7c}{95}$ b) $\frac{13c}{85}$ c) $\frac{3c}{5}$ d) $\frac{63c}{95}$

77) The energy of the particle P in the rest frame of the particle Q is

- a) $\frac{1}{2}m_g c^2$ b) $\frac{5}{4}m_0 c^2$ c) $\frac{19}{13}m_0 c^2$ d) $\frac{11}{2}m$

Statement for Linked Answer Questions 78 and 79

The atomic density of a solid is $5.85 \times 10^{32} m^{-3}$. Its electrical resistivity is $1.6 \times 10^{-2} \Omega m$.

Assume that electrical conduction is described by the Drude model (classical theory), and that each atom contributes one conduction electron.

78) The drift mobility (in $m^2 V^{-1} s^{-1}$) of the conduction electrons is

- a) 6.67×10^{-3} b) 6.67×10^{-6} c) 7.63×10^{-1} d) 7.63×10^{-9}

79) The relaxation time (mean free time), in seconds, of the conduction electrons is

- a) 3.98×10^{-13} b) 3.79×10^{-14} c) 2.84×10^{-12} d) 2.64×10^{-11}

Statement for Linked Answer Questions 80 and 81:

A sphere of radius R carries a polarization $\vec{P} = kr$, where k is a constant and \vec{r} is measured from the centre of the sphere.

80) The bound surface and volume charge densities are given, respectively, by

a) $-k \left| \vec{r} \right|$ and $3k$

b) $k \left| \vec{r} \right|$ and $-3k$

c) $k \left| \vec{r} \right|$ and $4\pi kR$

d) $-k \left| \vec{r} \right|$ and $-4\pi kR$

81) The electric field \vec{E} at a point outside the sphere is given by

a) $\vec{E} = 0$

b) $\vec{E} = \frac{kR(R^2 - r^2)}{4\pi\epsilon_0 r^3} \hat{r}$

c) $\vec{E} = \frac{kR(R^2 - r^2)}{4\pi\epsilon_0 r^3} \hat{r}$

d) $\vec{E} = \frac{3k(r-R)}{4\pi\epsilon_0 r^4} \hat{r}$

Statement for Linked Answer Questions 82 and 83:

An ensemble of quantum harmonic oscillators is kept at a finite temperature $T = \frac{1}{k_B\beta}$.

82) The partition function of a single oscillator with energy levels $\left(n + \frac{1}{2}\right) \hbar\omega$ is given by

a) $Z = \frac{e^{-\beta\hbar\omega/2}}{1 - e^{-\beta\hbar\omega}}$

b) $Z = \frac{e^{-\beta\hbar\omega}}{1 - e^{-\beta\hbar\omega}}$

c) $Z = \frac{1}{1 - e^{-\beta\hbar\omega}}$

d) $Z = \frac{1}{1 - e^{-2\beta\hbar\omega - \mu}}$

83) The average number of energy quanta of the oscillators is given by

a) $\langle n \rangle = \frac{1}{e^{\beta\hbar\omega} - 1}$

b) $\langle n \rangle = \frac{e^{-\beta\hbar\omega}}{e^{\beta\hbar\omega} - 1}$

c) $\langle n \rangle = \frac{e^{-2\beta\hbar\omega}}{e^{2\beta\hbar\omega} + 1}$

d) $\langle n \rangle = \frac{1}{e^{\beta\hbar\omega} + 1}$

Statement for Linked Answer Questions 84 and 85:

A $16 \mu A$ beam of alpha particles, having cross-sectional area $10^{-4} m^2$, is incident on a rhodium target of thickness $1 \mu m$. This produces neutrons through the reaction $^{103}Rh + \alpha \rightarrow ^{106}Pd + 3n$.

84) The number of alpha particles hitting the target per second is

a) 0.5×10^{14}

b) 1.0×10^{14}

c) 2.0×10^{20}

d) 4.0×10^{19}

85) The neutrons are observed at the rate of $1.806 \times 10^8 s^{-1}$. If the density of rhodium is approximated as $10^4 kg m^{-3}$, the cross-section for the reaction (in barns) is

a) 0.1

b) 0.2

c) 0.4

d) 0.8