

I. CARRY ONE MARK EACH

- 1) Interference fringes are seen at an observation plane $z = 0$, by the superposition of two plane waves $A_1 \exp[i(\vec{k}_1 \cdot \vec{r} - \omega t)]$ **and** $A_2 \exp[i(\vec{k}_2 \cdot \vec{r} - \omega t)]$, where A_1 and A_2 are real amplitudes. The condition for interference maximum is
 - a) $(\vec{k}_1 - \vec{k}_2) \cdot \vec{r} = (2m + 1)\pi$
 - b) $(\vec{k}_1 - \vec{k}_2) \cdot \vec{r} = 2m\pi$
 - c) $(\vec{k}_1 + \vec{k}_2) \cdot \vec{r} = (2m + 1)\pi$
 - d) $(\vec{k}_1 + \vec{k}_2) \cdot \vec{r} = 2m\pi$
- 2) For a scalar function ϕ satisfying the Laplace equation, $\nabla\phi$ has
 - a) zero curl and non-zero divergence
 - b) non-zero curl and zero divergence
 - c) zero curl and zero divergence
 - d) non-zero curl and non-zero divergence
- 3) A circularly polarized monochromatic plane wave is incident on a dielectric interface at Brewster angle. Which one of the following statements is CORRECT?
 - a) The reflected light is plane polarized in the plane of incidence and the transmitted light is circularly polarized.
 - b) The reflected light is plane polarized perpendicular to the plane of incidence and the transmitted light is plane polarized in the plane of incidence.
 - c) The reflected light is plane polarized perpendicular to the plane of incidence and the transmitted light is elliptically polarized.
 - d) There will be no reflected light and the transmitted light is circularly polarized.
- 4) Which one of the following commutation relations is NOT CORRECT? Here, symbols have their usual meanings.
 - a) (A) $[L^2, L_z] = 0$
 - b) (B) $[L_x, L_y] = i\hbar L_z$
 - c) (C) $[L_z, L_+] = \hbar L_+$
 - d) (D) $[L_z, L_-] = \hbar L_-$
- 5) The Lagrangian of a system with one degree of freedom q is given by $L = \alpha\dot{q}^2 + \beta q^2$, where α and β are non-zero constants. If p_q denotes the canonical momentum conjugate to q then which one of the following statements is CORRECT?
 - a) $p_q = 2\beta q$ and it is a conserved quantity.
 - b) $p_q = 2\beta q$ and it is not a conserved quantity.
 - c) $p_q = 2\alpha\dot{q}$ and it is a conserved quantity.
 - d) $p_q = 2\alpha\dot{q}$ and it is not a conserved quantity.

6) What should be the clock frequency of a 6-bit A/D converter so that its maximum conversion time is $32\mu\text{s}$?

- a) 1 MHz b) 2 MHz c) 0.5 MHz d) 4 MHz

7) A phosphorous doped silicon semiconductor (doping density: $10^{17}/\text{cm}^3$) is heated from 100°C to 200°C . Which one of the following statements is CORRECT?

- a) Position of Fermi level moves towards conduction band
 b) Position of dopant level moves towards conduction band
 c) Position of Fermi level moves towards middle of energy gap
 d) Position of dopant level moves towards middle of energy gap

8) Considering the BCS theory of superconductors, which one of the following statements is NOT CORRECT?

(h is the Planck's constant and e is the electronic charge)

- a) Presence of energy gap at temperatures below the critical temperature
 b) Different critical temperatures for isotopes
 c) Quantization of magnetic flux in superconducting ring in the unit of $\left(\frac{h}{e}\right)$
 d) Presence of Meissner effect

9) Group I contains elementary excitations in solids. Group II gives the associated fields with these excitations. MATCH the excitations with their associated field and select your answer as per codes given below.

Group I	Group II
(P) phonon	(i) photon + lattice vibration
(Q) plasmon	(ii) electron + elastic deformation
(R) polaron	(iii) collective electron oscillations
(S) polariton	(iv) elastic wave

Codes

- a) (P-iv), (Q-iii), (R-i), (S-ii)
 b) (P-iv), (Q-iii), (R-ii), (S-i)
 c) (P-i), (Q-iii), (R-ii), (S-iv)
 d) (P-iii), (Q-iv), (R-ii), (S-i)

10) The number of distinct ways of placing four indistinguishable balls into five distinguishable boxes is _____.

11) A voltage regulator has ripple rejection of -50dB . If input ripple is 1 mV, what is the output ripple voltage in μV ? The answer should be up to two decimal places.

12) _____
 The number of spectral lines allowed in the spectrum for the $3^2D \rightarrow 3^2P$ transition in sodium is

II. CARRY TWO MARKS EACH

13) Which of the following pairs of the given function $F(t)$ and its Laplace transform $f(s)$ is NOT CORRECT?

a) $F(t) = \delta(t)$, $f(s) = 1$, (Singularity at $+0$)

b) $F(t) = 1$, $f(s) = \frac{1}{s}$, ($s > 0$)

c) $F(t) = \sin kt$, $f(s) = \frac{k}{s^2 + k^2}$, ($s > 0$)

d) $F(t) = te^{kt}$, $f(s) = \frac{1}{(s-k)^2}$, ($s > k, s > 0$)