SRM INSTITUTE OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF PHYSICS

21PYB102J-Semiconductor Physics and Computational Methods

CHAPTER - 3

PART – A

1. An absorbed photon can result in transition between a donor (or acceptor) level and a band in a doped semiconductor called ____.
(A) Band to band transition
(B) Impurity to band transition
(C) Free carrier Transition
(D) Photonic transition

2. The direct band to band absorption and emission can take place only at frequencies for which photon energy _____.
(A) $h\gamma > Eg$
(B) $h\gamma < Eg$
(C) $h\gamma = Eg$
(D) $h\gamma = 0$

3. _____ is the process where the energy due to recombination is dissipated as photons.
(A) Radiative transition
(B) Non-radiative transition
(C) Absorption
(D) Radiation

4. The _____ process is in which the electron-hole pairs are created and recombined radiatively.
(A) Luminescence
(B) Photon emission
(C) Phonon emission
(D) Radiation.

5. The average velocity acquired by the electrons in a particular direction during the presence of electric field is called _____.
(A) Relaxation time
(B) Drift velocity
(C) Collision time
(D) Diffusion current

6. The maximum voltage generated across the terminals of solar cell when they are kept open is called _____.
(A) Short circuit voltage
(B) Open circuit voltage
(C) Fill factor
(D) Drift Voltage.

7. The photons of energy value ____ that of the band gap values do not get absorbed in photovoltaic cell.
(A) Greater than
(B) Less than
(C) Nearly equal than
(D) Zero

8. An absorbed photon can result in upward transition of electron from valence band to conduction band is called _____.
(A) Band to band transition
(B) Impurity to band transition
(C) Free carrier Transition
(D) Photonic transition

9. The direct band to band absorption and emission can take place only at wave length for which photon energy _____.
(A) $\lambda_g = \lambda$
(B) $\lambda_g < \lambda$
(C) $\lambda_g > \lambda$
(D) $\lambda_g = 0$

10. _____ is the process where the excess energy due to recombination is usually imported to phonons and dissipated as heat.
(A) Radiative transition
(B) Non-radiative transition
(C) absorption
(D) Radiation.

11. The radiative recombination of electron-hole pair created by injection of photons is called _____.
(A) Photoluminescence
(B) Photon emission
(C) Phonon emission
(D) Radiation

12. The maximum current flows in solar cell when its P-side & N-side terminal are shorted, such a current is called _____.
(A) Drift current
(B) Diffuse current
(C) Short-circuit current
(D) Alternative current

13. _____ is the process of radiative recombination of electron–hole pairs created by electron bombardment.
(A) Photoluminescence
(B) photon emission
(C) Phonon emission
(D) Cathodoluminescence

14. The band to band transition (inter-band transition) occurs in _____.
(A) Direct band gap semiconductors
(B) Indirect band gap semiconductors

(C) Metal – semiconductors
(D) Superconductors

15. The impurity to band transition occurs in --------.
(A) Direct band gap semiconductors
(B) Indirect band gap semiconductors
(C) Metal - semiconductors
(D) Superconductors

16. The _____ does not require any external energy for process to take place.
(A) Stimulated emission
(B) Spontaneous emission
(C) Stimulated absorption
(D) Stimulated radiation.

17. The process where upper energy level is more populated than lower energy level is called _____.
(A) Stimulated emission
(B) Spontaneous emission
(C) Population inversion
(D) Temperature inversion.

18. The light amplification is achieved by _____ from an atomic or molecular system.
(A) Spontaneous emission
(B) Stimulated emission
(C) Time inversion
(D) Temperature inversion

19. The sun light can be converted to electricity due to the _____.
(A) Photovoltaic effect
(B) Compton effect
(C) Raman effect
(D) Zeeman Effect.

20. The ratio of the maximum power that can be extracted from a solar cell to the ideal power is called ___.
(A) Short circuit voltage
(B) Open circuit voltage
(C) Fill factor
(D) Drift Voltage.

21. The open circuit voltage of a solar cell increases with _____.
(A) Increase in bandgap
(B) Decrease in band gap
(C) Increase of in holes
(D) Decrease in holes
.
22. The ratio between spontaneous and stimulated emission coefficients is called _____.
(A) Lorenz number
(B) Lorentz coefficient
(C) Absorption coefficient
(D) Einstein's coefficient

23. _____ is the process where the energy due to recombination is dissipated as photons
(A) Radiative transition
(B) Non-radiative transition
(C) Absorption
(D) Radiation

24. Efficiency of single crystalline Silicone is about --------
(A) 14 – 17
(B) 1-7
(C) 13 – 15
(D) 5 – 7

25. Which one of the following is related to thisexpression?

$$W_{abs} = \frac{2\pi}{\hbar}|\langle f|H_{int}|i\rangle|^2\ \delta(E_f - E_i - \hbar\omega)$$

(A) Joint density of states
(B) Fermi's Golden Rule
(C) Energy density
(D) Fermi Energy

26. Fill factor of PV cell equal to ----------
(A) (I mp) / (I SC . VOC)
(B) (I mp . Vmp) / (I SC . VOC)
(C) (Vmp) / (I SC)
(D) (I mp . Vmp) / (VOC)

27. The semiconductor material for which the lowest energy absorption takes place is :
(A)GaAs
(B)Silicon
(C)GaSb
(D)Germanium

28. Optical processes directly involve _____absorption and emission
(A) electron
(B) proton
(C**) photon**
(D) neutron

29. Commercially used solar cells are made of _____
(A) Aluminum
(B) Germanium
(C) Silicon
(D) Cadmium

30. When light shines on a solar cell the current flows in the _____direction to that of the generated voltage.
(A) Same
(B) Opposite
(C) Negative
(D) None of the above

31. The current density of a photo voltaic cell ranges from _____
(A) 10 – 20 mA/cm^2
(B). **40 – 50 mA/cm^2**
(C). 20 – 40 mA/cm^2
(D). 60 – 100 mA/cm^2

PART –B

1. Discuss how photon interactions affect the bulk semiconductors.
2. Describe about the optical recombination process.
3. Explain the optical absorption and emission process in semiconductors using band diagram.
4. Distinguish between spontaneous emission and stimulated emission.
5. Write notes on optical loss.
6. Write notes on optical gain.
7. What happens to the bands when we illuminate a light on PN junction diode under forward bias?
8. Discuss about the parameters affecting efficiency of a Photovoltaic cell.
9. Explain photovoltaic effect and their working principles?
10. Explain photovoltaic effect using band diagram?
11. Write the applictions of Photovoltaic effect?
12. Discuss the efficiency of solar cell with I-V diagram?

PART – C

1. Derive an expression for spontanious emission rate and of radiation.
2. Explain about the transition rates in optical process.
3. Explain about the joint density of states in a optical materials.
4. Explain about the density of states of photons.
5. Define Photovoltaic effect. Discuss about the application of photovoltaic effect. Write notes on the efficiency of Photovoltaic cell.
6. (i)Explain optical absorption and emission process? (ii) Discuss about recombination process and its application?
7. Determination of efficiency of a Photovoltaic cell and write the any five applications of photovoltaic cell.

Numericals

1. Determine the Open-Circuit Voltage V_{oc} of the solar cell, if Saturation Current (I_s) = $1x10^{-10}$ A, Light Generated Current(I_L) = 0.5 A, Ideality Factor (n) =1, and Temperature (T) = 300 K

Solution:

Open-Circuit Voltage $V_{OC} = \frac{nkT}{q} \ln(1 + \frac{I_L}{I_S}) = \frac{1x1.38x10^{-23}x300}{1.61x10^{-19}} \ln(1 + \frac{0.5}{1x10^{-10}})$

$= 0.57V$

2. Determine the Fill Factor FF of the solar cell, if Short-Circuit Current (I_{sc}) = 2.75 A, Open-Circuit Voltage (V_{oc}) = 0.6V, Current at Maximum Power (I_m) = 2 A and Voltage at Maximum Power (V_m) = 0.5V

Solution: Fill Factor = $FF = \frac{I_m V_m}{I_{sc} V_{oc}} = \frac{2x0.5}{2.75x0.6} = 0.606$

3. Determine the Conversion Efficiency η of the solar cell, if Short-Circuit Current (I_{sc}) = 3.5A, Open-Circuit Voltage (V_{oc}) = 0.6V, Fill Factor (FF) = 0.7 and Input Power (P_{in}) = 10W

Solution:

Efficiency $\eta = \frac{I_{sc} V_{oc} FF}{P_{in}} \times 100\%$

$= \frac{3.5x0.6x0.7}{10} \times 100\% = 14.7\%$