SOLAR ENERGY ENGINEERING
(REEN 5201)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) The statement that maximum wavelength of radiation is inversely proportional to the temperature is _____
(a) Stefan-Boltzmann law (b) Plank's distribution law
(c) Kirchhoff's law of thermal radiation (d) Wien's displacement law

(ii) The emissivity of a perfect black body _____
(a) is 1 (b) is 0
(c) depends of temperature (d) is undefined

(iii) Hour angle at solar time 10 A.M is _____
(a) -30° (b) 30°
(c) -60° (d) 60°

(iv) The sunshine hour of a place on earth with latitude -75° on a day with declination angle -20° is _____
(a) 0 (b) 12
(c) 18 (d) 24

(v) At north pole on 21st June the sunset hour angle is _____
(a) 0° (b) 180°
(c) 90° (d) 45°

(vi) When a pentavalent impurity is added to a pure semiconductor, it becomes _____
(a) an insulator (b) an intrinsic semiconductor
(c) p-type semiconductor (d) n-type semiconductor

(vii) The region where the electrons and holes diffused across the junction is called _____
(a) Depletion Junction (b) Depletion region
(c) Depletion space (d) Depletion boundary

(viii) Solar cells are made from bulk materials that are cut into wafer of _____ thickness.

(a) 120-180μm (b) 120-220μm
(c) 180-220μm (d) 180-240μm

(ix) _____ is one of the most important materials is also known as solar grade silicon.

(a) Crushed silicon (b) Crystalline silicon
(c) Powdered silicon (d) Silicon

(x) _____ photo voltaic devices in the form of thin films.

(a) Cadmium Telluride (b) Cadmium oxide
(c) Cadmium sulphide (d) Cadmium sulphate

Group – B

2. (a) What is Wien's displacement law? Starting from the Plank's Distribution law of black body radiation establish the relation of Wien's Displacement Law.

(b) It has been observed that when the sun is overhead the earth's surface on a clear day, the radiation received by the earth's surface is 1 kW/m^2 and an additional 0.3 kW/m^2 is absorbed by the earth's atmosphere. Assuming the sun to be a black body, determine the temperature of the sun. Data Give: dia of sun = 1.39×10^9 m, dia of earth = 12.6×10^7 m, distance between sun and earth = 1.5×10^{11} m.

8 + 4 = 12

3. (a) Why standard time is different from solar time of a place on earth. Determine the Indian standard time based on latitude 82.5°E of solar noon of New Delhi, India (28.6139° N, 77.2090° E) on 22nd December.

(b) What is monthly average daily extraterrestrial radiation on a horizontal surface? Determine the ratio of monthly average daily extraterrestrial radiation on a horizontal surface at New Delhi, India for the month of June to December. Given: Solar constant is 1350 W/m^2. Monthly mean day for June and December are 11th and 10th respectively.

6 + 6 = 12

Group – C

4. (a) Derive a steady state temperature distribution between tubes of a flat plate solar collector and determine an expression of collector efficiency factor.

(b) Estimate the tilt factor of a south facing collector with an angle of inclination 45° at Kolkata, India (22.5726° N, 88.3639° E) on 2:00 pm solar time 21st June.

7 + 5 = 12

5. (a) What is concentration ratio of solar collector? Determine the maximum possible concentration ratio of a concentrating solar collector.

(b) Calculate the heat removal factor, the useful heat gain for a cylindrical parabolic concentrator having 2.5 m width and 9 m length, the outside diameter of the absorber tube being 6.5 cm. The temperature of the fluid to be heated at the inlet is 16°C with a flow rate of 450 kg/h. The incident beam radiation is 700 W/m^2. The ambient temperature is 28°C. The optical properties are as given below:
P = 0.85, $(\tau\alpha)_b$ = 0.78, τ = 0.93, c_p = 1.256 kJ/kg°C, collector efficiency factor = 0.85, Heat loss coefficient = 7.0 W/m^2°C

(2 + 4) + 6 = 12

Group – D

6. (a) Define energy band gap of a material.

(b) Draw the circuit arrangement for evaluating *V-I* characteristics of p-n junction diode (a) in forward bias, (b) in reverse bias, (c) typical *V-I* characteristics of a silicon diode. Calculate the resistance of the silicon diode at I_D= 15 mA and (b) V_D = -10V.

(c) A silicon wafer is doped with 10^{16} arsenic atoms/cm^3. Find the carrier concentrations and the Fermi level at room temperature (300K).

2 + (4 + 2) + 4 = 12

7. (a) Using the mobility and diffusivity chart (Fig. 1) for Si at 300K as a function of impurity concentration, find the room temperature resistivity of an n-type silicon wafer doped with 10^{16} atoms/cm^3 of phosphorus.

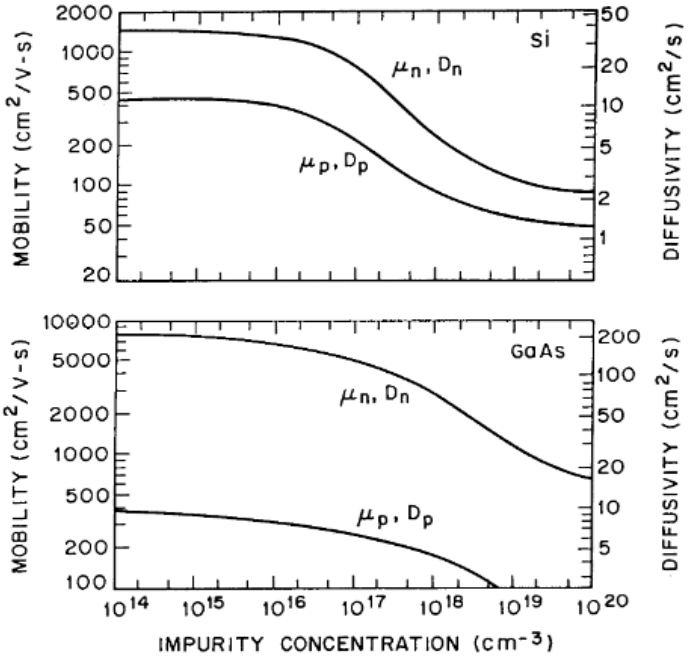

Fig. 1

(b) Describe the generation and recombination processes. C, Si and Ge have same lattice structure. Why is C insulator while Si and Ge intrinsic semiconductors?

6 + (4 + 2) = 12

Group – E

8. (a) State two field failure modes for crystalline silicon based modules? What tests have been done if a module passes the IEC 61215?

   (b) What failure modes does the bypass diode thermal test check?

(2 + 6) + 4 = 12

9. (a) Describe the steps involved in the fabrication of PV modules using solar cells as starting material.

   (b) State three main categories of solar cell degradation. Explain one type of failures observed under each category and its corresponding testing procedure.

6 + 6 = 12

Department & Section	Submission Link
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