Roll No: --------------------------

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2017

Program:	**M.Tech. Energy Systems**	**Semester**	**: III**
Subject (Course):	**Renewable Energy Technologies - 2**	**Max. Marks**	**: 100**
Course Code:	**MNEG 742**	**Duration**	**: 3 Hrs**
No. of page/s:	**5**		

Section A

All questions are mandatory: (Each question: 5 marks)

1) Explain the following terms:
    a) Extrinsic Semiconductors
    b) N-type semiconductor
    c) Diffusion of carriers
    d) Indirect band gap semiconductors
    e) Electronic grade silicon

2) State the typical structure of a Cadmium telluride / Cadmium sulphide solar cell on a glass substrate, with a metal back contact and a transparent front contact. Indicate the direction from which solar radiation strikes the solar cell. (Cadmium Telluride has a band gap of 1.4 eV, and Cadmium Sulphide has a band gap of 2.4 eV)

3) a) Explain the difference between Combustion, Pyrolysis and Gasification.
    b) Explain the difference between Biogas and Producer gas.

4) Explain why a Down-draft Gasifier is better than an Up-draft Gasifier for power generation.

Section B

All questions are mandatory: (Each question: 10 marks)

5) Define the following terms:
    a) Short circuit current
    b) Open circuit voltage
    c) Fill Factor
    d) Maximum Power Point
    e) Indicate the above 4 terms on the “I-V curve” for a typical silicon solar.

6) At a height of 30 metres above ground level (a.g.l.) the reference wind speed is 5.5 m/s. Using the Logarithmic Law, estimate the wind speeds at a height of 50 metres a.g.l. for the following terrain conditions:
    a) Rough pasture (Surface Roughness Length = 10 mm)
    b) Suburbs (Surface Roughness Length = 1500 mm)
    c) Few trees (Surface Roughness Length = 100 mm)
    d) Forest and Woodlands (Surface Roughness Length = 500 mm)

7) Compare the Environmental Impacts of Biochemical conversion with Thermochemical conversion of lignocellulosic materials to Ethanol.

8) Explain the main steps in the production of the Methanol from natural gas.

Section C

Answer both questions: (Each question: 20 marks)

<u>EITHER</u>

9) Calculate the overall loss coefficient for a flat-plate collector with two glass covers.

    Given the following data:

Size of the absorber plate (L1 X L2)	1.90 m X 0.90 m
Spacing between plate and first glass cover (L)	4 cm
Spacing between .first and second glass cover (L)	4 cm

Plate emissivity (ε_p)	0.92
Glass cover emissivity (ε_c)	0.88
Collector tilt (β)	20°
Mean plate temperature (T_{pm})	70°C
Ambient air temperature (T_a)	24°C
Wind speed (V_∞)	2.5 m/s
Back insulation thickness (δ)	8 cm
Side insulation thickness (δ)	4 cm
Thermal conductivity of insulation (k_i)	0.05 W/m-K

$$h_w = 8.55 + 2.56\, V_\infty$$

where h_w is in W/m^2 and V_∞ is in m/s.

Malhotra *et al.* have given the following correlation.

$$U_t = \left[\frac{M}{\left(\frac{C}{T_{pm}}\right)\left(\frac{T_{pm} - T_a}{M + f}\right)^{0.252}} + \frac{1}{h_w} \right]^{-1} + \left[\frac{\sigma (T_{pm}^2 + T_a^2)(T_{pm} + T_a)}{\frac{1}{\varepsilon_p + 0.0425\, M(1 - \varepsilon_p)} + \frac{2M + f - 1}{\varepsilon_c} - M} \right]$$

where $f = \left(\frac{9}{h_w} - \frac{30}{h_w^2}\right)\left(\frac{T_a}{316.9}\right)(1 + 0.091M)$

$C = 204.429\ (\cos\ \beta)^{0.252}/L^{0.24}$, and

$L =$ spacing (m).

OR

9) a) Analyze and discuss the effect of a Selective Surface on the performance of a solar collector by examining the Table given below:

Table 4.2 *Effect of a selective surface on performance of collector*

	Selective surface $\alpha = 0.94, \varepsilon_p = 0.14$ (Sec. 4. 8)	Non-selective surface $\alpha = \varepsilon_p = 0.94$	Selective surface $\alpha = 0.95, \varepsilon_p = 0.085$
T_{pm}(K)	351.2	346.2	351.9
U_t(W/m^2-K)	4.12	7.26	3.83
q_u(W)	888.3	642.0	924.1
T_{fo}(K)	344.1	341.1	344.6
η_i(%)	43.6	31.5	45.4

b) Analyze and discuss the effect of Number of Covers and Selective Surface on the performance of a solar collector by examining the two Tables given below:

Table 4.3 *Effect of number of covers on performance of collector (selective surface, $\alpha = 0.94$, $\varepsilon_p = 0.14$)*

	Number of covers		
	1	2	3
$(\tau\alpha)_b$	0.8041	0.6892	0.5932
$(\tau\alpha)_d$	0.7284	0.6008	0.5114
U_t(W/m^2-K)	4.12	2.68	1.99
η_i (%)	43.6	41.0	36.6

Table 4.4 *Effect of number of covers on performance of collector (non-selective surface, $\alpha = \varepsilon_p = 0.94$)*

	Number of covers		
	1	2	3
$(\tau\alpha)_b$	0.8041	0.6892	0.5932
$(\tau\alpha)_d$	0.7284	0.6008	0.5114
U_t(W/m^2-K)	7.26	4.04	2.75
η_i (%)	31.5	35.3	33.4

10) Time series Hourly Wind Data for one year was separated into bins having a wind speed interval of 2 m/s as shown in Table below (left side). The Table on the right side shows the Wind Turbine Power Curve for a Bergey EXCEL-R wind turbine rated at 7.5 kW

Using the Method of Bins, Calculate:

a) Average Wind Power Density (Air Density = 1.225 kg/m^3).
a) Annual Power Generation of this wind turbine.
b) Capacity Factor of this wind turbine (Rated Power = 7.5 kW).

Wind Speed Frequency Distribution	
Bin Width	Number of Occurences
m/s	Hours
0 - 2	440
2 - 4	935
4 - 6	1313
6 - 8	1468
8 - 10	1515
10 - 12	1192
12 - 14	860
14 - 16	514
16 - 18	311
18 - 20	149
20 - 22	63
TOTAL =	**8760**

POWER CURVE for Wind Turbine	
Wind Speed	Power Output
m/s	kW
0	0.0
1	0.0
2	0.0
3	0.0
4	0.2
5	0.6
6	1.0
7	1.7
8	2.6
9	3.7
10	4.8
11	6.2
12	7.3
13	8.7
14	10.1
15	11.3
16	12.0
17	11.9
18	11.6
19	11.0
20	10.5
21	9.8
22	9.1

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Section A

All questions are mandatory: (Each question: 5 marks)

1) Explain the following terms:
   a) Direct band gap semiconductors
   b) P-type semiconductor
   c) Drift of carriers
   d) Intrinsic Semiconductors
   e) Metallurgical grade silicon

2) Describe the equipment used and the process for the Czochralski method of manufacturing single crystal silicon. (draw a schematic).

3) Identify two types of Biogas plants that are commonly used in India and explain the main differences between them.

4) Explain the difference between a Down-draft Gasifier and an Up-draft Gasifier. (Draw a schematic for both).

Section B

All questions are mandatory: (Each question: 10 marks)

5) a) What is the difference between a "Stand-Alone Solar PV system" and a "Grid-connected Solar PV system" ?
   b) What are the main components of a "Stand-Alone Solar PV system" ?
   c) Explain briefly the function of each of the components of a "Stand-Alone Solar PV system".

6) A wind monitoring station has a 30 meter wind mast that measures 10-minute average wind speeds at two levels: 20 m and 30 m above ground level (a.g.l.). For one particular 10 minute interval the wind speed at 20 m a.g.l. is 5.0 m/s and the wind speed at 30 m a.g.l. is 5.5 m/s.

   a) Calculate the Power Law Index for this site.
   b) Using the power law estimate the wind speed at 50 m, 80 m and 100 m a.g.l. ?

7) a) Explain the production of Briquettes from fine biomass residues such as sawdust. (Draw a schematic).
   b) Discuss the advantages of Briquetting.

8) Explain the main steps in the production of the biofuel Ethanol from Molasses.

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Section C

Answer both questions: (Each question: 20 marks)

<u>EITHER</u>

9) Analyze and compare the production and utilization of the two main Biofuels used in India in the transport sector, namely Ethanol and Biodiesel, based on the following:
   i) Feedstocks from which they are produced.
   ii) Production process.
   iii) Diesel vehicles and Petrol vehicles.
   iv) Spark ignition engines and Compression ignition engines.

OR

9) Using the Isotropic Diffuse model and the Erbs *et al* correlation given below, estimate the beam, diffuse and ground-reflected components of solar radiation, and the total radiation on a vertical surface facing south at Mumbai (19°07'N, 72°51'E) for the hour 11:00 to 12:00 on March 16. Take ρ_g = 0.2 and I = 0.888 kWh/m^2.

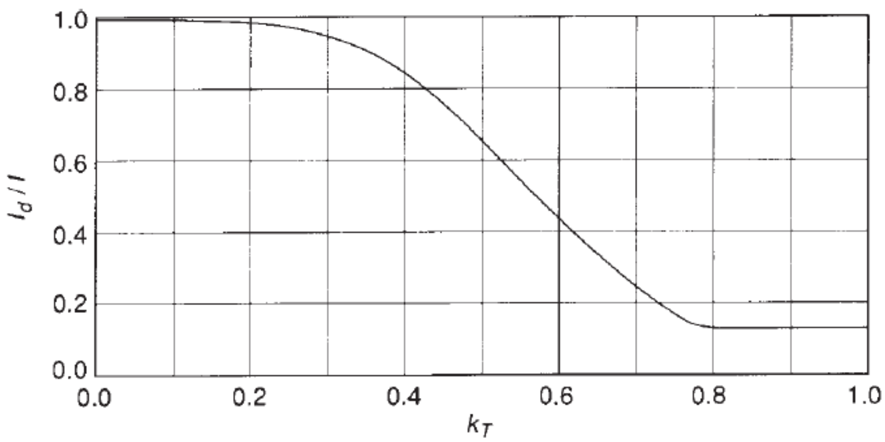

Figure 2.10.3 The ratio I_d/I as a function of hourly clearness index k_T. From Erbs et al. (1982).

correlations are shown in Figure 2.10.2. They are essentially identical, although they were derived from three separate databases. The Erbs et al. correlation (Figure 2.10.3) is[11]

$$\frac{I_d}{I} = \begin{cases} 1.0 - 0.09k_T & \text{for } k_T \leq 0.22 \\ 0.9511 - 0.1604k_T + 4.388k_T^2 & \\ \quad -16.638k_T^3 + 12.336k_T^4 & \text{for } 0.22 < k_T \leq 0.80 \\ 0.165 & \text{for } k_T > 0.8 \end{cases} \qquad (2.10.1)$$

10) Time series Hourly Wind Data for one year was separated into bins having a wind speed interval of 2 m/s as shown in Table below (left side). The Table on the right side shows the Wind Turbine Power Curve for a Bergey EXCEL-R wind turbine.
(Rated Power = 7.5 kW)

Calculate the following parameters:

a) Average wind speed.
b) Standard deviation.
c) Average Wind Power Density (Air Density = 1.225 kg/m^3).

Wind Speed Frequency Distribution	
Bin Width	Number of Occurences
m/s	Hours
0 - 2	440
2 - 4	935
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7	1.7
8	2.6
9	3.7
10	4.8
11	6.2
12	7.3
13	8.7
14	10.1
15	11.3
16	12.0
17	11.9
18	11.6
19	11.0
20	10.5
21	9.8
22	9.1