BITS Pilani
Dubai Campus

IVth Year II Semester 2012-2013

Compre Exam (Closed Book)

Course No. BITS C462 **Course Title:** RENEWABLE ENERGY

Date: 02-06-2013 **Duration:** 3 Hrs

Max.Marks: 40 **Weightage:** 40%

Note:
- Answer all the questions
- Draw neat sketches wherever necessary
- Make suitable assumptions if required and clearly state them

1. Calculate the monthly average solar flux received on a flat-plate collector vertical surface facing due south. The collector is located at a place 15 ^{0} 00' N on 20th day of October, 2012. Assume $\theta = \Phi$

   The data given are:

   Time 11:12 hr

   H_g = 2408 kJ/m^2/h

   H_d = 1073 kJ/m^2/h

   Ground reflectivity, $\rho = 0.25$, $\omega = 7.5^0$ (6 Marks)

2. (a) Discuss in detail about the parameters governing the performance of cylindrical parabolic collector. (3 Marks)

   (b) Explain thermo-chemical storage system (2 Marks)

3. Find the rotor diameter for a multi blade wind turbine that operates in a wind speed of 10 kmph to pump water at a rate of 6 m^3/hour with a lift of 6 m, at the atmospheric pressure and temperature of 20 ^{0}C. Also calculate the angular velocity of the rotor in rpm. Data given are: Water density = 1000 kg/m^3 , efficiency of turbine = 60 %, efficiency of pump = 85 %, coefficient of performance, C_p = 0.35 and tip speed ratio = 1.0 (5marks)

4. (a) Explain the low, medium and high temperature type of solar power plants. (3 marks)

(b) Write a short note on Amorphous Silicon Solar Cells (2 marks)

5. (a) Discuss the varies types of geothermal power plants and compare their performance (3marks)

(b) Define the specific speed for turbine and also give the range of specific speeds for Pelton and Kaplan turbines (2marks)

6. The basin area of the tidal project is 0.72 sq.km, with a difference of 6 m between the high and low water levels. The average available head is 5 m and the system generates electric power for four hours in each cycle. If the power at any point of time is 12070 kW, find the overall efficiency of the plant; assume density of sea water as 1025 kg/m^3. Calculate also the average tidal cycles in a year if the yearly power generation is 337.96 x 10^5 kW. (5marks)

7. The following data are given for a family bio gas digester suitable for output of five cows: the retention time is 20 days, temperature 30^{0}C, dry matter consumed = 2 kg/day. Burner efficiency is 60 %, methane proportion is 0.8. Assume the density of mixture as 50 kg/m^3. (i) If volume of bio gas is 2.4 m^3 per day, find biogas yield and (ii) if the power available from the digester is 400 W, calculate the heat of combustion of methane in MJ/m^3 (4 Marks)

8. (a) Explain the production process of ethanol from biomass. (2.5 Marks)

(b) What are the different types of fuel cells and discuss their applications? (2.5 Marks)

B.Tech (UG) RENEWABLE ENERGY

Compre Exam Solution I Sem 2012-13

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1) $\delta = 23.45 \sin\left[\frac{360}{365}(284+293)\right] = -11.40$

$$R_b = \frac{\sin\delta \sin(\theta-\beta) + \cos\beta \cos\omega \cos(\phi-\beta)}{\sin\phi \sin\delta + \cos\phi \cos\delta \cos\omega}$$

$$= \frac{\sin(-11.4)\sin(15-90) + \cos 90 \cos 7.5 \cos(15-90)}{\sin 15 \sin(-11.4) + \cos 15 \cos(-11.4) \cos 7.5}$$

$$= \frac{-0.197 \times -.966 + 0}{.259 \times -.97 + .966 \times .98 \times .99} = 0.277$$

$$R_d = \frac{1+\cos\beta}{2} = \frac{1+0}{2} = 0.5$$

$$R_r = 0.25\left(\frac{1-\cos\beta}{2}\right) = 0.25 \times 0.5 = 0.125$$

$$\frac{H_T}{H_g} = \left(1 - \frac{H_d}{H_g}\right) R_b + \frac{H_d}{H_g} R_d + R_r$$

$$= \left(1 - \frac{1073}{2408}\right) \times .277 + \frac{1073}{2408} \times 0.5 + .125$$

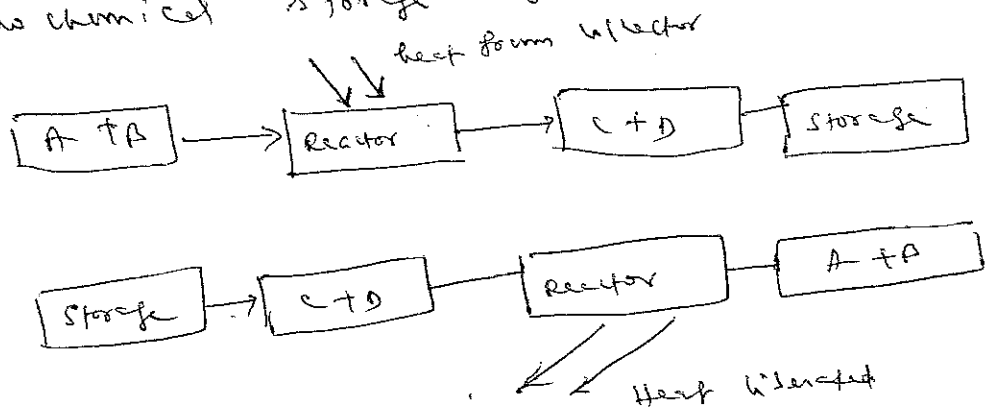
$$= 0.5013$$

$$H_T = \underline{\underline{1207}} \text{ kJ/m}^2/\text{h}$$

2) a) Parabolic collector performance is based on: Inner dia of absorber tube, outer diameter, concentration ratio, beam radiation, the reflectivity of concentrator surface, overall

heatloss coefficient, local temp of absorber tube, ambient temp, transmissivity - absorptivity product

b) Thermochemical storage system



3) a) low temp solar power plant: (T upto 90°C)
organic fluid is working fluid to run the turbine in low temp solar power plant

medium temp solar power plant: (T upto 400°C)
Parabolic collector - synthetic oil - heat exchanger converting water to steam to run the turbine

High temp solar power plant:
central power station is utilized in this power plant.

b) Amorphous silicon solar cells:
It has high photo - conductivity and high optical absorption. It is comparatively low cost. It can be fabricated in form structures i) metal insulator semiconductor ii) p-i-n devices iii) heterojunction iv) schottky barriers.

4) Power required to pump water $= \rho Q g H$

$$= \frac{1000 \times 6}{3600} \times 9.81 \times 6$$

$$= 98.1 \text{ W}$$

Power required at rotor $= \frac{98.1}{0.05 \times 0.85} = 192.4 \text{ W}$

$$C_p = \frac{P_{rotor}}{P_{wind}}$$

$$\rho = \frac{P}{RT}$$

$$= \frac{1.0132 \times 10^5}{287 \times 293}$$

$$= 1.205 \text{ kg/m}^3$$

$$0.35 \left[\frac{1}{2} \rho A V^3 \right] = 192.4$$

$$0.35 \left(\frac{1}{2} \times 1.205 \times \frac{\pi}{4} D^2 \times 9.77^3 \right) = 192.4$$

$$3.52 \, D^2 = 192.4$$

$$D = 7.4 \text{ m}$$

$$V = \frac{10 \times 1000}{3600}$$

$$= 9.77 \text{ m/s}$$

$$\lambda = \frac{\omega R}{V_i} \Rightarrow$$

$$\omega = \frac{1 \times 2.77}{3.7} = 0.748 \text{ rad/s}$$

$$= \frac{1 \text{ rev}}{2\pi} \times 0.748 \times 60 = 7.15 \text{ rpm}$$

5) a) Various ways of geothermal power generation:

Liquid - dominated
- Flashed steam power plant
- Binary cycle power plant

Vapour - dominated power plant

Total - flow system power plant.

b) speed at which the turbine will run under unit head so as to produce unit power.

$$N_s = \frac{N\sqrt{P}}{H^{5/4}}$$

Pelton wheel : 10 – 50

Kaplan : 300 – 1000

6, volume of basin area $= 0.7 \times 10^6 \times 6$

$= 4,320,000\ m^2$

Discharge $= 4,320,000 / 4 \times 3600$

$= 300\ m^3/s$

Power at any point of time $= \dfrac{1025 \times 300 \times 5 \times \eta_o \times 0.73}{75}$

$\left(\dfrac{\rho Q H}{75}\right) \times \eta \times 0.736$

$= 12070\ kW$

$\Rightarrow \eta_o = 80\%$

Energy generated per tidal cycle $= 12070 \times 4 = 48280\ kWh$

Average tidal cycles $= \dfrac{337.96 \times 10^5}{48280}$

$= \underline{\underline{700}}$

7, mass of dry input, $m_o = 2 \times 5 = 10\ kg/day$

fluid volume $V_f = \dfrac{m_o}{\rho_m} = \dfrac{10\ kg/day}{50\ kg/m^3}$

$= 0.2\ m^3/day$

V_d : digester volume $= V_f \times t_r$

$= 0.2 \times 20 = 4\ m^3$

Biogas yield, $\Rightarrow C \times m_o = V_b$, $C = \dfrac{2.4}{10} = \underline{\underline{.24}}\ m^3/kg$

Power available from the digester:

$$E = \eta H_m f_m V_b$$

$$400 = 0.6 \times H_m \times 0.8 \times 2.4$$

$$H_m = 347.22 \frac{W}{m^3} \cdot day$$

$$= 347.22 \times 24 \times 3600 \ J/m^3$$

Heat of combustion $= \underline{\underline{30 \ MJ/m^3}}$.

8, a. Ethanol fermentation involves biological conversion of sugars into ethanol and CO_2

Fuel cell	Applications
b. Alkaline fuel cell	: Space and military
PEMFC	: Residential, cellular phones, video camera, car etc.
Phosphoric acid fuel cell	: Railways.
Molten Carbonate fuel cell	: Utility power
Solid oxide fuel cell	: Domestic, commercial utility power, railways.

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IV Year II Semester 2012-2013

Test 2 (Open Book)

Course No. BITS C462 **Course Title:** RENEWABLE ENERGY

Date: 22-04-2013 **Max.Marks:** 20

Weightage: 20% **Duration:** 50 min.

Note:

- Answer all the questions
- Draw neat sketches wherever necessary
- Make suitable assumptions if required and clearly state them

1. (a) (i) A wind turbine maintains a tip-speed ratio of 8 at all wind speeds. At which wind speed will the blade tip speed exceed the speed of sound (330 m/s)? (ii) A large wind turbine has a blade diameter of 100 m . At what rotor speed will the tip-speed exceed the speed of sound? (4 Marks)

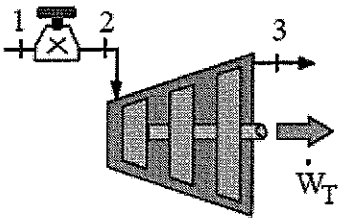
   (b)Discuss the favorable sites for installing wind mills. (3 Marks)

2. Discuss and differentiate between reaction and impulse turbine. (4 Marks)

3. (a) Compare the performance of Single stage flash system, Binary –cycle system and Total-flow system of geothermal power plants (3 Marks)

(b) In a vapor dominated hydrothermal power plant, one technique for operating a steam turbine in part- load power output is to throttle the steam to a lower pressure before it enters the turbine as shown in Fig. The steam conditions are 2 MPa, 400 ^{0}C and the turbine exhaust pressure is 10 kPa. Assuming the expansion inside the

turbine is to be isentropic process, calculate (i) the full – load actual work out put of the turbine per unit steam mass flow rate and (ii) the pressure and temperature of the steam must be throttled to for 80 % of full- load output (6 Marks)



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IV Year II Semester 2012-2013

Test 2 (Open Book)

Course No. BITS C462 **Course Title:** RENEWABLE ENERGY

Date: 22-04-2013 **Max.Marks:** 20

Weightage: 20% **Duration:** 50 min.

SOLUTION

1, (a) i, Tip speed ratio, $\lambda = \frac{\omega R}{v_i} = 8$

$V_{tip} = \lambda V_i$

If $V_{tip} = 330 \Rightarrow V_i = \frac{330}{8} = 41$ m/s

ii, $\lambda = \frac{\omega R}{v_i}$, $V_{tip} = \omega R = \lambda v_i$

$\omega = \frac{\lambda v_i}{R} = \frac{330}{50}$

$= 6.6$ Rad/Sec.

$\pi D N = 6.6$

$N = \frac{6.6}{\pi D} = \frac{6.6}{\pi \times 100} = .021$ rev/sec

b, favorable sites:
1. Wind farms away from cities and forests
2. Flat open area
3. Adequate and uniform average velocity
4. Altitude of proposed site
5. Ground surface should be stable
6. Approach roads to site for movement of cranes & equipment & transport
7. Cost of land is favorable.

2, Reaction Turbine: It works on medium and low head turbines.

Ex: Francis Turbine.

Major components:

1. Penstock pipe
2. Scroll casing
3. Guide vanes
4. Turbine wheel
5. Draft tube.

Impulse Turbine: This works under high head of water. The pressure of water before entering turbine causes energy converted into the and impinging wheel.

Major components

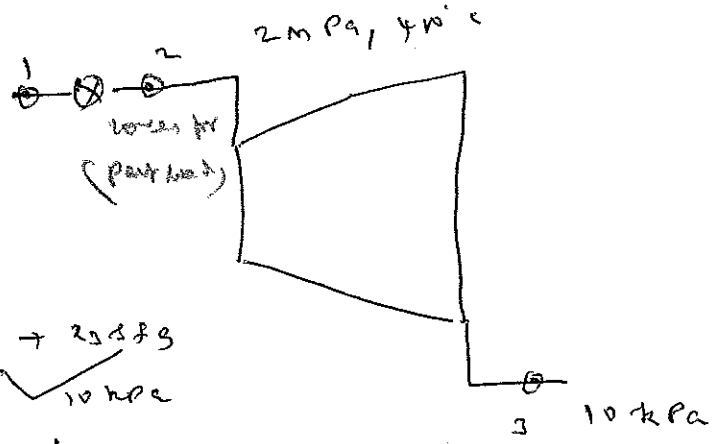
1. Penstock pipe
2. Nozzle
3. Turbine wheel
4. Draft tube.

3. a) Total flow system: Performance is much higher than other two system, since the mass flow rate is more.

Binary system: It is low temp system. It's performance is very less compared to other two system.

Single flash system: The performance of this system is in between of these two system.

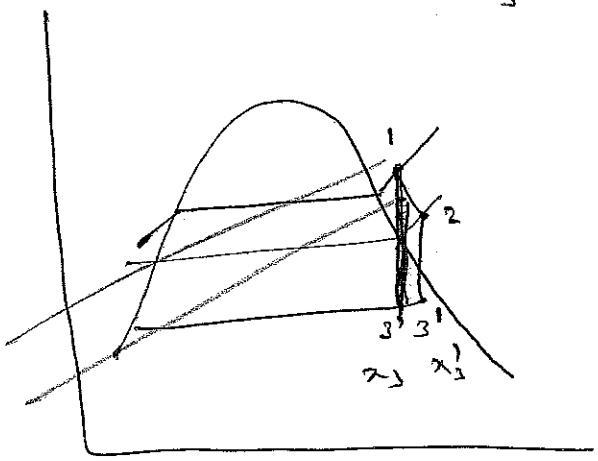
5, b) At part load condition, the steam at ① to lower pressure at ②.



At full load condition, ① and ② are same.

$s_2\big|_{2MPa,400°C} = s_3 = 7.127 = s_f + x_3 s_{fg}$ (10 kPa)

$\Rightarrow x_3 = 0.864$



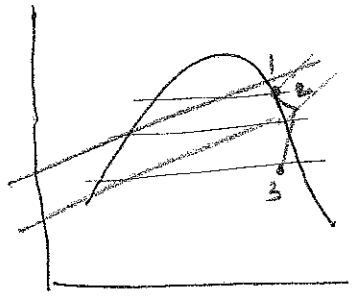
$h_3 = h_f + x_3 h_{fg}$ (10 kPa)

$= 2258$

$\frac{W_T}{\dot{m}} = h_2\big|_{2MPa,400°C} - h_3 =$

$3247.6 - 2258$ (Assume $\eta_T = 1$)

$= 989$ kJ/kg ✓



Part load $W_T' = 0.8 \times 989 = 791.4$ kJ/kg

$= h_1 - h_3' = 3247.6 - h_3'$

(At ②, pressure is lowered, h_3' is different but exhaust pr is same)

$\Rightarrow h_3' = 2456 = h_f + x_3' h_{fg}$ (10 kPa) $= x_3' = 0.946$

$s_3' = s_f + x_3' s_{fg}$ (10 kPa) $= 7.747$

Look for p_2, T_2 for $s_2 = (s_3' = 7.747,\ h_1 = h_2 = 3247)$

$p_2 = 510$ kPa

$T_2 = 388$ K

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IV Year II Semester 2012-2013

Test 1 (Closed Book)

Course No. BITS C462 **Course Title:** RENEWABLE ENERGY

Date: 04-03-2013 **Max.Marks:** 25

Weightage: 25% **Duration:** 50 min.

Note:

- Answer all the questions
- Draw neat sketches wherever necessary
- Make suitable assumptions if required and clearly state them

1 . Data for a Flat plate collector used for heating are given below: **[7 Marks]**

FACTOR	SPECIFICATION
Location & Latitude	COIMBATORE $22^0\ 30^1$ N
Day & time	Jan 1 , 11.30- 12.30(IST)
Average Intensity of solar radiation	350 W/m^2
Collector tilt	Latitude + 15^0
No. of glass cover	2 (assume ρ = 0.24)
Heat removal factor for collector	0.810
Transmittance of glass	0.88
Absorptance of the glass	0.90
Top loss coefficient(U_L) for collector	7.88 W/m^2 ^{0}C
Collector Efficiency	6.7 %
Ambient temperature	15^0C

Calculate

(i) Solar altitude angle

(ii) Incident angle and

(iii) Collector fluid temperature

2.Define the following terms: **[6 Marks]**

a. Hour Angle

b. Solar Constant

c. Concentration Ratio

3. Describe in detail about the major atmospheric pollution released from coal based power plants. **[5 Marks]**

4. Evaluate the monthly average clearness index for 20th April, 2002, at a surface located at latitude 35° N. the monthly average daily terrestrial radiation on a horizontal surface is 925kJ/m^2/hr **[7 Marks]**

Renewable Energy II Sem 2012-13

Test-1 SOLUTION

1) $\sin\alpha = \cos 22.5 \cos(-23) \cos\theta + \sin 22.5 \sin(-23)$

$= .923 \times .921 \times 1 + .383(-.391)$

$= .700 \quad \Rightarrow \alpha = 44.42^\circ$

$\theta = 90 - 44.42 = 45.58^\circ$

$$R_b = \frac{\cos(22.5 - 23)\cos(-23)\cos\theta + \sin(22.5-23)\sin(-23)}{\cos(22.5)\cos(-23)\cos\theta + \sin 22.5 \sin(-23)}$$

$$= \frac{.996 \times .921 \times 1 + .25 \times -.391}{.924 \times .921 + .383 \times -.391}$$

$= 1.412$

$$\langle\tau\alpha\rangle = \frac{\tau\alpha\rho}{1-(1-\alpha)\rho} = \frac{.88 \times .9}{1-(1-.9).24} = 0.811$$

$S = H_b R_b \langle(\tau\alpha)\rangle = 350 \times 1.412 \times .811$

$= 400.8 \ W/m^2$

$Q_u = F_R[S - U_L(T_{fi} - T_a)]$

$= \eta H_b R_b = .617 \times 350 \times 1.412$

$= 32.1 \ W/m^2$

$400.8 - 7.88(T_{fi} - 15) = 40.82$

$T_{fi} = 60.67^\circ C.$

2) a) <u>hour angle</u> : w is the angle through which the earth must rotate to bring the meridian of the point directly under the sun. It is the angular measure of time at the rate of 15° per hour.

$$w = 15(12 - IST)$$

b) Solar Constant : $I_s = 1367\ W/m^2$.
rate at which solar radiation energy arrives.

c) concentration ratio c : $\frac{\text{effective aperture area}}{\text{absorber area}}$.

3) Major pollutants : SO_2, NO_x, CO, CO_2, ozone.

i) oxides of sulphur (SO_2)
ii) oxides of nitrogen (NO_x)
iii) oxide of carbon (CO, CO_2)
iv) ~~hydrocarbon~~
v) ~~particulates~~

4) $$\delta = 23.45 \sin\left[\frac{360}{365}(284 + 111)\right] = \underline{\underline{11.58°}}$$

$$w = \cos^{-1}\left[-\tan 25 \tan 11.58\right] = \underline{\underline{81.98°}}$$

$$H_0 = \frac{24}{\pi} I_{sc}\left[1 + .033 \cos\frac{360 \times 9}{365}\right)(w \sin\phi \sin\delta + \cos\phi \cos\delta \sin w)$$

$$= \frac{24}{\pi} 1367(.660)\left(\frac{\pi}{180} \times 81.98 \times .579 \times .2 + .819 \times .98 \times .991\right)$$

$$= 23.94\ MJ/m^2/hr$$

$$K_T = \frac{22.2}{23.94} = \underline{\underline{0.927}}$$

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Second Semester 2012 - 2013

Course: BITS C462 Renewable Energy

B

QUIZ- 2[Closed book]

Max.Marks :7
Weightage: 7 %

Date:20.05.2013
Time: 20 min

Note: (i) Answer all the Questions.
(ii) Assume suitable value if required

1. Find the digester volume, if the fluid volume is 0.2 m^3/day and retention time of biomass in the digester is 20 days.

2. What are the main steps involving in the biogas production process?

3. What is the function of flash separator and purpose of water from deep sea in open cycle?

4. Find the solar radiation intensity at surface of sea, if the solar radiation intensity at 10 m depth of sea is 67.36 W/m^2 and at 20 m depth of sea is 3.35 W/m^2 respectively.

5. How is bio-oil produced?

6. Name three working fluids in closed cycle of OTEC plant.

7. What is bio-fouling in OTEC plant?

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Second Semester 2012 - 2013

Course: BITS C462 Renewable Energy **B**

QUIZ- 2[Closed book]

Max.Marks :7 Date:20.05.2013

Weightage: 7 % Time: 20 min

Note: (i) Answer all the Questions.
(ii) Assume suitable value if required

1. Find the digester volume, if the fluid volume is 0.2 m^3/day and retention time of biomass in the digester is 20 days.

4 m^3

2. What are the main steps involving in the biogas production process?

Hydrolysis
Acid formation
methane formation

3. What is the function of flash separator and purpose of water from deep sea in open cycle?

Flash separator: separating steam from the mixture of steam and water.

deep sea water: to condense vapor with water in condenser.

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4. Find the solar radiation intensity at surface of sea, if the solar radiation intensity at 10 m depth of sea is 67.36 W/m^2 and at 20 m depth of sea is 3.35 W/m^2 respectively.

1345 W/m^2

5. How is bio-oil produced?

Biomass is heated in the absence of O2 to form oil like liquid ⇒ bio oil.

6. Name three working fluids in closed cycle of OTEC plant.

NH3, propane, freon.

7. What is bio-fouling in OTEC plant?

Organic fungus formation in Heat exchanger pipes, which will reduce the efficiency of heat exchanger.

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Second Semester 2012 - 2013

Course: BITS C462 Renewable Energy **A**

QUIZ- 1[Closed book]

Max.Marks :8 **Date:25.03.2013**
Weightage: 8 % **Time: 20 min**

Note: (i) Answer all the Questions.
(ii) Assume suitable value if required

1. Name the three organic fluids used in low temperature solar thermal energy applications.

2. What is the working principle of solar pond thermal power plant?

3. In solar distillation, solar radiation beam falls 30 ^{o} to the transparent cover of 1m^2. The latent heat of evaporation of water is 36 W/kg. Solar intensity is 1.2 kW/m^2 . If the water collected is 10 liter find efficiency of the system.

4. What is heliostat and where is it used?

5. What is the best fixed orientation for power production from a photovoltaic module located at the South Pole?

6. Calculate the flow of junction current in a p-n junction in the dark, if the saturation current is 10^{-8} Am^{-2}

7. Find the area of single –crystalline PV cell for the following data: solar radiation flux = 1.2 kW/m^2, efficiency = 12 %, fill factor 0.7 and the product of open circuit voltage x short circuit current = 50W.

8. Why is hydrogenated amorphous silicon (a-Si:H) suitable material for thin film solar cells?

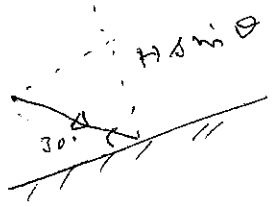
SOLUTION: Unit-1

BITS C462: RENEWABLE ENERGY 25.3.13

1) Freon, Ammonia, butane

2) High concentrated, high temp saline water is utilized to heat & vaporize the organic fluid to run the turbine.

3) Solar radiation falling on plate $H' = H\sin\theta$



$\sin\theta = \frac{H'}{H}$

$$\eta = \frac{w\,\Delta h}{H'}$$

$$= \frac{10 \times 36\ w/kg \cdot kg}{1200 \times 0.5\ W/m^2 \cdot m^2}$$

$$= 60\%$$

4. Highly polished thin plate – heliostat used in central power system.

5. Facing downwards, so avoiding snow covers and allowing reflection into the module from the snow.

6. $$I_s = (10^{-8}\ Am^2)\left[\exp\left(\frac{eV}{kT}\right) - 1\right]$$

7 $$ff = \eta \cdot \frac{I_s A c}{I_{sc} V_{oc}} \Rightarrow A = \frac{ff \times I_{sc} V_{oc}}{\eta\, I_s}$$

$$= \frac{0.7 \times 50}{.12 \times 1200} = .243\ A$$

8. High photoconductivity
high optical absorption

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II Semester 2012-2013 Compre Exam **Scheme of Valuation**

Course No. BITS C462 **Course Title:** RENEWABLE ENERGY

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1. Calculation of δ, R_b, R_d , R_r = -11.40^0 , 0.227, 0.5 0.125 4 Marks

monthly average solar flux = 1207 $kJ/m^2/hr$ 2 Marks

2. (a)Detailed discussion on the parameters governing the performance of cylindrical parabolic collector 3 Marks

(b) thermo-chemical storage system with diagram 2 Marks

3. rotor diameter = 7.4 m 3 Marks

the angular velocity of the rotor = 7.15 rpm 2 Marks

4. (a)Explanation of low, medium and high temperature type of solar power plants with diagram 3 Marks

(b) Amorphous Silicon Solar Cells details 2 Marks

5. (a) Types of geothermal power plant 2 Marks

Comparison 1 Mark

(b) Definition of specific speed for turbine 1 Mark

range of specific speeds for Pelton and Kaplan turbines 1 Mark

6. overall efficiency of the plant = 80 % 3 Marks

average tidal cycles in a year = 700 2 Marks

7. biogas yield = 0.24 m^3/kg 2 Marks

heat of combustion of methane = 30 MJ/m^3 2 Marks

8. (a) production process of ethanol from biomass 2.5 Marks

(b) types of fuel cells and their applications 2.5 Marks