S'06 : 2 AN : MC 413 (1503)

NON-CONVENTIONAL ENERGY SYSTEMS

Time : Three hours

Maximum marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a, b, etc) should be answered at one place.

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Group A

1. (*a*) Describe the factors that affect bio digestion. 5

   (*b*) A propeller type wind turbine having blade diameter of 60 m is in operation at a speed of 175 rpm with a wind velocity of 25 m/s the atmospheric air temperature being 30 °C. Calculate the total power density in the wind, maximum obtainable power density and average total power at normal conditions with an efficiency of 30%. 5

   (*c*) What are the various methods of tidal energy generation ? Explain in detail. 5

   (*d*) Define Solar constant and also di ferentiate between beam and diffuse radiation. 5

2. (*a*) Explain about yaw, pitch and teething control in a horizontal wind generator with neat sketches. 5

(Turn Over)

(*b*) How does a KVIC biogas plant operates ? Explain with a figure. 5

(*c*) What are the different types of concentrating collectors ? Specify their advantages over flat plate collectors. 5

(*d*) What is meant by Greenhouse effect and explain its significance ? 5

3. (*a*) What are the methods to maintain biogas production in a biogas plant and explain them in brief ? 5

(*b*) Calculate the average power available for one tidal period for the data given below:

Surface area = 10,000 m^2

Range of tide = 9 m. 5

(*c*) How solar energy is used for crop drying and explain its operating principles ? 5

(*d*) Explain the working of Savonius type wind mill. 5

4. (*a*) List the various types of instruments used to measure solar radiation and describe the working of Ebbley pyranometer. 5

(*b*) Differentiate between aerobic and anaerobic digestion and state the advantages of anaerobic digestion. 5

(*c*) What are the losses affecting the efficiency of flat plate collector ? Explain how do you reduce the same ? 5

(*d*) Discuss about solar thermal and electrical energy storage systems. 5

Group B

5. (*a*) Describe the working of an open cycle MHD generation. 5

(*b*) With a sketch explain the working of a grid integrated PV system. 5

(*c*) Explain the basic operation of a hybrid OTEC system. 5

(*d*) Describe different methods of plasma heating. 5

6. (*a*) Classify the prime movers used in geothermal energy systems. 5

(*b*) What is superconductivity and explain how it is used for energy storage ? 5

(*c*) Explain the working of a H_2—O_2 fuel cell. 5

(*d*) Discuss about the barriers in implementing renewable energy systems in India. 5

7. (*a*) Describe the advantages of nuclear fusion. 5

(*b*) For a thermoelectric power generator following parameters are given:

Temperature of hot reservoir of source = 300 °C

Temperature of sink = 27 °C

Figure merit for material (z) = $2{\cdot}2 \times 10^{-3}$ /K

Calculate the efficiency and compare it with the Carnot efficiency. 5

(*c*) What are the advantages and disadvantages of geothermal energy systems ? 5

(*d*) Calculate the reversible voltage for a H_2—O_2 fuel cell having the reaction given below:

$H_2 + 1/2O_2 = a H_2O$ (l)

Take $(\Delta G^\circ)_{25} = -237{\cdot}3 \times 10^3$ J/gm-mole of H_2. 5

8. (*a*) Describe the working principle and constructional details of a thermionic generator. 5

(*b*) How do you analyse the life-cycle cost of a solar flat plate collector? 5

(*c*) Calculate the cost of energy for a wind power plant and a biomass power plant with the following data: 10

	Wind mill	*Biomass gasifier*
Investment/MW	Rs. 5·5 Crores	Rs. 5 Crores
Cost of capital servicing	9%	9%
Depreciation cost	5%	5%
Operation and maintenance cost	8%	18%
Plant load factor	0·35	0·85

Group C

9. Choose the *correct* answer: 2×10

(*i*) The collecting surface of PV module is made of

(*a*) aluminium

(*b*) mono-crystalline silicon

(*c*) transparent to infrared radiation

(*d*) transparent to ultra-violet radiation

(*ii*) The best orientation of a solar plate collector is

(*a*) facing south

(*b*) facing north

(*c*) facing south-east

(*d*) any orientation

(*iii*) Stall effect means

(*a*) control of wind turbine by changing the rotor blade angle

(*b*) control of wind turbine by tear-off of the flow around a rotor blade profile

(*c*) shut down a wind turbine by breaking the rotor by a mechanical brake

(*d*) None of these

(*iv*) If a glass plate reflects 5% of the incident light and absorbs 10%, the amount of light transmitted is

(*a*) 95%

(*b*) 85%

(*c*) 90%

(*d*) 15%

(*v*) For optimum storage of heat with rocks, small pebbles should be used because

(*a*) this gives a large surface area to mass ratio

(*b*) this gives a small surface area to mass ratio

(*c*) this increases the specific heat

(*d*) the economical cost of the rocks is decreased

(*vi*) *p*-type silicon is formed by adding minute amounts of elements with

(*a*) three valence electrons

(*b*) four valence electrons

(*c*) five valence electrons

(*d*) six valence electrons

(*vii*) One eV is defined as the energy gained by an electron when it is accelerated by a voltage difference of

(*a*) 1 V

(*b*) 1 kV

(*c*) 1 MV

(*d*) 1 mV

(*viii*) In OTEC, the following parameter is used to generate power

(*a*) salinity

(*b*) temperature

(*c*) pressure

(*d*) density

(*ix*) Tides arise

(*a*) once a day

(*b*) twice a day

(*c*) thrice a day

(*d*) four times a day

(*x*) Addition of ethylene glycol into water causes depression in

(*a*) freezing point

(*b*) pour point

(*c*) boiling point

(*d*) None of these.

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Group A

1. (*a*) What are the biomass conversion technologies? Explain 'thermochemical' and 'biochemical' conversion in relation with the bioenergy. 6

(*b*) Describe one biogas plant which is popular in India. Discuss various parameters which have to be controlled to achieve the efficient production of biogas. 8

(*c*) Write notes on (*i*) Landfill gas production, and (*ii*) Energy plantation. 6

2. (*a*) Define different types of mechanical control used in wind energy conversion system (WECS). How are pitch control and yaw control associated with the types of generator used in WECS ? 8

(*Turn Over*)

(*b*) Compare vertical axis wind turbine with horizontal axis turbine. 6

(*c*) A propeller wind turbine runs at 40 rpm. Calculate (*i*) total power density in wind stream, (*ii*) maximum obtainable power density and actual power density (take efficiency 35%), and (*iii*) total power produced and torque at maximum efficiency. Turbine diameter 120 m, wind velocity 15 m/s, air density 1·226 kg/m^3. 6

3. (*a*) What are the limitations of single-pool tidal system? How are these overcome in modulated single-pool tidal system and two-pool tidal system? 8

(*b*) A single basin tidal power plant has a basin area 30×10^6 m^2. The tide has a range 12 m. The turbine can work with head of 3 m. Estimate the total power generated in one filling empting cycle. Efficiency of turbine generator is 73%. 6

(*c*) Write notes on materials used in latent heat storage system. 6

4. (*a*) Discuss the theory and working principle of ocean thermal energy conversion (OTEC) system. Also, list the various plants based upon it. 8

(*b*) Explain open cycle OTEC plant with the help of flow diagram and T-s diagram. 6

(*c*) Write notes on (*i*) Solar refrigeration, (*ii*) Limitation of uses of solar water heating system. 6

Group B

5. (*a*) What are solar collectors? Compare different types of solar collectors on the basis of construction and application. 6

(*b*) Derive the expression for power and efficiency of thermionic generator. 6

(*c*) Write notes on (*i*) Selection of thermoelectric materials, (*ii*) Figure of merit of thermoelectric generator. 8

6. (*a*) What are the advantages of coal-fired magneto-hydrodynamics (MHD) generator compared to conventional steam power plant. 6

(*b*) Give a scheme of closed loop MHD generator with details of its operational steps and operational problem. 8

(*c*) Calculate the open circuit voltage and maximum power output for the following MHD generator. Plate area = 0·25 m^2, Distance between plates = 0·50 m, Magnetic flux density = 2 Wb/m^2, Average gas velocity = 10^3 m/s, Gas conductivity = 10 mho/m. 6

7. (*a*) Give a classification of small hydropower plant. What are various types of hydraulic machines which can be used to exploit hydroenergy at small level? 8

(*b*) Compare small hydroproject power generation with conventional hydropower project. 6

(*c*) Write a short note on the benefits of cogeneration system. 6

8. (*a*) Compare fission reaction with fusion reaction, highlighting the environmental aspects. 6

(*b*) How energy audit lead to energy conservation? 6

(*c*) Write notes on (*i*) Stand alone, and (*ii*) Hybrid system of solar, SHP, wind engery. 8

Group C

9. (*A*) Match the quantities indicated in Group A with the quantities given in Group B (neglect extra term given in Group B): 2×5

Group A		*Group B*	
(*i*)	OTEC	(*a*)	MHD
(*ii*)	Toroidal field coil	(*b*)	Flash evaporation
(*iii*)	Seed material	(*c*)	Fusion energy
(*iv*)	Dolphin	(*d*)	Wave energy
(*v*)	Pitch control	(*e*)	Anderson type
		(*f*)	DUCT
		(*g*)	Wind energy

(*B*) Fill in the blanks from the given terms in the bracket [ ], neglect extra term in [ ]: 2×5

(*i*) The term upwind stream associated with WECS means the direction of wind flow from —— to ——.

(*ii*) —— energy depends on relative position of ——, —— and ——.

(*iii*) The —— daily solar radia at many places in India is about ——.

(*iv*) Storage requirement can be determined from ——.

(*v*) The pump storage plant is generaly used to supply ——.

[peak load, mean, average 50 kWh/m^2, 5 kWh/m^2, sun, earth, moon, blade, tail vane, hydrograph and mass curve, hydrograph and load curve].

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Group A

1. (*a*) List out the advantages of non-conventional energy systems. 5

   (*b*) With suitable sketches, explain the 'Anaerobic digestion method of producing biogas from the resources. 8

   (*c*) Explain the 'Fermentation' method of producing ethanol from sugarcane. 7

2. (*a*) Compare the vertical axis wind turbine with horizonal axis turbine with respect to construction, working and performance. 6

(*b*) Describe the construction and working of a three-blade horizontal shaft wind turbine generator unit. 7

(*c*) List the different wind turbine plants situated in India. Describe in detail the main considerations in selecting a site for wind energy forms. 7

3. (*a*) With a simple layout and tidal cycle curves, explain single-effect single basin tidal scheme. 7

(*b*) With a schematic diagram, explain the working of an oscillating hydraulic piston wave energy pumped storage plant. 7

(*c*) Compare ocean waves and ocean tides with reference to the period, energy density and energy conversion plants. 6

4. (*a*) Discuss different solar energy conversion systems and their related applications. 7

(*b*) With a simple sketch, explain the paraboloidal dish collector and state its advantages over other types. 7

(*c*) Write a short note about solar pond. 6

Group B

5. (*a*) A small household lighting system is powered from a 8V storage battery having a 30 A-h supply when charged. The lighting is used for 4h each night at 3A. Design a suitable photovoltaic power systems that will charge the battery from an arrangement of SI solar cells. 9

(*i*) How will you arrange the cells?

(*ii*) How will the circuit be connected?

(*iii*) How will you test the circuit and its performance.

(*b*) Discuss the following with respect to a solar photovoltaic system: (*i*) VI characteristics of a solar cell, (*ii*) power of a solar panel, and (*iii*) efficiency of a solar cell. 7

(*c*) Discuss the limitations of solar photovoltaic power generation. 4

6. (*a*) With a schematic layout, explain the working of a modified open cycle OTEC plant. List its advantages over the other plants. 7

(*b*) With a schematic layout, explain the working of a open cycle MHD power plant. 7

(*c*) List different types of fuels that can be used in the fuel cells. What are the advantages and disadvantages of fuel cell power plants? 6

7. (*a*) With a schematic diagram, explain the working of a liquid dominated single flashed geothermal power plant. 8

(*b*) List different types of geothermal power plants with respect to geothermal energy available and conversion plants. 6

(*c*) Explain the current status and the problems involved in the fusion energy conversion process. 6

8. (*a*) Briefly discuss about various non-conventional energy sources, different methods of extracting energy from them, and the relative cost considerations and economics. 10

(*b*) Write short notes on environmental aspects of harnessing different non-conventional energy resources. 5

(*c*) Briefly discuss the future developments expected in the fusion energy conversion system. 5

Group C

9. (*A*) Match the terms indicated in Group A with the terms given in Group B (neglect extra term given in Group B): 2 × 5

Group A	*Group B*
(*i*) Biochemical	(*a*) Photovoltaic power generation
(*ii*) Solar cell	(*b*) Direct energy conversion system
(*iii*) MHD	(*c*) Kayathar, Tamil Nadu
(*iv*) Angstrong's equation	(*d*) Anaerobic digester
(*v*) Wind energy power plants	(*e*) Chennai, Tamil Nadu
	(*f*) Global radiation
	(*g*) Fuel cell

(*B*) Fill in the blanks from the given terms in the brackets [ ], neglecting extra terms: 2 × 5

(*i*) The common instruments used for measuring solar radiation are —— and ——.

(*ii*) Both *p* and *n* type —— material have higher electrical conductivity than the —— basic material.

(*iii*) There are always periods without wind. Thus, WECS must be linked to —— or —— systems if supplies are to be maintained.

(*iv*) Three classes of geothermal regions are ——, —— and ——.

(*v*) Power in the wave is proportional to the square of the —— and to the ——.

[Intrinsic, extrinsic, hyperthermal, actinometer, semithermal, solarimeter, radiation meter, normal, storage, amplitude, parallel generating, period of motion, geothermal, silicon]

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Group A

1. (*a*) What are direct and indirect methods of solar energy utilization ? 5

(*b*) Explain flat-plate and concentrating solar energy collectors. What is tracking of the concentrator ? 6

(*c*) Explain with a sketch the central tower concept of utilizing solar energy in Rankine cycle operation for electricity generation. 7

(*d*) What is a solar pond ? 2

2. (*a*) What is the principle of photovoltaic power generation ? Explain the operation of a solar cell. What is fill factor ? 8

(*b*) Explain the advantages and disadvantages of solar cells. What is the concept of satellite power station? 6

(*c*) Explain the solar-hydrogen energy system. What is the importance of this system in the present day energy scenario? 6

3. (*a*) What are the functions and use of windmills. How do vertical shaft windmills compare with windmills having horizontal shaft? 6

(*b*) What is the total power of a wind stream? What do you mean by coefficient of performance and tip speed ratio of a windmill? On what factors does the performance of windmills depend? 8

(*c*) How is the power output of wind turbines controlled and utilized? 6

4. (*a*) What are the three technologies of tapping the energy source of ocean energy? What is OTEC? With the help of a schematic diagram explain a Rankine cycle OTEC plant. 6

(*b*) Explain the scope of utilizing ocean wave energy to generate electricity. 4

(*c*) Explain how tidal energy is converted to electrical energy. What do you mean by schedule and range of a tidal wave? Discuss the different tidal power schemes and configurations with neat sketches. 10

Group B

5. (*a*) What is biomass? How is it formed? What are biofuels? What do you understand by thermo-chemical and biochemical conversion? Explain anaerobic digestion and fermentation. 8

(*b*) What do you mean by an energy farm and an aquatic farm? 4

(*c*) With the help of a typical biogas plant explain the functions of the digestor and dome. How are animal wastes utilized to produce biogas? 8

6. (*a*) How does a fuel cell operate? How is it different from a battery? Explain the hydrogen-oxygen and carbon-oxygen fuel cells. 8

(*b*) Explain the thermodynamics of fuel cell reactions. What is a Faraday? What do you mean by the ideal voltage of a fuel cell? 8

(*c*) Give the applications of fuel cells. 2

(*d*) Enumerate the advantages of hydrogen as a fuel. 2

7. (*a*) Briefly discuss the principle of MHD power generation. Explain the operation of MHD steam power plant. What is the function of an inverter? Evaluate coal as the MHD fuel. 12

(*b*) Explain the principle of thermionic power generation. What do you mean by surface work function and Fermi energy? What is Richardson-Dushman equation? 8

8. (*a*) How is electricity generated by thermoelectric means? What is figure of merit? What are the suitable materials for thermoelectric elements? Discuss the merits of thermoelectric generators. 10

(*b*) Explain geothermal heat as an energy source. Briefly explain the different types of geothermal source, namely, hydrothermal, geopressurized and petro-thermal. What is hot dry rock? How can it be used to produce power? 10

Group C

4) Give the most appropriate answer to the following: 1×10

(*i*) The most useful type of material for solar cells are

(*a*) metals
(*b*) insulators
(*c*) semiconductors
(*d*) liquid crystals

(*ii*) The amount of power in solar radiation at sea-level is

(*a*) 1·35 kW/m^2
(*b*) 1·07 kW/m^2
(*c*) 214 W/m^2
(*d*) 100 W/m^2

(*iii*) The force $qv \times B$ on a charge q moving at a velocity v in a magnetic field B is called

(*a*) Maxwell's force
(*b*) Saha's force
(*c*) Einstein's force
(*d*) Lorentz force

(*iv*) A wind is blowing at a velocity V through an area A at right angles to it. The density of wind is ϱ. The kinetic energy of the wind is

(*a*) ϱAV^3
(*b*) ϱAV^2
(*c*) $\frac{1}{2}\varrho V^3/A$
(*d*) $\frac{1}{2}\varrho AV^2$

(*v*) Vertical axis wind turbines are known by names such as

(*a*) Smith-Putnam
(*b*) Savonius
(*c*) Darrieus
(*d*) both (*b*) and (*c*)

(*vi*) Tidal cycles at any location have a periodic time of

(*a*) 24 hr
(*b*) 24 hr 50 min
(*c*) 12 hr 25 min
(*d*) 6 hr 12·5 min

(*vii*) Hydrogen is used as fuel in

(*a*) Fuel cells
(*b*) Automobiles
(*c*) Gas turbines
(*d*) All three

(*viii*) 1 Faraday is the charge of the following number of electrons

(*a*) $1{\cdot}6 \times 10^{19}$
(*b*) $6{\cdot}022 \times 10^{12}$

(*c*) $6{\cdot}022 \times 10^{23}$

(*d*) $1{\cdot}6022 \times 10^{23}$

(*ix*) In a space satellite, $1\,m^2$ of solar panel will generate approximately a power of

(*a*) 1 kW

(*b*) 2 kW

(*c*) 10 kW

(*d*) 1 MW

(*x*) Geothermal power generation systems can be

(*a*) Dry steam plants

(*b*) Flash plants

(*c*) Binary plants

(*d*) Any or all three

(*B*) Answer the following in brief: $2\frac{1}{2} \times 4$

(*i*) Small hydroplants

(*ii*) Benefits of cogeneration systems

(*iii*) Nuclear fusion

(*iv*) Direct energy conversion methods.

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Group A

1. (*a*) What are the advantages and disadvantages of floating drum plant used for biogas digesters? 5

(*b*) Briefly explain the different biomass conversion routes. 4

(*c*) How are the gasifiers classified and explain their characteristics? 6

(*d*) Calculate the following parameters for a biogas system? 5

(*i*) Volume of biogas digester

(*ii*) Power available from digester.

Given data:

No. of cows	= 10
Retention period	= 20 days
Temperature for fermentation	= 30 °C
Density of dry matter	= 50 kg/m^3
Dry matter content/day/cow	= 2 kg
Burner efficiency	= 0·6
Methane proportion in gas	= 0·7
Heat of combustion of CH_4	= 28 MJ/m^3 at STP
Biogas per unit dry mass of whole input	= 0·2 m^3/kg

2. (*a*) Explain the construction details of a flat plate collector. 4

(*b*) What is the basic difference between active and passive solar heating system? 4

(*c*) Explain the method of solar thermal energy storage using sensible heat. 4

(*d*) Define the following: (*i*) Declination, (*ii*) Hour angle, (*iii*) Tilt angle, (*iv*) Angle of incidence. 8

3. (*a*) What are the principles used for measurement of wind speed? 4

(*b*) Develop an expression to find out the energy available in wind. 4

(*c*) Discuss the advantages and disadvantages of both horizontal and vertical axis wind mill. 6

(*d*) A wind generator with a 8 m dia blade has a cut-in windspeed of 5 m/s at which velocity generates 1·5 kW of power. Determine the efficiency of wind turbine generator set and horizontal force exerted by the wind on the supporting mast. What is the effect of doubling wind velocity to 10 m/s on power generation and the horizontal force. Given: ϱ_{air} = 1·2 kg/m^3 6

4. (*a*) The basin area of a tidal power plant is $3{\cdot}0 \times 10^6$ m^2. The tidal range is 10 m. Calculate the energy generated in kWh. 6

(*b*) Explain briefly the components of tidal power plant. 4

(*c*) Write short notes on (*i*) solar pond, and (*ii*) solar cooker. 4

(*d*) Calculate fill factor and cell efficiency, if a solar cell of area 4 cm^2 is irradiated with an intensity of 100 W/m^2. Given: V_{oc} = 0·24 V, V_{max} = 0·14 V, I_{sc} = – 10 mA, I_{max} = – 6·5 mA. 6

Group B

5. (*a*) Describe the principle of working and the constructional details of basic thermionic generator. 5

(*b*) What are the various losses associated with the operation of MHD generator? 5

(*c*) Find the reversible voltage for methanol fuel cell having the following reactions: 5

$$CH_3OH + 1{\cdot}5\,O_2 \longrightarrow CO_2 + 2H_2O\ (l)$$

$$CH_3OH + H_2O \longrightarrow CO_2 6H^+ + 6\,e^-$$

$$\Delta G_{25^\circ C} = -699481\ J/g\ mole.$$

(*d*) Explain the different polarizations occurring in fuel cells. 5

6. (*a*) Describe various energy extraction technologies used with hydrothermal resources. 5

(*b*) What are the major advantages and disadvantages of geothermal energy? 5

(*c*) Explain the origins and characteristics of ocean thermal energy conversion? 5

(*d*) What do you understand by bio-fouling in OTEC design? How is the problem handled? 5

7. (*a*) What are the main fusion reactions considered for use in fusion reaction? 6

(*b*) What are the methods of plasma confinement? 4

(*c*) Describe different methods of plasma heating? 6

(*d*) Differentiate between nuclear fusion and fission reaction. 4

8. (*a*) What are the advantages of hybrid energy systems? 4

(*b*) Compare the average efficiency of following energy conversion systems?
(*i*) Solar thermal, (*ii*) Solar PV, (*iii*) Wind, (*iv*) OTEC, (*v*) Tidal, and (*vi*) Fuel cell. 6

(*c*) Explain the principle of life-cycle costing and explain how it is useful for effectively utilizing the renewable energy sources for power generation. 5

(*d*) Calculate the cost per kWh for wind turbine of capacity 1 MW with the following cost parameters: 5

Item	*Cost*, Rs. (in lakh)
Capital cost	264
Operating cost (annual)	8
Maintenance (annual)	14
Preventive maintenance	3
Major overhaul (annual)	1

The life of turbine is 20 years and rate of interest is 10%.

Group C

9. (*A*) Choose the appropriate answer for the following: 1×10

(*i*) A pane of glass reflects 5% of incident light and absorbs 10%. The amount of light permitted through the glass is

(*a*) 95%

(*b*) 85%

(*c*) 90%

(*d*) 15%

(*ii*) The efficiency of a flat plate collector using water as a heat exchange fluid is largest at which of the following temperatures of the absorber plate assuming the ambient air to be at 25 °C

(*a*) 40 °C

(*b*) 60 °C

(*c*) 80 °C

(*d*) 100 °C

(*iii*) Wind energy transferred to the large sea surface is stored in waves as

(*a*) chemical energy.

(*b*) thermal energy.

(*c*) electrical energy.

(*d*) mechanical energy.

(*iv*) *n*-type silicon is formed by adding a minute amounts of elements with

(*a*) 3 valence electrons.

(*b*) 4 valence electrons.

(*c*) 5 valence electrons.

(*d*) 6 valence electrons.

(*v*) Tides arise

(*a*) once a day.

(*b*) twice a day.

(*c*) thrice a day.

(*d*) four times a day.

(*vi*) The temperature difference between water at the surface and lower levels of ocean [a few hundred meters] is about

(*a*) 40 °C

(*b*) 70 °C

(*c*) 20 °C

(*d*) 60 °C

(*vii*) Deutrium differs from hydrogen in

(*a*) chemical properties.

(*b*) physical properties.

(*c*) both physical and chemical properties.

(*d*) radioactive properties.

(*viii*) The output voltage of H_2–O_2 fuel cell at standard conditions is

(*a*) 1·5 V

(*b*) 1·23 V

(*c*) 1·75 V

(*d*) 1 V

(*ix*) The ideal pH values for digestion of raw animal or plant wastes is kept around

(*a*) 3·5

(*b*) 6·5

(*c*) 8·5

(*d*) 10·5

(*x*) Which one of the following is used as a working fluid in solar Rankine cycle

(*a*) Steam

(*b*) Air

(*c*) Hydrogen

(*d*) Helium

(*B*) Answer the following in brief: 3+3+4

(*i*) Biodiesel.

(*ii*) Solidity ratio.

(*iii*) Mini-hydel plants.

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Group A

1. (*a*) Differentiate between open sun drying, direct solar drying and indirect solar drying. Explain each with the help of suitable sketches. 8

(*b*) Explain the working of a solar still. 4

(*c*) Describe (*i*) distributed solar-thermal, and (*ii*) solar-thermal central-receiver systems of generating electricity. 8

2. Describe working of the following: 4×5

(*i*) Solar chimney

(*ii*) Solar pond

(*iii*) Solar cooker

(*iv*) Absorption cooling with the help of solar energy.

(*v*) Solar air heater.

3. (*a*) Draw the sketches of (*i*) horizontal axis downwind 4-blade wind turbine, and (*ii*) Darrius turbine with two blades. Describe their working and list relative merits and demerits. 8

(*b*) Explain the principle of power generation from tidal waves. Why should we go for either modulated single pool tidal system or two-pool tidal system? Describe each one of them. 8

(*c*) A tidal project has installed capacity of 2176 MW in 64 units, each of 34 MW rated output. The head at rated output is 5·52 m. The embankment is 6·4 km long. Assume 93% efficiency for both turbine and generator. The generation is 5 hr twice a day. Calculate the

(*i*) Quantity of water flowing through each turbine and the total flow out of the tidal basin,

(*ii*) Surface area of reservoir behind the embankment and the wash, and

(*iii*) Energy produced (in TW-h) per year (density of sea water = 1025 kg/m^3). 4

4. (*a*) List *five* types of conversion processes of biomass into useable gaseous and liquid fuels. Briefly describe these processes. 15

(*b*) Write a note on 'selective surfaces'. 3

(*c*) Write the composition and calorific value of biogas. 2

Group B

5. Write short notes on the following: 5 × 4

(*i*) Fusion energy: Present status and problems

(*ii*) Cost considerations and economics of integrated energy packages

(*iii*) Thermal energy storage

(*iv*) Comparative study of non-conventional energy sources

(*v*) Amorphous semiconductors.

6. (*a*) What do you understand by 'fuel cell'? List merits and demerits of fuel cells over other energy conversion systems. 2

(*b*) In an oxygen-hydrogen cell, describe the reactions taking place at the anode and cathode. Mention materials of anode, cathode and possible electrolytes. 6

(*c*) List the applications of fuel cells. 2

(*d*) Describe the principle of operation of MHD power generator. How gas velocity, conductivity, and magnetic flux density affect the power generated? 6

(*e*) For a MHD-duct, the specific resistance is 0·08 Ωm. The applied magnetic field strength B is 3·8 T and the electrode area is 1·2 m^2. At a duct width of 0·9, the plasma velocity is 950 m/s. Determine (*i*) plant net power output, and (*ii*) conversion efficiency. 4

7. (*a*) Describe the principle of working and the constructional details of thermionic converter. 5

(*b*) Consider the following data for a thermoelectric generator:

Length of materials: $L_n = L_p = 5$ cm

Area of materials: $A_n = 1{\cdot}5$ cm^2, $A_p = 1$ cm^2

Hot and cold temperature: $T_h = 500\,°C$, $T_c = 30\,°C$

Seebeck coefficients: $S_n = -300\,\mu V/°C$,

$S_p = 200\,\mu V/°C$

Specific resistances, $\varrho_n = 10^{-3}$ ohm-cm,

$\varrho_p = 8 \times 10^{-4}$ ohm-cm.

Calculate the

(*i*) Seebeck open-circuit voltage of generator,

(*ii*) Resistance of two materials,

(*iii*) Maximum power output, and

(*iv*) Current at maximum power output. 6

(*c*) Write a note on Seebeck, Peltier and Thomson effects. 4

(*d*) Explain 'plasma confinement in fusion reactor'. 5

8. (*a*) Two solar water heating systems have the following cost comparison. Why is system more economical if the money is worth 10 percent per year? 6

Cost Component	*System A*	*System B*
First cost, Rs.	20,000	30,000
Annual maintenance, Rs.	4,000	3,000
Salvage value, Rs.	500	1,500
Service life, years	2	3

(*b*) Describe a geothermal system known to you. Compare the properties of geothermal hot water and steam with fossil fuel for power generation in terms of temperature, pressure and efficiencies. 8

(*c*) Describe the working of a closed cycle OTEC system using NH_3 as the working fluid. Why are OTEC systems not yet in operation in the world's oceans for commercial power generation? 6

Group C

9. Answer the following in brief: 2×10

(*i*) Determine the overall efficiency of a combined-cycle power plant which consists of a MHD generator with an efficiency η_{MHD} of 0·4 and a steam power plant with an efficiency η_{ST} of 0·38 without supplementary firing.

(*ii*) What is meant by 'Heliostats'?

(*iii*) What do you understand by biodiesel?

(*iv*) What is seeding? What is its purpose in MHD power generation?

(*v*) Describe photosynthesis. What is its relation with biomass?

(*vi*) What is savonius turbine (rotor)?

(*vii*) Explain anaerobic digestion.

(*viii*) What is solar cell?

(*ix*) What is insolation? Write its standard value.

(*x*) Define declination.

S'09 : 2 AN : MC 413 (1503)

NON-CONVENTIONAL ENERGY SYSTEMS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) What are different non-conventional energy systems ? Give only the names of each of them ? What are the prospects of non-conventional energy in India ? 3+3

(*b*) For a wind turbine power station at an atmospheric temperature of 20°C and at atmospheric pressure if the wind velocity is 15 m/s, calculate (*i*) total power density in wind stream, and (*ii*) maximum obtainable power density. Given : Air density = 1·226 kg/m^3. 14

(*Turn Over*)

2. (*a*) Explain the simple digester system used for bio-conversion, with a neat sketch. 8

(*b*) Write the composition and calorific value of biogas. 8

(*c*) What are instruments used for measurement of solar energy? 4

3. (*a*) Explain the principle of Wind Energy Conversion. 4

(*b*) What are the basic components of wind energy conversion system? Explain with a neat diagram. 10

(*c*) Discuss the performance of wind machines in brief. 6

4. (*a*) Explain the basic components of solar collector and its working principle. 6

(*b*) Classify and explain different types of solar collectors. 10

(*c*) What are the advantages of selective surfaces? 4

Group B

5. (*a*) Explain the Hall effect in MHD generator and methods adopted to overcome the limitations. 6

(*b*) With a schematic layout, explain a typical open cycle MHD plant for power generation. 7

(*c*) Explain the advantages of fuel cell power sources. Draw a simple sketch of H_2-O_2 fuel cell and explain its working. 7

6. (*a*) With a simple sketch, explain the working principle of a thermionic converter. 6

(*b*) Discuss, in detail, the comparative cost considerations and economics of the following non-conventional energy sources: Solar, biogas, wind, tidal and geothermal. 14

7. (*a*) State the difference between 'nuclear fusion' and 'nuclear fission'. Explain how energy is liberated from a nuclear fusion reaction. 5

(*b*) Draw a sketch of laser inertial fusion reactor. Explain its working principle. 7

(*c*) Why is nuclear fusion reaction being given high priority in reseach and development? What are the basic problems with nuclear fusion and how are they being attacked and overcome? 8

8. (*a*) Explain the principle of ocean thermal energy conversion (OTEC). With a simple layout, explain the working of a closed cycle OTEC plant. 8

(*b*) State the merits and demerits of OTEC plants. Explain the major problems that need to be solved. 6

(*c*) State the principle of solar photovoltaic (PV) energy conversion and the applications of solar PV systems. 6

Group C

9. (*A*) Answer the following in *one* or *two* sentences: 7×2

(*i*) List out the different types of collectors used in solar power station.

(*ii*) Name *three* forms of energy conversion from ocean.

(*iii*) List out different bioenergy conversion processes.

(*iv*) Explain Carnot efficiency for an OTEC plant.

(*v*) What do you mean by spring tide and neap tide ?

(*vi*) What do you mean by petro-geothemal power plants ?

(*vii*) Distinguish between global radiation and diffuse radiation.

(*B*) Match the quantities in *List I* with related quantities in *List II* : 6×1

List I	*List II*
Solar PV cells	Low efficiency
Wind farm	Satellite application
Direct combustion	Kayathar
OTEC plant	MHD
Seed material	Incineration
Aquatic biomass	Hyacinth.

W'09 : 2 AN : MC 413 (1503)

NON-CONVENTIONAL ENERGY SYSTEMS

Time : *Three hours*

Maximum Marks : *100*

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Explain the principle of wind energy conversion. 4

(*b*) What are the basic components of wind energy conversion system ? Explain with a neat sketch. 10

(*c*) Discuss the performance of wind machines in brief. 6

2. (*a*) What are different non-conventional energy system ? Give only the names of them ? What are the prospects of non-conventional energy sources in India ? 3 + 3

(*b*) For a wind turbine power station at an atmospheric temperature of 20°C and at atmospheric pressure, if

the wind velocity is 15 m/s, calculate (*i*) total power density in wind stream; and (*ii*) maximum obtainable power density. Given : Air density = 1.226 kg/m^3. 14

3. (*a*) Explain the simple digester system used for bio-conversion with a neat sketch. 8

(*b*) Write the composition and calorific value of biogas. 8

(*c*) What are the instruments used for measurement of energy ? 4

4. (*a*) Explain the basic components of solar collector and its working principle. 6

(*b*) Classify and explain different types of solar collectors. 10

(*c*) What are the advantages of selective surfaces ? 4

Group B

5. Write short notes on following : 5 × 4

(*a*) Geothermal energy

(*b*) Fuel cells

(*c*) Fusion energy

(*d*) Electrochemical energy devices.

6. (*a*) What are the main elements of a solar photovoltaic (PV) system ? Also, explain the principle of PV systems with a neat sketch. 5 + 5

(*b*) Explain MHD converters. 5

(*c*) Discuss amorphous semiconductor used for PV system. 5

7. (*a*) Discuss the economics of solar PV cell as compared to conventional source of energy for 20 years. 10

(*b*) Explain the basic principle of thermoelectric power generation. 4

(*c*) Explain the open cycle OTEC system. 6

8. (*a*) Discuss the integrated energy packages using solar wind, biomass and *any one* auxiliary energy source. 12

(*b*) What are future prospects and present problems of fusion energy ? 8

Group C

9. (A) Choose the most appropriate answer from the choices given for the following : 10 × 1

(*i*) For the same rotor diameter, as the wind speed increases, total power developed

(*a*) decreases.

(*b*) increases.

(*c*) remains constant.

(*d*) may increase or decrease but does depend on wind speed.

(*ii*) Compressed air is a

(*a*) mechanical energy storage system.

(*b*) electrical energy storage system.

(*c*) chemical energy storage system.

(*d*) electromagnetic energy storage system.

(*iii*) Solar radiation absorbs by the earth atmosphere is about

(*a*) 0

(*b*) 5%

(*c*) 10-20%

(*d*) more than 50%

(*iv*) Haliostats is used for collecting

(*a*) wind energy.

(*b*) tidal energy.

(*c*) fusion energy.

(*d*) solar energy.

(*v*) Thermoelectric power is based on

(*a*) Seebeck effect.

(*b*) Peltier effect.

(*c*) Reynolds effect.

(*d*) None of the above.

(*vi*) Geothermal source is a source of energy from

(*a*) ocean.

(*b*) sun.

(*c*) wind.

(*d*) earth.

(*vii*) Digester is a essential part of

(*a*) MHD generator.

(*b*) fusion energy system.

(*c*) wind energy conversion system.

(*d*) biomass energy conversion system.

(*viii*) The device which is used in solar PV cell to convert d.c. to a.c. is

(*a*) battery.

(*b*) semiconductor.

(*c*) circuit breaker.

(*d*) invertor.

(*ix*) Yaw control is a part of

(*a*) solar concentrating collector.

(*b*) OTEC devices.

(*c*) biomass energy generator.

(*d*) wind energy conversion system.

(*x*) In case of concentrating solar collector, the ratio of absorber area to the radiation area is

(*a*) 0

(*b*) less than 1

(*c*) 1

(*d*) more than 1

(B) State whether the following statements are *true* or *false* : 10×1

(*i*) Flywheel is a electrical energy storage system.

(*ii*) Solar energy can be used to increase the output of biomass through gobar gas.

(*iii*) Fuel cells can be used in automobiles easily.

(*iv*) In wind turbine as tip speed ratio increases, number of blades also increases.

(*v*) Biogas cannot be utilised in IC engines.

(*vi*) Nucleas fission is energy released by combination of two light nuclei.

(*vii*) OTEC plants can be installed only at coastal area.

(*viii*) Methane is a major constituent in biogas.

(*ix*) In PV cells, capacitor is used to store the energy.

(*x*) Diffused radiation radiated by sun is more as compared to direct radiation in case of cloudy condition.

S'10 : 2 AN : MC 413 (1503)

NON-CONVENTIONAL ENERGY SYSTEMS

Time : Three hours

Maximum marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Calculate the heat removal factor, useful heat gain, exit fluid temperature, and collection efficiency 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 26 °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: $\varrho = 0.85$, $(\tau\alpha)_b = 0.78$, $\tau = 0.93$ and $C_p = 1.256$ kJ/kg °C, collector efficiency factor = 0.85, and heat loss coefficient = 7.0 W/m^2 °C. 10

(*b*) A CPC, 1.5 m long, has an acceptance angle of 20°. The surface of the absorber is flat with a width of 15 cm. Evaluate the concentration ratio, aperture height, and surface area of the concentrator. 5

(*c*) Explain the difference between active and passive solar heating systems. 5

2. (*a*) Calculate wind velocities at heights of 20 m, 40 m, 60 m, 80 m, and 120 m above ground, if the velocity at 10 m is 10 m/s. 6

(*b*) Explain how the energy produced by a wind turbine can be stored for re-use. What are the arrangements used for starting a Darrieus wind turbine? 6

(*c*) Prove that, in case of horizontal wind turbine, maximum power that can be obtained when exit velocity is one-third of wind velocity and it equals $(8/27)\rho A V_u^3$. 8

3. (*a*) Explain various solar thermal energy storage systems. 6

(*b*) A tidal power station has 24 generators, each of 10 MW, operating at a maximum head of 13.5 m. It generates for two 6-hour periods per day. Calculate the basin capacity (in m^3) and annual energy production. Again, assume 93% efficiency. 8

(*c*) Explain the working of a non-convective solar pond. 6

4. (*a*) Calculate the volume of a cow-dung based biogas plant required for cooking needs of a family of five adults and house light need with two 60 C.P. lamps for three hours daily. Also, calculate the required number of cows to feed the plant. 8

(*b*) Discuss on the factors affecting the performance of biogas digesters. 8

(*c*) Compare updraft and downdraft gasifiers. 4

Group B

5. (*a*) A 2 cm × 2 cm × 0.05 mm solar cell has the following I-V characteristic with approximate $I_{sc} = 0.166$ A and $V_{oc} = 0.6$ V. The I-V characteristic is constant at 0.166 A up to 0.5 V. Calculate the fill factor and cell efficiency. 6

(*b*) Discuss the importance of Wiedeman-Franz law and the Lorenz number. 6

(*c*) Explain the difference between band gap and barrier voltage in a solar cell. 4

(*d*) How does a solar chimney work? Explain. 4

6. (*a*) Classify geothermal sources. 5

(*b*) Explain the significance of Coulomb barrier in nuclear fusion generation of power. 5

(*c*) Describe the working of a closed cycle OTEC system using NH_3 as the working fluid. 10

7. (*a*) A MHD duct has an inlet pressure of 10 atm and discharges into the atmosphere. Find its volume for a length of 20 m and inlet diameter of 2 m, if the duct is of circular cross-section throughout as well as the outlet diameter. What will be the volume for a square duct of side 1.5 m and length 25 m? 6

(*b*) Describe at least *three* different processes for generating hydrogen and *three* systems for storing it. 8

(*c*) List *five* types of fuel cells developed in industry. Give all materials used for cathode, anode, and electrolyte. 6

8. (*a*) Describe a geothermal power plant using single-flash system. 6

(*b*) A solar hot water system, having an array of flat-plate collectors with an area of $30\,m^2$, is installed in a factory. It costs Rs. 1,50,000 and is set up with an initial down payment of 20 per cent of the investment, the balance 80 per cent being taken as a loan to be repaid in equal annual instalments over a 10 year period at an interest rate of 16 per cent. The cost of conventional fuel saved in the first year is Rs. 21,000 and this cost increases at the rate of 4 per cent every year. The annual expenditure required by way of maintenance, electrical energy for running subsidiary equipment, local taxes, insurance, etc. is Rs. 6,600 in the first year, and this expense increases at the rate of 5 per cent every year. Tax deductions are permissible only on depreciation, which is allowed at the rate of 25 per cent each year, and the company income-tax rate is 55 per cent. Assuming that the market discount rate is 10 per cent, calculate the cumulative solar savings over a period of 15 years. 10

(*c*) What is thermionic emission effect? How is space charge effect minimized? 4

Group C

9. Choose the *correct* answer for the following: 20×1

(*i*) Which one of these activities would result in a sustainable supply of biomass?

(*a*) Wide-scale logging

(*b*) Coppcing

(*c*) Hedge laying

(*d*) Slash and burn

(*ii*) Natural gas is transported mainly through

(*a*) pipelines

(*b*) trucks

(*c*) barges

(*d*) All of the above.

(*iii*) Hydrogen can play an important role as an alternative to conventional fuels as

(*a*) an energy carrier.

(*b*) an energy device.

(*c*) a fossil fuel source.

(*d*) an energy system.

(*iv*) How many days in a year, on an average, solar energy is available in India?

(*a*) 100 days

(*b*) 150 days

(*c*) 225 days

(*d*) 300 days

(*v*) Horizontal-axis wind mills of modern design can

(*a*) always turn to face wind.

(*b*) not adjust its output.

(*c*) not turn to winds directions.

(*d*) not turn to face wind.

(*vi*) Electrical output of a solar cell depends on

(*a*) intensity of solar radiation.

(*b*) heat component of solar radiation.

(*c*) UV component of solar radiation.

(*d*) MIR component of solar radiation.

(*vii*) The optimal pH for methane production ranges between

(*a*) 6.5 and 7.2.

(*b*) 5 and 5.6.

(*c*) 8 and 9.5.

(*d*) 2.3 and 4.5.

(*viii*) Gasification of biomass is a

(*a*) biochemical conversion process.

(*b*) chemical conversion process.

(*c*) thermochemical conversion process.

(*d*) biological conversion process.

(*ix*) The value of solar constant is about

(*a*) 6.5 kW/m^2

(*b*) 1.36 kW/m^2

(*c*) 3.64 kW/m^2

(*d*) 10 kW/m^2

(*x*) The maximum temperature that can be obtained in a parabolic disc concentrator-type solar cooker is about

(*a*) 75°C

(*b*) 250°C

(*c*) 450°C

(*d*) 300°C

(*xi*) Which one of the following processes takes place in fuel cell?

(*a*) Electromagnetic

(*b*) Electrochemical

(*c*) Thermionic

(*d*) Heat transfer

(*xii*) In the interior of the earth, the average thickness of crust above the magma is about

(*a*) 10-25 km

(*b*) 30-40 km

(*c*) 100-150 km

(*d*) 150-200 km

(*xiii*) Ocean Thermal Energy Conversion system to generate power is most suitable in

(*a*) sub-tropical region.

(*b*) tropical region.

(*c*) cole region.

(*d*) moderate climate region.

(*xiv*) Ocean and sea waves are indirectly caused by

(*a*) pressure gradients.

(*b*) solar energy.

(*c*) geothermal energy.

(*d*) None of the above.

(*xv*) The tidal range is defined as the difference between

(*a*) water movement speed.

(*b*) water movement direction.

(*c*) water elevation at high and low tide.

(*d*) None of the above.

(*xvi*) One flat-plate collector of 2 m × 1 m, capable of providing 100 litres size, is capable of providing 100 litres of hot water at about 60 °C. How many such collectors would be required to get about 1000 litres of hot water?

(*a*) 10 such collectors of 2 m × 1 m size

(*b*) 5 such collectors of 2 m × 2 m size

(*c*) 20 such collectors of 1 m × 1 m size

(*d*) All of the above.

(*xvii*) A pyranometer is an instrument which measures

(*a*) beam radiation.

(*b*) global radiation.

(*c*) diffuse radiation.

(*d*) duration of bright sunshine.

(*xviii*) Conversion efficiencies for silicon cells range between

(*a*) 10% and 15%

(*b*) 30% and 35%

(*c*) 90% and 95%

(*d*) 95% and 99%

(*xix*) Which one of the following windmill runs independently of the direction of the wind?

(*a*) Darrieus type

(*b*) Sail type

(*c*) Propeller type

(*d*) Multiblade type

(*xx*) The temperature difference between water at the surface and lower levels of the ocean (over a few hundred metres) is about

(*a*) 20 °C

(*b*) 40 °C

(*c*) 50 °C

(*d*) 60 °C

W' 10 : 2 AN : MC 413 (1503)

NON-CONVENTIONAL ENERGY SYSTEMS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

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Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) 'An energy-efficient solar collector should absorb incident solar radiation, convert it into thermal energy and deliver thermal energy to a heat-transfer medium with minimum loss at each step.' In the light of the above statement, mention important features of flat-plate solar collectors and selectively solar-absorbing coatings.

From basic energy balance equation, derive the expression for collection efficiency. 10

(*b*) Explain the principle of solar drying. Explain how is the solar thermal effect utilized in drying ? 5

(*c*) Describe a central-receiver-type solar thermal-electric conversion system. 5

2. (*a*) What is the origin of biomass energy? Name the raw materials which can be used for production of biogas. Compare relative performances of floating drum and fixed-dome-type biogas plants. 10

(*b*) Explain the working of a non-convective solar pond. 5

(*c*) Explain the working of a double slope passive solar still analyzing the flow of energy. 5

3. (*a*) For a simple single-pool tidal system, show that the average, theoretical power delivered by the water (P_{av}/A) is equal to

$$P_{ar}/\pi = 0.225\,R^2\ (\mathrm{W/m^2})$$

where R is the tidal range (in m). What are the deficiencies of such a system and how are these corrected in the modulated single-pool tidal system? 10

(*b*) What are the special features of non-conventional energy systems as compared to conventional systems? 4

(*c*) What is the need of energy storage? Describe various methods of storing the energy in brief. 6

4. (*a*) What is geothermal energy? List its merits and demerits, applications and environmental impact. 5

(*b*) With the help of a neat sketch, describe the vapour-dominated (dry steam)-type geothermal source of energy. 5

(*c*) The following data were measured for a horizontal axis wind turbine:
Speed of wind = 20 m/s at 1 atm and 27 °C
Diameter of rotor = 80 m
Speed of rotor = 40 rpm
Calculate the torque produced at the shaft for maximum output of the turbine. 5

(*d*) Explain (*i*) speed control strategies for wind turbines; and (*ii*) power-speed characteristics of wind turbines. 5

Group B

5. (*a*) Highlight special features of direct energy conversion technology. 2

(*b*) Describe the principle of solar photovoltaic energy conversion. How does the variation of insolation and temperature affect the I-V characteristics of a solar cell? 8

(*c*) Write a note on 'Amorphous Silicon Solar Cell'. 5

(*d*) Explain the heating and cooling applications of thermoelectric system. Comment on the type of materials used for low and high temperature applications. 5

6. (*a*) Describe the basic principle of operation of an MHD generator along with major advantages and limitations. Derive expressions for maximum power generation per unit volume of a generator. 7

(*b*) With the help of a schematic diagram, explain the operation of closed cycle MHD system. 7

(*c*) Explain the working of an elementary thermionic converter and list the merits and potential applications. On what parameters do the output voltage and current depend? 6

7. (*a*) Explain the principle of operation of a fuel cell by taking a real-life example. List the applications and advantages. Write the chemical reactions involved. 8

(*b*) What is the present status of development in fuel-cell technology? 2

(*c*) What is hybridization? Stress the need of integration of solar, biomass, wind or any other non-conventional forms of energy. 6

(*d*) List the requirements of a new energy source and methods for its economic evaluation. 4

8. (*a*) 'The sun is a continuous fusion reactor.' Support this statement by writing the reaction and the relevant details. 7

(*b*) Mention the problems in the development of this type of energy source, present status and future possibilities. 6

(*c*) Describe the functioning of an open cycle Ocean Thermal Energy Conversion (OTEC) plant. What are the relative advantages and limitations of floating and shore-based OTEC plants? Write the environmental impact. 7

Group C

9. Answer the following in brief: 10×2

(*i*) In extra terrestrial radiation, what is the approximate percentage content of infrared component?

(*ii*) Terrestrial radiation has a wavelength in the range of ——.

(*iii*) Write the standard value of solar constant.

(*iv*) The concentration ratio of a flat-plate collector is ——.

(*v*) Write the collector tilt angle in northern hemisphere for optimum gain in heating applications in winter season.

(*vi*) Write the efficiency range for a commercial solar cell.

(*vii*) Write the value of open-circuit voltage of a solar cell.

(*viii*) Which is the process/event responsible for movement of carriers after creation of an electron hole pair due to radiation?

(*ix*) What is the energy payback period of a single crystal silicon cell?

(*x*) Write the range of wind-speeds suitable for power generation.

S'12:2AN:MC413 (1503)

NON-CONVENTIONAL ENERGY SYSTEMS

Time : *Three hours*

Maximum Marks : *100*

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

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Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) How can solar energy be converted into electrical energy ? With the help of a schematic diagram, explain the working of distributed collector solar thermal electric power plant. 6

   (*b*) Differentiate between direct solar drying and indirect solar drying. With the help of a sketch, describe the functioning of an indirect solar drying system used for crop drying. 6

   (*c*) A flat plate collector system has aluminium absorber plate (K_P = 211 W/m-K) of thickness 0.35 mm and area 1.5 m^2 and it has ten riser tubes of diameter 0.025 m each. The length of the tube being 1 m,

(Turn Over)

find the collector efficiency factor, F', for the collector, if the convective heat transfer coefficient from inner tube surface to water is (*i*) 50 W/m²-K, (*ii*) 100 W/m²-K, (*iii*) 500 W/m²-K. The overall loss coefficient is 7.2 W/m²-K. 8

2. (*a*) Calculate the day's solar radiation on a horizontal surface (H_0) in the absence of the atmosphere at latitude 30 °N on 31 May 1995. 6

(*b*) Explain the working of a non-convective solar pond. 6

(*c*) (*i*) Compare the relative merits and demerits of LiBr-water and aqua-ammonia vapour absorption cooling system. 4

(*ii*) Explain the 'Structure of Sun'. 4

3. (*a*) Explain the functioning of Darrieus-type wind energy system. 6

(*b*) How are deficiencies of a simple single-pool tidal system corrected in a modulated single-pool tidal system ? Explain. 8

(*c*) For a tidal mill, having a blade length of 3 m, compute the power captured by the blades when the tidal current is 18.52 km/h and the power coefficient of the tidal mill is 0.45. If a wind mill has the same diameter as the tidal mill and the wind speed is equivalent to the tidal speed and the power coefficient is also 0.45, compute the power captured by the blades. Prove that the two powers have the same ratio as the ratio of water density to air density. 6

4. (*a*) Explain the process of production of biogas from biomass. What are the main advantages of anaerobic digestion of biomass ? 6

(*b*) Explain the process of gasification of solid biofuels. What is the general composition of the gas produced and what is the heating value ? What are the main applications ? 7

(*c*) Explain the desirable features of bioethanol that make it suitable for automobiles. What is the grade required for blending with petrol ? Explain the process of commercial production of ethanol from biomass. 7

Group B

5. (*a*) An ideal PV cell produces 2.5 W at 0.5 V during certain environmental conditions. Compute the output power, current and voltage, if the cells are connected in the following arrangements : 3 × 2

(*i*) When the PV cells are connected as a panel of four parallel columns and each column has 10 series cells ;

(*ii*) When several panels are connected as an array of two parallel columns and each column has four series modules ; and

(*iii*) When several arrays are connected as a solar system consisting of 10 parallel columns and each column has 20 series arrays.

(*b*) How is the conversion of heat directly realized in a thermionic converter ? Write the expression for ideal current density. 6

(*c*) Explain the basic principle of MHD generator. With the help of a suitable diagram, explain the operation of an open cycle MHD generator system. 8

6. (*a*) Discuss different geothermal resources. 6

(*b*) Calculate the open-circuit voltage, the maximum work, and the thermal efficiency for a H_2-O_2 fuel cell at 25 °C and 1 atmosphere (1.013 bar). The product H_2O is in liquid state. Determine the power output in reversible and actual energy conversion processes as well as the overall efficiency of the fuel cell, when the performance factor is 0.7. The hourly hydrogen consumption is 1.3 kg/h. Given : Gibb's free energy change and production enthalpy for H_2O (liquid) at 1.013 bar and 25 °C are : 8

$$\Delta G_{H_2O} = -237.14 \text{ kJ/mol}$$

$$\Delta H_{H_2O} = -285.83 \text{ kJ/mol}$$

(*c*) Explain the working of an open cycle OTEC system. 6

7. (*a*) Discuss the method/methods of generation of hydrogen for fuel cells and its storage system. 6

(*b*) Explain the fundamental principle of fusion process. What is plasma confinement in fusion reactor ? 8

(*c*) Write a note on 'superconductivity'. 6

8. (*a*) Write a note on integrated energy systems using solar, wind, biomass, etc. 8

(*b*) Discuss the main features of various types of renewable and non-renewable energy sources and explain the importance of non-conventional energy sources in the context of global warming. 6

(*c*) A 100 lit/day domestic solar water heater saves consumption of electricity on 100 days (electric geyser) of the year by heating 100 litre of water from 15 °C to 60 °C. The useful life of the solar water heater is estimated to be 10 years. Determine the present worth of saving through the use of the solar water heater, if the efficiency of the electric geyser is 90% and the cost of electricity is Rs. 4/ kW. Assume interest rate as 12%. 6

Group C

9. Answer the following brief : 10×2

(*i*) Explain selective surface.

(*ii*) What is wind farm ? List *any five* locations of wind farm in India.

(*iii*) List the applications of fuel cells.

(*iv*) Explain 'photosynthesis' and list necessary conditions for it.

(*v*) Explain the terms 'air mass' and 'albedo'.

(*vi*) What is thermoelectric energy conversion ?

(*vii*) Explain the meaning of passive heating or cooling systems.

(*viii*) What is a solar still ?

(*ix*) Explain the functioning of solar chimney.

(*x*) What are the future possibilities of fusion energy generation ?

W'12: 2 AN: MC 413 (1503)

NON-CONVENTIONAL ENERGY SYSTEMS

Time : *Three hours*

Maximum Marks : *100*

Answer FIVE *questions*, *taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks

Group A

1. (*a*) What is the principle of photovoltaic power generation ? Explain the operation of a solar cell. What is fill factor ? 8

(*b*) Explain the advantages and limitations of solar cells. Discuss the concept of satellite power station. 6

(*c*) What is solar-hydrogen energy system ? Discuss the importance of this system in the present-day energy scenario. 6

2. (*a*) What are direct and indirect methods of solar energy utilization ? 6

(*b*) Explain flat plate and concentrating solar energy collectors. What is tracking of the concentrator ? 6

(*c*) Discuss, with a neat sketch, the central tower concept of utilizing solar energy in Rankine cycle operation for electricity generation. 8

3. (*a*) What are the three technologies of tapping the energy source of ocean energy ? What is OTEC ? Explain a Rankine cycle OTEC plant with an appropriate schematic diagram. 6

(*b*) Discuss the scope of utilizing ocean wave energy to generate electricity. 4

(*c*) How is tidal energy converted to electrical energy ? What do you mean by schedule and range of a tidal wave ? Discuss different tidal power schemes and configurations with neat sketches. 10

4. (*a*) Explain the functions and use of windmills. How do vertical shaft windmills compare with windmills having horizontal shaft ? 6

(*b*) What is the total power of a wind stream ? What do you mean by coefficient of performance and tip speed ratio of a windmill. On what factors does the performance of windmills depend ? 8

(*c*) How is the power output of wind turbine controlled and utilized ? 6

Group B

5. (*a*) How does a fuel cell operate ? How is it different from a battery ? Explain the hydrogen-oxygen and carbon-oxygen fuel cells. 8

(*b*) Explain the thermodynamics of fuel cell reactions. What is a Faraday ? Discuss the meaning of ideal voltage of a fuel cell. 8

(*c*) Give the applications of fuel cell. What are the advantages of hydrogen as a fuel ? 2 + 2

6. (*a*) What is biomass and how is it formed ? What are biofuels ? What do you understand by thermo-chemical and biochemical conversions ? Explain anaerobic digestion and fermentation. 8

(*b*) What do you understand by an energy farm and an aquatic farm ? 4

(*c*) Explain the functions of the digester and dome with the help of a typical biogas plant. How are animal wastes utilized to produce biogas ? 8

7. (*a*) How is electricity generated by thermoelectric means ? What is figure of merit ? What are the suitable materials for thermoelectric elements ? Mention the advantages of thermoelectric generators. 10

(*b*) Explain geothermal heat as an energy source. Briefly explain different types of geothermal source, namely, hydrothermal, geopressurized and petro-thermal. What is hot dry rock ? How can it be used to produce power ? 10

8. (*a*) Discuss the principle of MHD power generation. Explain the operation of MHD steam power plant. What is the function of an inverter ? Evaluate coal as the MHD fuel. 12

(*b*) What is the principle of thermionic power generation ? Explain the meaning of surface work function and Fermi energy. What is Richardson-Dushman equation ? 8

Group C

9. (A) Answer the following in brief : 4 × 3

(*i*) Nuclear fusion

(*ii*) Benefits of cogeneration systems

(*b*) Savonius

(*c*) Darrieus

(*d*) Both (*b*) and (*c*) above.

(*viii*) The most useful type of material for solar cells is the

(*a*) metal.

(*b*) insulator.

(*c*) semiconductor.

(*d*) Liquid crystal.

S'13 : 2 AN : MC 413 (1503)

NON-CONVENTIONAL ENERGY SYSTEMS

Time : *Three hours*

Maximum Marks : *100*

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Explain the working of distributed collector solar thermal electric power plant, with the help of a schematic diagram. 6

(*b*) Explain the principle of solar drying taking a case of simple cabinet-type solar drier. 6

(*c*) Describe the flat plate collector with the help of a suitable diagram. What are its main advantages ? 8

2. Write notes on the following : 4 × 5

(*i*) Thermal energy storage

(*ii*) Structure of the sun

(*iii*) Solar house

(*iv*) Advantages and limitations of renewable sources of energy.

3. (*a*) What is biomass and how is it found ? What are biofuels ? What do you understand by thermochemical and biochemical conversions ? Explain anaerobic digestion and fermentation. Mention the calorific value of prominent biofuels. 10

(*b*) Describe a community-type Gobar Gas Plant. Also, list the requirements for its operations. 6

(*c*) Explain 'energy farming'. Discuss the availability of biomass in India. 4

4. (*a*) Derive an expression for energy available in wind. 4

(*b*) Differentiate between global (planetary) and local winds. Discuss factors affecting the distribution of wind energy on the surface of the earth. 6

(*c*) Sketch the Horizontal Axis Wind Turbine (HAWT) and Vertical Axis Wind Turbine (VAWT) and explain the function of main components. 10

Group B

5. (*a*) Describe the basic principle of operation of an MHD generator. With the help of schematic diagram, explain the operation of closed cycle MHD generating system. 8

(*b*) What is a fuel cell ? Discuss classification, advantages and applications of fuel cells. Explain the principle of operation of an alkaline fuel cell. 8

(*c*) Comment on the possibilities of hydrogen as a potential energy carrier in future. 4

6. (*a*) What are the basic principle of operation of (*i*) thermionic generator, and (*ii*) thermoelectric generator. Explain clearly with the help of suitable line diagrams. 4 + 4

(*b*) What are the advantages and disadvantages of direct energy conversion system over the conventional power generating system ? Describe the principle of solar photovoltaic energy conversion system. 6

(*c*) Explain how the variation of insolation and temperature affects the *i-v* characteristics of a solar cell. Define energy payback period. 6

7. (*a*) Explain the meaning of (*i*) geothermal energy, and (*ii*) geothermal field. List the merits and limitation of geothermal energy. Explain 'dry-steam hydrothermal system'. 8

(*b*) What is the source of tidal energy ? What is the minimum tidal range required for a practical tidal plant ? How much is the potential in tides ? 6

(*c*) Explain the functioning of modulated single pool tidal system. 6

8. (*a*) Explain thermonuclear fusion and prove that it is the future source of energy. List the main fusion reactions along with the advantages and limitations of fusion energy. 10

(*b*) Explain the two processes of magnetic confinement and inertial confinement used for plasma confinement. 10

Group C

9. Answer the following in brief : 10 × 2

(*i*) Selective surfaces

(*ii*) Solar air heaters

(*iii*) Integrated energy packages

(*iv*) Solar still

(*v*) Environmental impact of OTEC

(*vi*) Sun tracking

(*vii*) Output of a wind turbine with tip speed of the rotor

(*viii*) Internal rate of return (IRR)

(*ix*) Solar cooking

(*x*) Amorphous semiconductors.

W'13 : 2 AN : MC 413 (1503)

NON-CONVENTIONAL ENERGY SYSTEMS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) What are the main advantages of biogas ? What are its constituents ? What are its applications ? 12

   (*b*) What is tip speed ratio ? Explain the variations of power output of a wind turbine with tip speed ratio of different rotors. 8

2. (*a*) The basin area of a single basis type tidal park plant is 25×10^6 m^2. The tidal range is 10 m. The turbine, however, stops operating when the head on it falls below 4 m. Calculate the energy generated in one filling process, if the turbine generator efficiency is 0.7. 12

   (*b*) Explain the characteristics of various types of rotors used in windmills. 8

3. (*a*) Define solar irradiance, solar constant, extra-terrestrial and terrestrial radiations. 8

(*b*) What are the advantages and disadvantages of concentrating collector over flat plate collectors ? Estimate the hot water tank storage capacity and also the collector area required for a hotel hot water requirements which are as follows : 12

No. of rooms	:	80 (120 beds)
% of occupation	:	80%
Hot water demand per person	:	40 litre
Hot water demand in kitchen	:	160 litre
Hot water losses	:	20%
Hot water temperature	:	60 °C
Cold water temperature	:	30 °C
Cp of water	:	1.16 kWh/m^3 °K
Average solar radiation in that location	:	2.5 kWh/day/m^2
Efficiency of collector	:	0.6
Systems efficiency (piping, etc.)	:	0.85

4. (*a*) Describe operating of a non-convective solar pond and explain how it can be used for power generation. 8

(*b*) Explain a solar air heating system using different collector configurations along with their advantages and disadvantages. 12

Group B

5. (*a*) Explain various factors contributing to losses and efficiency reduction in a solar cell. 8

(*b*) Describe the classification of solar cells based on the type of active material used. 12

6. (*a*) Explain the heating and cooling applications of thermoelectric system. Comment on the types of materials used for low and high temperature applications. 8

(*b*) Explain V-I characteristics of fuel cell and explain different losses and measures to reduce the same. 12

7. (*a*) Explain the open cycle OTEC system and discuss its advantages. 8

(*b*) Describe various energy extraction technologies used with hydrothermal resources. 12

8. (*a*) What is meant by 'uranium enrichment' ? Why is it required ? Describe some methods of uranium enrichment. 8

(*b*) A solar pond is to be built in a location where the annual global radiation incident on the pond surface is about 2000 kWh/m^2. The area of the pond is 6000 m^2. The total initial cost of the pond, including associated heat exchange equipment, is Rs. 6,600,000. Assuming an annual collection efficiency of 20%, calculate the energy collected in the pond in one year. If conventional system using oil is used for the same purpose, calculate the amount of oil required per year. Assume a oil heating value of 38000 kJ/litre and an efficiency of 80% for the equipment. Calculate the payback period for the pond assuming a fuel cost of Rs. 6/litre, and a fuel inflation rate of 6%. Assume a discount rate of 9%. 12

Group C

9. Choose the *correct* answer for the following :

(*i*) A pyrheliometer is an instrument which measures

(*a*) beam radiation.

(*b*) diffuse radiation.

(*c*) global radiation.

(*d*) duration of bright sunshine.

(*ii*) The hour angle is an angular measure of time and is equivalent to

(*a*) 5° per hour.

(*b*) 10° per hour.

(*c*) 15° per hour.

(*d*) 30° per hour.

(*iii*) For optimum storage of heat with rocks, small pebbles should be utilized, because it

(*a*) gives large surface area to mass ratio.

(*b*) gives small surface area to mass ratio.

(*c*) increases specific heat.

(*d*) decreases the cost of rocks.

(*iv*) The fill factor for silicon cell may vary from

(*a*) 0.1 to 0.15

(*b*) 0.2 to 0.3

(*c*) 0.35 to 0.5

(*d*) 0.65 to 0.8

(*v*) Sail type windmill has

(*a*) 2 blades.

(*b*) 3 blades.

(*c*) 4 blades.

(*d*) 5 blades.

(*vi*) Tides arise

(*a*) once a day.

(*b*) twice a day.

(*c*) thrice a day.

(*d*) four times a day.

(*vii*) Which one of the following is not a source of power ?

(*a*) Thermocouple

(*b*) PV cell

(*c*) Fuel cell

(*d*) Photoelectric cell

(*viii*) The outermost layer of the earth is

(*a*) magma.

(*b*) mantle.

(*c*) crust.

(*d*) solid iron core.

(*ix*) Boiler water reactors and pressurized water reactors are

(*a*) nuclear reactors.

(*b*) solar reactors.

(*c*) OTEC

(*d*) biogas reactors.

(*x*) Ocean thermal energy is due to

(*a*) energy stored by water in ocean.

(*b*) temperature difference at different levels in the ocean.

(*c*) pressure difference at different levels in the ocean.

(*d*) tides arising out in the ocean.