

H_0 can be obtained from charts or it can be calculated by the equation

$$H_0 = \frac{24}{\pi} I_{sc} \left[\left\{ 1 + 0.033 \cos \left(\frac{360 n}{365} \right) \right\} \left(\cos \phi \cos \delta \sin \omega_s + \frac{2\pi \omega_s}{360} \sin \phi \sin \delta \right) \right]$$

where I_{sc} = Solar constant per hour

δ = Declination

n = Day of the year and

ω_s = Sunrise hour angle = $-\tan \phi + \tan \delta$

1.12. TWO MARK QUESTIONS AND ANSWERS

1. Define: Energy. What are the different forms of energy?

Energy is the capacity for doing work, generating heat and emitting light. It is measured in terms of the total amount of work that the body can do.

The different forms of energy are:

1. Mechanical energy (kinetic and potential)
2. Thermal (or) Heat energy
3. Chemical energy
4. Electrical energy
5. Nuclear energy
6. Electromagnetic energy
7. Gravitational energy.

2. How the energy resources are classified?

(a) Based on nature of availability of energy

- (i) Primary resources
- (ii) Secondary resources

(b) Based on utilisation of energy

- (i) Direct source of energy
- (ii) Indirect source of energy
- (iii) Supplementary source of energy

- (c) Based on traditional use
 - (i) Conventional energy
 - (ii) Non-conventional energy
- (d) Based on long term availability
 - (i) Non-renewable
 - (ii) Renewable
- (e) Based on commercial application
 - (i) Commercial energy source
 - (ii) Non-commercial energy source
- (f) Based on origin
 - (i) Fossil fuels energy
 - (ii) Nuclear energy
 - (iii) Hydro energy
 - (iv) Solar energy
 - (v) Wind energy
 - (vi) Biomass energy
 - (vii) Geothermal energy
 - (viii) Tidal energy
 - (ix) Ocean thermal energy
 - (x) Ocean wave energy.

3. What is meant by primary and secondary energy sources? Give examples.

Primary energy sources can be defined as sources which are either found or stored in nature. These energy sources provide a net supply of energy. Examples: Coal, natural gas, oil, biomass, solar, tidal, hydro and nuclear energy.

Secondary sources of energy are derived from the primary energy sources. Producing electrical energy from coal and producing hydrogen from hydrolysis of water are examples of this type of energy.

4. Write short notes on renewable source of energy.

Renewable energy is the energy obtained from regenerative or virtually inexhaustible sources of energy occurring in the natural environment such as solar energy, wind energy

etc. This type of energy is passing through the environment irrespective of there being a man-made device to intercept and harness the power.

5. Write any four differences between renewable and non-renewable sources.

| S. No. | Renewable sources | Non-renewable sources |
|--------|--|---|
| 1. | Renewable resources are those which can be used again and again. | Non-renewable resources are those which are used only for a limited time and rate. |
| 2. | Renewable resources have a higher rate of decomposition than their rate of consumption. | Non-renewable resources have a lower rate of decomposition than the rate of consumption. |
| 3. | Renewable sources have low carbon emissions. Therefore, they are considered as green and environment friendly. | Non-renewable sources release toxic gases in the air when burnt which are the major cause for global warming. |
| 4. | Examples of renewable resources are: wind, sunlight, tides, biomass, etc. | Examples of non-renewable resources are fossil fuels such as coal, oil and natural gases. |

6. List most common forms of renewable energy sources.

Some of the common forms of renewable energy sources are as follows:

- (a) Solar energy
- (b) Wind energy
- (c) Tidal energy
- (d) Wave energy
- (e) Geothermal energy
- (f) Biomass energy.

7. What advantages and disadvantages of non-conventional energy resources?

Advantages:

- Non-conventional sources are available in nature free of cost
- They produce no or little pollution. Thus, by and large, they are environment friendly.

- They are inexhaustible.
- They have a low gestation period.
- They do not deplete natural resources.
- They can sustain energy supply for many generations.

Disadvantages:

- The energy available is in dilute form from these sources.
- Though available freely in nature, the cost of harnessing energy from a non-conventional source is generally high.
- Availability is uncertain which means that the energy flow depends on various natural phenomena beyond human control.
- Difficulty in transporting such forms of energy.

8. Give a short note on renewable Energy potential in India.

The total potential for renewable power generation in the country as on 31.03.17 was estimated as 1001 GW. The source-wise renewable energy potential in India is as below:

1. Solar power - 649 GW (64.86%)
2. Wind power - 302 GW (30.19%) at 100 m hub height
3. Small hydro - 21 GW (2%)
4. Biomass power – 18.6 GW (1.86%)
5. Bagasse cogeneration – 7.3 GW (0.73%)
6. Waste to energy – 2.6 GW (0.26%)

9. List down the environmental impacts associated with solar power.

- (i) Land use and habitat loss
- (ii) Water use
- (iii) Use of hazardous materials in manufacturing
- (iv) Life-cycle global warming emissions.

10. Mention the applications of solar energy.

1. Passive heating applications.
2. Solar thermal energy applications of medium temperature and high temperature.
3. Solar to electrical energy direct conversion by photo-voltaic cells (PV-cells or solar cells) for low and medium power ratings.
4. Large solar central receiver thermal power plants in MW range.

11. Define: Solar constant.

Solar constant is the amount of energy received in unit time on a unit area perpendicular to the sun's direction at the mean distance of the earth from the sun.

12. Define: Beam radiation and diffuse radiation.**Beam radiation:**

Solar radiation that has not been absorbed or scattered and reaches the ground directly from the sun is called *direct radiation* or *Beam radiation*.

Diffuse radiation:

It is the solar radiation received from the sun after its direction has been changed by reflection and scattering by the atmosphere.

13. Define hour angle.

Hour angle is the angle through which the earth must turn to bring the meridian of a point directly in the line with the sun rays. It is equivalent to 15° per hour.

14. What is Zenith angle?

Zenith angle is a vertical angle between the sun rays and a line perpendicular to the horizontal plane through the point.

It is denoted as θ_z and $\theta_z = \frac{\pi}{2} - \alpha$

where α = solar altitude.

15. What is pyrhelimeter and pyranometer?

Pyrhelimeter is an instrument which measures the beam radiation.

Pyranometer is an instrument which measures the total or global radiation over a hemispherical field of view.

16. What is the use of sunshine recorder?

The duration of bright sunshine in a day is measured by means of a sunshine recorder.

17. Define local apparent time.

The time used for calculating the hour angle ω is the local apparent time. It can be obtained from the standard time observed on a clock by applying two corrections.

18. What is angle of incidence?

Angle of incidence is the angle between the incident beam (I_{bn}) and normal (N) to surface (S). It is shown in Figure 1.17.

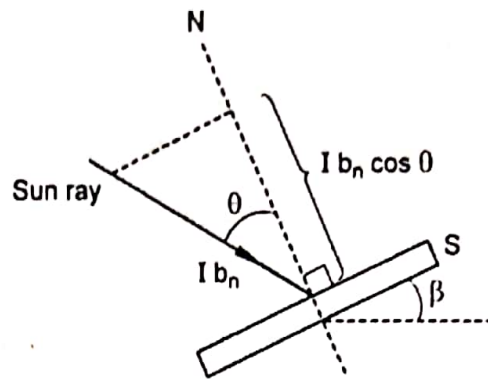


Figure 1.17

19. **What is angle of latitude?**

Angle of latitude is the angle between equatorial plane of earth and line joining the point on the earth's surface and earth's centre.

20. **Explain angle of declination.**

Angle of declination is the angle between the line joining centre of the sun and earth and the equatorial plane.

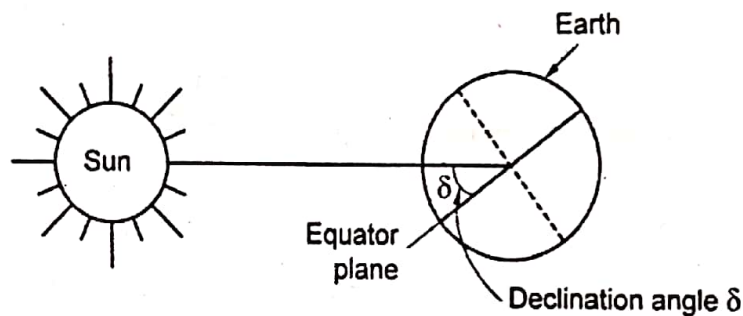


Figure 1.18

21. **What is total radiation?**

Total radiation is the beam and diffuse component of solar radiation which are absorbed in flat plate type collectors.

22. **List down the information contained in solar radiation data.**

Solar radiation data contain the following solar irradiation information:

1. Whether it is measured or computed
2. Whether it is direct, diffuse or global
3. Whether it is hourly, daily or monthly
4. What is the receiving surface orientation? Whether it is incident on a horizontal or inclined surface
5. What is the azimuth of the surface?

6. What is the time or time period of measurement?
7. Whether it is averaged? If so, what is the time period over which it is averaged?
8. What type of instrument is used for measurement?

23. *What are the factors considered in collecting solar radiation data?*

- (a) Solar power calculations with reference to the movement of the sun, latitude of the location etc.
- (b) Hourly measurements of solar radiation at the location and calculation of daily average global radiation for the month, monthly average global radiation for the year and yearly average global radiation for few years.

24. *Name the types of solar radiation data.*

- (a) Typical meteorological year (TMY) data sets
- (b) Solar radiation atlas map.

1.13. SOLVED QUESTIONS

1. Classify sources of energy.

Refer chapter 1.2 in Page 1.2.

2. Write short notes on

(i) Conventional or Non-renewable energy sources.

Refer chapter 1.3.1 in Page 1.4.

(ii) Renewable energy sources

Refer chapter 1.3.2 in Page 1.6.

3. What are the roles of new and renewable energy sources?

Refer chapter 1.4 in Page 1.8.

4. Explain the global potential of renewable energy sources.

Refer chapter 1.5 in Page 1.9.

5. Briefly explain about the renewable energy potential in India.

Refer chapter 1.6 in Page 1.16.

6. Neatly explain the hydroelectric energy resources in India. [Anna Univ. (EEE) May'11]

Refer chapter 1.6.4 in Page 1.21.

2. It provides good efficiency. By concentrating the sunlight, this system can get better efficient than simple solar cells.
3. A larger area can be covered by using relatively inexpensive mirrors rather than using expensive solar cells.
4. Concentrated light can be redirected to a suitable location via, optical fiber cable. For example, illuminating buildings similar to hybrid solar lighting.

Disadvantages:

1. Concentrated collector systems require dual axis sun tracking to maintain the sunlight focus at the collector.
2. Inability to provide power in diffused light conditions. Solar cells are able to provide some output even if the sky becomes cloudy but power output from concentrating systems drop drastically in cloudy conditions as the diffused light cannot be concentrated passively.

2.16. TWO MARK QUESTIONS AND ANSWERS

1. State various characteristic features of a solar collector system.

1. Type of solar collector: Whether focusing or non-focusing.
2. The temperature of working fluid such as low temperature, medium temperature and high temperature.
3. Whether tracking system is used or not. If used, what type of tracking system used i.e. Tracking type or non-tracking type and tracking in one plane or two planes.
4. Cost of the solar collector system such as low cost or high cost.
5. Design of the solar collector system such as complex or simple design.
6. Layout and configuration of collectors in the solar field.

2. What are the important aspects of solar collector system?

1. Concentration ratio (CR)
2. Temperature range
3. Absorption/Reflection ratio (α/ϵ)
4. Collector efficiency.

3. **Define concentration ratio.**

$$\text{Concentration ratio (CR)} = \frac{\text{kW/m}^2 \text{ in solar radiation on surface}}{\text{kW/m}^2 \text{ on surface of focus of collector}}$$

4. **List down the factors affecting solar collectors system's efficiency.**

1. Shadow effect
2. Cosine loss factor
3. Reflective loss factor.

5. **What is collector efficiency?**

$$\text{Collector efficiency} = \frac{\text{Energy collected by the collector (J)}}{\text{Energy incident on the collector (J)}}$$

6. **What is cosine loss factor?**

An important source of 'loss' in solar concentrators arises from the fact that solar collectors cannot always be aligned normal to the incident solar rays. When a collector is reflecting off-axis, the apparent area of the collectors is reduced according to the cosine of the incidence angle. Let us consider θ be the angle between direction of sun rays and plane perpendicular to the collector's surface. The area of sun beam intercepted by the collector's surface is proportional to $\cos\theta$. Therefore, solar power collected is proportional to $\cos\theta$. Here, the term $\cos\theta$ is the *cosine loss factor*.

7. **Define reflective loss factor.**

The collector glass surface and the reflector surface collect dust, dirt and moisture. The reflector surface gets rusted, deformed and loses the shine. Therefore, the efficiency of the collector is significantly reduced with the passage of time. This effect is called *reflective loss factor*.

8. **What are the two types of flat plate type solar collector?**

1. Non-concentrating or flat plate type solar collector.
2. Concentrating (focusing) type solar collector.

9. **State any two advantages and disadvantages of solar air heaters.**

Advantages:

1. It is compact, simple in construction and requires little maintenance.
2. The need to transfer thermal energy from the working fluid to another fluid is eliminated as air is used directly as the working fluid.

Disadvantages:

1. A large amount of fluid is to be handled due to low density. As a result, the electrical power required to blow the air through the system can be significant if the pressure drop is not kept within prescribed limits.
2. Heat transfer between the absorber plate and air is poor.

10. Name the various types of air heaters operated by solar principles.

1. Solar air heater with non-porous absorber.
2. Solar air heater with porous absorber.

11. Write down the applications of solar air heaters.

1. Heating greenhouse buildings
2. Drying agricultural products
3. Heat source for a heat engine
4. Air-conditioning buildings.

12. What are the factors affecting performance of flat plate collectors?

1. Incident solar radiation falling on the solar collector.
2. Number of cover plates.
3. Slope of the flat plate collector which is tilted at an angle of latitude of the location.
5. Spacing between absorber plate and cover plate. Internal heat loss can be prevented by providing more space.
6. Inlet temperature of the working fluid.
7. Dust deposited on the cover which should be minimised for obtaining higher efficiency.

13. Write down the advantages of flat-plate collectors.

1. It has the advantages of using both beam and diffuse solar radiations.
2. It does not require orientation towards the sun.
3. It requires a little maintenance.
4. These collectors are simpler than concentrating reflectors.

14. Mention the disadvantages of flat-plate collectors.

1. The temperature attained by the working fluid is low.

2. The construction is heavy in weight.
3. Conduction heat loss is more as the area is large.
4. Initial installation cost of the collector is more.

15. What are the different applications of flat-plate collectors?

1. It is used in solar water heating systems.
2. It is used in solar space heating and cooling systems.
3. It is used in low temperature power generation.
4. It is used in solar heating dryers.

16. What is heliostat?

'Heliostat' is a large and flat reflecting mirror with a provision to track the sun in two planes. The solar rays are reflected by each individual heliostat onto the central receiver mounted on a tall tower. A central receiver is mounted on a tall tower.

17. What are the different types of concentrating collectors?

1. Line focusing and
2. Point focusing type.

18. What are the main types of concentrating collectors?

1. Parabolic trough collector
2. Mirror strip reflector
3. Fresnel lens collector
4. Flat plate collector with adjustable mirrors.

19. State the advantages of concentrating collectors.

1. The reflecting surface of the concentrating collector requires less material and structurally simpler than flat-plate collectors.
2. The absorber area of a concentrator system is smaller than a flat-plate system.
3. The area from which the heat is lost to surroundings is less than flat-plate collectors.
4. It can be used for electric power generation.

20. What are the disadvantages of concentrating collectors?

1. In concentrating collectors, only the beam component is collected because the diffuse component cannot reflect.

2. Costly orienting systems must be used to track the sun.
3. Additional maintenance is required to retain the quality of reflecting surface against dirt, weather and oxidation.
4. It is non-uniform flux on the absorber whereas the flux in flat-plate collector is uniform.
5. Optical losses and interrupt loss are in energy balance.

21. Differentiate between flat-plate and concentrating collectors.

| S. No. | Concentrating collectors | Flat-plate collectors |
|--------|--|--|
| 1. | Concentrating collectors can absorb only direct solar radiation. | Flat-plate collectors can absorb both direct and diffuse solar radiation. |
| 2. | They need continuous tracking mechanisms and more expensive (pivoting) mounting structure. | These collectors do not require tracking mechanisms and mounting is simple. |
| 3. | They can generate high temperature of about 750°C . | They can generate low temperature of about 140°C . |
| 4. | The amount of heat which can be stored per unit volume is more. | The amount of heat which can be stored per unit volume is less. |
| 5. | They can be used for electric power generation. | They can be used only for heating of domestic water and heating, and cooling of buildings. |
| 6. | The absorber area of a concentrator system is small. | The absorber area of a flat-plate system is big. |

2.17. SOLVED QUESTIONS

1. How is solar energy systems classified? Give brief explanation of these systems.

Refer chapter 2.1 in Page 2.1.

2. Describe the various active solar thermal energy systems commonly used.

Refer chapter 2.1.2 in Page 2.2.

3. List the applications of passive and active solar thermal energy systems.

Refer Table 2.1 in Page 2.5.

calculator for several years between battery changes, making solar calculators less common. In contrast, solar powered remote fixed devices have seen increasing use recently due to increasing cost of labour for connection of main electricity or a regular maintenance programme. In particular, it is used in parking meters, emergency telephones and temporary traffic signs, etc.

3.14. TWO MARK QUESTIONS AND ANSWERS

1. *Name the types of solar energy storage methods.*

1. Thermal energy storage
2. Sorption storage
3. Chemical energy storage.

2. *List down the methods of thermal energy storage.*

- (i) Sensible heat storage
- (ii) Latent heat storage
- (iii) Stratified storage.

3. *Briefly explain the principle of sensible heat storage.*

In Sensible Heat Storage (SHS), thermal energy is stored by raising the temperature of a solid or liquid by using its heat capacity. SHS system utilizes the heat capacity and the change in temperature of the material during the process of charging and discharging. The amount of heat stored depends on the specific heat of the medium, temperature change and amount of storage material.

4. *State the advantages of rocks for solid sensible heat storage.*

- (a) Rocks are not toxic and non-flammable
- (b) Rocks are inexpensive
- (c) Rocks act both as heat transfer surface and storage medium
- (d) The heat transfer between air and a rock bed is good due to the very large heat transfer area and the effective heat conductance of the rock pile is low due to the small area of contact between rocks.

5. *What is the basic principle of latent heat storage?*

Latent heat storage uses the latent heat of the material to store thermal energy. Latent heat is the amount of heat absorbed or released during the change of the material from one phase to another phase.

6. **Classify Phase Change Materials (PCM).**

- (i) Organic PCM (paraffin, fatty acids)
- (ii) Inorganic PCM (hydrates, molten salts, metal) and
- (iii) Eutectic PCM (organic-organic, organic-inorganic, inorganic-inorganic compounds).

7. **What are the advantages of latent heat storage?**

- (i) It includes large density of heat storage and constant temperature.
- (ii) The process is completely reversible and it can be repeatedly utilized without degradation.

8. **Define stratification.**

Stratification is defined as a natural process in which both warmth and density of water are inversely proportional properties. The warm water will always settle on the top of cold water. The process takes place in a stratified thermal energy storage tanks in terms of two operations such as charging and discharging.

9. **Write down the advantages of stratified heat storage.**

1. **Energy efficiency:**

TES tanks are able to minimize energy loss and save the peak energy capacity due to use of measurement technologies which ensure charging and discharging cycles reliable.

2. **Optimum process:**

It has a unique load curve that determines the charge and discharge rates as well as the energy capacity of the system. To serve a wide range of applications, ARANER tanks are available in different shapes and sizes.

3. **Reliable material:**

The tanks are made with corrosion resistant material. Mainly, the material is capable of maintaining the stratification for long periods. Also, its thermal insulation properties are excellent.

10. **What are the factors to be considered while selecting the method of storage?**

- (i) The temperature range, over which the storage has to operate.
- (ii) The capacity of the storage has a significant effect on the operation of the rest of the system. A smaller storage unit operates at a higher mean temperature. This results in a reduced heat transfer equipment output as compared to a system having

a larger storage unit. The general observation which can be made regarding optimum capacity is that "short-term" storage units which can meet fluctuations over a period of two or three days have been generally found to be the most economical for building applications.

- (iii) Heat losses from the storage have to be kept to a minimum. Heat losses are particularly important for long-term storage.
- (iv) The rate of charging and discharging.
- (v) *Cost of the storage unit*: It includes the initial cost of the storage medium, containers and insulation, and operating cost.

11. What is solar pond?

Solar pond, also called *solar salt pond*, is an artificially designed pond filled with salty water maintaining a definite concentration gradient. It combines both solar energy radiation and sensible heat storage and it is also utilized for collecting and storing solar energy.

12. Sketch the solar pond and name different zones.

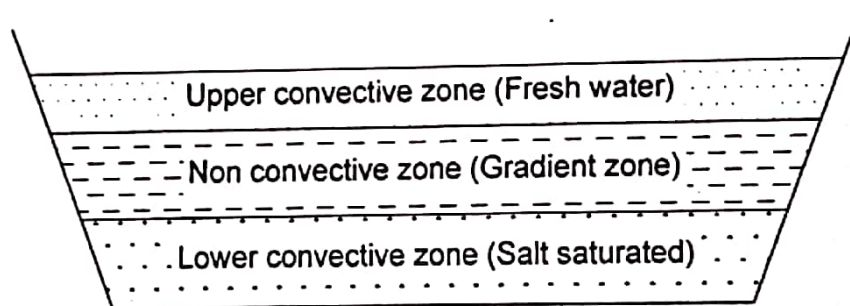


Figure 3.38 Convective zones in solar pond

13. List down the factors in determining the optical transmission properties and collection efficiency of solar ponds.

- (i) Salt concentration.
- (ii) The quantity of suspended dust or other particles.
- (iii) Surface impurities like leaves or debris, biological material like bacteria and algae.
- (iv) The type of salt.

14. What are the applications of solar pond?

1. Power generation
2. Space heating and cooling

3. Crop drying
4. Desalination
5. Process heat.

15. State any four advantages and disadvantages of solar pond.

Advantages of solar ponds:

- (i) It provides low investment costs per installed collection area.
- (ii) Thermal storage is incorporated into the collector and it is of very low cost.
- (iii) Diffuse radiation (cloudy days) is fully used.
- (iv) Very large surfaces can be built, thus, large scale energy generation is possible.

Disadvantages of solar ponds:

- (i) Although solar ponds are simple to construct, they are costly in terms of energy efficiency. The maximum theoretical efficiency of a solar pond is 17% when it is operated between 80°C and 20°C.
- (ii) It needs large land area to function properly.
- (iii) The accumulated salt crystals have to be removed periodically and it adds maintenance expense.
- (iv) It can be only operated only operate in sunny days and if the site is shaded by tall trees or building, it may not work properly.

16. Name the components of a solar water heater.

- (i) A flat plate collector to absorb solar radiation and convert it into thermal energy.
- (ii) Storage tank to hold water for use and cold water feeding the flat plate collector.
- (iii) Connecting pipes inlet and outlet for feeding cold water from the storage tank and taking hot water to the storage tank or point of use.

17. What do you mean by solar direct thermal applications?

Direct thermal applications involve the direct use of heat, thereby resulting from the absorption of solar radiation for space heating and cooling of residences and other buildings, to provide hot-water for such buildings, and to provide heat for agricultural, industrial and other processes that require only moderate temperatures.

18. What is passive solar heating?

Passive solar energy technologies absorb solar energy, store and distribute it in a natural manner without using mechanical elements and also use natural ventilation.

19. *Classify solar cooker.*

- (i) Flat plate box type solar cooker with or without reflector
- (ii) Multi reflector type solar cooker
- (iii) Parabolic disc concentrator type solar cooker.

20. *List down the methods of solar drying.*

- (i) Open sun drying
- (ii) Direct solar drying
- (iii) Indirect solar drying.

21. *Mention the advantages of solar distillation.*

- (i) Low energy consumption
- (ii) No fuel required
- (iii) Low maintenance cost
- (iv) No pollution
- (v) Simple design.

22. *State the advantages of vapour absorption solar cooling system.*

- (1) It is compact and less bulky. Hence, less space is required for installation.
- (2) It has no moving part except the motor driven pump and hence, it produces less wear.
- (3) It is quiet in operation and it has less moving parts.
- (4) Less maintenance is required.

23. *What is a solar cell?*

[Anna Univ. (EEE) May'12 & Dec'12]

Solar cell is a device which directly converts the energy of light into electrical energy through the process of photovoltaic effect.

24. *What is the efficiency of a solar cell?*

$$\text{Efficiency of a solar cell} = \frac{\text{Electrical power output}}{\text{Power intercepted}}$$

25. *What are the components of photo-voltaic system?*

1. Solar cell array
2. Load leveler

3. Storage system
4. Tracking system.

26. *What are the applications of solar photovoltaic system?*

1. Water pumping sets for micro irrigation and drinking water supply.
2. Weather monitoring.
3. Railway signaling equipment.

27. *State the advantages of photovoltaic solar energy conversion.*

1. It does not need moving parts.
2. It is highly reliable.
3. It is a long effective life.
4. It does not create pollution.

28. *What are the disadvantages of solar energy conversion?*

1. It is costly.
2. It requires energy storage.
3. It needs no insolation at night.

29. *What are the three different types of 'Homojunction' PV cells?*

1. Amorphous silicon
2. Poly crystalline silicon
3. Single crystal silicon.

30. *What is 'crystal growing'?*

Crystals have highly ordered atomic and molecular structure. The process of converting poly-crystalline silicon to the single crystal silicon is called '*crystal growing*'.

31. *What are the different types of PN junction?*

1. Cadmium-sulphide
2. Gallium-arsenide
3. Zinc-sulphide
4. Gallium-antimonide.

with annual escalation of 5.72% (from second year) on plant and machinery by reckoning 85% of the capital cost as the cost of plant and machinery. Gross Calorific Value (GCV) is in the range of 3100 - 3600 kcal/kWhr. Specific fuel consumption is a function of GCV, the specific fuel consumption works out to 1.20 kg/kWhr. Fuel cost as prescribed by the government as on 17-04-2017 is at Rs.2892.03/MT with 5% escalation p.a.

4.28. TWO MARK QUESTIONS AND ANSWERS

1. *What is wind energy?*

Wind energy is an indirect form of solar energy. Wind power is the conversion of wind energy into a useful form of energy such as using wind turbines to make electricity, windmills for mechanical power, wind pumps for water pumping or drainage or sails to propel ships.

2. *Write down the applications of wind power.*

- (a) Wind turbines are used to generate electricity
- (b) Windmills are used for producing mechanical power
- (c) Wind pumps are used for water pumping or drainage
- (d) Wind power is used in sails to propel ships.

3. *Mention the characteristics of wind energy.*

- (i) Wind-power systems do not pollute the atmosphere.
- (ii) Fuel provision and transport are not required in wind-power systems.
- (iii) Wind energy is a renewable source of energy.
- (iv) Wind energy when produced on small scale is cheaper but competitive with conventional power generating system when produced on a large scale.

4. *Define wind shear.*

The wind speed varies with the height above the ground. It is called *wind shear*.

5. *What is wind power density?*

A yardstick frequently used to determine good locations is referred as *Wind Power Density (WPD)*.

6. *What is meant by wind turbine?*

A *wind turbine* is a rotating machine which converts the kinetic energy of wind into mechanical energy.

7. **Define capacity factor.**

The ratio between actual productivity in a year and theoretical maximum is called *capacity factor*. Typical capacity factors are 20-40%.

$$\text{Capacity factor} = \frac{\text{Actual productivity in a year}}{\text{Theoretical maximum productivity in a year}}$$

8. **How will you define wind energy penetration?**

Wind energy penetration is defined as the fraction of energy produced by wind from the total available generation capacity.

9. **Mention various advantages of wind power.**

- (a) Wind power emits absolutely no greenhouse gases. Therefore, there is no pollution.
- (b) Wind is obtained at free of cost.
- (c) Wind power is helpful in supplying electricity to remote areas.
- (d) Wind energy itself is both renewable and sustainable. The wind will never run out.
- (e) The potential of wind power is enormous i.e. 20 times more than what the entire human population needs.

10. **What are the disadvantages of wind power?**

- (a) Wind is a fluctuating (intermittent) source of energy and it is not suited to meet the base load energy demand.
- (b) Wind energy requires some form of energy storage e.g. batteries, pumped hydro.
- (c) The manufacturing and installation of wind turbines require heavy investments.
- (d) Wind turbines can be a threat to wildlife (e.g. birds, bats).
- (e) Some wind turbines tend to generate a lot of noise which can be unpleasant.

11. **Define Betz limit of a wind turbine.**

Betz limit is the theoretical limit assigned to efficiency of a wind turbine.

12. **What is meant by stalling?**

If the air pressure increases on the low pressure side, enormous turbulence is produced which reduces the lift force and it leads to increase the drag significantly called *stalling*.

13. **State the characteristics of lift and drag.**

- (a) Drag is in the direction of airflow.
- (b) Lift is perpendicular to the direction of airflow.

- (c) Generation of lift always causes a certain amount of drag to be developed with a good aerofoil.
- (d) The lift produced can be thirty times greater than drag.
- (e) Lift devices are generally more efficient than drag devices.

14. What are the components of wind energy system?

- Wind turbine which consists of Nacelle, Rotor i.e. the assembly of blades, and Hub and shaft.
- Transmission system
- Electric generator
- Yaw control system
- Storage
- Energy converters
- Tower to support the rotor system.

15. List any four advantages of wind turbine.

[Anna Univ. Dec'10]

- (i) Wind industry developers and manufacturers make a lot of money by investing them due to government subsidies and cash incentives.
- (ii) They make the environmentalists happy may be because man is finally punished against the earth.

16. Mention any four advantages of HAWT.

- (i) Variable blade pitch gives the turbine blades the optimum angle of attack.
- (ii) The tall tower base allows the access to stronger wind in sites with wind shear.
- (iii) It produces high efficiency since the blades always move perpendicularly to the wind which receives power through the whole rotation.
- (iv) The face of a horizontal axis blade is struck by the wind at a consistent angle regardless of the position in its rotation.

17. State any four disadvantages of HAWT.

- (i) Massive tower construction is required to support heavy blades, gearbox and generator.
- (ii) Reflections from tall HAWTs may affect side lobes of radar installations creating signal clutter although filtering can suppress it.

- (iii) Their height makes them obtrusively visible across large areas, disrupting the appearance of the landscape and sometimes, creating local opposition.
- (iv) Downwind variants suffer from fatigue and structural failure caused by turbulence when a blade passes through tower's wind shadow.

18. *Classify vertical axis wind turbine based on blade profile.*

- (i) Multiple blade type
- (ii) Savonius type
- (iii) Darrieus type.

19. *Write down any two advantages and disadvantages of VAWT.*

Advantages:

- (i) VAWTs may be built at locations where taller structures are prohibited.
- (ii) VAWTs situated close to the ground can take the advantage of locations where hilltops, ridgelines and it passes funnel the wind. It increases the wind velocity.

Disadvantages:

- (i) The stress in each blade due to wind loading changes sign twice during each revolution as the apparent wind direction moves through 360° .
- (ii) While VAWTs' parts are located on the ground, they are also located under the weight of the structure above it which can make changing out parts nearly impossible without dismantling the structure if not designed properly.

20. *List down the parameters considered in designing wind turbine rotors.*

- 1) Solidity
- 2) Tip-speed ratio
- 3) Performance coefficient
- 4) Torque
- 5) Rotor power control.

21. *Define solidity.*

Solidity is defined as the percentage of the circumference of the rotor which contains the material instead of air.

22. *What is tip-speed ratio?*

Tip-speed ratio is defined as the ratio of the speed of the blade tip of a wind mill rotor to the speed of the free wind. It is a measure to know the gearing ratio of the rotor.

23. Define performance coefficient related to wind machine.

The performance coefficient (C_p) is a function of tip speed ratio which is normally used to classify the rotor.

$$C_p = \frac{\text{Power delivered by the rotor}}{\text{Maximu power available in the wind}}$$

C_p does not exceed 0.593 for horizontal axis wind machine.

24. Write down the characteristic of wind speed.

- (i) *Cut-in wind speed*: The speed at which the machine begins to produce power.
- (ii) *Design wind speed*: The speed at which the windmill reaches its maximum efficiency.
- (iii) *Rated wind speed*: The speed at which the machine reaches its maximum output power.
- (iv) *Furling wind speed*: The speed at which the machine furls to prevent damage at high wind speeds.

25. Classify wind power plants.

- (i) Remote wind power plant
- (ii) Hybrid wind power plant
- (iii) Small wind turbine
- (iv) Grid connected wind power plant
- (v) Wind farm.

26. Mention the sites selected to install wind mills.

- (i) Plane sites
- (ii) Hill top sites
- (iii) Sea-shore sites
- (iv) Off-shore shallow water sites.

27. What do you understand by zero energy houses?

[Anna Univ. June'13]

A zero-energy building is also known as a zero net energy (ZNE) building or net-zero energy building (NZEB). It refers to a building with zero net energy consumption and zero carbon emissions annually.

30. **What is biomass and biomass energy?**

Biomass is organic matter produced by plants, both terrestrial (those grown on land) and aquatic (those grown in water). E.g., Wood and Agriculture residues. The energy obtained from biomass is called *biomass energy*.

31. **What are the two major classifications of biomass resources?**

1. Biomass from cultivated fields, crops, forests and harvested periodically.
2. Biomass derived from waste e.g., municipal waste, animal dung, forest waste, agricultural waste and bioprocess waste.

32. **What is the scope of biomass energy?**

1. Rural application of biomass energy
2. Urban and industrial applications of biomass energy
3. Biomass as a primary source for large scale electrical power generation.

33. **Define photosynthesis.**

Photosynthesis converts solar energy into biomass energy. It consists of building up of simple carbohydrates such as sugar in the green leaf in the presence of sunlight.

34. **What are the necessary conditions for photo-synthesis process?**

1. **Light:** It is one of the important inputs for biomass production.
2. **CO₂ concentration:** It is the primary raw material for photo synthesis.
3. **Temperature:** Photosynthesis is restricted to the temperature range 0°C to 60°C.

35. **What are the different types of biomass waste?**

- (i) Urban waste
- (ii) Process waste
- (iii) Agricultural waste
- (iv) Forest waste
- (v) Fishery and poultry
- (vi) Animal and human excreta.

36. **Mention the advantages of bioenergy.**

1. It is a renewable source.

2. The pollutant emissions from combustion of biomass are usually lower than fossil fuels.
3. Commercial use of biomass may avoid or reduce the problems of waste disposal in other industries.
4. Use of biogas plants apart from supplying clean gas also leads to improved and stabilized sanitation.
5. The forestry and agricultural industries which supply feed stocks also provide substantial economic development opportunities in rural areas.
6. The energy storage is an in-built feature of it.

35. What are the disadvantages of bio energy?

1. It is dispersed and land intensive source.
2. It is often of low energy density.
3. It is also labour intensive and the cost of collecting large quantities of biomass for commercial application is significant.

36. List down the various biofuels.

1. Fuel wood
2. Charcoal
3. Fuel pellets
4. Bio-ethanol
5. Bio gas
6. Producer gas
7. Vegetable oils (bio-diesel).

37. What are the major categories of biomass conversion process?

1. Direct combustion (Incineration)
2. Thermo chemical conversion.
3. Biochemical conversion.

38. What are briquetting and pelletisation?

Briquetting is the process of compressing balings. Densification is carried out by compression under a die.

Pelletisation is a process in which wood is compressed and extracted in the form of rods (5–12 mm diameter and 12 mm long).

39. **What is carbonization?**

Wood is heated with a restricted air flow to form a high carbon product by removing volatile materials from. It is termed as *carbonisation*.

40. **What is fermentation?**

It is the breakdown of complex molecules in organic compound under the influence of ferment such as yeast, bacteria, enzymes, etc.

41. **What is meant by gasification?**

Gasification of biomass is thermal decomposition in the presence of controlled air. It is the conversion process of solid carbonaceous fuels into combustible gas mixtures known as *producer gas*. It is also referred to as *wood gas*, *water gas* and *synthesis gas*.

42. **What does steam gasification refer?**

Methane is directly produced from woody matter by treating them at high temperature and pressure with hydrogen gas.

43. **Define liquefaction.**

Liquefaction is the process of maximizing liquid yields by rapid heating of feed stock to comparatively low temperature.

44. **Mention the two processes of liquefaction of biomass.**

- (a) Liquefaction through pyrolysis without any gasification medium and
- (b) Liquefaction through methanol synthesis with gasification medium.

45. **Define anaerobic digestion.**

Anaerobic digestion is a type of biochemical conversion involving microbial digestion of biomass. It generates methane and CO₂ gas.

46. **How does anaerobic digestion take place?**

It is the process of making complete digestion of a biomass. It is applicable to wet organic matters. The process involves microbial digestion of biomass. An anaerobe is a microorganism which lives and grows on biomass at low temperature (< 65°C).

47. **List down the phases involved in anaerobic digestion.**

- (i) Hydrolysis
- (ii) Acid phase and
- (iii) Methane phase.

48. What do you mean alcoholic fermentation?

Alcoholic fermentation or ethanol fermentation is the decomposition of biomass in the absence of air and simple hexose sugars ($C_6H_{12}O_6$) in aqueous solution by the action of enzyme present in yeast in acidic conditions.

49. What is gasifier?

Gasifier is the equipment which can gasify a variety of biomass such as wood waste, agricultural waste, such as stalks and roots of various crops, maize cobs, etc.

50. What are the advantages of a gasifier?

1. It is very easy to operate the gasifier.
2. Maintenance is easy.
3. It is reliable in operation.

51. What are the three major designs of fixed bed gasifiers?

1. Updraft gasifiers
2. Downdraft gasifiers
3. Cross-draft gasifiers.

52. What is equivalence ratio?

$$\text{Equivalence ratio (ER)} = \frac{\text{Weight of oxygen/Weight of dry fuel}}{\text{Weight of oxygen/Weight of dry fuel}}$$

53. What are the advantages of fluidized bed gasifiers?

1. It has good heat storage capacity.
2. Consistent rate of combustion is obtained.
3. Output rate is high.

54. Define biogas.

Biogas is a gaseous fuel obtained from biomass by the process of anaerobic digestion (Fermentation).

55. What is the average composition of biogas?

| | | |
|---------------------------|---|-----------|
| Methane (CH_4) | – | 55 to 60% |
| Carbon dioxide (CO_2) | – | 35 to 40% |
| Hydrogen (H_2) | – | 5% |
| H_2S and O_2 | – | Traces. |

56. **State the advantages of anaerobic digestion.**

1. It can be used as an energy source to produce steam and water.
2. New sludge production occurs because of the conversion of organic matter to methane and CO_2 .
3. It has low running cost.
4. It produces less odour.
6. The sludge can act as a soil conditioner.

57. **List down the factors affecting anaerobic digestion.**

1. pH concentration
2. Total solid content
3. Seeding
4. Temperature
5. Loading rate
6. Type of feed
7. Pressure
8. Nutrients
9. Diameter to depth ratio
10. Mixing of the content
11. Retention time or rate of feeding
12. Carbon to nitrogen ratio.

58. **Classify biogas plants.**

1. Continuous and batch types
2. Dome and drum types
3. Different variations in the drum type.

59. **What are the main features of continuous process biogas?**

1. It requires small digestion chambers.
2. It will continuously produce gas.
3. It has fewer problems compared to a batch type.
4. It needs lesser period of digestion.

60. **What is gobar gas?**

Biogas produced from cow dung in a plant is called *biogas*. It is used in cooking, lighting, running diesel engines and fuel for furnaces.

61. **What are the main features of the batch type gas plant?**

1. The gas production is intermittent.
2. It needs several digesters.
3. Batch type plants are good for long fibrous materials.

62. What are the materials used for bio-gas generation?

1. Animal wastes
2. Human wastes
3. Agricultural wastes
4. Waste of aquatic origin.

63. What is hydrolysis?

Hydrolysis is the technology which converts cellulose into alcohols through fermentation.

64. What are the advantages of fixed dome type digester?

1. It has no corrosion trouble.
2. It requires less cost compared to a floating drum type.
3. Cattle, human excreta and long fibrous stalks can be fed.
4. It does not need maintenance.

65. List down the disadvantages of fixed dome type digester.

1. Gas production per m^3 of the digester volume is also less.
2. It produces a variable gas pressure.
3. It requires skilled masons.
4. Scum formation is a problem if no stirring arrangement is made.

66. Mention the advantages of floating drum digester.

1. It has less trouble because solids are constantly submerged.
2. It has no problem of gas leakage.
3. Higher gas production per m^3 of the digester volume is achieved.
4. Constant gas pressure is obtained.

67. State the disadvantages of floating drum digester.

1. It is not suitable for colder regions because of heat lost through the metal holder.
2. It has higher cost.
3. It requires painting once or twice a year depending on the humidity of the location.
4. It requires maintenance in flexible pipe joining area and main gas pipe.

68. Compare floating drum digester with fixed-dome digester.

| S. No. | Floating gasholder type | Fixed-dome type |
|--------|---|--|
| (i) | Gas is released at constant pressure. | Gas is released at variable pressure. |
| (ii) | Identifying the defects in gas holder easy. | Identifying defects is difficult. |
| (iii) | Cost of maintenance is high. | Cost of maintenance is low. |
| (iv) | Capital cost is high. | Capital cost is low (for same capacity). |

69. Define gas yield.

Biogas yield is the amount of volatile matter destroyed or the portion of the volatile matter content which is capable of being decomposed within a comparatively short time.

70. Mention the factors considered for selection of size of a biogas plant.

1. Distance
2. Open space
3. Seasonal run off water
4. Distance from wells
5. Water table
6. Space requirements
7. Availability of water.

4.29. SOLVED QUESTIONS

1. Write short notes on the following:

(i) Source of wind

Refer chapter 4.1.1 in Page 4.2.

(ii) Wind energy potential.

Refer chapter 4.2 in Page 4.4.

2. What is a Betz criterion? Show that the maximum efficiency of a wind turbine is 59.3%.

Refer chapter 4.6.2 in Page 4.10.

3. Write a short note on the principle of wind energy conversion systems.

Refer chapter 4.7 in Page 4.13.

4. Discuss the various components of wind energy system.

Refer chapter 4.8 in Page 4.16.

Based on T - s diagram, it can be written as

- In process 1-2, change in temperature, $\Delta T = 0$
- In process 2-3, change in entropy, $\Delta S = 0$ due to $\Delta q = 0$
- In process 3-4, change in temperature, $\Delta T = 0$
- In process 4-1, change in entropy, ΔS due to $\Delta q = 0$.

15. ADVANTAGES OF DEC

- (i) Direct energy conversion is rapid process.
- (ii) It produces large amount of energy in less time.
- (iii) Maintenance is easy.
- (iv) It provides environment friendly.
- (v) It is more compactible and less weight.
- (vi) Reliability is more.
- (vii) Operation is noiseless.

16. TWO MARK QUESTIONS AND ANSWERS

1. *What is geothermal energy?*

Geothermal energy is the heat from high pressure steam coming from within the earth. It is a renewable source of energy derived from the rain water in the earth heated to over 180°C by subterranean hot rocks.

2. *What are the applications of geothermal energy?*

- (a) Generation of electric power
- (b) Space heating for buildings
- (c) Industrial process heat.

3. *List some geothermal fluids.*

- (a) Hot water
- (b) Hot brine
- (c) Wet stream
- (d) Combination of above.

4. *What are the forms of geothermal energy stored deeply inside the earth?*
- Hot water springs
 - Fumaroles
 - Volcanic eruptions.
5. *What are the important criteria while selecting the geothermal energy?*
- Temperature of geothermal fluid, °C.
 - Discharge rate, m^3/day
 - Useful life of production well, years
 - Mineral contents $gram/m^3$.
6. *What are the different types of geothermal energy deposits?*
- Hydro-geothermal energy resources
 - Petro-geothermal energy deposits
 - Hot-dry rock.
7. *Classify geothermal electrical power plants.*
- According to geothermal energy resource
 - Geothermal steam
 - Geothermal brine
 - Geothermal hot water
 - Hot rock.
 - According to thermodynamic cycle
 - Steam turbine cycle
 - Binary cycle
 - Total flow concept.
8. *List down the advantages of geothermal energy over other energy forms.*
- It is versatile in its use and reliable source of energy.
 - It is cheaper as compared to energies obtained from other sources both zero fuels and fossil fuels.
 - It delivers a greater amount of net energy from its system than other alternative or conventional systems.
 - It has the highest annual load factor of 90% as compared to conventional plants.

9. What are the disadvantages of geothermal energy over other energy forms?

1. Overall efficiency for power production is low about 15% when compared to 35-40% for fossil fuel plants.
2. The steam and hot water gushing out of the earth may contain H_2S , CO_2 , NH_3 and radon gas, etc. These gases are to be removed by chemical action before they are discharged.
3. Drilling operation is noisy.
4. Large area is required for the exploitation of geo-thermal energy as much diffused.

10. What are the applications of geothermal energy?

1. Generation of electric power
2. Industrial process heat and
3. Space heating for various kinds of buildings.

11. What are magma resources?

In some cases, especially in the vicinity of relatively recent volcanic activity molten or practically molten rock occurs at moderate depth. Very high temperature above $650^\circ C$ and large volume make magma a substantial geothermal resource.

12. What is the principle of OTEC?

The ocean water gets heated up naturally due to solar radiation. The temperature of water near surface is higher than deep water. Significant amount of heat can be extracted from ocean water by ocean thermal gradient principle of thermodynamics.

13. What are the different types of OTEC cycles?

- a) Open cycle (Claude cycle, Steam cycle)
- b) Closed cycle (Anderson cycle, Vapour cycle).

14. How can be the efficiency increased slightly with modified open cycle OTEC system?

- i) Controlled *flash-steam evaporator* is used instead of a conventional type of evaporator
- ii) Contact condenser is replaced by a surface condenser.
- iii) The open cycle OTEC can be used as a co-generation cycle to produce both electrical power and fresh water.

15. What are the limitations of open cycle OTEC system?

1. Turbine is physically large.
2. The cost of plant is high.
3. It can allow a very large flow of ocean water in terms of mass and volume.

16. List down the components of closed cycle OTEC system.

1. Evaporator
2. Vapour turbine (Turbogenerator)
3. Vapour condenser
4. Liquid pressuriser.

17. What are the working fluids in closed cycle OTEC?

- a) Ammonia (NH_3)
- b) Freon
- c) Butane.

18. Name the main materials used for manufacturing OTEC heat exchangers.

- (i) Titanium
- (ii) Aluminium
- (iii) Copper-nickel alloy
- (iv) Graphite
- (v) Plastics.

19. Define anti-fouling.

Anti-fouling is the process of removing the accumulation or preventing its accumulation.

20. List down the factors considered for locating OTEC power plants.

- (i) During continuous power generation, the large flow of hot and cold water might change the local and global environment.
- (ii) Carbon dioxide present in the deep sea water might be released suddenly while pumping and heated in the evaporator. The releases of carbon dioxide will deaerate the sea water before entering into the evaporator.
- (iii) There may be a possibility that biota including eggs, larvae and fish could be entertained and destroyed due to intake and expulsion of large volumes of water. Also, OTEC plant might affect the life of sea animals.

- (iv) Release of large quantities of cold water into warmer surface environment will also have biological effects.

21. Mention the advantages of OTEC.

- (i) Power from OTEC is continuous, renewable, pollution free and environmentally friendly.
- (ii) Unlike other forms of solar energy, output of OTEC shows very little daily or seasonal variation. OTEC power plants can produce electricity 24 hours a day or 365 days a year.
- (iii) Drawing of warm and cold sea water and returning of the sea water, close to the thermocline, could be accomplished with minimum environment impact.
- (iv) Electric power generated by OTEC could be used to produce hydrogen.

22. State the disadvantages of OTEC.

- (i) Capital investment is very high.
- (ii) Seasonal variations and natural calamities affect OTEC performance.
- (iii) Due to small temperature difference in between the surface water and deep water, the conversion efficiency is very low about 3-4%.
- (iv) Low efficiency of these plants coupled with high capital cost and maintenance cost makes them uneconomical for small plants.

23. What are the applications of OTEC?

- (i) Open cycle OTEC plant is used to produce desalinated water which is mainly used for irrigation and human consumption.
- (ii) A closed cycle OTEC plant is used as a chemical treatment plant.
- (iii) The deep sea water can be used in refrigeration and air conditioning systems mainly in offshore Industries. In majority of the air conditioning plant, open cycle OTEC is used. The release of used working fluid will be in the sea itself.
- (iv) The power generated by OTEC plants can be used in hydrogen production through water electrolysis process.

24. What is the basic principle of tidal power generation?

Tides are produced mainly by the gravitational attraction of moon and sun on the water of solid earth and oceans. About 70% of the tide producing force is due to the moon and remaining 30% is due to the sun.

25. Define the term range of tide.

Range is the difference between high and low water levels denoted by R .

$$R = \text{Water elevation at high tide} - \text{Water elevation at low tide.}$$

26. What are spring tides?

If the tide's range is maximum, it is called *spring tide*. These spring tides are called *high tides*.

27. What is meant by neap tide?

When the moon is at first quarter or third quarter, the sun and moon are separated by 90° when viewed from the Earth and the solar gravitational force partially cancels the moon. At these points in the lunar cycle, the tide's range is minimum called *neap tide*.

28. List down the types of tidal energy technologies.

- (a) Tidal barrages
- (b) Tidal stream generators
- (c) Dynamic tidal power.

29. What are the components of tidal power plants?

1. Dam or dyke
2. Sluice ways
3. Embankments
4. Power house.

30. What are the modes of operation of tidal barrage power plants?

- (a) Ebb generation
- (b) Flood generation
- (c) Two-way generation
- (d) Pumping and turbining.

31. How can the generation of power be achieved in a single basin arrangement?

The power generation in a single basin arrangement can be achieved by any one of the following systems.

- a) Single ebb-cycle system
- b) Single tide-cycle system
- c) Double cycle system.

32. *Classify tidal stream generator support structures.*

- (a) Gravity structures
- (b) Piled structures
- (c) Floating structures.

33. *Mention the major types of tidal stream generators.*

- (a) Axial turbines
- (b) Vertical and horizontal axis cross flow turbines
- (c) Helical turbine.

34. *Name the types of turbines used in tidal power stations.*

- (a) Bulb turbine
- (b) Rim turbine
- (c) Tubular turbine.

35. *State any four site requirements for tidal power plant erection.*

- (i) Short length of dam is to create a basin of reasonable storage. It is possible at a narrow inlet to an estuary of bay.
- (ii) It should be near the local location or near the ocean.
- (iii) It should be protected from high waves.
- (iv) It should not hamper shipping traffic.

36. *What are the advantages of tidal power generation?*

- (a) Tidal power is in exhaustible.
- (b) Free from pollution.
- (c) These power plants do not demand large area of valuable land.

37. *What are the limitations of tidal power generation?*

- (a) The tidal ranges are highly variable and thus, the turbines have to work on a wide range of head variation.
- (b) Construction in sea is found difficult.
- (c) Cost is not favourable when compared to other sources of energy.

38. *Define wave energy.*

Wave energy is energy of interchanging potential and kinetic energy in the wave.

39. List down the parameters involved wave data collection.

- (i) Height of the wave
- (ii) Period of wave
- (iii) Energy period
- (iv) Energy density
- (v) Power density
- (vi) Power per unit width.

40. What are wave energy converters?

The technologies developed to generate energy from waves and currents called *hydrokinetic energy conversion devices* are generally categorized as either *Wave Energy Converters* (WECs).

41. Mention the various wave energy devices used in converting wave power into electric power.

- (a) Wave profile devices
- (b) Oscillating water columns
- (c) Wave capture devices
- (d) Rotating wave devices.

42. Define the following terms: point absorber and linear absorber.

If the physical size of the wave profile device is very small as compared to the periodic length of the wave, this type of wave energy device is called "*point absorber*".

If the size of the device is larger or longer than the typical periodic wavelength, it is called "*linear absorber*".

43. What is called water collector?

An *Oscillating Water Column* (OWC) has a partially submerged structure which opens to the ocean below the water surface. This structure is called *wave collector*.

44. Mention the advantages of wave energy.

- (a) The wave energy naturally concentrated by accumulation at all times, space and transported than wind and solar energies.
- (b) Wave conditions are predictable and hence, the energy is also predictable.
- (c) Wave from transportation across a plane perpendicular to the wave propagation direction at a good site is from 10 to 100 times large.

- (d) Wave power devices are not required to use large land masses such as wind or solar.

45. *What are the disadvantages of wave energy?*

- (a) The main disadvantages are difficult maintenance, construction cost, life time and reliability due to wave energy available on the ocean. Also, it needs a greater distance to shore for transporting energy.
- (b) Wave energy conversion devices must withstand the severe peak stresses during storms.
- (c) Irregularity of wave pattern in amplitude, phase and direction makes it difficult to extract power efficiently.
- (d) Harnessing the power of it is difficult.

46. *Define the term "Hydrology".*

[Anna Univ. Dec'10]

Hydrology is the study of science concentrating the properties of the earth's water and the movement of earth with respect to land.

47. *What is hydrograph?*

[Anna Univ. May'13]

Hydrograph is a graph plotted for the rate of flow versus time past a specific point in a river or other channel or conduit carrying flow.

48. *For which purposes hydro projects are developed?*

[Anna Univ. Dec'13]

- (a) To meet the power needs during peak and off peak requirements
- (b) To run of the river
- (c) To obtain a clean process of power generation
- (d) To avoid suffering from the limitation of inflation on account of fuel consumption in the long run.

49. *What is the purpose of using dams?*

[Anna Univ. Dec'12]

The dam is used in hydro power plants to increase the height of water level thereby increasing the capacity of reservoir. The dam also helps to increase the working head of the power plant.

50. *Define Run-off.*

[Anna Univ. Dec'13]

Run-off is defined as the movement of land water to the oceans mainly in the form of rivers, lakes and streams.

51. Classify power plants on the basis of traditional use.

[Anna Univ. May'11]

- (i) Concrete gravity dam type hydroelectric power plant
- (ii) Embankment dam type hydroelectric power plant.

52. List out the important parameters of a turbine.

[Anna Univ. Nov'07]

- (i) Power output of the turbine
- (ii) Friction losses based on isentropic efficiency
- (iii) Maximum temperature which can be taken by the turbine
- (iv) Temperature at the exhaust of the turbine.

53. What is hydraulic turbine?

Hydraulic turbines are the machines which convert the energy of flowing water into mechanical energy.

54. What is hydroelectric power?

The turbine converts the hydraulic energy into mechanical energy. This mechanical energy is converted into electrical energy. So, the conversion of energy from hydraulic form to electric form is called *hydroelectric power*.

55. List down the components of small hydroelectric power system.

- (a) Diversion and intake
- (b) Desilting chamber or tank
- (c) Water conductor system
- (d) Forebay/balancing reservoir
- (e) Surge tank
- (f) Penstock
- (g) Power house comprising of turbine, generator, protection and control system, dewatering system, drainage system, auxiliary power system, grounding, emergency and standby power system, lighting and ventilation.
- (h) Tail race channel.

56. Name any two advantages and limitations of small scale hydroelectric equipment.

Advantages:

1. It requires the shortest time for developing a unit.
2. Once, it is built the running expenditure almost negligible.

Limitations:

1. Non-availability of indigenous equipment for generating plant and import procedures are time-consuming.
2. General lack of awareness of benefits from small development.

57. State the need for direct energy conversion.

- (i) There is no need of using conversion of energy into mechanical and to electricity.
- (ii) Less losses occur in conversion process.
- (iii) It is more efficient process.
- (iv) The energy conversion cost is drastically reduced.

58. Define Seebeck effect.

When the junctions of two different metals are maintained at different temperature, the *emf* is produced in the circuit. This is known as *Seebeck effect*. The material A is maintained at $T + \Delta T$ temperature. The material B is maintained at temperature T . Since the junctions are maintained at different temperature, the *emf* V is generated.

59. State Peltier effect.

Whenever current passes through the circuit of two dissimilar conductors depending on the current direction, either heat is absorbed or released at the junction of the two conductors. This is known as *Peltier effect*.

60. What is called Joule effect?

Irreversible conversion of electrical energy into heat when a current I flows through a resistance R .

$$\text{Electrical energy, } Q_j = I^2 R$$

61. List the various direct energy conversion systems.

- (i) Magneto hydrodynamic (MHD) systems
- (ii) Thermionic power generation
- (iii) Thermoelectric power generation
- (iv) Solar photovoltaic power systems
- (v) Fuel cells and
- (vi) Thermo nuclear direct energy conversion.

62. Mention the advantages of MHD generator.

1. High efficiency when compared to other power plants.
2. Fuel economy.
3. Eliminating the link process of producing mechanical energy via steam.
4. It is capable of tapping the vast potential offered by modern furnaces.

63. What is called thermionic generator?

A thermionic generator (converter) converts heat energy directly to electrical energy by utilizing thermionic emission effect. All metals and some oxides have free electrons which are released on heating. In a thermionic converter, electrons act as the working fluid in place of a vapour or gas. In a thermionic converter, the electrons are emitted from the surface of heated metal. The energy required to extract an electron from the metal is known as *work function* and expressed in electron volts (eV).

64. State the advantages and disadvantages of thermionic generator.

Advantages:

1. Since there are no rotating parts and hence, there is no frictional losses.
2. Maintenance is easy.
3. Liquid-Vapour phase problems do not exist.
4. These systems are compact and have less weight.

Disadvantages of thermionic generator:

1. The operating temperature of cathode is very high. So, costly materials such as tungsten, rhenium are required for cathode.
2. Individual convertors are low voltage and high current devices. A large number of convertors must be sequentially arranged to obtain useful voltage
3. Ionised cesium vapour has to be filled in the interspace to reduce the space charge barrier to promote electron emission from the cathode.

4. Discuss the principle of thermoelectric generator.

When any electrical conductor is exposed to a thermal gradient by heating one end while maintaining the other end at a low temperature, it will generate a voltage between hot and cold ends. This effect is called *thermoelectric effect*. Thermoelectric power generator is a device that converts the heat energy into electrical energy based on the principles of *Seebeck effect*. It means that when the junctions of two different metals are maintained at different temperature, the *emf* is produced in the circuit.

65. Write down the properties of thermoelectric materials.

1. Large Seebeck coefficients
2. High electrical conductivity
3. Low thermal conductivity.

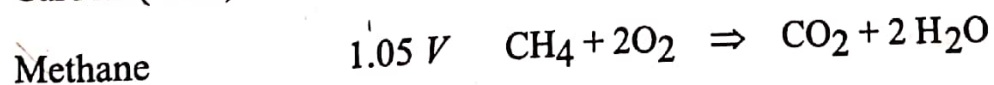
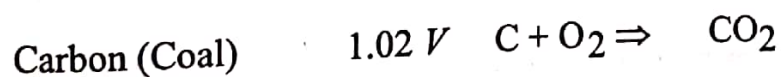
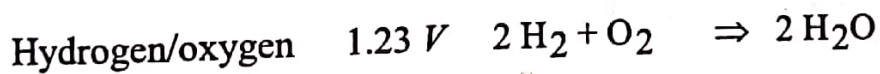
66. Compare thermionic and thermoelectric generators.

1. Both thermionic and thermoelectric generators employ the electron gas as the working fluid.
2. A thermionic generator is based on the ballistic current flow which is highly efficient, and its theoretical efficiency is close to the Carnot efficiency.
3. A thermoelectric generator has poor efficiency due to the diffusive current flow.
4. A thermionic generator usually requires a high temperature heat source (e.g. 1500 K) to generate a practically useful current.
5. A thermoelectric generator, however, can produce electrical power from low-quality heat energy sources.

67. What is fuel cell?

Fuel cell is a device that uses hydrogen (or a hydrogen-rich fuel) and oxygen to create an electric current.

68. List down the possible reaction involved in fuel cells.



69. Mention the various parts of fuel cell.

- (i) Membrane electrode assembly
- (ii) Catalyst
- (iii) Chemistry of a fuel cell
- (iv) Hardware.

70. List down the major sections of a fuel cell.

- (i) Fuel processing section
- (ii) Fuel cell power pack

- (iii) Power conditioning section
- (iv) Switchgear and supply section
- (v) Control subsystem section
- (vi) Heating section.

71. Define nuclear fission.

Nuclear fission is the process of splitting of nucleus into two almost equal fragments accompanied by the release of heat.

72. What is meant by nuclear fusion?

Nuclear fusion is the process of combining two lighter nuclei into a stable and heavier nucleus by fusion. In this process, a large amount of energy is released because mass of the product nucleus is low when compared to mass of the two nuclei which are fused.

73. List the methods used for direct energy conversion from fusion reactions.

- (i) Electrostatic direct energy conversion
- (ii) Magnetic compression-expansion direct energy conversion.

74. What are the advantages of DEC?

- (i) Direct energy conversion is rapid process.
- (ii) It produces large amount of energy in less time.
- (iii) Maintenance is easy.
- (iv) It provides environment friendly.
- (v) It is more compactible and less weight.
- (vi) Reliability is more.
- (vii) Operation is noiseless.

5.17. SOLVED QUESTIONS

1. Briefly explain geothermal energy sources.

Refer chapter 5.2 in Page 5.2.

2. Classify geothermal wells.

Refer chapter 5.3 in Page 5.4.