

3

Sources of Energy

CHAPTER

CHAPTER COVERAGE

- 1. Sources of Energy :** Any system from where energy can be tapped is called a source of energy.
- 2. Characters of Source of Energy:**
 - (i) Capable of providing adequate amount of energy.
 - (ii) Should be convenient to use and easy to store and transport.
 - (iii) Should be capable of giving desired quantity at required rate steadily over a long period.
 - (iv) Should release energy in mostly all forms in which the day-to-day requirement exists.
- 3. Forms of Energy:** Energy exists in different forms. Some of them are listed below:
 - (i) Muscular energy - Energy spent by muscle to do work.
 - (ii) Heat energy - Energy that brings warmth or coldness.
 - (iii) Light energy - Energy getting the vision of objects.
 - (iv) Chemical energy - Energy due to chemical reaction.
 - (v) Nuclear energy - Energy due to nuclear reaction like fission and fusion.
 - (vi) Solar energy - Energy from sun.
 - (vii) Wind energy - Energy from moving wind.
 - (viii) Tidal energy - Energy from tides in sea-water.
 - (ix) Geothermal energy - Energy from hot water springs found under the earth.
 - (x) Ocean thermal energy - Energy from temperature gradient in ocean water.
- 4. Law of Conservation of Energy:** Energy can neither be created nor destroyed, but can be transformed from one to another.
- 5. Fossil Fuel:** The fuels which are obtained from the remains of plants and animals are called **fossil fuels**, e.g., coal, petroleum and natural gas are examples of **fossil fuels**.

The remains of plants and animals which got buried inside the earth million of years ago, changed into coal, petroleum and natural gas due to excess of heat and high pressure inside the earth. These conditions do not exist any more, so new reserves of these fuels are not being formed now.

Disadvantages of using fossil fuels:

1. Burning of coal and petroleum lead to air pollution.
2. They cause acid rain by forming acidic oxides of Carbon, Nitrogen and Sulphur.

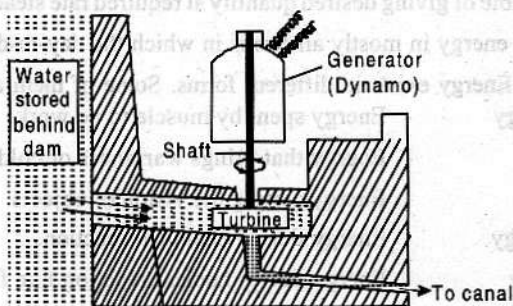
However it can be reduced by the use of efficient combustion process and techniques to reduce gases and ashes dropped in the surrounding.

6. **Thermal power plant:** In power stations, one needs energy to run turbines. Large quantity of fossil fuels like coal is burnt to produce heat energy. This produces steam which is used to rotate turbines to produce electricity. The flow of energy is as listed below:

Fossil fuels \rightarrow Heat Energy \rightarrow Mechanical Energy \rightarrow Electrical Energy.

7. **Hydroelectricity:** The energy of water flowing through rivers or stored in dam is another potential source of energy. It is also indirect source of solar energy. It is the solar energy which recycles water in nature from oceans and the earth's surface through rain and snow. The energy of water flowing through rivers has been used for rotating the wheels of watermills which are still operating in remote hilly areas.

8. **Generation of Hydroelectricity :** The water flowing in river is collected in the dam which is allowed to fall from the top of dam. Water turbine is located near the bottom of the dam and the shaft of water turbine is connected to electric generator. When fast moving water coming from the dam falls on the blades of water-turbine, then the kinetic energy of water rotates the water turbine rapidly. When the water-turbine rotates, then the armature (coil) of generator also rotates rapidly and generates electricity. In generation of hydroelectricity, potential energy of stored water is converted into kinetic energy of flowing water which is converted into electrical energy using turbine.



Hydroelectric power station

Bhakra Nangal Dam is being used to produce electricity.

Advantages of Hydroelectricity:

- (i) It does not create pollution.
- (ii) Water energy is renewable source of energy which will never get exhausted.

Disadvantages:

- (i) The construction of dams may lead to ecological imbalances.
- (ii) A vast variety of animals, plants get submerged in water.
- (iii) It decreases fertility of soil in down-stream area and affects crops.
- (iv) Creates problem of satisfactory rehabilitation (e.g. Tehri dam-Sardar Sarovar project on Narmada)
- (v) Rotten submerged vegetation produces green house gases.

9. **Biomass:** The material contained in the bodies of plants and animals is called *biomass*. It acts as a fuel. It includes wastes from tree and grass, crops, forestry, agricultural and urban wastes. The excreta of living organisms and their bodies after death also contribute to the biomass.
10. **Bagasse:** It is the residue of sugarcane after extracting (taking out) juice from them. It is used as fuel in industries.
11. **Uses of Biomass:** It has been a traditional source of energy, e.g. wood, crop residues, bagasse are burnt to produce heat for domestic as well as industrial purposes.
Biomass is also utilised to produce electricity.
12. **Biomass as Fuel:** Wood is still a source of heat in many households in our country. Usually firewood is burnt in traditional *Chulhas* for cooking and heating water for domestic purposes.
13. **Biogas :** It is mixture of gases such as methane (75%), carbon dioxide, hydrogen sulphide, etc. which is obtained by the decomposition of animal and plant wastes like animal dung, etc. with the help of micro-organisms in the presence of water. It is used as fuel in gas-stoves these days especially in rural areas. It can be used for street lighting and for running engines.
14. **Production of Biogas:** Biogas is a mixture of gases produced during decay of biomass in the absence of oxygen.

Methane is main constituent of biogas, which is an excellent fuel. Animal dung, sewage, crop residues, vegetable wastes, poultry droppings, wastes from agro based industries are some forms of biomass that are most suitable to produce biogas.

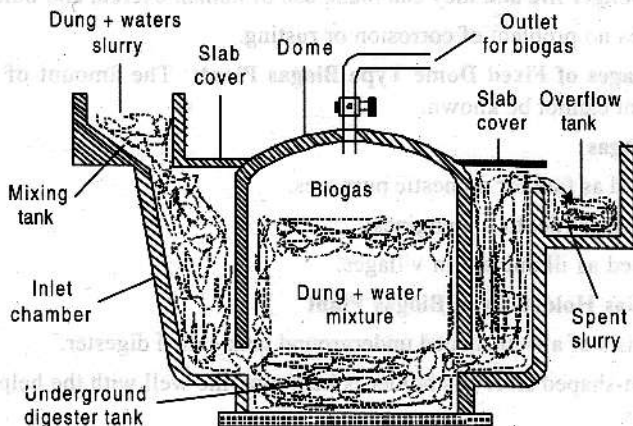
Metal pieces, plastic, polythene, glass pieces, paper are not suitable for production of biogas.

Biogas technologies are gaining acceptance as a self sustaining source of fuel and electricity by both rural and urban population.

There are two designs of commonly used Biogas plants - (i) Fixed dome type (ii) Floating gas holder type.

15. Fixed Dome Type Biogas Plant:

- It consists of well shaped underground tank (called digester) covered with dome-shaped roof, both made of bricks and cement.



Fixed dome type biogas plant

- The dome of the digester is fixed so that it acts as gas holder (or gas storage tank) for the biogas produced.
- At the top of dome, there is a gas outlet pipe and a gas valve.
- There is sloping inlet chamber called mixing tank on the left side of the digester and on the right side, there is a rectangular outlet chamber, both made up of bricks and cement.
- Fresh cattle dung and water from slurry which is introduced in the inlet chamber while the spent dung slurry gets collected in the outlet chamber. The inlet chamber is connected to the mixing tank; while the outlet chamber is connected to the overflow tank.

Working

- Slurry (made by mixing equal proportions of animal dung and water) is fed into digester tank via the inlet chamber, till the slurry level becomes nearly equal to the cylindrical top level.
- The biogas plant starts functioning in about 50-60 days. During this time, cattle dung undergoes fermentation in the presence of anaerobic bacteria with gradual evolution of biogas, which starts collecting in dome shaped space.
- As the time passes, more and more biogas collects inside the dome, thereby exerting pressure on the slurry in the digester tank and this in turn forces the **spent slurry** to the overflow tank via outlet chamber.
- The spent slurry is withdrawn periodically and used as a good **manure** because it is rich in essential plant nutrients.
- Fresh slurry is added to the mixing tank and fed to digester for the regular supply of biogas.
- The biogas collected in the dome is taken out through the outlet pipe by opening the gas valve and then used as fuel gas.
- Fixed dome type biogas plant is also called **Janta gobar gas plant**.

16. Advantages of Fixed Dome Type Biogas Plant

- It is quite cheap, since it is made up of cement and bricks.
- There is less cost on the maintenance.
- It has longer life and they can make use of human excreta and other biowastes.
- There is no problem of corrosion or rusting.

17. Disadvantages of Fixed Dome Type Biogas Plant: The amount of biogas present in biogas plant cannot be known.

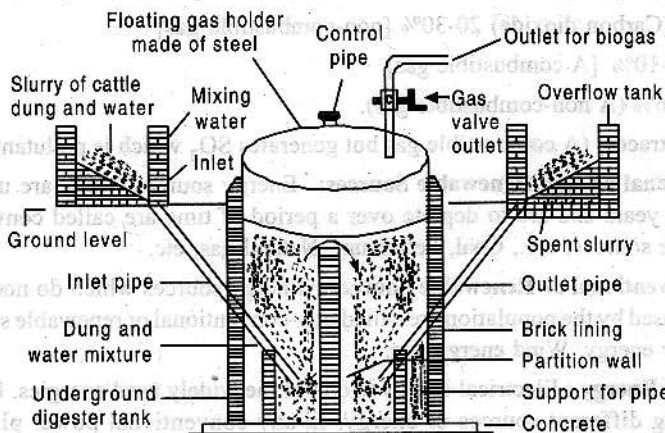
18. Uses of Biogas

- (i) It is used as fuel for domestic purposes.
- (ii) It is used as fuel to run engines.
- (iii) It is used as illuminant in villages.

19. Floating Gas Holder Type Biogas Plant

- It consists of a well shaped underground tank called digester.
- A drum-shaped steel gas holder is kept over the well with the help of steel ropes and weights.

- Digester is connected to mixing tank (inlet tank) with the help of a pipe and it is also connected to outlet tank (overflow tank with the help of steel pipe).
- There is a partition wall in digester with a little space at the top.



Cross-section of floating gas holder type biogas

- The spent slurry rises up and enters the right chamber which is taken out in overflow tank.

The working of floating gas holder type biogas plant is similar to that of fixed dome type biogas plant except that the level of biogas present in biogas plant can be known by observing the level of steel dome.

20. Advantages of Floating Gas Holder Type Biogas Plant: The level of biogas present inside the biogas plant can be known.

Disadvantages of Floating Gas Holder Type Biogas Plant:

- It is more expensive due to steel gas holder.
- Rusting of gas holder may lead to leakage of the biogas.
- Maintenance cost is higher, since steel gas holder requires frequent painting to avoid corosions.
- Cow dung is mainly used to obtain biogas.

21. Advantages of Biogas:

- Biogas is excellent fuel because it contains about 75% of methane. It is used as a fuel at home as well as in industries.
- It burns without smoke, therefore causes no pollution.
- Its calorific value is high.
- It is a very clean and convenient fuel, and does not leave any residue.
- It does not involve storage problems because biogas is supplied through pipes.
- It is used for production of electricity.
- The slurry left behind in digester is a good manure because it is rich in plant nutrients, i.e., rich in nitrogenous and phosphorous compounds.

- It gives us an excellent method to dispose of wastes which otherwise creates air pollution and water pollution, if dumped into water.
- 22. Composition of Biogas:** The average composition of Biogas is:
- CH_4 (Methane) 65-75% (combustible gas with high calorific value)
 - CO_2 (Carbon dioxide) 20-30% [non-combustible gas]
 - H_2 5 -10% [A combustible gas]
 - N_2 2-6% (A non-combustible gas).
 - H_2S (traces) (A combustible gas but generates SO_2 which is pollutant).
- 23. Conventional or Non-Renewable Sources:** Energy sources which are used traditionally for many years and are to deplete over a period of time are called conventional or non-renewable sources, e.g., Coal, Petroleum, Natural gas, etc.
- 24. Non-Conventional or Renewable Sources:** Energy sources which do not deplete and are scarcely used by the population are called non-conventional or renewable sources of energy, e.g., Solar energy, Wind energy, etc.
- 25. Electrical Energy :** Electrical energy is one of the widely used energies. It is generated by harnessing different sources of energy. In any conventional power plants, turbines of generators are rotated by using steam arrived by heating water from one source of energy say coal, water, gas, etc.
- 26. Energy Crisis:** Fossil fuels like coal, petroleum and natural gas are used extensively to fulfill energy requirements due to:
- Ever-growing demand for fuels.
 - Depleting nature of fossil fuels.
 - The difficulty in identifying new resources.
 - The difficulty in unearthing the resources.
 - Growing population.
- 27. Overcoming Energy Crisis :** Energy crisis can be overcome by:
- Judicious use of the available energy
 - Promoting renewable energy sources
 - Promoting efficient conversion mechanism, and
 - Accelerate the pace of development of technologies required for harnessing new sources.
- 28. Solar Energy is the Main Source:** Indirectly or directly all forms of energy originate from the solar energy. So ancient man was worshipping Sun as the source GOD. For example, Hydro-electricity can be proved to be an indirect solar energy as below:
- The solar energy forms clouds by evaporating the water in lakes, rivers, oceans and other water bodies. It comes down to the surface in the form of rain and snow. It flows in rivers and oceans. The energy with flowing water can be used for getting hydro-electricity.
- 29. Solar Energy :** Nuclear fusion of deuterium is said to power the Sun. The energy that radiates out in all the directions is received to some extent by various planets and other celestial bodies. It is estimated that the earth receives only 0.000000045792% of total solar energy. Besides heat energy, ultraviolet, gamma rays and visible light also come from solar energy.

30. Solar Constant: The amount of solar energy received per square metre per second on the surface of earth is called Solar Constant. It is approximately $1.4 \text{ kJ/m}^2\text{s}$.

Only 47% of the solar energy reaching the atmosphere reaches the surface of earth.

31. Advantages of Solar Energy:

- (i) Drying clothes is made easier.
- (ii) To obtain salt from sea-water by evaporation.
- (iii) To get rid of moisture content in food grains.
- (iv) To preserve fruits, vegetables, sea foods by sun-drying.

32. Limitations of Solar Energy:

- (i) Energy reaching the surface is very much diffused and so the direct utility is limited.
- (ii) It is not available uniformly all the time and at all the places.
- (iii) It is not available in night.
- (iv) Cloud formation may obstruct the reception.

33. Direct and Indirect Harnessing of Solar Energy:

Direct Sources: Conversion of solar energy to heat directly using solar cooker or electricity production using solar cells.

Indirect Sources: Biomass production is a chemical reaction in the presence of solar energy. Harnessing wind, tidal and various other forms are due to the difference in temperature at different levels is an indirect source.

34. Composition of Solar Energy: Solar energy consists of light and heat energies. The light consists of waves called Electromagnetic waves. Different wavelengths of visible light give different colour perception. Besides visible light, ultraviolet, infrared radiations are also received from Sun. Nearly $1/3^{\text{rd}}$ of the sunlight consists of infrared radiations.

35. Wavelength : Length of a wave or separation between two points in successive waves which are in same phase is called wavelength. It is expressed in metre.

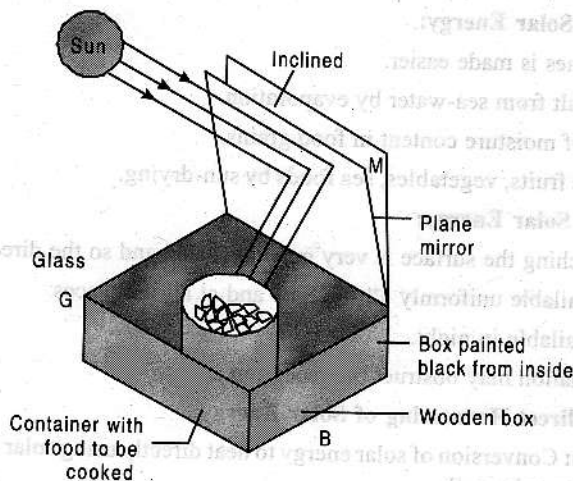
36. Frequency : The number of wave motions in one second is called frequency. It is expressed in hertz.

37. Visible Light: The sunlight consists of a spectrum or group of seven colours. VIBGYOR- Violet, Indigo, Blue, Green, Yellow, Orange and Red. The range of wavelength from violet to red is 0.4 micron to 0.7 micron respectively ($1 \text{ micron} = 10^{-6} \text{ m}$).

38. Infra-red Radiations : The light of wavelength which is greater than wavelength of red, called IR radiation. They are not visible to human eye but are having the property of heat the bodies on its way. All hot bodies radiate infra-red radiations. Based on the temperature the wavelength varies. Sun being very hot, the wavelength of IR radiations is very short in comparison to low temperature bodies on earth.

39. Solar Cooker : A solar cooker is a device which is used to cook food using solar energy. It consists of an insulated metal box or wooden box, which is painted all black from inside. There is a thick glass cover, glass sheet as a cover over the box and a plane mirror which acts as reflector attached to the box. The food to be cooked is placed in a metal container and the black painted container is kept in box and covered with glass sheet. Solar cooker is kept in sunlight in such a way that strong beam of sunlight falls over the cooker top. The sun rays pass through the glass sheet cover and get absorbed by black surface and temperature

in the box slowly rises up and reaches 100°C to 140°C by infrared rays. The heat cooks the food.



Box type solar cooker

Advantages of Solar Cooker:

- (i) It saves fuel.
- (ii) It does not create pollution.
- (iii) The nutrients of food do not get destroyed.

Limitations of Solar Cooker:

- (i) It cannot be used during night time.
- (ii) It cannot be used on cloudy day.
- (iii) The direction of reflector of solar cooker has to be adjusted frequently.
- (iv) It cannot be used for frying.
- (v) It cannot be used for making *Chapaties*.
- (vi) It takes longer time for cooking.

40. Spherical Reflector Type Solar Cooker: In this solar cooker, concave reflector or parabolic reflector is used. It concentrates its solar energy in a small region called focus and therefore quite high temperature can be produced. Therefore, food materials which require strong heating can also be cooked. It can be used for baking and frying also. We can bake *chapaties* and fry eggs.

41. Solar Cells: It is a device which converts solar energy, i.e., light energy directly into electricity. They are made up of semiconductors like silicon, germanium and selenium.

How solar cells are made : Solar cells are made up of silicon and gallium. In solar cell, the pieces (usually wafers) of semiconducting materials containing impurities are so fused that a potential difference develops between the two regions of semiconductors when light falls on it. The current produced by single cell measuring about 4 cm^2 may be of the order of 0.4 to 0.5 V at 6.0 mA (milliamperes).

Solar Cell Panel: It comprises of a large number of solar cells and can provide much higher power of many uses.

Uses of Solar Cells:

- (i) All artificial satellites and space probes mainly depend upon electricity generated by solar cells.
- (ii) In India, solar cells are used for lighting, operating water pumps, for running radio and television sets in remote areas and traffic signals etc.
- (iii) They are being used to provide electric power to light houses and off shore oil drilling rig platforms.
- (iv) Solar cells are used for calculators and electronic watches.

Advantages:

- 1. Immobile so less maintenance.
- 2. Can be made available even in area inaccessible to other energy means.

42. Semiconductors: They are those substances which have very low electrical conductivity. They are in between the good conductors and insulators. They conduct only small amount of current under ordinary conditions.

If certain impurities are added, their electrical conductivity is increased. When sunlight falls on semiconducting material, their conductance increases, e.g. Silicon, germanium, selenium are semiconductors.

43. Wind Energy: The blowing wind has energy which is called wind energy. Wind is associated with kinetic energy.

Cause of Wind to Blow: Solar energy is responsible for the blowing of the wind. The intensity of sun-rays is much more stronger near the equator of the earth than in the polar regions due to which the air near the surface of the earth in equatorial regions becomes quite hot. The hot air, being lighter, rises upward. The coolest air from the polar regions of the earth starts flowing towards the equatorial regions of the earth to fill the space vacated by the hot rising air. This flow of air from one place to another constitutes wind. The three factors responsible for blowing of wind are:

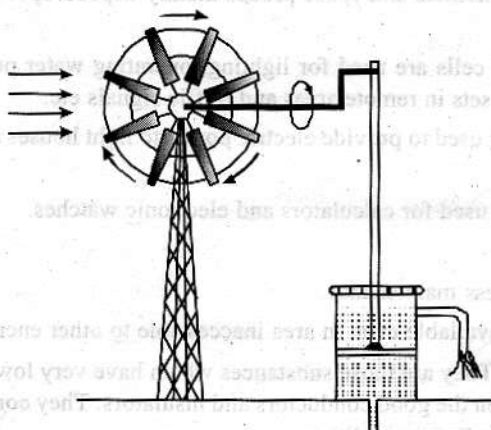
- (i) The uneven heating of equatorial region and polar region of earth by sun rays.
- (ii) Rotation of earth
- (iii) Local conditions.

Uses of Wind Energy

- (i) It is used to propel sail boats.
- (ii) It is used to drive windmills. They are used in water-lighting pumps and flour mills.
- (iii) The aeroplane make use of wind energy. Gliders depend totally on the wind energy.
- (iv) Wind energy is being used for generating electricity.

44. Windmill: The windmill works on the principle, that when the blowing wind strikes across the blades of a windmill it exerts a force which rotates its blades. The rotational effect is due to a special design of the blades similar to those of an electric fan, the windmill may be considered as an electric fan working in the reverse order in which blowing air rotates the blades of the windmill.

Denmark called as "Country of winds" uses wind energy to fulfil 25% of its total energy requirements. India producing 45,000 MW stands fifth behind Germany, Denmark. The largest wind farm in India produces 400 MW of electricity and is located near Kanya Kumari in Tamil Nadu.



Windmill to pump-out water from a well or flooded coal mine

45. Advantages : (i) Involves no recurring expenditure.

(ii) Eco-friendly and efficient.

Disadvantages: (i) Not available at all times and at all places.

(ii) Needs large open field.

(iii) Initial cost is very high.

(iv) Needs higher level of maintainence.

46. Energy from Oceans: It is a potential source of renewable energy. There are many forms of ocean energy.

(i) **Ocean Thermal Energy (OTE):** There is always a temperature difference between water at the surface and at deeper level up to 20°C . This form of energy is called ocean thermal energy which can be converted into electricity.

(ii) **Sea-Waves Energy :** Energy from oceans is also available in form of sea-waves. Due to blowing of wind on the surface of ocean, very fast sea-waves move on its surface. It has lot of kinetic energy due to high speed. It can be used to produce electricity. Some specially designed devices are set up in the sea which move as the sea-waves pass them. Their movement can be used to drive dynamos which generate electricity.

(iii) **Tidal Energy:** The rise of ocean water due to attraction of moon is called 'high tides' whereas fall of ocean water is called 'low tides'. The tidal waves rise and fall twice a day. The enormous movement of water between 'high tides' and 'low tides' provides a very large source of energy in the coastal areas of the world. Tidal energy can be harnessed by constructing a tidal barrage or tidal dam. The sea water risen during high tide trapped by the barrage is allowed to fall down on water turbines due to which they start rotating. The rotating water turbines drive generators which produce electricity.

(iv) **Energy from Salinity Gradient in Seas:** The concentration of salts in water of different seas is different. The difference in concentration of salts in the water of two different

seas is called 'salinity gradient'. The difference in concentration of salts where water from different seas meet can be used to obtain energy in usable form.

(v) **Energy from Sea-Vegetation or Biomass:** Sea vegetation or biomass is another indirect source of energy from the oceans. For example, the vast amount of sea-weeds present in oceans may provide an endless supply of methane as fuel in future.

(vi) **Energy from Nuclear Fusion of Heavy Hydrogen (${}^2_1\text{H}$) in Oceans :** The ocean water is an unlimited source of heavy hydrogen called deuterium in the form of heavy water. Efforts are being made to produce energy by controlled nuclear fusion of deuterium.

Tidal Energy in India: The following are potential sites for tidal energy:

(i) Gulf of Kutch in Gujarat

(ii) Cambay in Gujarat and

(iii) Sunderban along the east coast in West Bengal.

47. Geothermal Energy: The heat from inside the earth heats up the water below the surface. This hot water can be used under favourable conditions as a source of energy. This energy with hot water below the earth is called geothermal energy. Underground water gets converted into steam and remains trapped between rocks at high pressure. The steam taken out at high pressure can run turbine to generate electricity. In some places without any drilling, hot water with steam comes out. They are called as hot springs or geysers.

Advantages:

(i) Available all the time (24 hours, 365 days)

(ii) It is clean.

(iii) It is environment friendly.

(iv) It is cost effective when converted to electricity.

Hot springs are seen at three places in India, but none of them is of use to us on commercial basis. The three places are in (i) Madhya Pradesh, (ii) at Sohna, Gurgaon district of Haryana and (iii) At Manikaran, Kullu district of Himachal Pradesh.

New Zealand and USA are two major areas where commercial use of geothermal energy is done.

48. Atomic Mass Unit (amu). Atomic mass unit is defined as $1/12$ th of mass of carbon atom ${}^{12}_6\text{C}$.

1 amu = 1.66×10^{-27} kg. Based on amu, the mass of electron is $M_e = 0.00055$ amu, proton is $M_p = 1.0073$ amu, neutron is $M_n = 1.0086$ amu.

Electron-Volt (eV): Unit for energy associated with electrons accelerated through a potential of 1 volt.

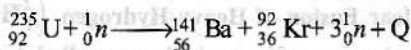
1 eV = 1.6×10^{-19} joule. Also, 1 MeV = 1.6×10^{-13} joule.

49. Mass-Energy Equivalence : According to Einstein, the mass and energy are inter-convertible. They are related by the relation $E = mc^2$ where c is the velocity of light ($3 \times 10^8 \text{ ms}^{-1}$).

Since 1 amu = 1.66×10^{-27} kg. The energy associated with 1 amu is,

$E = 1.66 \times 10^{-27} \times (3 \times 10^8)^2 = 1.49 \times 10^{-10}$ joule = 931 MeV

50. Nuclear Fission: In 1930's attempts were made to create elements with atomic number higher than that of Uranium. In 1939, it was Otto Hahn and Fritz Strassman, two German scientists, who discovered the nuclear fission. When Uranium is bombarded with neutrons, it splits into two parts Barium ($Z = 56$) and Krypton ($Z = 36$), with the release of large amount of energy (200 MeV). Thus the process in which the heavy Uranium nucleus splits into lighter nuclei of smaller atomic numbers is called Nuclear Fission.



Q refers to the energy of 200 MeV released. Two new elements and three neutrons are released.

51. Thermal Neutrons: Neutrons needed for bombardment of Uranium nuclei is not very large. They are called as thermal neutrons. They have an energy of 1/40 eV and velocity of 2.22 km/sec.

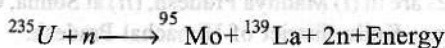
52. Fission Products : Fission of ${}^{235}\text{U}$ produces nuclei having mass numbers 72 to 158. There are two prominent groups one with mass numbers in the range 130-149 amu and the other with mass numbers 85-104 amu. The most prominent products are Molybdenum (${}_{42}\text{Mo}$) and Lanthanum (${}_{57}\text{La}$).

53. Prompt and Delayed Fission. As and when the projectile bombards the nuclei if it splits then the fissions prompt. When the projectile enters the nucleus, and brings instability leading to the split, it is called delayed fission.

54. Spontaneous Fission: If the fission takes place without any projectile being used, it is called as spontaneous fission.

55. Threshold Energy: The projectile (say neutron) should have some minimum energy, in order to create fission. This minimum energy is called threshold energy.

56. Energy Released in Fission: Fission takes place when neutron of sufficient energy bombards ${}^{235}\text{U}$ nuclei. If we consider Molybdenum ${}_{42}^{95}\text{Mo}$ and Lanthanum ${}_{57}^{139}\text{La}$ as the products, the fission reaction can be written as below:



Two neutrons are released in the process besides energy released.

$$\text{Mass of } {}^{235}\text{U} = 235.124 \text{ u}$$

$$\text{Mass of } {}_0^1n = 1.009 \text{ u}$$

$$\text{Mass of } {}_{42}^{95}\text{Mo} = 94.946 \text{ u}$$

$$\text{Mass of } {}_{57}^{139}\text{La} = 138.955 \text{ u}$$

$$\text{Mass of } {}^{235}\text{U} \text{ and } {}_0^1n = 236.133 \text{ u}$$

$$\text{Mass of Mo, La and two neutrons} = 235.919 \text{ u}$$

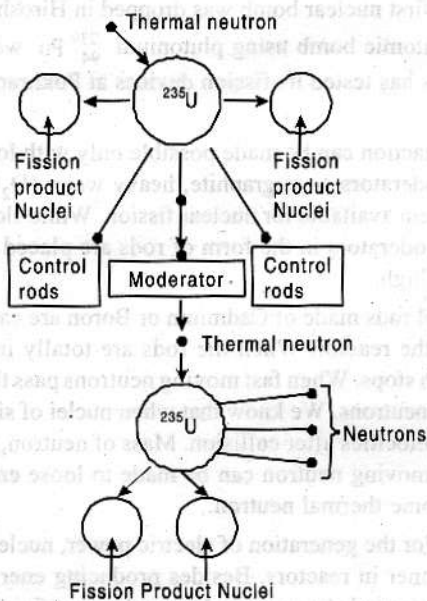
Difference in masses of the reactants and the products is converted into energy. The difference in mass is, 0.214 u equivalent to an energy of $0.214 \times 931 \text{ MeV}$. The energy is approximately 200 MeV or $3.2 \times 10^{-11} \text{ joule}$. 1 kg of ${}^{235}\text{U}$ releases an energy of 10^9 W day , while undergoing fission. It is approximately the energy released by 2500 tons of coal.

57. Nuclear Power Corporation (NPC) produces electrical energy for commercial purpose. The power plants are:

- (i) Tarapore in Maharashtra, (ii) Kota in Rajasthan,
 (iii) Kalpakkam in Tamil Nadu, and (iv) Narora in Uttar Pradesh.

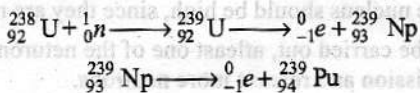
58. Chain Reaction: When nuclear fission reaction takes place, it also releases neutrons which are capable of creating further fission. For continuous production of energy, fission should be continuous. The neutrons released are made to bombard other Uranium nuclei to produce more fission. Such self-sustained reactions are called chain reactions. It was first successfully carried out by Enrico Fermi and his co-workers in University of Chicago in 1942. For chain reaction there are two problems namely (i) the neutrons released during fission may have more energy ($\approx 2 \text{ MeV}$) and needs to be reduced (ii) the probability of the neutron hitting the nucleus should be high, since they are released in all the directions. For chain reaction to be carried out, atleast one of the neutrons formed should hit another ^{235}U nuclei to cause fission and release more neutrons.

Chain reaction is shown schematically below. As you can observe the thermal neutrons continue the fission, while the other fast neutrons are absorbed by the control rods.



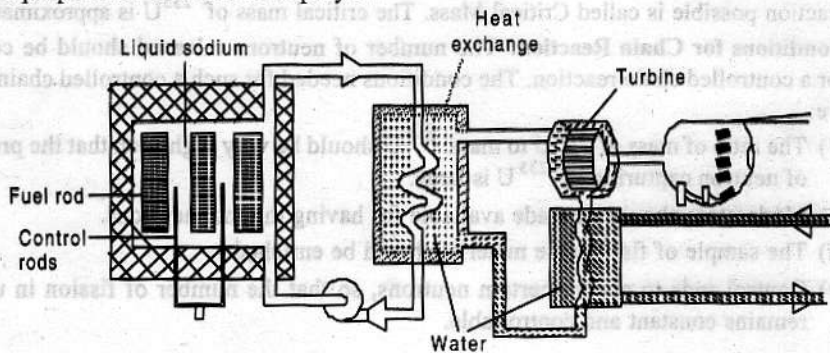
- 59. Critical Mass :** In order to make a chain reaction possible there should exist sufficient ^{235}U nuclei. The minimum mass of fissionable material required in order to make a chain reaction possible is called Critical Mass. The critical mass of ^{235}U is approximately 1 kg.
- 60. Conditions for Chain Reaction:** The number of neutrons released should be controlled for a controlled chain reaction. The conditions needed for such a controlled chain reaction are:
- The ratio of mass of ^{235}U to mass ^{238}U should be very high such that the probability of neutron capturing by ^{235}U is large.
 - Moderators should be made available for having thermal neutrons.
 - The sample of fissionable material should be enriched.
 - Control rods to absorb certain neutrons, so that the number of fission in unit time remains constant and controllable.

- 61. Enrichment:** Naturally occurring ^{235}U is very less. 99.28% of Uranium available is ^{238}U and ^{235}U is available only 0.715 %, so for chain reaction to increase the probability of fission, the concentration of ^{235}U in the sample should be increased. This process is called enrichment. Enriched fuel can produce large energy in a short time and volume.
- 62. Atomic Bomb:** When the mass of Uranium is greater than or equal to the critical mass, the fission reaction accelerates and releases large amount of energy in a very short time. Such reactions lead to explosion—uncontrolled chain reaction.
- 63. Process of Enrichment:** Instead of enriching the Uranium, one can also use Plutonium (Pu). It is a product of a series of nuclear reactions. The steps can be shown by the equation.



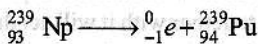
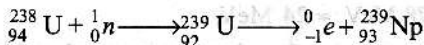
Two β - particles and a Neptunium are released to get ${}_{94}^{239}\text{Pu}$ from ${}_{92}^{238}\text{U}$.

- 64. Nuclear Bomb:** The first nuclear bomb was dropped in Hiroshima on August 6, 1945 and ^{235}U was used. The atomic bomb using plutonium ${}_{94}^{239}\text{Pu}$ was dropped on Nagasaki on August 9, 1945. India has tested its fission devices at Pokhran in Rajasthan on 11th, 13th May 1998.
- 65. Moderators:** Chain reaction can be made possible only with low energy neutrons (thermal neutrons). Use of moderators, e.g. graphite, heavy water (D_2O) reduce the speed of the neutrons and make them available for nuclear fission. While slowing down, the moderators get heated up. The moderators in the form of rods are placed such that the probability of the chain reaction is high.
- 66. Control Rods:** Control rods made of Cadmium or Boron are capable of absorbing neutrons and thereby control the reactor. When the rods are totally inserted into the chamber of reactor, chain reaction stops. When fast moving neutrons pass through the moderator heavy water we get thermal neutrons. We know that when nuclei of similar range of mass collide, they exchange their velocities after collision. Mass of neutron, proton and hydrogen nuclei being same, the fast moving neutron can be made to loose energy to hydrogen nuclei in heavy water and become thermal neutron.
- 67. Nuclear Reactors:** For the generation of electric power, nuclear fission reaction is carried out in controlled manner in reactors. Besides producing energy, it can be also used as a source of neutron for research purposes and to produce artificial elements or radio-isotopes. The reactors differ in the nature of fuel used, the moderator and the coolant employed and the purpose for which it is employed.



Nuclear reactor

- 68. Coolants:** Water, heavy water as well as gases are used as coolants. Liquid sodium is highly considered. They remove the heat from the reaction chamber.
- 69. Breeder Reactors:** When natural Uranium, not rich in ^{235}U is used and Plutonium is produced for fission to happen, inside the reactor itself, then the reactor is called Breeder Reactor (producing fuel by themselves). From $^{238}_{92}\text{U}$ by bombarding neutron ^{239}Pu can be arrived at by the following reaction:



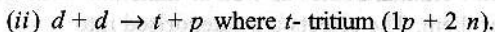
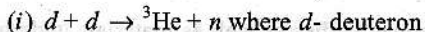
$^{239}_{94}\text{Pu}$ is best used as nuclear fuel.

- 70. Electrical Energy:** The core of the reaction chamber should be made good, so that it can withstand very high pressures and temperature. The heat produced as a result of chain reaction is carried by coolant which exchanges the heat with water which is further converted into steam. The steam is carried to turbine generator and energy can be converted into mechanical energy (of rotation of turbine). Thus electrical energy can be generated as the turbine rotates. The use of moderators and control rods make fission possible in a controlled manner.

Nuclear power is used for generation of electricity in industrialised countries like Belgium, France, Germany, Japan, Spain, Sweden, Switzerland. The use accounts for 30% of the total power requirement. But in India only 3% is made using nuclear power.

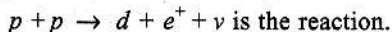
- 71. Nuclear Fusion:** The phenomenon of bringing together of two or more lighter nuclei to form a single heavier nucleus is called nuclear fusion. Large amount of energy is released in the process. e.g. Fusion of two deuterons to form isotope of helium (^3_2He).

- 72. Deuteron:** Deuteron is the heavier isotope of hydrogen. It has one proton and one neutron. The fusion can be indicated by the following reactions.



- 73. Fusion:** Fusion of lighter nuclei is possible with high energy nuclei. So the temperature has to be very high of the order of 10^7 K to 10^8 K . The high temperature fusion is also called thermo-nuclear reaction.

When two protons fuse together, one proton becomes a deuteron, with the formation of positron and a neutrino.

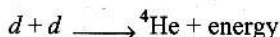


e^+ refers to positron which has same charge as electron but of opposite nature.

ν refers to neutrino which is neutral particle with negligible mass.

Fusion reactions are produced by accelerating lighter nuclei and bombarding on another lighter nuclei. At high temperatures, the bombarding nuclei will have high velocity to overcome the electrostatic repulsion.

- 74. Energy Released in Fusion:** Fusion of two deuterium nuclei to form helium nuclei is indicated below:



Mass of deuteron = 2.01471 amu,

Mass of α - particle = 4.00388 amu

Difference in mass between the reactants and product is

$$(2 \times 2.01471 - 4.00388) \text{ amu} = 0.02554 \text{ amu}$$

1 amu has an energy of 931 MeV.

So the energy released in fusion is

$$0.02554 \times 931 = 23.78 \text{ MeV} \approx 24 \text{ MeV}$$

75. Hydrogen Bombs : An atom bomb is detonated to produce high temperature in few milliseconds. The hydrogen bomb, together with it will act due to the high temperature conditions. The hydrogen bomb contains deuterium, tritium and ${}^6\text{Li}$. Large amount of energy is released but till now, it could not be controlled safely.

76. Thermo-Nuclear Reaction: Thermo-nuclear reactions are said to power our Sun. It was Hans Bethe who proposed the action in Sun, to release energy. These reactions are also responsible for large destruction by hydrogen bombs.

77. Plasma : At high temperatures every atom is made a mixture of electrons and nuclei-ionise. They all will be moving and the total charge will be zero. Such a group of charged particles moving at high speed is called as Plasma.

78. Radioactivity: The phenomena of emission of α , β particles and γ rays by unstable heavier nuclei is called radioactivity. Unstable elements have high neutron over proton ratio.

α -particles. Positively charged particles, comparable to helium nuclei (${}^4_2\text{He}$). They have least penetrating power but most ionising power. They travel with a velocity of 1/10th of the velocity of light.

β -particles. Negatively charged particles (${}^0_{-1}\text{e}$) similar to an electron. They have more penetrating power than α -particles.

γ -rays : They are electromagnetic waves of very short wavelength. Due to the neutral nature they have higher penetrating power.

79. Harmful Effects of Nuclear Radiation : Human bodies as well as materials undergo large change when nuclear radiations enter them. The effects are categorised into

(i) Somatic and (ii) Genetic.

Somatic effects lead to increase chance of cancer like diseases. Genetic effects lead to disorders that are carried to generations. Mutation is the process leading to this disorder.

80. Pollution: Nuclear wastes cause more harm than the pollution caused by fossil fuels.

The major sources are:

(i) Processing of nuclear fuel

(ii) Leakage from a nuclear reactor

(iii) Disposal of nuclear wastes

(iv) Accidents in nuclear reactors.

81. Nuclear Accidents: They are caused due to possible leakage of nuclear radiations. Three accidents encountered recently are:

(i) Three Mile Island - USA on 28th March, 1978.

(ii) Chernobyl - Ukraine on 26th April, 1986.

(iii) Japan, March 2011

82. Disposal of nuclear wastes

- (i) Stored in strong and leak proof containers, which are buried under the ground.
- (ii) Nuclear wastes are put in concrete blocks and dropped into sea.
- (iii) Put in leak proof containers and dumped in vacated coal mines.

83. Merits of Fusion: Fusion is advantageous than fission, because

- (i) Energy released in fusion reaction is more,
- (ii) The products are non-radioactive and harmless,
- (iii) Less pollution problems.

The major disadvantage is the inability in control the reaction energy.

84. Differences between Nuclear and Chemical Reactions

<i>Chemical Reactions</i>	<i>Nuclear Reactions</i>
(i) Only outermost electrons of an atom take part in reaction.	(i) The nucleus of an atom undergoes a change.
(ii) New element is not formed.	(ii) New element is formed.
(iii) Less energy is released.	(iii) Tremendous amount of energy is released.
(iv) They are affected by temperature, pressure etc.	(iv) They are not affected by temperature and pressure.

NCERT EXERCISES WITH ANSWERS

Q.1. What is good source of energy?

Ans. A good source of energy is one which:

- (i) does large amount of work/unit volume or mass.
- (ii) is easily accessible,
- (iii) easy to store and transport,
- (iv) is economical.

Q.2. What is good fuel?

Ans. A fuel which provides large amount of heat energy without causing pollution.

Q.3. If you could use any source of energy for heating your food, which one would you use and why?

Ans. We would use microwave oven for heating our food. This is because the nutritional value of food is not lost when heated in a microwave oven.

Q.4. What are the disadvantages of fossil fuels?

- Ans.**
- (i) They cause environmental pollution.
 - (ii) They cause global warming.
 - (iii) They do not supply enough heat energy.
 - (iv) The by-products of burning fuels cause acid rain which pollute water resources.

Q.5. Why are we looking at alternate sources of energy?

Ans. Because the conventional sources of energy may completely be exhausted one day if their use at the present rate continues.

Q.6. How has the traditional use of wind energy and water been modified for our convenience?

Ans. These energies have been converted into electrical energy using electric generators.

Q.7. What kind of mirror—concave, convex or plane would be best suited for the use in a solar cooker. Why?

Ans. Concave mirror, because it focuses the sun rays at a point to raise the temperature at that point.

Q.8. What are the limitations of the energy that can be obtained from oceans?

Ans. (i) Energy from oceans is available only when high tides are in the ocean.

(ii) Power plants used to convert ocean energy into electric energy do not operate continuously.

Q.9. What is geothermal energy?

Ans. The heat energy stored in the hot spots of earth's crust is called geothermal energy.

Q.10. What are the advantages of nuclear energy?

Ans. (i) A small quantity of nuclear fuel gives a large amount of energy.

(ii) In a nuclear power plant, the nuclear fuel is inserted once to get energy over a longer period of time.

Q.11. Can any source of energy be pollution free? Why or why not?

Ans. No source of energy is there which is pollution free. However, some sources of energy cause more pollution and some sources of energy cause less pollution.

Q.12. Hydrogen has been used as a rocket fuel. Would you consider it a cleaner fuel than CNG? Why or why not?

Ans. Hydrogen causes less air pollution than C.N.G. because burning of hydrogen produces water vapours and burning of CNG produced CO_2 . When the concentration of CO_2 increases in the atmosphere, then the temperature of the atmosphere increases. This effect is known as green house effect. The increased temperature of the atmosphere affects life on the earth.

Q.13. Name two energy sources that you would consider to be renewable. Give reasons for your choices.

Ans. (i) Bio-mass is considered as a renewable source of energy because forests can be replenished.

(ii) Water is also a renewable source of energy as water is continuously available to use due to water cycle in nature.

Q.14. Give the names of two energy sources that you would consider to be exhaustible. Give reasons for your choices.

Ans. (i) Coal (ii) Petroleum

They will be exhaustible when continuously extracted. Moreover, the formation of these fuels under the earth takes a longer period of time.

NCERT EXERCISES WITH ANSWERS

Q.1. A solar water heater cannot be used to get hot water on:

(a) a sunny day (b) a cloudy day (c) a hot day (d) a windy day

Ans. (b) On a cloudy day, heat radiations coming from the Sun do not reach the solar water heater.

Q.2. Which of the following is not an example of bio-mass energy source?

(a) wood (b) gobar gas (c) atomic energy (d) coal

Ans. (c)

Q.3. Most of the sources of energy we use represent stored solar energy. Which of the following is not ultimately derived from the sun's energy?

- (a) Geothermal energy
- (b) Wind energy
- (c) Fossil fuels
- (d) Bio-mass

Ans. (a)

Q.4. Compare and contrast fossil fuels and the sun as sources of energy.

Ans. The following table brings out the contrast between fossil-fuels and solar energy.

<i>Fossil fuels</i>	<i>Solar energy</i>
(i) Limited reserves	(i) Unlimited reserves
(ii) Cause pollution on burning	(ii) Pollution free
(iii) Can provide energy at any time	(iii) Can provide energy only during the day with no clouds around
(iv) Concentrated form of energy	(iv) Diffused form of energy

Q.5. Compare and contrast bio-mass and hydroelectricity as sources of energy.

Ans. The following table brings out the comparison and contrast between biomass and hydro-electricity.

<i>Bio-mass</i>	<i>Hydro-electricity</i>
(i) Renewable source of energy only if we plant trees in a planned manner.	(i) Renewable source of energy.
(ii) The energy from bio-mass can be obtained by using a <i>chullah</i> or a <i>gobar gas plant</i> .	(ii) Production of hydro-electricity requires construction of dams on rivers.
(iii) Bio-mass provides pollution-free energy only when converted into biogas.	(iii) Hydro-electricity is totally pollution free.

Q.6. What are the limitations of extracting energy from (a) the wind (b) waves (c) tides?

Ans. (a) Following are the limitations of wind energy:

- (i) Wind has a very low energy density.
- (ii) Favourable winds are available only in a few geographical areas away from cities. The velocity required for a windmill to function is about 15 kmh^{-1} .
- (iii) Direction of wind changes and is never the same.
- (iv) Wind farms require flat, vacant land free from forests.
- (v) The construction cost of wind farms is very high.

(b) Following are the limitations of wave energy:

- (i) The power output is not consistent.
- (ii) It is expensive because of the presently available technologies.
- (iii) It can be extracted only if strong winds blow all the time across the sea.

(c) The following are drawbacks of tidal energy:

- (i) Tidal energy plant can extract energy from the waves only when difference between the water levels of high and low tide is very large.

Q.7. On what basis you classify energy source as :

(a) Renewable and Non-renewable?

(b) Exhaustible and Inexhaustible

Are the options given in (a) and (b) the same?

Ans. (a) Renewable sources of energy are those which (i) can be replaced as we use them and (ii) can be used to produce energy again and again.

Non-renewable sources of energy are those which cannot be replaced once these are used.

(b) Exhaustible sources of energy are those whose supply is limited, e.g., coal, petroleum and natural gas.

Inexhaustible sources of energy are those whose energy supply is unlimited, e.g., solar energy, water energy, wind energy, nuclear energy etc.

Renewable sources of energy are inexhaustible whereas non-renewable sources of energy are exhaustible with some exceptions. For example, biomass is a renewable source of energy only if we plant trees in a planned manner. On the other hand, geothermal energy and nuclear energy though inexhaustible are non-renewable.

Q.8. What are the qualities of an ideal source of energy?

Ans. (i) It supplies useful energy continuously.

(ii) It does not cause environment pollution.

(iii) It is economical.

Q.9. What are the advantages and disadvantages of using a solar cooker? Are there places where solar cookers would have limited utility?

Ans. Advantages:

Like other solar applications, solar cooker has the following advantages:

(i) One of the most important advantage of a solar cooker is that it can be used for cooking food free of cost for many years.

(ii) It saves fuel, a non-renewable source.

(iii) Solar cooker does not produce smoke or other residue due to which the environment does not get polluted.

(iv) When food is cooked in solar cooker, all the nutrients are retained and do not get destroyed as it cooks food at a very low temperature.

Disadvantages of solar cooker:

Although a solar cooker has so many advantages, it has certain disadvantages also:

(i) Solar cooker cannot be used to cook food during night.

(ii) As the direction of sun changes with respect to the earth, the direction of reflector of solar cooker has to be changed continuously.

(iii) It cannot be used under poor weather conditions. For example, on a rainy day or when the sky is covered with clouds.

(iv) It cannot be used during winters. Solar cookers have limited utility at places which remain cloudy or have longer winter duration, e.g. hilly areas.

Q.10. What are the environmental consequences of the increasing demand for energy? What steps would you suggest to reduce energy consumption?

- Ans.** (i) More use of fossil fuels for fulfilling the increasing demand for energy has been polluting air.
- (ii) L.P.G. and C.N.G. are considered as clean but the extraction and transportation of these fuels cause environmental pollution.
- (iii) The use of large number of sources of energy is causing global warming.

Suggestions

- (i) Fossil fuels should be used with care and caution to derive maximum benefits out of them.
- (ii) Fuel saving devices such as pressure cooker etc. should be used.
- (iii) Efficiency of energy sources should be maintained by getting them regularly serviced.
- (iv) We should be economical in our energy consumption as energy saved is energy produced.

VERY SHORT ANSWER TYPE QUESTIONS

Q.1. What is the use of reflector in a solar heating device?

Ans. It is used to concentrate the Sun's rays at a point.

Q.2. What is green house effect?

Ans. The confinement of heat radiations by the glass cover or earth's atmosphere thereby raising temperature is called green house effect.

Q.3. What part of sunlight is used for heating a solar device?

Ans. Infrared radiations.

Q.4. Why are solar heating devices painted black from inside?

Ans. So that they can absorb maximum amount of sun's heat.

Q.5. Name any two materials that are used to make solar cells.

Ans. Silicon and selenium.

Q.6. List two applications of geothermal energy.

Ans. Geothermal heat energy is used (i) to warm up people's houses (ii) for electricity production by trapping the steam generated to rotate the turbine of the dynamo.

Q.7. What is the biggest hindrance in trapping geothermal energy?

Ans. The geographical location of hot spring or geysers is a big hindrance in trapping geothermal sources of energy for practical uses.

Q.8. name the most powerful form of energy.

Ans. The nuclear energy.

Q.9. Give full form of CNG and LPG.

Ans. CNG - Compressed Natural Gas

LPG - Liquefied Petroleum Gas

Q.10. Name two forms in which solar energy manifests itself in oceans.

Ans. Tidal energy and Ocean thermal energy.

Q.11. Why copper tubes should be given more number of coils in a solar water heater?

Ans. More the number of turns of copper tube, hotter the water will become.

Q.12. What is a solar panel?

Ans. A group of solar cells arranged in a definite pattern is called a solar panel.

Q.13. Why is coke seldom used as a fuel?

Ans. Coke is more valuable if it is used as a reducing agent during metallurgical process. Therefore, it is seldom used as a fuel.

Q.14. What is the advantage of a spherical reflector over a plane reflector?

Ans. It can raise a temperature upto 1500°C .

Q.15. What are disadvantages of using wood as a fuel?

Ans. It has low calorific value and causes a lot of pollution.

Q.16. Name the component of sunlight prolonged exposure to which may cause skin cancer.

Ans. Ultraviolet radiation.

Q.17. Name the type of fuel which can be provided by sea-weed plantation.

Ans. Biomass fuel.

Q.18. Why CNG is considered as environmental friendly fuel?

Ans. Because it does not produce any toxic gases on burning.

Q.19. Which out of biogas and LPG has a lower calorific value?

Ans. Biogas has a lower calorific value.

Q.20. 'Charcoal is a better fuel than wood' Explain.

Ans. It is because:

- (i) Charcoal burns easily as compared to wood.
- (ii) Charcoal does not produce smoke on burning and so it causes no air pollution.
- (iii) The amount of heat produced by burning charcoal is much more than that produced by burning wood.

SHORT ANSWER TYPE QUESTIONS (2 Marks)

Q.1. Why is the use of wood as a fuel not advised although forests can be replenished?

Ans. This is because

- (i) Deforestation causes many problems like floods, erosion of fertile land and environmental imbalance.
- (ii) Replenishment of forests takes long time, as such wood cannot be available to supply continuous energy.

Q.2. Why is biogas a better fuel than animal dung cakes?

Ans. Because biogas does not produce smoke during burning and hence there is no air pollution. On the other hand, burning of animal dung cakes causes air pollution. Moreover, biogas gives more heat energy than the animal dung cakes.

Q.3. Out of the two solar cookers, one was covered by a plane glass slab and other was left open. Which of the two will be more efficient and why?

Ans. A solar cooker covered by a plane glass slab will be more efficient.

This is because glass slab does not allow the heat radiations to escape from the solar cooker and hence the temperature of the solar cooker covered with glass slab increases more than the temperature of the solar cooker which is left open.

Q.4. (a) Why is the solar cooker box covered with a plane glass plate?

(b) Why is energy of water flowing in a river considered to be an indirect form of solar energy?

(c) Why is nuclear fission reaction considered better? (C.B. S.E. (Delhi) 2007)

Ans. (a) Plane glass plate does not allow the infrared or heat radiation entered in the box to go out side the box. Thus, the box becomes hot. The phenomenon is known as green house effect.

(b) Solar energy evaporates water in rivers, lakes and oceans. These water vapours are converted into clouds (Kinetic energy + Potential energy). The clouds give rise to rain and hence water flows in rivers. Thus, energy of flowing water in the form of kinetic energy is the indirect form of solar energy.

(c) Nuclear fusion reaction gives rise to energy which is pollution-free.

Q.5. Explain why obtaining of energy from nuclear fusion reactions is preferable to obtaining of energy from nuclear fission reactions? Give two reasons.

Ans. Obtaining of energy from nuclear fusion reactions is preferable to obtaining energy from nuclear fission reactions because:

(i) For a given mass, energy released from nuclear fusion is much larger than the energy released from nuclear fission.

(ii) Nuclear waste in nuclear fission is radioactive. Its disposal is a big challenge. There is no such difficulty in nuclear fusion.

Q.6. Give four characteristics of a good fuel.

Ans. A good fuel should possess the following characteristics:

(i) It should do a large amount of work per unit volume of mass

(ii) It should be easily accessible.

(iii) It should be easy to store and transport.

(iv) It should be economical.

Q.7. 'Hydrogen is a cleaner fuel and better than CNG'. Comment.

Ans. (i) Hydrogen on burning produces more heat energy than produced by burning CNG.

(ii) Burning of hydrogen produces water vapours and burning of CNG produces CO_2 . So, burning of hydrogen causes less air pollution than CNG. Hence, hydrogen is cleaner and better fuel than CNG.

Q.8. (a) Name the device used to convert (i) Solar energy into heat and (ii) Solar energy into electricity.

(b) Explain the working of a wind mill. (C.B.S.E. (All India) 2006 (C))

Ans. (a) (i) Solar cooker **(ii)** Solar cell.

- (b) When wind blows with a minimum speed of 15 km/h, the kinetic energy of the wind is used to rotate the blades of wind mill. The rotational energy of the blades is used to rotate the armature of the generator to produce electricity.

Q.9. Mention any two differences between the two common designs of solar cooker.

Ans. The two common designs of solar cooker are –

- (i) box type solar cooker (ii) Reflector type solar cooker.

<i>Box type solar cooker</i>	<i>Reflector type solar cooker</i>
1. It does not concentrate solar energy at one point as plane reflector is used.	1. It concentrates energy at one point as concave reflector is used.
2. It can attain temperature in the range of 100°C to 140° C.	2. It can attain temperature in the range of 500 °C to 550 °C.

Q.10. Electricity generated with a windmill is another form of solar energy. Explain.

Ans. Solar energy is the cause of wind i.e. kinetic energy of moving air. Wind energy is converted into electricity by a windmill when it runs a turbine. Thus, a windmill converts solar energy into electrical energy.

SHORT ANSWER TYPE QUESTIONS (3 Marks)

Q.1. Explain how is the energy of flowing water related to solar energy?

Ans. The energy of flowing water is related to the solar energy through the water cycle as explained below.

Due to the heat of the sun evaporation of water from oceans, rivers and other water bodies takes place to form clouds. The clouds are taken to distant places by air currents, and ultimately water comes back to the earth's surface in the form of rain and snow. During evaporation, a part of the solar energy gets converted into potential energy (PE) of water molecules, which rise up in the air to form clouds. The potential energy of water molecules gets converted into kinetic energy (KE) during rain and snowfall. The water due to melting of ice and rains in high altitude, flows through rivers and streams as it has a higher gravitational potential energy. In the process, the potential energy gets transformed into kinetic energy of running water.

Q.2. What is biogas? How can biogas be obtained? Why is the use of biogas obtained from cow dung advised in preference to burning cow dung cakes? (AISSE 2006)

Ans. Biogas is a mixture of four gases: methane, carbon di oxide, hydrogen and hydrogen sulphide.

Biogas can be obtained from the anerobic decomposition of cow dung in the biogas plant.

It is preferred over cow dung cakes because:

(i) It does not cause air pollution.

(ii) It does not leave any residue unlike cow dung cakes.

Q.3. What are semiconductors ? Explain the principle of working of solar cell made of semiconductors. Why are solar cell panels used in artificial satellites ?

Ans. Those substances which have very low electrical conductivity are called semiconductors. To make a solar cell, thin layers of semiconductor materials like silicon and gallium containing impurities are arranged in such a way that when light falls on them, then a potential difference is produced between two regions of the semiconductor layers. This potential difference

produces electric current. Solar cell panels are used in artificial satellites to provide electricity. They can also be used for the working of water pumps, street lighting, and for radio and television sets in the remote areas.

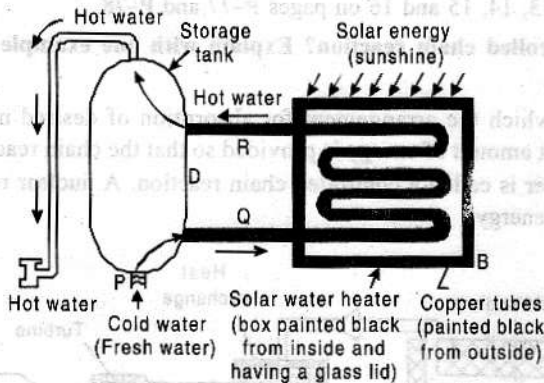
Q.4. Explain the formation process of fossil fuels (coal, oil and natural gas) in brief.

Ans. Long back, during prehistoric time (million of years ago), when plants, dinosaurs, animals, and other ancient creatures died, they decomposed and were buried layer upon layer under the earth. Their decomposed remains gradually changed over the years. It took millions of years to change these layers into a hard, black rock-like substance called coal, a thick liquid called oil or petroleum and an odourless combustible natural gas.

LONG ANSWER TYPE QUESTIONS (5 Marks each)

Q.1. With the help of a labelled diagram, explain the construction and working of a solar water heater.

Ans. Solar water heater consists of an insulated metallic box which is painted black from inside and outside. In this box copper tubes, painted black from outside, are fitted in a zig-zag shape. The box and copper tubes are painted black so that they may absorb maximum radiant heat energy of the Sun efficiently. The box is covered with a glass sheet lid to trap sun-rays by producing green house effect. The two ends of copper tubes are joined to a water storage tank as shown in figure. The solar water heater and its water storage tank are fitted on the roof of a building so that they may absorb the maximum radiant heat energy of the sun.



Working of Solar Water Heater: When the sun shines the radiant heat energy enters the metal box through glass sheet lid and is absorbed by water present in copper tubes. This water gets heated and it comes out through the other end of copper tube R and goes into storage tank. As long as sunshine is there, the water keeps in circulating between the solar heater box and insulated storage tank. The water keeps on circulating of its own because water on getting hot expands and pushes itself in the copper tube and finally moves into storage tank through tube Q. Now to replace this hot water fresh cold water moves into the copper tubes through tube for fresh water. In this way all the water in storage tank gets heated which can be taken out for use from the tap attached to pipe.

Q.2. Why are fossil fuels classified as non-renewable sources of energy? What steps should be taken to conserve these sources?

Ans. The term fossil means the remains of pre-historic plants and animals buried under the earth millions of years ago, may be due to some natural calamity. Fossil fuels are formed from dead plants and animals which got buried deep in the earth and got covered with sediments like mud and sand in the absence of oxygen. Chemical reactions, high pressure, heat and the action of anaerobic bacteria converted these fossils into fossil fuels like coal, petroleum and natural gas. This happened over a period of millions of years due to certain slow changes under special circumstances. Since these conditions are not prevailing now, therefore no new fossil fuels are being formed now. Hence they have been classified as non-renewable sources.

The following steps should be taken to conserve these fuels:

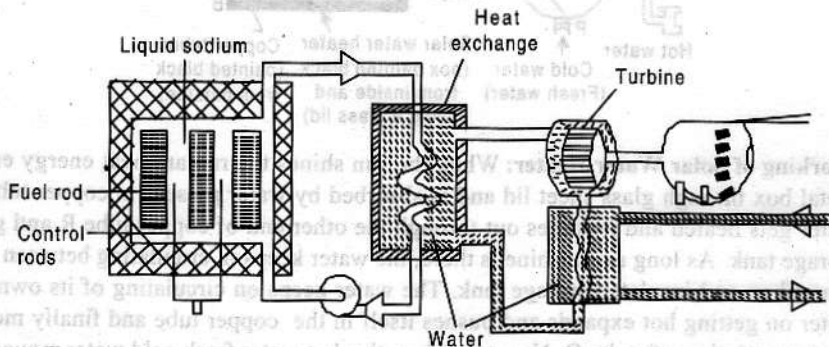
Use of alternative forms of energies like solar energy; waste biomass energy; sea wave energy, tidal energy, geothermal energy, wind energy and fusion energy. Understand that "Energy saved is energy produced". Therefore try to use energy judiciously. Do not waste energy uselessly. Put off all the lights and fans in your school, home and other places if they are not being used. Use geysers, electric iron and other energy consuming appliances carefully. Do not unnecessary use motor vehicles unless four to five persons are required to travel to reach a destination. Use public transport instead. Such small steps taken by all of us can save the earth from the energy getting exhausted.

Q.3. What are the main constituents of biogas? Describe with labelled diagram how it is prepared in a fixed dome type plant? What is the advantage of this plant?

Ans. Refer to points 13, 14, 15 and 16 on pages P-77 and P-78.

Q.4. What is a controlled chain reaction? Explain with one example. Draw a diagram of nuclear reactor.

Ans. The system in which the arrangement for absorption of desired number of neutrons to produce constant amount of energy is provided so that the chain reaction may proceed in a controlled manner is called a controlled chain reaction. A nuclear reactor is a source of a large amount of energy.



In order to absorb the undesired neutrons during the chain reaction, certain absorbing materials such as Cadmium, Boron etc. are used. The rods of Cadmium or Boron are inserted in such a manner that the right number of neutrons are absorbed by them.

The speed of the resulting neutrons is also to be reduced. This is done with the help of the moderators. The examples of moderators are heavy water, paraffin etc.

ACTIVITY BASED QUESTIONS

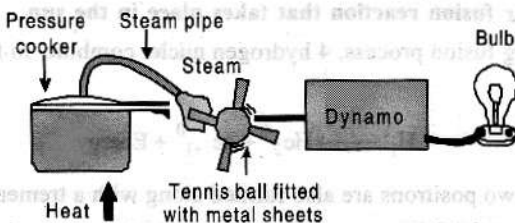
Q.1. Describe an activity to show that a black surface is a good absorber of heat than the white surface.

- Ans.**
- **Aim** – To show that a black surface is a good absorber of heat than the white surface.
 - **Apparatus required** – Two identical conical flasks, two thermometers, white and black paint, water.
 - **Procedure** –
 - (i) Take two conical flasks. Paint the outer surface of one flask with black paint and the outer surface of other flask with white paint.
 - (ii) Fill these flasks with water and put thermometers in both the flasks.
 - (iii) Place both the conical flasks in direct sun light for one hour.
 - (iv) Now touch the outer parts of both the flasks one by one. It is found that the flask painted black is hotter than the flask painted white.
 - (v) Note the readings of both the thermometers. It is found that the temperature of water in black painted flask is more than the temperature of water in white painted flask.

This activity shows that a black surface is a good absorber of heat than the white surface.

Q.2. Describe an activity to set up a model to generate electricity.

- **Aim** : To set up a model to generate electricity.
- **Apparatus Required**: Table tennis ball, pressure cooker, a pipe, light metallic sheets as blades, dynamo or a coil and magnet set up, bulb on a holder, a nail.
- **Procedure**:



Steam from cooker does work on blades to transform energy

- (i) Make three slits in the table tennis ball.
- (ii) Pierce three metallic thin blades on these slits.
- (iii) Pivot the ball on an axle using nail so that the ball can freely rotate.
- (iv) Heat water in a pressure cooker and attach the pipe to the steam outlet.
- (v) Connect a cycle dynamo or the coil in a magnetic field to the axle of the ball.
- (vi) Direct the steam from cooker outlet to the blades and make the ball to rotate.
- (vii) Observe the bulb connected to the dynamo or the coil.

• **Observation:**

- (i) Steam rotates the ball.
- (ii) The ball rotates the dynamo or coil.
- (iii) As the dynamo rotates, the bulb glows.

HIGHER ORDER THINKING SKILLS

Q.1. "A biogas plant solves the fuel as well as environmental problems." Discuss.

Ans. Biogas is an ideal fuel, as —

- It has high calorific value.
- It does not produce smoke.
- It has moderate ignition temperature.
- It does not form harmful products.
- It is very cheap and can be made available easily.

Because of the above mentioned characteristics

- Biogas acts as an excellent fuel and hence solves the fuel problem.
- Biogas does not create air pollution, therefore, it solves environmental problem also.
- Biogas also prevents water pollution.

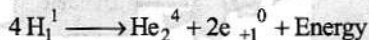
Q.2. What is the relationship between the masses m_1 and m_2 of lighter nuclei, which combine to make a heavy nucleus of mass M during nuclear fusion?

Ans. During the fusion process, if lighter nuclei of masses m_1 and m_2 combine to form a heavy nucleus of mass M , then the mass of heavy nucleus will always be less than the sum of the masses of lighter nuclei, i.e., $M < (m_1 + m_2)$. It is the difference of mass between the original nuclei and the product nucleus, i.e., $\Delta m = (m_1 + m_2) - M$, which gets converted into nuclear energy as per Einstein's Mass Energy formula.

Nuclear energy of mass Δm is, $E = \Delta mc^2$.

Q.3. Describe nuclear fusion reaction that takes place in the sun.

Ans. In the sun, during fusion process, 4 hydrogen nuclei combine to form a helium nucleus as per the reaction



In this process, two positrons are also formed along with a tremendous amount of energy.

Q.4. A student constructed a box type solar cooker. He found that it did not work efficiently. What could this be due to? Give any four possible mistakes in the solar construction and operation of the cooker. What maximum temperature can ordinarily be reached inside a solar cooker? (A.I.C.B.S.E. 1999)

Ans. He might be committing the following mistakes:

- He might have not blackened the interior of the solar cooker.
- He might be using a plastic cover instead of a glass cover.
- He might have not made it insulated.
- He might have not used black containers.

Maximum temperature attained in a solar cooker is about 140°C .

Q.5. A student has set up a solar cooker in a box by using a black painted aluminium sheet, a black cooking vessel, some glass wool, a glass sheet and a mirror plate. What is the role of each item used in the solar cooker?

Ans. Black painted aluminium sheet absorbs heat radiation.

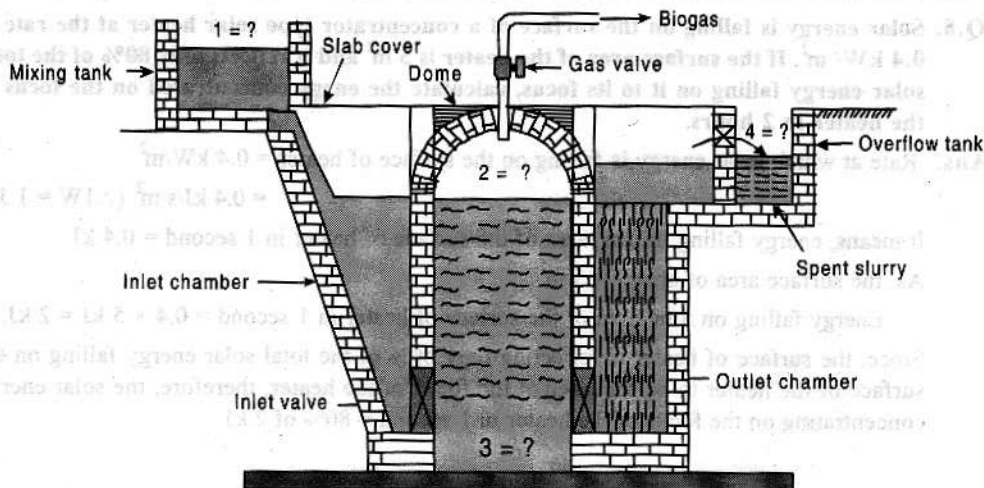
Black cooking vessel also absorbs heat radiation to cook food.

Glass wool prevents the loss of heat.

Glass sheet prevents the escape of heat radiation from the box.

Mirror plate reflects the sunlight to fall on the glass sheet.

Q.6. A diagram shown below is a biogas plant.



(i) Identify the parts indicated by question marks and labelled 1, 2, 3 and 4 in the diagram.

(ii) Name the micro organisms responsible for the fermentation of the slurry in the digester.

(iii) Name two chemical elements present in the manure or spent slurry.

Ans. (i) (1) Slurry of cattle dung and water

(2) Gas tank containing bio-gas

(3) Digester

(4) Spent slurry or manure

(ii) Anaerobic micro organisms

(iii) Nitrogen and phosphorous are present in the manure.

Q.7. Give reasons to explain why is it not possible to use solar cells to meet all our energy needs.

Or

Solar cell panels used in satellites to supply energy cannot be used to meet our domestic needs electricity. Explain, why?

Ans. Solar panels have limited uses. They cannot be used for domestic needs of electricity.

This is because of the following reasons:

(i) The solar cells used in a solar panel are made of pure silicon. The production of pure silicon is very costly affair. These solar cells in a solar panel are joined to each other with a best conductor silver to reduce the resistance of the solar panel to get maximum electricity. But

silver metal is also costly. Thus, we find that the cost of fabricating a solar panel is very high.

- (ii) The storage battery connected to a solar panel can supply direct current (D.C.). So only those electric appliances can operate with the solar panel which require direct current. However, the electric appliances which require alternating current (A.C.) cannot be operated with the solar panel.
- (iii) Solar panel can supply the electricity continuously only if the sun shines during day time.

Q.8. Solar energy is falling on the surface of a concentrator type solar heater at the rate of 0.4 kW/m^2 . If the surface area of the heater is 5 m^2 and it reflects only 80% of the total solar energy falling on it to its focus, calculate the energy concentrated on the focus of the heater in 2 hours.

Ans. Rate at which solar energy is falling on the surface of heater = 0.4 kW/m^2
= 0.4 kJ/s m^2 ($\therefore 1 \text{ W} = 1 \text{ J/s}$)

It means, energy falling on 1 m^2 area of the surface of heater in 1 second = 0.4 kJ

As, the surface area of heater = 5 m^2

\therefore Energy falling on 5 m^2 area of the surface of heater in 1 second = $0.4 \times 5 \text{ kJ} = 2 \text{ kJ}$.

Since, the surface of heater is reflecting only 80% of the total solar energy falling on the surface of the heater to be focussed at the focus of the heater, therefore, the solar energy concentrating on the focus of the heater in 1 second = 80% of 2 kJ

$$= \frac{80}{100} \times 2 \text{ kJ} = 1.6 \text{ kJ}$$

Solar energy concentrated on the focus of the heater in 2 hours (= $2 \times 60 \times 60$ second)

$$= 1.6 \times 2 \times 60 \times 60 \text{ kJ} = 11520 \text{ kJ}$$

Q.9. Hydroelectricity generated at a dam may be considered to be another form of solar energy. Why?

Ans. Heat energy of solar radiation causes vaporisation of surface water. These vapours after condensation return to the earth as rain or snowfall and this takes the form of running water. The heat radiations of Sun also cause melting of ice present on mountains. This melted ice takes the form of running water. The kinetic energy of flowing water is used for producing electricity. Thus, hydro-electricity is an indirect source of solar energy.

Q.10. The waste materials collected from a market complex are scrap paper, thermocol, vegetable waste, tin cans and glass bottles. Which of these can be used for producing biogas? Mention three advantages of converting these into biogas rather than burning them.

Ans. Scrap paper and vegetable can be used to produce biogas. Converting these into biogas has the following advantages:

- (i) It produces cheap and valuable fuel for which there is a great demand.
- (ii) It utilizes those substances which would, otherwise be wasted and, require space for its safe dumping.
- (iii) If this waste is left as such then it will be decomposed by micro-organisms. This results in release of harmful gases which increases environmental pollution.

SELF EVALUATION TEST

- Q.1 Why do we not use only solar energy in place of fossil fuels?
- Q.2. What is the other name of non-renewable source of energy?
- Q.3. Name the countries which tap large quantity of geothermal energy.
- Q.4. Name the place where India tested its nuclear capability.
- Q.5. Which is more powerful—Fission or Fusion?
- Q.6. What are the characters of a good source of energy? How do you classify them?
- Q.7. What prevents us in making use of solar cell panels to meet all our domestic needs of electricity?
- Q.8. What is the cause for the energy release in nuclear reactions? How do we express it?
- Q.9. Draw a neat diagram of a Solar cooker. Label its parts. What is the range of temperature one can attain in two hours of exposure to sunlight?
- Q.10. List some environmental consequences of the increasing demand for energy.
- Q.11. What are the various sources of energy? How each one affects the environment? On the basis of their merits and demerits, which is the best source of energy and why?

FORMATIVE ASSESSMENT

Fill in the blanks:

- Solar cell converts solar energy into electrical energy.
- Plane mirror type of reflector is used in a box type solar cooker.
- In order to trap the sun's heat inside a solar heating device glass sheet is used.
- Solar cell is a small wafer of semiconductor devices.
- The other name of a solar cell is photo voltaic.
- A group of solar cells, arranged in a definite pattern is called a Solar panel.
- The efficiency of a solar cell is around 10–25%.
- Flowing water contains kinetic form of energy.
- In hydroelectricity mechanical form of energy converts to electrical form.
- Periodic rise and fall of ocean water twice in a day is called Tide.
- Ocean thermal energy is due to difference in temperature of layers.

Match the Columns

Match No.1

Column I	Column II
(A) Visible range of electromagnetic waves	(p) Moderator
(B) It is not a chain reaction	(q) Fission
(C) It can be a chain reaction	(r) Fusion
(D) It takes place only at very high temp. (10^7 °C)	(s) 4000 Å - 8000 Å
(E) It slows down speed of neutrons	(t) Coolant
(F) Energy liberated per nuclei is more	(u) Heavy water
(G) To carry away the heat produced during fission	

Ans. (A, s), (B, r), (C, q), (D, r), (E, p, u), (F, r), (G, t)

Match No. 2

Column I	Column II
(A) Methane	(p) Not likely to be potential source of energy
(B) Silicon and Selenium	(q) Renewable sources of energy
(C) Solar energy and wind energy	(r) Likely to be a future source of energy
(D) Fossil fuel, petroleum	(s) Used in solar cells
(E) Tidal energy	(t) Non-renewable sources of energy
(F) Nuclear energy	(u) Main constituent of biogas

Ans. (A, u), (B, s), (C, q), (D, t), (E, p), (F, r)

Match No. 3

Column I	Column II
(A) Calorific value, combustion and ignition temperature	(p) Uses green house effect
(B) Tidal energy and thermal energy	(q) Non-renewable source of energy
(C) Petroleum gas	(r) Renewable source of energy
(D) Box type solar cooker	(s) Energy
(E) Hydro-energy, wind energy	(t) Qualities of a fuel
	(u) Clean source of energy

Ans. (A, s), (B, r), (C, q), (D, p), (E, r, u)

MULTIPLE CHOICE QUESTIONS

Q.1. The radiation carrying heat energy is

- (a) visible light (b) infra-red radiaton
(c) ultraviolet radiation (d) micro-wave

Q.2. Radiations which are harmful to the living organism are

- (a) infra-red radiation (b) ultraviolet radiation
(c) visible radiation (d) micro-waves

Q.3. A solar water heater cannot be used to get hot water on

- (a) a hot day (b) a sunny day
(c) a windy day (d) a cloudy day

Q.4. The radiation in the sunlight that gives the feeling of hotness is

- (a) visible (b) infra-red
(c) red (d) ultra-violet

Q.5. Solar constant is

- (a) 140 W m^{-2} (b) 1.4 W m^{-2}
(c) 1.4 k W m^{-2} (d) 1.4 M W m^{-2}

- Q.6.** Which of the followings is not a bio-mass energy source?
(a) gobar gas (b) coal
(c) wood (d) nuclear energy
- Q.7.** The energy which is not derived from the sun is
(a) bio-mass (b) fossil fuels
(c) hydro-electricity (d) geo-thermal energy
- Q.8.** Solar cells are made of
(a) metals (b) insulators
(c) semi-conductors (d) none of these
- Q.9.** Minimum speed of wind to operate generator to produce electricity is
(a) 15 ms^{-1} (b) 150 ms^{-1} (c) 1500 ms^{-1} (d) 15000 ms^{-1}
- Q.10.** Most of the sources of energy, we use, represent stored solar energy. Which of the following is not ultimately derived from the sun's energy?
(a) wind energy (b) bio-mass
(c) both wind energy and bio-mass (d) nuclear energy
- Q.11.** The main constituent of LPG is
(a) methane (b) butane (c) hydrogen (d) none of these
- Q.12.** The main constituent of CNG is
(a) butane (b) methane
(c) ethane (d) propane
- Q.13.** Which of these is not a renewable source of energy?
(a) The sun (b) Natural gas
(c) Wind (d) Ocean tidal energy
- Q.14.** The radiation absorbed by ozone layer are
(a) infra-red (b) visible
(c) ultra-violet (d) gamma rays

ANSWERS

1. (b) 2. (b), 3. (d), 4. (b), 5. (c), 6. (d), 7. (d), 8. (c), 9. (d), 10. (d),
11. (b), 12. (b), 13. (b), 14. (c)