IAT-2 NCES

Scheme and solutions

1) Explain the construction and working of Tidal Power Plant.

The three main components of a tidal power plant are:

(i) The power house ⇒ The turbine, electric generators and other auxiliary equipments are the main components of a power house.

(ii) Dam or Barrage (low wall) ⇒ The function of dam is to form a barrier between the sea and the basin or between one basin and the other in case of multiple basins.

(iii) Sluice ways – The sluice ways from the basins to the sea and viceversa are used either to fill the basin during the high tide or empty the basin during low tide, as per the operational requirements. [3 marks]

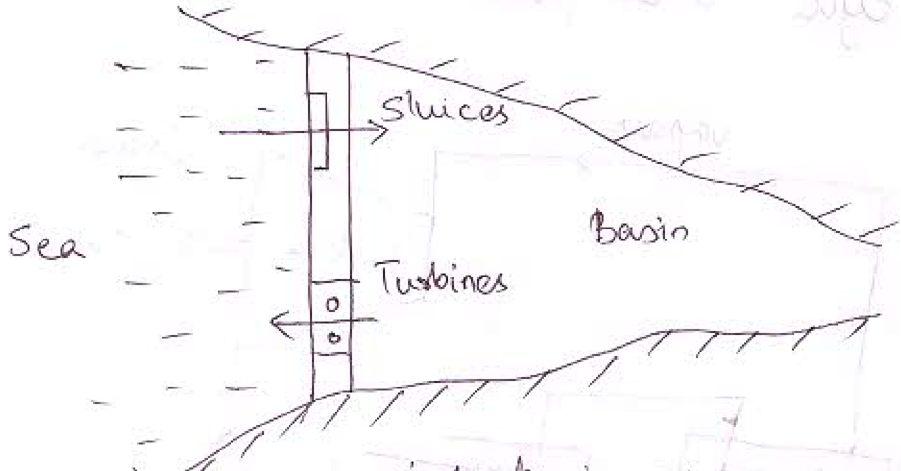
Working of Tidal Power plant

The generation of electricity from water power requires that ~~there~~ there should be a difference in levels between which water flows. A number of concepts have been proposed for generating electricity by utilizing the head that can be produced by the rise and fall of tides to operate a hydraulic turbine. The power generation from tides involves flow between an artificially developed basin and the sea. However, in order to have a more or less continous generation, this basic scheme can be elaborated by having two or more basins. Accordingly, we can distinguish the following types of arrangements:

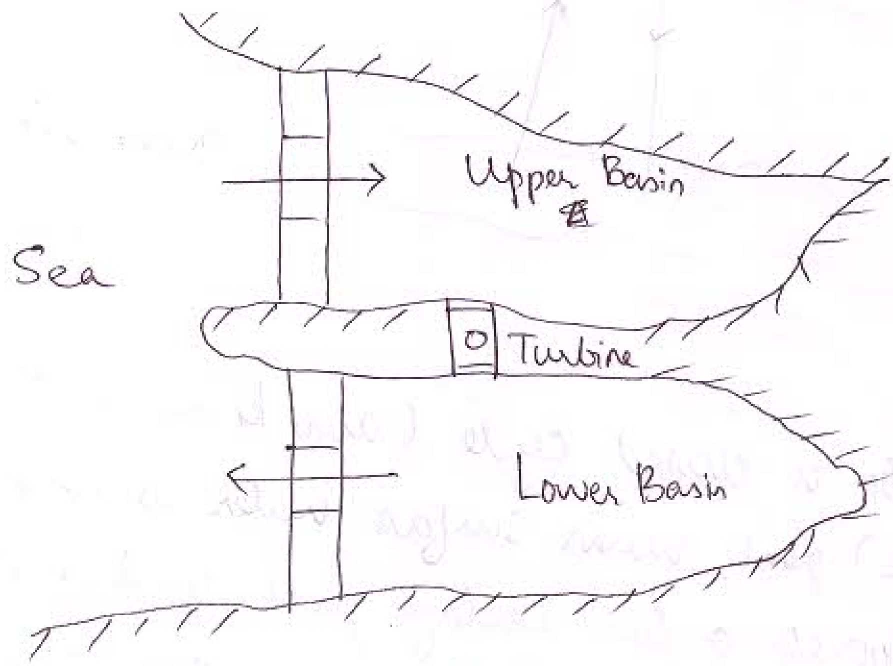
(1) Single basin arrangement → This can generate power only aleimittently.

(2) Double basin arrangement → This can provide power on demand or continously, but the civil works are more extensive compared to single basin arrangement.

In the simplest double basin scheme, there must be a dam between each basin and the sea, and also a dam between the basins containing the power house. One basin is maintained at a lower level than the other. The lower basin empties at lower tide, and the upper basin replenished at high tide. [4 marks]



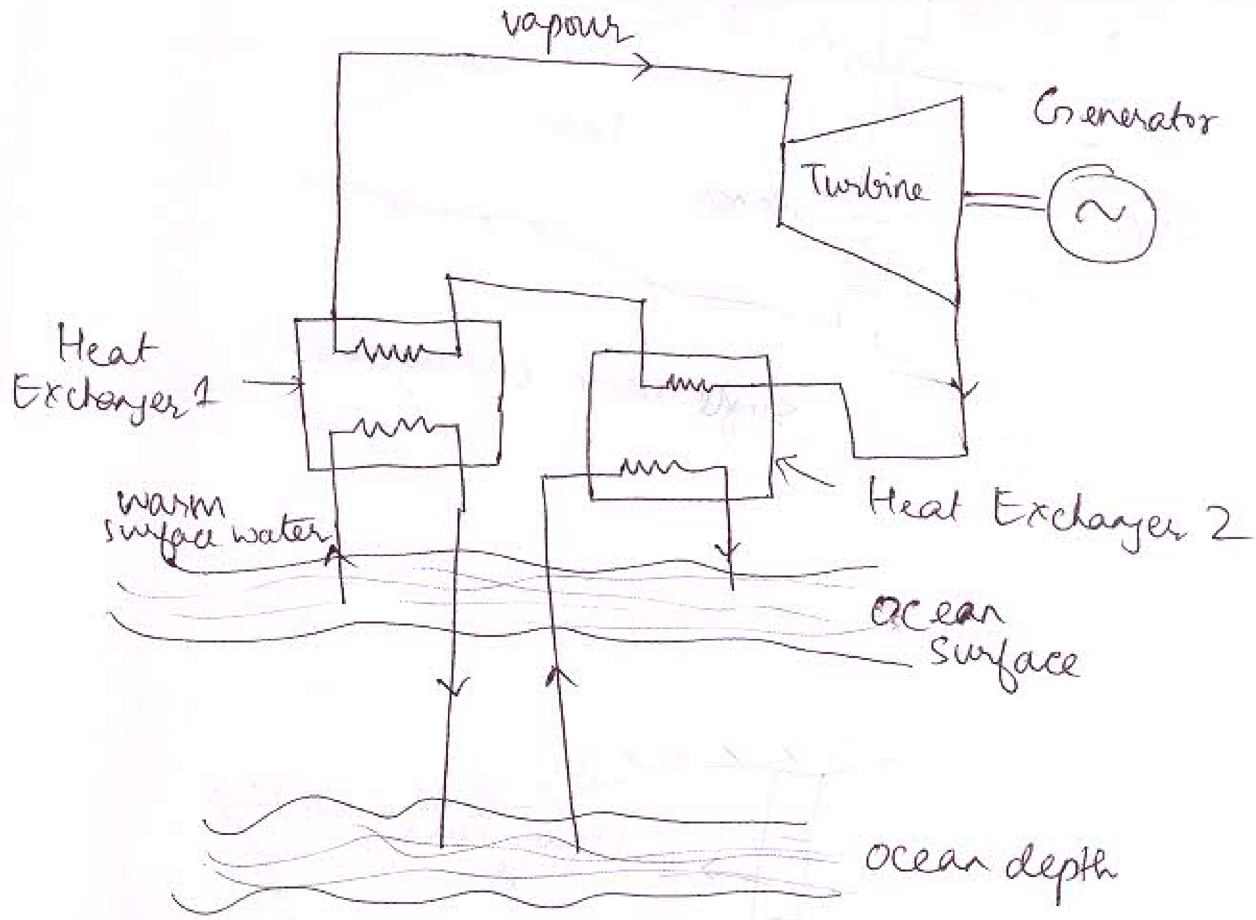
single basin arrangement



Double basin arrangement.

[3 marks]

2) Closed cycle OTEC plant



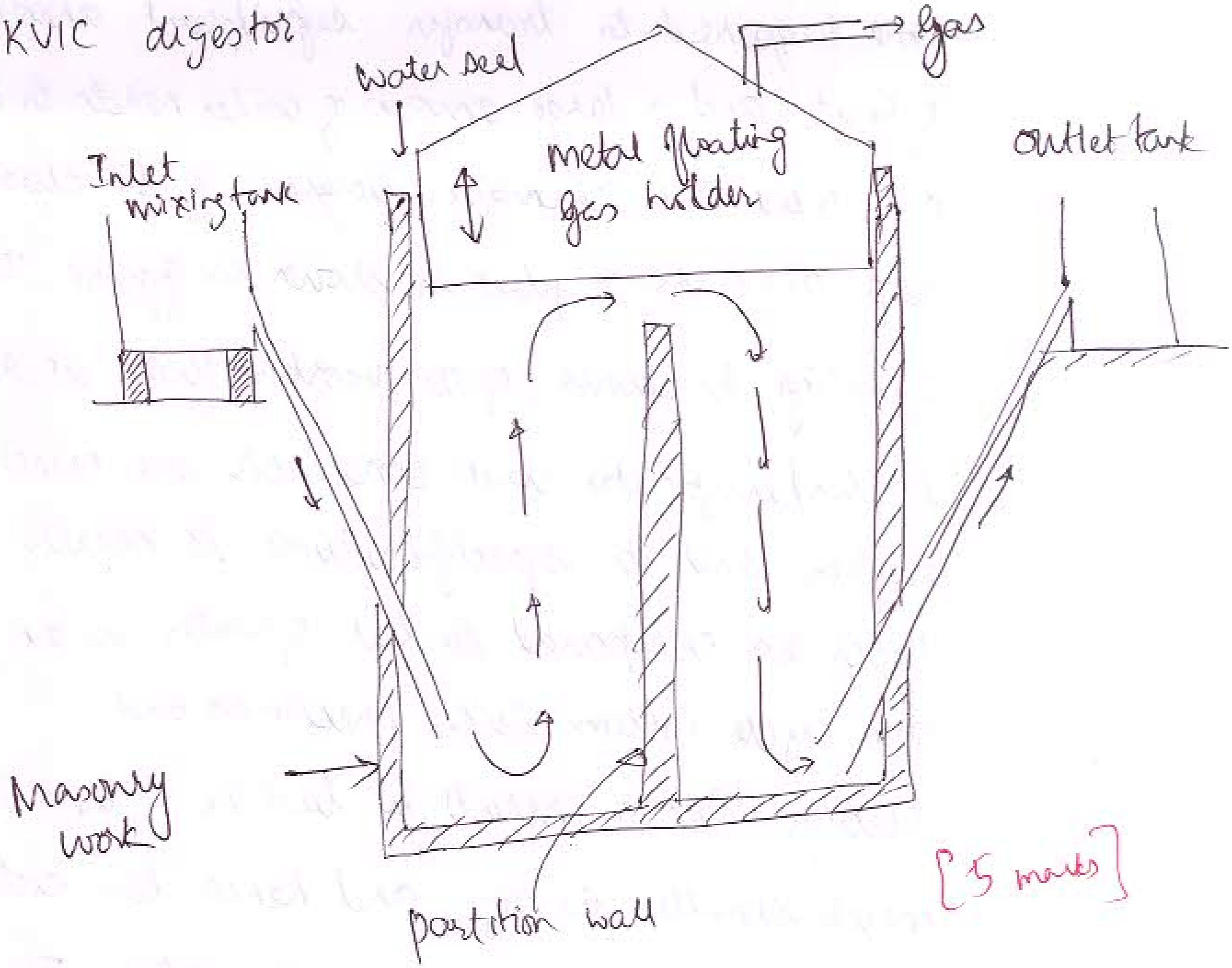
[5 marks]

In a closed cycle (also known as Anderson cycle) plant, warm surface water is used to evaporate a low boiling point working fluid such as ammonia, freon or propane. The vapour flows through the turbine and is then cooled and condensed by cold water pumped from the ocean depths. Because of the low quality of heat, large surface area of heat exchangers (evaporators and condensors) are required to transfer significant amount of heat and a large amount of water needs to be circulated. The schematic diagram of the closed loop OTEC power plant is shown in figure. The operating pressures of the working fluid at the boiler/evaporator and condensor are much higher and its specific volume is much lower as compared to that of water in an open cycle system. Such pressures and specific volumes result in turbine that is much smaller in size and hence less costly as compared to an open cycle system. The closed-cycle system thus appears more promising in the near future.

Both open cycle and closed cycle plants can be mounted on ships or built on shore. The cooling water taken from the sea depth is nutrient rich and can be diverted to lagoon to develop mariculture after utilizing its cooling effects.

[5 marks]

3) KVIC digestor



[5 marks]

The KVIC model (Khadi and Village Industries Comission) consists of an inverted mild steel drum to work as gas holder. The digestor is an underground masonry construction with a partition wall. The bifurcation of a digestion chamber through a partitioning wall provides optimum conditions for growth of acid formers and methane formers as the pH values for these bacteria are different.

The depth of the digestor varies from 3.5m to 6m. and the diameter from 1.35m to 6m depending on gas generating capacity and quantity of raw material ~~feed~~ fed each day. The partition wall is lower than the level of the digestor rim and hence it is submerged in slurry when the digester is full. Two slanting pipes reach the bottom of the well on either side of the partition wall. One pipe serves as the inlet and the other as outlet. An inlet chamber near the digestor at surface level serves for mixing dung and water which is done either manually or mechanically. The gas holder fits into the digestor like a stopper. It sinks into the slurry due to its own weight and rests upon the ring constructed for this purpose. As the gas is generated, the holder rises and floats freely on the surface of the slurry. A pipe is provided at the top of the holder for flow of gas for usage.

[5 marks]

4 (a) Photosynthesis

Photosynthesis is the process by which plants combine CO_2 from the atmosphere with water under the presence of light to produce oxygen and carbohydrates (sugars, starches, celluloses and hemicelluloses). They are the ultimate source of most of our foods and other necessities of daily life such as clothes (in the form of cotton), furniture (in the form of wood etc).

$$xCO_2 + yH_2O + \text{light energy} \longrightarrow xO_2 + C_x(H_2O)_y$$

Photosynthesis is a complex process and involves several successive stages, but the overall basic reaction may be expressed as shown above. The generalized symbol $C_x(H_2O)_y$ is used to indicate the carbohydrates. The intake of CO_2 and thus the rate of photosynthesis is a function of many factors especially temperature, concentration of CO_2, and the intensity and wavelength distribution of the incident light.

[5 marks]

4(b) Energy Plantation

~~Dynamics of plant~~

Energy plantation is the method of tapping maximum solar energy by growing plants. Energy farms are ideal solar collectors requiring virtually no maintenance, it is economical and non-polluting. It uses an established technology and stores energy. Growth of plants for their fuel value offers a renewable source of liquid fuel and organic chemicals. Energy plantations can be considered as long term alternative to fossil and nuclear energy.

Energy plantations by design are managed and operated to provide substantial amounts of useable fuel continously throughout the year at the costs competetive with other fuels.

It is worth considering energy plantations seriously because plants as they grow, serve as a convenient single service disposal solar energy storage device from which accumulated energy can be released at will, at temperatures comparable with those achieved from fossil fuels.

[5 marks]

5) Production of Hydrogen

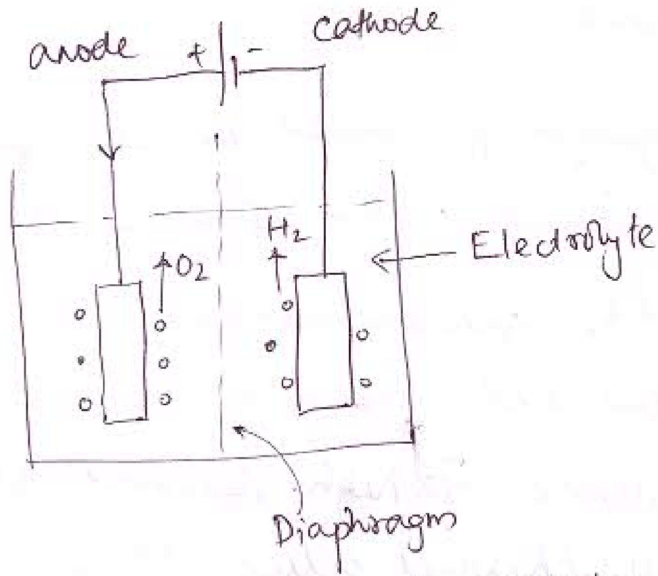
Hydrogen does not exist in free state, except for small quantities in the upper atmosphere. It is therefore, not a primary ~~source~~ an energy source. However, large amounts of combined hydrogen are present in compounds such as water, fossil fuels and biomass. It can therefore be produced through two routes:

(i) Fossil fuels, such as natural gas, coal, methanol, gasoline, etc are decomposed by thermo-chemical (steam reforming or partial oxidation) methods to obtain hydrogen. This route of hydrogen production causes CO_2 emission.

(ii) Hydrogen can also be produced by splitting H_2O into hydrogen and oxygen by using energy from nuclear or renewable sources such as solar, wind and geothermal through electrical or thermal means (i.e electrolysis and thermolysis respectively). Water splitting is also possible through bio-photolysis process using solar radiation.

[5 marks]

Electrolysis of water



Electrolysis is the simplest method of hydrogen production. An electrolytic cell consists of two electrodes, commonly flat metal or carbon plates, immersed in an aqueous conducting solution called electrolyte. A direct current decomposes water into H_2 and O_2 which are released at cathode and anode respectively. As water itself is a poor conductor of electricity, an electrolyte, commonly aqueous KOH is used. A diaphragm (usually woven asbestos) prevents electronic contact between the electrodes and passage of gas or gas bubbles. Ideally, a voltage of 1.23V per cell should be sufficient, however, due to various reasons, above 2V per cell is applied in practice.

[5 marks]

6(a) <u>Transportation of Hydrogen</u>

<u>Pipelines</u>-

Hydrogen produced in centralised locations can be delivered (i) via pipelines, or (ii) stored in tanks, cylinders, tubes etc, that are loaded onto trucks and rail cars and transported to consumers. For high-demand areas, pipelines are the cheapest option. For low-demand areas, it is transported via road/rail. In the range of about 300 km, hydrogen is being transported via high-pressure cylinders. For very long distances in the range of 1500 km, hydrogen is usually transported as liquid in super insulated cryogenic tankers on road or rail. Hydrogen can also be transported as a solid metal hydride. The main drawback is the weight of the hydride relative to its hydrogen content.

[5 marks]

6(b) Storage of hydrogen

Large amounts of hydrogen for subsequent distribution would be stored in underground facilities similar to those used for natural gas, eg depleted oil and gas reserves and aquifers.

Hydrogen is can be stored in strong steel tank or cylinder. It is stored typically at pressures of 350 to 700 atm.

Hydrogen can also be stored as compact storage in liquid form at low temperature. It takes up low storage volume but requires cryogenic containers, as the boiling point of H_2 is 20K.

Hydrogen can also be stored at high densities in reversible metal hydrides. When required, it can be released by heating the hydride, and the original metal or alloy recovered for further recycling.

$$3H_2 + LaNi_5 \rightleftharpoons (LaNi_5)H_6 + \text{heat}$$

$$FeTi + H_2 \rightleftharpoons (FeTi)H_2 + \text{heat}$$

$$Mg_2Ni + 2H_2 \rightleftharpoons (Mg_2Ni)H_4 + \text{heat}$$

[5 marks]