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Page : 20
April : 2024

TED (21) – 5023C

REVISION - 2021

2109230044

SCHEME OF EVALUATION

POWER PLANT ENGINEERING

PART- A

I. Answer ***all*** the following questions in one word or sentence. Each question carries ***1 mark***.

(9× 1=9 marks)

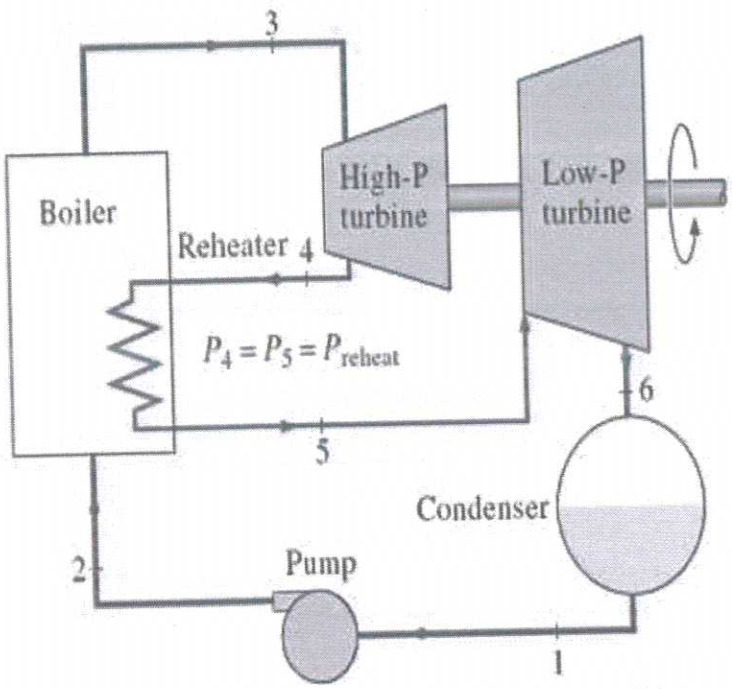
Q. No	Scoring Indicators	Split Score	Sub Total
I.1	The assembly of equipment, that produces mechanical Energy by utilising the available energy source and converting it to electrical energy.	1	1
I.2	Pour point	1	1
I.3	The amount of heat liberated in kilo calorie or kilo joules by the complete combustion of 1 Kg of fuel	1	1
I.4	Surge Tank	1	1
I.5	Bleeding	1	1
I.6	Thermal Pollution	1	1
I.7	Dry deposition	1	1
I.8	Sodium (Na)	1	1
I.9	Global Warming	1	1

PART- B

II. Answer ***any Eight*** questions from the following. Each question carries ***3 marks***.

(8 × 3=24 marks)

Q. No	Scoring Indicators	Split Score	Sub Total
II.1	**Gaseous Fuels Advantages:** 1. They are free from solid and liquid impurities. 2. Maximum complete combustion of gaseous fuel is possible. 3. The rate of combustion and temperature in the combustion chamber can be easily controlled. 4. For complete combustion less amount of excess air is required. 5. Do not produce ash and smoke. 6. Large amount of heat and temperature is obtained at a moderate cost.	3x1	3

II.2	 The efficiency of the steam cycle (Rankine cycle) could be increased by increasing steam pressure in the boiler and superheating the steam. But this increases the moisture content of the steam in the lower pressure stages in the turbine, which may lead to erosion of the turbine blade. Therefore, a reheat cycle has been developed to take advantage of the increased pressure of the boiler, avoiding the excessive moisture of the steam in the low pressure stages. In the reheat cycle, steam after partial expansion in the turbine is brought back to the boiler, reheated by combustion gases and then fed back to the turbine for further expansion. **Advantages of reheating of steam** ➢ It increases the work done through the turbine. ➢ It increases the efficiency of the turbine. ➢ It reduces the erosion of the blades, because of increase in dryness fraction of steam at exhaust. ➢ The amount of water required in the condenser of the turbine is reduced, due to reduction in the specific steam consumption.	3	3
II.3	A good fuel should have; 1) Low ignition point. 2) High calorific value. 3) Freely burn with high efficiency. 4) Should not produce harmful gases. 5) Should produce less quantity of smoke and gases. 6) Should be economical. 7) Easy to store. 8) Easy, safe and convenient for transportation	6x0.5	3

II.4	**Definition:** Thermal pollution refers to the release of heated water from power plant cooling systems into nearby water bodies. **Temperature Increase:** Discharging hot water can cause a significant increase in water temperature, which can harm aquatic life and ecosystems. **Oxygen Depletion:** Elevated water temperatures can reduce the dissolved oxygen content in water, making it difficult for fish and other aquatic organisms to survive. **Regulation:** Regulations often require power plants to use cooling technologies, such as cooling towers, to minimize thermal pollution. **Mitigation:** Advanced cooling technologies and best practices can help reduce the impact of thermal pollution on water bodies.	3x1	3
II.5	**<u>Nuclear Power Plant/Engineering</u>** • **Need:** Worlds energy resources (coal, fossil fuels, hydroelectric potentials) will be unable to meet the demands of energy requirements, atomic energy is the only solution E.g. 1 kg of Uranium produces heat equivalent to 4500 tonnes of coal. • The ability of nuclear power plants to produce electricity economically and safely without the generation of green house, make it more attractive. • Nuclear power plant is similar to steam power plant except that there is a nuclear reactor and a heat exchanger instead of furnace and boiler. • The heat energy released during controlled fission chain reactions in radioactive elements/isotopes such as uranium, plutonium etc. is utilized to generate steam. • The steam is generated either directly in the reactor or in a heat exchanger. The other cycle of operations and components are same as for a steam power plant. • The fluid used to transfer heat energy produced in the reactor to a steam generator (boiler) is called coolant. • **Nuclear Fission Energy → Electrical Energy**	3	3
II.6	Hydroelectric power plants are classified according to water flow regulation as 1. Run-off river plant with and without pondage. 2. Hydroelectric power plants with storage reservoirs/river 3. Pumped storage plant	3x1	3
II.7	➢ **Fuel:** A fuel is defined as a combustible substance, containing mostly carbon (main constituent) and hydrogen. Which on burning with oxygen in atmospheric air, produces a large amount of heat. The amount of heat generated is known as calorific value of the fuel.	1	

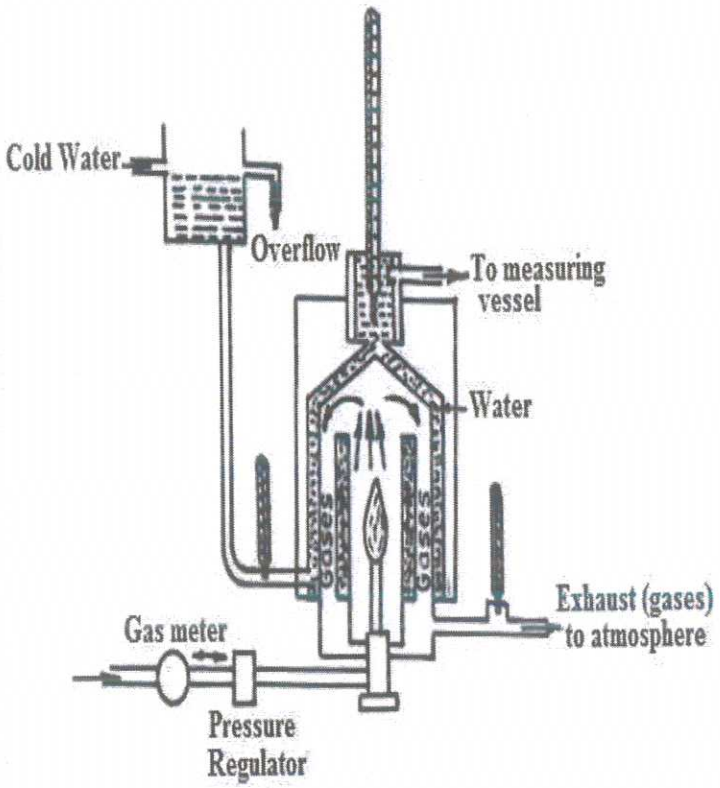
	➢ **Flash point:** Flash point of a flammable liquid is defined as the minimum temperature at which the fuel upon heating form an ignitable mixture. which after mixing with the air give a sudden flash when a source of fire is brought in contact with it. ➢ **Fire point**: It is the temperature at which vapors of the flammable liquid continue to burn after being ignited even after the source of ignition is removed. So, the fire point is more than the flash point for a particular petroleum fraction. Hence, flash point is more important than fire point in view of any fire hazard.	1 1	3
II.8	**Prevention Greenhouse effect** 1. **Reduce Carbon Emissions:** The most effective way to prevent the greenhouse effect is to reduce carbon emissions. This can be achieved by using renewable energy sources, such as wind, solar, and hydro power, reducing dependence on fossil fuels, promoting energy efficiency, and adopting sustainable practices. 2. **Promote Afforestation:** Trees absorb carbon dioxide from the atmosphere and release oxygen, making afforestation a crucial measure for reducing greenhouse gas concentrations. Promoting afforestation, especially in urban areas, can also help to reduce air pollution and enhance the quality of life. 3. **Reduce Waste:** Landfills are a major source of greenhouse gas emissions. Reducing waste can help to reduce the amount of methane produced in landfills. This can be achieved by reducing, reusing, and recycling waste materials. 4. **Adopt Sustainable Agricultural Practices:** Agriculture is another major source of greenhouse gas emissions. Adopting sustainable agricultural practices, such as reducing fertilizer use, promoting organic farming, and adopting water conservation techniques, can help to reduce greenhouse gas emissions from agriculture. 5. **Promote Sustainable Transportation:** Transportation is a major source of greenhouse gas emissions. Promoting sustainable transportation, such as public transportation, carpooling, cycling, and walking, can help to reduce greenhouse gas emissions and improve air quality.	3x1	3
II.9	**<u>Social Issues:</u>** 1. **Environmental Impact:** Pollution, habitat destruction, and contributions to climate change. 2. **Health Impacts:** Illness, healthcare costs, and reduced economic productivity due to emissions.	3x0.5	

	3. **Land Use and Property Values:** Conflicts over land use and potential property value reductions. 4. **Social Disruption:** Noise, traffic, and changes in local populations during construction and operation. 5. **Community Engagement and Equity:** Concerns about decision-making processes and environmental justice. 6. **Energy Access:** Disparities in access to reliable electricity. **<u>Economic Issues:</u>** 1. **Energy Costs:** High energy costs affecting household budgets and industries. 2. **Job Creation and Economic Development:** Job opportunities and economic growth in host communities. 3. **Water Use:** Competition for water resources and increased water costs. 4. **Technological Innovation:** Balancing reliability with cleaner energy alternatives.	3x0.5	3
II.10	Radiations from nuclear-power plant effluents are low-dose-level types of radiations. The effluents are mainly gases and liquids. Mainly the effects of these radiations on the populations living near the plants prompt environmental concerns about nuclear power plants. Sources of effluents vary with the type of reactor. 1. **Gamma Radiation:** Highly penetrating electromagnetic radiation emitted by radioactive materials. 2. **Beta Radiation:** High-energy electrons or positrons emitted by certain radioactive isotopes. 3. **Alpha Radiation:** Relatively heavy alpha particles emitted by select radioactive materials. 4. **Neutron Radiation:** Subatomic particles found in atomic nuclei, released in nuclear reactions. 5. **X-rays:** Generated for various purposes within nuclear facilities, including diagnostics. 6. **Tritium Emissions:** Release of tritium, a radioactive form of hydrogen, often in gaseous effluents. 7. **Other Radionuclides:** Various radioactive isotopes like Cs-137, Sr-90, and I-131, each emitting specific types of radiation.	3x1	3

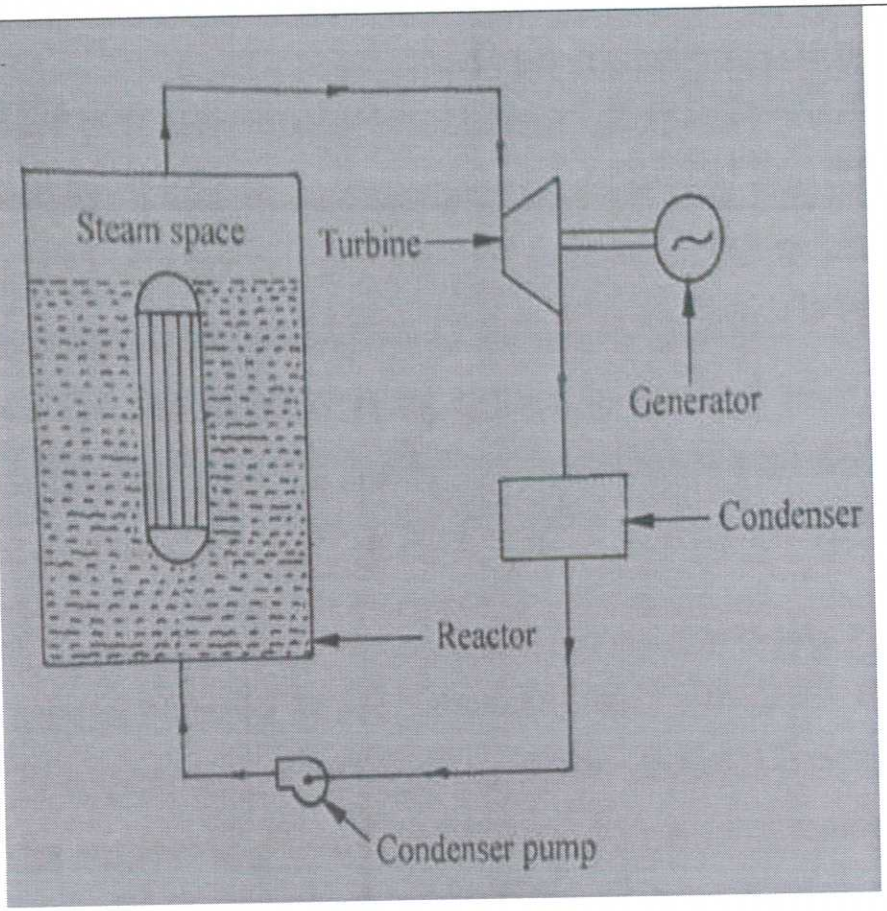
PART- C

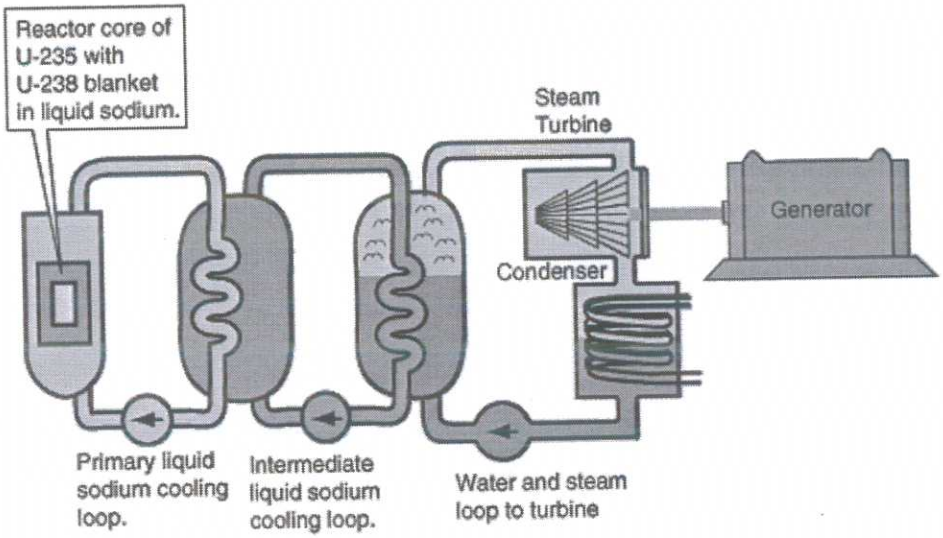
Answer ***all*** questions from the following. Each question carries ***7 marks***.

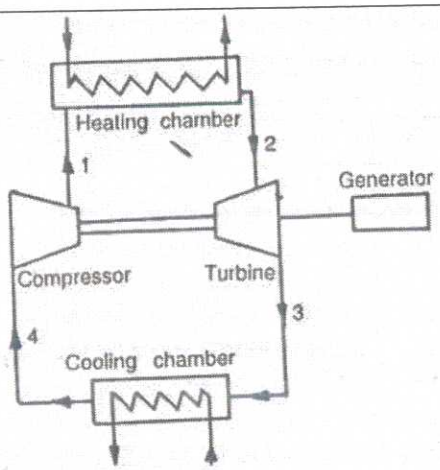
(6 × 7=42 marks)

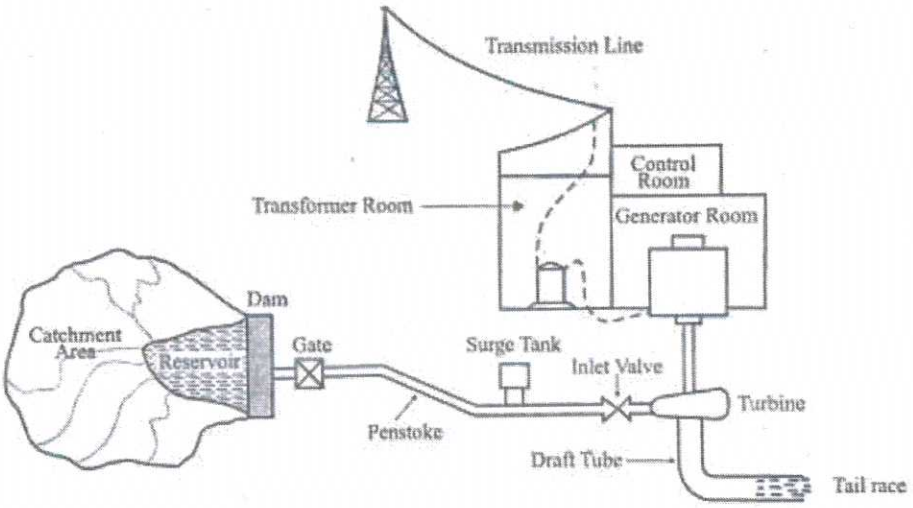
Q. No	Scoring Indicators	Split Score	Sub Total
III		4	7
	➢ The metered gaseous fuel is continuously supplied to calorimeter at constant pressure, where it is burnt in presence of air. In its simplest construction, it consists of a combustion chamber in which the gas is burnt. A water jacket through which a set of tubes called flue gas pass surrounds this chamber. Thermometers are incorporated at different places to measure the temperatures.	3	
	➢ ***Procedure:*** A metered quantity of gas whose calorific value is to be determined is supplied to the gas burner *via* a gas meter which records its volume and a gas pressure regulator which measures the pressure of the gas by means of a manometer. When the gas burns, the hot products of combustion travel upwards in the chamber and then downwards through the flues and finally escape to the atmosphere through the outlet. The temperature of the escaping gas is recorded by the thermometer fitted at the exit and this		

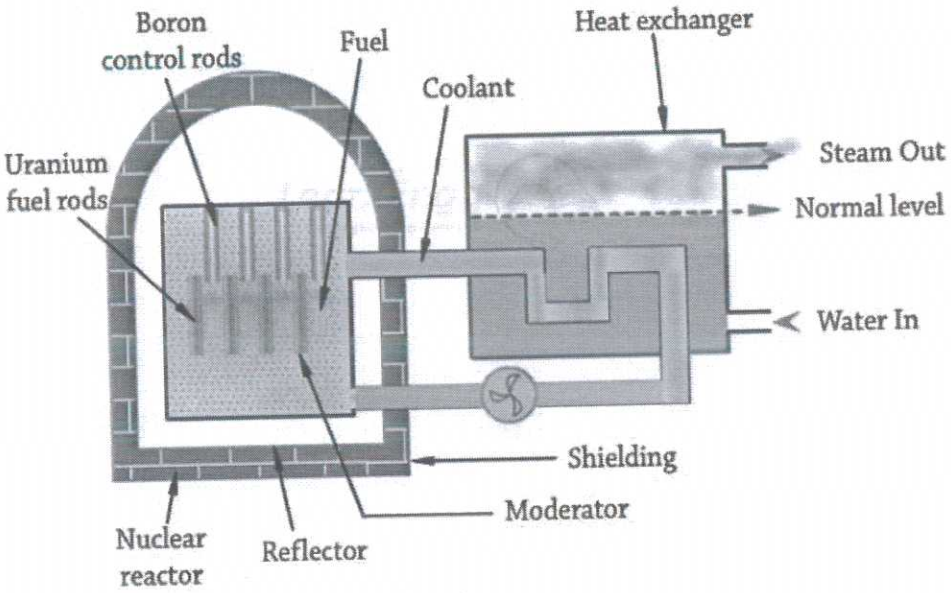
	temperature should be as close to room temperature as possible so that entire heat of combustion is absorbed by water. The cold water enters the calorimeter near the bottom and leaves near the top. Water which is formed by condensation of steam is collected in a pot. The quantity of gas used during the experiment is accurately measured by the meter and temperatures of ingoing and outgoing water are indicated by the thermometers. From the above data the calorific value of the gas can be calculated.		
	OR		
IV	**Liquid fuels:** Most of the liquid fuels in use are the hydrocarbons which exist in the liquid phase at room temperature. 1. *Petrol or gasoline*. It is the lightest and most volatile liquid fuel, mainly used for light petrol engines. It is distilled at a temperature from 65° to 220° C. 2. *Kerosene or paraffin oil*. It is heavier and less volatile fuel than the petrol, and is used as heating and lighting fuel. It is distilled at a temperature from 220° to 345° C. 3. *Heavy fuel oils*. The liquid fuels distilled after petrol and kerosene are known as heavy fuel oils. These oils are used in diesel engines and in oil-fired boilers. These are distilled at a temperature from 345° to 470° C. **Advantages:** 1) Liquid fuel have high calorific value. 2) Less space is required for storage. 3) Easy control of combustion by stopping supply of fuel. 4) It is very clean fuel, dust free. 5) Reduction in cost of handling. 6) Easily transported through pipes. 7) During burning it does not form ash. **Disadvantages:** 1) Cost of liquid fuel is high. 2) The storage tank specially designed. 3) It has higher cost. 4) Danger of explosion. 5) Liquid fuels mostly are imported from other countries.	3 4x0.5 4x0.5	7

V	 • **Essential Elements/Parts** **Nuclear reactor:** It is the device where nuclear fission takes place and energy is liberated. It is done under controlled environment **Pump:** It circulates water in the nuclear reactor **Steam Turbine:** It receives the vapour and converts energy to work **Condenser:** It receives the output from the turbine, reject heat from it and converts it to liquid • ***Working*** ✓ Its working is very much similar to the thermal power plant except boiler ✓ In nuclear reactor due to nuclear fission reaction emits a lot of energy, which is used directly to heat the water for steam generation. ✓ The steam is then passed to turbine to obtain the work output ✓ The steam losses energy and the low pressure steam condenses to water ✓ The water is again pumped back to reactor and the cycle is completed ✓ Here the reactor is given a covering and water is put in this covering and heated.	3 4	7
	OR			

VI	 ❖ In this reactor no moderator is used. ❖ In this reactor the core containing U-235 is surrounded by a blanket of fertile material (U^{238}). ❖ The fast moving neutrons liberated due to fission of U-235 is absorbed by U^{238} which gets converted into fissionable material PU^{239}, which is capable of sustaining chain reaction. $\text{Uranium} - 238 + 1\ \text{Neutron} \rightarrow \text{Plutonium} - 239 \longrightarrow U^{238} + 1\ n \rightarrow Pu^{239}$ ❖ This reactor is important because it breeds fissionable material from fertile material U^{238} available in large quantities. ❖ Like Sodium Graphite Reactor (SGR), Fast Breeder Reactor also uses two liquid metal coolant circuits. ❖ Liquid Sodium (Na) is used as primary coolant when circulated through the tubes of intermediate heat exchange transfers its heat to secondary coolant Sodium Potassium (NaK) alloy. The secondary coolant while flowing through the tubes of steam generator transfer its heat to feed water. ❖ Sodium (Na) has the following advantages: It has very low absorption cross sectional area, Good heat transfer properties at high temperature and low pressure, it does not react with any of the structural material used in primary circuit ❖ Commonly used coolants for FBR are Liquid Metal (Na and NaK), Helium (He), Carbon dioxide ❖ Fast breeder reactors are better than conventional reactor both from the point of view of safety and thermal efficiency.	3 4	7

VII	 Schematic arrangement of a closed cycle gas turbine. A closed cycle gas turbine power plant is shown in figure, here the working fluid is air which is circulated continuously within the turbine. The components of this power plant are compressor, heating chamber, gas turbine and a cooling chamber. **1. Compressor:** It is used to compress the gas. **2. Heating chamber:** The heating of the compressed gas is takes place in the heating chamber. **3. Gas turbine:** it is used to produce the useful work which is used by the generator to generate electricity. **4. Generator:** It generates the electricity with the help of the gas turbine. **5. Cooling chamber:** Cooling of the gas after passing from the turbine takes place in the cooling chamber **Working** The closed cycle gas turbine works on the principle of Joule's or Brayton's cycle. In this turbine, the gas is compressed isentropically and then passed into the heating chamber. The compressor generally used is of rotary type. The compressed air is heated with the help of some external source and then made to flow over the turbine blades. The turbine used here is of reaction type. The gas while flowing over the blades of the turbine, gets expanded. From the turbine the gas is passed to the cooling chamber. Here the gas is cooled at constant pressure with the help of circulating water to its original temperature. Now the gas is again made to flow through the compressor to repeat the process. Here the same gas is circulated again and again in the working of a closed cycle gas turbine. **OR**	3 4	7

VIII	 • Plants designed to produce **Electricity from Water Power** • Source of Energy- **Potential Energy of Water** • The primary source of water is rainfall and depends on the **Hydrological Cycle of Nature** • **Essential Elements** ✓ Storage Reservoir ✓ Dam ✓ Waterways ✓ Control Works ✓ Surge Tank ✓ Power House ✓ Water Turbines • **Working Principle** Potential Energy/Kinetic Energy of Water → Mechanical Power at Turbines → Electrical Energy at Generator **Working** Water available from the catchment area is collected in the reservoir behind the dam The power house is located at a lower level, so that maximum possible head is available for the supply water The power house provided with water turbines are coupled to electric generators for the production of electricity. Water from the reservoir is supplied to the turbines through penstock. Gates and valves control the rate of water flow entering the turbine. A storage reservoir known as surge tank is fitted to the penstock at a point near to the turbine. It is provided to avoid the effect of water hammer in the penstock. The turbines convert the kinetic energy of flowing water into mechanical energy. The mechanical energy developed by the turbine is utilised for running the electric generator. The water after doing work on the turbine passes through the draft tube to the tail race. Transformers and transmission lines are provided for the efficient distribution of electric power generated.	3 4	7

IX	 Reactor is the most Essential Element of a Nuclear Power Plant, it is the device where nuclear fission takes place and energy is liberated. The heat energy liberated in the reactor is taken up by the coolant circulating through the core It is a source of intense radioactivity A thick concrete shielding and a pressure vessel are provided to prevent the escape of these radiations to atmosphere. • The nuclear fuel (U^{235}) is subjected to nuclear fission. It controls the chain reaction that starts once the fission is done. • If the chain reaction is not controlled the result will be an explosion due to the fast increase in the energy released. • A nuclear reactor is a cylindrical stout pressure vessel which houses fuel rods (uranium) moderator and control rods. • The fuel rods constitute the fission material and release huge amount of energy when bombarded with slow moving neutrons. • The moderator consists of graphite rods which enclose the fuel rods. • The moderator slows down the fast moving neutrons before they bombard the fuel rods. • The control rods are of cadmium or boron and are inserted into the reactor. • Cadmium is strong neutron absorber and thus regulates the supply of neutrons for fission. • The control rods as they are being withdrawn more and more of these fission neutrons cause fission and hence the intensity of chain reaction is increased. • By pulling out the control rods, power of the nuclear reactor is increased whereas by pushing them in, it is reduced.	4 3	7

- The lowering or raising of control rods is accomplished automatically according to the requirement of load.
- The heat produced in the reactor is removed by the coolant generally liquid sodium.
- The coolant carries the heat to the heat exchanger.

OR

X

3

7

i. Control Rods

Control rods

- The function of control rod is:
  - To control the rate of fission.
  - To start the nuclear chain reaction when reactor is started from cold.
  - To shut down the reactor under emergency condition.
  - To maintain the chain reaction at a steady state.
  - To prevent the melting of fuel rods.
- Boron, Cadmium and Hafnium are mostly used as control rods.
- These control rods are used to absorb the neutrons thereby reducing the chain reaction.
- The control rods must be able to absorb excess neutrons.
- The position of these rods is regulated by electronic or electro mechanical device.
- Control rods should possess the following properties:
  - Good stability under heat and radiation
  - Better corrosion resistance
  - Adequate heat transfer properties
  - Sufficient cross-sectional area for the absorption of neutrons.

Control rods Materials

Boron

- Boron is commonly used as control rod material as
  - It has high melting point (2300°C),
  - High resistance to corrosion and
  - High temperature and cracks.
- A boron-carbide clad with stainless steel works as a better control rod material.

Cadmium

- High resistance to corrosion in the presence of water and air.
- Relatively low melting point (320°C).
- It does not have sufficient strength and therefore, some other material is added for strengthening. Generally aluminium sheet is used.

Hafnium

- It is most desirable material to use as control rods.
- It possess corrosion resistance.
- Its thermal neutron absorption cross-section is relatively low.

ii. Moderator

Moderator

- The process of slowing down the neutrons from high velocity without capturing them is known as **moderation.**
- **Moderator** is a material which is used to slow down the neutrons from high velocities without capturing them.
- The fast moving neutrons are far less effective in causing the fission and try to escape from the reactor.
- Thus, the speed of the fast moving neutron is reduced by introducing moderator.
- Heavy water (D_2O), Water (H_2O), Beryllium (Be), Graphite (C) and Helium (He) gas are commonly used moderators.
- The moderator is characterized by moderating ratio which is the ratio of moderating power to the macroscopic neutron capture coefficient.
- If the moderating ratio is high, then the given substance is more suitable for slowing down the neutrons.

- A good moderator should possess the following properties:
  - High thermal conductivity
  - High slowing down power
  - Low parasite captures
  - Lighter
  - High resistance to corrosion
  - Stability under heat and radiation
  - Abundance availabilty in pure form
  - High melting point for solids and low melting point for liquids.

- The following elements or isotopes are used as moderators:

Light water

- Light water is cheap, but has a small neutron absorption cross section.
- It is used as coolant and moderator when enriched uranium is used as fuel.
- It should not contain the sodium salt, cadmium and boron.

Heavy water (D_2O)

- It is the most effective moderator ever known having highest moderating ratio and lowest absorption cross section area.
- The cost of D_2O is more.

4

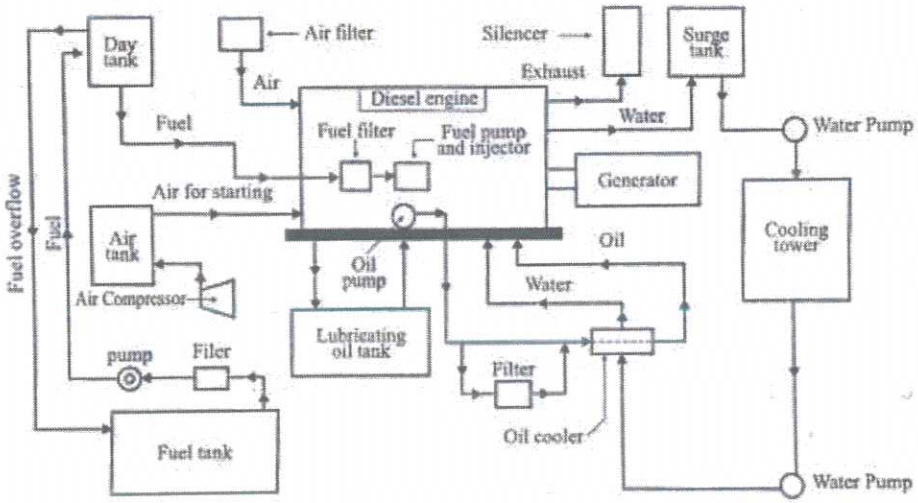
Graphite

- Graphite is considered a superior moderator as compared to H_2O.
- The outstanding features of graphite as moderator are it does not react with other materials and can be used at high temperatures with non corrosive nature.
- Graphite is low in cost but is structurally weak.
- It is non-toxic.

Beryllium

- It is considered a very good moderator as it has excellent chemical and corrosion resistance properties.
- It has high radiation stability.
- Beryllium is chemically stable at room temperature but readily combines with oxygen when heated and its melting point is 2530°C.
- It is very expensive and not widely used in reactors.

XI



Diesel Engine (CI engine)

✓ Central Power Producing Element

✓ Atmospheric air enters→ compressed to high pressure and temperature→ fuel injected and ignited→ product of combustion expands and exert force on piston→ motion converted to rotary using crankshaft and fly wheel→ Engine shaft directly coupled to generator produces electricity→ exhaust gases passes to atmosphere through silencer

4

7

Starting System

✓ A compressed air system is used for Starting the engine, which produces sufficient momentum due to air thrust

✓ Electric cranking motors and Auxiliary gasoline engines are employed for mechanical cranking

✓ Staring air pressure is to be maintained at 20 bar

3

Fuel Supply System

✓ The liquid fuel delivered to the power plant is received in storage tanks

✓ Fuel transfer pump draw the Filtered Fuel from storage tank to day tanks, which are placed at a greater elevation than engine so that the fuel flows by gravity without any external power

✓ Fuel from day tank passes through a filter to remove impurities present in the fuel, before injected into the cylinder of the engine

	Air Intake System ✓ Large diesel engines require considerable amount of air for combustion ✓ Atmospheric Air vary in temperature and dust content ✓ Air intake system is provided with a filter to remove dust (which cause wear of engine) ✓ The filter may be oil impingement, oil bath or dry type **Exhaust System** ✓ Exhaust Manifold is conveying the exhaust gases to the atmosphere ✓ The muffling of exhaust noise is met by using silencers ✓ The gases must be discharged sufficiently high above the ground to reduce air pollution **Cooling System** ✓ The high temperature due to burning of fuel may cause uneven expansion of engine parts (cylinder head, walls, piston and exhaust valve) hence a well-designed cooling system is essential. ✓ Cooling water is kept in circulation around the cylinder by the jacket circulation pump, hot water is passed to a heat exchanger where it gives up the heat with the help of a cooling tower **Lubricating System** ✓ Essential to reduce the wear and tear of moving parts ✓ It is also used for cooling the engine to a certain extent ✓ The hot lubricating oil returns to the **lubricating tank**, from there it is sent to **the oil cooler**, where it is cooled by cold water coming out of the heat exchanger. ✓ From oil cooler it again enters the diesel engine for the purpose of lubrication **OR**		
XII	• **Advantages–** • Operating Cost is extremely minimum • Maintenance Cost of Hydraulic Power Plant is less • Man power Required for the operation and maintenance is low • Less air pollution and safety requirements • Quick starting and synchronization is possible with hydraulic power plants • Rapid fluctuating loads can be managed most economically in hydraulic power plants • Hydraulic power plants can also be used for irrigation and flood control • There is no problem of fuel and ash handling, storage and disposal of waste. • Life of hydroelectric power plants (50 years) is more than that of thermal plants. • Since these are situated away from developed area, land cost is less	7x1	7

	• **Disadvantages-** • Overall initial cost is considerably more than other plants • Power generation will not be steady and reliable as it depends on availability of water • Cost of power transmission is high. Also there will be loss of power during transmission • Considerably long time for its planning and erection compared with other power plants.		
XIII	Following are the safety practices observed in boiler operation: • Good housekeeping for safety and good plant operation. Maintaining proper ventilation and fresh air circulation. • Proper clothing should be worn at all time. Avoid loose clothing and jewelry. • Providing the boiler operating log book. • The boiler operator must be experienced and familiar with boiler accessories mounting and other safety devices. • Investigate and identify the causes of any trip before attempting to start. • Before starting the boiler, always purge the Furnace thoroughly and boiler room should be free from Dangerous explosive materials. • Perform routine maintenance, calibration, and testing of the burner management system and combustion control safety device and transmitter. • Verify that the water treatment system is operating properly producing boiler feed water of sufficiently high quality. • Never allow the use of untreated water in a boiler. • Blow down all the dead legs of the low water tips, water column, etc. on a regular basis, to prevent sludge buildup. • Verify that the water leaving is free from oxygen so that it is operated at the proper pressure. • Maintain the storage tank water at saturation temperature. • A Continuous vent from the deaerator is necessary to allow the discharge of non-condensable gases.	7x1	7

	• Continuously monitor the quality of condensate coming from the process which enables the diversion of condensate in the event of catastrophic process equipment failure. • Adjust continuous blowdown to maintain the conductivity of the boiler water within the required operating limits. • Never blow down the furnace wall header while the boiler is operating. • The boiler water side should be inspected on a regular basis. If there is any sign of the scaling for the build-up of solid on the tubes, water treatment adjustment should be made. • The deaerator vessel and internal should be inspected on a regular basis for signs of corrosion. • Maintain regular preventive maintenance according to the manufacturer's manual. **OR**		
XIV	**(i) <u>Greenhouse effect</u>** **Definition:** The greenhouse effect is a natural process by which certain gases in Earth's atmosphere traps heat from the sun, preventing it from escaping into space. **Greenhouse Gases:** Greenhouse gases include carbon dioxide (CO2), methane (CH4), water vapor (H2O), nitrous oxide (N2O), and ozone (O3). These gases play a crucial role in the greenhouse effect. **Function/Working** 1. **Solar Radiation:** The sun emits energy in the form of sunlight, which includes visible and ultraviolet radiation. This energy reaches the Earth's surface. 2. **Absorption of Heat:** Some of the incoming sunlight is absorbed by the Earth's surface, warming it. 3. **Infrared Radiation:** As the Earth's surface warms, it emits heat in the form of infrared radiation (heat energy). 4. **Greenhouse Gases:** Greenhouse gases in the Earth's atmosphere, like a blanket, absorb and re-radiate some of the infrared radiation, trapping heat in the lower atmosphere.	7x1	7

5. **Natural Regulation:** This natural greenhouse effect is essential for maintaining Earth's temperature within a habitable range. Without it, the planet would be too cold to support life.

However, human activities, such as burning fossil fuels (coal, oil, and natural gas) and deforestation, have increased the concentration of greenhouse gases in the atmosphere. This enhanced greenhouse effect is contributing to global warming, causing Earth's average temperature to rise, which in turn leads to changes in climate patterns, including more frequent and severe weather events, rising sea levels, and disruptions to ecosystems.

(ii) Acid precipitation or Acid rain

Definition: It refers to any form of precipitation (such as rain, snow, sleet, or hail) that has an unusually low pH level, making it more acidic than normal rainwater. This increased acidity is primarily caused by emissions of sulfur dioxide (SO_2) and nitrogen oxides (NOx) into the atmosphere, which reacts with water vapor to form sulfuric acid (H_2SO_4) and nitric acid (HNO_3).

Causes: The primary sources of sulfur dioxide and nitrogen oxides in the atmosphere are the burning of fossil fuels (like coal and oil) in power plants, industrial facilities, and vehicles. Natural sources, such as volcanic eruptions, can also contribute to these emissions.

Chemical Reactions: Once in the atmosphere, sulfur dioxide and nitrogen oxides undergo chemical reactions with atmospheric moisture to form sulfuric acid and nitric acid. These acids are then carried by winds and incorporated into clouds.

Precipitation: When these acid-laden clouds release their moisture as rain or other forms of precipitation, the resulting rainwater has a lower pH level than normal rain, which has a pH of around 5.6.

Environmental Impact: Acid rain can have detrimental effects on the environment. It can harm aquatic ecosystems by making water bodies more acidic, which can lead to the decline of fish populations and other aquatic life. It can also damage forests by leaching important nutrients from the soil, making it difficult for trees to grow.

Infrastructure Damage: Acid rain can corrode buildings, statues, and infrastructure made of limestone, marble, and other calcareous materials. This can have cultural and economic consequences.

	Health Concerns: While direct exposure to acid rain is not generally considered a significant health risk, the pollutants that cause acid rain, such as sulfur dioxide and nitrogen oxides, can contribute to respiratory problems in humans. **Mitigation:** Efforts to mitigate acid rain have included regulations to limit emissions of sulfur dioxide and nitrogen oxides from industrial and transportation sources. These measures have been somewhat successful in reducing the acidity of rain in some regions. **International Agreements**: International agreements, such as the 1979 Geneva Convention on Long-Range Transboundary Air Pollution, and regional initiatives have aimed to address the issue of acid rain on a global scale. **Long-Term Effects:** While progress has been made in reducing acid rain in some areas, its effects can persist for many years, and damaged ecosystems may take a long time to recover. **Ongoing Monitoring:** Monitoring and research continue to track the extent and impact of acid precipitation, as well as the effectiveness of pollution control measures.		