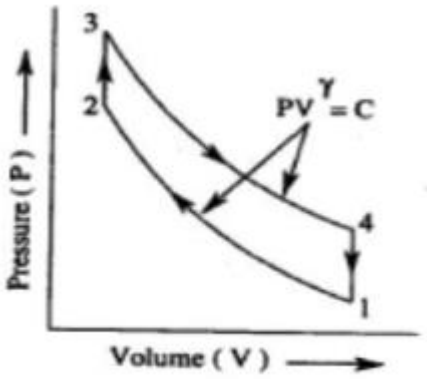
**SUMMER – 19 EXAMINATION**

**Subject Name: Heat power Engineering** **Model Answer** 22441

**Important Instructions to examiners:**

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

| Q. No. | Sub Q. N. | Answer | Marking Scheme |
|---|---|---|---|
| 1 | | **Attempt any Five of the following.** | **10** |
| | **a** | **Draw P-V diagram of Otto cycle.** | |
| | |  | **02** |
| | **b** | **List the different types of thermodynamic system.** | **02** |
| | | 1- Open system<br>2- Closed system<br>3- Isolated system | |
| | **c** | **Define calorific value of fuel and state its unit.** | **02** |
| | | **"Calorific value" of fuel:**<br>It is defined as the amount of heat liberated during complete combustion of 1 kg of fuel.<br>It is expressed in terms of KJ/kg. | **01**<br>**01** |

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| | **d** | **State any four requirements of good fuel** | **02** |
| | | 1. It should have high calorific value.<br>2. An ideal fuel should have moderate ignition temperature.<br>3. Its moisture content should be low.<br>4. It should evolve large amount of heat when it burnt.<br>5. Moderate velocity of combustion.<br>6. Easy to transport<br>**7.** Low cost. | ½ mark for each |
| | **e** | **Write the PVT relation for adiabatic process and give the meaning of each suffix used.** | **02** |
| | | $\mathbf{P_2 / P_1 = (V_2/V_1)^{\gamma} = (T_2/T_1)^{\gamma/\gamma-1}}$<br>$\gamma$ =adiabatic index<br>$P_1$, $P_2$ = pressure at inlet and outlet<br>$V_1$,$V_2$= volume at inlet and outlet<br>$T_1$,$T_2$ = temperature at inlet and outlet | |
| | **f** | **Write any four application of compressed air in automobile industry.** | **02** |
| | | 1.Operating tools in factories<br>2. Operating drills and hammers in road building<br>3. Starting diesel engines<br>4. Operating brakes on buses, trucks and trains<br>5. Spray painting<br>6. Excavating<br>7. To clean the large workshops | **½ mark for each** |
| | **g** | **Enlist non-conventional energy sources.** | **02** |
| | | Solar power<br>Hydro-electric power<br>Wind power<br>Tidal power<br>Ocean wave power<br>Geothermal power<br>Ocean thermal power<br>Biomass, Bio-fuel etc. | |

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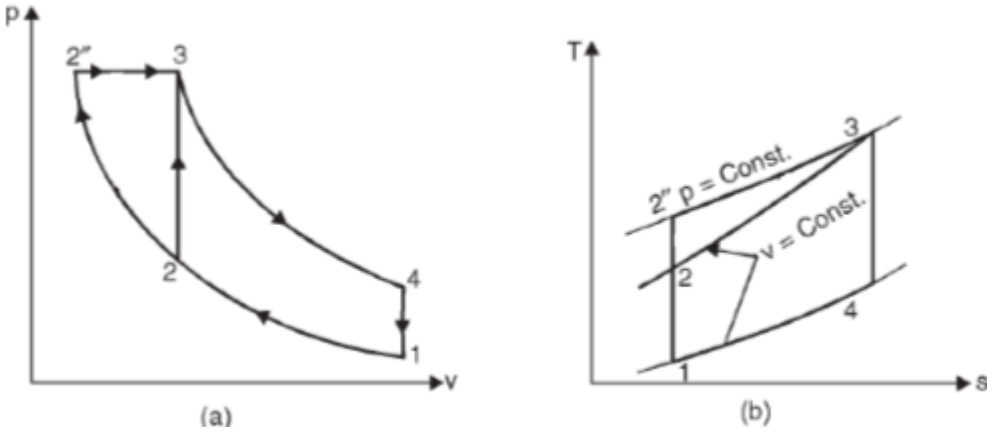
| **2** | | **Attempt any Three of the following** | 12 |
| | a) | **Compare the efficiency of Otto cycle and diesel cycle for same maximum pressure with neat sketch.** | |
| | | Comparison of efficiency of Otto Cycle and Diesel cycle for same pressure ration and same conditions. | **02** |




The air-standard Otto and Diesel cycles are drawn on common p-v and T-s diagrams for the same pressure ratio and maximum temperature, for the purpose of comparison.

Otto Cycle 1-2-3-4-1 And Diesel Cycle 1-2"-3-4-1

The construction of cycles on T-s diagram proves that for the given conditions the heat rejected is same for all the Otto and Diesel cycles (area under process line 4-1). **02**

Since, by definition,

the cycle, with greater heat addition will be more efficient. From the T-s diagram,

$Q_{s(diesel)=}$ area under 2"-3

$Q_{s(otto)}$ =area under 2-3

Therefore for the same pressure ratio

$Q_{s(diesel)} > Q_{s(otto)}$

Thus ,

$\eta_{diesel} > \eta_{otto}$

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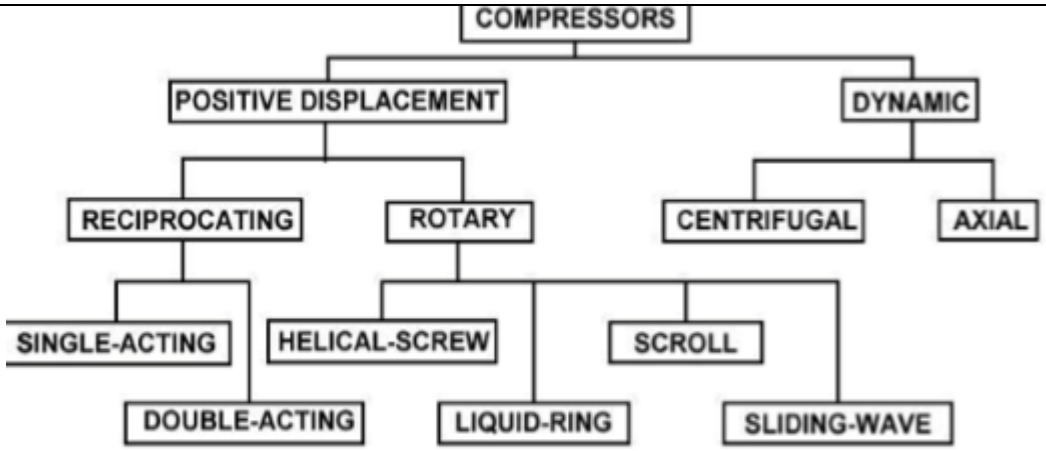
| | b) | **Write the classification of air compressor.** | 04 |
| | |  | |
| | c) | **One kg of gas occupying 0.1m^3 at pressure of 14 bar is expanded at constant pressure to 0.2m^3. Determine an initial and final temperature of gas. Take Cp=1.008KJ/KgK, Cv =0.72KJ/KgK.** | **4** |
| | | $V_1$=0.1m^3<br>$V_2$=0.2 m^3<br>$P_1$=P2=14 bar<br>$C_p$=1.008 KJ/KgK<br>$C_v$=0.72 KJ/KgK<br><br>R=Cp-Cv<br>R=1.008-0.72<br>R=0.288KJ/KgK<br>Characteristic gas equation,<br>$P_1V_1=mRT_1$<br>14*10^5*0.1=1*288*T1<br>**$T_1$=486.11K**<br>For constant pressure process,<br>V1/T1=V2/T2<br>0.1/486.11=0.2/T2<br>**$T_2$=972.22K** | **02**<br><br>**02** |
| | d) | **Write factors used for governing the selection of cogeneration system and state the advantages of cogeneration.** | 04 |
| | | **Factor governing the selection of cogeneration system:**<br>1) electrical load matching<br>2) thermal load matching<br>3) Electrical load matching<br>4) Thermal load matching<br>5)Thermal to electrical energy ratio<br>6) Quality of required thermal energy<br>7) Fuel availability<br>8) Installation and available space<br>9) Operational costs | **02** |

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| | | 10) Pollution concern<br>**Advantages of Cogeneration:**<br>1) Co-generation can meet both power & heat needs.<br>2) Less costly.<br>3) Very high efficiency.<br>4) Reduction in emission of pollutants due to reduced fuel consumption. | **02** |
| **3** | | **Attempt any THREE of the following.** | **12** |
| | a | **Explain application of conduction and convection mode of heat transfer in automobile.** | **04** |
| | | (Any suitable Answer should be given full marks)<br>Applications of conduction-<br>1. Fins provided on motor cycle engine<br>2. Electric fuse cut off<br>3. Electric heater<br>4. Carbonisation of coal<br>5. Melting of iron in blast furnace<br>6. Fission reactions in nuclear fuel rods of nuclear reactors.<br>7. Electrical wiring in housing<br>8. Electric discharge machining in manufacturing<br>Applications of convection-<br>1. Forced Convection is used to cool down the headed plate .<br>2. Forced Convection is used to cool down the heated engine of vehicle .<br>3. Forced convection is used to cool down the laptop and super computer etc.<br>4. Forced convection is used to cool down human body in summer season.<br>5. Radiator - Puts warm air out at the top and draws in cooler air at the bottom. | **02**<br>**02** |

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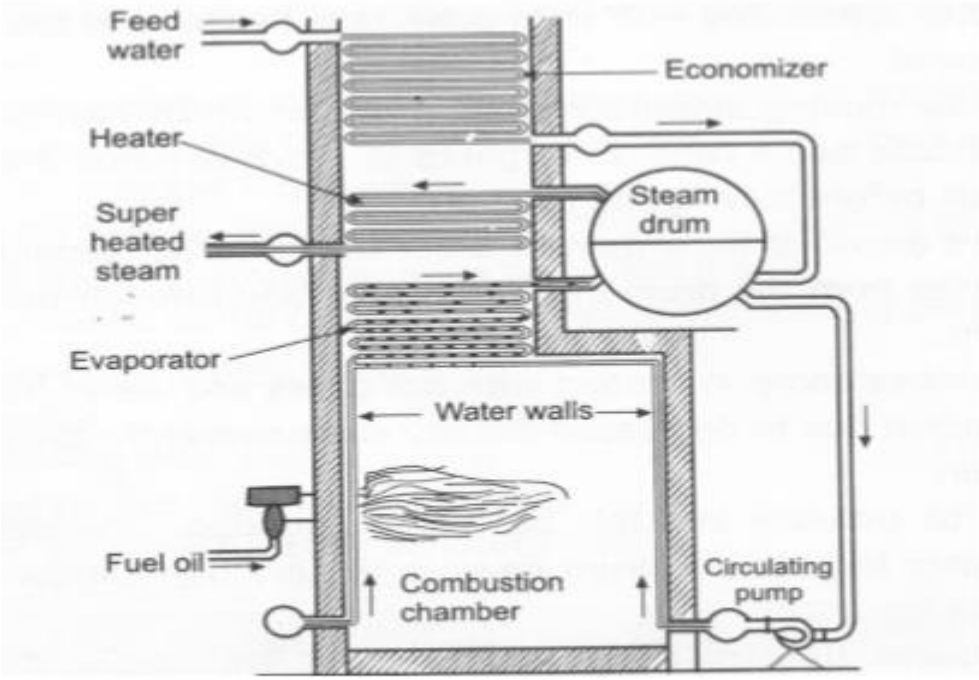
| | **b)** | **Draw neat labelled sketch of Lamont boiler.** | 04 |
| | **Ans.** |  **Fig : La Mont Boiler** | |
| | **c)** | **Determine the amount of heat required to produce 1Kg of steam at a pressure of 7 bar, at a temperature 29 degree Celsius, under the following .**<br>**(i) When the steam is wet having dryness fraction 0.87**<br>**(ii) When the steam is dry saturated**<br>**Assume specific heat = 2.35KJ/KgK** | |
| | **Ans.** | P 7bar<br>T 29$^{o}$C<br>x=0.9<br>m =1kg<br>C p =2.35 KJ/KgK<br>At pressure 7 bar saturation Temp<br>T sat =165 $^{o}$C<br>h $_{f}$ =697.2 KJ/Kg<br>h $_{fg}$= 2064.8 KJ/Kg<br>**i) Heat required when steam is wet**<br>$h=h_f+xh_{fg}$<br>=2555.52<br>since the water is at 29 $^{o}$C ,<br>heat already in water = specific heat of water* rise in temperature<br>=4.2*29<br>=121.8<br>Heat actually required =h-heat already in water<br>=2555.52-121.8 | **02** |

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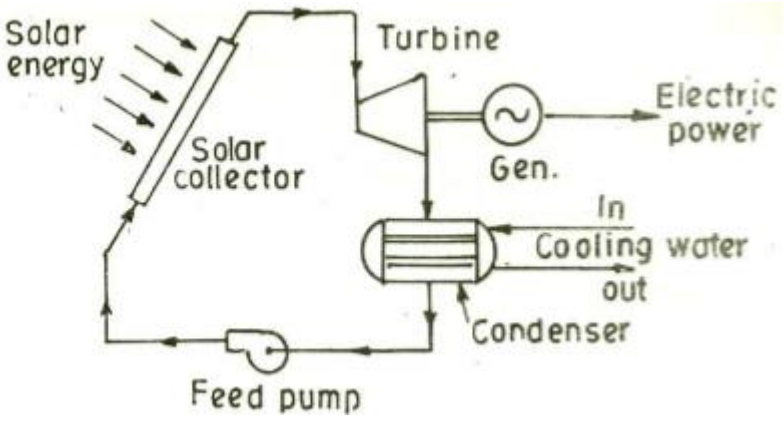
| | | =2433.72KJ/Kg<br><br>**ii) When the stem is dry saturated**<br>$h_g=h_f+h_{fg}$<br>=2762 kj<br>Heat actually required = 2762-121.8<br>= 2640.2 kj | **02** |
| | **d)** | **Explain solar power plant and write its two advantages.** | **04** |
| | **Ans.** | **Construction:** The basic components of solar power plant are also exactly identical to thermal power plant except the boiler is replaced by solar collector. The arrangement of component is as shown in figure. The energy from solar radiation is collected and utilized to generate steam to run the turbine.<br>  <br><br>**Figure: Solar power plant**<br>**Working:** Steam is generated in solar collector of solar power plant. The steam generated is passed through steam turbine where part of it‟s thermal energy is converted into mechanical energy which is further used for generating the electric power. The steam coming out of steam turbine is condensed in condenser and condensate is supplied back to solar collector with the help of feed pump.<br>Advantages (any two)<br>i) It is renewable energy source<br>ii) ii) Pollution free<br>iii) iii) Available all over the world.<br>**iv)** iv) Less maintenance. | **02**<br><br>02 |
| **4** | | **Attempt any THREE of the following** | **12** |
| | **a)** | **Write the importance and impact of energy conservation on environment and economy.** | **04** |
| | | • (Any suitable Answer should be given full marks)<br>• **Impact of energy conservation on Economy**-Reduced dependence on non-renewable sources of energy: Based on current known reserves and consumption of these fuels. It protects the economy and consumers from possible price fluctuations and from energy service disruptions due to natural disasters or other | **02** |

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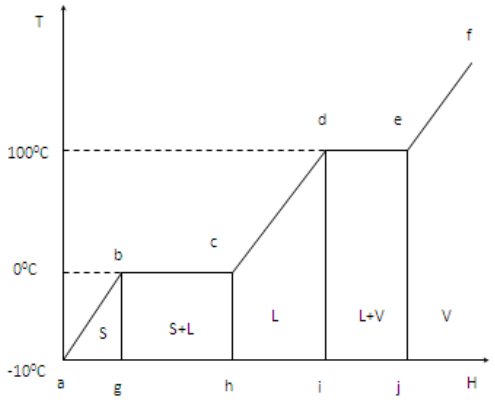
| | | causes. The increasing demand for electricity and natural gas requires your utility to find new supplies of energy. Most new supply options require a great deal of money up front, which increases you utility bills. Energy efficiency programs provide customers with home improvements that enhance home comfort and increase property values for homeowners and businesses.<br><br>**Impact of energy conservation on Environment** The other reason for conserving energy is the health and well-being of every life form on the entire planet. Using fossil fuels and some other energy forms typically pollute the environment in a number of ways. The air is polluted when fossil fuels like coal are burned and released into it | **02** |
| | **b)** | **Explain the process of formulation of steam from $0^0$C water with T-H diagram** | |
| | |  <br>Consider formation of steam from ice at -100 C<br>**i)** **Solid phase-** When the heat is added in ice which is at -100 C the temperature of ice increases to 00 C as shown in figure by process a-b.in this stage solid phase exists.<br>**ii)** **Solid+ Liquid phase-** The point b is called is saturation point when heat is further added this heat cannot increase the temperature but ice is converted into water that means phase transformation takes place, thus in-between region b-c, solid and liquid phase exists.<br>**iii)** **Liquid phase**- From point c-further heat is added up to 1000 C, in this region no phase change takes place, there is only liquid phase present. | **02**<br><br>**02** |
| | **c)** | **Explain combustion chemistry of carbon, methane and hydrogen** | **04** |
| | | **i) Carbon**: Burning of carbon to carbon dioxide ( complete combustion )<br>$C + O_2 \rightleftharpoons CO_2$<br>i.e. $12 + (16 \times 2) = 12 + 16 \times 2$<br>i.e. $12 + 32 = 44$<br>$1 + 2.67 = 3.67$ | **01** |

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| | | That means 1 kg of carbon needs 2.67 kg oxygen and produces 3.67 kg of carbon dioxide<br>ii)**Methane (CH4):**<br>$CH_4 + 2O_2 \rightleftharpoons CO_2 + 2H_2O$<br>i.e. $(12+1\times4)+2(16\times2)=(12+16\times2)+2(1\times2+16)$<br>$16+64=44+36$<br>$1+4=\frac{11}{4}+\frac{9}{4}$<br>Burning of methane with oxygen to carbon dioxide and water/ steam<br>i.e. That means 1 kg of methane needs 4 kg of oxygen to produce 11/4 kg of carbon dioxide and 9/4 kg of water /steam<br>**iii)Hydrogen:**<br>$2H_2 + O_2 = 2H_2O$<br>$2(1\times2)+(16\times2)=2(1\times2+16)$<br>$1+8=9$<br>The union of hydrogen with oxygen produces steam it is represented by the following equitation 1 kg of hydrogen combines with 8 kg of oxygen to produce 9 kg of steam. | **02**<br>**01** |
| | **d)** | **Explain higher and lower calorific value of a coal having following composition by mass**<br>**Carbon 81%,Hydrogen 7%, Oxygen 8%,Nitrogen 2.5%, sulphur 1.5% and remaining is ash** | **04** |
| | | Carbon C = 81% = 0.81<br>Hydrogen = H2 = 7% = 0.07<br>Oxygen = O2 = 8% = 0.08<br>Nitrogen = N = 2.5% = 0.025<br>Sulphur = S =1.5% = 0.015<br>Ash = 2.5% = 0.025<br>**Dulong's formula: H.C.V. of coal**<br>= 33800 C + 144500 ( H2 - O2/8 ) + 9300 S KJ / Kg<br>=33800 x 0.81 + 144500 (0.07 - 0.08/8) + 9300 x 0.015<br>H.C.V. of coal = 36187.5 KJ / Kg | **02** |

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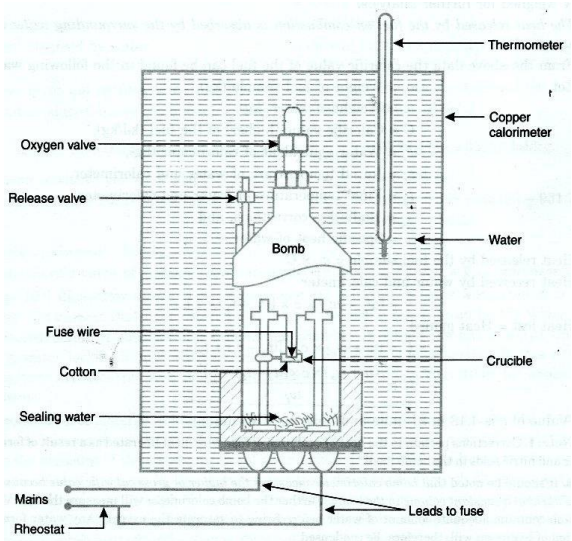
| | | **L.C.V. of coal**<br>= H.C.V.- 9H2 x 2442 KJ / Kg<br>= 36187.5– 9 x 0.07 x 2442<br>L.C.V. of coal = 34649.04 KJ / Kg | **02** |
| | **e** | **Define**<br>**(i) I.P**<br>**(ii) B.P**<br>**(iii)Volumetric efficiency**<br>**(iv)Isothermal efficiency of air compressor** | **04** |
| | **Ans** | **i) I.P. -** It is the ratio of polytrophic work into speed of compressor in revolution per second.<br>$I.P = \frac{W \times N}{60}$ watts<br>**ii) B.P. -** It is the power required to drive the compressor or power delivered to the shaft of compressor<br>**iii) Volumetric efficiency -** It is the ratio of volume of free air delivery per stroke to the swept Volume of piston**.**<br>**iv) Compressor efficiency** - For the same pressure ratio, It is the ratio of theoretical isothermal work to the actual work required to drive the compressor. OR It is the ratio of isothermal power to the shaft power or brake power of motor required to drive the compressor | **01**<br>**01**<br>**01**<br>**01** |
| **5.** | | **Attempt any TWO of the following** | **12** |
| | **a)** | **(i) Draw the neat sketch of bomb calorimeter**.<br>**(ii) Write any three sources of air leakage in steam condenser.**<br>**(i)**<br>  <br> | **03** |

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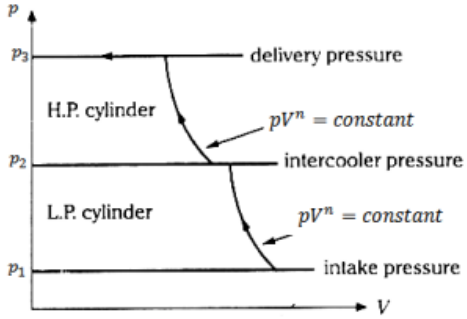
| | | **(ii)**<br>Sources of air leakage in condenser:<br>i) Air leak through joints and packing.<br>ii) Air also comes in condenser with the steam.<br>iii) In jet condensers dissolved air in the cooling water enters the condenser. | **03** |
| | **b)** | **Explain the necessity of multi-staging and inter cooling in case of two stage compressor with PV diagram** | **06** |
| | | **Necessity of multi staging with intercooling in air compression:**<br>The large pressure ratio gives rise in high compression ratio and high discharged temperature which produce adverse effect on the efficiency and performance of the system.<br>In such application efficiency decreases and works done and power increases.<br>So to get better performance and saving in work and power multi staging with intercooling is necessary.<br>  <br> | **03**<br><br>**03** |
| | **c)** | **Write the strength and limitation of biomass power plant.** | **06** |
| | | **Strength**<br>1) Raw material used as cow dung is easily available in villages, rural area at free of cost.<br>2) Easy to operate and having less maintenance.<br>3) No additional Co2 emission to environment.<br>4) Digested matter used as fertilizer<br>**Limitation**<br>1)Effectively implemented only where open space is available<br>2) For producing gas it takes more time.<br>3) Initial investment is required for construction of well. | **03**<br><br>**03** |
| **6.** | | **Attempt any TWO of the following.** | **12** |
| | **a)** | **Explain the construction and working of electricity generation through photovoltaic system.** | |
| | | (Any suitable Answer should be given full marks)<br>**Construction-**A photovoltaic (PV) system is a system composed of one or more solar panels combined with an inverter and other electrical and mechanical hardware that use energy from the Sun to generate electricity. PV systems can vary greatly in size from small rooftop or portable systems to massive utility-scale generation plants. Although PV systems can operate by themselves as off-grid PV systems, this article focuses on systems connected to the utility grid, or grid-tied PV systems.<br>**Working-**<br>The light from the Sun, made up of packets of energy called photons, falls onto a solar panel and creates an electric current through a process called the photovoltaic effect. | **03** |

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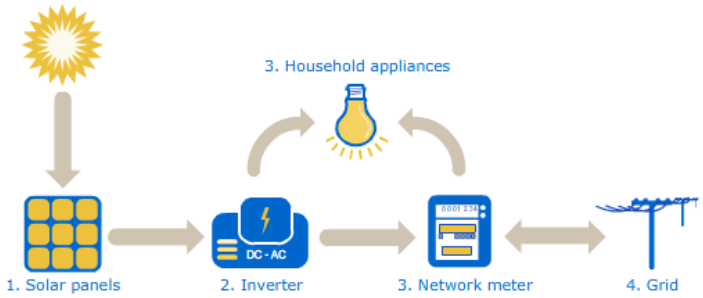
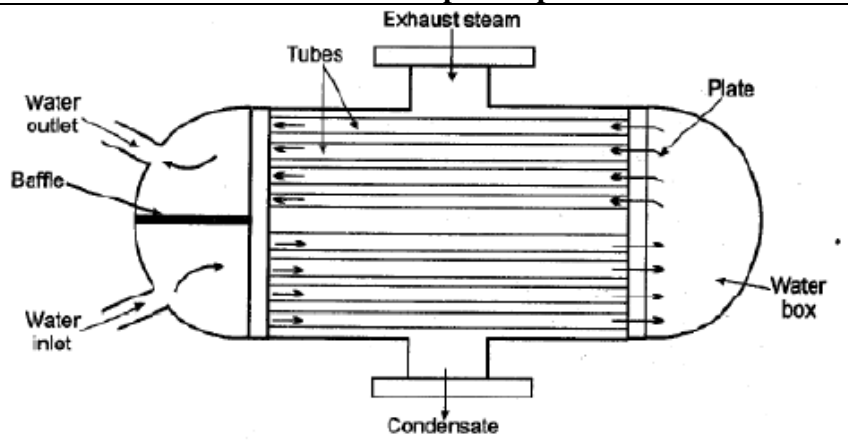
| | | Each panel produces a relatively small amount of energy, but can be linked together with other panels to produce higher amounts of energy as a solar array. The electricity produced from a solar panel (or array) is in the form of direct current (DC). Although many electronic devices use DC electricity, including your phone or laptop, they are designed to operate using the electrical utility grid which provides (and requires) alternating current (AC). Therefore, in order for the solar electricity to be useful it must first be converted from DC to AC using an inverter. This AC electricity from the inverter can then be used to power electronics locally, or be sent on to the electrical grid for use elsewhere.<br>  <br><br>**(Any suitable sketch should be given full marks )** | **03** |
| | **b)** | **Describe the construction and working of two pass flow surface condenser also write it's function and location in steam power plant.** | **06** |
| | |  <br> | **02** |
| | | **Construction:** It consists of horizontal cast iron cylindrical vessel pack with tubes, through which the cooling water flows. The ends of the condenser are cut off by vertical perforated type plates in to which water tubes are fixed. This is done in such a manner that the leakage of water in to the center condensing space is prevented.<br>**Working:** The water tubes pass horizontally through the main condensing space for the steam. The steam enters at the top & is forced to flow downwards over the tubes due to the suction of the extraction pump at the bottom. The cooling water flows in one direction through lower half of the tubes & return in opposite direction through the upper half as shown in figure. The condensate does not mix with cooling water which is used for cooling steam & Convert into water; therefore whole condensate can be the reused in the boiler. | **02** |
| | | **Function**: It is used to increase the turbine output by maintaining backpressure on exhaust side of steam engine or turbine & the secondary function of condenser is to supply pure and hot feed water to boiler. | **01** |
| | | **Location in steam power plant-** between turbine and feed pump | **01** |

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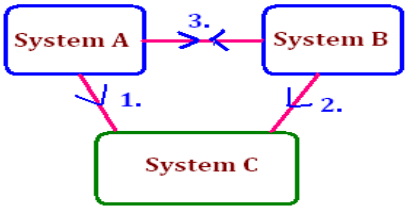
| | **c)** | **(i) Explain zeroth law of thermodynamic with neat sketch.**<br>**(ii) Write the procedure for Energy saving in household appliances.** | **06** |
| | **i)** | **Zeroth law of thermodynamics** – If two **thermodynamic** systems are each in thermal equilibrium with a third, then they are in thermal equilibrium with each other<br>  <br><br>1. A & C are in thermal equilibrium<br>2. B & C are in thermal equilibrium<br>then<br>3. A & B are also in thermal equilibrium with each other<br>**(Any suitable sketch should be given full marks )** | **03** |
| | **ii)** | **(Any suitable procedure should be given full marks )**<br>**Procedure for Energy saving in household appliances.**<br>• Adjust your day-to-day behaviors.<br>• Replace your light bulbs<br>• Use smart power strips. (LED)<br>• Install a programmable or smart thermostat.<br>• Purchase energy efficient appliances like fridge, Ac etc<br>• Reduce your water heating expenses.<br>• Install energy efficient open glass windows to use sun light.<br>• Upgrade your HVAC system. | **03** |