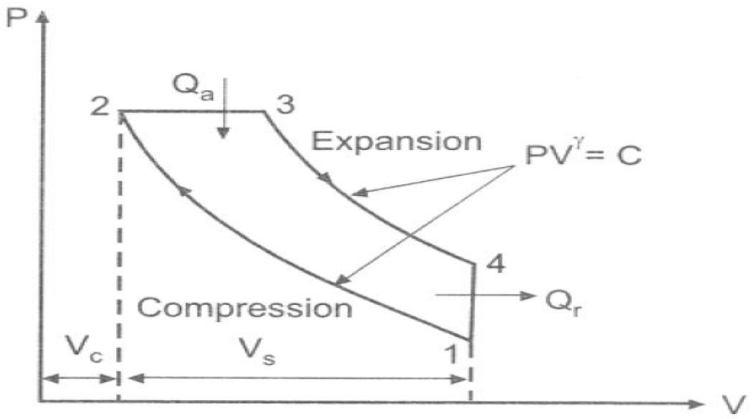
SUMMER – 2022 EXAMINATION

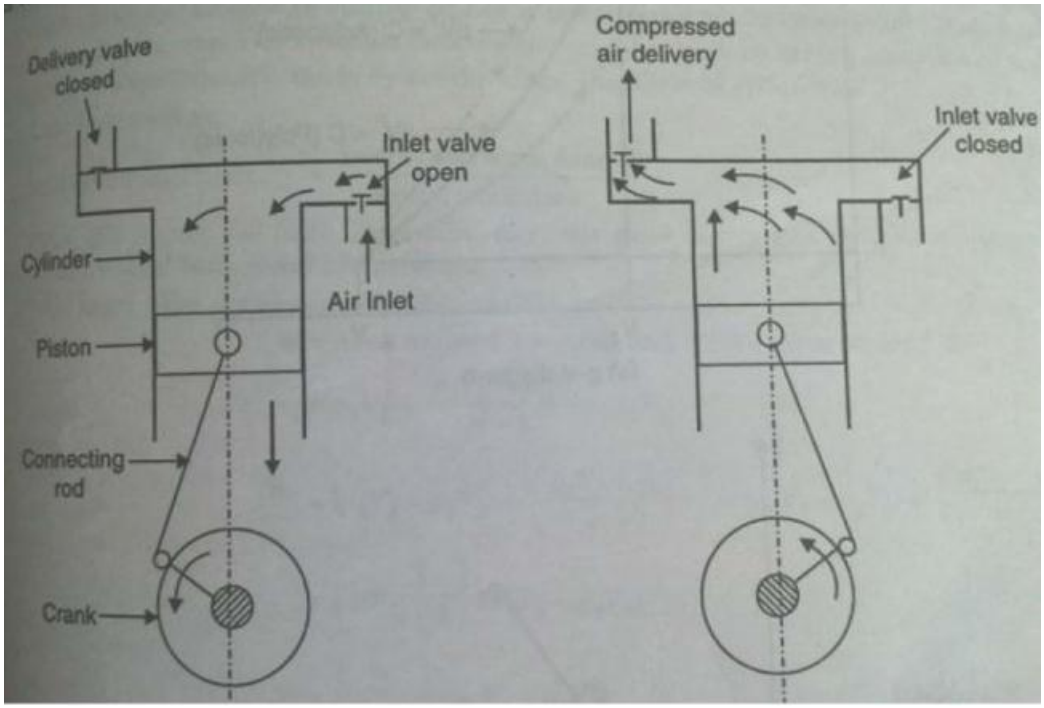
Subject Name: Heat Power Engineering (HPE) **Model Answer** **Subject Code:** 22441

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.
8) As per the policy decision of Maharashtra State Government, teaching in English/Marathi and Bilingual (English + Marathi) medium is introduced at first year of AICTE diploma Programme from academic year 2021-2022. Hence if the students in first year (first and second semesters) write answers in Marathi or bilingual language (English +Marathi), the Examiner shall consider the same and assess the answer based on matching of concepts with model answer.

Q. No	Sub Q. N.	Answer	Marking Scheme
1		**Attempt Any Five of the Following.**	**20**
	a.	**List the different types of thermodynamic system.**	**02**
	Ans.	1. Open system 2. Closed system 3. Isolated system	**02 Marks**
	b.	**Draw with P-V diagram of diesel cycle**	**02**
	Ans.	 Fig. (a) P-V diagram (Diesel cycle)	**02 Marks**

	c.	**State advantages of liquid fuel over solid fuel.**	**02**
	Ans.	**Merits of liquid fuel over solid fuel: (any four)** 1. Require less space for storage. 2. Higher calorific value. 3. Easy control of consumption. 4. Cleanliness. 5. No ash produced. 6. non-deterioration of the oil in storage	**½ Marks for each**
	d	**Define: i) Dryness fraction ii) Degree of superheat**	**02**
	Ans.	**i) Dryness fraction:** Dryness fraction is defined ratio of the mass of the dry steam present in the total mass of steam. **OR** Dryness fraction is ratio of the mass of actual dry steam to the mass of wet steam. Therefore, x = ms / (ms + mw) Where ms and mw are the masses of steam and water in the mixture of (ms + mw). **ii) Degree of superheat:** It i difference between the temperature of Superheated Steam and the saturation temperature correspondingly to given pressure is said to be Degree of Superheat.	**01 Marks for each**
	e.	**Define :- (i) Indicating Power (ii)Volumetric efficiency**	**02**
	Ans.	**i) Indicating Power -** It is the ratio of polytrophic work into speed of compressor in revolution per second. $$I.P = \frac{W \times N}{60} \text{ watts}$$ **ii) Volumetric efficiency -** It is the ratio of volume of free air delivery per stroke to the swept Volume of piston.	**01 Marks for each**
	f.	**List different Non-Conventional energy sources**	**02**
	Ans.	1. Solar power 2. Hydro-electric power 3. Wind power 4. Tidal power 5. Ocean wave power 6. Geothermal power 7. Ocean thermal power 8. Biomass, Bio-fuel etc	**½ Marks for each**

	g.	**State the advantages of biomass power.**	**02**
	Ans.	1. Raw material used as cow dung is easily available in villages, rural area at free of cost. 2. Easy to operate and having less maintenance. 3. No additional Co2 emission to environment. 4. Digested matter used as fertilizer	**½ marks for each**
	h.	**Draw a neat sketch of single stage reciprocating air compressor**	**02**
	Ans.		**02 Marks for labeled Sketch**
2		**Attempt Any Three of the Following.**	**12**
	a.	**Write classification of steam boilers.**	**4**
	Ans.	Steam boilers are classified as, **i) Content in the tubes:** a) Fire tube boiler b) Water tube boiler **ii) Circulation of water and steam:** a) Natural circulation boiler b) Forced circulation boiler iii)According to boiler use: a) Stationary boiler b) Mobile boiler	**01 Marks for each**

iv) According to axis of shell

a) Horizontal boiler

b) Vertical boiler

c) Inclined boiler

v) According to type of Furnace

a) Internally fired Boilers

b) Externally Fired boilers

v) According to number of Tubes

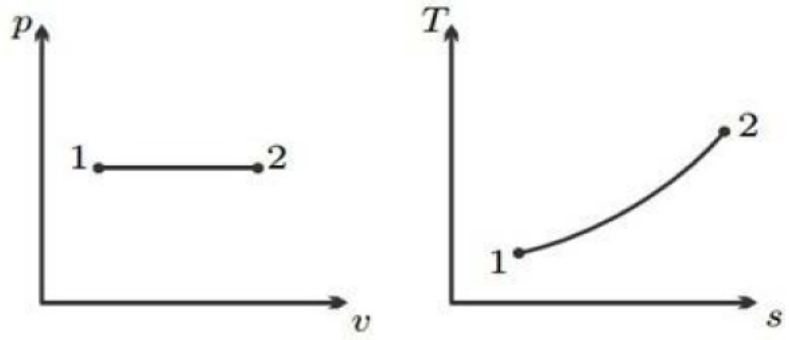
a) Single Tube Boilers

b) Multi-tubular boilers

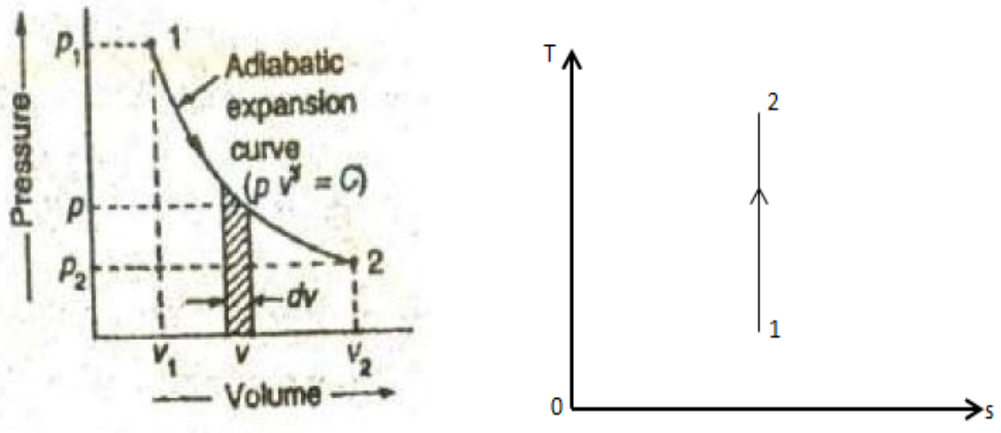
b. Sketch P-V and T-S diagram of isobaric process and isentropic process. **4**

Ans.

i) Isobaric Process



ii) Isentropic Process



02 Marks for each

<table>
<tr><td></td><td>c.</td><td>Compare impulse turbine and reaction turbine on the basis of</td><td>4</td></tr>
<tr><td></td><td>Ans.</td><td>
<table>
<tr><th>Sr. No</th><th>Impulse Turbine</th><th>Reaction Turbine</th></tr>
<tr><td>Pressure drop</td><td>Large pressure drop.</td><td>Small pressure drop</td></tr>
<tr><td>Blade speed & steam speed</td><td>The velocity of steam and turbine blades is higher due to the large pressure drop.</td><td>The velocity of steam and turbine blades is lower due to the small pressure drop.</td></tr>
<tr><td>Friction losses</td><td>Friction losses are more</td><td>Friction losses are less</td></tr>
<tr><td>Power capacity</td><td>These turbines are used for output capacity up to 200 MW (Low power output)</td><td>These turbines are used for output capacity up to 220 MW (High power output)</td></tr>
</table>
</td><td>01 Marks for each</td></tr>
<tr><td></td><td>d.</td><td>Classify the air compressor on the basis of</td><td>4</td></tr>
<tr><td></td><td>Ans.</td><td>i) Displacement:
a) Positive Displacement
b) Non Positive Displacement
ii) According to Motion
a) Reciprocating air compressor
b) Rotary air compressor
iii) Number of stages
a)Single stage compressor
b)Multistage compressor
iv) Capacity of compressor
a) Low capacity compressor : Less than 0.15 m3/s
b) Medium capacity compressor : Between 0.153/s
c) High Capacity compressor : More than 5 m3/s</td><td>01 Marks for each</td></tr>
<tr><td>3</td><td></td><td>Attempt Any Three of the following</td><td>12</td></tr>
<tr><td></td><td>a.</td><td>Explain Otto cycle with P-V and T-S diagram. Write its equation for thermal efficiency with its significance.</td><td>4</td></tr>
<tr><td></td><td>Ans.</td><td>P V and T S diagram of Otto cycle
The various processes involved in below cycle are,
1-2 Isentropic compression of air
2-3 the combustion of fuel at constant volume.
3-4 Isentropic expansion during which work is done by the system</td><td></td></tr>
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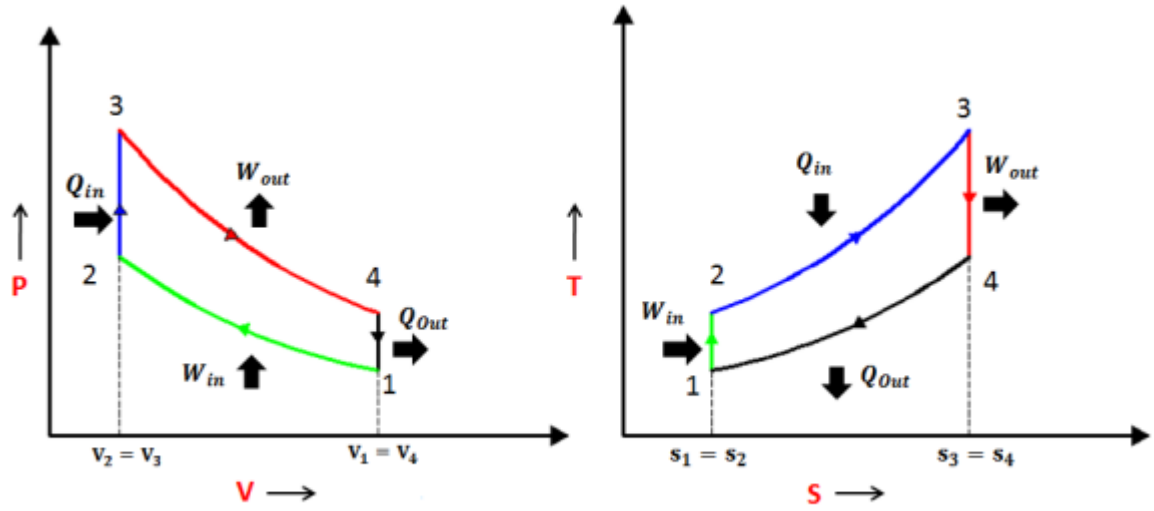
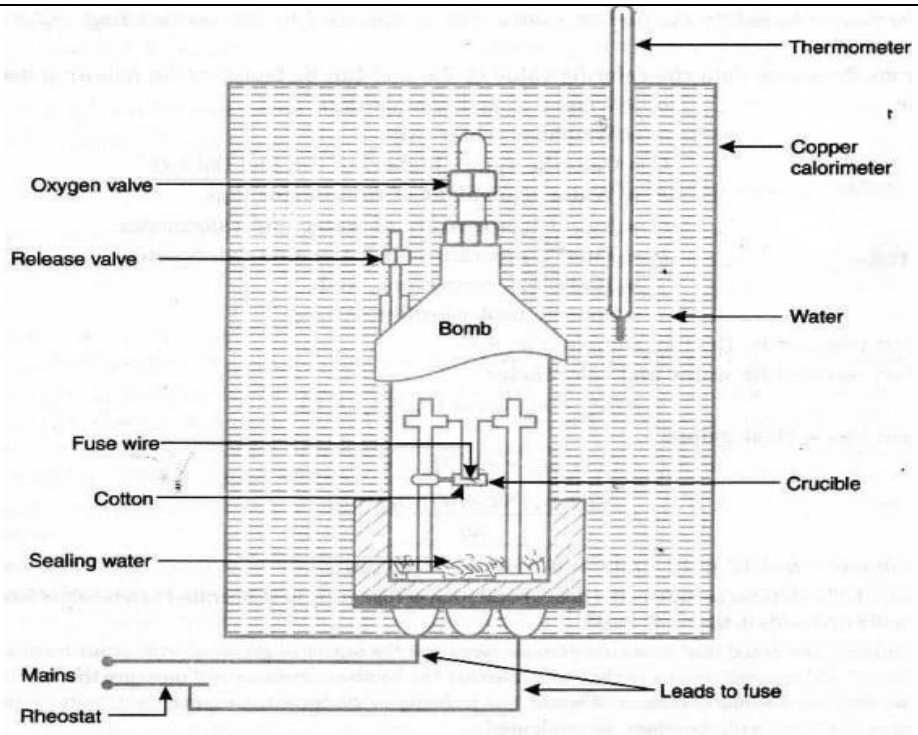
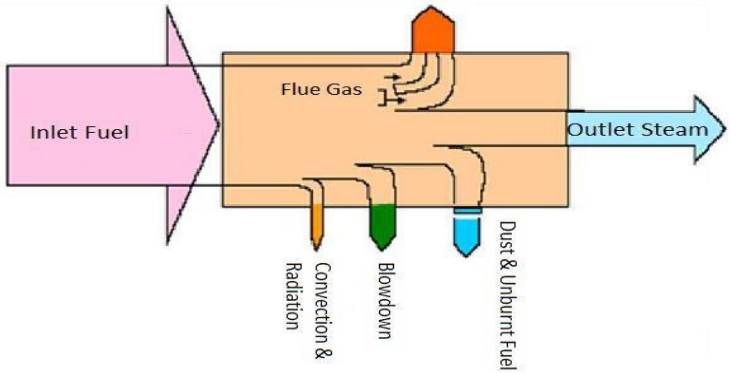
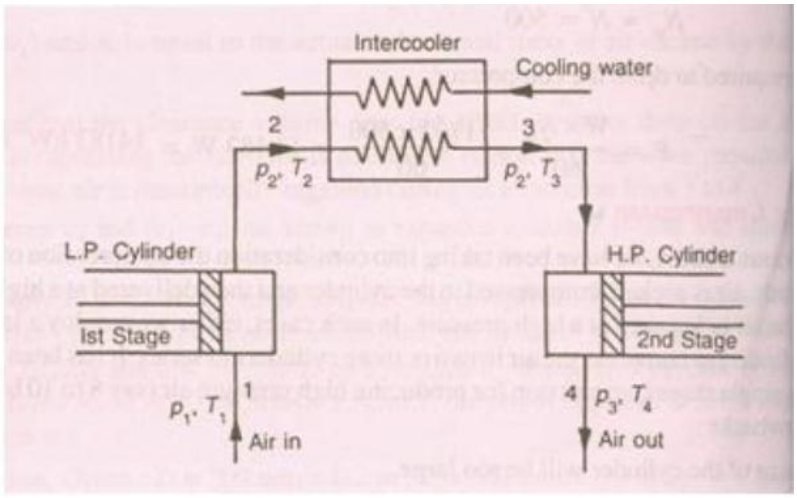
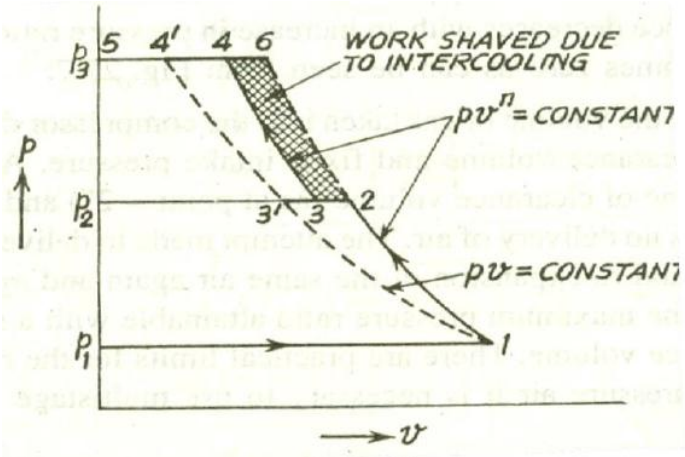
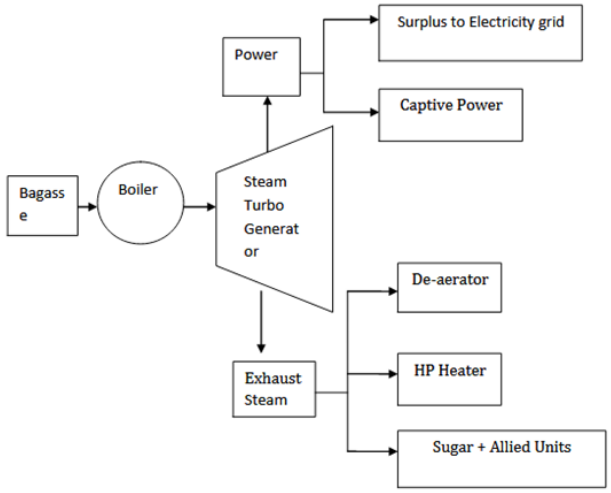
		4-1 Heat rejection at constant volume  P-V and T-S Diagram of Otto Cycle $\eta_{th} = 1 - \frac{1}{r^{(\gamma - 1)}}$ From above equation it is clear that efficiency of Otto cycle is depends on compression ratio. As compression ratio increases, efficiency of Otto cycle increases and as compression ratio decreases efficiency of Otto cycle decreases	**Diagram 02 Marks** **Equation-1 and Significance-1 Marks**
	b.	**A sample of coal has the following composition on the mass basis:- carbon 82% hydrogen 8% sulphur 2% oxygen 4% and ash 4%. Calculate using Dulong's formula for higher and lower calorific value of fuel.**	**4**
		Given: Carbon C = 82% = 0.82 Hydrogen = H2 = 8% = 0.08 Oxygen = O2 = 4% = 0.04 Ash= N = 4% = 0.004 Sulphur = S =2% = 0.002	**02 Marks**

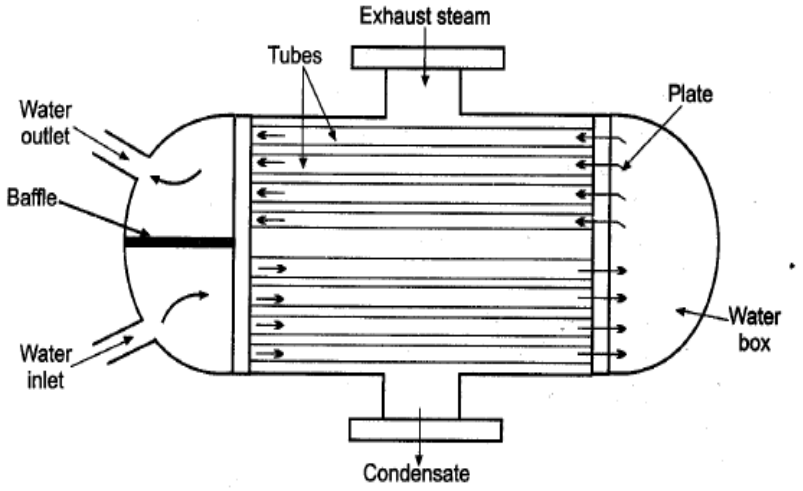
		Dulong's formula: **H.C.V. of coal**= 33800 C + 144500 (H_2 - O2/8) + 9300 S KJ / Kg =33800 x 0.82 + 144500 (0.08 – 0.04/8) + 9300 x 0.002 **H.C.V. of coal = 32792.1 KJ / Kg** **L.C.V. of coal:**= H.C.V. - 9H2 x 2446 KJ / Kg = 34498.27– 9 x 0.08 x 2446 **L.C.V. of coal = 31030.98 KJ / Kg**	**02 Marks**
	c	**Suggest energy conservation techniques used in refrigeration**	**4**
	Ans	**Any four points** 1. Maintain Proper System Boundaries 2. Maintain Daily, Seasonal Thermostat Set Points 3. Use Automatic Controls Where Possible 4. Maintain Equipment Set Points 5. Adjust and Set HVAC Operation for Seasonal Change 6. Consider Variable Speed Equipment 7. Properly Specify and Size Your System 8. Schedule and Maintain Equipment Properly.	**1 mark for each**
	d	**A gas of volume of 0.16 m^3 pressure 2 bar and temperature 100^0C. if gas is compressed at constant pressure until its volume becomes 0.112 m^3. Determine temperature at the end of compression.**	**4**
		Given: V1=0.16 m^3 V2=0.112 m^3 $T_1 = 100^0C = 100+273 = 373K$ P1=P2=2 bar For constant pressure process, V1/T1=V2/T2 0.16/373=0.112/T2 **T2=261.13K**	**Formula 02 Marks** **Answer 02 Marks**
4		**Attempt any Three of the following**	**12**

	a.	**Explain application of conduction and convection mode of heat transfer in automobile.**	**4**
	Ans.	**Applications of conduction-** 1. Fins provided on motor cycle engine 2. Heating the engine of vehicle 3. Heat transfer through shaft **Applications of convection-** 1. Forced Convection is used to cool down the headed plate. 2. Forced Convection is used to cool down the heated engine of vehicle. 3. Radiator - Puts warm air out at the top and draws in cooler air at the bottom.	**02 Marks** **02 Marks**
	b	**Describe with neat sketch working of bomb calorimeter.**	**04**
	A	 **Working:** The calorimeter is made of austenitic steel which provides considerable resistance to corrosion and enables it to withstand high pressure. In the calorimeter use of a strong cylindrical bomb in which combustion occurs. The bomb has two valves at the top. One supplies oxygen to the bomb and the other releases the exhaust gases. A crucible in	**Diagram 02 marks**

		which a weighed quantity of fuel sample is burnt is arranged between the two electrodes as shown in fig. The calorimeter is fitted with a water jacket that surrounds the bomb to reduce the losses due to radiation. A stirrer for keeping the temperature of water uniform and a thermometer the temperature up to the accuracy of 0.001 degree C is fitted through the lid of the calorimeter. The heat released by the fuel on combustion is absorbed by the surrounding water and the calorimeter. From the above data the calorific value of the fuel can be found.	**Working 02 Marks**
	c	**Sketch energy flow diagram for steam boiler.**	**4**
		 Figure: Energy flow diagram for steam boiler	**Neat Sketch 04 Marks**
	d.	**Describe with neat sketch working of two stage reciprocating air compressor with P-V diagram.**	**4**
	Ans.	As shown in ig. Shows two stages reciprocating air compressor with water cooled and intercooler. First of all fresh air is sucked from atmosphere in low pressure (L.P) cylinder during its suction stroke at inlet pressure P1 and temp T1.The air after compression in L,P cylinder (I st stage) from 1 to 2 is delivered to intercooler at pressure P2 and temp T2.Now air is cooled in intercooler from 2 to3 at constant pressure P2 and from temp T2 to T3.After that air is sucked in high pressure (H.P) cylinder during its suction stroke. Finally air after further compression in H.P. cylinder (ie second stage) from 3 to 4 is delivered by the compressor at pressure P3 & Temp	**Explanation 01 Mark**

		 	**Diagram 02 marks** **P-V Diagram 01Mark**
	e	**Explain co-generation system on the basis of sequence of energy use.**	**4**
	Ans.	Cogeneration or Combined Heat and Power (CHP) is defined as the sequential generation of two different forms of useful energy from a single primary energy source, typically mechanical energy and thermal energy. Mechanical energy may be used to drive an alternator for producing electricity, or rotating equipment such as motor, compressor, pump or fan for delivering various services. Thermal energy can be used either for direct process applications or for indirectly producing steam, hot water, hot air for dryer or chilled water for process cooling. Cogeneration provides a wide range of technologies for application in various domains of economic activities. The overall efficiency of energy use in cogeneration mode can be up to 85 per cent and above in some cases.	**02 marks for explanations**

		 **Figure: Schematic of Cogeneration Process:**	**02 Marks for diagram**
5		**Attempt any TWO of the following**	**12**
	a.	**Describe ultimate analysis and proximate analysis of solid fuels.**	**06**
	Ans.	**Ultimate analysis:-** • The ultimate analysis of coal is the process of determining different chemical elements present in solid fuel. • This analysis is important for large scale trials. • This technique allows us to get more comprehensive results compared to the proximate analysis process. • It serves the basis for calculation of the amount of air required for complete combustion of 1kg of fuel. • It gives percentage content on mass basis of carbon, hydrogen, oxygen, Sulphur and ash. • Therefore, each and every chemical element in the sample is analyzed through chemical routes and then we can express the contents as percentages with respect to the total mass of the sample. • Mostly, this analysis technique is useful in the coal and coke industry. • We are able to calculate the Calorific value of coal. • Accuracy of this process is very high	**03 Marks**

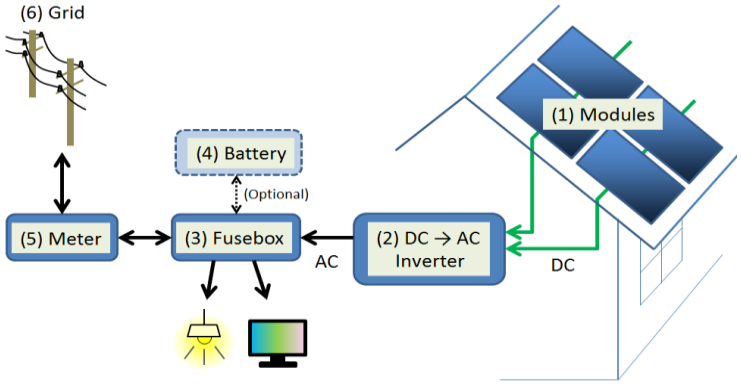
		Proximate analysis:- • Proximate analysis of coal is the process of determining the presence of different compounds and their amounts in solid fuel. • The technique of proximate analysis was developed by Henneberg and Stohmann (German scientists) in 1860. • This analysis technique involves the partitioning of compounds into different categories depending on the chemical properties of these compounds. • This analysis made by means of a chemical balance & temperature control Furnace. • Mainly, there are six categories of compounds as moisture, ash, crude protein, crude lipid, crude fibre, and nitrogen-free extracts. • In the process of proximate analysis of coal, the moisture content of coal, ash content of coal and the fixed carbon content of coal are determined. • This is used to calculate the heating value of coal • Accuracy of this process is Low.	**03 Marks**
	b.	**Draw a neat sketch of surface condenser and write four applications of surface condenser.**	**06**
	Ans.	 **Fig. Surface condenser**	**04 Marks for Sketch**

		Applications:- (Any four) i) Steam power plant ii) Ice plant factory iii) Cold Storage iv) Vacuum evaporation v) Vacuum refrigeration vi) Ocean thermal energy vii) Geothermal energy recovery viii) Distillation system of water.	**02 Marks for Applications**
	c.	**Describe government policy (MNRE) for harnessing the potential power of renewable energy sources.**	**6**
	Ans.	• The Ministry of New and Renewable Energy (MNRE) is the nodal Ministry of the Government of India for all matters relating to new and renewable energy. • The broad aim of the Ministry is to develop and deploy new and renewable energy to supplement the energy requirements of the country. • The estimated potential of small hydro power in India is about 15000 MW. • The estimated potential of wind energy in India is about 45,000 MW. • The estimated potential of solar power in India is about 20,000 MW. • The estimated potential of Biomass energy in India is about 19,500 MW • India can meet all energy needs with Renewable Energy Sources. • Solution to long-term energy problems will come only through research, development & implementation of such developments & recherché in the field of renewable energy sources. • The total estimated potential of renewable Energy is around 152,000 MW, which is much greater than the current total installed energy generating capacity of India. • To overcome energy crises, Government has developed many projects, programs & policies for proper utilization of renewable energy resources. • Energy problem is global problem. Only the government cannot do everything. However individual & co-operative efforts can do a lot.	**06 Marks** **(Note:- Give Credit to Relevant Answer)**

6		Attempt any TWO of the following:	12
	a.	**Compare centrifugal and axial compressor on the basis of** **i) Working principle ii) Capacity iii) Nature of flow iv) Application** **v) Maintenance vi) Delivery pressure range**	06
	Ans.		**01 Marks for each**

Parameter	Centrifugal Compressor	Axial Compressor
i) Working principle	When the air passes through the rotating impeller it experiences force or work which is performed by centrifugal forces. The air flow loses its velocity and increases pressure after entering in the diffuser section.	The rotor imparts kinetic energy to the gas. This kinetic energy is later converted to static pressure when it is diffused through passages or when it strikes on the rotor.
ii) Capacity	The mass flow rate in centrifugal compressor is very small about 15 kg/s.	The mass flow rate in axial Flow compressor is very high about 100 kg/s.
iii) Nature of flow	The gas typically enters the impeller axially and is discharged radially	The gas typically enters and exits the compressor in an axial direction (parallel to the axis of rotation).
iv) Application	Centrifugal Flow compressor is more suited for jet propulsion (flight) system. (Small engines)	Axial Flow compressor is more suitable for jet engines (large Engines)
v) Maintenance	low	High
vi) Delivery pressure range	Higher (about 40 bar)	Lower (20 bar)

	b.	**Calculate the enthalpy of 1kg of steam at a pressure of 7 bar and dryness fraction 0.8. How much heat would be required to generate 2kg of this steam from water at 300C** **Take sp. heat of water Cpw-4.187 KJ/kg K, hf-697.20 KJ/kg. hfg- 2066.3 KJ/kg.**	**06**
	Ans.	Given data: - At p=7 bar Dryness fraction x = 0.8 Mass of steam m=1kg Cpw-4.187 KJ/kg K Enthalpy of 1kg of steam. $h = m(h_f + xh_{fg})$ $h = 1\ X\ (697.20 + 0.8\ X\ 2066.3)$ $h = 2350.24\ KJ$ Total Heat required to generate 2kg of this steam :- m =2kg, $h = m\ (h_f + xh_{fg})$ $h = 2\ X\ (697.20 + 0.8\ X\ 2066.3)$ h = 4700.48 KJ since the water is at 30^0 C , heat already in water = m x (specific heat of water × rise in temperature) = 2 x $(4.187 \times 30) = 251.22kJ$ Heat actually required = Total Heat – heat exist in water at 30^0C $= 4700.48 - 251.2$ Heat actually required = 4449.28K	**02** **02** **02**

	c.	**Explain the construction and working of electricity generation through photovoltaic system.**	**06**
	Ans.		**02 Marks for Diagram**
		Construction: - • A photovoltaic system is solar power system, it is an electric power system designed to supply usable power by means of photovoltaic and sun power. • It consists of an arrangement of several components, including solar panels to absorb and convert sunlight into electricity. • A solar inverter to convert the output from direct to alternating current, as well as mounting, cabling, and other electrical accessories to set up a working system. • It may also use a solar tracking system to improve the system's overall performance and include an integrated battery.	**02 Marks for Construction**
		Working: - • A photovoltaic system converts the Sun's radiation, in the form of light, into usable electricity. • This is a form of decentralized electricity generation. Feeding electricity into the grid requires the transformation of DC into AC by a special, synchronising grid-tie inverter. • This energy shared to residential and feeds energy directly into the grid. • PV systems rarely use battery storage.	**02 Marks for Working**