**WINTER – 15 EXAMINATION**

Subject Code: **17406** **Model Answer**

**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. 1 a)**

**(i) Define I. C. Engine, how these engines are classified. ( def.1xclas.1)(1+1=2)**

**(Any four basis of classification points)**

An Internal Combustion Engine (IC Engine) is a type of combustion engine that converts chemical energy into thermal energy, to produce useful mechanical work. In an IC engine, combustion chamber is an integral part of the working fluid circuit.

Types of Internal Combustion Engines:

1. Based on the fuel used
    1. Diesel Engine
    2. Petrol Engine (or Gasoline Engine)
2. Based on the type of cycle
    1. Otto Cycle Engine
    2. Diesel Cycle Engine
    3. Dual Cycle Engine
3. Based on the number of strokes per cycle
    1. Two-stroke Engine
    2. Four-stroke Engine
4. Based on the number of cylinders
    1. Single Cylinder Engine
    2. Multi cylinder Engine
        i. Twin Cylinder Engine
        ii. Three Cylinder Engine

iii. Four Cylinder Engine
iv. Six Cylinder Engine
v. Eight Cylinder Engine
vi. Twelve Cylinder Engine
vii. Sixteen Cylinder Engine

5. Based on the type of ignition
    1. Spark Ignition Engine (S.I. Engine)
    2. Compression Ignition Engine (C.I. Engine)
6. Based on the lubrication system used
    1. Dry sump lubricated engine
    2. Wet sump lubricated Engine
7. Based on the cooling system used
    1. Air-cooled Engine
    2. Water-cooled Engine
8. Based on the arrangement of valves
    1. L-head Engine
    2. I-head Engine
    3. T-head Engine
    4. F-head Engine
9. Based on the position of cylinders
    1. Horizontal Engine
    2. Vertical Engine
    3. Radial Engine
    4. Opposed Piston Engine
    5. Opposed Cylinder Engine
    6. V Engine
    7. W Engine
    8. Inline Engine
10. Based on the pressure boost given to the inlet air or air-fuel mixture
    1. Naturally aspired Engine
    2. Supercharged Engine
    3. Turbocharged Engine
    4. Crankcase compressed Engine
11. Based on application

1. Automobile Engine
2. Aircraft Engine
3. Locomotive Engine
4. Marine Engine
5. Stationary Engine

**(ii) Define fuel cell and give its types (1 def. x any two basis from the below 1 mark) (1+1=2)**

**Fuel cell :** Fuel cells are electrochemical devices that convert a fuel chemical energy directly to electrical energy without an intermediate combustion or thermal cycle.

With no internal moving parts fuel cells operate similar to batteries. An important difference is that batteries store energy while fuel cells produce electricity continuously as along as fuel and air are supplied. Fuel cells virtually emit no pollution as the waste exhaust is simply water vapour and heat.

Fuel cells are classified as follows:

**1) On the basis of type of electrolyte**

i) Phosphoric acid fuel cell (PAFC)

ii) Alkaline fuel cell (AFC)

iii) Molten Carbon fuel cell (MCFC)

iv) Solid oxide fuel cell (SOFC)

v) Polymer membrane Fuel cell (PEMFC)

**2) On the basis of type of fuel and oxidant**

i) Hydrogen-oxygen fuel cell

ii) Hydrogen rich gas air fuel cell

iii) Ammonia air fuel cell

iv) Synthesis gas air fuel cell

v) Hydrogen air fuel cell

**3) On the basis of operating temperature**

i) Low temperature fuel cell ( Below 150 $^{o}$ C )

ii) Medium temperature fuel cell (150 $^{o}$ C – 250 $^{o}$ C )

iii) High temperature fuel cell (250 $^{o}$ C – 800 $^{o}$ C )

iv) Very high temperature fuel cell (800$^{o}$ C – 1100 $^{o}$ C )

**(iii) State Kelvin-Plank statement of second law of thermodynamics. (2 marks)**

Kelvin-Plank Statement of second law of thermodynamics: "It is impossible to construct a heat engine to work in a cyclic process whose sole effect is to convert all the heat supplied to into an equivalent amount of work"

**(iv) State Avogadro's law for ideal gases. (2 marks)**

Avogadro's law states that, "Equal volumes of all gases, at the same temperature and pressure, have the same number of molecules".

For a given mass of an ideal gas, the volume and amount (moles) of the gas are directly proportional if the temperature and pressure are constant.

**(v) Define dryness fraction of steam. What is the value for saturated liquid? (2 marks)**

The quality of steam is designated by the term 'dryness fraction of steam" which is defined as the ratio of the mass of dry vapor to the total mass of the mixture (vapor & liquid) and is designated by "x".

The value of dryness fraction for saturated liquid is zero.

**(vi) Give the classification of compressor.**

**Classification of air compressor:- (Any four from below points 1/2 mark each)(4x1/2=2)**

a) According to number of stages:-

i) Single stage: - Delivery pressure up to 10 bar ii) Multistate:- Delivery pressure above 10 bar.

b) According to number of cylinder:- i) Single cylinder ii) Multi cylinder.

c) According to method of cooling:- i) Air cooled ii) Water cooled.

d) According to action of air:- i) Single acting ii)Double acting.

e) According to capacity:- i) Low capacity ii) Medium capacity iii) High capacity.

f) According to drive:- i) Steam engine drive ii) Steam turbine drive iii) Electric motor drive iv) Internal combustion drive.

**(vii) Mention uses of compressed air. (Any four from below points 1 mark each) (1x2=2)**

The power of compressed air is used in thousands of applications and is vital to the productivity of industries around the globe.

1) To drive air motors in coal mines.
2) To inject fuel in air injection diesel engines.
3) To operate pneumatic drills, hammers, hoists, sand blasters.
4) For cleaning purposes.

5) To cool large buildings.
6) In the processing of food and farm maintenance.
7) For spray painting in paint industry.
8) In automobile & railway braking systems.
9) To operate air tools like air guns.
10) To hold & index cutting tools on machines like milling.

**(viii) What is COP of refrigeration? (2 marks)**

For the refrigerator when the purpose is to achieve the maximum heat transfer from the cold reservoir, the measure of performance or success is called the co-efficient of performance (C.O.P.) It is defined as the ratio of amount of heat removed from cold reservoir to the amount of work supplied

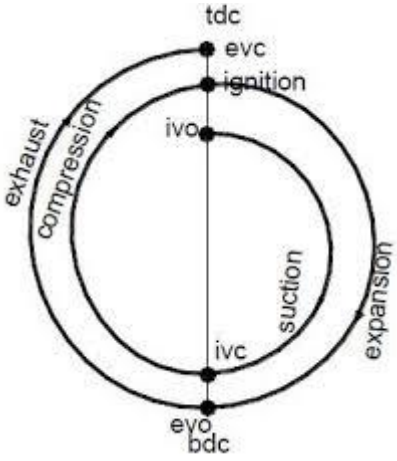
Co-efficient of performance, (C.O.P.) = Q/W

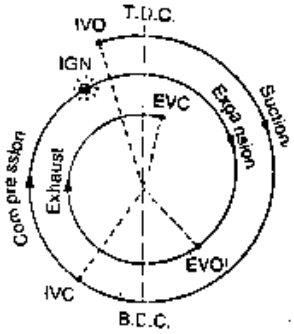
where, Q = Heat transfer from cold reservoir, and
W = The net work transfer to the refrigerator.

The COP has no units.

**Q. 1 b)**

**(i) Explain theoretical and actual valve time diagram for petrol engine. (4 marks for fig. and 4 marks for explanation) (4+4=8)**




*TDC* : Top dead centre
*BDC* : Bottom dead centre
*IVO* : Inlet valve opens (10°-20° before *TDC*)
*IVC* : Inlet valve closes (30°- 40° after *BDC*)
*IGN* : Ignition (20°-30° before *TDC*)
*EVO* : Exit valve opens (30°-50° before *BDC*)
*EVC* : Exit valve closes (10°-15° after *TDC*)

Theoretical valve time diagram Actual valve time diagram

According to theoretical valve timing diagram, each stroke takes 180 degree of crank rotation. Compression & expansion also takes place during $180^0$ of crank rotation. Compression & expansion are isentropic.

The correct timing of opening & closing of inlet & exhaust valves improves the power and efficiency of the engine & it reduces the specific fuel consumption.

In actual, the inlet valve opens few degrees before TDC as shown in the figure, when the pressure drops below the atmosphere inside the cylinder, fresh charge is admitted. When the piston reaches BDC and starts its compression stroke, the charge continues to move into the cylinder due to its

kinetic energy .To take its advantage the inlet valve is kept opened for few degrees after BDC. The inlet valve for low speed engine opens before TDC and closes after BDC, while the respective valves for a high speed engine are before TDC and after BDC.

The exhaust valve opens few degrees before BDC and closes few degrees after TDC.

The exhaust valve remains open even after the inlet valve has opened. This period of valve overlap helps in driving out the exhaust gases efficiently. For high speed engine, exhaust valve opens before BDC and closes after TDC.

Due to time lag between the supply of spark and ignition of charge, the spark is provided few degrees before end of compression stroke called ignition advance.

**(ii) Define thermodynamic system and its types with suitable example. (4 for description 4 for classification) (4 +4=8)**

A thermodynamic system (or simply 'system') is a definite macroscopic region or space in the universe, in which one or more thermodynamic processes take place.

Everything external to a thermodynamic system is called surroundings.

System and surroundings are separated by a definite border called boundary. System, surroundings and boundary constitute the universe.

Types of Thermodynamic System:

Thermodynamic systems can be broadly classified into three types. They are:

1. Open System
2. Closed System
3. Isolated System

**1. Open System:**

An open system is a thermodynamic system which allows both mass and energy to flow in and out of it, across its boundary.

Example of open system: Water heated in an open container – Here, heat is the energy transferred, water is the mass transferred and container is the thermodynamic system. Both heat and water can pass in and out of the container.

**2. Closed System:**

A closed system allows only energy (heat and work) to pass in and out of it. It does not allow mass transfer across its boundary.

Example of closed system: Water heated in a closed vessel – Here only heat energy can pass in and out of the vessel.

**3. Isolated System:**

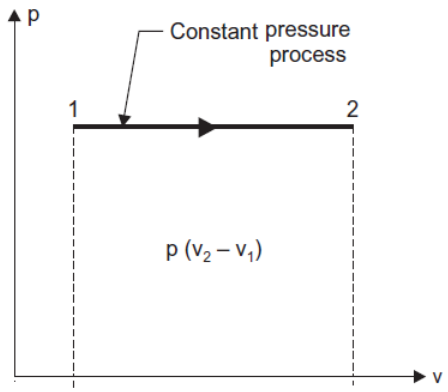
An isolated system does not interact with its surroundings. It does not allow both mass and energy transfer across its boundary. It is more restrictive.

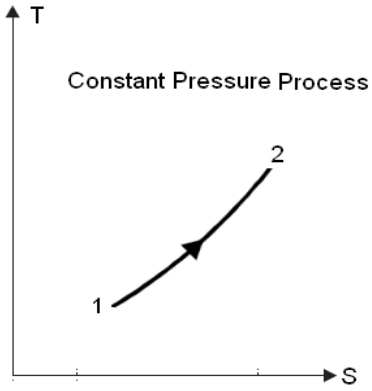
In reality, complete isolated systems do not exist. However, some systems behave like an isolated system for a finite period of time.

Example of Isolated system: coffee in a thermas flask.

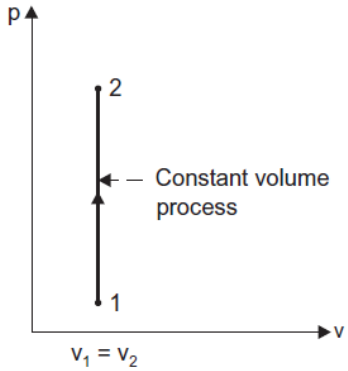
**(iii) Draw P-V and T-S diagram for following processes: (2 marks for each process) (2 x4=8)**

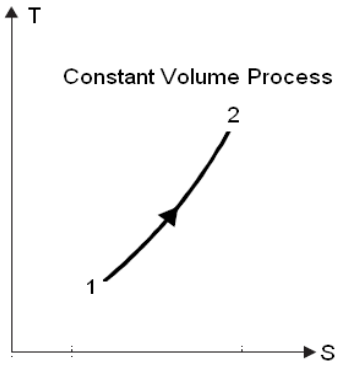
1) Isobaric Process



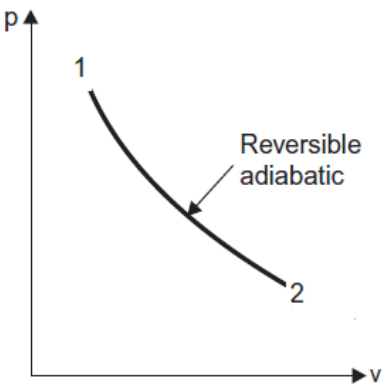



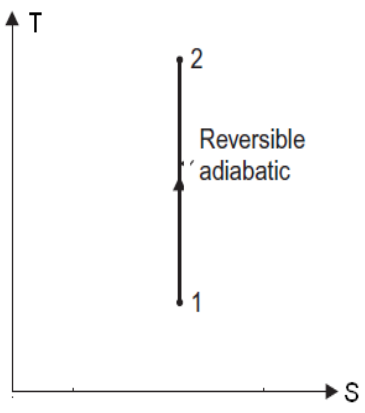

2) Isochoric process



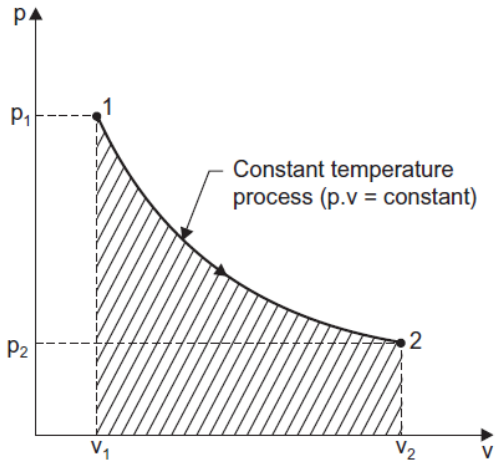



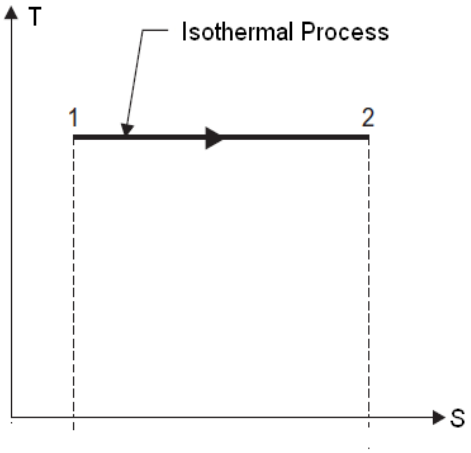

3) Isentropic process (Reversible adiabatic)



4) Isothermal process

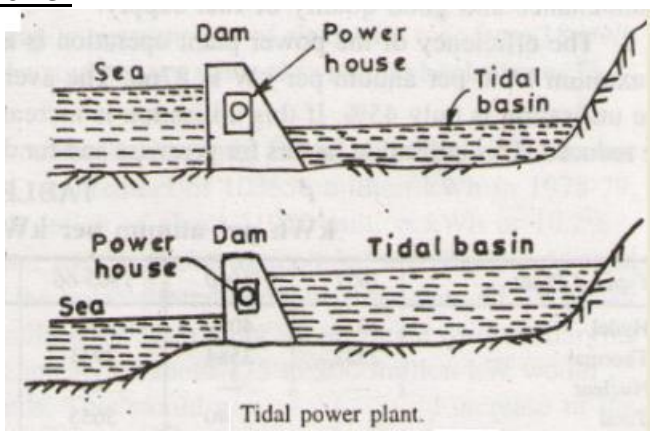



**Q.2 a) Differentiate between S.I. Engine and C.I. Engine. ( Any four points)** **( 01 Mark for each )**

| S.I Engine | C.I. Engine |
|---|---|
| 1. During suction stroke the mixture of air and petrol is sucked in the engine cylinder. | 1. During suction stroke only air is sucked in the engine cylinder. |
| 2. Petrol engine works on Otto cycle. | 2. Diesel engine works on Diesel cycle. |
| 3. Spark plug is used to ignite the charge with electric spark. | 3. Fuel injector is used. The fuel burns by the heat of compressed air. |
| 4. Compression ratio varies from 6 – 11. | 4. Compression ratio varies from 14 – 22. |
| 5. Light and less stronger. | 5. Heavier and stronger. |
| 6. There is a chance of pre-ignition. | 6. No chance of pre-ignition. |
| 7. Lower thermal efficiency. | 7. Higher thermal efficiency |
| 8. Less initial cost.<br>9. High running cost. | 8. High initial cost.<br>9. Low running cost. |
| 10. Used in cars, scooters and motorcycles. | 10. Used in heavy duty vehicles like trucks, buses and locomotive engines. |

**b) Explain with neat sketch Tidal Power Plant. (2 marks for sketch and 2 for explanation)**



Tidal power plant.

In this type of the power plant, tide of the sea is used for running the water turbine. The ocean tides contain large amount of potential energy which is used for power generation. The arrangement of this system is shown in figure.

During the high tide period, the water flows from sea into the tidal basin through the water turbine as the level of tide is more than the water level in the tidal basin. This operates the turbine & ultimately the generator.

During the low tide period the water falls from the tidal basin to sea as the water level in the basin is more than that of the tide in the sea. During this period also the flowing water turns turbine and generates the power. The generation of power stops only when sea level and tidal level are equal.

**c) Explain Thermodynamic work and heat. ( 2 marks each)**

**Heat:** Heat is the energy interaction driving forces caused by the temperature difference between the system and surrounding. It is low grade energy.

**Work:** In thermodynamics, work is considered as interaction occurring between the system and the surrounding. Work is said to be done by a system if sole effect on things external to the system can be reduced to the raising of a weight.

**d) State and explain each term of equation of state for ideal gas. (2 x 2=4)**

The state of an amount of gas is determined by its pressure, volume, and temperature. The modern form of the equation relates these simply in two main forms. The temperature used in the equation of state is an absolute temperature: in the SI system of units, Kelvin. The most frequently introduced form is

$PV = mRT$

where:

*P* is the pressure of the gas

*V* is the volume of the gas

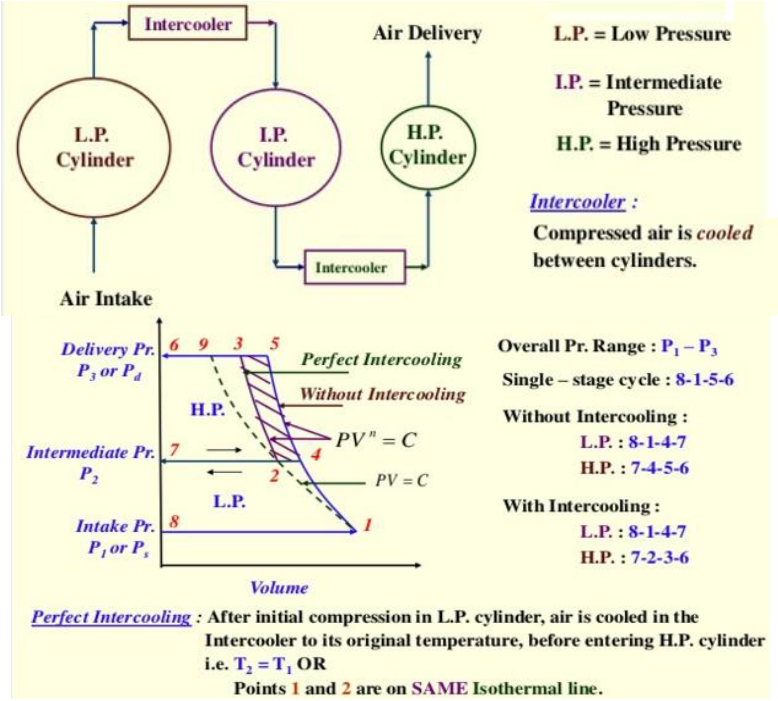
*m* is the mass of gas

*R* is the ideal, or universal, gas constant, equal to the product of the Boltzmann constant and the Avogadro constant.

*T* is the temperature of the gas

In SI units, *P* is measured in pascals, *V* is measured in cubic metres, *n* is measured in moles, and *T* in Kelvin (The Kelvin scale is a shifted Celsius scale where 0.00 Kelvin = -273.15 degrees Celsius, the lowest possible temperature). R has the value 8.314 $J \cdot K^{-1} \cdot mol^{-1}$ or 0.08206 $L \cdot atm \cdot mol^{-1} \cdot K^{-1}$or ≈2 calories if using pressure in standard atmospheres (atm) instead of Pascal, and volume in litres instead of cubic metres.

**e) Explain two stage reciprocating compressor with P-V diagram. (2 for figure x 2 for description)**




Sometimes it is not economical to compress air in single stage as it requires more work for compression, so we go for two or multi stage compression. Air from atmosphere is taken in low pressure cylinder first, it is compressed to certain intermediate pressure and then it is further compressed to the desired value in high pressure cylinder. Intercooler is a device which is used in between the two stages as shown in fig. which lowers the temperature of air before it passes to next stage, to minimize work of compression. Shaded area in fig. shows the amount of work saved due to intercooling. Intercooling is said to be perfect if the temp. of air, after passing through intercooler is lowered to the value at the beginning of first stage compression.

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**f) Differentiate between Isobaric and Isochoric Process.**

**(Any four points) (01 Mark for each) (1 x 4=4)**

| ISOBORIC PROCESS | ISOCHORIC PROCESS |
|---|---|
| 1. Here pressure is constant during process (P=C) | 1. Here Volume is constant during process (V=C) |
| 2. N= 0 | 2. Here n=∞ |
| 3. Work Done =$P(V_2-V_1)$ | 3. work Done = 0 |
| 4. Occurs is a piston & cylindrical arrangement | 4. Occurs in constant volume vessel |
| 5. Here specific heat at constant pressure is assumed to be constant (Cp). | 5. Here sp. Heat at constant volume is assumed to be constant (Cv). |

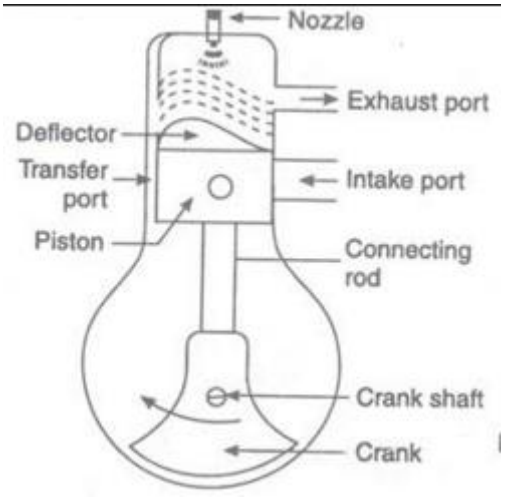
**Q.3 a) State Clausius statement of 2nd law of Irreversibility. (4 marks)**

Clausius statement of second law of Thermodynamics:- It states that it is impossible to construct a device working in a cyclic process whose sole effect is the transfer of energy in the form of heat from a body at a lower temperature (sink) to a body at a higher temperature ( source).

Or

It is impossible for energy in the form of heat to flow from body at a lower temperature to a body at a higher temperature without the aid of external work.

**b) Describe with neat sketch working of two stroke diesel engine. (2 x 2=4)**




In this engine, the working cycle is completed in two strokes of the piston or one revolution of the crankshaft. Here the valves are replaced by ports. Two rows of the ports at different levels are cut in the cylinder walls as shown in figure. These are known as exhaust and transfer ports. In case of

single cylinder engines, a third row of ports is provided below the first two, which are known as inlet ports.

A specific shape is given to the piston crown as shown, which helps to prevent the loss of incoming fresh charge being short circuited through the transfer ports and helps for exhausting only the burned gases.

During the downward movement of the piston following processes are completed,

a) Power is developed by the piston caused by the expansion of high pressure gases.
b) The exhausts gases are removed completely form the cylinder by scavenging.
c) The charge is compressed in the crankcase with the help of underside of the piston.

During the upward movement of the piston following process are a completed,

a) Partly scavenging takes place.
b) The fresh charge is sucked in the crankcase.
c) Compression of the charge is completed as the piston moves towards TDC.

**c) State the advantages and limitations of wind energy. (2 x 2=4)( 2 for advantages and 2 for limitations)**

Advantages:- (Any four)

1. The wind is free and with modern technology it can be captured efficiently.

2. Once the wind turbine is built the energy it produces does not cause green house gases or other pollutants.

3. Although wind turbines can be very tall each takes up only a small plot of land. This means that the land below can still be used. This is especially the case in agricultural areas as farming can still continue.

4. Many people find wind farms an interesting feature of the landscape.

5. Remote areas that are not connected to the electricity power grid can use wind turbines to produce their own supply.

6. Wind turbines have a role to play in both the developed and third world.

7. Wind turbines are available in a range of sizes which means a vast range of people and businesses can use them. Single households to small towns and villages can make good use of range of wind turbines available today.

Limitations:- (Any four)

1.The strength of the wind is not constant and it varies from zero to storm force. This means that wind turbines do not produce the same amount of electricity all the time. There will be times when they produce no electricity at all.

2. Many people feel that the countryside should be left untouched, without these large structures being built. The landscape should left in its natural form for everyone to enjoy.

3. Wind turbines are noisy. Each one can generate the same level of noise as a family car travelling at 70 mph.

4. Many people see large wind turbines as unsightly structures and not pleasant or interesting to look at. They disfigure the countryside and are generally ugly.

5. When wind turbines are being manufactured some pollution is produced. Therefore wind power does produce some pollution.

6. Large wind farms are needed to provide entire communities with enough electricity. For example, the largest single turbine available today can only provide enough electricity for 475 homes, when running at full capacity. How many would be needed for a town of 100 000 people?

**d)Write advantages of two stage compression over single stage compression for same compression ratio. (any four points) ( 1 mark each point)**

Advantages:-

1. Two stage compressor is compact in size.
2. No need to accommodate high pressure ratios.
3. Smooth operation, no problem of balancing.
4. No fluctuations of torque.
5. No need to install heavy flywheels.
6. High power to weight ratio.
7. Power required to drive the compressor can be reduced by using intercooler.

**e)what are the characteristics of gas constant and universal gas constant? (2 x 2=4)**

The equation of state for a perfect gas is given by $PV=RT$, where $R$ is called the specific gas constant or characteristic gas constant. The magnitude of this constant depends upon the particular gas. For m kg of mass occupying V m3 of volume, the equation becomes,

$$\boldsymbol{PV=mRT.}$$

If the mass is equal to molecular weight of the gas then one mole of the gas have been considered i.e 1 kg mole of oxygen is 32 kg of oxygen.

The equation of state then written as, $\boldsymbol{PV_0=mRT.}$ Where $V_0$ is equal to molar volume. If $\boldsymbol{M}$ is molecular weight of the gas, then according to Avogadro's law , it may be seen that M X R = a constant $=R_0$

Then above equation can be written as $\boldsymbol{PV_0=R_0T}$

in above equation $R_0$ is called as molar or universal gas constant and its value is 8.3143 KJ/kgmole-$^{O}K$

**f) Give the classification of boiler in detail.** *Any four points from below* **(1 mark each) (1 x 4=4)**

Steam boilers are classified mainly as follows. ( Any four) 1 mark each.

i) Depending upon relative position of water and fuel gases.

a) Fire tube boilers.

b) Water tube boilers

ii) Depending upon position of axis of boilers.

a) Vertical boilers.

b) Horizontal boilers

iii) Depending upon position of furnace.

a) Internally fires boilers.

b) Externally fires boilers.

iv) Depending upon application.

a) Stationary boilers.

b) Portable boilers.

c) Locomotive boilers.

d) Marine boilers.

v) Depending upon circulation of boilers.

a) Natural circulation boilers.

b) Forced circulation boilers.

vi) Depending upon pressure of steam generated.

a) Low pressure boilers.

b) High pressure boilers.

vii) Depending upon nature of draught employed.

a) Natural or chimney draught

b) Artificial draught.

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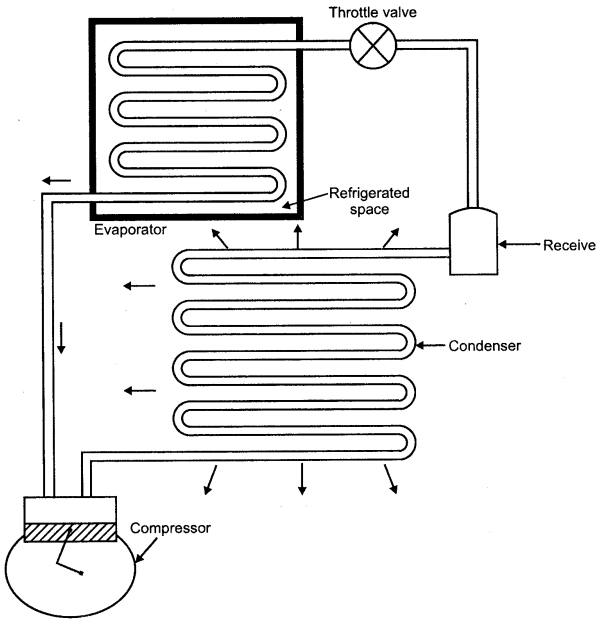
**Q.4 a) Explain construction and working of vapour compression cycle and its application.**

**Fig. of Vapour Compression Refrigeration Cycle (3 marks) (3+3+2=8)**




The main components of VCC are: **( 3 Marks)**

1) Compressor: Compressor is the most important component of VCC refrigeration system and is considered being the heart of the system. The function of compressor is to compress the low pressure refrigerant from evaporator to condenser pressure at a temperature more than saturation temperature corresponding to condenser pressure.

2) Condenser: condenser is heat rejection component in vapour compression system.

Function of condenser in refrigeration system is to superheat and condense the compressor discharged vapour and frequently to sub-cool the liquid with minimum pressure drop.

3) Expansion Device: It is the pressure reducing component in vapour compression system. Its function is to reduce pressure of refrigerant from condenser pressure to evaporator pressure by throttling and to control mass flow rate of refrigerant entering in evaporator as per load on evaporator.

4) Evaporator: It is a component in which refrigerating effect is obtained. Refrigerating effect is produced in evaporator. The liquid at low pressure enters in evaporator, by absorbing heat it converts into vapours. These vapours are drawn in suction line of compressor.

**Applications of V.C.C. ( 2 Marks)**

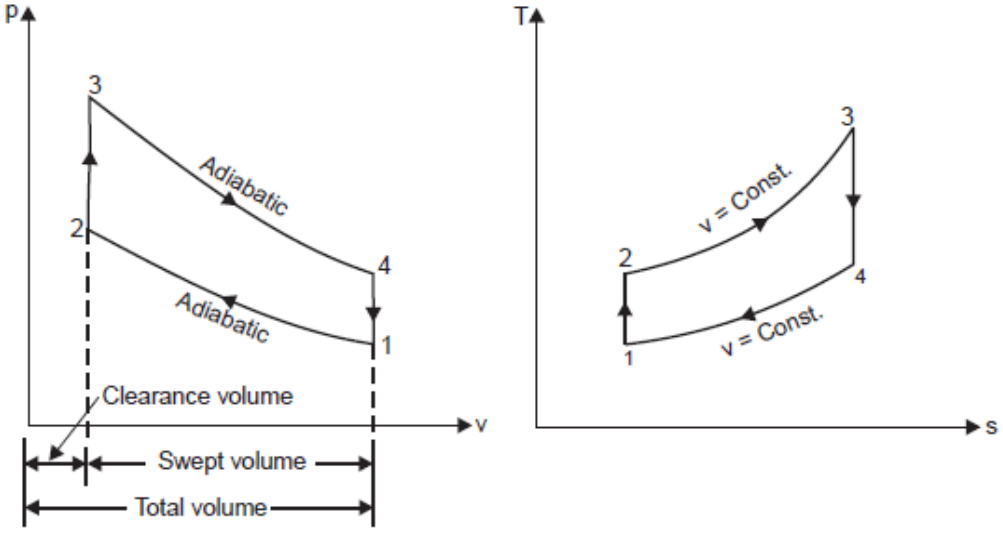
1) Water cooler
2) Domestic refrigerator
3) Ice plant

4) Cold storage

5) Air Conditioner

**b) Explain Otto cycle with P-V and T-S diagram and derive expression for air standard efficiency. (2+2+4=8)**

(Cycle explanation 02 marks, P-V & T-S diagram 02 marks each & derivation 04 marks)




This cycle is so named as it was conceived by 'Otto'. On this cycle, petrol, gas and many types of oil engines work. It is the standard of comparison for internal combustion engines. Figs. shows the theoretical *p-V* diagram and *T-s* diagrams of this cycle respectively.

_ The point 1 represents that cylinder is full of air with volume V1, pressure p1 and absolute temperature T1.

_ Line 1-2 represents the adiabatic compression of air due to which p1, V1 and T1 change to p2,V2 and T2, respectively.

_ Line 2-3 shows the supply of heat to the air at constant volume so that p2 and T2 change to p3 and T3 (V3 being the same as V2).

_ Line 3-4 represents the adiabatic expansion of the air. During expansion p3, V3 and T3 change to a final value of p4, V4 or V1 and T4, respectively.

_ Line 4-1 shows the rejection of heat by air at constant volume till original state (point 1) reaches.

**Consider 1 kg of air** (working substance) :

Heat supplied at constant volume = $c_v(T_3 - T_2)$.

Heat rejected at constant volume = $c_v (T_4 - T_1)$.

But, work done = Heat supplied – Heat rejected

$= c_v (T_3 - T_2) - c_v (T_4 - T_1)$

$$\therefore \quad \text{Efficiency} = \frac{\text{Work done}}{\text{Heat supplied}} = \frac{c_v (T_3 - T_2) - c_v (T_4 - T_1)}{c_v (T_3 - T_2)}$$

$$= 1 - \frac{T_4 - T_1}{T_3 - T_2} \qquad \ldots(i)$$

Let compression ratio, $r_c\ (= r) = \frac{v_1}{v_2}$

and expansion ratio, $r_e\ (= r) = \frac{v_4}{v_3}$

(These *two ratios are same* in this cycle)

As $$\frac{T_2}{T_1} = \left(\frac{v_1}{v_2}\right)^{\gamma - 1}$$

Then, $$T_2 = T_1 \,.\, (r)^{\gamma - 1}$$

Similarly, $$\frac{T_3}{T_4} = \left(\frac{v_4}{v_3}\right)^{\gamma - 1}$$

or $$T_3 = T_4 \,.\, (r)^{\gamma - 1}$$

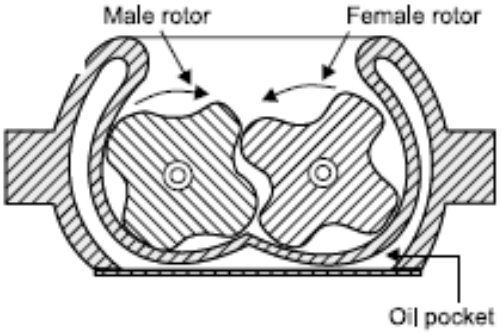
Inserting the values of $T_2$ and $T_3$ in equation $(i)$, we get

$$\eta_{otto} = 1 - \frac{T_4 - T_1}{T_4 \,.\, (r)^{\gamma - 1} - T_1 \,.\, (r)^{\gamma - 1}} = 1 - \frac{T_4 - T_1}{r^{\gamma - 1}(T_4 - T_1)}$$

$$= 1 - \frac{1}{(r)^{\gamma - 1}}$$

**c) Explain construction and working of screw compressor. What are its applications?**

(Sketch 02 marks, Working 04 marks, applications 02 marks) **(2+4+2=8)**




*Screw type compressor:* Screw type compressor is very much similar to roots blower. These may have two spiral lobed rotors, out of which one may be called male rotor having3–4 lobes and other female rotor having 4–6 lobes which intermesh with small clearance. Meshing is such that lobes

jutting out of male rotor get placed in matching hollow portion in female rotors. Initially, before this intermeshing the hollows remain filled with gaseous fluid at inlet port. As rotation begins the surface in contact move parallel to the axis of rotors toward the outlet end gradually compressing the fluid till the trapped volume reaches up to outlet port for getting discharged out at designed pressure. Since the number of lobes is different so the rotors operate at different speed.

Two rotors are brought into synchronization by the screw gears. Thrust upon rotors is taken care of by oil lubricated thrust bearings. These compressors are capable of handling gas flows ranging from 200 to 20000 m3/h under discharge pressures of 3 bar in single stage and up to 13 bar gauge in two stages. Even with increase in number of stages pressures up to 100 bar absolute have been obtained with stage pressure ratio of 2.Mechanical efficiency of these compressors is quite high and their isothermal efficiencies are even more than vane blowers and may be compared with centrifugal and axial compressors. But these are very noisy, sensitive to dust and fragile due to small clearances.

Applications : 1) It is applicable where high volumetric efficiency is obtained .

2) Where in the absence of suction and discharge valve eliminates pressure drop
3) With refrigerant R22 and ammonia
4) Where even torque is there

**Q.5 a)** Given data

Mass of gas = 1 kg

$T_1 = 25\ ^{O}C = 298^{0}k$

$T_2 = 90\ ^{O}C = 363^{0}k$

$R = 0.284\ kJ/kg\text{-}^{0}k$

$\gamma = 1.18$

Cp, Cv,dH &dU = ?

We know,

$R = Cp - Cv$

$0.284 = Cp - Cv$ _ _ _ _ _ (i)

Also, $\gamma = Cp / Cv$

$1.18 = Cp / Cv$

i.e. $Cp = 1.18\ Cv$

putting in equation (i)

$0.284 = 1.18\ Cv - Cv$

$0.284 = Cv\ (1.18-1)$

Cv = 1.5777 & from eq. (i) Cp = 1.8616

Change in enthalpy = m x Cp x ($T_2$ - $T_1$)

= 1 x 1.8616 x (363-298)

= 121.004 kJ/kg

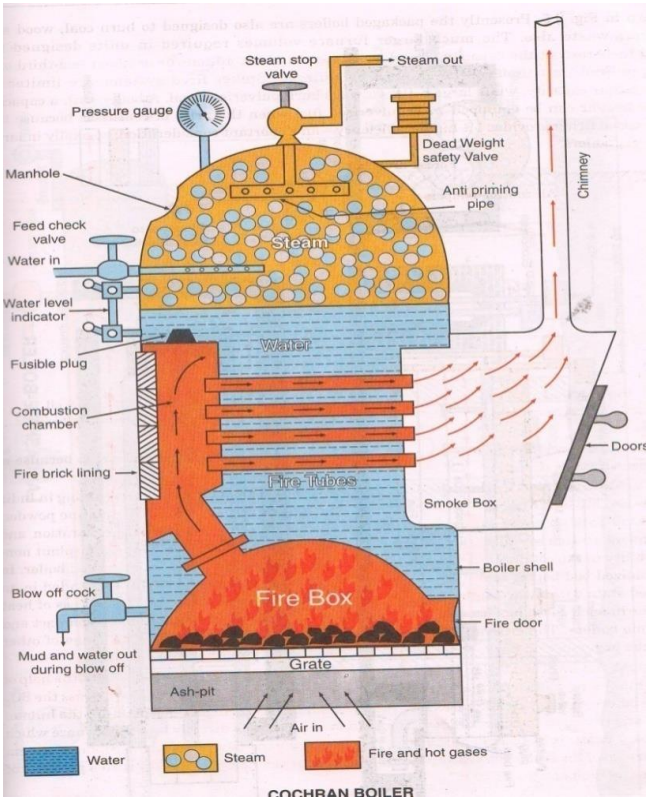
Change in internal energy = m x Cv x ($T_2$ - $T_1$)

= 1 x 1.5777 x (363-298)

= 102.5505 kJ/kg

**b) Draw labeled sketch of Cochran boiler. Show the path of water, steam and flue gases.**

Sketch of Cochran Boiler (4 for figure & 4 for label) (4+4=8)




**c) Classify air conditioning systems and explain window air conditioning system with neat sketch.** **(4+2+2=8)**

( 4 marks for classification, 2 for figure and 2 for explanation )

Air conditioning systems are classified as

**1) Classification as to major function-**

i) Comfort air-conditioning - air conditioning in hotels, homes, offices etc.

ii) Commercial air-conditioning- air conditioning for malls, super market etc

iii) Industrial air-conditioning – air conditioning for processing, laboratories etc

**2) Classification as to season of the year-**

i) Summer air-conditioning - These system control all the four atmospheric conditions for summer comfort.

ii) Winter air-conditioning – This system is designed for comfort in winter.

iii) Year round air-conditioning – These system consists of heating and cooling equipments with automatic control to produce comfortable condition throughout the year

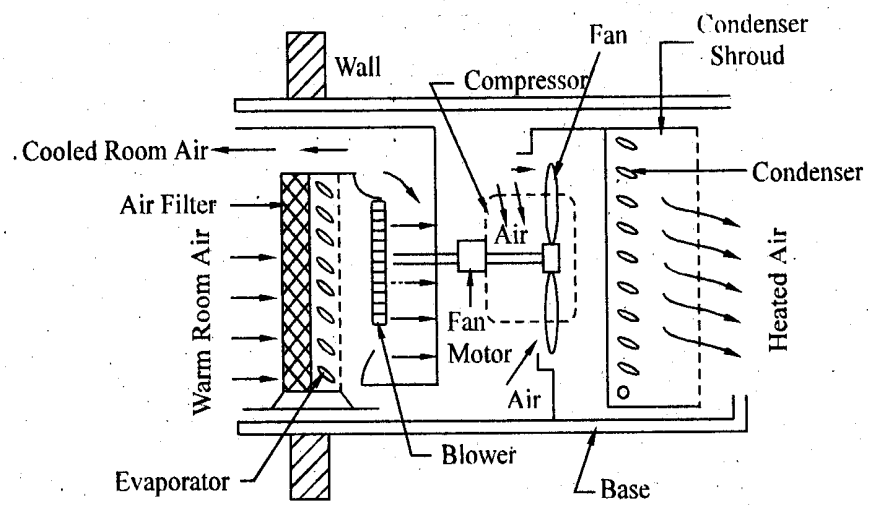
**3) Classification as to Equipment Arrangement-**

i) Unitary system

ii) Central system

Working of window air conditioner

The low pressure and low temperature refrigerant vapour from evaporator is sucked by compressor. The compressor compresses the vapour to high pressure and high temperature and discharges to the condenser. On the condenser the refrigerant vapour condenses by dissipating heat to the cooling medium (air) the liquid refrigerant coming out of condenser passes through filter, dryer into capillary tube where it is again throated back to the evaporated pressure. The low pressure low temp liquid refrigerant then flows to evaporator which it boil off by extracting heat from air to be circuited to the conditioned space.




**Q.6 a)State zeroth law and first law of thermodynamics. (2+2=4)**

**Zeroth law of Thermodynamics:** It states that if two systems are in thermal equilibrium with third system separately then they are in thermal equilibrium with each other.

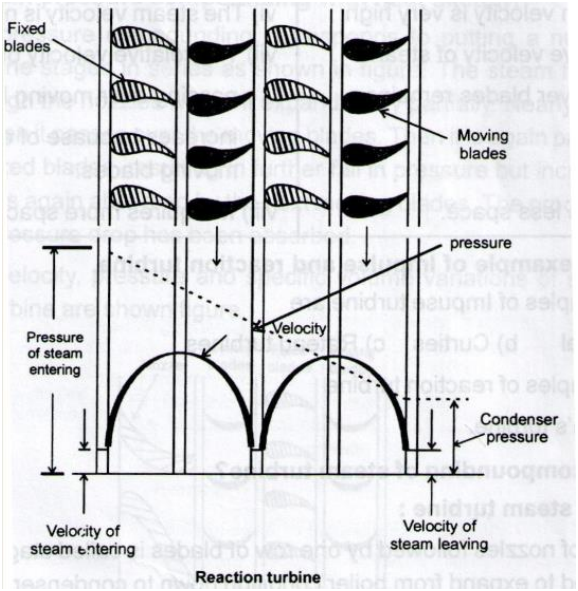
Consider three bodies A, B and C. When body A and B are in thermal equilibrium with Body C separately, then body A & B are in thermal equilibrium with each other.

**First Law of Thermodynamics**: - It states that if a system executes a cycle , transferring work and heat through its boundary, the net heat transfer is equivalent to the net work transfer.

$$\text{or} \qquad \oint dQ = \oint dW$$

where $\oint$ represents the sum for a complete cycle.

**b)Explain construction and working of reaction turbine. (2+2=4)**




The reaction turbine is as shown in figure.

In this turbine the high pressure steam from the boiler is passed through the nozzle when the steam comes out through these nozzles, the velocity of steam increases relative to the rotating disc. The resulting reacting force of the steam on nozzle gives the rotating motion to the disc and shaft. The shaft rotates in opposite direction to that of steam jet.

Here moving blade channel nozzle are of same shape, due to this the pressure drop occurs both in the nozzles as well as in the moving rows of blades.

The pressure and velocity variation is as shown in figure.

**c) Differentiate between open system and closed system. (1 x 4=4)**

| OPEN SYSTEM | CLOSED SYSTEM |
|---|---|
| 1. In this mass and energy both gets across the boundary out of the system. | 1. In this only energy but not mass gets across the boundary of the system. |
| 2. Boundary of the system may or may not | 2. Boundary of the system does not change. |

| | |
|---|---|
| change. | |
| 3. The volume does not change. | 3. The volume need not be constant. |
| 4. Compressor,IC engine. | 4. Thermal power plant |

**d) (i) Define entropy. State its unit. (2+2=4)**

Entropy is a thermodynamics property of a working substance which increases with the addition of heat and decreases with the removal of heat. Entropy means "transformation "and is a measure of extent of irreversibility of the process undergone by the system.

It is denoted by "S" or "ϕ". The units of entropy is kJ/kg -$^{o}$K

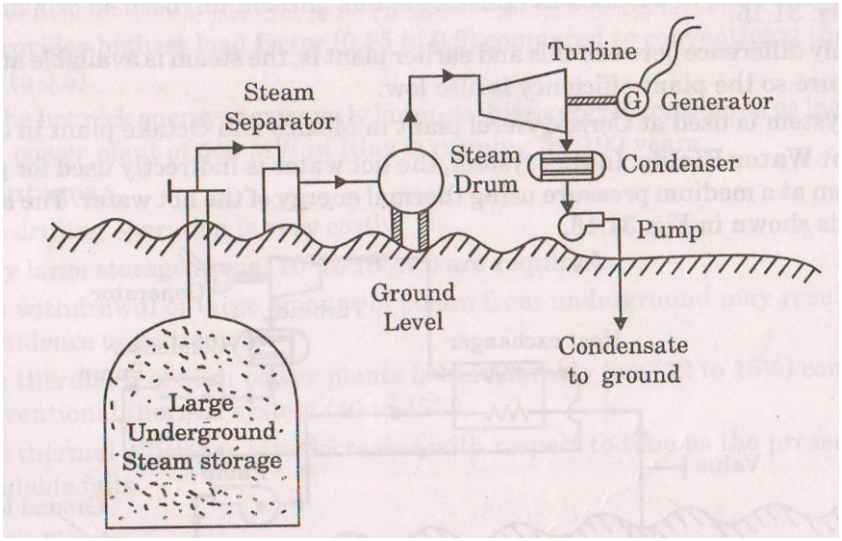
**(ii) Define specific heat.**

The specific heat is the amount of heat per unit mass required to raise the temperature by one degree Celsius.

**e) Explain working principle of geothermal power plant with neat sketch. (2+2=4)**

( 02 Mark for description and 02 marks for sketch )

Geothermal power Plant: This is also known as one form of nonconventional energy source. The power plant sketch is as shown in figure. It consists of availability of large amount of steam in the crust of earth. Raw steam from underground is taken into steam separator and dry steam is stored into steam drum. The dry steam is then passed through the turbine. The condenser performs the function of condensation and the condensate from the condenser is reinjected into the ground. This condensate under the ground absorbs the heat from the rock and again steam is generated.




**f) List the components used in vapour compression cycle and explain function of any one.**

(2 marks for listing & 2 marks for function of any one component) **(2+2=4)**

The main components of VCC are –

1. **Compressor:** Compressor is the most important component of VCC refrigeration system and is considered being the heart of the system. The function of compressor is to compress the low pressure refrigerant from evaporator to condenser pressure at a temperature more than saturation temperature corresponding to condenser pressure.

2. **Condenser:** condenser is heat rejection component in vapour compression system.Function of condenser in refrigeration system is to superheat and condense the compressor discharged vapour and frequently to sub-cool the liquid with minimum pressure drop.
3. **Expansion Device:** It is the pressure reducing component in vapour compression system. Its function is to reduce pressure of refrigerant from condenser pressure to evaporator pressure by throttling and to control mass flow rate of refrigerant entering in evaporator as per load on evaporator.
4. **Evaporator:** It is a component in which refrigerating effect is obtained. Refrigerating effect is produced in evaporator. The liquid at low pressure enters in evaporator, by absorbing heat it converts into vapours. These vapours are drawn in suction line of compressor.