**SUMMER – 13 EXAMINATION**

Subject Code:12246 **Model Answer**

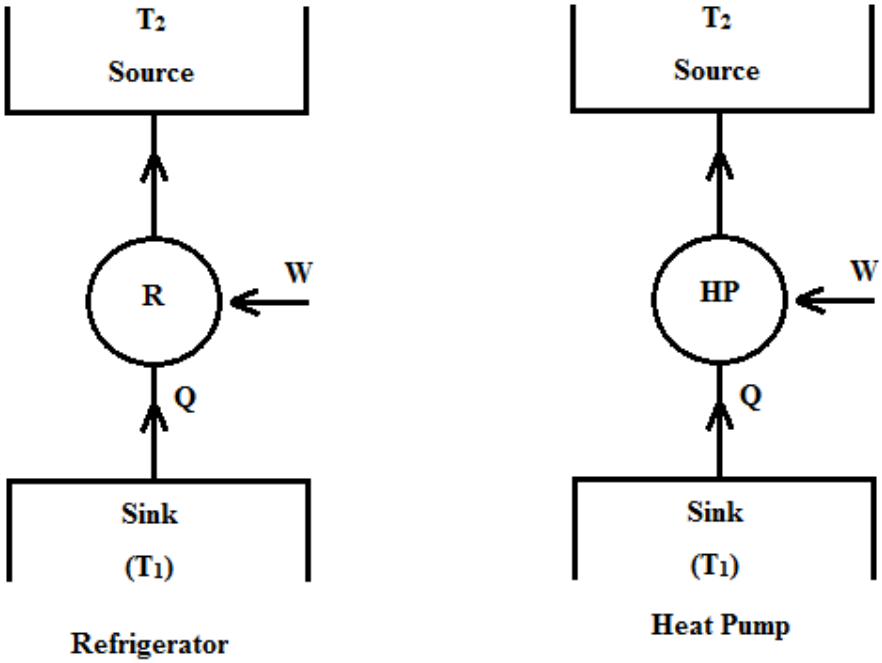
**Important Instructions to examiners:**

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.

**SUMMER – 13 EXAMINATION**

Subject Code:12246 **Model Answer**

**Q. 1 a) i)** There is no difference between the cycle of operation of a heat pump and a refrigerator.




In case of refrigerator, we maintain the temperature $T_1$, where $T_1 < T_2$ where $T_2$ is the atmospheric temperature and for doing so most economically, the maximum heat Q must be removed with minimum work W so

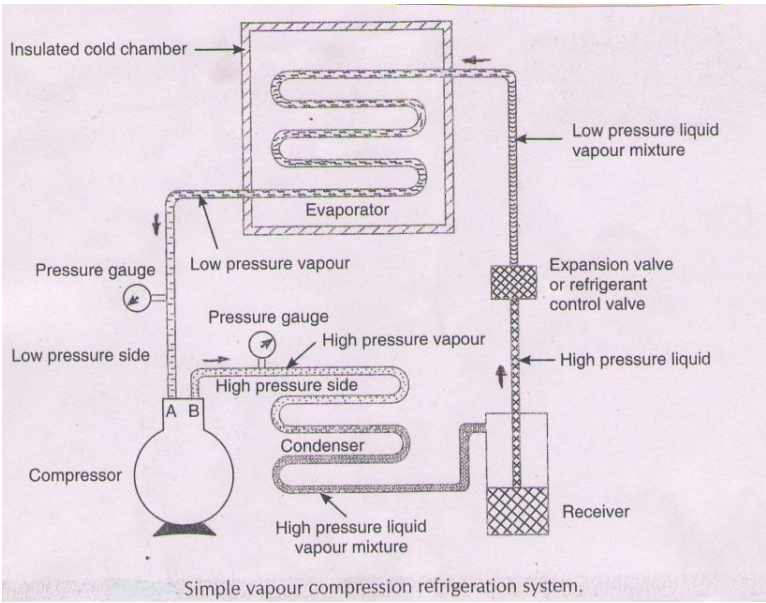
The same cycle can be used as heat pump. Only difference is, we are interested to deliver the quantity of heat to the source instead of absorbing heat from sink, but more quantity of heat will be delivered to the source. So, the performance of heat pump, called as energy performance ratio is given by.

**( Fig. -1 mark, explain – 3 Marks )**

**SUMMER – 13 EXAMINATION**

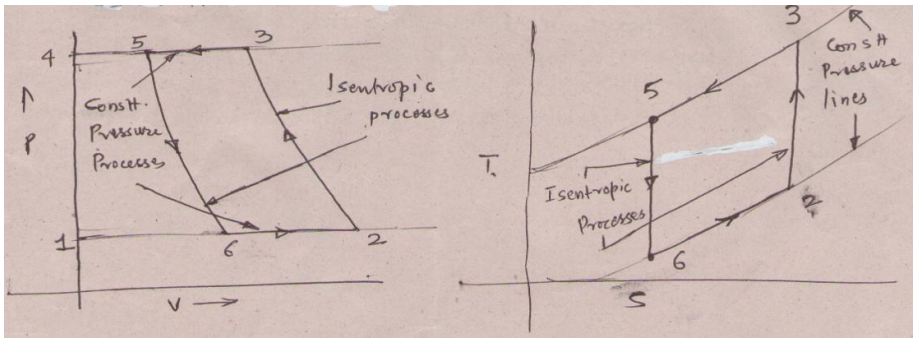
Subject Code:12246 **Model Answer**

**Q. 1 a) ii) Simple vapour compression refrigeration system. (1 mark for each component )**



Simple vapour compression refrigeration system.

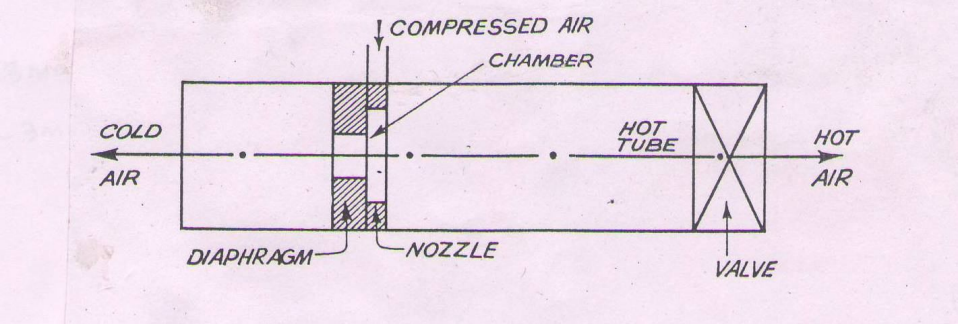
**Q. 1 a) iii) Bell Coleman Cycle. ( 2 Marks for each diagram )**



**SUMMER – 13 EXAMINATION**

Subject Code:12246 **Model Answer**

**Q. 1 a) iv) Vortex Tube** **( Fig. 2 Marks, Explain -2 marks)**



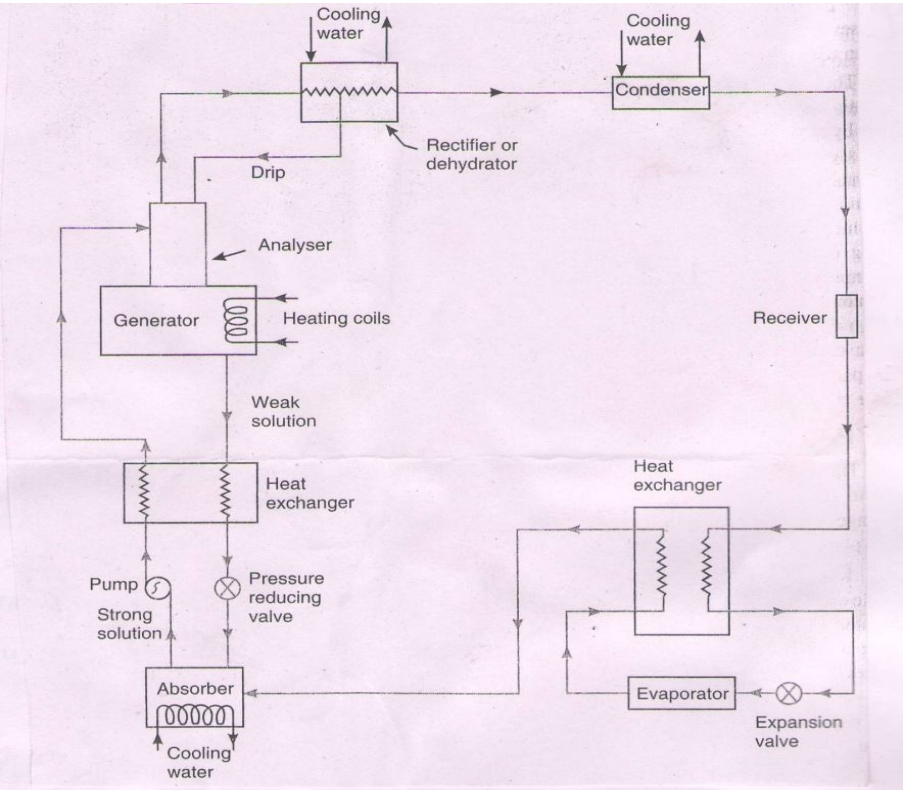

**Vortex Tube**

**Principle :-** Vortex tube is simple device of producing cold. A compressed air is passed tangentially through nozzle. Here air velocity increases due to expansion and particular shape of nozzle. A vortex flow is created in the chamber and air flows in spiral motion along periphery of hot side. This flow is restricted by valve. If the pressure of air near valve is increased by partly closing of valve, a reversed axial flow through the core of hot side starts from high pressure to low pressure region. During this process, energy transfer takes place between reversed stream and forward stream through the core gets cooled below the inlet temperature of the air in the vortex tube while air stream in forward direction gets heated. The cold stream is escaped through the diaphragm hole into the cold side, while hot stream is passed through the opening valve.

**SUMMER – 13 EXAMINATION**

Subject Code:12246 **Model Answer**

**Q. 1 b) i) Practical aqua-ammonia vapor absorption. ( Fig. 3 Marks, Explain -3 marks)**




The ammonia vapours have affinity with water for mixing. As the temperature of water decreases, the absorption rate into water increases. In this system, the low pressure ammonia vapors leaving evaporator are passed through heat exchanger where they are heated by ammonia coming from condenser. The ammonia going to expansion valve is sub cooled, so, refrigeration effect increases. This NH3 goes to absorber in which weak solution coming from generator is cooled by cold water. So absorption rate increases. The strong solution thus formed is pumped to generator via heat exchanger, during which the solution is heated, resulting low heat input to generator. In generator NH3 vapors comes out first as it is having low boiling point. The pump increases pressure to lobar. The remaining weak solution left back comes through heat exchanger and pressure reducing valve to absorber.

The analyser water trapping trays which disallows water drops to go to condenser. If some vapour/drops are travelled beyond analyser, they are condensed by cold water in rectifier and drip is collected back to generator.

Condenser condenses ammonia to liquid which further goes to evaporator through receiver, heat exchanger and expansion valve.

**Q. 1 b) ii) Advantage of hermetically sealed compressor.**

**( Advantages -3 Marks, Disadvantages – 3 marks)**

1) The leakage of refrigerant in completely prevented.
2) It is less noisy.
3) It occupies small space.
4) The lubricating is simple as the motor and compressor operate in sealed space with lubricating oil.

**Disadvantages :**

1) The maintenance is not easy because moving parts are inaccessible.
2) A separate pump is required for charging of refrigerant.
3) As maintenance is hard, generally compressors are use and throw type so, it is costly.

**Q. 2 a) Solution :**

Given Load = 10 tones.

= 10 × 3.517

= 35.17 KJ/sec. **(01 mark)**

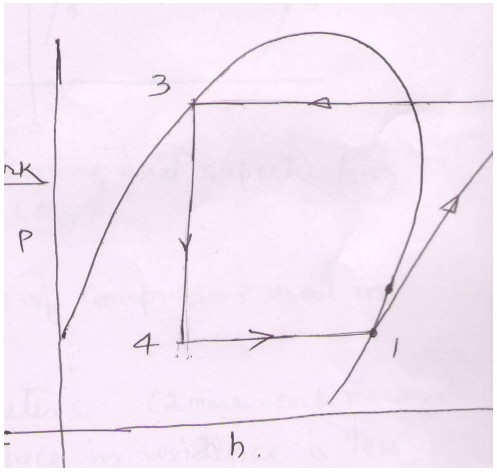
Assume, there is no under cooling.

Total refrigeration effect.

$$N = m_{ref.} ( H_1 - H_4 )$$

$$35.17 = m_{ref.} ( 185-70 )$$

**(02 mark)**




Total Power = mref ( $H_2$-$H_1$ )

= 0.3058 ( 206-185 )

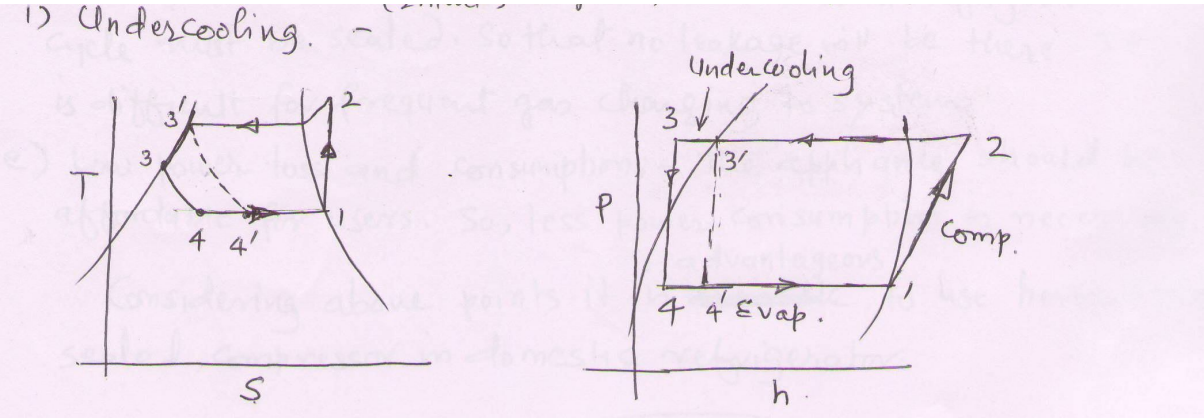
= 6.4218 KJ/sec.

= 64218 KW **(02 mark)**

**(02 mark) (01 mark for appropriate fig.)**

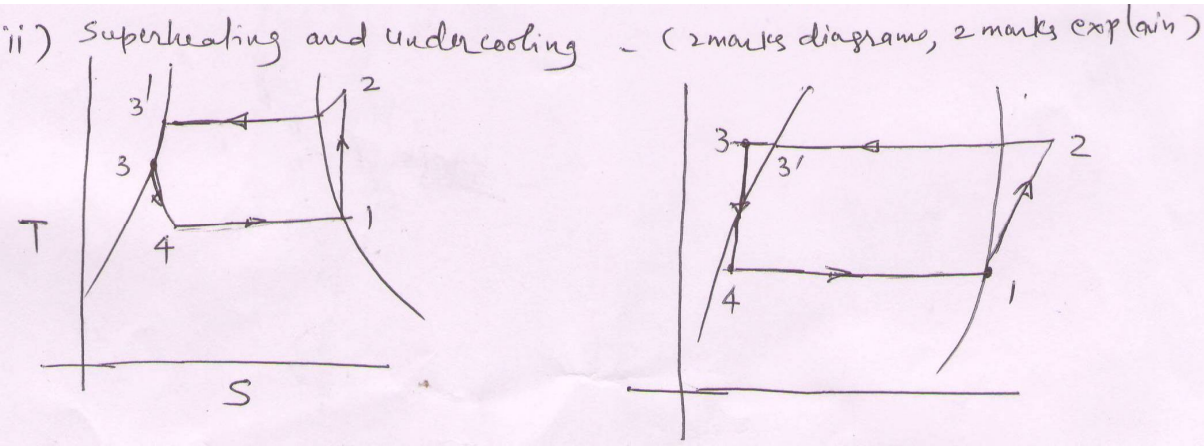
**Q. 2 b) Solution :(02 marks each for diagram &explanation of undercooling & superheating)**

**i) Under cooling :-**




The ultimate effect of under cooling in to increase the value of COP under the same set conditions.

**ii) Superheating and Under cooling :**




The ultimate effect of under cooling and superheating will increase the refrigeration effect.

**Q. 2 c) Four parameters for selection of compressor used in domestic refrigerator.**

Following are the parameters. **( 04 parameters, 02 marks for each)**

**a) Compact size :-** As the space in residence is less, the appliance and in turn the compressor should have compact size.

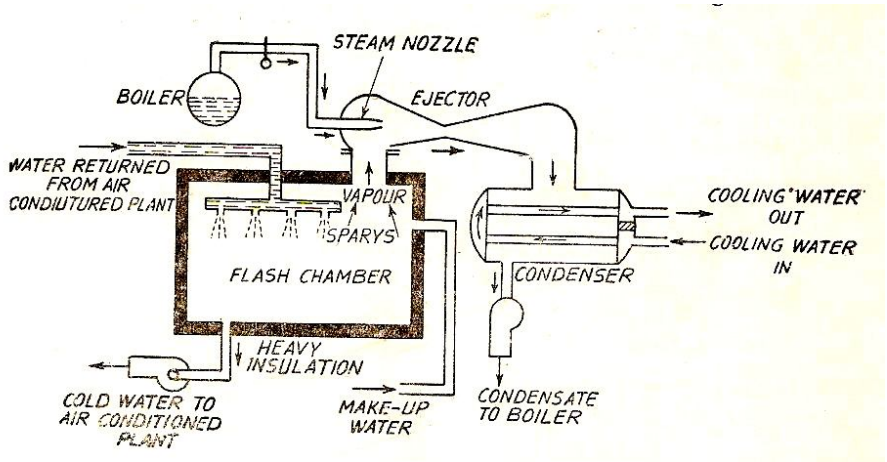
**b) Less weight :-** The compressor should be of less weight. The appliance in residence should be light, as it can be moved in the house as per requirement.

**c) Compatibility with eco-friendly refrigerant: -** Nowadays the R-12 is not allowed for refrigeration. So the domestic refrigerator compressor will be using the eco-friendly refrigerants like R-134.

**d) Sealed construction :-** For domestic use the total refrigeration cycle must be sealed. So that no leakage will be there. It is difficult for frequent gas charging to system.

**e) Low power loss and consumption :-** The appliance should be affordable for users. So, less power consumption in necessary. Considering above points it is advantageous to use hermetically sealed compressor in domestic refrigerator.

**Q.No.3 a**.




**Steam Jet Refrigeration System**

**Appropriate Figure -------- 04 Marks**

**SUMMER – 13 EXAMINATION**

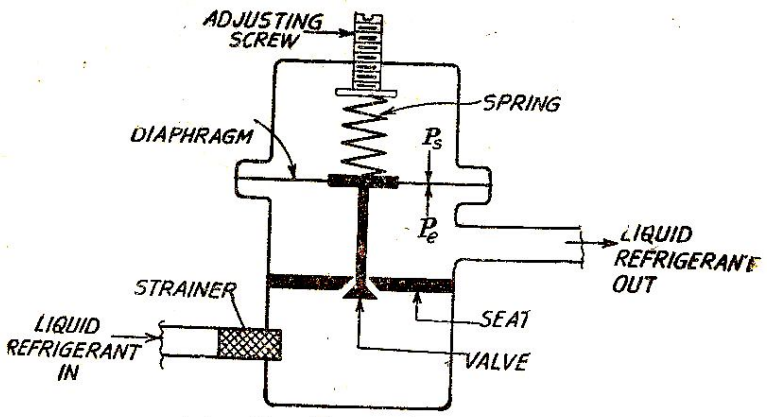
Subject Code:12246 **Model Answer**

**Q.No.3 b.** **Refrigerents Used for Systems**

- Air Conditioners – **R22**
- Domestic Refrigerator – **R134-a**
- Ice Plant – **Ammonia**
- Water Cooler - **R-134-a**

---------- **04 Marks**

**Q.No.3 c.** **Automatic Expansion Valve**




Automatic or Constant Pressure expanssion valve

**Correct Figure with Labels --------- 04 Marks**

**Q.No.3 d.** **i. Primary Refrigerent**

The refrigerant which directly extracts or carries the heat from heat generating source in the refrigeration system in the evaporator of refrigeration system is called as the primary refrigerant. Primary refrigerant directly absorbs or extracts heat from heat generating source and rejects this heat to atmosphere in the condenser. Primary Refrigerents are used in vapour compression systems of Domestic refrigerators, Window air conditioners. Examples are R134a , R22.

**ii. Secondary Refrigerent**

In many applications it is not desirable to carry the heat from place which is to be cooled directly by refrigerant, then it is carried by using the secondary refrigerant such as Air, Water, or Brine.The heat carried away by secondary refrigerant is given to primary refrigerant in evaporator and secondary refrigerant is circulated again and again.The secondary refrigerant circuit is used in all commercial and industrial refrigeration plants. It has advantages like maintenance of different temperatures in different zones by varying circulation of secondary refrigerant, maintenance of lower temperatures etc. Commonly used types of secondary refrigerants are,

1. **Water:** Used in Air conditioning systems for cooling, Dehumidification etc.
2. **Brine:** Used in Ice plants to maintain temperatures lower than atmospheric temperatures.

**Relevant correct coverage—04 Mark**

**Q.No.3 e. Application Areas Of Refrigeration System**

1. **Domestic Applications:** The domestic applications of refrigeration includes the household refrigerators used for storing food, vegetables. This uses vapor compression cycle. Temperatures maintained in household refrigerator for storage has a range of 0 to 4 degrees centigrade's. A freezer compartment is also provided to maintain temperatures below zero degree centigrade which is used for storage of frozen food for a short duration. For storing of frozen food, Ice creams, meat, milk, for a long duration. House hold refrigerators works on Vapour Compression cycle as well as Vapour Absorption cycle. Generally R134a is used as refrigerant. Typical other applications includes Room air conditioners or Split air conditioners, Water coolers for cooling water.

**2.Commercial Applications:** Commercial Applications involves the Deep freezers. They are used to store frozen food, fish, cold drinks, Ice creams, milk for a long duration . Temperatures up to -15 degree centigrade's can be maintained here. These work on Vapour compression system and uses generally R134a, as refrigerant. Refrigerated trucks and railway wagons are also used for transportation of Gases, Milk, Food at a low temperature.Ice

plants are used for manufacturing of Ice. They work on Vapour compression cycle with Ammonia as primary refrigerant and Brine as secondary refrigerant.

**3.Industrial Applications:** Industrial air conditioning involves following,

- Air-conditioning for comfort of workers
- For textile industries for production of quality textile products.
- For manufacturing process in photographic industry.
- In printing industries for quality printing.
- In paper industries for production of paper.
- For preservation of food in food industries.

**4.Marine Applications:** Air conditioning of passenger ships is done for comfort of passengers. Air-conditioning of cargo ships is done for preservation of food and perishable products. Temperature in the range of -23 to 12 degrees centigrades is maintained in the atmosphere. R22 is used as refrigerant.

**Four relevant applications with detailing ------ 04 Marks**

**Q.No.4 a.i.** **Ozone Layer Depletion**

Continuous Destruction of protective Ozone gas layer around earth's atmosphere by chemical reaction of CFC refrigerants which are leaked from innumerable refrigeration systems on earth's surface is known as "Ozone Layer Depletion".

In the outer atmosphere of earth upto 50 Km, there is layer called Stratosphere. In this layer there is more concentration of Ozone gas.This ozone layer forms a protective layer around earths surface which absorbs the Harmful Ultraviolet rays (UV) from Sun's rays and allows only beneficial light and heat rays to reach on earths surface. Prevention of UV rays reaching to earths surface protects human and animal life.

Continuous leaking of Cloro-Floro-Carbon refrigerants from millions of refrigeration systems on earths surface takes place. These molecules are stable and have a long life. They slowly rises in earth's atmosphere and slowly reaches to ozone layer by molecular diffusion caused by partial pressure difference.CFC molecules reacts with Ozone by following reactions,

$CCl_2F_2$ (Sunlight) ------ $CClF_2 + Cl$
$O_3 + Cl$ -------- $ClO + O_2$

Depletion of Ozone layer leads to formation of "Ozone Holes" in the Ozone layer and through these ozone holes Harmful Ultra Violet rays enters into the atmosphere endangering the earths biolife.

Ultra Violet rays are extremely dangerous to biolife. They cause cancer of skin to humans and animals. Effect of UV rays is harmful to Plants and animals. Effect of UV rays is harmful to eyes.

"Ozone Layer Depletion" is caused by halogen based CFC's so in order to reduce this effect, use of CFC's is reduced and place of halogen based refrigents is taken by "Eco- Friendly Refrigerents". For example Ozone Depletion Potential (ODP) of R12 is 1.00 so it is replaced by Eco friendly refrigerant R134a which has ODP of 0.00.

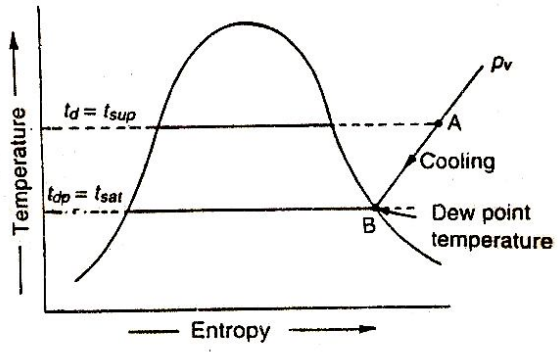
**Relevant Coverage of Points ------- 04 Marks**

**Q.No.4 a.ii.** **1. Relative Humidity**

It is the ratio of actual mass of water vapor in a given volume of moist air to mass of water vapor in the same volume of saturated air at the same temperature and pressure.

**2. Dew Point temperature**

It is the temperature of air recorded by thermometer, when the moisture (water vapor) present in it begins to condense. In other word the dew point temperature is the saturation temperature corresponding to the partial pressure of water vapour.




**Correct Explanation -------- 04 Marks**

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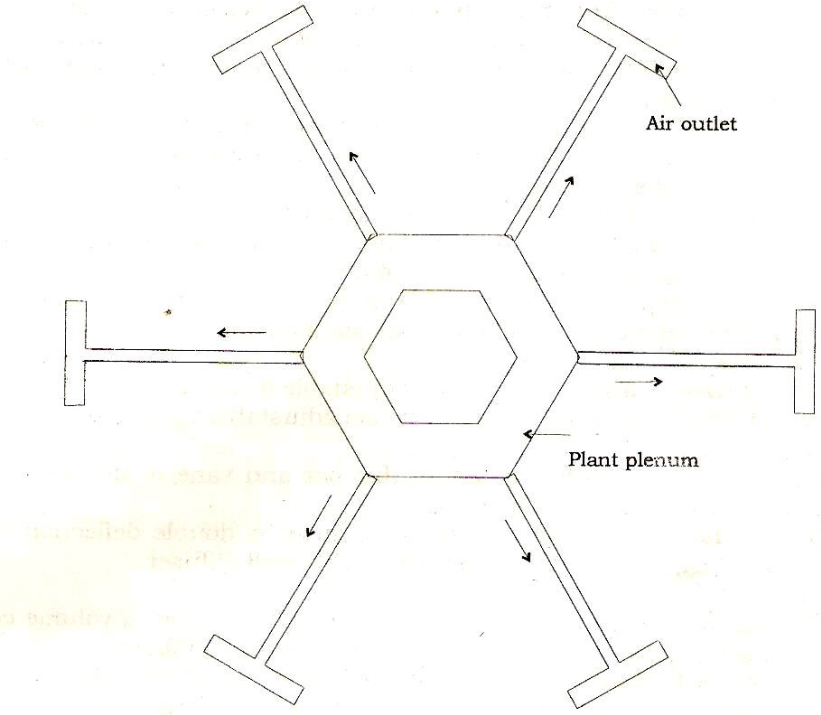
Subject Code:12246 **Model Answer**

**Q.No.4 a.iii.** **Radial Perimeter Duct System**




**Radical perimeter duct system**

**Appropriate Figure ----- 04 Marks**

**Q.No.4 a.iv. Difference between Air Cooled Condenser and Water Cooled Condenser**

| Air Cooled Condenser | Water Cooled Condenser |
|---|---|
| 1.Air is used as cooling media | 1.Water is used as cooling media |
| 2.Simple Construction | 2.Complicated construction |
| 3. Low in cost | 3.High in cost |
| 4.Low Maintenance Cost | 4.High Maintenance Cost |
| 5.No piping required to carry air | 5.Piping required to carry water. |
| 6.No corrosion, No fouling effect | 6. Corrosion and fouling effect. |
| 7.Low heat transfer capacity due to low | 7.High heat transfer due to high |

| | |
|---|---|
| thermal conductivity of air | thermal conductivity of water |
| 8.Fan Noise is excessive | 8. No fan noise |
| 9.Used for low capacity plants (less than 5 TR) | 9. Used for high capacity plants (More than 5 TR) |

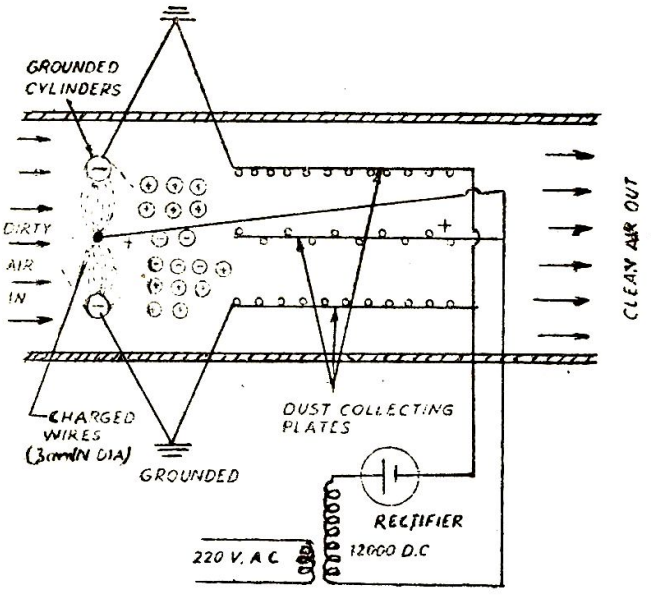
**Any four correct points --- 04 Marks**

**Q.No.4 b.i.** **Filters**

- Dry Filters
- Viscous Filters
- Wet Filters
- Electric Filters

---------- **02 Marks**

**Electric Filter**




Electric Filter.

Electric filter is shown in the figure.It is used to remove dust from air. Air is passed between oppositely charged conductors and becomes ionized. Large voltage in tune of 8000 to 15000 Volts is applied between plates. As air is passed, both negative ion (20 %) and positive ions(80 %) are

formed. Air then passes to collecting unit containing alternating positively and negatively charged plates .Positively and negatively charged particles are attracted in these plates and removed.

**Advantages of this filter are as under,**

1.Low initial cost, working cost, maintenance cost.

2.Ease in operation

3.Smaller installation space.

4.Effective for small particles.

**Disadvantages of this filter are as under,**

1.High voltage used so possibility of sparking

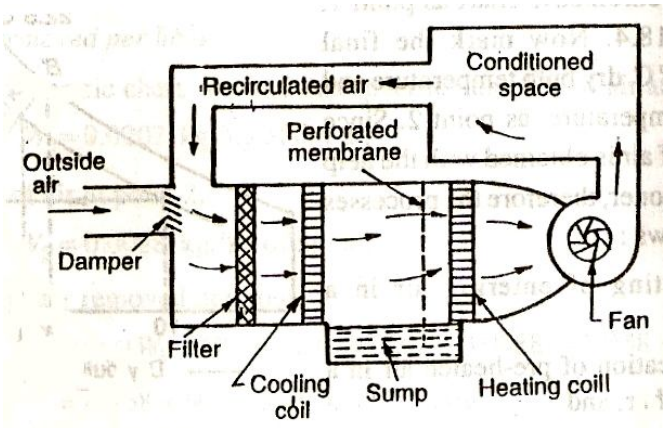
2.Pre-Filter is essential

3.As quantity of air increases, efficiency of filter decreases.

4.Generates ozone as air passes via filter.

**Figure with proper description ---------- 04 Marks**

**Q.No.4 b.ii.** **Summer Air conditioning System**




. Summer air conditioning system.

**Appropriate Figure ---------- 03 Marks**

This system is used in summer air conditioning applications. In this system air is cooled and generally dehumidified. Schematic diagram is shown in figure. The outside air flows through damper and mixes up with recirculated air .which is obtained from air conditioned space. The mixed air passes through a filter to remove dirt, dust and other impurities. The air now passes

through cooling coil. The coil has a temperature much less than required dry bulb temperature of the air in the conditioned space. The cooled air passes through a perforated membrane and loses its moisture in the condensed form which is collected in a sump.Air now passes through a heating coil which heats up the air slightly, in order to bring air to requisite DBT and relative humidity. Now conditioned air passes to conditioned space by a fan. From the conditioned space the part of air is exhausted to atmosphere by exhaust fans or ventilators.The remaining part of the used air or recirculated air is again conditioned as shown in the figure. The outside air is sucked and made to mix with recirculated air in order to make up for the loss of conditioned or used air through exhaust fans or ventilators from conditioned space.

**Appropriate Description ---------- 03 Marks**

**Q. 5 a) ( any 04 points each for sensible & latent, 01 mark for each point)**

**1) Sensible Heat Gain :**

Sensible heat is the heat as it flows into conditioned space or produced in the conditioned space, which will tend to cause rise in temperature of conditioned space.

Sensible heat gain to the conditioned space includes.

a) Heat deception through the building structure as a result of conduction, convection and radiation.
b) Sensible heat brought in with the outside air by ventilation.
c) Sensible heat produced by occupant.
d) Sensible heat produced in conditioned space by lights, equipments, motors etc.
e) Sensible heat extracted or generated by process carried out in conditioned space.
f) Sensible heat coming by solar radiation.

**2) Latent Heat Gain:**

Latent heat is transferred whenever there is change of phase. It is in the form of moisture change (change in relative humidity) taking place at constant temperature.

Latent heat gain includes.

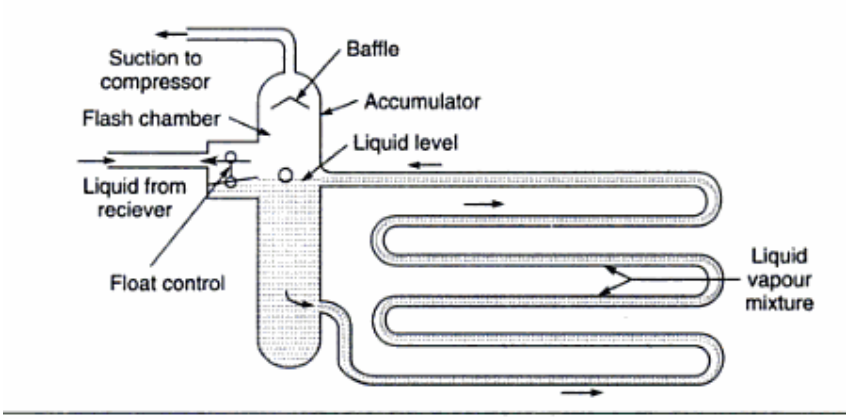
a) Latent heat of ventilation air coming in conditioned space.
b) Latent heat of occupant.

c) Latent heat generated from cooking, hot baths or other vaporization process carried out in conditioned space.

d) Latent heat from products or materials brought into conditioned space.

**b) Flooded type evaporator. ( 03 marks each for fig. & explanation, 02 marks for application)**

**Diagram :**



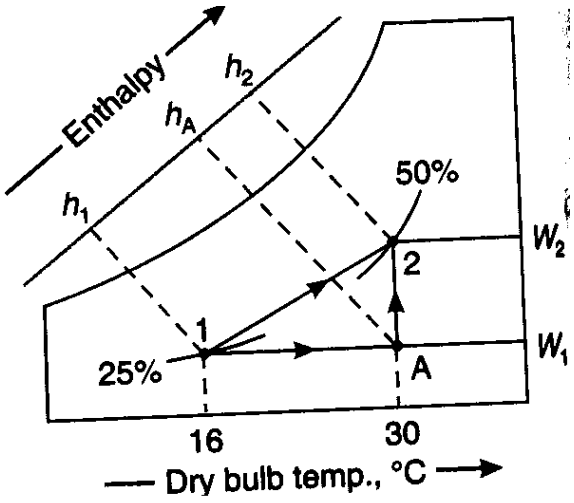

Flooded type of evaporator feeds excess of liquid refrigerant so that the exit of evaporator will be mixture of liquid and vapour refrigerant.

In flooded type of evaporator coil remains completely filled with liquid refrigerant as shown in figure. The level of liquid refrigerant is maintained constant in surge chamber by using float control. The liquid refrigerant enters into evaporator coil from surge chamber. In evaporator coil part of liquid refrigerant boils and converts into vapour. The vapour formed is collected at the top of surge chamber and remaining liquid refrigerant is returned to surge chamber. From top of surge chamber refrigerant vapours are drawn in suction line of compressor. In flooded type evaporator rate of heat transfer is very high as whole evaporator coil remains in contact with liquid refrigerant but this type of refrigerant requires large amount of refrigerant.

Applications of flooded type evaporator:- This type of evaporator are used for

1) Large installations, where refrigerating capacity is high.
2) In a refrigeration system where load fluctuation are higher.
3) For multi evaporator system.

**c)** solution :- from Psychrometric chart we have




Enthalpies at point 1, 2 and A are

$h_1$= 23 kJ/kg of dry air

$h_2$= 64 kJ/kg of dry air

$h_A$= 38 kJ/kg of dry air

Thus heat added to the air = $h_2 - h_1$

= 64-23

= 41 kJ/kg of dry air

Also we have (from Psychrometric chart)

$W_1$ = 0.0026 kg/kg of dry air

$W_2$ = 0.0132kg/kg of dry air

Thus moisture added to the air = $W_2 - W_1$

= 0.0132-0.00026

= 0.0106 kg/kg of dry air

We know that Sensible heat factor the process is given as,

SHF = $h_A - h_1 / h_2 - h_1$

= 38-23 / 64-23

= 0.366

**Note : (03 marks each for heat added, moisture added & 02 marks for SHF)**

Q. 6 a) Factors affecting comfort air conditioning:- **( 01 mark for each factor)**

Human comfort is the science of providing and maintaining comfort conditions for human being irrespective of outdoor conditions. The human comfort varies person to person as per his individual taste or choice. As such there is no fix condition of environment in which every human being feel comfortable. Factors affecting comfort air conditioning are (Temperature, Humidity, Air purity, Air Motion and circulation)

1) Temperature :

   Temperature is the most important factor which affects comfort air conditioning to a great extent. Most of the human being feels comfortable at a temperature $22.8^0$C to $25^0$C.

2) Humidity :

   The control of humidity is not only necessary for comfort air conditioning but it is also important from point of view of efficiency of worker. For human comfort relative humidity is kept within a range of 35% to 60%.

3) Air purity :

   We do not feel comfortable when breathing in contaminated air even if temperature and humidity is within comfortable range. Therefore proper filtration, cleaning and purification of air is necessary to keep it free from dust, dirt, and other impurities. The proper percentage of oxygen must be maintained. Therefore in public places like theatre, auditorium, and shopping center exhaust fan must be used.

4) Air Motion and circulation :

   Even if temperature, humidity and purity of air is satisfactory, certain amount of air motion is necessary for human comfort air conditioning. We do not feel comfortable in dead and still air. Moreover the air movement and circulation is required in order to ensure uniform conditions in every corner of air conditioned space.

b) Air conditioning is required for the following purposes in industry

- To provide comforts to worker
- To provide necessary low temp.
- To provide clean and standard room for precision work
- To preserve foods / drying of foods

The industrial applications of a air conditioning systems are

1. Textile industry
2. Photographic industry
3. Printing industry
4. Food industry etc **( Any four applications 4 marks)**

c) Ducts : **( 01 mark for each point)**

Passage ways for supply and return air is known as duct. The main purpose of duct is to supply conditioned air from central air conditioning plant to various rooms and to collect warm air from air conditioned space to cooling coil. The duct may have single line or several branches.

.

1) Classification of duct :

Ducts are classified as :

1) According to cross section of duct
   a) Circular duct.
   b) Rectangular duct.
   c) Square duct.
2) According to type of air it carries.
   a) Supply air duct.
   b) Return air duct.
3) According to velocity of flow in duct.
   a) Low velocity duct.
   b) High velocity duct.
4) According to pressure in duct.
   a) Low pressure duct.
   b) Medium pressure duct.
   c) High pressure duct.

d) Properties of insulating material : **( 02 marks each for thermal & Mechanical properties)**

Properties of insulating material can be described as

1) Thermal properties.
2) Mechanical properties.
3) Physical properties.

1) Thermal Properties:

**a)** Thermal conductivity: The most important thermal property of insulating material is thermal conductivity. Thermal conductivity is defined as ability of material to transfer heat. For material to be insulator it should have low thermal conductivity. Thermal conductivity changes with material and density of material. Compressible substance such as wool, if loosely packed is better insulator than if closely packed.

b) Coefficient of expansion.

c) Specific heat capacity.

2) Mechanical Properties.

A mechanical property of insulating material is important when insulating material provided has to carry some load. Important mechanical properties are strength in compression, tension, shear and impact.

Q 6 e) Effective Temperature:- **( 02 marks for def. & 02 marks for significance)**

Effective temperature is defined as the term which correlates the combined effects of the factors air temperature, relative humidity, and air motion on the human body. The numerical value of effective temperature is made equal to the temperature of still saturated air, which produces the same sensation of warmth or coolness as produced under the given conditions.

The practical application of effective temperature is presented by the comfort chart. This chart is the result of research made on different kinds of people subjected to wide range of air temperature, relative humidity, and air motion. A close study of the chart reveals that the several combinations of wet and dry bulb temperatures with different relative humilities will produce the same effective temperature.

However all points located on given effective temperature line do not indicate conditions of equal comfort or discomfort. Relative humidity lies between 30 to 70 %. Dry bulb temperature 19 to 26$^{o}$C and the air velocities may vary from 0 to 210 m/min