TED (21) – 5022
REVISION 2021

DIPLOMA EXAMINATION IN ENGINEERING/TECHNOLOGY/ MANAGEMENT/COMMERCIAL PRACTICE

Refrigeration and Air-Conditioning

SCHEME OF VALUATION

Time: 3 hours

Maximum Marks: 75

Qn No	Scoring Indicator	Split up score	Sub total	Total Marks

PART A

I. Answer all questions in one word or one sentence.

(9x1=9 Marks)

1	Dry ice.	1	1	9
2	3	1	1	
3	accumulator	1	1	
4	R-12, R-11,R-123,air etc	1	1	
5	Absorber.	1	1	
6	Cascade refrigeration system	1	1	
7	Space Rocket propulsion Cryogenic engines are powered by cryogenic propellants Mechanical Applications- Magnetic Separation , Heat treatment The life of the tools die castings & their dies, forgings, jigs & fixtures etc increase when subjected to cryogenic heat treatment. Recycling• Cryogenic recycling - turns the scrap into raw material by subjecting it to cryogenic	1	1	
8	$\frac{\text{Sensible Heat}}{\text{Total Heat}} = \frac{SH}{SH + LH} = \frac{h_A - h_2}{h_1 - h_2}$	1	1	

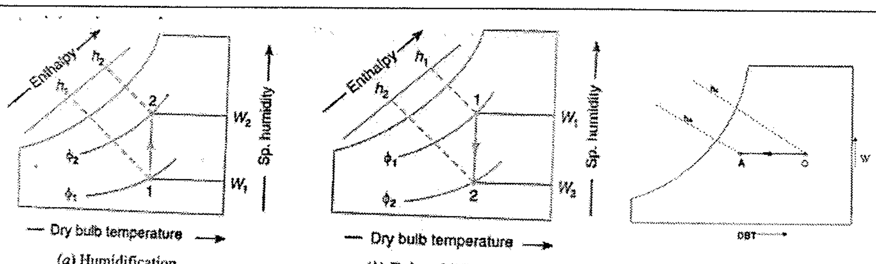
9	psychrometer	1	1	

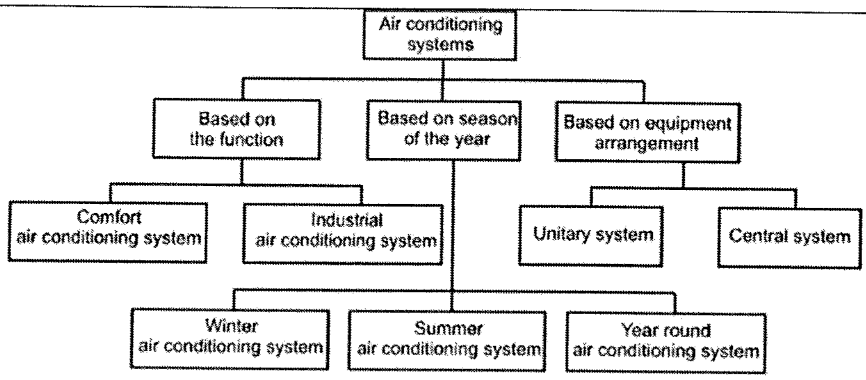
PART B

II. Answer any 8 questions from the following.

(8x3=24 Marks)

1	COP is defined as the ratio of the heat extracted from the refrigerated space to the amount of work or energy input required to achieve that heat transfer. COP of system COP of Bell-coleman cycle= $\frac{1}{r_p^{\frac{\upsilon-1}{\upsilon}}-1}$	3	3	
2	Compressor, condenser, evaporator and expansion valve	1*3	3	
3	R-134 a, Tetrafluoro-ethane(CF_3CH_2F) . Since the refrigerent R-134a has no chloride atom, therefore this refrigerent has zero ozone depleting potential (ODP) has 74% less global warming potential (GWP) as compared to R-12. The R-134a is considered to be the most preferred substitute for refrigerent R-12. Its boiling point is -26.15 C which is quite close to the boiling point of R-12. R-134 a is, now-a-days, widely used in car air-conditioners.	Iden -1 Feat- 2	3	
4	Superheating in a refrigeration cycle refers to the process of increasing the temperature of the refrigerant vapor above its saturation temperature, typically after it has been vaporized in the evaporator but before it enters the compressor. The effect of superheating on the coefficient of performance (COP) of a refrigeration cycle can be explained as follows: Improved Compressor Efficiency: Superheating the refrigerant vapor before it enters the compressor helps reduce the refrigerant's density and increases its specific volume. This results in a decrease in the	1*3	3	3

	compressor's volumetric and refrigerant mass flow rates, reducing the work required to compress the refrigerant. As a result, the compressor operates more efficiently, requiring less energy input. This improved compressor efficiency can lead to an increase in the COP of the refrigeration cycle. Reduced Potential for Liquid Slugging: Superheating the refrigerant vapor helps ensure that only vapor enters the compressor, eliminating or minimizing the presence of liquid droplets. Liquid slugging occurs when liquid refrigerant enters the compressor, leading to potential damage due to hydraulic forces. By avoiding liquid slugging, the compressor operates more smoothly and reliably, contributing to improved efficiency and a higher COP. Better Heat Transfer in the Condenser: Superheating the refrigerant vapor can enhance heat transfer in the condenser.			
5	Ultra low temperatures can be achieved, high cooling capacity, precise temperature control, Liquefaction of Gases, Energy efficiency	1.5*4	3	
6	 (a) Humidification. (b) Dehumidification. Sensible cooling process O-A	Fig-2 Listing-1	3	3
7	Temperature, humidity, air movement, noise levels,indoor air quality, thermal comfort zones	1*3	3	3

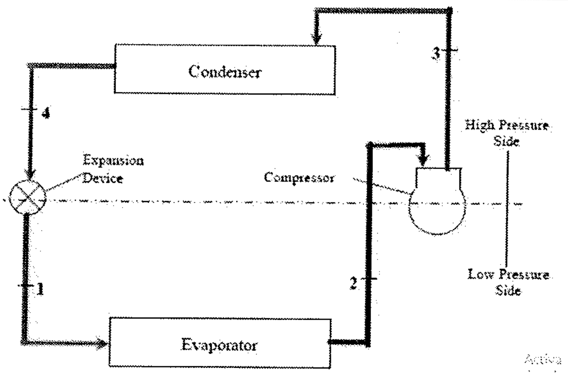
8		3	3	3
9	Heating, ventilation, and air conditioning is the use of various technologies to control the temperature, humidity, and purity of the air in an enclosed space. Its goal is to provide thermal comfort and acceptable indoor air	3	3	3
10	Conduction through Walls, Roof, and Windows, Infiltration, Ventilation Air, Equipment Heat, Radiation	1.5* 4	3	3

PART C

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

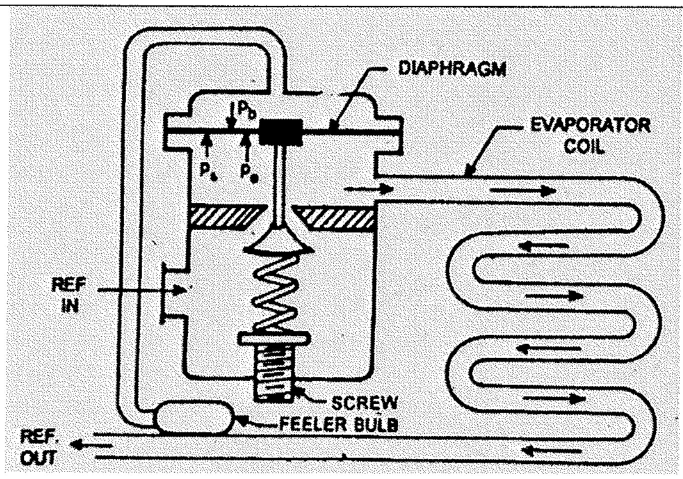
(6x7=42 Marks)

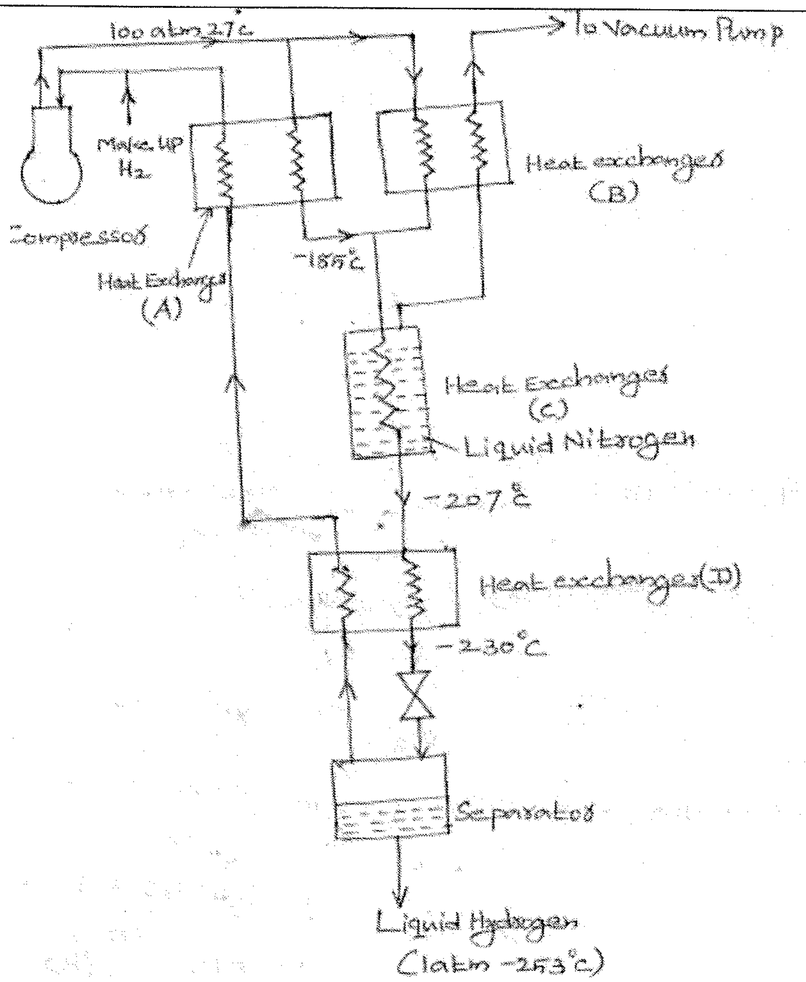
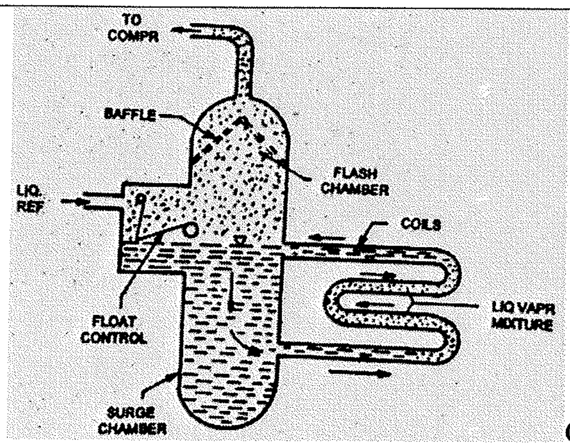
III	Condenser temperature , T_H = 27 °C= 300 K Evaporator temperature, T_L = -10 °C= 263 K i) C.O.P. of the refrigerating machine= $\frac{T_L}{T_H - T_L} = \frac{263}{37}$ =7.10 ii) C.O.P. of the Heat pump= $\frac{T_H}{T_H - T_L} = \frac{300}{37}$ = 8.10	4 3	7	
	OR			
IV	mass of air is circulated per hour, $\dot{m}$ = 500 Kg/Hr. suction pressures P1= 1 bar compression pressures P2= 5 bar. temperature before compression,T_1 =8 °C =281 K T_3=28 °C. = 301 K	2	7	

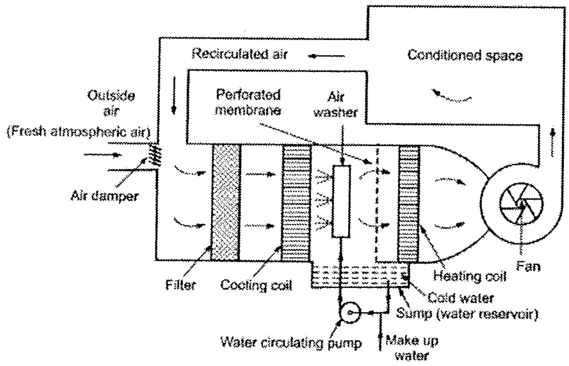
	$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$$ expansion ratio, $r_p = 5$ Cp of air =1.003 kJ/kg.K ; adiabatic index, $\gamma = 1.4$. $T_2 = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} T_1 == \left(\frac{5}{1}\right)^{\frac{1.4-1}{\gamma}} 281 = 444.54$ i) Heat extracted from the cold chamber per hour= $C_p \dot{m}\, \Delta T$=500× 1.003 × 20= 1985.31 kJ/Hr ii) COP of system=$\frac{1}{r_p^{\frac{\upsilon-1}{\upsilon}} - 1}$= 1.71	2 3		
V	 1. Compressor It is the heart of the system, it is motor driven. It sucks vapor refrigerant from evaporator, compresses it and delivers to the condenser 2. Condenser High pressure vapor refrigerant from the compressor is condensed into liquid form at constant pressure. The condensation is done using a cooling medium such as water. Here the vapour refrigerant transform into liquid state by rejecting latent heat of evaporation. 3. Expansion Valve	Fig-3 1 1	7	

	Here, high pressure liquid refrigerant from condenser is throttled down(isenthalpically) to evaporator pressure. Rate of flow of refrigerant is metered here In this stage, refrigerant has a tendency to change its state from liquid to vapour, but there will be no heat energy to change. 4. Evaporator. It is the cooling chamber in which products to be cooled is placed. Low pressure liquid refrigerant flows through the coils of evaporator and absorbs heat from the products at evaporator pressure. So refrigerant vapourises and passes to the compressor.	1 1		
	OR			
VI	Advantages- higher efficiency,wide range of applications, Greater cooling capacity, better temperature control, ability to provide heating Disadvantages- Higher initial cost, environmental effect, maintenance and service req., noise and vibration,size and space req.	4 3	7	
VII	(see table below)	1*7=7	7	
	OR			

Sl.No.	Water cooled condenser	Air cooled condenser
1.	Initial cost and maintenance costs are high	It is simple in construction. It is cheap. Maintenance cost is also very low.
2.	Additional pipes are required to take water to and from the condenser.	No piping work is involved.
3.	If there is no water re-circulation system disposing of used water is difficult.	No problem in disposing of air.
4.	Corrosion occurs inside the water carrying surface and there are more fouling effects.	Corrosion and fouling effects are negligible.
5.	Heat transfer rate is high.	Heat transfer rate is low.
6.	Used for large capacity plants.	Its use is restricted to small capacity refrigeration units.
7.	It is silent in operation as there is no fan.	It produces noise in forced air circulation because of fan.
8.	Flexibility is low	High flexibility.
9.	Even distribution of water on the condensing surface area.	Un even distribution of air on the condenser surface area.

VIII	 It is a variable restriction type expansion device. Its name is misleading because control is not actuated by the temperature in the evaporator but by the magnitude of 'superheat' of the vapour refrigerant leaving the evaporator. So it is called superheat control valve. It responds to temperature of vapour leaving the evaporator and pressure in the evaporator. Construction It consists of a diaphragm with centrally connected valve, adjusting screw with spring and a feeler bulb containing power fluid (liquid refrigerant) clamped to the outlet of the evaporator. Working • The pressure of the power fluid (Pb) acts on the top of the diaphragm and the evaporator pressure (Pe) and spring pressure (Ps) acts on the bottom of the diaphragm. And it counterbalance the power fluid pressure. ie:-Pb=Ps+Pe. • When cooling load increases, Pb increases and Pb>(Ps+Pe), the diaphragm deflects downward moving the valve off the valve seat. • More quantity of refrigerant enters the valve and expands (throttles through valve opening into the evaporator. • When the cooling load decreases, Pb<(Ps+Pe), the diaphragm deflects upward pulling up the valve and thus narrowing the valve opening. • Less quantity of refrigerant flows-in until state of balance is reached.	Fig-3 Work-4	7	

IX	 	Fig-4 Exp-3	7	
	OR			
X	 Construction • It consists of a surge chamber with full of liquid refrigerant connected to evaporator coil, a float valve to maintain the level of liquid refrigerant, a	Fig-3	U	

<table>
<tr><td></td><td>flash chamber with baffles to eliminate the liquid refrigerant.
Working
• The liquid refrigerant flows from the surge chamber by gravity to the evaporator coils in which it vaporises by absorbing its latent heat from the surroundings and liquid- vapour mixture returns to the chamber. Here, the liquid and vapour are separated.
• The vapour is collected in flash chamber and from there it is drawn off into suction line leading to compressor.
Advantages
• The surface of evaporator coil is in contact with the liquid refrigerant under all load conditions.
• They provide high rate of heat transfer.
Disadvantages
• They are bulky in size.</td><td>Exp-4</td><td></td><td></td></tr>
<tr><td>XI</td><td>

The outside air flows through the damper, and mixes up with recirculated air (which is had from the conditioned space). The mixed air passes through a filter for removing dirt, dust and other impurities. The air now passes through a cooling coil, which has a temperature much below the required dry bulb temperature of air in the conditioned space.

The cooled air passes through a perforated membrane and loses its moisture</td><td>fig-3

Exp-4</td><td>7</td><td></td></tr>
</table>

	in the condensed form which is collected in a sump. After that, air is made to pass through a heating coil to heat up the air slightly. This is accomplished for bringing the air to the designed dry bulb temperature and relative humidity. Now the conditioned air is supplied to the conditioned space by a fan. From the conditioned space, a part of the used air is exhausted to atmosphere by the exhaust fans or ventilators. The remaining part of the used air, known as recirculated air, is again conditioned as illustrated in Fig. 9.10. The outside air is sucked and made to mix with the recirculated air in order to make up for the loss of conditioned (or used) air through exhaust fans or ventilators from the conditioned space.			
	OR			
XII	In air conditioning load calculation, various sources contribute to heat gain in a space. These sources include: Occupancy Heat: The heat generated by people occupying the space. The number of occupants and their activity levels affect the heat gain. For example, a crowded room with active individuals will generate more heat than a sparsely populated space. Lighting: The heat generated by lighting fixtures, such as incandescent or halogen bulbs. While modern LED lights produce less heat, traditional lighting sources can contribute significantly to heat gain, particularly in large spaces with many fixtures. Equipment Heat: Heat generated by electronic devices, appliances, machinery, and other equipment present in the space. This can include computers, printers, refrigeration units, cooking appliances, and more. The heat produced by these devices needs to be accounted for in load calculations.	listing-1 Exp-1.5*4	7	

	Solar Radiation: Heat gain from direct sunlight entering through windows or other openings. Solar radiation can significantly contribute to heat gain, especially in spaces with large windows or poor shading. The orientation of the building and the presence of external shading devices or glazing properties affect the amount of solar heat gain. Infiltration: The unintentional flow of outdoor air into the conditioned space through cracks, gaps, or unsealed openings. Infiltration brings in outdoor air along with its temperature and humidity, affecting the heat gain in the space. Transmission through Building Envelope: Heat gain through the walls, roof, windows, and doors of the building. The thermal characteristics of the building materials, insulation levels, and air leakage through the envelope impact the rate of heat transmission. Ventilation Air: Heat gain from the supply of outdoor air for ventilation purposes. In commercial buildings, fresh air is introduced to maintain indoor air quality. The temperature and humidity of the outdoor air affect the heat gain in the space.			
XIII	h_1 = 22.7 kJ/kg h_2 =62.3 kJ/kg h_A = 40 kJ/kg W_1= 0.003 kg/kg of dry air. W_2= 0.0171 kg/kg of dry air. Heat added to air = h_2 - h_1 = 62.3 -22.7 =39.6 kJ/kg Moisture added to air = W_2 - W_1 = 0.0171 – 0.003 =0.0088 kg/kg of dry air	5 2	7	
	OR			

XIV	From psychrometric chart , corresponding to initial condition, Specific volume at entry, V_{s1}= 0.8267 m^3/kg Specific enthalpy at initial condition, h_1= 35.4 kJ/kg Specific enthalpy at final condition,h_2= 45.2 kJ/kg RH of heated air= 41% WBT of heated air=16.1 Mass flow of air at entry, $m = 100\ kg$ Ref. effect to be produced, = $\dot{m}(h_1 - h_2)$=100(45.2-35.4) = 980kJ/min	2 3 2	7	