20th NATIONAL CERTIFICATION EXAMINATION
FOR
ENERGY MANAGERS & ENERGY AUDITORS – September, 2019

PAPER – 3: ENERGY EFFICIENCY IN ELECTRICAL UTILITIES

Section – I: OBJECTIVE TYPE **Marks: 50 x 1 = 50**

i) Answer all **50** questions
ii) Each question carries **one** mark
iii) Please hatch the appropriate oval in the OMR answer sheet with HB pencil only, as per instructions

1.	A medium voltage end consumer receives 83 million units with a transmission and distribution cascade efficiency of 82%. The million units generated will be _____________. a) **101.2** b) 68.1 c) 83 d) None of the above
2.	A 1000 kW Gas engine is designed for 38 % efficiency. The operating load of the engine is 825 kW. If the GCV of gas is 8700 kcal/m^3, the hourly gas consumption will be _____________m^3/hr a) **214.6** b) 260.13 c)188.89 d) 272.74
3.	In an electrical power system, transmission efficiency increases as ________________. **a) both voltage and power factor increases** b) both voltage and power factor decreases c) voltage increases but power factor decreases d) Voltage decreases but power factor increases.
4.	Which of the following is expressed in terms of percentage? a) Absolute humidity **b) Relative humidity** c) Specific Gravity d) All of the above
5.	Which among the following is one of the parameters used to classify fans, blowers & Compressors? a) Volume flow rate b) Mass flow rate **c) Specific ratio** d) None of the above
6.	What is the function of drift eliminators in cooling towers? a) maximize water and air contact **b) capture water droplets escaping with air stream** c) enables entry of air to the cooling tower d) eliminates uneven distribution of water into the cooling tower
7.	Which of the following statements is not true regarding centrifugal pumps? a) Flow is zero at shut off head

	b) Maximum efficiency will be at design rated flow of the pump c) Head decreases with increase in flow **d) Power increases with throttling**
8.	Which of the following is not true with respect to Color Rendering Index (CRI)? a) The CRI is expressed in a relative scale ranging from 0 -100. b) CRI indicates, how perceived colors match with actual colors. **c) LED lamps are having comparatively higher CRI than Incandescent Lamps.** d) The higher the color rendering index, the less color shift or distortion occurs
9.	Flow control with ___________in a fan system will not change the fan characteristic curve. a) Inlet guide vane b) speed change with variable frequency drive c) speed change with hydraulic coupling **d) discharge damper**
10.	The primary purpose of inter-cooling in a multistage compressor is to _____________. a) remove the moisture in the air **b) reduce the work of compression** c) separate moisture and oil vapour d) none of the above
11.	Illuminance of a surface is expressed in _____________ a) radians b) **lux** c) lumens d) LPD
12.	A pump discharge has to be reduced from 120 m^3/hr to 110 m^3/hr by trimming the impeller. What should be the percentage reduction in impeller size? a)10.52 % b) **8.34%** c) 9.7 1% d)17.1%
13.	Which of the following power plants has the highest efficiency? a) Open cycle Gas Turbine b) Diesel Engine c) **Combined cycle gas turbine** d) Conventional coal plants
14.	COP of a single effect absorption refrigeration system is likely to be in the range of____________ a) **0.6 to 0.7** b) 1to 1.2 c) 1.5 to 2 d) 3.0 to 4.0
15.	If 30240 kcal of heat is removed from a room every hour then the refrigeration tonnage will be nearly equal to____________. a) 30.24TR b) 3.024TR c) 1TR d) **10 TR**
16.	HVDS (High Voltage Distribution System) is preferred to____________________ **a) Reduce technical loss in distribution system** b) Reduce commercial loss in distribution system c) Reduce capital investment d) Reduce energy bill for the end consumer

17.	When evaporator temperature is reduced,________ a) refrigeration capacity increases **b) refrigeration capacity decreases** c) specific power consumption remains same d) condenser load increases	
18.	A 4 pole 50 Hz induction motor is running at 1470 rpm. What is the slip value? a) 0.2 b) **0.02** c) 0.04 d) 0.4	
19.	The basic function of an air dryer in an air compressor is to a) Prevent dust from entering the compressor b) Remove moisture before the intercooler c) Remove moisture in compressor suction **d) Remove moisture in air supplied to the plants**	
20.	Power factor is highest in the case of_________________ a) Sodium vapour lamps b) Induction lamps c) LED Lamps d) **Incandescent lamps**	
21.	If the COP of a vapour compression system is 3.5 and the motor draws a power of 10.8 kW at 90% motor efficiency, the cooling effect of vapour compression system will be_________. a) **34 kW** b) 42 kW c) 2.8 kW d) 3.4 kW	
22.	The blow down requirement in m^3/hr of a cooling tower with evaporation rate of 16 m^3/hr and CoC of 3 is ____________. a) 4 b) 5.3 c) **8** d) 48	
23.	The percentage reduction in distribution losses when tail end power factor is raised from 0.8 to 0.95 is__________ a) **29.4%** b)15.5% c)16.6% d)24.7%	
24.	Energy performance index (EPI) kWh/m^2 /yr is the ratio of total building annual energy consumption to __________ **a) Built up area** b) Carpet area c) Roof Area d) Window and Wall Area	
25.	Which of the following is not a climate zone as per ECBC classification? a) hot-dry b) warm-humid **c) Cold-humid** d) cold	
26.	In a pumping system, if the temperature of the liquid handled increases, then___________________. a) NPSHa increases b) **NPSHa decreases** c) NPSHa remains constant d) NPSHa and NPSHr are independent of temperature	

27.	Which of the following component has maximum effect on cooling tower performance? a) **Fill media** b) drift c) louvers d) casing
28.	In a vapour compression refrigeration system, the quantum of energy transferred at condenser is more than the energy transferred at ___________. a) Compressor b) Expansion Valve c) Evaporator d) **All of the above**
29.	Demand side Management helps ____________ a) to reduce the energy losses b) to reduce system peak demand c) to promote energy efficiency among users. d) **All of the above**
30.	Which one of the following is true to estimate the range of cooling tower? a) Range = Cooling water inlet temperature – Wet bulb temperature b) Range = Cooling water outlet temperature – Wet bulb temperature c) Range = Wet Bulb Temperature – Cooling Water Inlet Temperature d) **None of the above**
31.	Modest flow variation between 80% to 100%, in a centrifugal fan is achieved more efficiently with ___________________. a) Inlet damper b) Outlet damper c) **Inlet guide vanes** d) Impeller Change
32.	____________is used as refrigerant both in vapour compression and vapour absorption systems a) Lithium Bromide b) Water c) HFC 134A d) **Ammonia**
33.	In electrical distribution system, commercial loss covers discrepancies due to ________________. Meter Reading b) Metering c) Collection Efficiency d) **All of the above**
34.	Which of the following parameters is not required for evaluating volumetric efficiency of reciprocating air compressor? a) **Power input** b) FAD c) Cylinder Stroke d) Cylinder bore
35.	_____________ is not used for speed control. a) Variable Frequency drive **b) Soft starter** c) Hydraulic coupling Eddy current drives
36.	When compared to standard motors, energy efficient motors will have ____________. a) Higher slip b) Higher starting torque **c) Lower No load current** All the above

37.	For a given air requirement, providing higher volume air receiver will ______________. a) Increase energy consumption b) Reduce energy consumption c) Reduce Unload Power **d) Reduce Pressure fluctuations**
38.	Harmonics generation will be more in _______________ **a. Inverter drives** b. LED Lamps c. Transformers d. Resistance heaters
39.	Thermal Power Plant efficiency is low due to _________________. a) Higher steam Pressure b) Higher superheat temperature c) Low GCV coal d) Higher Heat loss in condenser
40.	Among the following, ___________ has highest design efficiency. a) High tension motors **b) Power transformers** c) Alternators d) Electric melting furnaces
41.	The difference between wet bulb temperature and cooling water inlet temperature in a cooling tower is called _____________. a)Approach b) Range c) Effectiveness **d) None of the above**
42.	Technical loss in a distribution system can be reduced by _______________. a) Maintaining low HT/LT ratio b) Accurate meter reading **c) High voltage supply to consumers** d) Improving Collection Efficiency
43.	Pressure drop can be reduced in a compressed air distribution line by providing ____________. a) After Coolers b) Small diameter distribution pipes c) High pressure air flow **d) Large Diameter Distribution pipes.**
44.	Power consumption is very high for __________ type of compressed air dryers. a) Refrigeration type b) Blower reactivated type c) Heat of compression type **d) Heatless purge type**
45.	A DC excitation is used to vary the speed of ___________. **a) Eddy Current Coupling** b) fluid coupling c) variable frequency drive d) None of the above
46.	The isothermal power of 500 CFM air compressor is 72 kW and the efficiency is 76 %. The actual power drawn by the compressor will be _______

	a) 56 kW **b) 94.7 kW** c) 89 kW d) 72 kW
47.	Power factor improvement of a 75-kW compressor motor will ____________ a) Reduce input power to the motor b) Increase input power to the motor c) Reduce the compressor motor shaft power d) **None of the above**
48.	A 500-kVA transformer is designed for No load loss of 750 watts and load loss of 5700 Watts. The calculated total transformer loss is 1662 watts. What will be the percentage loading of the transformer? a) 54.8 % b) 29 % **c) 40 %** d) 25.7 %
49.	Rating of PF correction capacitors for Induction Motors terminal should be a) 100 % kVAr of the induction motor b) 20 % of Motor Rating c) 25 % of Motor rating d) **90 % of the no-load kVAr induction motor**
50.	LLF in lighting calculation refers to a) Light Load factor b) Light lumen factor c) Light Lux factor **d) Light loss factor**

…………. End of Section – I ………….

Section – II: SHORT DESCRIPTIVE QUESTIONS **Marks: 8 x 5 = 40**

(i) Answer all **Eight** questions
(ii) Each question carries **Five** marks

S1	***Write short notes on any two of the following:*** 1. Integrated Part Load Value (IPLV) for chillers 2. Evaporative Cooling 3. Heat Pump (Each 2.5 Marks)
	Ans : 1. Integrated Part Load Value (IPLV) for chillers, (Page No. 126) 2. Evaporative Cooling, (Page No. 136) 3. Heat Pump (Page No. 133)
S2	**Write short notes on any two of the following:** 1. Solar Heat Gain Coefficient (SHGC) 2. Visible Light Transmittance (VLT) 3. Cool Roof (Each 2.5 Marks)
	Ans 1. Solar Heat Gain Coefficient (SHGC), (Page No. 272) 2. Visible Light Transmittance (VLT), (Page No. 272) 3. Cool Roof, (Page No. 271)
S3	One of the Machining centres has installed 2 No's of 270 cfm compressors for pneumatic operation and also for cleaning operation of components after machining. The compressors are operated at 7 kg/cm^2(g) and are on-load for 80 % of the time. The load Power and the un-load Power of each 270 cfm compressor is, 40 kW and 15 kW respectively. The energy audit estimated that cleaning air requirement is 60% of the air generated. Calculate the daily energy consumption for cleaning air alone, assuming continuous operation of the compressor.
	Ans : Compressor capacity = 270 cfm % Loading = 80 % Air Delivered by 2 compressors = (270 X 0.80 x 2) = 432 cfm Loading Power drawn by the compressors = (40 + 40) = 80 kW Un-Loading power drawn by the compressors = (15 + 15) = 30 kW Average kW drawn by the compressors = [(80 x (0.8 x24))+ (30x (0.2 x 24))]/(24) = 70 kW SEC of compressor = (70/432) = 0.162 kW/cfm

	Cleaning air consumption at 7 Kg/cm^2 = (60 % of generation) = (0.60 x 432) = 259 cfm Energy requirement for Cleaning air per day = (259 x 0.162 x 24) = **1007 kWh/day** **(or) Alternate Solution** =(Load Power x load time) +(Unload Power x Unload time) =(40 x 0.8) + (15 x 0.2) =32+3 =35 KW Average KW drawn by the compressors = 35 x 2 = 70 KW Energy requirement for Cleaning air per day = (70 kW x 0.6) x 24 **=1008 kWh/day**
S-4	In a pharmaceutical industry a centrifugal pump is pumping 80 m^3/hr of water into a pressurized container. The container pressure is 3 kg/cm^2(g). The discharge head of the pump is 5 kg/cm^2(g) and water level is 5 meters below the pump central line. If the power drawn by the motor is 22 kW, find out the pump efficiency. Assume motor efficiency as 90% and the water density as 1000 kg/m^3.
	Ans :

Sl. No.	Parameter	Process	Value
1	Water Flow Rate (m^3/hr)	given	80
2	Discharge Head (meters)	given	50
3	Suction Head (meter)	given	-5
4	Power input to Motor (kW)	given	22
5	Motor Efficiency	given	90%
6	Power Input to Pump (kW)	Sl. 4* Sl. 5	=22 x 0.9 = 19.8
7	Liquid kW	(Sl. 1/3600)*((Sl. 2*10) - Sl. 3)*9.81	= (80/3600) x (50 - (-5) x 9.81=11.98
8	Pump Efficiency	Sl. 7 / Sl. 6	60.56%

S5	A Refrigeration system designed with 10 TR AHU is operating at 8.25 TR. The measured air parameters are given below: Inlet enthalpy = 10.26 kcal/kg Outlet enthalpy = 7.26 kcal/kg. Specific volume of air = 0.83 m^3/kg Calculate the volume of air in m^3/hr handled by AHU.

	Ans : Cooling delivered (TR = (Difference in enthalpy) x (Volume of air / sp. volume x 3024) = (Hi – Ho) x V / (v x 3024) **Volume of air handled by AHU** = (TR x v x 3024 / (Hi – Ho)) = ((8.25 x 0.83 x 3024) / (10.26-7.26)) = **6903 m^3/hr**
S6	A fan is designed for 1300 m^3/hr, 50 Hz and drawing 3 kW. If the fan is operated with VFD at 37 Hz for 6000 hours, calculate the velocity of air, when air is supplied through 150 mm diameter duct and the annual energy savings.
	Ans : Power Drawn at 50 HZ = 3 kW Operating frequency = 37 Hz Flow at 37 Hz = 1300 x (37 / 50) = 962 m^3/hr Diameter of the duct = 150 mm Area of the duct = 0.0177 m^2 Velocity of the air in the duct = [(962 / 3600)] / [(0.0177)] = 15.09 m/s Power consumption with 37 Hz = $(37/50)^3$ x 3 = 1.22 kW **Annual Energy Savings for 6000 hours operation** = 6000 x (3 -1.22) = **10,680 kWh**
S7	A foundry unit draws power to the tune of 2500 kW. The demand observed during furnace operation is given below: 5 minutes : 2940 kVA 7 minutes : 2550 kVA 3 minutes : 2777 kVA If the billing meter is monitoring demand every 15 minutes, calculate the maximum demand registered and also the average PF, during the demand interval.
	Ans : Maximum demand registered = [2940 * (5/15) + 2550 * (7/15) + 2777 * (3/15)] = [980 + 1190 + 555.4] = 2725.4 kVA PF 5 minutes: 2940 KVA = (2500 / 2940) = 0.85 7 minutes 2550 KVA = (2500 / 2550) = 0.98 3 minutes 2777 kVA. = (2500 / 2777) = 0.90 Average PF = [0.85 *(5/15) + 0.98* (7/15) + 0.9 * (3/15)] = 0.92
S8	A process plant has installed 4-cell cooling tower, with 45 kW CT fans for each cell and operating at 40 kW at 1450 rpm. As a part of the energy conservation program, the existing fan motors are replaced with two speed motors which would operate at 1450 rpm and 740 rpm. The cooling

	towers are operated at high speed mode for 5300 hours and at low speed mode for 1800 hours, in a year. Estimate the annual energy savings when compared to operation of fans continuously at a fixed speed of 1450 rpm.
	Ans : Present energy consumption of all 4 fans = (4 x 40 x (5300 + 1800)) = 11,36,000 kWh Energy consumption for fans at 1450 rpm for 5300 hours = (4 x 40 x 5300) = 8,48,000 kWh Energy consumption for fans at 740 rpm for 1800 hours = [$(740/1450)^3$x 40 x 4 x 1800] = 38281 kWh Annual savings = [11,36,000 - (8,48,000+38,281)] = 2,49,719 kWh

……….…….. End of Section - II …………….

Section – III: LONG DESCRIPTIVE QUESTIONS **Marks: 6 x 10 = 60**

(i) Answer all **Six** questions
(ii) Each question carries **Ten** marks

L-1

a) In an energy audit of a fan, it was observed that the fan was delivering 24,000 Nm^3/hr of air. Suction static pressure was recorded as -15 mm WC and discharge static pressure as 35 mmWC.

The power measurement of the motor using power analyser was recorded as 7 kW. The motor operating efficiency taken from motor performance curve was 90%. What is the static efficiency of the fan?

b) Match the Following

1. Heat Pump – NPSHR
2. Compressor – Static Head
3. Pumping Pressure – Static Pressure
4. Fan – Compressor
5. Pump – Free air delivery test

Soln :

a)

Q = 24.000 Nm^3 / hr. = 6.67 m^3/sec

Static pressure rise = 35 – (-15)
= 50 mmWC

η_s =?

Power input to motor = 7 kW

Power input to fan shaft = 7 x 0.90 = 6.3 kW

$$\text{Fan static } \eta = \frac{\text{Volume in } m^3/sec \times \Delta P_{st} \text{ in mmWc}}{102 \times \text{Power input to shaft}}$$

$$= (6.67 \times 50) / (102 \times 6.3)$$

$$= 0.519 \text{ (or) } = 51.9\ \%$$

b) Match the Following

1. Heat Pump – Compressor
2. Compressor – Free air delivery test
3. Pumping Pressure – Static Head
4. Fan – Static Pressure
5. Pump – NPSHR

L-2

A. For each one of the following, mention whether they belong to "Prescriptive Method" or "Whole Building Performance Method".

(5 Marks)

1. Compliance by meeting or exceeding specific levels for each individual element of building
2. Allows Trade-off option for building envelope
3. Allows use of energy simulation software
4. Computer model of the proposed design (energy consumption) is compared with Standard Design
5. Compliance if energy use in proposed design is less than energy use in standard design

B. Match the Following: (5 Marks)

1.	Building envelope	a)	Day lighting of building
2.	Passive solar design strategy	b)	Exfiltration and Infiltration of air
3.	Visual Light Transmittance	c)	Roof, walls, windows, skylights, doors and other openings
4.	Weather stripping	d)	Property of high solar reflectance and emittance
5.	Cool roof	e)	Cross ventilation

Ans :

A.

1. Prescriptive Method
2. Prescriptive Method
3. Whole Building Performance Method
4. Whole Building Performance Method
5. Whole Building Performance Method

B.

1	Building envelope	C	Roof, walls, windows, skylights, doors and other openings
2	Passive solar design strategy	E	Cross-ventilation
3	Visual Light Transmittance	A	Day lighting of building
4	Weather stripping	B	Exfiltration and Infiltration of air
5	Cool roof	D	Property of high solar reflectance and emittance

L-3 An energy audit was conducted in a large machine shop and the audit report suggested

Motor Rating in kW	Operating Load %	Old Motor Efficiency%	New Motor efficiency%	No of motors
7.5	75	86	89	12
11.5	85	88	91	7
15	70	89	92	11

replacing 30 machine motors with energy efficient motors. The loading details of old and new motors are given below:

	Assuming motor loading in both cases remains same, calculate the annual energy savings, for 4000 hours operation per year.

Ans :

Motor Rating in KW	Operating Load %	Actual Old Motor Load In kW	Actual New Motor Load In kw	Old Motor efficiency	New Motor efficiency	No of motors
7.5	75	7.5/0.86=8.72 =8.72x 0.75=6.54	7.5/0.89=8.43 =8.43x 0.75= 6.32	86	89	12
11.5	85	11.5/0.88=13.07 =13.07 x 0.85= 11.11	11.5/0.91=12.64 =12.64 x 0.85= 10.74	88	91	7
15	70	15/0.89=16.85 =16.85x 0.7= 11.79	15/0.92=16.30 =16.30 x 0.7 11.41	89	92	11

Annual Savings for 7.5 KW Motors,
12 numbers, operating 4000 hours = [4,000 (6.54-6.32) x 12]
= 10,560 kWh

Annual Savings for 11 KW Motors,
7 numbers, operating 4000 hours = [4000 (11.11 -10.74) x 7]
= 10,360 kWh

Annual Savings for 15 KW Motors,
11 numbers operating 4000 hours = [4,000 (11.79-11.41) x11]
= 16,720 kWh

Total annual savings for 30 high efficiency motors **= 37,640 kWh**

L-4

A 10 MW co-generation plant is operating at a daily load factor of 85 %. Power is generated at 11 KV.

- 35 % of the power generated, is exported to grid, through a 7.5 MVA Transformer with 99 % efficiency.
- 32 % power generated, is supplied to mill motors, at 600 Volts, through a 5 MVA step down transformer, with 98 % efficiency.
- The balance power generated is supplied to other LT Loads and auxiliaries, at 415 Volts, through a 2 MVA transformer, with 98 % efficiency.

Calculate the following:

1) Daily energy exported to grid at 33 KV.
2) Daily mill motors consumption at 600 V.
3) Daily LT loads and auxiliary consumption at 415 V.
4) Daily transformers losses in kWh and % transformers losses

(Each 2.5 Marks)

Ans :

1.

Daily generation = (10,000 x 0.85 x 24)
= 2,04,000 kWh

Daily energy generation for export purpose = (2,04,000 x 0.35)
= 71,400 KWh

7.5 MVA transformer loss = [71,400 - (71,400 x 0.99)]
= (71,400 – 70,686)
= 714 kWh

Net energy export to the Grid at 33 KV level = (71,400 kWh - 714 kWh)
=70,686 KWh

2.

Daily energy generation for mill motor consumption = (2,04,000 x 0.32)
= 65,280 kWh

5 MVA Transformer loss = [65,280 - (65,280 x 0.98)]
= (65,280 - 63,974.4)
= 1,306 kWh

Net mill Consumption = 63,974 KWh

3.

Daily generation for LT loads & Auxiliary consumption = (2,04,000 x 0.33)
= 67,320 kWh

2MVA Transformer loss = [67320 - (67320 x 0.98)]
= 67,320 - 65,974
= 1,346 kWh

Net LT loads & Auxiliary Consumption = 65,974 kWh

4.

Transformers losses = (714 +1306 +1346)
= 3,366 kWh day

% transformers losses = (3,366 / 2,04,000) x 100
= 1.65 %

(Or)

To meet the plant LT loads and co-gen auxiliary load the transformer capacity should be more than 2 MVA.

L-5 A small machine shop has installed 220 cfm screw compressor to meet air requirement for various operation. The operating details are given below:

Shift reference (8 hrs/ Shift)	Load time in sec	Un-Load time in sec
I	60	10
II	45	25
III	25	45

Load Power = 37 KW
Un-load power = 11 KW

	Calculate the following: 1. Energy loss per day (4 Marks) 2. Shift wise average air requirement in cfm (2 Marks) 3. The plant has proposed to install a VFD for the compressor. Calculate the energy savings after installing the VFD operated compressor, if the VFD loss is 3 % of load power. (4 Marks)
	Ans : I[st] shift consumption = ((60 / 70) x 37) + (10 / 70) x 11) x 8) = (31.71+1.57) x 8 **= 266.24 kWh** II[nd] shift consumption = ((0.64 x 37 + 0.36 x 11) x 8) = (23.68 + 3.96) x 8 **= 221.12 kWh** III[rd] shift consumption = ((0.36 x 37 + 0.64 x 11) x 8) = (13.32 +7.04) x 8) **= 162.88 kWh** Daily Total Energy consumption = (266.24 + 221.12 + 162.88) **= 650.24 kWh** Daily Energy loss due to unloading = (1.57 +3.96 +7.04) x 8 **= 100.56 kWh** Daily load cycle Energy consumption = (650.24 – 100.56) **= 549.68 kWh** Daily energy consumption with VFD = (549.68 / 0.97) **= 566.68 kWh** Daily Energy loss due to VFD = (566.68 – 549.68) **= 17 kWh** Daily Net Energy savings with VFD compressor = (100.56 – 17) **= 83.56 kWh** I[st] shift air requirement = (0.86 x 220) **= 189.2 cfm**

	II^{nd} shift air requirement	= (0.64 x 220) **= 140.8 cfm**
	III^{rd} shift air requirement	= (0.36 x 220) **= 79.2 cfm**
L-6	(a) What is L/G ratio and how it is useful in operation of a cooling tower ? (3 Marks) (b) What are the functions of fill media in a cooling tower? (3 Marks) (c) Calculate the L/G ratio for the cooling tower given the following: (4 Marks) Water Flow = 4540 m^3/hour Approach = 4.45 ^oC Air entering enthalpy at 26.67 ^oC = 24.17 kcal/kg Air leaving enthalpy at 37.8 ^oC = 39.67 Kcal/kg Hot water temperature = 47.77 ^oC Cold water temperature = 31.11^oC	

Ans :

a)
Liquid / Gas (L / G) ratio of a cooling tower is the "ratio between the water and air mass flow rates".

Against the design values, seasonal variations require, adjustment and tuning of water and air flow rates, to get the best cooling tower effectiveness, through measures like, water box loading changes, blade angle adjustments etc.

By energy balance,

$L(T_1 - T_2) = G(h_2 - h_1)$
$L / G = (h_2 - h_1) / (T_1 - T_2)$
L / G = Liquid to gas mass flow ratio (kg/kg)
Where :

T_1 = hot water temperature oC
T_2 = cold water temperature ^oC
h_2 = Enthalpy of air water vapour mixture at exhaust wet bulb temperature
h_1 = Enthalpy of air water vapour mixture at inlet wet bulb temperature

(b) Page 209, para of Function of Fill media in a cooling tower

c)

$L / G = (h_2 - h_1) / (T_1 - T_2)$
L (47.77 - 31.11) = G (39.67 - 24.17)
L / G Ratio = (39.67 - 24.17)/ (47.77 - 31.11)
= 0.93

------- End of Section - III -----