Important Instruction 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 principle components indicated in a 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 some questions credit may be given by judgment on part of examiner of relevant answer based on candidate understands.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q.1 A) Attempt any THREE of the following: ---------- 12 Marks

i) Write any four requirements of a good heating material. (1 Mark to each point)

Following Requirements of good heating material:- (Any four point expected)

i) **High resistivity:** It should have high resistivity. So that is becomes compact in size and produces more heat with small input current.

ii) **High melting point:** It should have high melting point to withstand at high temperature.

iii) **High Oxidizing temperature:** It should have high oxidizing temperature or it should not oxidize even at high temperature**.**

iv) **High Resistance to corrosion:** It should have high resistance to corrosion to avoid rusting.

v) **Mechanical Strength:** It should have high mechanical strength to withstand from mechanical injury.

vi) **Ductile:** It should be ductile so that it can be manufactured into different size & shape.

vii) **Long Life:** It should have long life.

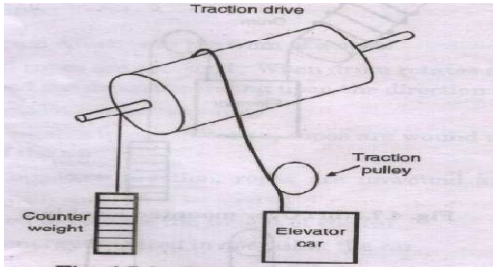
viii) **Less Costly:** It should be less costly and easily available.

ix) Low temperature co-efficient of resistance: For accurate temperature control, it should have low temperature co-efficient of resistance.

x) It should not be brittle.

ii) With the help of a neat diagram, discuss about traction elevator

(2 Mark for fig. & 2 Mark for Explanation -Total 4 Marks)

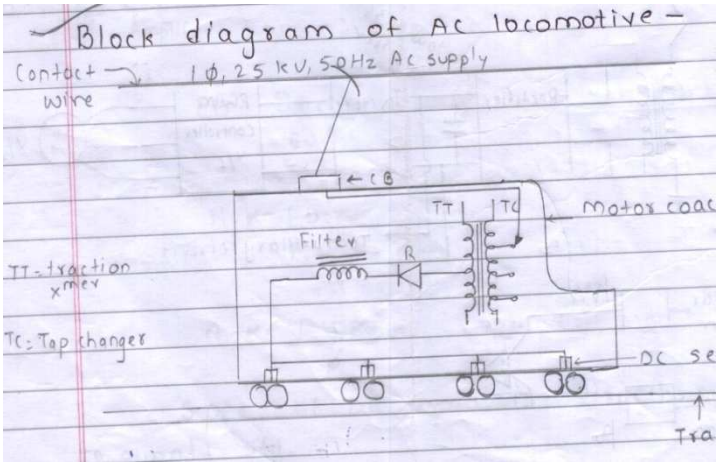


or Equivalent fig

Explanation:

- In case of traction elevators, the motion is transferred by means of traction i.e. through the friction existing between the driving pulley and hoisting ropes.
- In this case ropes are not wound on the drum.
- A continuous rope from car to the counter-weight passes over a driving pulley as shown in figures.

iii) Draw a neat block diagram of AC electric locomotive. **(4 Marks)**



or Equivalent fig

iv) Explain any four factors governing the selection of motors. **(1 Mark to Each Point)**

In case some questions credit may be given by judgment on part of examiner of relevant answer based on candidate understands.

Following Factors governing electric drive (Motor): **(Any four points expected)**

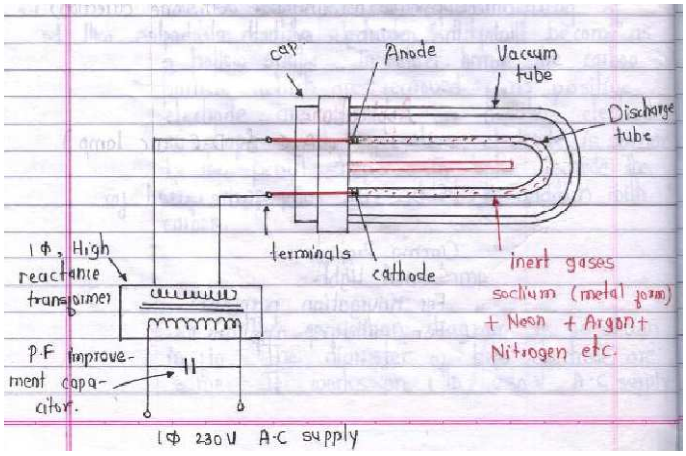
i) **Nature of supply:** Whether supply available is AC, pure DC or rectified DC.
ii) **Nature of Drive (Motor):** Whether motor is used to drive individual machine or group of machines.
iii) **Nature of load:** Whether load required light or heavy starting torque or load having high inertia ,require starting torque for long duration. **OR** Whether load torque increases with speed ($T \alpha N$) or decreases with speed ($T \alpha 1/N$) **or** remains constant with speed (T = N) or increases with square of speed ($T \alpha N^2$)
iv) **Electric Characteristics of drive:** Starting, running, speed control and braking characteristics of electric drive should be studied and it should be matched with load.
v) **Size and rating of motor:** Whether motor is short time or continuously or intermittently running or used for variable load cycle. Whether overload capacity, pull out torque is sufficient.
vi) **Mechanical Considerations:** Types of enclosure, Types of bearing, Transmission of mechanical power, Noise and load equalization etc.
vii) **Cost:** Capital, running and maintenance cost should be less.

Q.1 B) Attempt any ONE of the following: ---------- 6 Marks

i) Explain with neat diagram, the construction and working of sodium Vapour lamp.

(2 Mark for fig. & 2 Mark for construction& 2 Marks for working: Total-6 Marks)

Sodium Vapour Lamp Figure:-



or equivalent figure

Construction:-

Above figure shows constructional details of sodium vapour lamp. It consists of 'U' shaped tube and at the ends of the tube two electrodes are sealed. This tube is filled with sodium and small quantity of neon gas. Since there is great effect of the change of surrounding temperature on the light output given by the lamp, hence the inner tube is enclosed in an outer double walled glass tube. Before sealing the lamp vaccum is created between the two glass tube (inner & outer).

Working:-

Before the lamp starts working, the sodium is usually in the solid form deposited on the sides of the inner tube wall. When the voltage is applied to the lamp it warms up and starts vaporizing slowly and radiates out yellow colour light and after about 20 minutes, the lamp starts giving it's full output.

ii)

Given Data: - P= 500KW, $\cos\phi = 0.7$ lag, working Hours = 3000/annum

Tariff = $(Rs.1300/KVA\ of\ \max imum\ demand/annum + Rs.0.80/Kwh)$

The annual cost of phase advancing plant = Rs.150 / KVAR

- $KVA = \frac{KW}{Cos\phi}$

$KVA = \frac{500}{0.7}$

$KVA = 714.28571$ ---------- **(1 Mark)**

- **No. of Units consume in One Year**

$= M.D(KW) \times No.of\ working\ hours\ in\ one\ year$

$= 1 \times 500 \times 3000$

$= 1500000\ Kwh$ ---------- ------ **(1 Mark)**

- **Annual Energy Bill :-**

$= (Rs.1300/KVA\ of\ \max imum\ demand/annum + Rs.0.80/Kwh)$

$= (Rs.1300 \times 714.28571 + Rs.0.80 \times 1500000)$

$= (Rs.928571.423 + Rs.1200000)$

= 2128571.423 Rs. ----------**Equation No. 1**---------- **(1 Mark)**

Saving will be maximum only at most Economical Power factor hence: Most Economical Power factor is calculated.

- **Most Economical P.f.** = $\sqrt{1-\left(\frac{Y}{X}\right)^2}$

$$=\sqrt{1-\left(\frac{150}{1300}\right)^2}$$

= 0.99332 lagging ---------- **(1Mark)**

- **New Maximum Demand =**

$$KVA=\frac{KW}{New\ Cos\phi}$$

$$New\ KVA=\frac{500}{0.99332}$$

$$New\ KVA=503.3620$$ ---------- **(1Mark)**

- **Annual Energy Bill if the Power factor load is improved:-**

$$= \left(Rs.1300/KVA\ of\ \max imum\ demand/annum + Rs.0.80/Kwh\right)$$

$$= \left(Rs.1300\times 503.3620 + Rs.0.80\times 1500000\right)$$

$$= \left(Rs.654370.60 + Rs.1200000\right)$$

= 1854370.60 *Rs.*---------- **Equation No. ------2----- (1/2 Mark)**

- **Annual Saving =** Equation 1 – Equation 2

= 2128571.423 Rs. – 1854370.60 Rs.

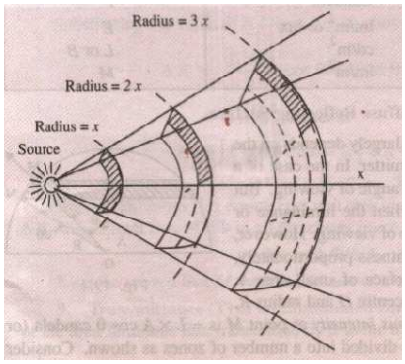
= 274200.823 Rs. Saving if the power factor of load is improved **(1/2 mark)**

Q.2 Attempt any Four of the following----------16 Marks

i) What are two laws of illumination? State and explain both of them.

Laws of illumination: - **(Figure 1 Mark & Statement 1 Mark for each law)**

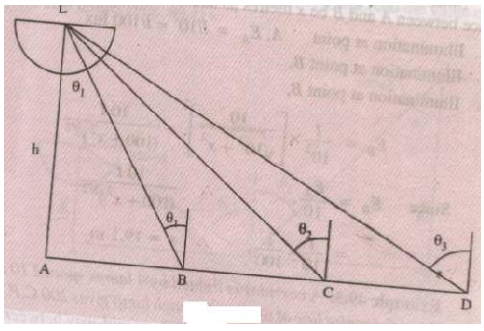
a) Inverse Square Law :-



or Equivalent fig.

Illumination is inversely proportional to the Square of distance between source and plain of the surface . $E \propto \frac{1}{r^2}$

b) Lambert's cosine law :-



or Equivalent fig.

The illumination of a surface is directly proportional to cosine of angle made by the normal to the illuminated surface with the direction of the incident flux.

$E_B = E_A \cos^3 \phi_1$, $E_C = E_A \cos^3 \phi_2$, $E_D = E_A \cos^3 \phi_3$ *and so on.*

ii) Explain formation and characteristics of Electric arc.

(1 Mark for fig. 2 Mark for explaination&1 Marks for characteristics.Total-4 Marks)

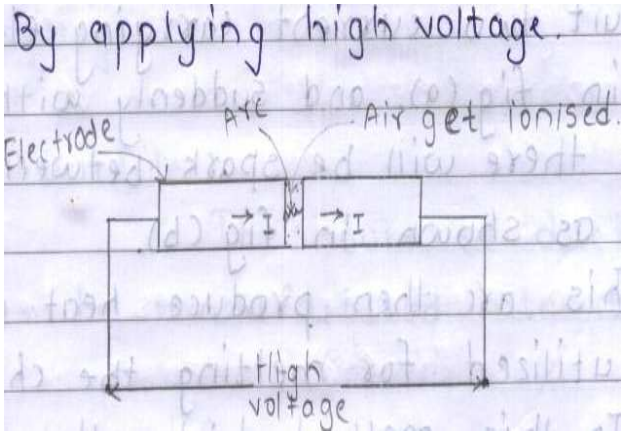
Arc can be form by any one of the following method. (Any one method is expected to explain)

a) By applying High Voltage

b) By separation of two current carrying electrodes suddenly

EXPLANATION:-

a) By applying High Voltage:-

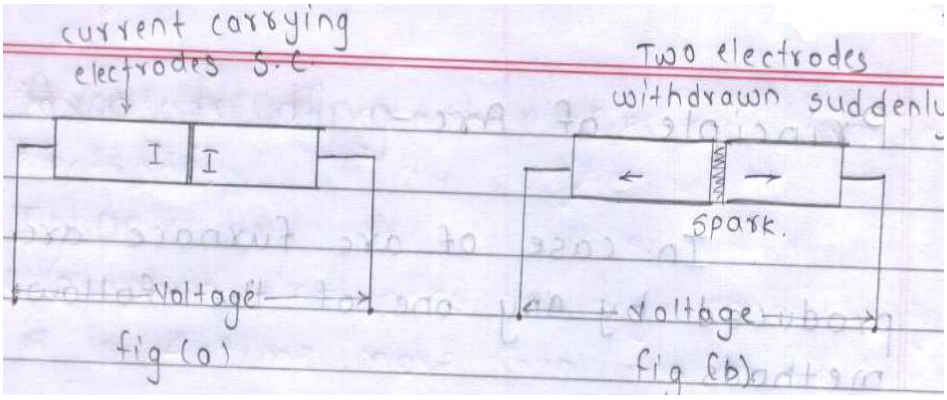


Equivalent fig.

When very high voltage is applied across any two electrodes separated by small air gap then air between two electrodes gets ionized and ionized air is conducting, so current starts flowing from one electrode to another electrode in the form of spark (arc).

This arc produces heat energy which is utilized for melting the charge. Once arc is struck between two electrodes then low voltage is sufficient to maintain the arc.

b) By Separation of two current carrying electrodes suddenly:-



Equivalent fig.

Another way to produce arc is to short circuit two current carrying electrodes as shown in fig (a) and suddenly withdraw them, then there will be spark between two electrodes as shown in figure (b). This arc then produce heat energy which is utilized for melting the charge. In this method high voltage is not necessary to produce the arc.

Characteristics of arc :(Any two characteristics are expected)

i) To produce arc high voltage is required then to maintain the arc.

ii) Arc is conducting.

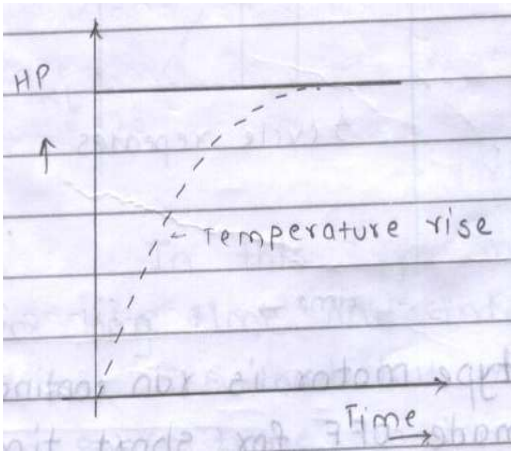
iii) Arc has negative temperature coefficient of resistance.

iii) Discuss with necessary graphs, the following

(1 Mark for graph, 1 Mark for Explanation for each rating Total-4 Marks)

1) Continuous Rating 2) Short time Rating

1) Continuous Rating: Graph



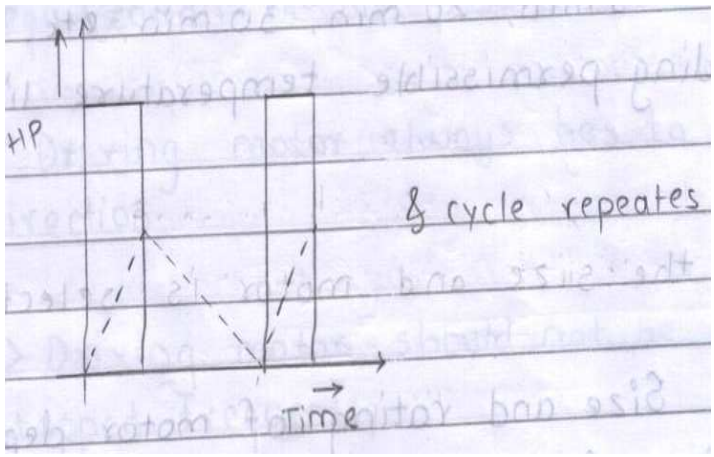
Equivalent fig.

In this case motor is loaded and run continuously (non-stop) for few days or months also, for example water pumping motor, generating power house auxiliary motors etc.

2) Short Time Rating:

In short time loading motor is operated for short period. For example: 15/30 min etc. then it is made OFF. This OFF load interval is sufficient to cool the motor temperature to its normal value.

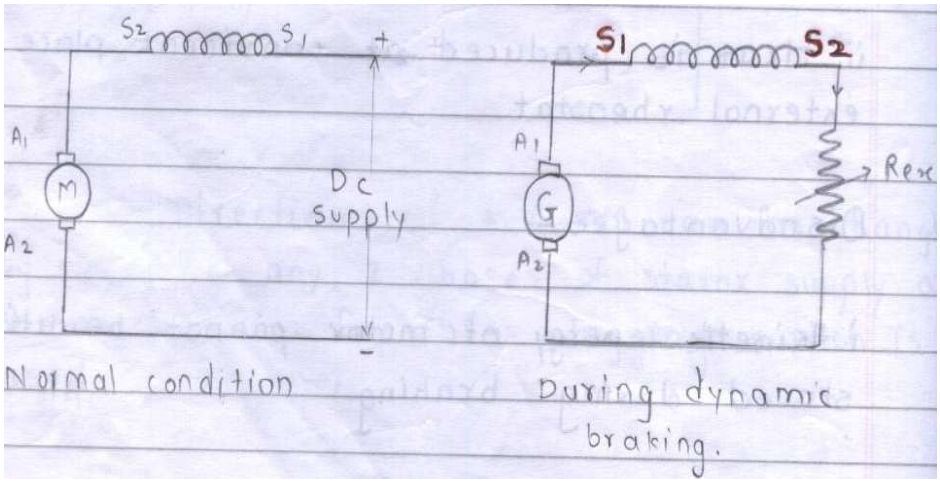
Graph



Equivalent fig.

iv) Explain with neat sketch, Rheostaic braking as applied to DC series Motor.

(2 Mark for Sketch, 2 Mark for Explanation Total-4 Marks)



Equivalent fig.

In this method at the time of braking armature is disconnected from supply but supply to field winding (excitation) remains as it is. At this time motor works as a generator. All the kinetic energy of rotating parts is converted into electrical energy which is dissipated in external

resistance, connected in armature circuit, is called dynamic or rheostat braking, for final stopping of motor excitation is disconnected and mechanical braking is applied.

In case of DC series motor field winding connections must be reversed when it acts as a generator i.e. A1 is connected to S1 as shown in figure. and

Value of external resistance connected in armature circuit must be less the critical value otherwise there will be no excitation.

v) Explain any two advantages and any two disadvantages of a 25 KV AC System.

Advantages of 25 KV AC System :- (Any two advantages, 1 Mark for each Total 2 Marks)

i) As system voltage is high (25KV) as compared to DC supply system (3000V) so current drawn by overhead conductor is less because. ($I \propto 1/V$)

ii) Due to low current cross section of overhead conductor reduces. So its weight reduces.

iii) As weight of overhead conductor reduces design of supporting structure becomes lighter.

iv) Due to low current copper losses in transmission line reduces, so transmission efficiency increases.

v) Due to low current voltage drop in transmission line decreases. Due to this distance between two substation increases. So number of substation required is less than DC track electrification system for same track distance. eg.

S.No.	Voltage level	Distance between 2 substation
1	1-ph AC, 25KV	50 to 80 KM
2	3000V DC	12 to 30 KM
3	1500V DC	5 to 12 KM
4	750/600V DC	2 to 5 KM

vi) Due to low current size (capacity) of AC substation is more than DC substation. So number of substation required is less than DC track electrification system for same track distance.

S.No.	Supply System	Size of Substation
1	1-ph AC, 25KV	10 to 15 MW
2	3000V DC	2 to 6 MW

vii) Due to all above advantages cost of track electrification less as compared to DC track electrification system.

viii)Characteristics of 1-Ph AC series motor such as high starting torque, variable speed are suitable for traction purpose.

ix) Starting efficiency is high in case of AC supply system as voltage is reduced with the help of transformer.

Disadvantages of 25KV AC System: (Any 2 disadvantages: 1 Mark each, Total 2 Marks)

i) As system voltage is high as compared to DC supply system so its insulation cost is more.

ii) Torque obtained by 1-Ph AC series motor is not uniform like DC series motor because of presence of frequency. So it affects riding quality.

iii) In this supply system 1-Ph series motor is used to obtain necessary torque. But AC series motor is less superior than DC series motor for traction purpose. Because AC series motor has less starting torque, acceleration and retardation than DC series motor. (because of power factor)

iv) Weight of 1-Ph AC Series motor is 1.5 times greater than weight of DC series motor for same HP, so it affects pay load capacity.

v) Maintenance cost of 1-Ph AC series motor is more than DC series motor.

vi) Its overload capacity is less than DC series motor.

vi) State any two objectives and any 4 requirements of Tariff

Objectives of Tariff: (While calculating tariff following are some objectives)

(Any 2 objective: 1 Mark for each, total 2 Marks)

i) All expenses like interest and depreciation (I &D) i.e recovery of cost of producing electrical energy at the generating station.

ii) Interest & Depreciation on capital investment made on T&D line.

iii) Recovery of cost of operation and maintenance of supply of electrical energy.

iv) T&D losses also considered while calculating tariff.

v) We should also think that electricity cannot be stored (not economically). It has to be consumed as soon as it is generated while calculating tariff.

vi)We should also think about investment required for future expansion.

vii) A reasonable profit should be added while calculating tariff.

Requirements of Tariff:- **(Any Four requirements, 1/2 Mark each Total 2 Marks)**

i) It should be easy to understand to consumer.

ii) Easy to calculate.

iii) Tariff should be attractive; It should not be too high or too low. It should be reasonable.

iv) Tariff should be economical as compare to other types of energy sources.

v) Tariff must be fair, so that different types of consumers are satisfied with rate of electrical energy charges.

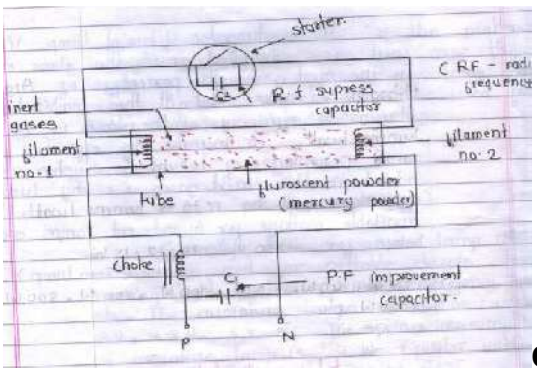
vi) Tariff should be formed into two parts i.e fixed charges + running charges.

viii) While calculating tariff it should cover all expenses and reasonable profit,

Q.3 Attempt any Four of the following **16 Marks**

i) Draw a neat labelled of fluorescent tube and also states the function of choke, starter and the capacitors in the tube circuit.

Sketch of fluorescent tube: **(1 Mark)**



OR Equivalent fig.

Function: **(Each Function 1 Marks)**

i) Choke: For providing high voltage at the time of starting.

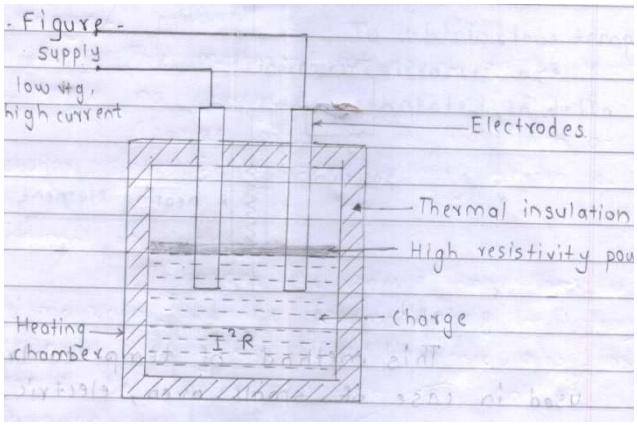
ii) Starter: To make and break the circuit to start the tube.

iii) Capacitor: To improve the power factor, To minimize the radio interference.

ii) Explain with neat sketch, the working of direct resistance heating.

(2 Mark for Sketch, 2 Mark for explanation Total-4 Marks)

Figure:



Equivalent fig.

(Note: - For explanation any two points should be covered from following, not all)

Working Principle:

- When current is passed through charge heat is produced due to I^2R losses taking place in the charge. Where, R is the resistance of the charge and I be the current passed through charge.

Definition:

- As heat is produced in the charge itself hence its name is direct resistance heating.

Precautions:

- Immersion of current carrying electrodes directly into the highly conductive materials (Charge) is nothing but direct short circuit. To avoid S.C high resistive powder is spread on the surface of charge as shown in figure.

- To start the furnace, a piece of carbon is used for bridging between them ,If the charge is in the form of lumpy material

Type of supply used:

- Supply used may be AC or DC and for large capacity furnace 3-PH, AC supply is used.
- Supply used is of low voltage (2 to 20V) and high current (300A), purpose of using high current is to obtain more heat in less time.

Number of Electrode used:

- For 1-Ph AC and DC supply two electrodes are used and for 3-Ph AC supply 3 electrodes are used. Electrodes are made up of carbon or graphite.

Charge:

- The material which is to be heated is called as charge. Charge may be in the form of powder, small solid pieces or may be liquid

Thermal Insulation:

- In order to reduce heat loss and to maintain temperature of furnace chamber heat insulating material like glass wool, ceramic, asbestos, etc. are to be provided in between wall of furnace and heating chamber. For large capacity furnace wall of furnace is made from refractory material.

Efficiency:

- It has high efficiency.

Temperature control:

- Heat produced $\alpha V^2/R$ charge, Voltage control method is used for adjusting temperature.

Application:

- It is used for carbonizing, tempering, quenching and hardening of steel tools & heating of water in boiler.

iii) Compare Group drive & Individual Drive based on the following Factors: (Each point 1/2 Marks)

S.No.	Point	Group Drive	Individual Drive
1	Definition	In a group drive single large capacity electric drives is used to run number of machine through a long common shaft.	In this type of drive each machine has its own separate electric drive (motor). It may be directly coupled or indirectly coupled
2	Cost	Less	High
3	Total HP	Less	More
4	Appearance	Not good	Good
5	Safety	It is less Safe	It is more safe
6	Flexibility	Less Flexibility	More Flexibility
7	Performance	Better if operated at full load	Better if operated at full load
8	Any one application of each	Textile Industry **(Similar application will be consider)**	Lathe Machine **(Similar application will be consider)**

iv) What is coefficient of adhesion? Explain the factor affecting it. (Definition-2 Marks & factor affecting-2 Marks)

Coefficient of Adhesion:-

Coefficient of adhesion (μ) is the ratio of maximum force between wheels and track to the weight of train on driving axle. i.e ma = F/W

The Factors affecting the coefficient of adhesion: (Expected any four point)

1) Condition of Track :-

- When track is completely wet, partially wet or oily then coefficient of adhesion reduces.
- When Track is completely dry then coefficient of adhesion is more.
- In morning coefficient of adhesion is less and at afternoon it improves.
- At the point of crossing the curvature contact area between track & wheel reduces due to coefficient of adhesion reduces.
- Variation in cross & longitudinal levels of track reduces.

- Sparking between wheel and rail friction and it will destroy rough bodies on the track so, coefficient of adhesion reduces.
- With chemical treatment like sodium mettasilicate on track, coefficient of adhesion is increased
- With sand treatment coefficient of adhesion can be improved.

2) Mechanical Parts:-

- Unequal distribution of load on axle reduces coefficient of adhesion.
- Fully loaded bogie has more coefficient of adhesion than lightly loaded bogie.
- Better elastic suspension and damping arrangement in bogie increases coefficient of adhesion
- Train will not slip when F ma 〈 F/W
- Train will slip when F ma 〉 F/W

V) State various types of Tariff. Explain the suitable tariff for industrial consumer.

(Types of tariff – 2 Marks & Explanation – 2 Marks)

Types of Tariff:-

i) Flat-demands Tariff

ii) Simple-demand Tariff or Uniform Tariff

iii) Flat-rate Tariff

iv) Step-rate Tariff

v) Block-rate Tariff

vi) Two-part Tariff

vii) Maximum demand Tariff

viii) Three-part Tariff

ix) Power factor Tariff :- a) KVA maximum demand Tariff

b) Sliding Scale Tariff or Average P.F.Tariff

c) KW and KVAR Tariff

x) TOD (Time of Day) Tariff

Suitable Tariff for Industrial Consumer: (Any One Explanation Expected)

i) Maximum Demand Tariff/KVA MD Tariff:-

- It is similar to two part tariff except that maximum demand (KVA) is actually measured by installing maximum demand (in KVA)
- M.D. Meter is installed in the premises of consumer, in addition to energy meter.
- Industrial consumer is trying to improve power factor to reduce maximum demand charges.
- This type of tariff is applicable to industrial consumer/H.T. consumer.

ii) Power Factor Tariff:-

- The tariff in which P.f. of industrial consumer is taken into consideration.
- Power factor tariff is used for industrial consumer /H.T. consumer.
- If the P.F. of consumer is less than P.F. declared by Supply Company (say below 0.92 lag.) than penalty will be charged in energy bill.
- If The P.F. of consumer is more than P.F. declared by Supply Company (say above 0 .96 lag) than discount will be given in energy bill.

iii) Time of Day (TOD) Tariff or OFF-load Tariff:-

- TOD energy meter is installed in the HT consumer premises.
- If the P.F. of consumer is less than P.F. declared by Supply Company (say below 0 .92 lag) then penalty will be charged in energy bill.
- This meter is specially designed to measure energy consumption w.r.t time.
- This type of tariff is such that energy consumption charges/unit are less during OFF-load period
- There is a higher tariff rate energy consumption charge during peak-load period.
- This type of tariff is introduced to encourage industrial consumers to run their maximum load during OFF-load period.

Q.4 A) Attempt any Three of the following **12 Marks**

i) Compare between spot welding and arc welding w.r.t. four points. (Expected any four point: 1 Mark each point)

S.No	Parameters	Spot Welding	Arc Welding
1	Type of welding	Plastic / Pressure / Non-fusion welding	Fusion / Non pressure welding
2	Principle of heat developed	Heat is developed due to I^2R losses where R is the contact resistance	Heat developed due to arc produced in between electrode and job
3	External filler material required	Not required	Required during welding
4	External pressure required	Required	Not required
5	Type of supply used	AC supply is used	Metal arc welding – AC supply and Carbon arc welding –DC supply are used
6	Voltage &current required	Low voltage (2 to 20V AC) and high current (40 to 400A) supply is required	High voltage required to produce arc at starting. Once arc is struck low voltage is sufficient to maintain arc. Metal Arc welding Voltage- 70 to 100V AC and Carbon arc welding voltage- 50 to 60V DC, current- 50-600-800A
7	Power consumption	Low	High
8	Temperature obtained	Temperature obtained is not very high (up to 1350^0C)	Temperature obtained is very high (up to 3500^0C to 6000^0C)
9	Power factor	Low	Poor
10	Application	It is suitable for mass production	It is suitable for maintenance and repair work
11	Type of electrode	Non-consumable electrode	Coated electrodes are used for arc welding and bare electrodes are used for carbon arc welding.(Electrodes may be consumable or non-consumable)

ii) Give any four differences between Actual Speed and Schedule Speed. (Each point 1 Mark)

Note : Other points than below of difference should be consider while giving marks

S.No	Actual Speed	Schedule Speed
1	Distance / Time	Distance / Actual time of run + Stop time
2	Actual speed is the speed you are traveling at any given moment at any given point.	Schedule speed is a true speed which includes stop time also
3	Railway or any time table is not based on schedule speed	Railway or any time table is based on schedule speed
4	Actual Speed is more	Scheduled Speed is less

iii) Given Data

V_{sch} = 30Km/hr D= 1 M T_{stop} = 20 sec β = 3 Km/hr.sec $V_{max} = 1.25\ V_{av}$

Solution:

- $V_{sch} = \dfrac{3600\ D}{Schedule\ Time}$ ----------**(1/2 Mark)**

  $\therefore\ Schedule\ Time\ (T_{sch}) = \dfrac{3600\ D}{V_{sch}}$

  $\therefore\ Schedule\ Time\ (T_{sch}) = \dfrac{3600 \times 1}{30}$

  $\therefore\ Schedule\ Time\ (T_{sch}) = \dfrac{3600}{30}$

  $\therefore\ Schedule\ Time (T_{sch}) = 120$ sec.---------- **(1/2 Mark)**

- $Schudele\ Time(T_{sch}) = Actual\ Time\ of\ Run\ (T) + Stop\ time\ (T_{stop})$

  $\therefore\ Actual\ Time\ of\ Run\ (T) = Schedule\ Time\ (T_{sch}) - Stop\ time(T_{stop})$

  $\therefore\ Actual\ Time\ of\ Run\ (T) = 120 - 20$

  $\therefore\ Actual\ Time\ of\ Run\ (T) = 100$ sec.---------- **(1/2 Mark)**

- $V_{av} = \dfrac{3600\ D}{T}$

$$V_{av} = \frac{3600 \times 1}{100}$$

$$V_{av} = 36 Km/hr$$

---------- **(1/2 Marks)**

- For Given Condition =

$$V_{max} = 1.25 \times V_{av} \qquad V_{max} = 1.25 \times 36$$

$$V_{max} = 45 KM\ KM/hr$$

---------- (**1/2 Mark)**

Now, $\dfrac{1}{\alpha} + \dfrac{1}{\beta} = \dfrac{7200D}{V^2_{max}} \left[\dfrac{V_{max}}{V_{av}} - 1 \right]$ ---------- **(1/2 Mark)**

$$\frac{1}{\alpha} + \frac{1}{\beta} = \frac{7200 \times 1}{45^2} \left[\frac{45}{36} - 1 \right]$$ ---------- **(1/2 Mark)**

$$\frac{1}{\alpha} + \frac{1}{\beta} = \frac{7200}{2025} \times \frac{1}{36}$$

$$\frac{1}{\alpha} + \frac{1}{\beta} = \frac{8}{9}$$

$$\frac{1}{\alpha} = \frac{8}{9} - \frac{1}{\beta}$$

$$\frac{1}{\alpha} = \frac{8}{9} - \frac{1}{3}$$

$$\frac{1}{\alpha} = \frac{5}{9} \quad \alpha = \frac{9}{5}$$

$$\alpha = 1.8\ Km/hr - \sec$$

---------- **(1/2 Marks)**

iv) Given Data

V_{sch} = 50Km/hr D= 5 M T_{stop} 50 sec α = 3 km/hr-sec β = 2 Km/hr.sec

Solution:

- $V_{sch} = \dfrac{3600\,D}{Schedule\ Time\ (T_{sch})}$ ----------**(1/2 Mark)**

  $\therefore\ Schedule\ Time\ (T_{sch}) = \dfrac{3600 \times D}{V_{sch}}$

  $\therefore\ Schedule\ Time\ (T_{sch}) = \dfrac{3600 \times 5}{50}$

  $\therefore\ Schedule\ Time\ (T_{sch}) = \dfrac{18000}{50}$

  $\therefore\ Schedule Time(T_{sch}) = 360$ sec.---------- **(1/2 Mark)**

- $Schudele Time(T_{sch}) = Actual\ Time\ of\ Run\ (T) + Stop\ time\ (T_{stop})$

  $\therefore\ Actual\ Time\ of\ Run\ (T) = Schedule Time\ (T_{sch}) - Stop\ time(T_{stop})$

  $\therefore\ Actual\ Time\ of\ Run\ (T) = 360 - 50$

  $\therefore\ Actual\ Time\ of\ Run\ (T) = 310$ sec. ---------- **(1/2 Mark)**

- Maximum Speed =

  $V_{max} = \dfrac{T - \sqrt{T^2 - 4K3600D}}{2K}$ ---------- **(1/2 Mark)**

  But, $K = \dfrac{\alpha + \beta}{2(\alpha \times \beta)}$ ---------- **(1/2 Mark)**

  $K = \dfrac{2+3}{2(2\times 3)}$

  $K = 0.4167$ ---------- **(1/2 Mark)**

Now, $V_{max} = \frac{T - \sqrt{T^2 - 4K3600D}}{2K}$ ---------- **(1/2 Mark)**

$$V_{max} = \frac{310 - \sqrt{310^2 - 4 \times 0.4167 \times 3600 \times 5}}{2 \times 0.4167}$$

$$V_{max} = \frac{310 - 257.09}{2 \times 0.4167}$$

$V_{max} = 63.4869$ Km/hr ----------Answer---------- **(1/2 Mark)**

Q.4 B) Attempt any one of the following **6 Mark**

i) Define the following terms related to illumination. **(Each Definition 1 Mark)**

1) Luminous intensity:-

The Luminous flux emitted per unit solid angle is called the luminous intensity of the source. And its **unit is Candela**

2) Depreciation Factor :

$$= \frac{Illumination\ under\ normal\ condition\ of\ old\ installation}{Illumination\ under\ ideal\ conditions\ of\ new\ installation}$$

3) MSCP : (Mean spherical candle power)

It is the mean of candle powers in all directions in all planes.

4) Luminous flux (F):-

The total energy radiated by a source of light in all directions in unit is called Luminous flux. And its **unit is Lumen**

5) Solid angle:-

The angle subtended at a point in space by an area is called solid angle.

6) Lumens:-

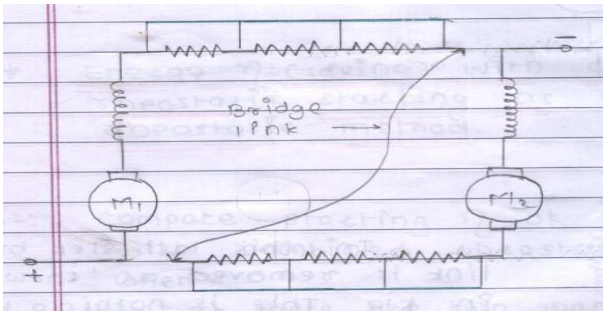
One lumen is defined as the luminous flux emitted in a unit solid angle by a source of one candle power. i.e Lumens = Candle power x solid angle ,It is unit of luminous flux.

ii) Sketch and explain the various steps required for bridge transition system.

(Each Step 1.5 Marks)

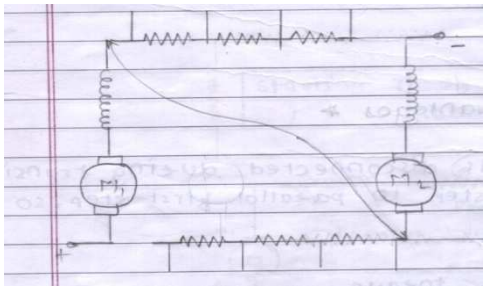
In bridge transition, series last step to parallel first step, is carried out by following steps

Step i) - Bridge link is connected between two motors as shown in figure**.**



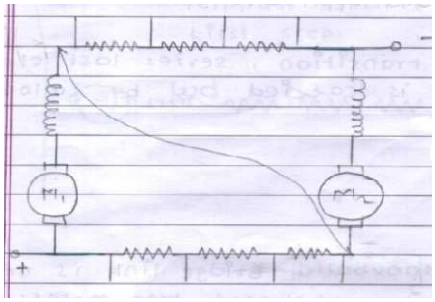
or Equivalent fig.

Step ii) - Bridge link is so rotated that two motors are put in series without starting resistance. Which are un-shorted at the same time



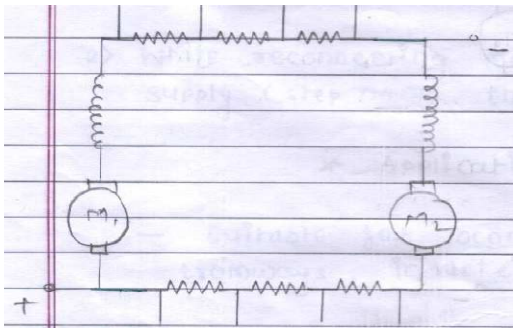
or Equivalent fig.

Step iii) – The portion of external resistance are connected in each motor circuit as shown in fig.



or Equivalent fig.

Step iv) – In this last step bridge link is removed as shown in fig. This is the parallel first step.



or Equivalent fig.

Q.5 Attempt any Four of the following.

i) State and explain any four desirable characteristics of traction Motor.

Following Characteristics of traction motor:

(Any four Points expected following Characteristics: 1 Marks each point)

A) Mechanical Properties or characteristics:

1) It should be robust in construction & simple in design to withstand against continuous vibrations.
2) Weight of motor per HP should be minimum in order to increase pay load capacity.
3) It must be small in overall dimensions, specially in overall diameter.
4) It must have totally enclosed type enclosure to provide protection against entry of dirt, dust in drive.
5) When motors are running in parallel they should share almost equal load. (even where there is unequal wear & tear of wheels)

B) Electrical Properties or characteristics:

6) It should be having starting torque.
7) It should possess high rate of acceleration & retardation.
8) It should be variable speed motor.
9) Its speed-torque characteristics should be such that as torque increases speed decreases, due to this characteristic motor is protected against overload.

10) Motor must be capable of taking excessive overload in case of emergency.
11) It should have simple speed control methods.
12) Electrical braking system should be reliable, easy to operate and control, specially regenerative braking is possible.
13) Motor should draw low inrush (Starting current) current.
14) It should withstand for voltage fluctuation without affecting its performance.

C) General Properties or characteristics:

15) It should have less maintenance cost.
16) It should have high efficiency.
17) Long life.
18) Low initial cost.

ii) Compare AC welding with DC welding on the following points: (Each Point 1/2 Mark)

S.No	Points	AC Welding	DC Welding
1	Equipment	Welding Transformer	DC differential Compound Generator, or Rectifier
2	Operating Efficiency	High	Low
3	Cost	Low	High
4	No load voltage	2 to 20V	50 to 60V
5	Power Factor	Low	Not applicable
6	Arc Blow	Not So Pronounced (Not effective)	Pronounced (effective)
7	Heating Effect	Not Uniform	Uniform
8	Arc Stability	Use of series Reactor	D.C Differential component. Generator has dropping characteristics.

iii) State any four factors to be considered for selection of shape and size of the car of the elevator. (Any four point Expected Each Point 1 Mark)

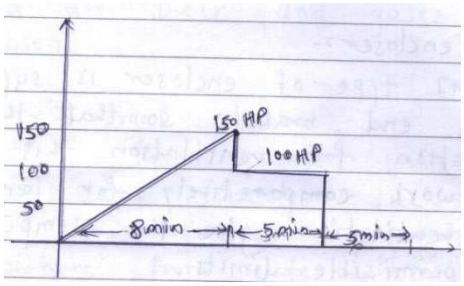
Following factors to be considered for selection of shape and size of the car of the elevator:

- Number of passengers to be carried**:**

- While selecting the size of car it is an usual practice to allow a space of 2 Sq.fit per person.
- Average weight of passenger is assumed to be 68 Kg per person.
- Thus the maximum load capacity of elevator is considered 34 Kg per sq.ft.
- There should be wide frontage and shallow depth.
- Limitation in the building design:-Shape of elevator depends on space available in building.

iv) Given Data:

i) Load rising from 0 to 150 HP :- 8 min
ii) Constant load of 100 HP :- 5 min
iv) No load :- 5 min



or Equivalent fig----------(1/2 Marks)

Where, $T = t_1 + t_2 + t_3$ ---------- **(1 Mark)**

$T = 8 + 5 + 5$

T = 18 min.---------- ---------- **(1/2 Marks)**

$$HP = \sqrt{\frac{\frac{1}{3}\left(H_1^{\,2} + H_1 H_2 + H_2^{\,2}\right)\times t_1 + H_3^{\,2} t_2 + H_4^{\,2} t_3}{18}}$$ ----------**(1 Mark)**

$$HP = \sqrt{\frac{\frac{1}{3}\left(0^2 + 0\times 150 + 150^2\right)\times 8 + 100^2 \times 5 + 0^2 \times 5}{18}}$$ --------- ---------- **(1/2 Marks)**

$$HP = \sqrt{\frac{110000}{18}} = HP = 78\ HP$$ ----------Answer---------- **(1/2 Marks)**

v) Enlist eight advantages of electric traction system.

(Any Eight Point Expected 1/2 Mark Each point)

Advantages of Electric Traction:-

1) **Cleanliness: -** Since there is no burning of fuel. There is no Ash and smoke.
2) **Starting Time: -** Electric locomotive can start any time & it is quick.
3) **Underground Facility: -** As there is no smoke electric traction system is more suitable for underground railway.
4) **High rate of acceleration and retardation:-** Electric traction system has high rate of acceleration of 1.5 to 2.5 kmphps. As against 0.5 to 0.8 kmphps. in case of steam locomotive also retardation is high.
5) **Schedule Speed: -** As rate of acceleration and retardation is high electric traction is able to achieve high schedule speed.
6) **Traffic Handing Capacity: -** Due to high schedule speed traffic handling capacity of electric traction is double that of steam traction system.
7) **Maintenance and running cost: -** Electric locomotive maintenance is about 50% less than that of steam locomotive. Hence maintenance cost and running cost is less.
8) **Time required for maintenance: -** Electric traction system requires much less time for maintenance. So availability of engine (motor coach) on track is more.
9) **Speed and speed control: -** With electric locomotive it is possible to obtain high co-efficient of adhesion. So we can run electric locomotive at higher possible speed. Also speed control methods are easy.
10) **Braking: -** Electric Braking system is most reliable and smooth. There are less friction lossess of break shoes and track. Also regenerative breaking is possible when train is going down the gradient. So we can convert 80% of kinetic energy into electrical energy.
11) **Absence of unbalance forces:-** Due to absence of unbalance forces co-efficient of adhesion is more in case of electric traction.
12) **Riding Quality:-** Due to absence of unbalance forces riding quality of electric traction is better(Smooth running, less vibration)

13) Centre of gravity:-Centre of gravity of electric locomotive is lower than that of steam locomotive. Due to this higher speeds are possible even at curvature track.

14) Increase in line (Track) capacity:- Due to use of electric traction system line capacity increases because electric traction system has high rate of acceleration and retardation, due to absence of unbalance forces, higher speeds are possible.

15) Pay-load Capacity: - High pay load capacity because no additional fuel storage is required to carry.

16) Flexibility of operation: - electric traction unit can be run in both directions also we can add number of traction unit (motor coach) in existing railway as per traffic density.

17) Efficiency: - Stand by losses is zero. So electric traction system has highest efficiency than any other type of traction system

vi) Explain any four disadvantages of Low power factor.

(Any Four Point Expected 1 Mark Each Point)

Disadvantages of Low power Factor: -

1) Cross section of conductor increases: - (C/s of conductor $\alpha\ I\ \alpha 1/(pf)$ OR As power factor reduces current increases, cross section of conductor increases. Hence its cost increases.

2) Design of supporting structure: - As power factor reduces, cross section of conductor increases, so its weight increases. To handle this weight design of supporting structure becomes heavier, so its cost increases.

3) Cross section of terminals increases: - As power factor reduces, current increases, Hence cross section of switch gear, bus bar, contacts, and terminals increases. So its cost increases.

4) Copper losses increases: - (copper losses $\alpha\ I^2\ \alpha\ 1/pf$) OR As power factor reduces current increases. So copper losses increases. As a effect efficiency reduces.

5) Voltage drop increases: - ($Voltage\ drop\ \alpha\ I\ \alpha 1/pf$) OR As P.f reduces current increases. Therefore voltage drop increases, so regulation becomes poor.

6) Handling Capacity of equipment reduces: Handling capacity (KW) of each equipment reduces as power factor reduces.

7) **High KVA rating of equipment required:-** $KVA \propto I \propto 1/pf$, OR As power factor decreases KVA rating of all equipments increases, so that its cost increases.

8) **Cost/unit increases: -** From all above disadvantages it is seen that cost of generation, transmission & distribution increases. Also its performance efficiency & regulation reduces, So that cost/unit increases.

Q.6 Attempt any four of the following **16 Marks**

i) Explain any four causes of failure of heating elements. (Any Four Point Expected 1 Mark Each Point)

Following of the different causes of failure of heating element:

i) Formation of hot spot:

Hot spot on heating element is the point which is at higher temperature than remaining heating element portion. So there is possibility of breaking of heating element at hot spot.

ii) Due to oxidization:

At high temperature material gets oxidized which may cause failure of heating element.

iii) Due to corrosion:

If heating element is directly exposed to chemical fuses then there is possibility of rusting of heating element which causes failure of heating element.

iv) Mechanical Failure:

Measure heating element alloy contain iron which is brittle. Due to frequent heating & cooling of heating element, it may break (fail) due to small mechanical injury also.

ii) Given Data:

Weight of charge brass: 1500 Kg (1.5 T)	Latent heat of fusion of brass = 38 Kcal/Kg
Initial temperature of brass = 20^0C	Melting point of brass = 920^0C
Specific heat of brass = 0.094	Efficiency expected = 80% = 0.8%

Solutions:

- **Rise in temperature** = Melting temperature of charge – Temperature of charge

  $= 920^0C - 20^0C$

  Rise in temperature = 900^0C ---------- **(1/2 Mark)**

- Heat required to rise temp. of Charge = Specific heat of brass x Wt. of charge x Rise in Temp.

  $= 0.094 \times 1500 \times 900$

  Heat required to rise temp. of Charge = **126900 ^{0}K cal**---------- **(1/2 Mark)**

- Heat required to melt the metal = Latent heat of fusion X Weight of charge

  $= 38 \times 1500$

  = 57000 ^{0}K cal---------- **(1/2 Mark)**

- Total heat required = 126900 + 57000

  = 183900 K cal---------- **(1/2 Mark)**

- Input heat required for furnace = $\frac{Total\ heat\ required}{\eta\ of\ \ furance}$ ---------- **(1/2 Mark)**

  $= \frac{183900}{0.8}$

  Input heat required for furnace **= 229875 K cal** ---------- **(1/2 Mark)**

- Convert K cal into KWH = $\frac{229875}{860}$

  Energy required = 267.2965 KWH----------**Answer**----- **(1/2 Mark)**

- Rating of Furnace = $\frac{267.2965}{1.5}$

  Rating of furnace = 178.1976 KW----------**Answer**---- **(1/2 Mark)**

iii) Explain the factors governing selection of 3-Phase induction motor for electric drive.

(Any Four Point Expected 1 Mark Each Point)
(In case some questions credit may be given by judgment on part of examiner of relevant answer based on candidate understands.)

Following Factors governing selection of 3-ph induction motor:

i) **Nature of Drive (Motor):** Whether motor is used to drive individual machine or group of machines.

ii) **Nature of load:** Whether load required light or heavy starting torque or load having high inertia, require starting torque for long duration. **OR** Whether load torque increases with speed ($T \propto N$) or decreases with speed ($T \propto 1/N$) **or** remains constant with speed (T = N) or increases with square of speed ($T \propto N^2$)

iii) **Electric Characteristics of drive:** Starting, running, speed control and braking characteristics of electric drive should be studied and it should be matched with load.

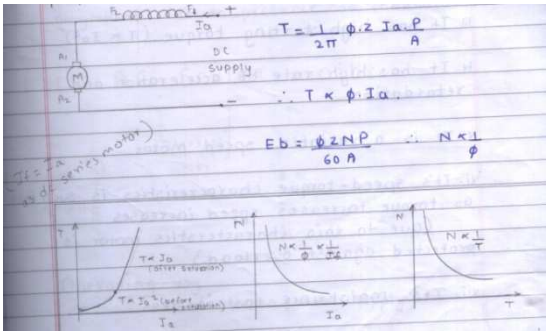
iv) **Size and rating of motor:** Whether motor is short time or continuously or intermittently running or used for variable load cycle. Whether overload capacity, pull out torque is sufficient.

v) **Mechanical Considerations:** Types of enclosure, Types of bearing, Transmission of mechanical power, Noise and load equalization etc.

vi) **Cost:** Capital, running and maintenance cost should be less.

iv) Explain the factors governing selection of DC series motor for traction duty. (Any Four Point Expected 1 Mark Each Point)

Due to following characteristics and advantages of DC series motor it is suitable for traction duty: 1) Characteristics



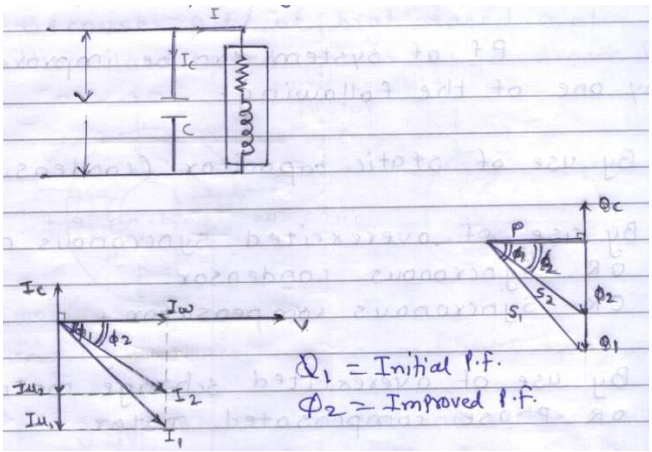
or Equivalent fig.

Due to above characteristics shown on figure DC series Motor is suitable for traction purpose.

1) DC series motor has High torque at low speeds, low torque at high speeds, this is the basic requirement of traction unit.
2) DC Series motor robust in construction and capable to withstand against continuous vibration.
3) DC series motor weight is 1.5 times less than 1-Ph AC series motor for same H.P.
4) DC Series motor has high starting torque.
5) DC Series motor has high rate of acceleration and retardation.
6) DC Series motor variable speed motor.
7) DC Series motor speed-torque characteristics are such that as torque increases speed increases. (Due to this characteristics motor is protected against overload)
8) DC Series motor maintenance cost is less.
9) When DC series motor are running in parallel the all motors share almost equal load.
10) Torque obtained by DC series motor is smooth and uniform, so it improves riding quality.

v) Explain briefly the static capacitor method of power factor improvement.

(1 Marks for any one figure, Vector diagram 1 Mark, Formula 1 Mark & advantages & disadvantages (Any Two) – 1 Mark)



$$I_2 = \sqrt{(I_w)^2 + (I\mu)^2}$$

Calculation from current vector diagram: $I_w = I \times Cos\phi_1$

$$I_C = I\mu_1 - I\mu_2 \quad \therefore I_C = [I\mu_1 \tan\phi_1] - [I\mu_2 \tan\phi 2]$$

Now, $I_C = \frac{V}{X_C}$ $\therefore X_C = \frac{V}{I_C}$ $\therefore X_C = \frac{1}{2\times\pi\times f\times c}$

$$\therefore C = \frac{1}{2\times\pi\times f\times X_C}$$

$$I_2 = \sqrt{(I_w)^2 + (I\mu)^2}$$

Calculation from power triangle = $Q_C = Q_1 - Q_2$

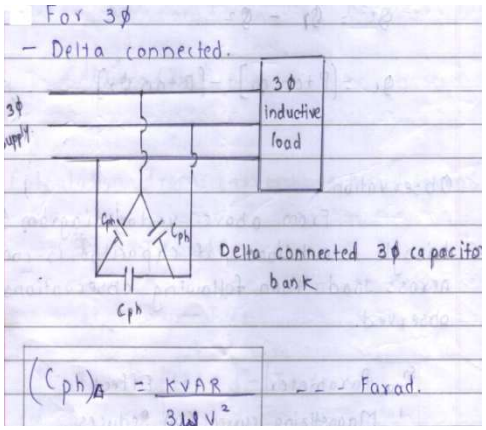
$$Q_C = [P \tan\phi_1] - [P \tan\phi_2] \text{ KVAr rating of capacitor}$$

Observation:

- From above vector diagram & power triangle calculations, if capacitor is connected across load than following observations are observed.

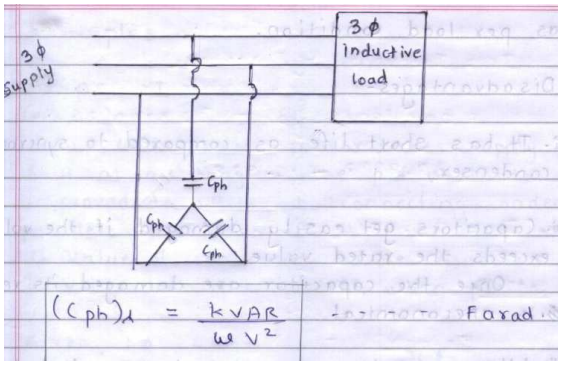
S.No.	Parameter	Effect
1	Magnetizing current ($I\mu$)	Reduces
2	Power factor	Improves
5	Total current	Reduces
4	Lagging reactive power (KVAr)	Reduces

- **Connection diagram to connect capacitor to improve power factor (Delta connection)**



$\omega = 2\pi f$

- **3-ph Star connected Capacitor Bank:**



- **Advantages of Static Capacitor: (Expected any two)**
  1. Initial cost is low.
  2. Low operating cost.
  3. Low maintenance cost.
  4. Losses are very less (less than 0.5%)than that of rated value
  5. Noise less operation as it is a static piece.
  6. Less space is required. Therefore can be installed near load.
  7. Greater reliability.
  8. KVAr (leading) rating can be adjusted easily as per load condition.
- **Disadvantages of Static Capacitance: (Expected any two)**
  1. It has short life as compared to synchronous condenser.
  2. Capacitors get easily damaged if the voltage exceeds than its rated value. Once the capacitors are damaged its repair is uneconomical.
  3. When capacitor is switched OFF then precaution is taken before making it ON. In between OFF and ON time, time should be kept to discharge the capacitor, otherwise capacitor may fail.
  4. Switching current of capacitor is many times that of rated current; therefore cable size should be double of the normal current carrying capacity, so its cost increases.
  5. When there is no load or system is lightly loaded at that time capacitor bank must be made OFF otherwise voltage across transformer increases.

----------END----------