Important suggestions 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.
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) Some of the questions are not clearly indicative of the exact answer expected. In such cases, credit may be given by judgment of relevant answer based on candidate's understanding.

Page No: 1 to 28 Model Answer Paper Solution and Page No: 29 to 31 Question Paper & Summery of Marking Scheme

Q.1 a) Attempt Any Three of the following:

i) Define Terms: i) Light ii) Luminous flux iii) Lumens iv) Lux

(1mark to each definition total 4 mark)

1) Light:-

It is defined as that radiant energy from hot body which produces the visual sensation upon the human eye. It is denoted by 'Q' and expressed in Lumen-hours

2) 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

3) 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

4**) Lux** :-

It is unit of illumination and it is defined as luminous flux falling per unit area **OR** It is defined as the luminous flux falling per square meter on the surface which is perpendicular to the rays of light from the source of one candle power and one meter away from it. **OR**

It is defined as the illumination of the inside of a sphere of radius 1 m and a source of 1 C.P is fitted at the centre of sphere.

ii) State any four Differences between group drive & individual Drive (1mark to each point total 4 mark)

S.No.	Point	Group Drive	Individual Drive
1.	Initial Cost	Less	High
2.	Flexibility	Less Flexibility	More Flexibility
3	Safety	It is less Safe	It is more safe
4	Reliability	It has less reliability	It has high reliability
5	Space required	Less	More
6	Overload Capacity	Higher	Less
7	Maintenance cost	Less	More
8	Speed control	Difficult	Easily possible
9	Mechanical Power transmission losses	More Losses	Less losses
10	Addition/Alternation	Limited	Easily possible

iii) State different methods for starting of Induction motors. Explain any one method
(3Marks for name of different methods for starting &1mark for explanation)

Note: Accept any three names of starting of I.M from list below for three phase Induction Motor:-

1) Direct-on-line Starter.(DOL)
2) Stator resistance starting.
3) Autotransformer starting.
4) Star-delta Starting
5) Rotor Resistance Starting.

For Single phase Induction Motor:-

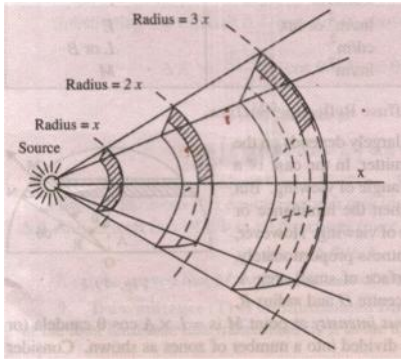
1) Split phase induction motor.
2) Capacitor Start induction motor.
3) Capacitor Start capacitor run induction motor.

Explanation: - Accept any one short explanation of above methods

iv) State: - 1) Law of inverse squares 2) Lambert's cosine law

(Figure 1 Mark & Statement 1 Mark for each law)

1) Inverse Square Law:-

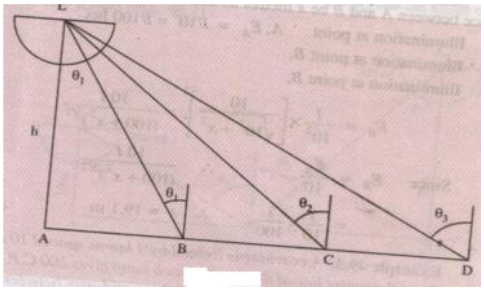


or Equivalent fig.

Illumination inversely proportional to Square of distance between sources of distance of the surface from the source $E \sim \frac{1}{r^2}$

2) 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.

$E_B = E_A \cos^3 ¤_1$, $E_C = E_A \cos^3 ¤_2$,

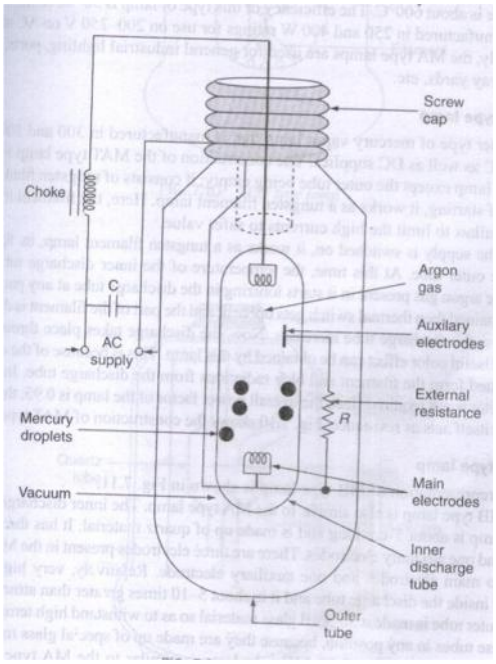
$E_D = E_A \cos^3 ¤_3$ *and so on.*

b) Attempt Any one of the following:

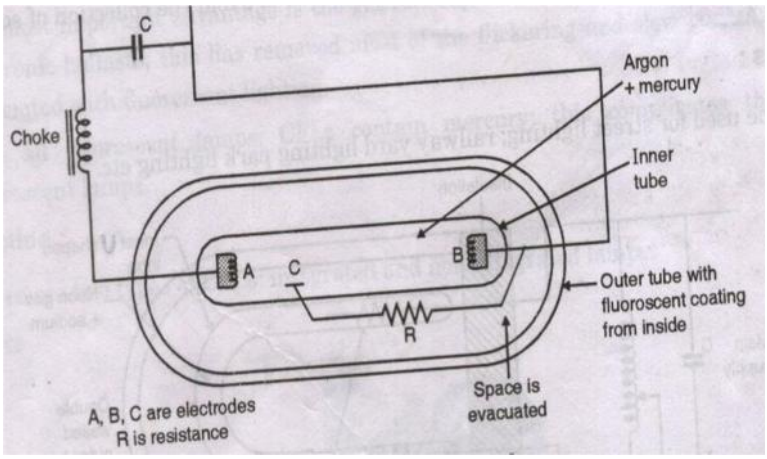
i) Explain working of High Pressure Mercury Vapour Discharge Lamp

(3 Mark for any one fig., & 3 Marks for Working. Total 6 Marks)

Figure :-



OR



Working:-

- When supply is switched on an initial discharge lamp is established in the Argon gas between main electrode A and aux. electrode C
- The heat is produced due to the discharge through gas which causes warming up of inner lamp
- Thus mercury gets vaporized and increasing its pressure and thus the light output.
- It takes about 5-7 min. for the mercury arc to buildup &give full light output.
- After 3-4 min. mercury vapors is greenish blue light.
- If the supply interrupted, the lamp must cool down and the vapour pressure be reduced before it will start. It takes approximately 3-4 min.
- The efficacy of this type of lamp is 30-40 lumens/W.
- Mercury lamps are available in 125W; 250W & 400W rating for use 250V AC Supply.

ii) Given Data :

Volt : line volts V = 400V, f= 50 Hz P= 200kW $\cos\phi_1$=0.8 $\cos\phi_2$ =1

$\therefore \tan\phi_1 = 0.75$, $\tan\phi_2 = 0$ ----------**(1/2 Mark)**

$Q_1 = P \tan\phi_1$ ---------- **(1/2 Mark)**

= 200 x 0.75

= 150 KVAR ---------- **(1/2 Mark)**

$Q_2 = P \tan\phi_2$ ---------- **(1/2 Mark)**

= 200 x 0

= 0 KVAR ---------- **(1/2 Mark)**

$KVAR = P (\tan\phi_1 - \tan\phi_2)$

$Q_C = Q_1 - Q_2$ ---------- **(1/2 Mark)**

= 150-0

= 150 KVAR ---------- **(1 Mark)**

∴ 1) Capacitor when connected in Star :-

$$C \ per \ phase = \frac{QC}{\mu \ V^2}$$

$$C \ per \ phase = \frac{150 \times 10^3}{2® \times 50 \times 400^2}$$

$$C \ per \ phase = \frac{150 \times 10^3}{50.265 \times 10^6}$$

$$C \ per \ phase = 2.984 \times 10^{-3} \text{ F}$$ ---------- **(1 Mark)**

∴ 2) Capacitor when connected in Delta:-

$$C \ per \ phase = \frac{QC}{3\mu \ V^2}$$

$$C \ per \ phase = \frac{150 \times 10^3}{3 \times 2® \times 50 \times 400^2}$$

$$C \ per \ phase = \frac{150 \times 10^3}{3 \times 50.265 \times 10^6}$$

$$C \ per \ phase = 9.947 \times 10^{-4} \text{ F}$$ ---------- **(1 Mark)**

Q.2 Attempt Any Four of the following

a) State Different types of interior Lighting System. Explain each of them in short.

(2 Marks for list of lighting system & 2Mark for explanation)

Different types of interior Lighting System :-

1) Direct lighting Scheme

2) Semi direct Lighting Scheme

3) Indirect Lighting Scheme

4) Semi-indirect lighting Scheme

5) General Lighting Scheme

1) Direct Lighting Scheme:-

- It is possible to make 90 % of light falls just below the lamp. And 10% upper hemisphere.
- This scheme is more efficient but it suffers from hard shadows and glare.

2) Semi direct Lighting Scheme:-

- In this scheme 60-90% of lamps luminous flux is made to fall down.
- It provides uniform distribution of the light and avoids glare.
- This type of scheme is employed in rooms with high ceiling.
- This scheme gives high brightness and efficiency.

3) Indirect Lighting Scheme:-

- In this lighting scheme 90% of total light is thrown upwards to the ceiling.
- This system provides less shadow.
- This scheme is very useful for function halls ,cinema theatres ,star hotels ,drawing offices and workshop .

4) Semi- indirect Lighting Schemes:-

- In this scheme about 60-90% of light is projected upwards to the ceiling and the remaining light reaches the working surface.
- In this scheme shadows are faint and fittings are used for indoor lighting decoration purpose.

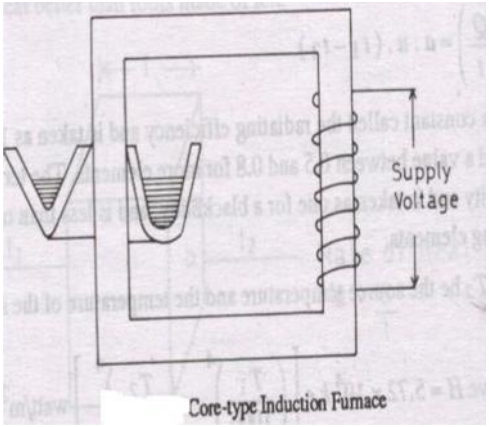
5) General Lighting Scheme:-

- This scheme of lighting use diffusing glasses to produce the equal illumination in all directions.
- Mounting height of the source should be much above eye level to avoid glare.

b) Explain working principle of induction arc Furnace:

(2 Marks for fig. & 2 Marks for explanation- total 4 Marks)

Note :- This question is not clearly indicate either to write direct or indirect Induction Furnace OR Arc Furnace, So accepts any one answer from these two furnaces:



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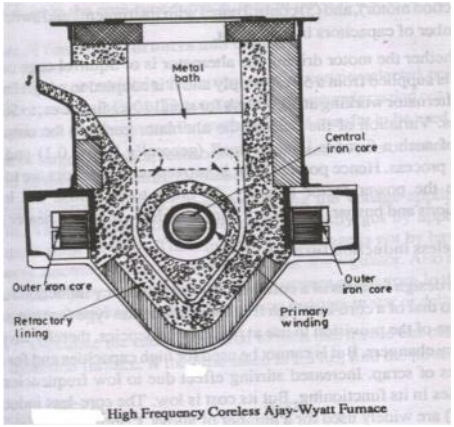


or Equivalent fig.

Working of core type Furnace:-

It is based on principle of transformer. In This type primary winding is as usual which is wound around the magnetic core but secondary winding is actually charge which to be melted.

When AC supply is given to primary winding current flows through primary winding which create alternating flux in magnetic core. This flux links to secondary winding i.e charge through magnetic core.

As charge forms a close circuit (i.e short circuited), so heavy current flows through the charge. This current is responsible to produce heat in the charge due to I^2R losses. Where R is the resistance of charge & I is the secondary current.

This heat is utilized for melting charge.

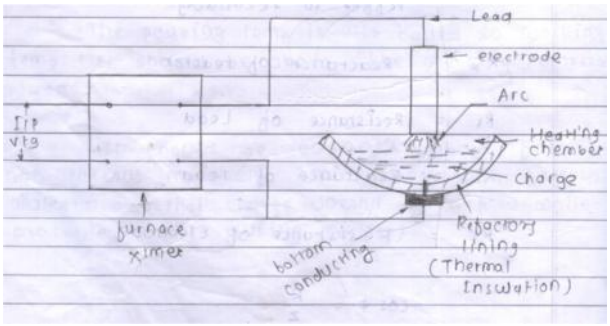
OR

Arc Furnace: - In case of arc heating arc is struck between electrodes and charge either by

1) Applying high voltage between two electrodes to produce arc and after producing arc normal voltage is applied
2) Or by separation of two current carrying electrodes suddenly to produce arc.

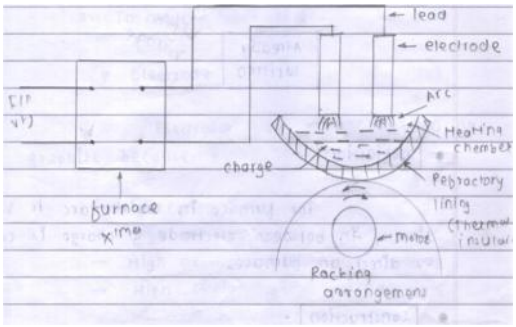
(Only one figure is expected from below)

a) Bottom Conducting direct arc Furnace

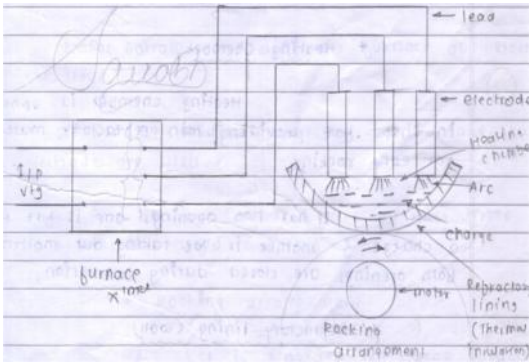


OR

b) 1-ph direct arc Furnace

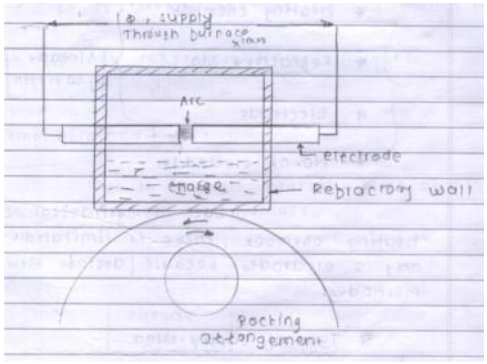


c) 3-Ph direct arc Furnace



OR

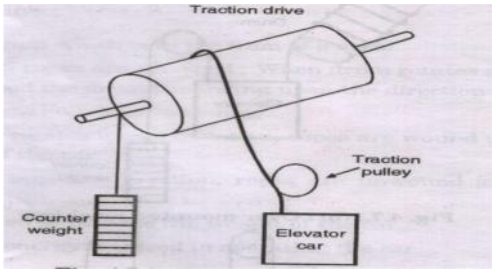
d) Indirect Arc Furnace



or Equivalent fig.

c) Explain Working of Traction Elevators

(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.

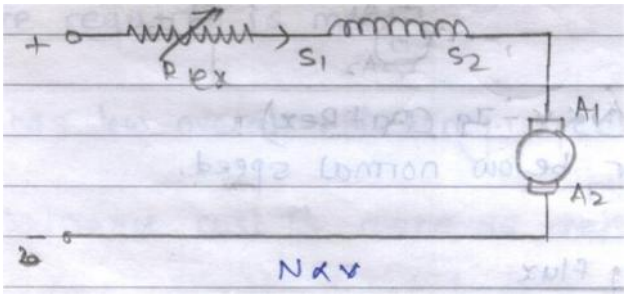
d) Explain any two methods of Speed control of DC Series Motor.

(2 Marks for each method total 4 Marks)

Methods of speed control

i) By Varying $I_a.R_a$ drop.(Armature voltage control method)
ii) By varying flux (Flux control method)

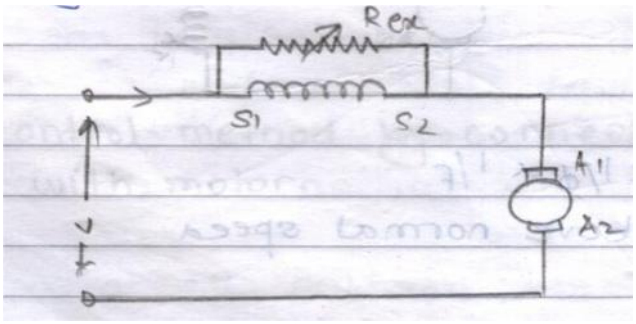
1) By inserting R_{ex} in series with motor (Armature Voltage control) :-



Speed below normal speed.

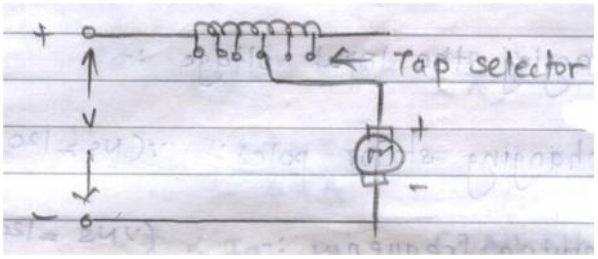
2) Flux Control Method:- (Any one fig. is expected from the following fig.)

a) By using filed diverter:-



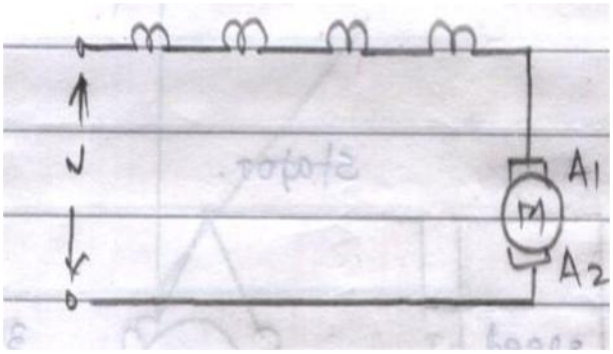
$N \sim \frac{1}{\phi}$ above normal speed control.

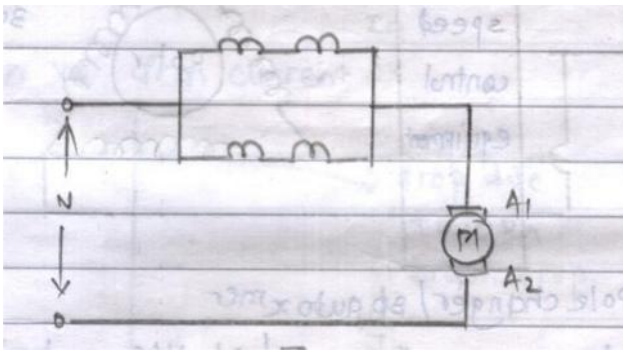
b) Tapped Field Control:-

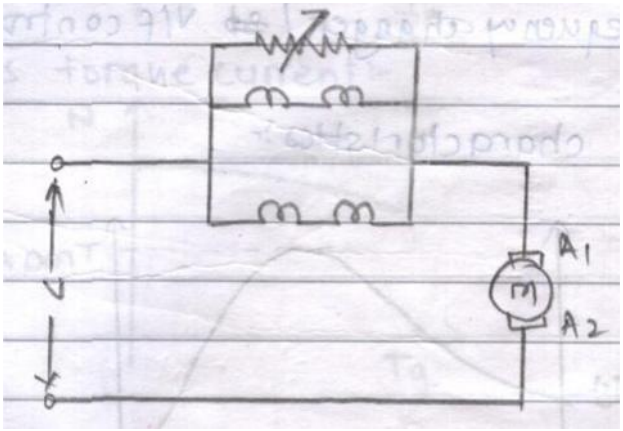


N ~ 1/¤ above normal speed control.

c) Regrouping of Field coils/ parallel connection of field coil:-







or Equivalent fig N ~ 1/¤ above normal speed control.

d) State any four advantages and four disadvantages of electric traction.

(1/2 Mark to each point in advantages any four points & 1/2 Mark to each point in disadvantages any four point total 4 Mark)

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 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 loss 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 speed 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.

Disadvantages of Electric Traction:-

1) **High Capital Cost: -** There is high capital cost for track electrification, so electric traction system is not economical for low traffic density.
2) **Not self- content: -** Electric traction system depends on external power supply, so it is not self-content. Power failure for few minutes can cause dis-location of traffic for hours.
3) **Track limitation: -** Electric traction system is only run where track is electrified.
4) **Disturbance to communication line: -** There is disturbance to communication line which is run near track.
5) **Effect of Ground return: -** In case of DC track electrification if ground is used as a return path then due to chemical action it causes corrosion of underground steel/metal work.

f) State any four disadvantages of Low power factor.

(1 Mark to each point -any four -total 4 Marks)

Disadvantages of Low power Factor: -

1) **Cross section of conductor increases: -** (C/s of conductor ~ $I \sim 1/(pf)$ 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 ~ $I^2 \sim 1/pf$) OR As power factor reduces current increases. So copper losses increases. As a effect efficiency reduces.
5) **Voltage drop increases: -** ($Voltage\ drop \sim I \sim 1/pf$) 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:-** $KVA \sim I \sim 1/pf$, 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.3 Attempt Any Four of the following

a) Explain effect of each of following on design of illumination:

(1Mark to each point total 4 Marks)

The following points if not considered result in inadequate / improper illumination design.

i) Shadows: - Shadows should be minimum.

ii) Glare: - Glare should be minimum.

iii) Uniformity: - uniform distribution of light throughout the working plane.

iv) Colour of light: - Choose fitting which produces colour like a day light e.g. Fluorescent tube

b) State any six application of Dielectric heating. Application of Dielectric Heating :-

(3 Marks for first four points & 1/2 Mark to each next two point -total 4 Marks)

Application of Dielectric Heating:-

1) In food processing industry, dielectric heating is used for Baking of cakes & biscuits in bakeries. Cooking of food without removing outer shell (eg-boiled egg) and pasteurizing of milk.
2) For Rubber vulcanizing.
3) In Tobacco manufacturing industry for dehydration of tobacco.
4) In wood industry for manufacturing of ply wood.
5) In plastic Industry for making different containers.
6) In cotton industry for drying & heating cotton cloths for different processes.
7) In tailoring industry for producing threads.
8) For manufacturing process of raincoats & umbrellas.
9) In medical lines for sterilization of instruments & bandages.
10) For heating of bones & tissues of body required for certain treatment to reduce pains & diseases.
11) For removal of moisture from oil.
12) For quick drying gum used for book binding purpose.
13) In foundry for heating of sand, core, which are used in molding process.

c) Given Data :

240 Nm for 20 min. Speed of motor : 720 rpm
140 Nm for 10 min. Rating of motor (KW) =?
300 Nm for 10 min. 200 Nm for 20 min.

Duty Cycle (T) $= t_1 + t_2 + t_3 + t_4$

$= 20+10+10+20$

$= 60$ Min. ---------- (1/2 Marks)

$$rating\ of\ motor\ (Torque) = \sqrt{\frac{T_1^2 \times t_1 + T_2^2 \times t_2 + T_3^2 \times t_3 + T_4^2 \times t_4}{T}}$$ ---------- (1/2 Marks)

$$rating\ of\ motor\ (Torque) = \sqrt{\frac{240^2 \times 20 + 140^2 \times 10 + 300^2 \times 10 + 200^2 \times 20}{60}}$$

$$rating\ of\ motor\ (Torque) = \sqrt{\frac{3048000}{60}}$$

$$rating\ of\ motor\ (Torque) = \sqrt{50800}\ Nm$$

$$rating\ of\ motor\ (Torque) = 225.38\ Nm$$ ---------- (1 Mark)

$$\therefore rating\ of\ motor\ (watt) = \frac{2\Re\ N\ T}{60}$$ ---------- (1/2 Mark)

$$rating\ of\ motor\ (watt) = \frac{2\Re \times 720 \times 225.38}{60}$$

$$rating\ of\ motor\ (watt) = 16995.4\ Watt$$ ---------- (1 mark)

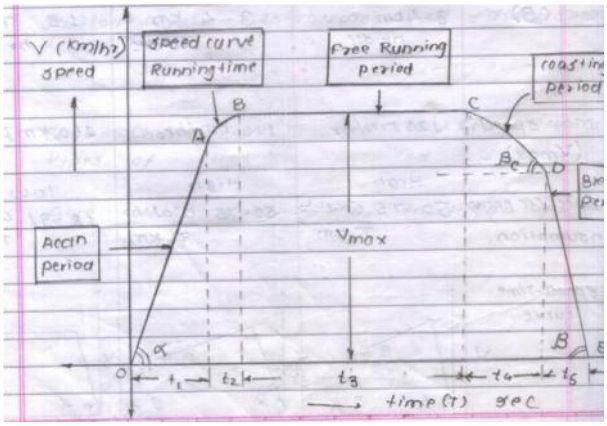
$$rating\ of\ motor\ (Kw) = \frac{16995.4}{1000}$$

$$rating\ of\ motor\ (kw) = 16.995\ kW$$ i.e.

$$\therefore rating\ of\ motor\ (kw) = 17\ kW$$ ----------(1/2 Mark)

d) Draw a typical speed time curve for traction line service; show different time periods on it.
(3 Mark for drawing curve & 1 Mark for showing time period)

Speed time curve for main traction line services:



or Equivalent fig

e) State any two causes of low power factor. State any two methods for improving power factor.

(1mark to each-any two causes & 1Mark to each –any two methods)

Causes of low power factor: -

i) Magnitude of Magnetizing Current (I «):- As magnetizing current increases, power factor reduces.

ii) Due to use of Induction Motor:- Most of industrial drives, agriculture pumps, lift, irrigation pump set uses I.M. which works at lagging power factor, So power factor reduces.

iii) Due to use of Transformer: - All transformers works at lagging power factor, so power factor of system reduces.

iv) Due to welding transformer: - Welding transformers are operated at low p.f. which reduces p.f. of the system.

v) Due to inductance of transmission & distribution Line: - In case of AC transmission & distribution lines, inductance is present which is the main cause of low power factor.

vi) Series Reactor:- Series reactor is used in substation to minimize fault current causes low power factor.

vii) Industrial electrical heating furnaces:- Induction and arc furnace used in steel manufacturing industry works at low p.f. which reduces p.f. of the system.

viii) Arc Lamp:- Arc lamp & electric discharge lamps operates at low p.f.so p.f. of the system reduces.

ix) Equipments operated at light load:- P.f. falls if equipments like alternator, transformer, I.M etc are not operated at full load.

x) Improper repairs and maintenance:- P.f. falls if proper maintenance or repairs of equipments are not done.

Methods of improving power factor:-

1) By use of static capacitor (Condenser)
2) By use of over excited synchronous motor (Synchronous condenser)
3) By use of over excited Schrage motor
4) By use of phase advancer.

OR

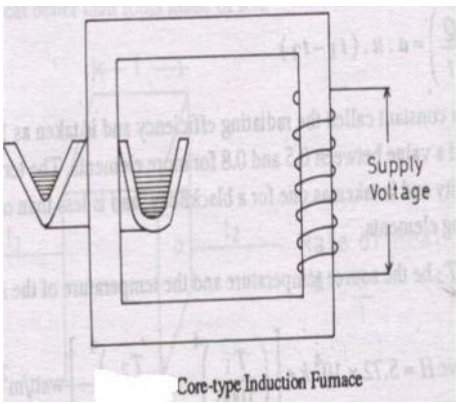
Methods of improving power factor:-

1) Use Dc supply for transmission & Distribution of AC supply:- As far as possible Dc drives are used instead of AC drives by some arrangement (using rectifier)
2) Use overexcited Synchronous motor and Schrage motor to get mechanical power instead of induction motor.
3) Use high speed I.M instead of low speed I.M because P.f. of high speed motor is more than low speed motor as it draws less I_u.
4) Air gap between Stator and rotor should be kept as minimum as possible. Due to this, leakage flux reduces. So motor will draw less Iu, So its P.f. gets improved.
5) All electrical equipments such as Alternator, transformer, motor has maximum Power factor. When fully loaded, so select the rating of all electrical equipments such that it always operated at full load.
6) Switch I.M delta winding to Star winding, when load on motor reduces (50% of full load) to increase the power factor.
7) All equipments such has transformer, alternator, motor if needed to repair or maintenance, then it should be repaired properly to avoid low power factor. i.e it should be repaired from authorized companies servicing centre.

Q.4 a) Attempt Any Three of the following:

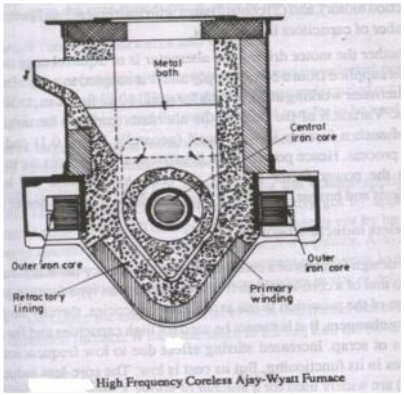
i) Explain working of direct core type of induction Heating:

(2 Marks to fig.& 2Marks for explanation total 4 Marks)



Core-type Induction Furnace

OR



High Frequency Coreless Ajay-Wyatt Furnace

or Equivalent fig.

Working of core type Furnace:-

It is based on principle of transformer. In this type primary winding is as usual which is wound around the magnetic core but secondary winding is actually charge which is to be melted.

When AC supply is given to primary winding current flows through primary winding which create alternating flux in magnetic core. This flux links to secondary winding i.e charge through magnetic core.

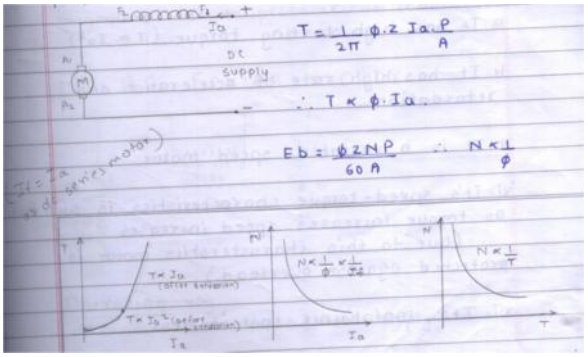
As charge forms a close circuit (i.e short circuited) So, heavy current flows through the charge. This current is responsible to produce heat in the charge due to I^2R losses. Where R is the resistance of the charge & I is the secondary current.

This heat is utilized for melting charge.

ii) State any four Characteristics which makes DC series motor suitable for electric traction:

(1 Mark to one point.)

Note : Either graph(diagram) or points are accepted



or Equivalent fig.

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

OR

Advantages of DC series Motor:

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

iii) Given Data:

Weight of train (W) :- 200 tonne

No. of Trains = 8 Nos

Gear ratio¥ = 4

Dia. of driving wheel = 90 cm = 0.9 m

Tractive resistance (r) = 50 N/ tonne

Gear efficiency ¦ = 80 %

Maximum speed V_m = 48 kmph

Up gradient 1 in 200 means G = 0.5%

∴ W_e= 1.10 x w

W_e= 1.10 x 200

W_e= 220 tonne---------- ----------(1/2 mark)

Acceleration (~) = $\frac{V_m}{t_1}$

Acceleration (~) = $\frac{48}{30}$

Acceleration (~) = 1.6 kmphps----------(1/2 mark)

Tractive effort $f_t = 277.8\ W_e \times \sim + 98.1 \times W \times G + W \times r$

Tractive effort $f_t = (277.8 \times 200 \times 1.6) + (98.1 \times 200 \times 0.5) + (200 \times 50)$

Tractive effort $f_t = (97785.6) + (9810) + (10000)$

Tractive effort f_t = 117595.6 *N* ---------- (1 mark)

Total Torque developed T = $\frac{F_t \times D}{¦ \times 2¥}$

Total Torque developed T = $\frac{117595.6 \times 0.9}{0.8 \times 2 \times 4}$

Total Torque developed T = $\frac{105836.04}{6.4}$

Total Torque developed T = 16536.8812 Nm---------- (1 mark)

∴ Torque developed by each motor = $\frac{T}{8}$

∴ Torque developed by each motor = $\frac{16536.8812}{8}$

∴ Torque developed by each motor = 2067.11 Nm---------- (1 Mark)

iv) Define:- 1) Average Speed 2) Schedule speed in traction Explain how increasing acceleration increases schedule speed.

(1.5 Mark for each definition & 1 Mark for reason for increase in schedule speed total 4 Mark)

1) Average Speed: - It is defined as distance covered between two stops divided by actual time of run is known as average speed. OR

$$V_{av} = \frac{3600D}{T}$$

Where T = is actual time of run in sec OR

$$Average\ Speed = \frac{Dis\tan ce\ between\ stops\ or\ stations}{Actual\ time\ of\ \ run}$$

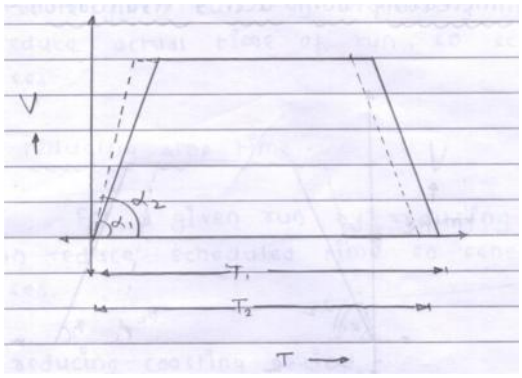
2) Schedule Speed: - It is defined as distance covered between two stops divided by schedule time is known as schedule speed. OR

$$Schedule\ Speed = \frac{Dis\tan ce\ between\ stops\ or\ stations}{(Actual\ time\ of\ \ run) + (Stop\ time)}$$ OR

$$Schedule\ Speed = \frac{Dis\tan ce\ between\ stops\ or\ stations}{Schedule\ time}$$

Effect of Increasing Acceleration:

For a given run by increasing acceleration we can reduce actual time of run, so schedule speed increases.



or Equivalent fig.

Q.4 b) Attempt any ONE of the following:

i) Explain meaning of: i) Flood lighting 2) Flood light projector. Explain different types of projector. **(2 Marks to each & 2 Marks for explanation total 6 marks)**

1) Flood Lighting: - Flood lighting means flooding of large surface area with light from powerful sources using projector.

2) Flood Light Projector: To concentrate the light from the light source into a beam on designated area is known as projector

There are three types of projector

a) Narrow beam Projector

b) Medium angle Projector

c) Wide angle Projector

a) Narrow beam Projectors: - Light beam with such a projectors spreads between 12^0 and 25^0. They can be employed for a distance of 70 meter.

b) Medium angle Projectors: - Projectors with beam spreads between 25^0 and 40^0. These are employed for a distance of 30-70 meter.

c) Wide angle Projectors: - Projectors with beam spreads between 40^0 and 90^0. They can be employed for a distance of 30 or below.

ii) Explain following system of track Electrification: 1) Single phase AC 2) Three phase AC

Note : Any three of the following points are acceptable for 1-ph & 3-Ph AC system. Either in the following form or in the form of paragraph.

(1 Mark to one point in case of Single Phase AC System & 3-Phase AC System –any three points from each system-total six mark)

1) Single Phase AC System:-

It is explained on following point:

i) Supply fed to traction sub-station:-

Traction sub-station receivers AC power from a 3-ph high voltage nearest transmission line. For e.g- 400KV, 220 KV etc

ii) Equipment in sub-station:-

In traction sub-station input voltage is step down to utilization voltage (1-ph, 25KV,AC) and its frequency is changed from normal frequency (50 Hz) to 25 Hz or $16^{2/3}$ Hz. So main equipments in traction substation are a) Step down transformer b) Frequency changer, c) Protective equipments, d) Switchgear e) Control panel etc

iii) Number of Overhead conductor :-

Single conductor contact wire is used and return being through rail.

iv) Normal Voltage fed to overhead conductor:

Voltage:- 1-ph,25 KV Ac or (15KV/1616KV) Frequency :- 25 Hz or $16^{2/3}$

v) Equipment in motor coach(locomotive):-

As working voltage of 1-ph AC series motor is 300/400 V AC. So supply voltage must be step down in locomotive with the help of step down transformer. This is installed in motor coach.

vi)Types of drives used :-

To obtain mechanical power to move the train 1-ph AC series motor is used. The working voltage of motor is 1-ph AC, 300/400V

vii) No. of traction sub-station required:-

No. of traction sub-station required are less then DC track electrification system for same track distance because voltage drop in line is less in case of 1-Ph, 25KV, AC system.

viii) Application :-

This system used for main line services because cost of track electrification is less then DC Track electrification. And in case of main line services cost of track electrification is important then high rate of acceleration & retardation.

2) Three Phase AC System :-

It is explained on following point:

i) Supply fed to traction sub-station:-

Traction sub-station receivers AC power from nearest high voltage transmission line. For e.g- 220/0KV

ii) Equipment in sub-station:-

In traction sub-station transmission voltage is step down to utilization voltage (3.3KV) and its frequency is reduced $16^{2/3}$/25 Hz Hz. So equipments in traction substation are

a) Step down transformer b) Frequency changer c) Protective equipments

d) Switch gears e) Control panel etc

iii) Number of Overhead conductor :-

Basic 3-ph line consists of 3 conductors and in traction there are two overhead conductor and rail from third phase.

iv) Normal Voltage fed to overhead conductor:

Voltage:- 3-ph, 3.3 KV AC Frequency :- 25 Hz or $16^{2/3}$

v) Types of drives used :-

3-Ph Slip ring I.M or Linear I.M (L I.M) are used.

vi) No. of traction sub-station required:-

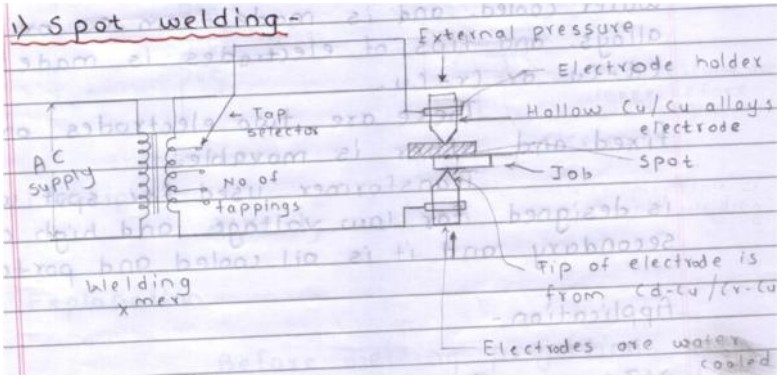
More as system voltage is low

vii) Application: - In hilly area track, where requirement of power is more.

Q.5 Attempt any Four of the following:

a) Explain Spot Welding with neat sketch.

(2 Mark to fig.& 2 Mark for explanation total 4 Mark)



or Equivalent fig.

Spot welding means the joining of two metal sheets at suitable spaced interval. As shown in fig.Job to be welded is placed one over the other between two electrodes under pressure.

When heavy current passed through the job through electrode. Current varies from 1000A to 10000A.and the voltage between electrodes is usually less than 2V.

The period of flow of current and magnitude of current depends upon thickness of sheet (job) to be welded. The electrodes are hallow and water cooled. And is made from copper or copper alloys and tips of electrodes is made from Cd-Cu or Cr-Cu.

There are two electrodes one is fixed and other is movable. and transformer used for spot welding.

b) Explain what is meant by electric arc welding. State different types of arc welding.

(2 Mark to meaning & 2 Mark for types total 4 Mark)

Electric Arc Welding:-

The processes in which two metal parts to be welded are brought to a molten state and then allowed to solidify is called as arc welding.

Melting of metal is obtained due to heat developed by an arc struck between an electrode and metal to be welded (job) **OR**

- In this type of welding heat is developed due to arc produced in between electrode & job.
- High voltage is required to produce arc at starting .once arc is struck low voltage is sufficient to maintain arc.
- No mechanical pressure is required, so this type of welding is also known as non- pressure welding.
- Temperature obtained by arc is very high (3500^0C to 6000^0C)
- Arc welding power factor is poor. And power consumption is high.
- At the time of welding external filler material is required.

Types of arc welding:

1) Metal Arc welding:
2) Carbon Arc Welding

c) State the four safety measures used in electric lifts. **(1 Mark to one safety.-Any four)**

- Close the door of car by simply pressing the button or manually.
- Do not exceed (over load) the capacity of elevator.
- Press button of right floor where you want to go.
- Do not try to open door when lift is running / starting / stopping.
- Do not try to enter elevator when elevator doors are closing.
- Do not allow children to play in or around the elevator.
- Do not put fingers, cloth, hand on door when lift is running.
- Do not try to open the door until the elevator (lift) has stopped fully.
- In lift car last in person is first out person. Last passenger should close the door of elevator.
- Pent house should be locked.
- Do not allow unauthorized entry of person into elevator machine room.

OR

Safety Device:-

- Door safety switch.
- Over travel switch.
- Over speed control switch.
- Car safety switch.
- Car operating switch.
- Emergency STOP Switch.
- Terminal Limit switch.

Protective Device:-

- Main line service switch (main switch and fuse)
- CB and overload relay.
- Phase failure protective relay.(1-ph preventer)
- Phase reversal protective relay.
- Over speed, slow down relay.

d) What is meant by regenerative Braking? Explain how it is obtained in Induction motor.
(2 Mark to meaning & 2 Mark for explanation)

Meaning;

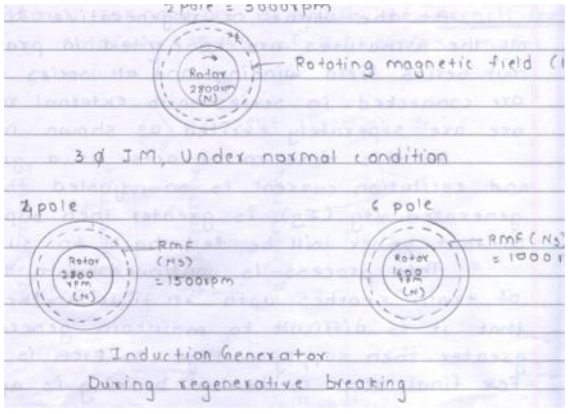
- In case regenerative braking traction motor is made to work as a generator.
- In this method only power is required to maintain excitation.
- Generated energy is fed back to the supply system.
- Regenerative braking is possible only when train going down the gradient.

Explanation -Regenerative Braking obtained in Induction Motor:-

- In case of I.M, when speed of rotor is greater than synchronous speed (Ns) of rotating Magnetic field then I.M acts as an Induction generator.
- So to obtain regenerative braking of Induction motor stator pole changing method is used.
- During regenerative braking of I.M. if number of stator poles are increased then its new rotor speed is found to be greater than synchronous speed, so I.M works as an induction generator.
- In this way by method of stator pole changing ERB of I.M. is possible.

OR

Regenerative braking of Induction motor can be expressed as below by figure.

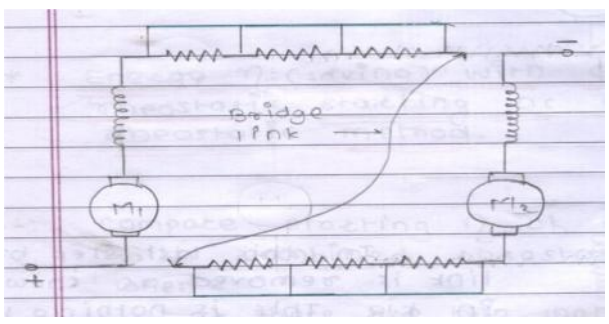


or Equivalent fig.

e) Explain Bridge transition method used in electric traction: **(1 Mark to one step)**

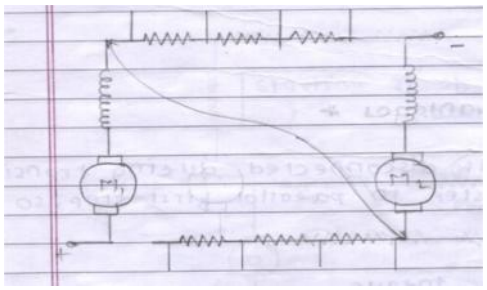
In bridge transition, series last step to parallel first step, is carried out by following steps

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



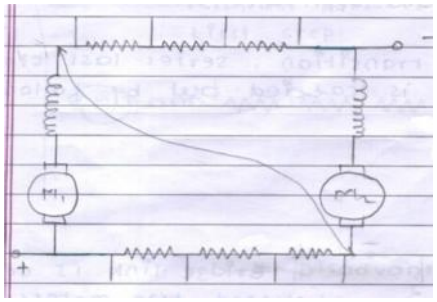
or Equivalent fig.

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.



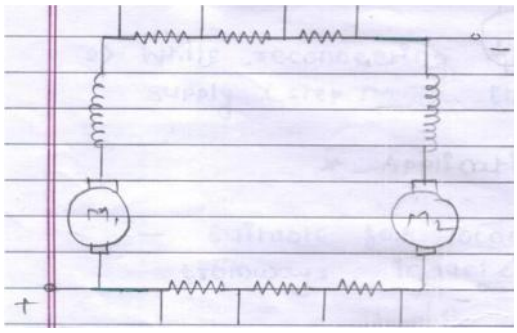
or Equivalent fig.

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.

f) State the any four advantages and four disadvantages of regenerative brakes used in electric traction. (1/2 Mark to each point in advantages & 1/2mark to each point in disadvantages -any four points from each-total 4 mark)

Advantages of Regenerative Braking:-

1. At the time of regenerative braking instead of wasting kinetic energy we can utilize 60 to 80% of kinetic energy is converted into electrical energy, which is feed back to the supply system. This is not possible in other types of braking.
2. It conserves electricity.
3. There is less wear and tear of brake block and brake shoe so less maintenance cost & its life increases.
4. Higher value of braking retardation is obtained, So its reduces braking actuation time.
5. Higher speed is possible even when train is going down the gradient as system is reliable.

Disadvantages of Regenerative Braking:-

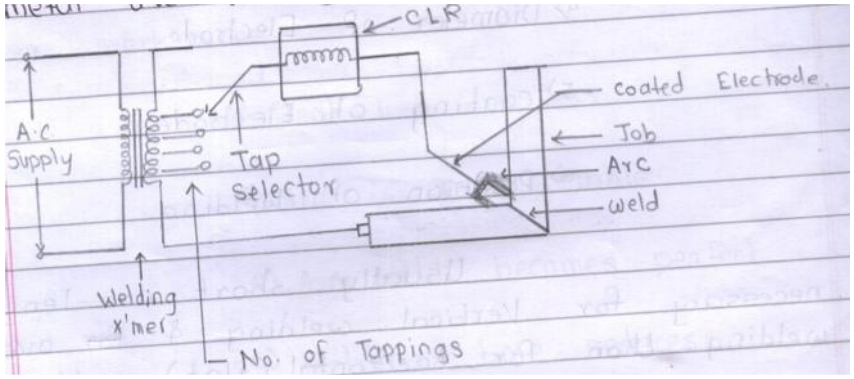
1. Initial cost is more because additional equipments are required.
2. When generated energy happens to be surplus at that operation in sub-station becomes complicated.
3. The DC machines required in case of regenerative braking are to be selected of large size (rating). So its initial cost increases then those of ordinary machines.
4. Over plane and up-gradient track ERB is not possible.
5. In addition to electrical braking system there must be arrangement of mechanical braking to rest the train.

Q.6 Attempt any Four of the following:

a) Explain Metal Arc welding: **(2 Mark to fig & 2Mark for explanation- total 4 marks)**

The process in which two metal parts to be welded are brought to a molten state and then allowed to solidify using an arc between them is called as arc welding.

Melting of metal is obtained due to heat developed by an arc struck between an electrode (of same metal as to be welded forming filler material) and metal to be welded (job)



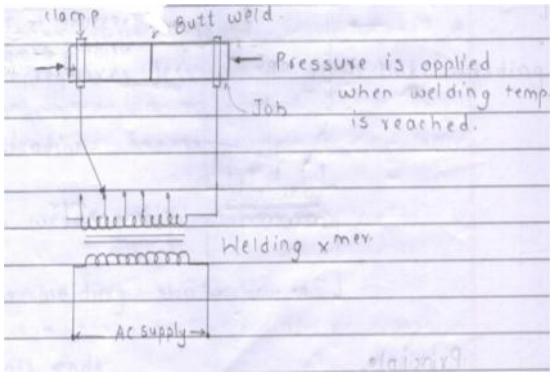
or Equivalent fig.

OR - Student may write following points (expected any four points)

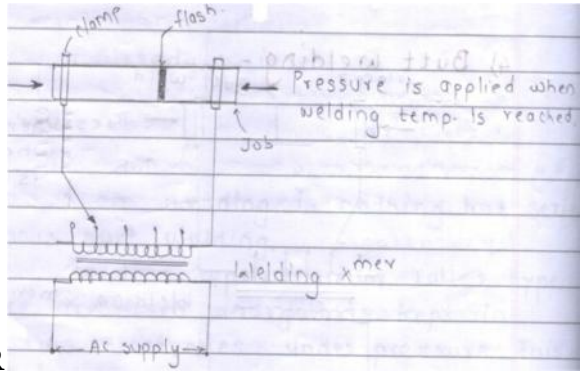
- In the metal arc welding AC supply is used.
- Coated electrodes are used compulsory.
- Welding transformer designed for low voltage and high current secondary. Secondary winding has number of tapping.
- Temperature obtained less as compared carbon arc welding.
- Series reactor is used to stabilize the arc.
- Possibility of arc blow is less.
- Initial cost, Running cost and maintenance cost is less.
- Standby losses are less, Efficiency is high.
- Metal arc welding voltage use 70 to 100V AC

b) Explain Upset Butt Welding: **(2 Mark to fig. & 2Mark for explanation total 4 Mark)**

Upset Butt welding:- or Equivalent fig.



OR



The job is clamped as shown in fig. two parts which are to be welded are brought together and heavy current is passed through joints by welding transformer, which creates necessary heat at joints due to I^2R loss.

When welding temperature is reached, supply is cut down and at the same time mechanical pressure is applied.

c) Suggest suitable type of electric motor for following application. Justify why they are used.

i) Domestic use ii) Electric Traction iii) Pumps iv) Lifts

(1/2 Mark to name of one motor &1/2mark for reason to every application total 4 mark)

NOTE: Any one Name & Reason, is expected

i) Domestic Use: - Capacitor start Induction motor/ Induction Motor/ universal Motor,

These motor are used because low cost, long life, less maintenance, Reliable

ii) Electric Traction: - DC Series motor/DC compound Motor/Induction Motor /1ph series motor

These motor are used because of High starting Torque, long life, reliable

iii) Pumps: - Squirrel cage Motor / Slip ring I.M,

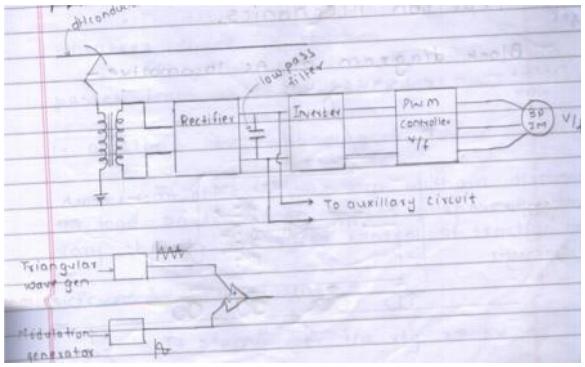
These motor are used because of long life, reliable, characteristics suitable for centrifugal and reciprocating pump

iv) Lifts: DC Series Motor /Dc compound motor/ Induction motor/Double cage I.M/Slip-ring I.M

These motor are used because of high Starting torque along with rapid acceleration and deceleration with jerks.

d) Explain with the help of block diagram principle of PWM control of Induction motor

(2 Mark to fig. & 2Mark for explanation total 4 Mark)



or Equivalent fig.

- Current is collected from overhead contact wire and is given to step down traction transformer. This step down voltage is converted to DC with the help of rectifier.
- Then it is filtered to obtain pure DC and it is given to inverter where Dc supply is converted into 3-Ph AC supply.
- Then before giving supply to induction motor, PWM controller is connected in between inverter and I.M. PWM controller controls: voltage and frequency electronically by controlling width of pulses of voltage to the motor.
- i.e it controls voltage/frequency ratio for speed control of I.M.

d) State any four types of electrical tariff. Explain any two of them in short.

(1/2 Mark to one method state any four of the following total 2 Mark) & for Explanation (1 Mark to one method explain any two of following total 2 Mark)

Types of Tariff:-

i) Flat-demand 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

Explanation (1 Mark to one method explain any two of Following total 2 Mark)

i) Flat Demand Tariff:

- It is used where energy consumption is fixed per day i.e where load is fixed and is used for fixed hours.
- E.g. Street lighting, Road Signal system and advertising board.
- In this type no energy meter is connected, so meter reading, billing, accounting, Stationary, bill distribution and collection etc expenses are eliminated and also save time for billing.

ii) Simple or uniform demand tariff:-

- In this type of tariff cost of energy charges is calculated on the basis of actual energy consume energy meter is connected in consumer premises.

iii) Flat Rate Tariff:-

- In this type of tariff there are two energy meter in one premises.
- One energy meter is for lighting circuit load and another meter is for power circuit load.
- Tariff rate for lighting and power load are different.
- Tariff rate for lighting is higher than tariff for power load.

iv) Step rate Tariff:-

- In this tariff there are steps for unit's consumption and cost/unit is less for more consumption of unit.
- The main disadvantage of this tariff is that the consumer unnecessary wastes the power to enter the next stage.
- For example 1) Step- I- Rs.2/KWH :- If consumption not to exceed 50 unit

  2) Step-II – Rs. 1.75/KWh:- If consumption not to exceed 200 unit.

  3) Step-II- Rs. 1.50/KWh:- If consumption exceeds above 200 units.

v) Block Rate Tariff:-

- In case of block rate tariff there are blocks of units consumed and each block tariff rate/unit (KWH) is different.
- If generation is less than utilization than tariff rate/unit in each block goes on increasing and vice versa.

vi) Two Part Tariff:-

- In this type of tariff energy bill is split into two parts.
- Only one energy meter is used to measure no. of units consumed it recovers a fixed charge which depends on load (KW).
- This type of tariff system is used for residential and commercial consumers.(up to 20 KW

- This type of tariff is not used for industrial consumers.
  ENERGY BILL= FIXED CHARGE +RUNNING CHARGE

vii) 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.

viii) Three part Tariff:-

- Fixed charges per month depend on connected load.
- This type tariff is used for HT consumer.
  ENERGY BILL= FIXED CHARGE+SEMI-FIXED CHARGE+RUNNING CHARGE

ix) 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.declar by Supply Company (say below .92iag.) than penalty will be charged in energy bill.
- If The P.F. of consumer is more than P.F.declar by supply company (say above .96 iag.) than discount will be given in energy bill.

x) 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.declar by supply company (say below .92iag.) than 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.

END

Question Paper and Summery of Marking Scheme

Q.1 a) Attempt Any Three of the following:

i) Define Terms: i) Light ii) Luminous flux iii) Lumens iv) Lux

(1mark to each definition total 4 mark)

ii) State any four Differences between group drive & individual Drive

(1mark to each point total 4 mark)

iii) State different methods for starting of Induction motors. Explain any one method

(3Marks for name of different methods for starting &1mark for explanation)

iv) State: - 1) Law of inverse squares 2)Lambert's cosine law

(Figure 1 Mark & Statement 1 Mark for each law)

b) Attempt Any Three of the following:

i) Explain working of High Pressure Mercury Vapour Discharge Lamp

(3 Mark for fig., & 3 Marks for Working total 6 Marks)

ii) Given Data : (Give stepwise mark if answer is wrong as indicated in solution)

Volt : 400V, F= 50 Hz P= 200Kw $\cos¤_1 = 0.8$ $\cos¤_2 = 1$

Answer Value of capacitor :-

1) Star connected :- $C \ per\ phase = 2.984 \times 10^{-3}$ F

2) Delta connected:- $C \ per\ phase = 9.947 \times 10^{-4}$ **F**

Q.2 Attempt Any Four of the following

a) State Different types of interior Lighting System. Explain each of them in short.

(2 Marks for list of lighting system & 2Mark for explanation)

b) Explain working principle of induction arc Furnace:

(2 Marks for fig. & 2 Marks for explanation- total 4 Marks)

Note :- This question is not clearly indicate either to write direct or indirect Induction Furnace OR Arc Furnace, So accepts any answer from this two furnaces

c) Explain Working of Traction Elevators

(2 Mark for fig. & 2 Mark for explanation -total 4 marks)

d) Explain any two methods of Speed control of DC Series Motor.

(2 Marks for each method total 4 Marks)

e) State any four advantages and four disadvantages of electric traction.

(1/2 Mark to each point in advantages any four points & 1/2 Mark to each point in disadvantages any four point total 4 Mark)

f) State any four disadvantages of Low power factor.

(1 Mark to each point -any four -total 4 Marks)

Q.3 Attempt Any Four of the following

a) Explain effect of each of following on design of illumination:

(1Mark to each point total 4 Marks)

b) State any six application of Dielectric heating. Application of Dielectric Heating :-

(3 Marks for first four points & 1/2 Mark to each next two point -total 4 Marks)

c) Given Data : (Give stepwise mark if answer is wrong as indicated in solution)

240 Nm for 20 min. Speed of motor: 720 rpm
140 Nm for 10 min. Rating of motor (KW) =?
300 Nm for 10 min. 200 Nm for 20 min.

Answer: - 17 KW

d) Draw a typical speed time curve for traction line service; show different time periods on it.

(3 Mark for drawing curve & 1 Mark for showing time period)

e) State any two causes of low power factor. State any two methods for improving power factor. **(1mark to each-any two causes & 1Mark to each –any two methods)**

Q.4 a) Attempt Any Three of the following:

i) Explain working of direct core type of induction Heating:

(2 Marks to fig.& 2Marks for explanation total 4 Marks)

ii) State any four Characteristics which makes DC series motor suitable for electric traction:

(1 Mark to one point.)

Note : Either graph(diagram) or points are accepted

iii) Given Data: (Give stepwise mark if answer is wrong as indicated in solution)

Weight of train (W) :- 200 tonne No. of Trains = 8 Nos Gear ratio¥ = 4
Dia. of driving wheel = 90 cm = 0.9 m Tractive resistance (r) = 50 N/ tonne
Gear efficiency ¦ = 80 % Maximum speed V_m = 48 kmph
Up gradient 1 in 200 means G = 0.5%

Answer : Torque developed by each motor = 2067.11 Nm

iv) Define:- 1) Average Speed 2) Schedule speed in traction Explain how increasing acceleration increases schedule speed**.**

(1.5 Mark for each definition & 1 Mark for reason for increase in schedule speed total 4 Mark)

b) Attempt any ONE of the following:

i) **Explain meaning of: i) Flood lighting 2) Flood light projector. Explain different types of projector.** **(2 Marks to each & 2 Marks for explanation total 6 marks)**

ii) Explain following system of track Electrification: 1) Single phase AC 2) Three phase AC

Note : Any three of the following points are acceptable for 1-ph & 3-Ph AC system. Either in the following form or in the form of paragraph

(1 Mark to one point in case of Single Phase AC System & 3-Phase AC System –any three points from each system-total six mark)

Q.5 Attempt any Four of the following:

a) Explain Spot Welding with neat sketch.
(2 Mark to fig.& 2 Mark for explanation total 4 Mark)

b) Explain what is meant by electric arc welding. State different types of arc welding.
(2 Mark to meaning & 2 Mark for types total 4 Mark)

c) State the four safety measures used in electric lifts. **(1 Mark to one safety.-any four)**

d) What is meant by regenerative Braking? Explain how it is obtained in Induction motor.
(2 Mark to meaning & 2 Mark for explanation)

e) Explain Bridge transition method used in electric traction: **(1 Mark to one step)**

f) State the any four advantages and four disadvantages of regenerative brakes used in electric traction**. (1/2 Mark to each point in advantages & 1/2mark to each point in disadvantages -any four points from each-total 4 mark)**

Q.6 Attempt any Four of the following:

a) Explain Metal Arc welding: **(2 Mark to fig & 2Mark for explanation- total 4 marks)**

b) Explain Upset Butt Welding**:** **(2 Mark to fig. & 2Mark for explanation total 4 Mark)**

c) Suggest suitable type of electric motor for following application. Justify why they are used.
i) Domestic use ii) Electric Traction iii) Pumps iv) Lifts
(1/2 Mark to name of one motor &1/2mark for reason to every application total 4 mark)
NOTE: Any one Name & Reason, is expected

d) Explain with the help of block diagram principle of PWM control of Induction motor
(2 Mark to fig. & 2Mark for explanation total 4 Mark)

e) State any four types of electrical tariff. Explain any two of them in short
(1/2 Mark to one method state any four of the following total 2 Mark) & for Explanation (1 Mark to one method explain any two of following total 2 Mark)