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. (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 :** **(3x4=12)**
a)	**State and explain any four factors governing the selection of electric drive.**
Ans:	**Following Factors governing / or are considered while selecting electric drive (Motor) for particular application:** **(Any Four factor expected: 1 Mark each)** **1. Nature of supply:** Whether supply available is ➢ AC, ➢ Pure DC ➢ Or Rectified DC **2. Nature of Drive (Motor):** Whether motor is used to drive (run) ➢ Individual machine ➢ OR group of machines. **3. Nature of load:** Whether load required light or heavy starting torque ➢ OR load having high inertia, requirehigh 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 ($T \alpha N^2$)

	4. Electric Characteristics of drive: ➢ Starting, ➢ Running, ➢ Speed control ➢ and braking characteristics of electric drive should be studied and it should be matched with load requirements(i.e. machine). **5. Size and rating of motor:** ➢ Whether motor is short time running ➢ OR continuously running ➢ OR intermittently running ➢ OR used for variable load cycle. Whether overload capacity, pull out torque is sufficient. **6. Mechanical Considerations:** ➢ Types of enclosure, ➢ Types of bearing, ➢ Transmission of mechanical power, ➢ Noise ➢ and load equalization **7. Cost:** ➢ Capital, ➢ Running ➢ and maintenance cost should be less.
b)	**List any 6 desired properties of heating element material. Write the names of any two heating material.**
Ans:	**Following desired properties of heating material :** **(Any Six Point are Expected : 1/2 Mark each)** **1. High resistivity:** It should have high resistivity. So that is becomes compact in size and produces more heat with small input current.

2. High melting point:

It should have high melting point to withstand at high temperature.

3. High Oxidizing temperature:

It should have high oxidizing temperature or it should not oxidize even at high temperature**.**

4. High Resistance to corrosion:

It should have high resistance to corrosion to avoid rusting.

5. High Mechanical Strength:

It should have high mechanical strength to withstand from mechanical injury.

6. Ductile:

It should be ductile so that it can be manufactured into different size & shape.

7. Long Life:

It should have long life.

8. Less Costly:

It should be less costly and easily available.

9. Low temperature co-efficient of resistance:

For accurate temperature control, it should have low temperature co-efficient of resistance.

10. It should not be brittle.

- **Names of Material used for manufacturing of heating element:**

(Any Two are Expected : 1/2 Mark each)

i) Nichrome

ii) Constantan or Eureka

iii) Nickel-chromium

iv) Iron-chromium-Aluminimum

v) Silicon carbonate

vi) Tungsten vii) Platinum viii) Carbon

c)	**Define the following terms related to illumination: 1) Luminous Intensity 2) Candle Power 3) MSCP 4) MHCP.**
Ans:	**(Each definition : 1 Mark)** **1) Luminous intensity:-** The luminous intensity in any particular direction is the luminous flux emitted by source per unit solid angle is called the luminous intensity of the source. And its **unit is Candela** **OR** $I = \frac{\phi}{w}$ $(Where\ \ \phi = lu\min ous\ \ flux, w = Solid\ \ Angle)$ **2) Candle power:** The candle power is the radiation capacity of the light source in the given direction. The candle power is always given in lumens output per unit solid angle of the given light source. $C.P = \frac{Lummens}{w}$, $(Where\ w = Solid\ \ Angle)$ **3) MSCP (Mean Spherical Candle power):** It is the average of all candle powers in all direction in all planes. **OR** $MSCP = \frac{Total\ Lu\min ous\ lux\ in\ lumens}{4\pi}$ **4) MHCP (Mean Horizontal candle Power (MHCP) :** MHCP is defined as the mean of the candle power of source in all directions in horizontal plane.
d)	**Explain any four disadvantages of low power factor.**
Ans:	**Disadvantages of Low power Factor: -** **(Any Four disadvantages expected: 1 Mark each)** 1) **Cross section of conductor increases**: - 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**: -

As power factor reduces current increases. So copper losses increases. As an effect efficiency reduces.

5) **Voltage drop increases**: -

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 such as Alternator, transformer reduces as power factor reduces

7) **High KVA rating of equipment required**:- ,

As power factor decreases KVA rating of all equipments increases, so that its cost increases.

8) **Cost/unit increases**: -

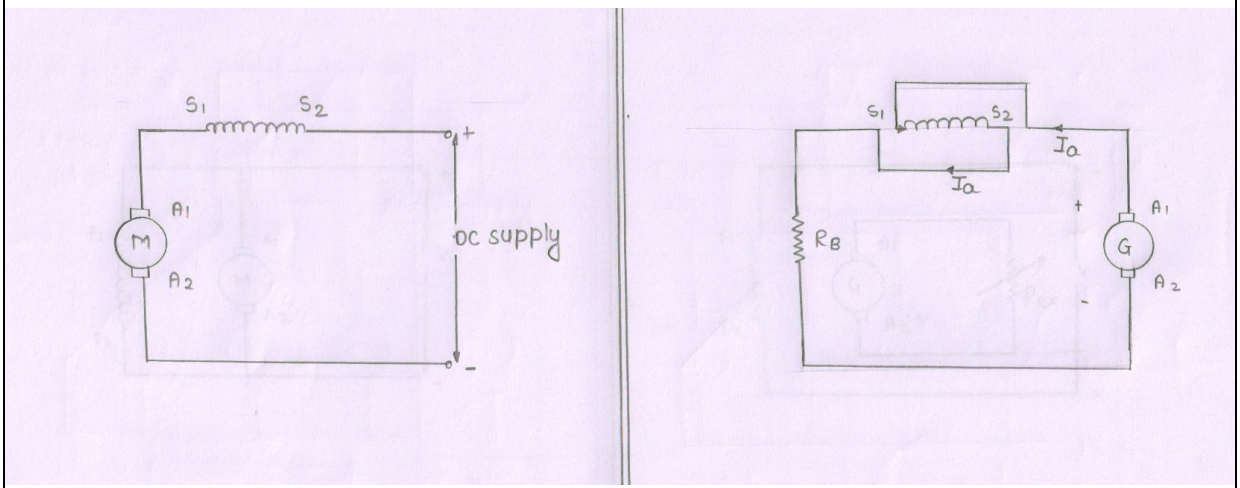
From all above disadvantages it is seen that cost of generation, transmission & distribution increases. Also its performance efficiency & regulation reduces, So that cost/unit increases.

Q.1B) **Attempt any ONE :** **(1x6=6)**

a) **Explain how Rheostatic Braking is achieved in case of :**
1) DC series motor 2) 3 phase Induction motor.

Ans: **Rheostaic braking or dynamic braking of DC series Motor:**

(Figure : 2 Mark & Explanation: 1 Mark)

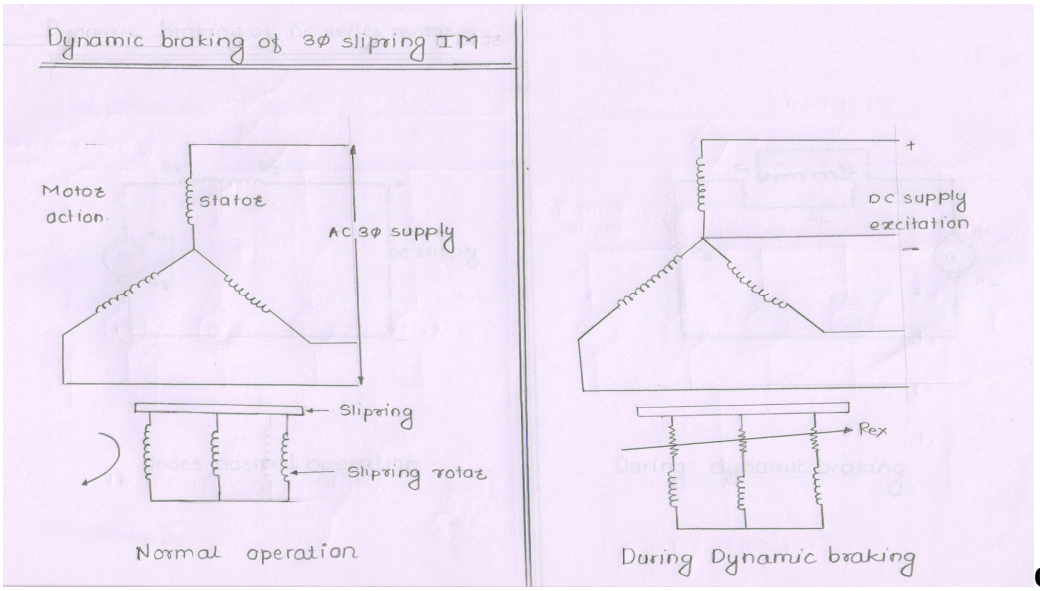


Under normal condition **Under Dynamic breaking condition**

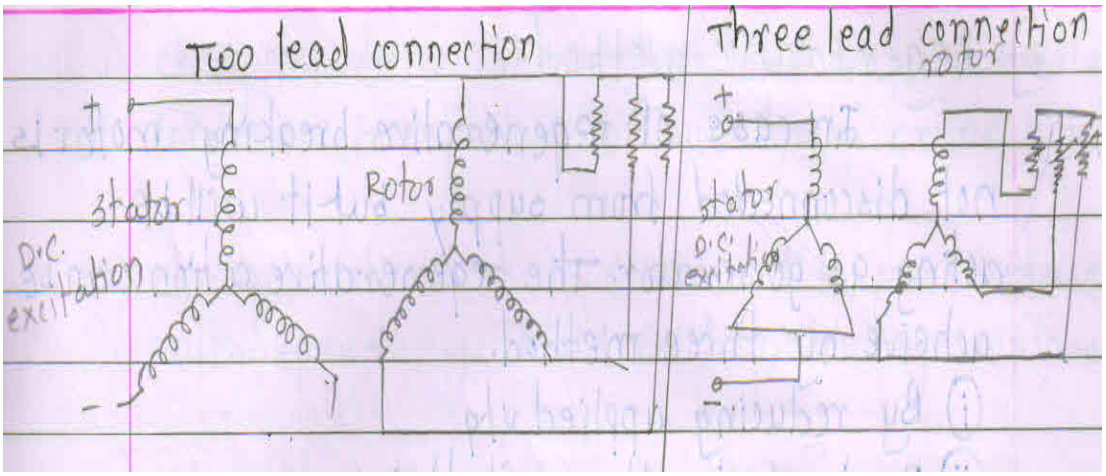
Explanation:

- In case of DC series motor field winding connections must be reversed when it acts as a generator i.e. A_1 is connected to S_1 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.

Rheostaic braking of 3 phase Induction motor:- **(Figure : 2 Mark & Explanation: 1 Mark)**



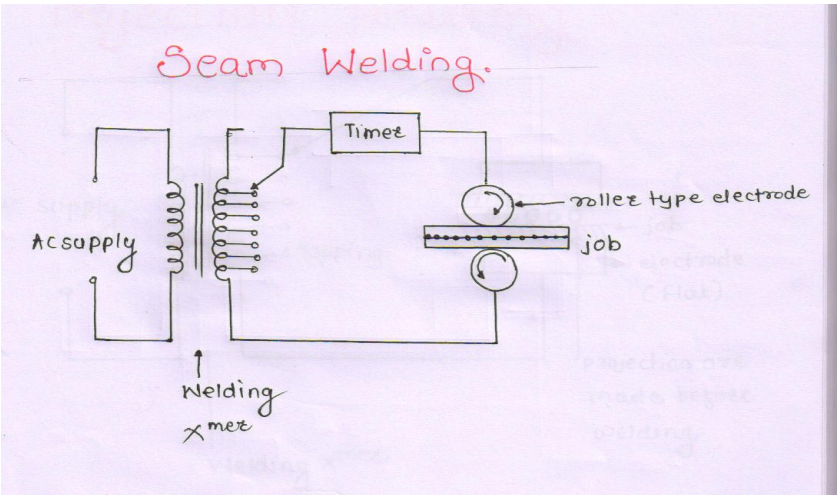
OR



Explanation:

- During generating supply 3-phase supply of stator is disconnected & excitation supply is given to one of winding & external resistance is added in rotor circuit through slip-ring.

b)	**For seam welding : 1) Draw its neat labelled sketch. 2) Explain its working. 3) Write any two applications.**
Ans:	**1) Seam Welding its neat labelled sketch:** **(3 Mark)**



Working:

- Job is kept in between two electrodes under pressure. This pressure is kept constant throughout.
- In this type intermittent current is used, it means current is ON for definite time and OFF for another time interval with the help of timer.
- If current is continuously passes then heat produced may cause burning of job.
- Heat is produced due to I2R losses where 'R' is the contact resistance.
- This heat is utilized to obtain welding temperature (to become a plastic state)
- When welding temperature is reached supply is cut down and external pressure is applied simultaneously across the job to complete weld.

Applications of Seam welding:- **(Any Two are Expected : 1/2 Mark each)**

It gives leak-proof joints.

1. Hence used for welding of various types of containers,
2. Pressure tank,
3. Tank of transformer,
4. Gas line,
5. Air craft tank,
6. Condenser,
7. Evaporator and
8. Refrigerator etc.

Q.2 **Attempt any FOUR :** **(4x4=16 Mark)**

a) **Compare Group Drive and Individual drive on the following parameters :**
1) Definition 2) Installation cost 3) Appearance 4) Safety and flexibility.

Ans: **(Each Point: 1 Mark)**

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 coupledor indirectly coupled.
2	**Installation cost**	Less	High
3	**Appearance**	Good / Not good	Better/Good
4	**Safety and flexibility**	Less Safe	More Safe

b) **Explain any four causes of failure of Heating Element.**

Ans: Following of the different causes of failure of heating element:

(Any Four causes expected: 1 Mark each)

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 fumes 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.

c) Compare 1-phase 25 kV AC and DC Track electrification on any eights factors (any four point)

Ans: **Compare 1-phase 25 kV AC and DC Track electrification :**

(Any Four point expected: 1 Mark each)

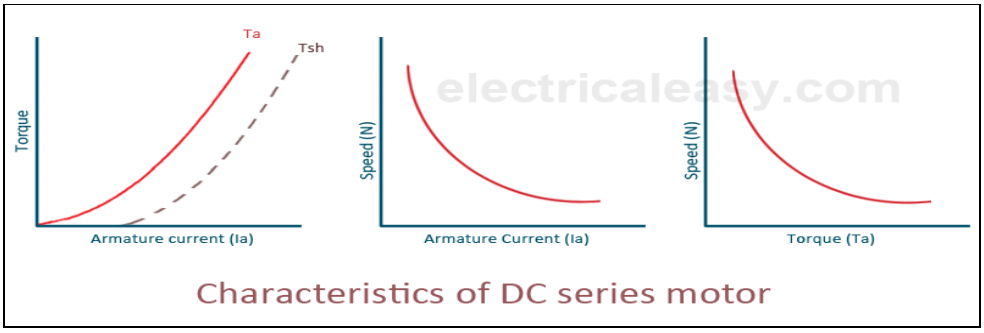
S.No	Points	AC System Traction	DC System Traction
1	Supply given to O/H condition	1-ph, 25KV, AC 25 Hz	600/750V-Tromways 1500/300V urban/suburban
2	Type of drive used	1-ph, AC series motor	DC series motor for tramways. DC compound motor
3	Weight of traction motor	1.5 times more than d.c series motor.	1.5 times less then a.c series motor
4	Starting torque $accl^n$ and retardation	Less starting torque	High starting torque
5	$Accl^n$ and retardation	Less than d.c series motor	High
6	Overhead capacity	Less than d.c series motor	High
7	Method of speed control	Simple and smooth	Limited, except chopper method
8	Maintenance cost of traction motor	More	Less
9	Starting Efficiency	More	Less
10	Regenerative braking	Easy	Difficult
11	Ridding quality	Less better than d.c	Smooth (Better)
12	Insulation cost	High	Low
13	Cross section of conductor	Less	More
14	Design of supporting structure	light	Heavy
15	Distance between two substation	More	Less
16	No.of substation required	Less	More
17	Size (capacity) of traction substation	More	Less
18	Capital & maintenance cost of substation	Less	More
19	Cost track electrification	Less	More
20	Electrolysis trouble	No	Yes, if ground is used as return path
21	Applications	Main line services	Urban and suburban area

d) Give any four justifying features which makes DC series motor suitable for traction work.

Ans: Due to following features, DC series motor is suitable for traction duty:

(Any Four Point expected: 1 Mark each)

1) **Characteristics:**



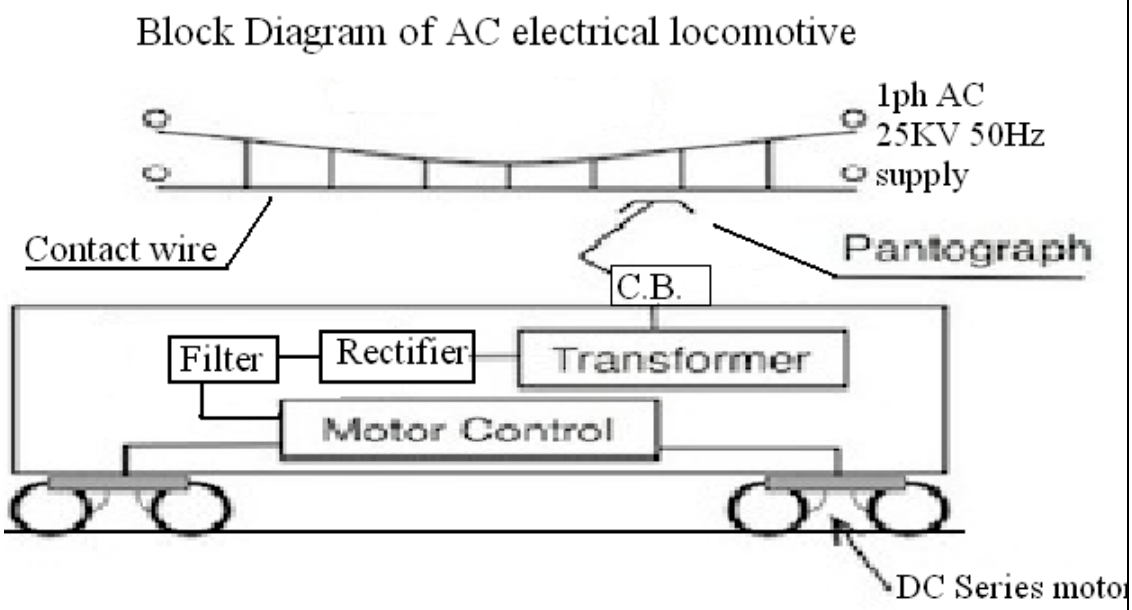
Characteristics of DC series motor

OR

Features of DC Series Motor : (Any Four Points Are Expected)

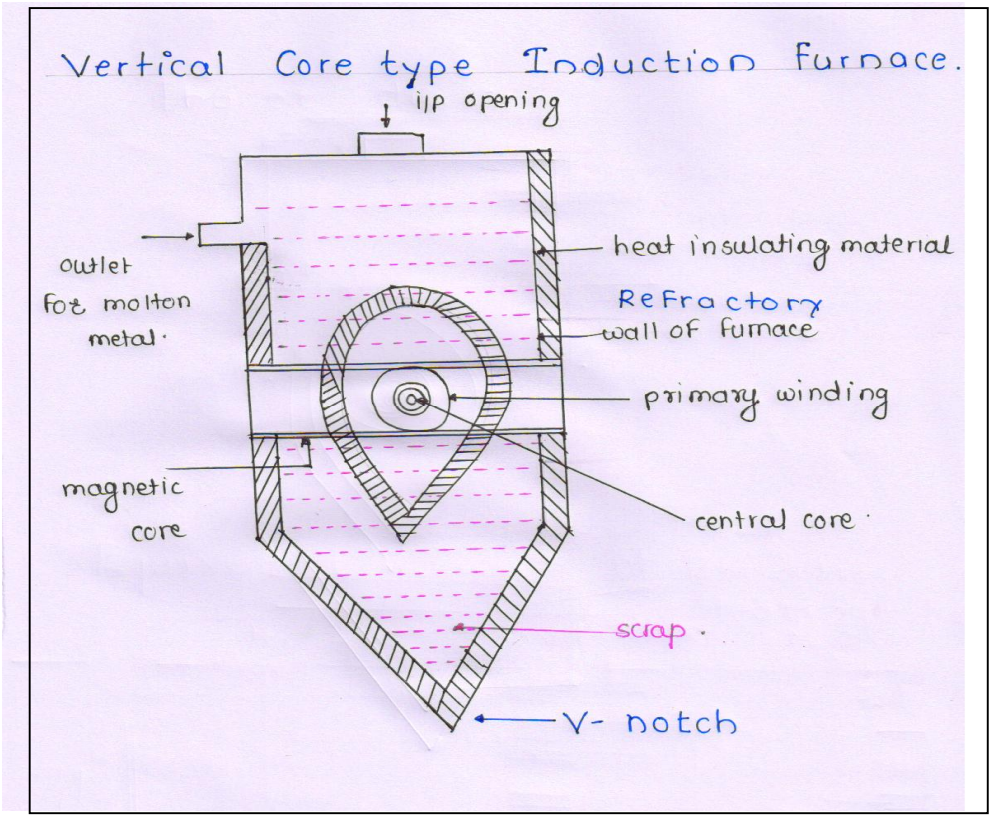
1. DC Series motor robust in construction and capable to withstand against continuous vibration.
2. DC series motor weight is 1.5 times less than 1-Ph AC series motor for same H.P.
3. DC Series motor has high starting torque.
4. DC Series motor has high rate of acceleration and retardation.
5. DC Series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

e)	**Draw a neat labelled Block diagram of A. C. locomotive.**
Ans:	**labelled diagram of A.C. locomotive:** **(Diagram: 4 Marks)**



Q.3	**Attempt any TWO :** **(2 x 8 =16 Marks)**
a) i)	**Give any four ideal requirements of elevators.**
Ans:	**Ideal requirements of elevator**: **(Any Four Points are Expected : 1 Mark each)**

1. There must be all safety features.
2. Compactable acceleration and retardation to avoid jerk.
3. It should have sufficient Speed (feet/min.) proportional to height of building.
4. There should adequate lighting and provision of fan.
5. There should better interior design of the car.
6. It should have minimum breaking period.
7. There should be wide-frontage for fast traffic.
8. It should have sufficient capacity to handle the weight (Average weight 68 Kg per person).
9. Sufficient space should be available for car (2 Sq,ft. per person).
10. There must be provision of back-up, when electric supply get's failure like D.G. sets.

a) ii)	**State the factors to be considered for selection of shape and size of elevator.**
Ans:	The size and shape of elevator car depends are following two factors: **(Any Four Factor are Expected : 1 Mark each)** No. of passenger to be carried: While selecting the size of car it is a usual practice to allow:- 1. A Space of 2 Sq.fit/ person. 2. Average weight of passenger is assumed 68 kg/person. 3. Thus the maximum load capacity of elevator is considered 34 kg/sq.ft 4. There should be wide frontage and shallow depth 5. Limitation in the building design 6. Shape of elevator depends on space available in building. 7. Type of building
b) i)	**Draw a neat labelled sketch to show construction of Ajax Wyatt furnace.**
Ans:	**Neat sketch of 'Ajax Wyatt' vertical core furnace:** **(3 Mark)** 

b) ii)	**Explain its working.**
Ans:	**Working of Induction heating:** **(3 Mark)** It is based on principle of transformer. In this type of Induction heating primary winding is as usual which is wound around one limb of magnetic core but secondary winding is actually charge which is to be melted is kept in crucible. When AC Supply is given to primary winding current flows through primary winding which creates alternating flux in magnetic core this flux links to the secondary winding i.e. charge through magnetic core. Hence according to faraday's law of electromagnetic induction emf will be induced in secondary winding that is in the charge. As charge forms a close circuit (secondary) heavy current flows through charge this current is responsible to produce heat in charge due to I^2R losses. This heat is utilized to melt the charge. Where, R = Resistance of charge & I secondary current.
b) iii)	**Any 2 advantages and any 2 application of Ajax Wyatt furnace.**
Ans:	**Advantages:** **(Any Two Points Are Expected : 1/2 Mark each)** 1) As furnace has narrow 'V' shape crucible at bottom. So small quantity of molten metal remains in narrow 'V' notch from previous operation, which will help to keep secondary short circuited. So no extra care is required to start the furnace 2) Magnetic coupling between primary & secondary winding is better because both windings are on central limb of magnetic core. So there will be less leakage flux, Hence leakage reactance is less, so power factor is better than horizontal crucible direct core type induction furnace. 3) Due to pinch effect in ordinary core type induction furnace there are chances of temporary interruption in secondary circuit when current density exceeds above 500A/cm2 OR 5Amp/mm2.. 4) But in this type of induction furnace there are no chances of interruption in secondary circuit even if current density exceeds 500A/cm2 OR 5Amp/mm2 Because tendency of weight of charge keep them in contact due to narrow 'V' shape. 5) So we can increase current density above 500A/cm2 OR 5Amp/mm2 to obtain more heat in less time. 6) Vertical crucible is always better than horizontal crucible for pouring and taking out the

metal. Also space required is less.

7) As heat is produced directly in the charge there is no heat transfer loss. So efficiency of furnace is more.

8) As heat is directly produced in the charge time required for melting metal is less. So energy consumption is less.

9) As current is directly induced in the charge there is automatic stirring action taking place in the charge due to electromagnetic forces developed in the charge due which,
   - Through mixing of molten metal is possible.
   - Uniform heating is possible

10) Accurate temperature control.

11) Ideal working condition in a cool atmosphere with no dirt , noise and fuel.

Application of 'Ajax Wyatt' vertical core furnace:

(Any Two Points Are Expected : 1/2 Mark each)

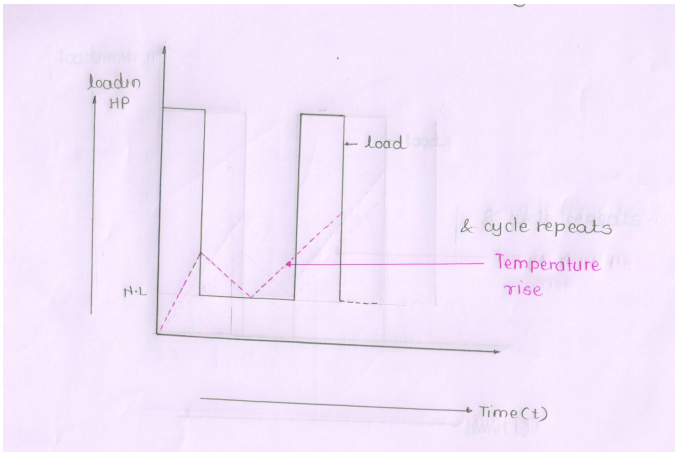
- It is used for melting metal having low resistivity.
- It is used for heat treatment of silver, Copper, nickel etc.
- Such type of furnace are used for continuous operations only and not used for intermittent services.

c) i) **i) Describe the concept of load cycle with their graphical representation :**
1) Continuous operation with Short Time Rating
2) Continuous operation with intermittent Rating.

Ans:

1). Continuous operations short time loading:- **(Graph : 1 Mark & Explanation: 1 Mark)**

Graphical representation

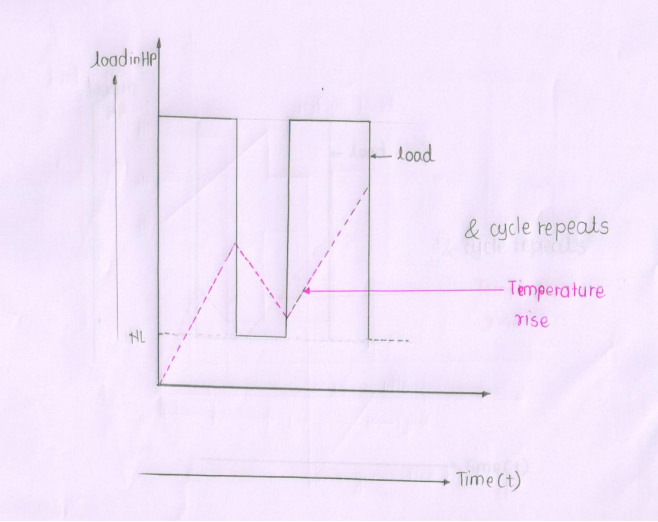


Explanation :-In this case motor is operated continuously for short time and interval between two load is not OFF- load but motor runs at no load for long time. So temperature of drive continuously increases. So

Temperature rise is more than short-time loading.

2) Continuous operations intermittent loading: - (Graph : 1 Mark & Explanation: 1 Mark)

Graphical representation



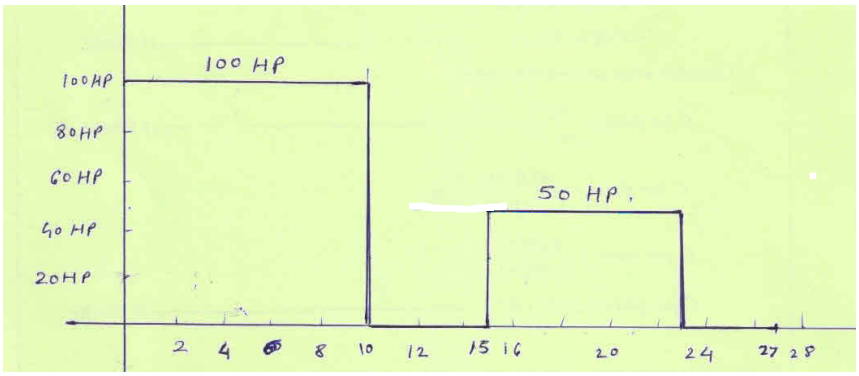
Explanation :-In this case motor is operated continuously for long time and interval between two load is not OFF- load but motor runs at no load for short time. So temperature of drive continuously increases.

c) ii)) A motor has to perform the following duty cycle :
1) 100 HP for 10 minutes 2) No load for 5 minutes
3) 50 HP for 8 minutes 4) No load for 4 minutes
The duty cycle is repeated indefinitely. Draw the curve for the load cycle. Assuming that the heating is proportional to the square of load. Determine the suitable size of continuously rated motor.

Ans:

1) 100 HP for 10 minutes Speed of motor : 750 rpm
2) No load for 5 minutes Rating of motor (KW) =?
3) 50 HP for 8 minutes
4) No load for 4 minutes

Graph:



-- **(1 Mark)**

Duty Cycle (T) $= t_1 + t_2 + t_3 + t_4$ ---------- **(1/2 Marks)**

$= 10+5+8+4$

$= 27$ Min. ---------- **(1/2 Marks)**

Continuous rating of Motor:

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

$$rating\ of\ motor = \sqrt{\frac{100^2 \times 10 + (0)^2 \times 5 + (50)^2 \times 8 + (0)^2 \times 4}{27}}$$

$$rating\ of\ motor = \sqrt{\frac{120000}{27}}$$

$rating\ of\ motor = 66.667\ HP$ ---------- **(1 Mark)**

Nearest Standard rating of motor should be selected

Q.4A)	**Attempt any THREE :** **(3 x 4 =12 Marks)**
a)	**List any four welding equipment and Accessories used for protection and safety and describe each of them in brief.**
Ans:	**(Any four equipment and Accessories are expected : 1 Mark each)**

1. **Series reactor:**
   To stabilize the arc in case of metal arc welding series reactor is used.
2. **Electrode holder:**
   Well insulated electrode holder is used to grip electrode. This holder is in operator's hand.

3. **Earthing clamp:**
   It is essential to complete electric circuit and safety purpose.
4. **Welding helmet and face shield :**
   Helmet is used for protection purpose and face shield protect face and eyes from rays of arc which contains UV and infra-red rays.
5. **Other:**
   Hand gloves, shoes, apparan, small hammer, file, small metal wire brush etc are essential during welding
6. **Safety equipments**.
   Welding shield (hood): This is the mask which is worn to protect the person welding from the bright flash of the arc, and from sparks being thrown during welding and also protect face and eyes from rays of arc which contains UV and infra-red rays.

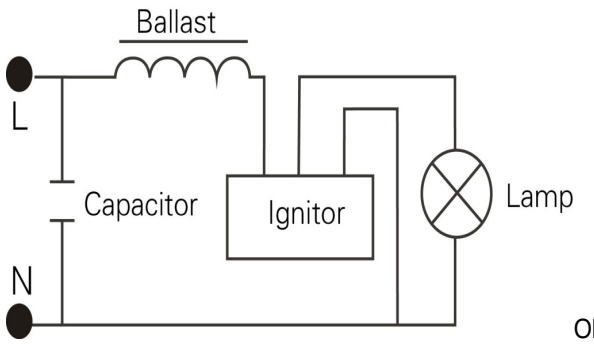
7 **Welding gloves** : These are special, insulated leather gloves that reach about 6 inches (15.2 cm) above the wrists, and protect the hands and lower arms of the welder (the person welding).

8 **Welding leathers**: This is an apron like leather jacket that covers the shoulders and chest of the welder, used for overhead work where sparks might ignite the welder's clothing, or cause burns.

9 **Work boots** : The person welding should wear at least a 6 inch (15.2 cm) lace-up type boot to prevent sparks and hot slag from burning his feet. These boots should have insulating soles made from a material which does not melt or burn easily.

b) **Draw a neat labelled sketch to show the construction of sodium vapour lamp and explain its working.**

Ans: **Sodium Vapour Lamp diagram:** **(Figure: 2 Mark, & Working : 2 Marks)**



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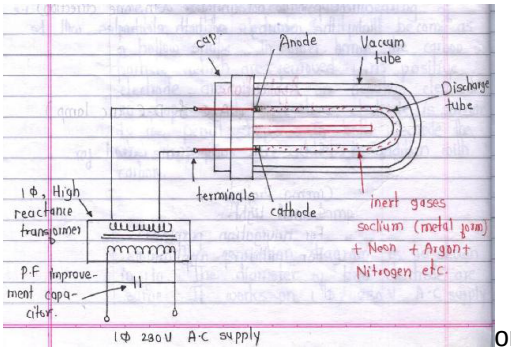
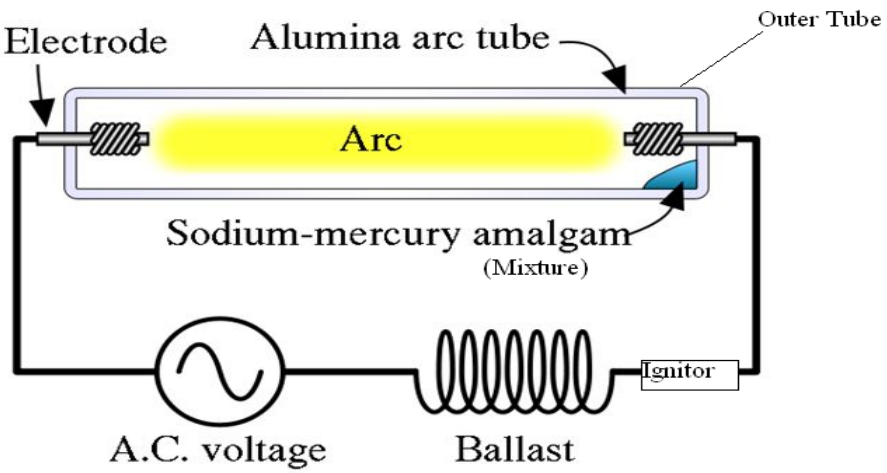


or equivalent figure

OR



Working Principle:

- When the lamp is turned on, a high voltage at staring is applied across two electrodes, to initiate an arc which discharges and vaporizes xenon /neon gas (starting gas), sodium and mercury.
- The energized metal atoms emit light.
- After 2 to 5 minutes lamp will glow 100 %.
- For running the lamp low voltage of about 165V is sufficient.
- The color of light produce is yellowish.

c) i) Define Tariff. ii) State any 4 desirable characteristics of tariff.

Ans:

Definition of Tariff: **(2 Mark)**

Tariff is the way of billing energy consumed by consumer. OR

The rate at which electrical energy is supplied to a consumer is known as tariff.

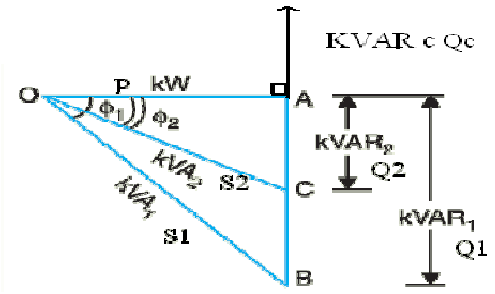
Following desirable characteristics of tariff: **(Any Four Point expected: 1/2 Mark)**

1. It should be easy to understand to consumer.
2. Easy to calculate.
3. Tariff should be attractive i.e. It should not be too high or too low. It should be reasonable.
4. Tariff should be economical as compare to other types of energy sources.
5. Tariff should be different for different types of consumers.

6. Tariff must be fair, so that different types of consumers are satisfied with rate of electrical energy charges.
7. Tariff should be framed into two parts i.e. fixed charges + running charges.
8. Tariff should be high during peak load period .
9. Tariff should be low during off load period.
10. For industrial consumer, in addition to basic tariff incentives and penalty related to PF and LF should be considered.

d) Show the derivation for most economical power factor.

Ans: **Derivation:** **(4 Mark)**



Let,

P = Active power KW

S_1, S_2 = KVA Maximum demand before and after improving power factor

Q_1, Q_2 = Lagging reactive power before & after improving power factor

Q_C = Leading Reactive power drawn by Capacitor

$\cos\phi_1$ = Initial Power factor

$\cos\phi_2$ = Improved Power factor

Rs X = Tariff charges towards M.D. (KVA) /year

Rs Y = Expenditure towards KVAr to be neutralized per year (Expenditure towards P.F. improving apparatus)

1) Before improving Power factor**:**

$$Q_1 = P \tan \phi_1$$

$$\text{Cos } \phi_1 = \frac{P}{S_1}$$

$$S_1 = \frac{P}{\text{Cos } \phi_1}$$

$$\therefore KVA_1 \ (S_1) = P \sec \phi_1$$

2) After improving Power factor**:**

$$Q_2 = P \tan \phi_2$$

$$\text{Cos } \phi_2 = \frac{P}{S_2}$$

$$S_2 = \frac{P}{\text{Cos } \phi_2}$$

$$\therefore KVA_2 \ (S_2) = P \sec \phi_2$$

3) Saving in KVA charges**:**

$$= Rs \ X \ (S_1 - S_2)$$

$$= Rs \ X \ (P \sec \phi_1 - P \sec \phi_2)$$

$$= Rs \ X \ .P \ (\sec \phi_1 - \sec \phi_2)$$

4) Expenditure towards KVAr to be neutralized**:**

$$= Rs \ Y \ (Q_1 - Q_2)$$

$$= Rs \ Y \ (P \tan \phi_1 - P \tan \phi_2)$$

$$= Rs \ Y x P \ (\tan \phi_1 - \tan \phi_2)$$

5) Net Saving**:**

= Saving in KVA charges - Expenditure towards KVAr to be neutralized.

$$= [\text{Rs X .P}(\sec\phi_1 - \sec\phi_2)] - [\text{Rs Y}(\text{P}\tan\phi_1 - \text{P}\tan\phi_2)]$$

Saving will be maximum when differentiate above equation with respect to ϕ_2 and equate to zero.

$$\frac{ds}{d\phi_2} = \frac{d}{d\phi_2}\left[\text{Rs X P}(\sec\phi_1 - \sec\phi_2)\right] - \left[\text{Rs Y P}(\tan\phi_1 - \tan\phi_2)\right]$$

$$= 0 - \text{X P}\sec\phi_2 \times \tan\phi_2 - 0 + \text{Y P}\sec^2\phi_2$$

$$0 = -\text{Rs X P}\sec\phi_2 . \tan\phi_2 - 0 + \text{Rs Y P}\sec^2\phi_2$$

$$\text{Rs X P}\sec\phi_2 . \tan\phi_2 = \text{Rs Y P}\sec^2\phi_2$$

$$\therefore \text{Rs X}\ \tan\phi_2 = \text{Rs Y}\ \sec\phi_2$$

$$\therefore \text{Rs X}\ \frac{\sin\phi_2}{\text{Cos}\phi_2} = \text{Rs Y}\ \frac{1}{\text{Cos}\phi_2}$$

$$\therefore \text{Rs X}\ \sin\phi_2 = \text{Rs Y}$$

$$\therefore \sin\phi_2 = \text{Rs}\frac{\text{Y}}{\text{X}}$$

6)

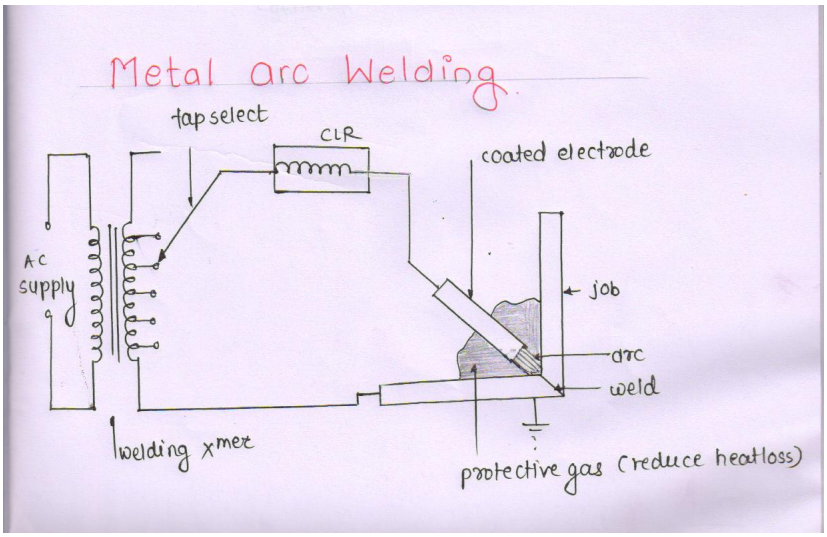
$$\therefore \sin^2\phi_2 + Cos^2\phi_2 = 1$$

$$Cos^2\phi_2 = 1 - \sin^2\phi_2$$

Most economical power factor = $Cos\ \phi_2 = \sqrt{1-(Y/x)^2}$

Most economical power factor at which maximum saving will occurs

Q. 4 B)	**Attempt any ONE** **06 Marks**
a)	**a) For metal arc welding :** **1) Draw its neat labelled sketch. 2) Explain its operation. 3) Any 2 applications.**
Ans:	**1) Diagram of metal arc welding:** **(2 Mark)**



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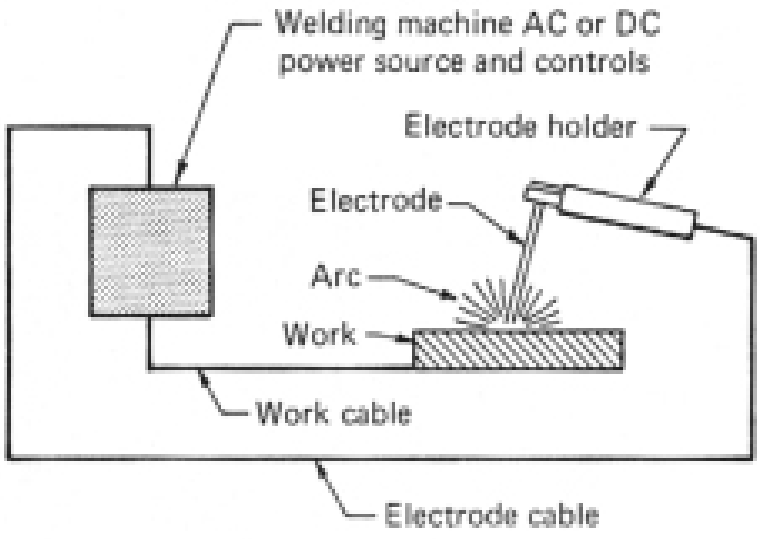


Operation of Metal Arc Welding : **(3 Mark)-**

The process 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 (Filler material) and metal to be welded (job)

OR

- Type of supply used:
- Both AC/DC Supplies can be used but generally A.C. Supply is used because it has more advantages.
- Supply Equipment used: Welding Transformer designed for low voltage high current secondary.
- Arc Stability: Series Reactor is used for arc stability.
- Temperature obtain: Less as A.C. supply is used.
- Possibility of arc blow is less.
- Capital Cost: Less since welding transformer is used as a supply equipment.
- Running cost: Less
- Maintenance cost :Less
- Stand by losses: Less
- Efficiency: More
- Voltage required: 72 to 100 volt A.C
- Types :Shielded & unshielded welding

(Any Two application expected: 1/2 Mark each)

Application: For welding Ferrous Metals, Can be used for vertical & overhead welding.

OR

Applications of Arc welding :

1. Extensively used in the construction of steel structures
2. In industrial fabrication
3. In manufacturing industry
4. In maintenance and repair industry
5. This method is used for welding ferrous metals (Iron , Steel , Stainless Steel) as well as for welding non ferrous metals (Aluminium , Nickel , copper alloys)

b) Explain the following Tariff in brief: 1) Two Part Tariff 2) Time of Day Tariff.

Ans:

1) Two Part Tariff :- **(3 Mark)**

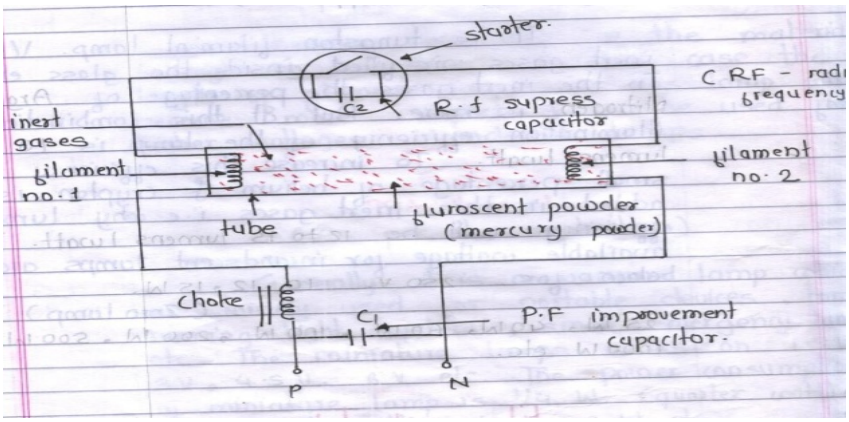
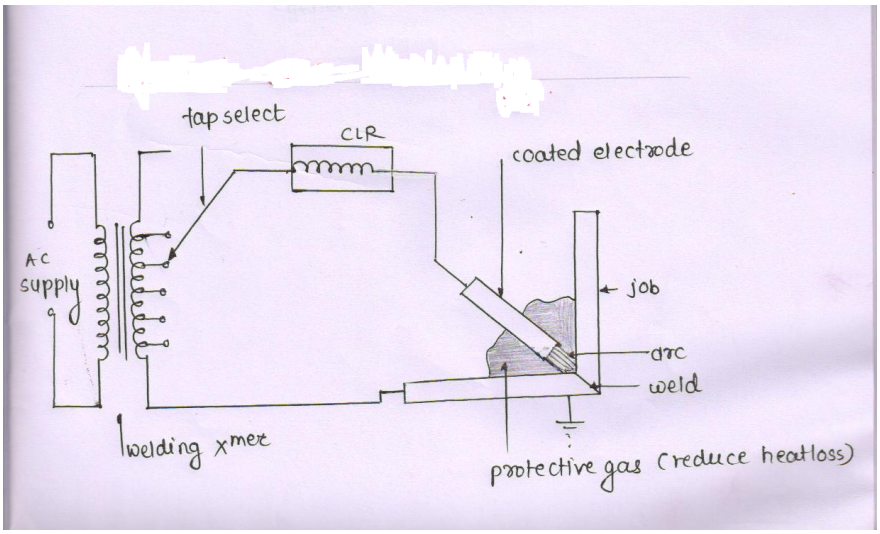
- In this type of tariff energy bill is split into two parts.

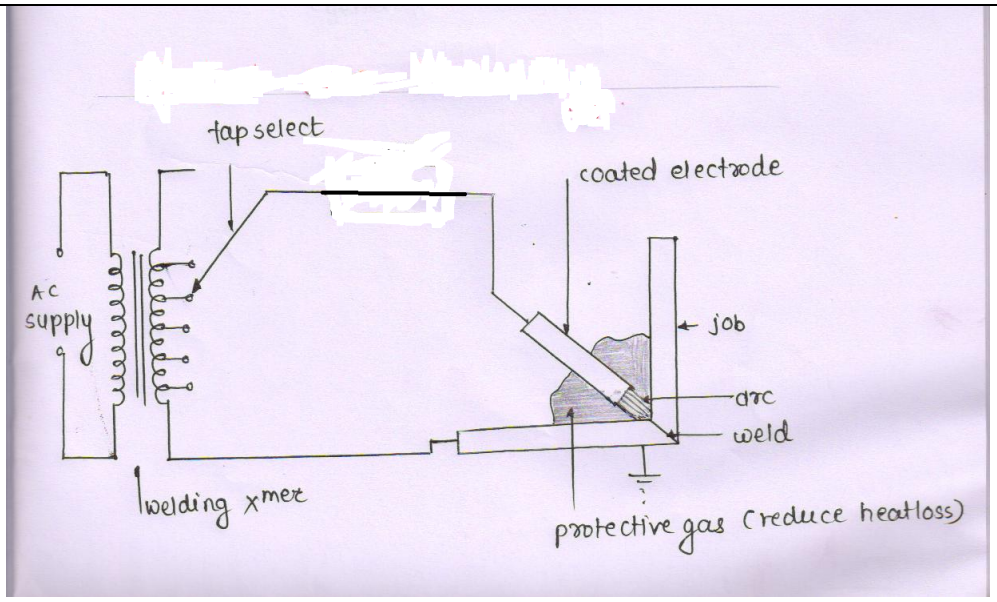
ENERGY BILL= FIXED CHARGE which depends on load (KW) +RUNNING (Variable) CHARGE which depends on actual energy consume (KWH)

- Fixed charge which depends on load (KW) which is declared by consumer on test report.
- There is no separate meter is installed to measure load.
- Only one energy meter is used to measure number of units consumed.
- 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.

2) Time of Day (TOD) Tariff or OFF-load Tariff:- **(3 Mark)**

- **In addition to basic tariff** Consumer has to pay energy consumption charges according to time for which energy is consumed.
- TOD energy meter is installed in the consumer premises.
- 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 at during OFF-load period
- Energy consumption charges/unit are more during PEAK -load period
- This type of tariff is introduced to encourage industrial consumers to run their maximum load during OFF-load period.

Q.5	**Attempt any FOUR :** **(4 x4=16 Marks)**
a)	**Draw a neat labelled diagram of fluorescent Tube and give the function of the following :** **1) Choke 2) Starter present in it.**
Ans:	**Diagram of fluorescent Tube :** **(2 Mark)**  **Function:** **(Each Function: 1 Mark)** i) Choke: For providing high voltage at the time of starting and limit the current. ii) Starter: To make and break the circuit to start the tube.
b)	**With the help of neat diagram, explain Tapped Reactor method for current control in Welding Transformer.**
Ans:	**Tapped Reactor method for current control in Welding Transformer:** **(Diagram : 2 Mark & Working: 2 Mark)**  **OR**



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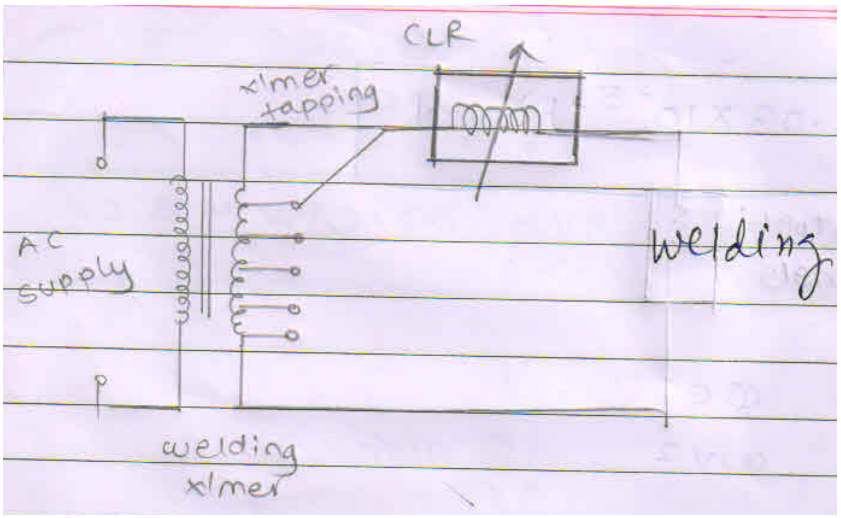


Working :-

- Reactor is used, to stabilize the arc. Arc has negative temperature co-efficient of resistance i.e. its resistance decreases as temperature increases. So arc does not remain stable. To stabilize the arc reactor is connected in series with arc furnace which control rise in current hence arc.
- Series reactor also serves as safety device by limiting current in circuit when there is short circuited.

OR

- When reactor is connected in circuit then there is voltage drop across reactor. So voltage across arc reduces. In this way the temperature control is obtained.

OR

- Input power of arc furnace can be controlled by changing trappings of furnace transformer. This is automatically done with the help of automatic current regulator.

c) Compare urban service, suburban service and main line service on the following parameters :
1) Value of Acceleration 2) Value of Retardation 3) Maximum speed 4) Distance between stations.

Ans:

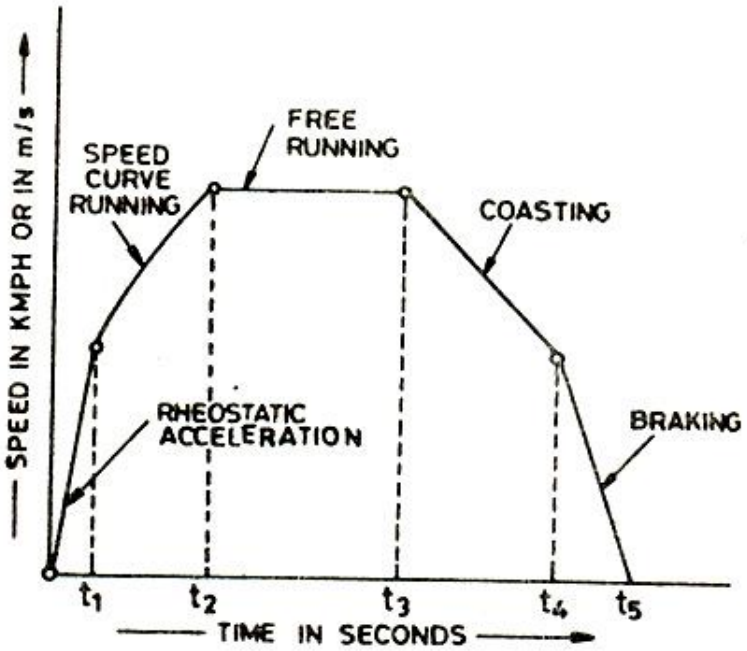
Compare urban service, suburban service and main line service : **(Each Point : 1 Mark)**

Sr.No	Points	Urban line services	Suburban line services	Main line services
1.	Acceleration (α)	High	High	low
2.	Retardation (β)	High	High	low
3.	Maximum Speed	120 km / hr	120 km / hr	160 km / hr
4.	Distance between two railway station	Low	Medium	High

OR

Sr.No	Points	Urban line services	Suburban line services	Main line services
1.	Acceleration (α)	High α = 1.5 to 4 km/hr-sec	High α = 1.5 to 4 km/hr-sec	low α = 0.6 to 0.8km/hr-sec
2.	Retardation (β)	High β = 3 to 4 km/hr-sec	High β = 3 to 4 km/hr-sec	low β = 1.5 km/hr-sec
3.	Maximum Speed	120 km / hr	120 km / hr	160 km / hr
4.	Distance between two railway station	Low (1km)	Medium (2.5 to 3 km)	High (above10km)

d)	**Draw the typical speed time curve for main traction line. Show the different time periods on it.**
Ans:	**Typical speed time curve for main traction line :** **(4 Mark)**



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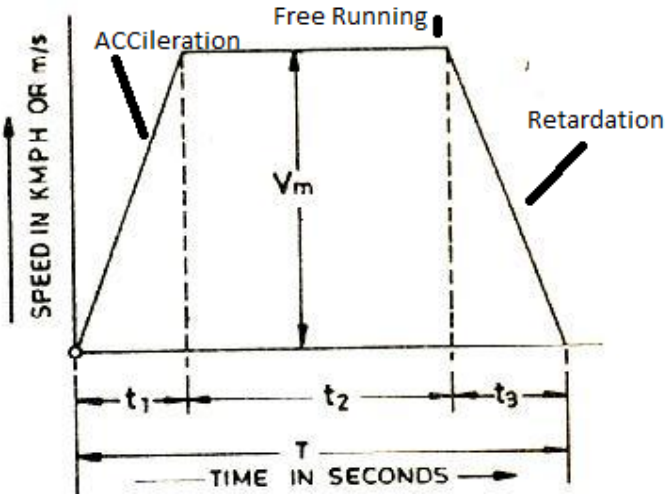
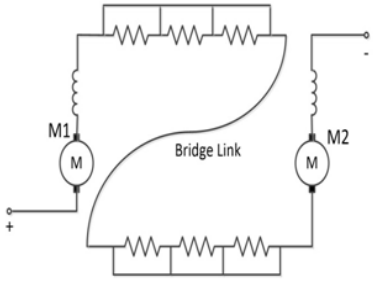


e) With the help of sketches, explain the various steps required for bridge transition system.

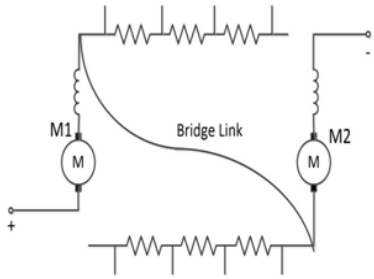
Ans: In bridge transition, series last step to parallel first step, is carried out by following steps :

(Each Step : 1 Mark)

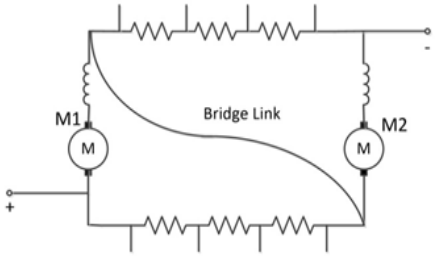
Step1: Bridge link is connected between two motors as shown in figure (Series last step)



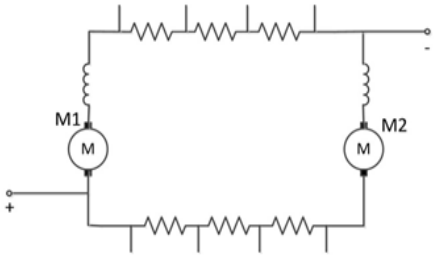
Step2:Bridge link is so rotated that two motors are put in series without starting resistance. Which are un-shorted at the same time.



Step 3:The portions of external resistance are connected in each motor circuit as shown in fig



Step4: In this last step bridge link is removed as shown in fig. This is nothing but parallel first step.



Q.6	**Attempt any TWO of the following :** **16 Marks**
a)	**A 20 kW single phase 220 V resistance oven employs a circular nichrome wire for its heating element. If wire temperature is not to exceed 1170^0 C and temperature of charge to be 500 C , calculate the diameter and the length of the wire, Take K = 0.57, e = 0.95 and ρ = 1.09 x 10^{-6} ohm meter.**
Ans:	**Given Data:**

$T_1 = 1170^0C = 1170+273 = 1443^0K$

$T_2 = 500^0C = 500 +273 = 773^0K$

Radiation efficiency = 0.57, specific resistance of Ni-Cr = 1.09×10^{-6} ohm m, emissivity = 0.95.

$$H = 5.72\times10^4 \text{ k.e}\left[\left(\frac{T_1}{1000}\right)^4 - \left(\frac{T_2}{1000}\right)^4\right] \quad w/m^2$$ **OR**

$$\mathbf{H} = 5.72\times\ k.e\left[\left(\frac{T_1}{100}\right)^4 - \left(\frac{T_2}{100}\right)^4\right] \quad w/m^2$$

---------- **(1 Mark)**

$$\mathbf{H} = 5.72\times\ 0.57\times0.95\left[\left(\frac{1443}{100}\right)^4 - \left(\frac{773}{100}\right)^4\right] \quad w/m^2$$

$$\mathbf{H} = 12.3236\times10^4 \quad w/m^2$$

---------- **(1 Mark)**

$\Rightarrow$ *Thickness* : 0.3 *mm* $\therefore 0.3\times10^{-3}$ *m*

➢

$$\therefore \frac{l}{d^2} = \frac{V^2\ \pi}{4\ P\ \rho}$$

---------- Equation No.1---------- **(1 Mark)**

$$\therefore \frac{l}{d^2} = \frac{(220)^2\ \pi}{4\times20\times1000\times1.09\times10^{-6}}$$

$$\therefore \frac{l}{d^2} = 1743728.032$$

---------- Equation No.2 ---------- **(1 Mark)**

Heat Dissipated = Electrical Power I/p

$$\pi\ d\ l\ H = P$$

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

$$\pi\ d\ l\ 12.3236\times10^4 = 20000$$

$$d\ l\ = 0.05165$$

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

By Simplifying :

$$\therefore\ d^2\ l^2\ = 2.6686\times10^{-3}$$

$$\therefore\ d^2\ = \frac{2.6686\times10^{-3}}{l^2}$$

Substitute Value of d^2 in Equation No.1 :

$$\therefore \frac{l}{\frac{2.6686\times10^{-3}}{l^2}} = 1743728.032$$ **mm**---------- **(1/2 Mark)**

$$\therefore l^3 = 1743728\ .032\ \times 2.6686\times10^{-3}$$

$$\therefore l = 16\ .69\ m$$

---------- **(1 Mark)**

Substitute Value of 'l' in Equation No.2 to calculate 'd' :

$$\therefore\ \frac{l}{d^2}\ =\ 1743728\ .032$$

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

$$\therefore\ d\ =\ 3.66\times10^{-3}\ mtr$$

$$\therefore\ d\ =\ 3.66\ mm$$

---------- **(1 Mark)**

Answer : $\therefore$ *Length* $l = 16.69\ mtr$

$\therefore$ *Diameter* $d = 3.66\ mm$

b) **The distance between two stations is 2 KM. It is desired to have scheduled speed of 40 km/hr with duration of stop of 20 seconds. Assuming, trapezoidal speed time curve, Calculate :**
1) The maximum speed required when the acceleration is to be limited to 1.2 km/hr/sec and braking retardation to 3 km/hr/sec.
2) The distance covered during acceleration and retardation.

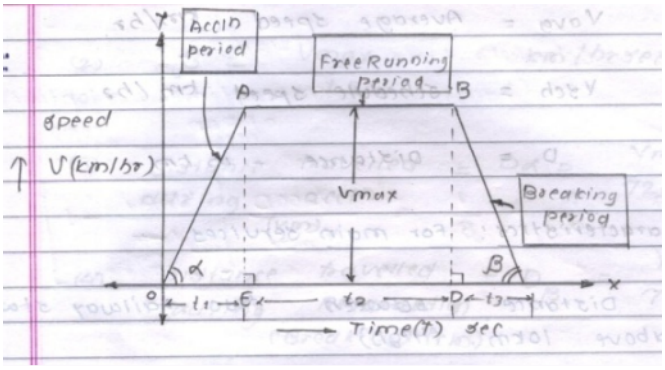
Ans:

Given Data :-

D = 2 KM, Schedule speed (V_{sch}) = 40KM / Hr, Stop Time = 20 sec.

Acceleration (α) = 1.2 Km/Hr/sec; Retardation (β) = 3 Km/Hr/sec.

Trapezoidal speed time curve :-



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

$\therefore \quad Schedule\,Time = \dfrac{3600\,D}{V_{sch}}$

$\therefore \quad Schedule\,Time = \dfrac{3600 \times 2}{40}$

$\therefore \quad Schedule\,Time = \dfrac{7200}{40}$

$\therefore \quad ScheduleTime = 180$ sec.---------- **(1 Mark)**

- $SchudeleTime = Actual\,Time\,of\;Run + Stop\,time$

$\therefore \quad Actual\,Time\,of\;Run = Schedule\,Time - Stop\,time$

$\therefore \quad Actual\,Time\,of\;Run = 180 - 20$

$\therefore \quad Actual\,Time\,of\;Run = 160$ sec.---------- **(1/2 Mark)**

- Maximum Speed =

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

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

$$K = \frac{1.2 + 3}{2(1.2 \times 3)}$$

$K = 0.5833$---------- **(1 Mark)**

$$V_{max} = \frac{160 - \sqrt{160^2 - 4 \times 0.5833 \times 3600 \times 2}}{2 \times 0.5833}$$

$V_{max} = 56.7345$ KM/Hr ----------Answer---------- **(1/2 Mark)**

- Distance covered during Acceleration ($D\alpha$) =

$$D\alpha = \frac{V_{max}^{\ 2}}{7200\,\alpha}$$ ---------- **(1 Mark)**

$$D\alpha = \frac{56.7345^{\ 2}}{7200 \times 1.2}$$

$D\alpha = 0.3725\,Km$ ----------Answer---------- **(1/2 Mark)**

Distance covered during Retardation ($D\beta$) =

$$D\beta = \frac{V_{max}^{\ 2}}{7200\,\beta}$$ ---------- **(1 Mark)**

$$D\beta = \frac{56.7345^{2}}{7200 \times 3}$$

$D\beta = 0.1490$ Km----------Answer--- **(1 /2 Mark)**

c) **A 300 HP, 3000 V, 50 c/s, 3 phase star connected induction motor has full load efficiency of 86% and pf of 0.707 lagging. If it is desired to improve the pf to 0.95 lagging by a bank of three capacitors, find out the :**
1) KVA Rating of the capacitor bank.
2) Capacitance of each unit when connected in i) Mesh ii) in star.

Ans: **Given Data**

Volt : 3000 V, f= 50 Hz

300 HP x 735.5 = 220650

P= 300 HP x 735.5 / 0.86 = 256569.7674 Watt = 256.57 kW

$\cos\phi_1$ =0.707 $\cos\phi_2$ =0.95

$\therefore$ $Cos\ \phi_1 = 0.707$

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

$\cos\phi_2$ =0.95

$\tan\phi_2 = 0.328$ ---------- ---------- **(1/2 Mark)**

$Q_1 = P \tan\phi_1$

= 256.57 x 1

= 256.57 KVAR ---------- **(1/2 Mark)**

$Q_2 = P \tan\phi_2$

$= 256.57 \times 0.328$

$= 84.15$ KVAR - ---------- **(1/2 Mark)**

i) KVA Rating of the capacitor Bank

$Q_C = Q_1 - Q_2$

$= P \tan\phi_1 - P \tan\phi_2$ ----------**(1 Mark)**

$= 256.57 - 84.15$

$= 172.42$ KVAR ---------- **(1 Mark)**

∴ **Capacitor when connected in Mesh :-**

$$C \text{ per phase} = \frac{Q_C}{3\omega V^2} \text{ -}$$ ---------- **(1 Mark)**

$$C \text{ per phase} = \frac{172.42 \times 10^3}{3 \times 2\pi \times 50 \times (3000)^2}$$

$$C \text{ per phase} = \frac{172.42 \times 10^3}{8482300165}$$

$C \text{ per phase} = 2.032 \times 10^{-8}$ F - ---------- **(1 Mark)**

∴ **Capacitor when connected in Star :-**

$$C \text{ per phase} = \frac{Q_C}{\omega V^2} \text{ -}$$ ---------- **(1 Mark)**

$$C \text{ per phase} = \frac{172.42 \times 10^3}{2\pi \times 50 \times (3000)^2}$$

$C \text{ per phase} = 6.098 \times 10^{-8}$ F - ---------- **(1 Mark)**

----------**END**----------