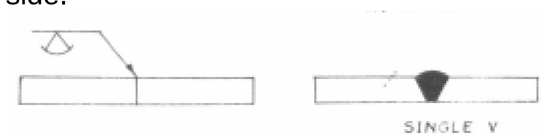
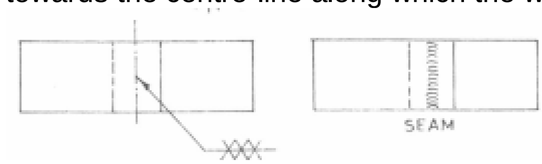
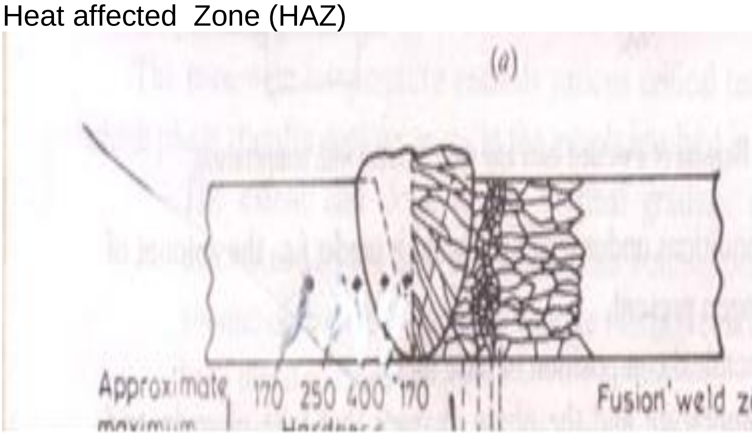
WINTER– 15 EXAMINATIONS

Subject Code: **17455** **Model Answer** Page No: ____/ N

Important Instructions 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 principal components indicated in the 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 of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q. NO.	MODEL ANSWER	MARKS	TOTAL
1.	**Attempt any five**		**20**
a)	i)The location of weld is indicated by an arrow and a reference line. For example, (a) When the weld symbol is below the reference line, the weld is made on the same side of the joint as the arrow-head, i.e. the arrow side.  ii)When resistance welds are to be indicated, the arrow shall point towards the centre-line along which the welds are to be made [Fig.].  	**2m each**	**4m**
b)	Arc Stability:- Arc is said to be stable if it is uniform and steady. A stable arc will produce good weld bead and a defect-free weld nugget. Defects commonly introduced by unstable arc slag entrapment, porosity, blow holes and lack of proper fusion. The stability of a welding arc is governed by so many factors, a few, as mentioned below. (a) Suitable matching of arc and power source characteristics. A little variation in arc length, i.e., arc voltage should not extinguish the arc. (b) Continuous and proper emission of electrons from the electrode (say cathode) and thermal iozation in the arc column. Emissivity of pure tungsten cathode is improved by making it thoriated or zirconiated. (c) Position and movements of cathode and anode spots. (d) Arc length and arc current. . (e) Electrode tip geometry in TIG welding. (g) Conditions promoting Arc Blow. (h) Presence of dampness, oil, grease etc. on the surface of workpiece. (i) Limited practice on the part of the welder. Advantages:- 1)A stable arc will produce good weld bead 2)A stable arc will produce a defect-free weld nugget 3)Production rate will increase 4)Arc will be stable ,steady and uniform	**3m** **1m**	**4m**

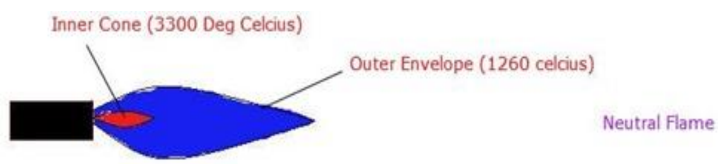
c)	Factors Affecting Arc Blow are as follows: (a) magnetic fields produced in the workpiece adjacent to the welding arc, because of the current flow through the arc, (b) presence of bus bars carrying large direct currents, in the neighborhood of the place where welding is being carried out, (c) With multiple welding heads, arc at one electrode may be affected by the magnetic field of the arc at the other electrode, (d) The magnetic field produced in the workpiece around the earth connection may tend to drive the arc away from the point where this connection is made. This magnetic field is produced because of current flow from the earth connection to the workpiece.	**1m each point**	**4m**
d)	Factors effecting weldability of metal are as follows • Composition of the metal • Brittleness and strength of metal at elevated temperature • Thermal properties of metal • Welding techniques, fluxing material and filler material • Proper heat treatment before and after the deposition of the metal.	**1m each point**	**4m**
e)	The factors which influence the solidification mode are- Low values of $G/\sqrt{R}$ indicate an increased tendency for constitutional super cooling, thus Z favoring the dendritic mode of solidification. On the other hand,steep temperature gradients in the liquid and slow growth rates favour cellular growth .Weld metal solidification rate influences metallurgical structure, properties and soundness of the weld	**4m**	**4m**
f)	Heat affected Zone (HAZ)  - Adjacent to the weld metal zone is the heat-affected zone that is composed of parent metal that did not melt but was heated to a high enough temperature for a sufficient period that grain growth occurred.	**2m(1/2 m for diagram)**	**4m**

	- Heat -affected zone is that portion of the base metal whose mechanical properties and microstructure have been altered by the heat of welding Characteristic:- - The heat-affected zone is subjected to a complex thermal cycle (sudden heating followed by rapid cooling) in which all temperatures from the melting range of the steel down to comparatively much lower temperatures are involved and HAZ therefore consists of a series of graded structures ringing the weld bead. - HAZ, usually contains a variety of microstructures. In plain carbon steels these structures may range from very narrow regions of hard martensite t6 coarse pearlite. This renders HAZ, the weakest area in a weld. Except where there are obvious defects in the weld deposit, most welding failures originate in the heat-affected zone. - The width of HAZ varies according to the welding process and technique; in arc welds it extends only a few mm from the fusion boundary, but in oxy-acetylene and electro slag welds it is somewhat wider. - The HAZ in low carbon steel of normal structure welded in one run with coated electrodes or by submerged arc process comprises three metallurgically distinguished regions. 1. The grain growth region 2. The grain refined region 3. The transition region	**2m(1m each point)**	
g)	(table below)	**1m each point**	**4m**

SR. NO	WELDING	BRAZING
1	These are the Strongest joints used to bear the load. Strength of a welded joint may be more than the strength of base metal.	These are stronger than soldering but weaker than welding. These can be used to bear the load up to some extent
2	Temperature required is upto 3800°C of Welding zone.	It may go to 600°C in brazing
3	Work piece to be joined need to be heated till their melting point.	Work pieces are heated but below their melting point.
4	Mechanical properties of base metal may change at the joint due to heating and cooling.	May change in mechanical properties of joint but it is almost negligible
5	Heat cost is involved and high skill level is required.	Cost involved and sill required are in between others two

6	Heat treatment is generally required to eliminate undesirable effects of welding	No heat treatment is required after brazing.
7	No preheating of workpiece is required before welding as it is carried out at high temperature.	Preheating is desirable to make strong joint as brazing is carried out at relatively low temperature

2.	ATTEMPT ANY FOUR		16
a)		2m for each topic (1/2 m for each diag)	4m

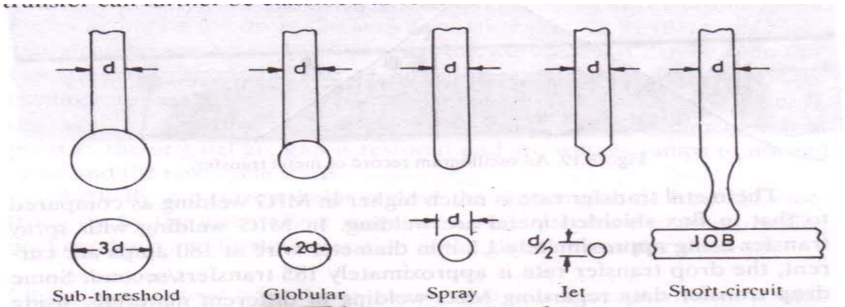


1) NEUTRAL FLAME:-

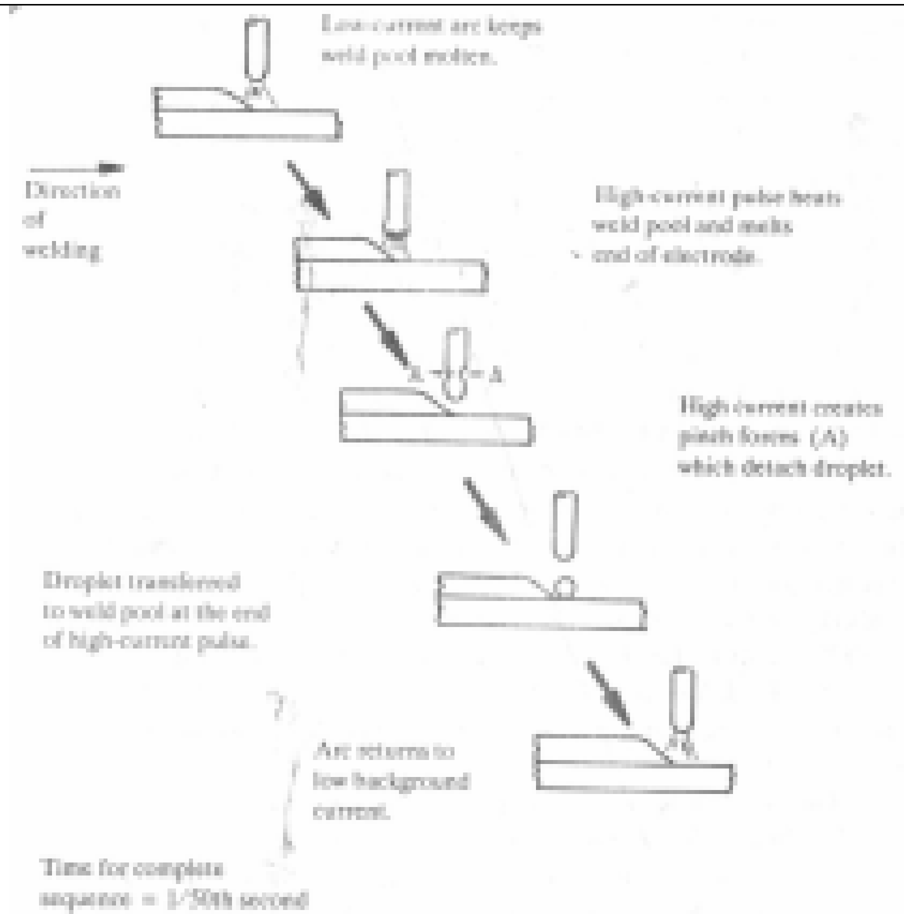
A neutral flame is produced when approximately equal volumes of Oxygen acetylene are mixed in the welding torch & burnt at the torch tip.
The temperature of the neutral flame is of the order about 5900° F.
The flame has a nicely defined inner cone which is light blue in colour.It is surrounded by an outer envelope which is much darker than blue.
Application:- Mild steel, Aluminium, Stainless Steel, Copper,
Cast iron

2) OXIDISING FLAME:-

If after the neutral flame has been established the supply of an oxidising flame can be recognised by the small white cone which is shorter , much blue in colour & more painted than that of the neutral flame. This is because of excess oxygen & which causes the temperature to rise as high as 6300 F.
Applications:-
Copper base metals, Zinc base metals, Manganese steel, cast iron.

b)	Free Flight Transfer. In which metal drops get detached from the electrode,pass through the arc and fall on the job. This category of metal transfer can further be classified as follows:  [redacted]. Types of metal transfer. (i) Sub-threshold type. The drop diameter is approximately equal to three times the electrode core wire diameter. (ii) Globular type. The drop diameter is approximately twice the electrode core wire diameter. This type of transfer is observed in both flux shielded metal arc welding and MIG welding processes. Globular transfer is observed at low arc currents or with longer arcs. The globules may pass freely through the welding arc or depending upon their size and arc gap they may short-circuit the arc. The number of drops transferred per second are very less. Globular transfer is associated with spatter loss and shallow penetration height. (iii) Spray type. In this case the drop diameter is approximately equal to electrode core wire diameter. The rate of drop transfer is much higher than that in globular transfer. There is a continuous spray of drops from the electrode to the job. This type of transfer occurs at high arc currents and low arc lengths. Spray transfer is observed in both flux-shielded metal arc welding and MIG welding. A mixture of argon and oxygen promotes spray transfer in MIG welding. Though associated with some spatter, spray mode of transfer produces a stable are, good weld bead, deep penetration, a strong joint and is recommended for thicker plates. (iv) Jet type: In jet type of transfer the drop diameter is approximately equal to half the diameter of the wire. In this case the electrode end becomes tapered and a jet of drops comes out from the electrode .The temperature of the droplet formed from a steel electrode just as it detaches, ranges from 1800-2000 0C.The size of a droplet ranges between 0.5 to 5 mm. The velocity at which drop transfer takes place depends upon drop size.	**3m for exp 1m for diag**	**4m**

c)	Pulsed type metal transfer 1) Pulsed-arc welding is a controlled method of spray transfer welding requiring a more sophisticated power source, whereas the types of transfer described previously can be obtained with standard power sources and wire feed units. 2) In spray transfer, droplets of metal are projected from the wire tip across the arc gap to the molten pool at a constant current. In dip transfer, metal is transferred to the molten pool somewhat irregularly during the periods of short circuiting. 3) Pulsed-arc welding enables droplets to be projected across the arc gap at a regular frequency, using pulses of current in the spray transfer range supplied from a special power source. 4) Transfer of metal from the wire tip to the molten pool occurs only at the period of pulse or peak current (see Fig.). 5)During the intervals between pulses a low 'background' current maintains the arc to keep the wire tip molten but no metal is transferred. 6) Pulsed transfer means that the weld metal is projected across the gap at high current, hut the mean welding current remains relatively low. 7) The operator can vary the pulse height and the background current to obtain full control of both the heat input and the amount of metal deposited; however, in many modern power sources the pulse procedure is preset by the manufacturer to simplify use.	**3m for exp 1m for diag**	**4m**

			
d)	Welding characteristics of gray cast iron 1) During welding a molten pool of gray cast iron, at the joint to be welded, is created which when solidified forms the weld. 2) If the percentage of silicon in gray cast iron is proper, the amount of carbon going into the combined state (as cementite etc.) or remaining in the free form (as flakes) will depend upon the cooling rate of the weld metal. 3)If the cooling rate is fast, most of the carbon will go in the combined state and the result will be a very hard, brittle, and un machinable white cast iron weld, Crack formation may also be there. 4) In order to obtain a soft, stress free and easily machinable weld, the weld metal cooling rate is retarded by preheating the gray cast iron part before welding to a temperature as high as 600-7000C. 5) Whether the preheating may be done only at and around the joint or the complete job maybe preheated, it depends upon the geometric shape and size of the workpiece.After the weld is completed, the job is allowed to cool down relatively slowly by covering the heated section of the component with asbestos, by burying it in dry sand etc. 6)Post-heat treatment of the entire component or of a localized area adjacent to the weld also helps minimizing the excessive cooling stresses and prevent the formation of white cast iron.	**4m**	**4m**

e)	METALLURGICAL EFFECTS OF WELDING ON METALS Welding operations give rise to many metallurgical effects : 1. Weld metal is essentially a small casting, with the inherent defects and characteristics of a casting. An appreciation of these characteristics can be easily attained by a study of the mechanism of solidification ofmetals and alloys. 2. Absorption of gases by weld metal and gas reactions is important in controlling the porosity of a weld, e.g., hydrogen in aluminium. 3. Gas such as hydrogen is more easily dissolved in the molten metal at high temperature and may subsequently be trapped in the solid metal if cooling is rapid. 4. The gas may either be retained in the microstructure or may form bubbles which can become trapped as porosity in the fast freezing metal. 5. Gas-metal reaction may take one of the two forms: physical (endothermic)solution, or exothermic reaction to form a stable chemical compound. 6. Endothermic solution does not exhibit fusion, but can result in porosity,either due to supersaturation of the weld pool with a particular gas or by reaction between two gases. Sometimes it may result in the crnbrittlement of HAZ also. 6. Slag inclusions are frequently trapped in fusion welds due to joint or bead contour and there is difficulty of removing or melting the slag in subsequent runs. 7. Hot cracking of welds. Under constrained welding conditions, the contractional strains, sometimes, cause intercrystalline 'lacks in hot welds, the fractured surface being tinted with oxidation film. 8.Hot cracking of welds occurs at elevated temperature. This may beattributed directly to the low ductility of the base metal at temperatures not too far below melting.	**1m per point**	**4m**
f)	Good Brazing joint design should be such that: (i) The filler metal can be placed on one side of the joint and pulled through the joint by capillary action. (ii) There is an allowance for preplacernent or feeding of the filler metal into the joint area. (iii) The joint meets service requirements, e.g. a)Mechanical performance b)Electrical and Thermal conductivity c) Pressure tightness d) Corrosion resistance e)Good appearance f)Service temperature. The type of joints used for brazing include the lap, scarf butt joint, square butt joint, tee joint, iv) The lap joint probably gives the most satisfactory results in terms of optimum strength requirements. The length of the lap should be equal to at least three times the thickness of the thinnest member of the joint.	**1m each point**	**4m**

3.	ATTEMPT ANY FOUR		16
a)	ADVANTAGES OF GAS WELDING 1. It is probably the most versatile process. It can be applied to a wide variety of manufacturing and maintenance situations. 2. Welder has considerable control over the temperature of the metal in the weld zone. When the rate of heat input from the flame is properly coordinated with the speed of welding, the size, viscosity and surface tension of the weld puddle can be controlled, permitting the pressure of the flame to be used to aid in positioning and shaping the weld. 3. The rate of heating and cooling is relatively slow. In some cases, this is an advantage. 4. Since the sources of heat and of filler metal are separate, the welder has control over filler-metal deposition rates. Heat can be applied prefer- entially to the base metal or the filler metal. 5. The equipment is versatile, low cost, self-sufficient and usually portable. Besides gas welding, the equipment can be used for preheating, post heating, braze welding, torch brazing and it is readily converted to oxygen cutting. 6. The cost and maintenance of the welding equipment is low when compared to that of some other welding processes. LIMITATION OF GAS WELDING 1. Heavy sections cannot be joined economically. 2. Flame temperature is less than the temperature of the arc. 3. Fluxes used in certain welding and brazing' operations produce fumes that are irritating to the eyes, nose, throat and lungs. 4. Refractory metals (e.g., tungsten, molybdenum, tantalum, etc.) and reactive metals (e.g., titanium and zirconium) cannot be gas welded. 5. Gas flame takes a long time to heat up the metal than an arc. 6. Prolonged heating of the joint in gas welding results in a larger heat-affected area. This often leads to increased grain growth, more distortion and, in some cases, loss of corrosion resistance. 7. More safety problems are associated with the handling and storing of gase. 8. Acetylene and oxygen gases are rather expensive. 9. Flux shielding in gas welding is not so effective as an inert gas shielding in TIG or MIG welding. Applications: sheet metal, heat exchangers, bridges, ship bodies, air craft, furnace parts, boilers etc	**2m for adv 2m for limit (1m each point)**	**4m**
b)	i)Depending upon the material of the electrode, it may melt and supply filler metal; if it is non-consumable, a separate filler addition generally becomes necessary. ii)The composition of the core wire depends upon the metal to be welded. iii) For example, to weld mild steel, core wire of similar composition will be prepared, in order to get a homogeneous welded joint. iv) The size or diameter of the core wire will depend upon the	**3m for exp(1m for diag)**	**4m**

amount of weld metal to be deposited and on the type of joint or the gap to be bridged between the two plates to be welded. v)Higher currents will be required to weld with bigger diameter electrodes.

vi) The length of the core wire is designed after considering rigidity, electrical resistance, the ease in welding and the diameter of the electrode.

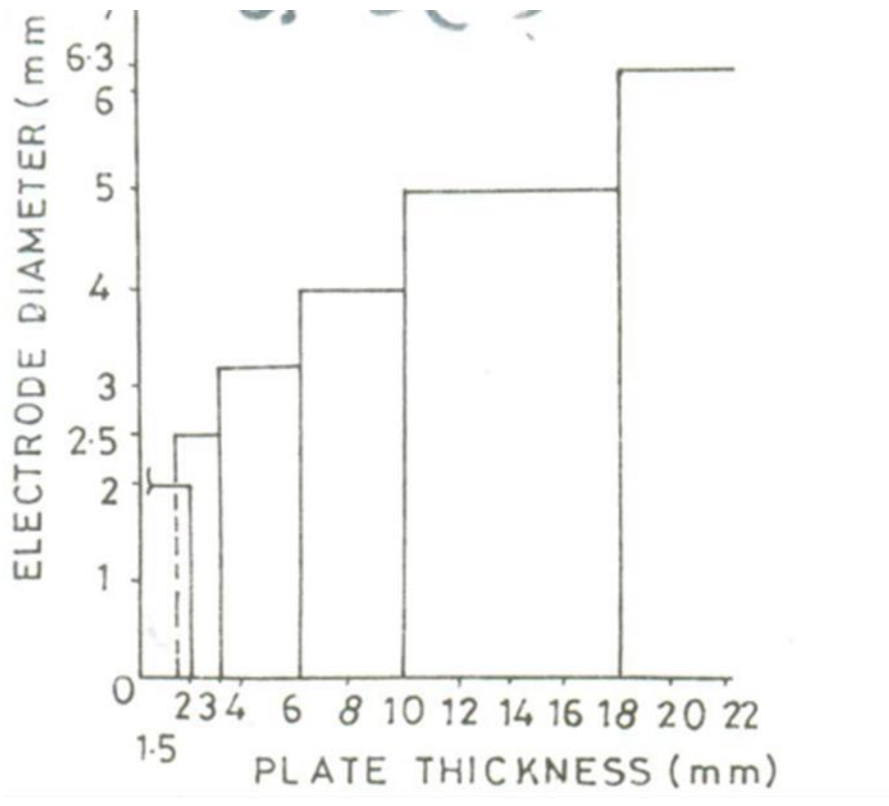
vii)Generally thin and larger diameter electrodes are of shorter lengths and medium sized electrodes have bigger lengths.

viii)The reason is if thin electrodes are made longer they may bend and welding may not be carried out properly; and if bigger diameter electrodes are made long, their weight may increase too much to make welding operation inconvenient for the operator.

ix) In longer electrodes, electrical resistance and thus the heat generated in the electrode body increases, which may spoil the electrode covering.

x)Diameter remaining same, an electrode of higher resistance material is normally made smaller in length.

xi) Thickness of worpiece suggests the values of electrode diameters for welding steel plates of different thicknesses. Preferably, electrode diameter should be less than the plate thickness.

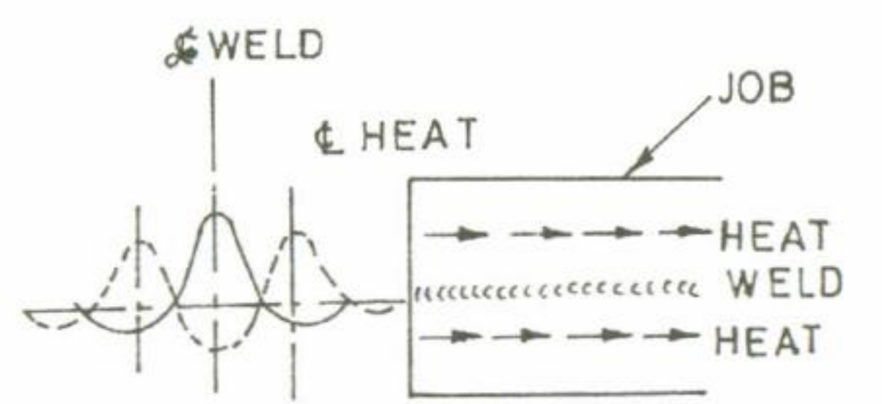


c)	i) Spot welding 1) Welding on cast iron involves repairs to castings, not joining casting to other members. 2) Cast iron typically has a carbon content of 2% - 4%, roughly 10 times as much as most steels. The high carbon content causes the carbon to form flakes of graphite. 3) This graphite gives gray cast iron its characteristic appearance when fractured. 4) A critical temperature in most cast iron is about 1450° F. When at this temperature, conditions that can lead to cracking occur. 5) The overall weldability of cast iron is low and depends on the material type, complexity, thickness, casting complexity and need for machinability. 6)There are many different cast irons, many of which are totally unweldable as they will crack when you heat them ii) Forge welding 1) When castings are made, molten iron is poured into a mold and allowed to slowly cool. 2) When this high carbon material is allowed to cool slowly, crack free castings can be made. Because of its molten state getting cooled it cannot be forged so easily. 3) A cast iron is an alloy of iron, carbon, and silicon, in which the amount of carbon is usually more than 1.7 percent and less than 4.5 percent. 4) There are many different cast irons, many of which are totally unweldable as they will crack when you heat them.	**2m (1m each point)** **2m (1m each point)**	**4m**
d)	Various heat treatment to reduce stresses are: 1.Peening 2.Vibratory stress-relief 3. Thermal treatment 4. Thermo-mechanical treatment 5. Overstressing technique 1. Peening - Peening has been employed with success for stress relieving purposes. When properly applied, peening causes plastic flow and subsequently relieves the restraint that set up in the residual stresses. - Instead by hand, peening may be better controlled if a pneumatic chisel with blunt rounded edge is used. - Peening reduces internal stresses of a very low intensity- far below any affected by heating below the critical point, because low temperature reduces only those internal stresses that are above the long-time yield point of the steel at the stress-relieving temperature. For this reason the general use of peening to reduce stresses below the fracture point during welding operations is	**2m for listing 2m for exp any one**	**4m**

	employed extensively. It eliminates need for successive heat treatments when welding a very thick section, say of 45 cm. - Peening also reduces distortion (stress relief by heat cannot accomplish this to the same degree). - Peening should not be employed on the first and last layers (or beads) of the welds, because peening the first layer could actually pierce the weld or displace the member sideways and peening the last layer will cold work it and thus injure the weld metal (as there is no subsequent application of heat to anneal the last layer). - Excessive peening should not be carried out as it may result in (i) cold working and strain hardening of the weld metal, (ii) bending, and (iii) cracking of the weld. - Peening should be employed only when the weld metal possesses sufficient ductility to undergo necessary deformation. 2. Vibratory Stress-relief - Welded structures (e.g., press frames) are subjected to vibrations to relieve residual stresses. - In this method of stress-relieving an oscillating or rotating wave generator is mechanically coupled to the part to be stress relieved. The welded structure is placed on a platform that vibrates and in turn. the welded structure vibrates at one of its natural (resonant) frequencies. For such a system to be effective, it must produce plastic yielding in the region to be stress relieved. - If not all the welding stresses, vibratory method can at least reduce the magnitude of peak stresses". Even this (i) reduces distortion in parts machined after welding, (ii) improves resistance to brittle fracture. - Since vibratory stress-relief treatment does not change the metallurgical structure of welds or heat -affected zone, it does not alter mechanical properties, i.e., the strength or toughness of the weldment. 3. Thermal treatment - Thermal treatment proves to be a better substitute than vibratory stress relief because it improves the strength or toughness of the weldment by bringing changes in microstructures. - Thermal stress-relief treatment consists of heating a welded structure uniformly to a suitable temperature (preferably in a furnace) below the critical range of the parent metal, holding it at this temperature for predetermined period of time, followed by uniform cooling. Still air is very desirable after the furnace is opened and until the structure is fully cooled. - A desirable thermal stress relieving treatment for a welded steel structure is heating uniformly to 595 to 650°C, holding at that temperature 2 hour per 25 mm of thickness and cooling slowly in the furnace to approximately 125°C and preferably lower. After treatment, the structure may be removed and allowed to cool to room temperature. 595 to 650°C temperature is high enough to reduce the residual		

stresses rapidly, in addition, this relatively low temperature avoids undue distortion of the weldment.
- The temperature used for stress-relief heat treatment may be in the range of 525-740°C for weldment in plain carbon and low alloy steels. When lower temperature in the specified range is used, longer soaking times are necessary.
- Thermal treatment reduces stresses to a level just below the yield point of the material at the temperature of the stress relief treatment. The residual stress remaining in a material after thermal stress relief will depend on the rate of cooling. Uneven cooling may undo much of the value of thermal treatment.
- The percentage relief of welding stresses is dependent on steel type, composition or yield strength.

4.Thermo-mechanical stress relief-treatment
- This technique aims at using thermal expansion to provide the mechanical forces required to set up another residual stress system to counteract and thereby cancel the original already set-up due to welding.
- In this process, two bands of heat (using two oxy-fuel gas torches moving in tandem along the weld) are applied to either side of a longitudinal welds (Fig.)

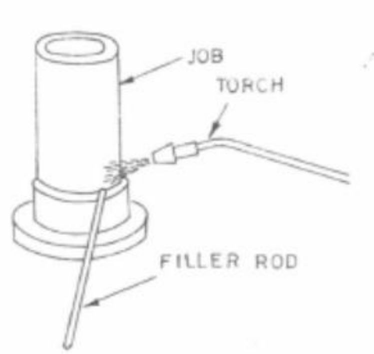


-The progression of these heated bands of metal, parallel to the weld and adjacent to each side, results in a travelling zone of thermal expansion in the base metal and a reciprocal tensile stress in the weld.
-The positions of heat bands are chosen such that this way developed residual stresses counteract and cancel the original stresses set-up due to welding.
- The metal on either side of a welded joint is heated to a temperature of 175 to 205°C, while the weld itself'1, kept relatively cool.
- Reductions in transverse residual stresses ranging up to 60%, as well as a considerable reduction in the longitudinal stresses, have been reported using thermo-mechanical stress relief treatment.
- Since this low-temperature treatment, in most metals, does not improve metallurgical properties of weld metal and heat affected

	zone, it is not considered as a good substitute for thermal stress relief treatment to provide ductility and notch toughness. 5. Overstressing technique - This method, more applicable to thin welds, has been applied for many years by many operators. It can be used for ductile welds and ductile steel. - All that is necessary is to bring the applied stresses above the yield stress of the material. Sometimes it is not necessary to load even that much. -In a structure where internal stresses are high it is only necessary to apply such a load as will bring the total to the neighbourhood of the yield, and the high internal stresses will relieve themselves without much distortion. - Welded pressure vessels may' be stress relieved by subjecting them to internal pressures (say hydrostatically) of such a value that the metal reaches the yield stress throughout. -When such pressure are removed the residual stress will be bound to have largely disappeared.		
e)	NEED OF HEAT TREATMENT AFTER WELDING:- 1) Post weld heat treatment defined as any heat treatment after welding, is often used to improve properties of a weldment. 2) the Post weld heat treatment can encompass many different potential treatments; fabrication, the two most common procedures however, in steel used are post heating and stress relieving 3) The need for Post weld heat treatment is driven by code and application requirements, as well as the service environment. In general, when Post weld heat treatment is required, the goal is to increase the resistance to brittle fracture and relaxing residual stresses. Other desired results from Post weld heat treatment may include hardness reduction, and material strength enhancements. 4)Post heating is used to minimize the potential for hydrogen induced cracking (HIC). 5)Stress relief heat treatment is used to reduce the stresses that remain locked in a structure as a consequence of manufacturing processes.	**1m per point**	**4m**
f)	TORCH BRAZING - Torch brazing is the most versatile method and it finds wide application in industry in both fabrication and repair work. - Heat is usually provided by ordinary gas welding equipment by burning gas combinations such as air and acetylene, oxygen and acetylene, oxygen and hydrogen and air and propane. - Air-gas torches provide the lowest flame temperature as well as the least heat, depending on the size of the torch. Oxy-hydrogen torches are often used for brazing aluminium and other non-ferrous alloys. - To braze, the operator plays the torch flame (which is neutral or slightly reducing) on the thoroughly cleaned parts, being careful to heat the heavier sections first. A flux is applied to the joint area to prevent oxidation of the parts during heating. As the flux becomes	**3m for exp(1m per point) 1m diag**	**4m**

molten, it cleans the joint area of oxides etc., and prepares the surfaces for wetting by the filler metal. The filler metal is then hand-fed to the joint area as soon as the joint is up to the brazing temperature.

- In many cases filler rods instead of being hand-fed,are preplaced in the form of a ring, washer, or insert to fit the contour of the joint.
- Commonly used filler metals need a joint clearance(at brazing temperature) of 0.05 to 0.125 mm for capillary flow. Lap joints are usually preferred.



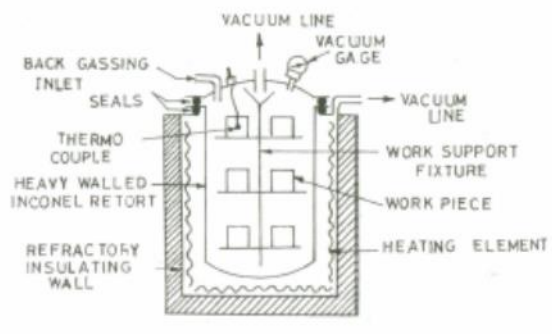
4.	ATTEMPT ANY FOUR		16
a)		1m per point	4m

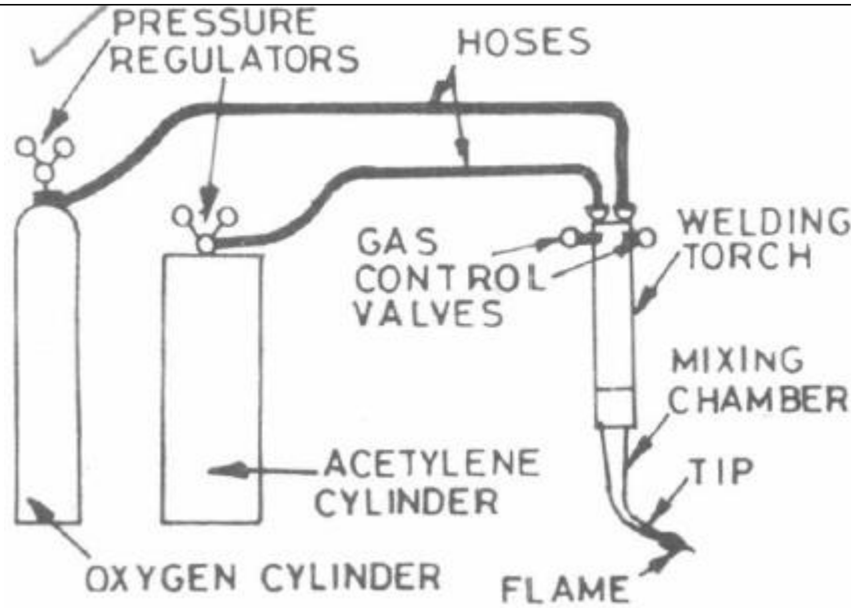
LEFTWARD TECHNIQUE	RIGHTWARD TECHNIQUE
The welding flame is directed away from the finished weld of the joint i.e towards the Unwelded part.	The welding flame is directed towards the finished weld of the joint ie away from the. the Unwelded part.
Welding begins at the right hand end of the weld and proceeds towards the left side end of the joint.	Welding begins at the left hand end of the weld and proceeds towards the right side end of the joint.
Sidewise motion of the torch is necessary.	No sidewise motion of the torch necessary.
This technique is used for relatively thin metals.	This technique is used for heavy sections.
More consumption of filler metal during welding so cost is higher.	Less consumption of filler metal so cost is low.
In this the welding torch is in between the filler rod and Unwelded portion of the weld	In this the filler rod is in between the welding torch and Unwelded portion of the weld.

b)	CARE AND STORAGE OF ELECTRODES Utmost care is required in handling and storage of electrodes. Due to Poor care and wrong storage the following disadvantages will take place: 1. Electrode, with damp coating will produce a violent are, porosity and cracks in the joint. Electrodes with damaged coating will produce joints of poor mechanical properties. 2. To avoid damage to coating, (a) electrodes during storage should neither bend nor deflect, (b) electrode packets should not be thrown or piled over each other. 3. Electrodes should be stored in dry and well-ventilated store rooms. Storage temperature should be about 12°C above that of external air temperature with 0-60% humidity. Cellulose electrodes arc not so critical but they should be protected against condensation and stored in a humidity of 0-90%. 4. Before use the electrodes may be dried as per manufacturer's recommendations e.g. BS : E 616 H or IS : M 616478H electrodes may be dried at 150°C for 1 hour before use. 5. All electrodes, and especially costlier ones, should be used till they arc left hardly 40-50 mm. 6. Electrodes should preferably be retained in original (manufacturer's) packing for identification. Loss of identity of electrodes can waste a lot of time in recognizing them correctly.	**1m per point**	**4m**
c)	welding Methods for alloy steels - The high strength alloy steels can be welded readily by all the common welding processes. 1. Oxy-acetylene Welding - The type of filler rod employed depends upon the mechanical properties required. -A high tensile steel rod will prove effective. -For corrosion resistance, etc., the weld metal must match with the parent metal. - A flux is used to counteract the oxidation of alloying elements. - After welding, a postheat -treatrnent is necessary for the heat treatable low-alloy steels to refine the grain structure. 2. Flux-shielded Metal Arc Welding - Mild steel electrodes will work very well with steels having a carbon content under 0.14%. -Weld develops tensile strength as high as 80,000 psi (5600 kg/cm2) as the result of alloy pick-up from the base steel. - Where higher strength at better ductility is desired, low alloy steel electrodes may be required. -Because of greater crack sensitivity of the low alloy steel electrodes, preheating may be necessary.	**4m for any one exp**	**4m**

	- Where corrosion is a factor, it may be advisable to use core wires of the same composition as the base steel. 3. Submerged Arc Welding - Both hot rolled and heat -treated grades of low-alloy steels are welded by using the method very similar to that used for welding low carbon steels. - Because of deep penetration characteristics of this process, mildsteel filler rods are usually satisfactory. - Preheating is generally not necessary. 4. Thermit Welding - Low alloy high strength steels can be therrnit-welded. Metallic elements are added to the thermit mixture to obtain composition close to that of the parent metal. -Metallic elements are added either as metallic pieces or in the form of combinations of oxides of the required elements with aluminium. -Stress-relieving heat-treatments, when required, should be carried out between 595 and 675°C. 5. Resistance Spot Welding - Spot welding can be carried out satisfactorily. -For alloys having high hardenability, special treatments such as preheating, grain refinement and tempering heat-treatments may be incorporated in the welding cycle.		
d)	-weldability of low alloy steels is dependent upon the composition and the hardenability those exbiting low hardenability being welded with relative ease -welding of such steel is carried out on much the same lines as that of carbon steels of equilent carbon contents -alloys of high strength require filler metal of mechanical properties matching the base metal -special alloys with creep resistant or corrosion resistant properties must be welded with filler metal of same chemical analysis -welding of low alloy high strength steels with high hydrogen types of covered mild steel electrode, usually require that assembly be preheated -many high strength low alloy steels is the prevention of under bead or cold cracking which can be minimised by using low hydrogen type electrode and slower rate of cooling. -welding with low hydrogen electrodes generally does not requirepre heating except for highly restrained sections	**1m each point**	**4m**

e)	<table><tr><td>SR.NO.</td><td>BRAZING</td><td>SOLDERING</td></tr><tr><td>1</td><td>These are stronger than soldering but weaker than welding. These can be used to bear the load up to some extent</td><td>These are weakest joint out of three. Not meant to bear the load. Use to make electrical contacts generally</td></tr><tr><td>2</td><td>It may go to 600C in brazing</td><td>Temperature requirement is up to 450C</td></tr><tr><td>3</td><td>Work pieces are heated but below their melting point</td><td>No need to heat the work pieces</td></tr><tr><td>4</td><td>May change in mechanical properties of joint but it is almost negligible.</td><td>No change in mechanical properties after joining</td></tr><tr><td>5</td><td>Cost involved and skill required are in between others two</td><td>Cost involved and skill requirements are very low.</td></tr><tr><td>6</td><td>No heat treatment is required after brazing.</td><td>No heat treatment is required</td></tr><tr><td>7</td><td>Preheating is desirable to make strong joint as brazing is carried out at relatively low temperature</td><td>Preheating of workpiece before soldering is good for making good quality joint.</td></tr><tr><td>8</td><td>Cost involved and sill required are in between others two</td><td>Cost involved and skill requirements are very low.</td></tr><tr><td>9</td><td>No heat treatment is required after brazing.</td><td>No heat treatment is required</td></tr></table>	**1m per point**	**4m**
f)	Vacuum brazing -It is a type of furnace brazing. Instead of a suitable atmosphere, vacuum is created in the furnace for carrying out brazing. - Because of the stability of surface oxides containing Cr, Mn, Ti,V, Al and Si, alloy steels containing a total of more than 2 or 3%of these		

	elements can be flux less brazed satisfactorily in vacuum. - In a hot retort vacuum furnace, the work load is placed into the retort and the retort is sealed, evacuated and heated from the outside by a furnace which is either gas fired or electrically heated. -Vacuum brazing furnaces of this type have been built for operation at temperatures up to about 11OO°C. - Vacuum pumps for brazing furnaces may be of the oil sealed mechanical type for pressures ranging from 10 torr to 0.1 torr.Turbo mechanical vacuum pumps (pressure 10-2 torr to 10-3 torr)arc used for brazing steels containing Cr, Si or other intermediately difficult to reduce oxide former. 		
5.	**ATTEMPT ANY FOUR**		**16**
a.	The basic equipment set are: 1. Oxygen gas cylinder 2. Acetylene gas cylinder. 3. Oxygen pressure regulator. 4. Acetylene pressure regulator. 5. Oxygen gas hose (Blue). 6. Acetylene gas hose (Red). 7. Welding torch or blow pipe with a set of nozzles and gas lighter. 8. Trolleys for the transportation of oxygen and acetylene cylinders. 9. A set of keys and spanners. 10. Filler rods and fluxes. 11. Protective clothing for the welder (e.g., asbestos apron, gloves,goggles, etc.)	**2m for diag 2m for exp**	**4m**



b)	Indian (IS) System: L X X X X X X L 1st Letter, 1st 2nd 3rd 4th 5th 6th DIGITS, Last letter Example: E307411 Various digits and letters indicate the following: 1st Letter -It can be E or R. E indicates that electrode is solid extruded and R means an electrode extruded with reinforcement. 1st Digit - It indicates the Glass of covering. It can be 1, 2, 3, 4, 5, 6 or 9 and has the meaning same as that of the first digit of British system, discussed earlier. 2nd Digit - It indicates the positions in which electrode can weld satisfactorily. Second digit may be 0, 1,2,3,4, or 9. 0 and 1 signify that the electrode can be used for welding in all positions, and in flat, horizontal, overhead and vertical positions respectively.4 indicates flat and horizontal fillet positions. 2, 3 and 9 have the same meaning as in British standard. 3rd Digit - It has the same meaning as that of the third digit of British standard, except that the open circuit voltage is 90 in place of 95 volts, and 50 instead of 45. 4th and - They indicate range of tensile strength and value of minimum 5th Digit yield stress., e.g. 41 (fourth and fifth digits) and 51 mean that tensile strength ranges from 410-510 and 510-610 N/mm2andminimum yield stress is 330 and 360 N/mm2 respectively. 6th Digit - It tells percentage elongation and impact value. Last Letter- P indicates a deep penetration electrode, H hydrogen control led electrode, and J, K, L indicate electrodes with iron powder coating and metal recovery 110-130%, 130-150% and above 150%, respectively.	**4m**	**4m**

	Example: E 307411 means (a) It is a solid extruded electrode. (b) Its covering contains appreciable amount of titania; a fluid slag. (c) It is all position electrode, (d) It can be operated on DCRP, DCSP or AC with a power sourcehaving, open circuit voltage 50 volts, (e) Weld metal tensile strength ranges between 410 and 510 N/rnm2 and minimum yield stress is 330 Nzmm", (10 N/mm2 = 1.02 kgf/mrn2). (f) Minimum percentage elongation of weld metal (in tension) is 20% of 5.65 v'SO and impact value of weld metal at s27°C is 4.8 kgf m (or 47 J). Where Sois the cross-section area of the specimen being tested		
c)	TIG WELDING for aluminium Its suitability are as follows: -TIG welding is the most commonly used method of welding aluminium today. Thinner gauges of aluminium can be joined without a filler metal. - TIG welding involves striking an arc between a tungsten (alloy) electrode and the workpiece to provide heat for joining. -A separate filler rod is employed when welding thicker workpieces. -TIG welding resembles gas welding because both employ a heat source independent of the filler (metal) electrode. -Gas welding employs a flux whereas TIG welding makes use of an inert gas to prevent any reaction between the molten weld metal and the atmosphere. -Thicknesses of aluminium alloys commonly welded by TIG processrange from 1 to 10 mm for manual welding and from 0.25 mm to 25 mm for automatic welding.	**1m per point**	**4m**
d	i)Cracking causes 1. Rigidity of the joint, i.e., joint members not free to expand or contract when subjected to welding heat and subsequent cooling (localized stresses). 2. Poor ductility of base metal. 3. Hardenability, high Sand C percentage of base metal. 4. Concave weld bead. 5. Fast arc travel speed. 6. Electrode with high H2 content] Remedies -Preheat -Relieve residual stresses mechanically -Minimize shrinkage stresses using backstep or block welding sequence -Change welding current and travel speed -Weld with covered electrode negative; butter the joint faces prior to welding. -Change to new electrode bake electrodes to remove moisture -Reduce root opening; build up the edges with weld metal -Increase electrode size; raise welding current, reduce travel speed	**1m each answer**	**4m**

	-Use filler metat low in sulfur -Fill crater before extinguishing the arc; use a welding current decay device when terminating the weld bead 2)INCOMPLETE PENETRATION Various causes of incomplete penetration are as follows: 1. Improper joints. (For example, it is simpler to obtain full penetration in U joint as compared to J butt joint). 2. Too large root face. 3. Root gap too small. 4. Too small bevel angle. 5. Less arc current. 6. Faster arc travel speed. 7. Too large electrode diameter. 8. Longer arc length. 9. Incorrect polarity when welding with direct current. 10. Wrongly held electrode. It should be in the centre of the joint Remdies 1) Increase included angle of groove joint. Change the groove design to a ‘J’ or a ‘U’ type. 2)Clean weld surfaces prior to welding 3)Maintain proper electrode position and current 4) Use correct manipulation techniques to melt the joint faces properly. UNDER-CUTTING In under-cutting a groove gets formed in the parent metal along the sides of the weld bead. Groove reduces the thickness of the plate and thus the area along the bead, which in turn weakens the weld. The main causes of undercutting are as follows: 1. Wrong manipulation and inclination of electrode and excessive weaving. 2. Too large electrode diameter. 3. Higher currents. 4. Longer arcs. 5. Faster arc travel speeds. 6. Magnetic arc blow. 7. Rusty and scaly job surfaces Remedies 1) Excessive current, causing the edges of the joint to melt and drain into the weld; this leaves a drain-like impression along the length of the weld. 2) If a poor technique is used that does not deposit enough filler metal along the edges of the weld. A third reason is using an incorrect filler metal, because it will create greater temperature gradients between the center of the weld and the edges 4)Right Selection of Gas Shielding 5)Correct welding Technique Correct Welding position		

iv) Blow holes

Causes of blow holes

1)Wet, unclean or damaged electrode.
2.Base metal surface covered with oil, rust, etc.
3.Over travelling speed.
4.Over currents
5.Excessively long or short arc length.
6.Too thick base-metal or too fast cooling rate

REMEDIES OF BLOW HOLES

1)Properly maintain and store electrode.
2.Properly clean base metal prior to welding.
3.Reduce travel speed.
4.Use proper welding current.
5.Maintain proper arc length.
6.Proceed proper pre-heating.

e) **1m per point** **4m**

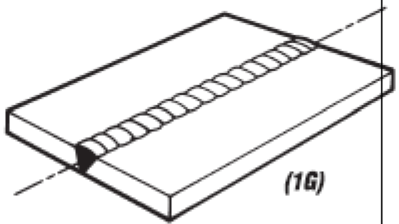
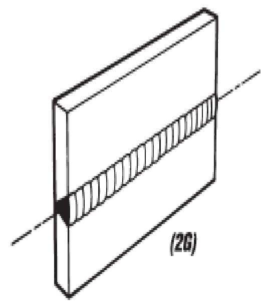
	Cold Cracking	Hot Cracking
1	Cold cracking is cracking that occurs as the result of hydrogen dissolving in the weld metal and then diffusing into the heat affected zone (HAZ). Cold cracks mostly develop long after the weld metal solidifies, but sometimes appear sooner	Hot cracking is the formation of shrinkage cracks during the solidification of weld metal. This phenomenon occurs in almost all metals.
2	Cold weld cracking occurs at temperatures well below 600°F	Hot weld cracking occurs at temperatures greater than 1200° C
3	Cold cracking is also known as hydrogen-induced cracking, delayed cracking or underbead cracking.	Hot cracking is also known as hot shortness, hot fissuring, solidification cracking and liquation cracking.
4	Cold cracking may occur fpr the following reasons: •There is hydrogen in the weld material or atmosphere •Susceptible microstructure	hot cracking occurs when: -Strain on the weld pool is too high •Liquid cannot reach

	(martensite) •Mechanical stresses (thermal or residual stresses)	the regions where it is needed due to inadequate supply or blockage/narrow channels between solidifying grains •Temperature is > 1200°C •Impurities such as carbon (C), sulfur (S) or phosphorus (P) are present
5	Cold weld cracking occurs at temperatures well below 600°F	Hot weld cracking occurs at temperatures greater than 1200° C

f)	PRINCIPLES OF GOOD SOLDERING PROCESS The principles of good soldering practice include the following: (i) Selection of the proper joint design and clearance. (ii) Selection of the right solder and f/ILL (iii) Adequately cleaning the joint components. (iv) Fluxing and assembling components with proper preplacement or addition of solder. (v) Heating the joint to the right soldering temperature for optimum time.The soldering operation is performed by bringing molten solder in contact with the preheated surfaces and heating the joint area to a good wetting temperature. This is roughly 55 to 8()<'e above the melting point of the solder alloy itself. Under these conditions, good wetting can occur. (I'i) The solder is then left to cool and freeze as quickly as possible in order to avoid disturbing the joint during solidification and causing internal microcracks to form. (I'ii) The soldered joint is then cleaned to remove any undesirable flux residues on the surfaces and to ensure the integrity of the soldered joint.	**1m each point**	**4m**

6)	ATTEMPT ANY FOUR		16
a)	Purpose of filler metal (A)FILLER METAL is the material that is added to the weld pool to assist in filling the gap {or groove). Filler metal forms an integral part of the weld. - Filler metal is usually available in rod form. These rods are called Filler Rods. - Filler rods have the same or nearly the same chemical composition as the base metal. - Welding filler rods are available in a variety of compositions (for welding different materials) and sizes. Some of them are given in Table Purpose of FLUXES - During welding, if the metal is heated/melted in air, oxygen from the air combines with the metal to form oxides which result in poor quality, low strength welds or, in some cases, may even make welding impossible. In order to avoid this difficulty, a flux is employed during welding A flux is a material used to prevent, dissolve or facilitate removal of oxides and other undesirable substances. A flux prevents the oxidation of molten metal. - The flux (material) is fusible and non-metallic. - During welding, flux chemically reacts with the oxides and a slag is formed that floats to and covers the top of the molten puddle of metal and thus helps keep out atmospheric oxygen and other gases	**2m (1m each point)** **2m (1m each point)**	**4m**
b)	(see table below)	**1m each point**	**4m**

Sr No	**Flat**	***Horizontal***
1	In a flat position, a weld is performed along largely a horizontal access and from above the joint.	In the horizontal position, the weld's axis is the horizontal plane.
2	In this position, the welding is performed from the upper side of the joint, and the face of the weld is approximately horizontal.	The axis of a weld is a line through the length of the weld, perpendicular to the cross section at its center of gravity.
3	For a fillet weld this type of welding is performed from the upper side of the joint. The face of the weld is approximately horizontal.	For a fillet weld, welding is performed on the upper side of an approximately horizontal surface and

		against an approximately vertical surface. For a groove weld, the face of the weld lies in an approximately vertical plane.
4		

c)	Section factors for power sources: The following factors influence the selection of a power source: 1. Available power (AC or DC, single phase, etc.). Where no power is available, a diesel engine driven DC generator may be used. 2. Available floor space. 3. Initial costs and running costs. 4. Location of operation (whether in the plant or in the field). 5. Personnel available for maintenance. 6. Versatility of equipment. 7. Required output. 8. Duty cycle. 9. Efficiency. 10. Type of electrodes to be used and metals to be welded, (e.g. non-ferrous materials and stainless steels are welded more effectively with DC than with AC). 11. Type of work	**½ m each point**	**4m**
d)	Welding method for non ferrous metal Welding method for aluminium The methods employed for welding aluminium and aluminium alloy components can be discussed under the following heads: 1. Oxy-Gas Welding. 2. Metallic Arc Welding. 3. MIG Welding. 4. TIG Welding. 5. Resistance Welding. 6. Solid-State Welding. 7. Carbon-arc Welding. 8. Atomic-hydrogen welding.	**4m**	**4m**

9. Brazing.
OXY.GAS WELDING
-Acetylene process is quite suitable for wrought and cast aluminum and aluminium alloys.
- The choice of a suitable flux is essential to ensure success in aluminium welding.
The flux must;
(i) Attack and dissolve the aluminium oxide film (melting point approximatc1y 1930°C) which is always present on the surface of the metal.
(ii) Prevent further oxidation during welding.
(iii) Be lighter when melted than aluminum, so that it will float any impurities to the surface, where they can be easily removed.
An aluminum flux' contains Lithium chloride Potassium fluoride Potassium chloride, etc. Most aluminum fluxes are very hygroscopic; they should be kept quite air-tight. Flux may be applied by ;
(i) dipping the hot end of the filler rod into the flux. Thus coated flux melts by the welding heat, runs down on the work and flows along the joint ahead of the torch flame, removing the oxide film and leaving the metal in ap absolutely clean condition.
(ii) brushing the flux paste onto the prepared edges of the sheet before weld
2) METALLIC ARCWELDING
- The metallic arc welding process for aluminium and its alloys has been developed more recently than gas welding owing chiefly to the inherently unstable nature of arcs between aluminium electrodes.
-In the arc welding of aluminium there remains a tendency to unsoundness in the welds.
-Aluminium sheets up to 6 mm can be butted together with no preparation, but with a gap between them for penetration heets thicker than 6 mm are prepared with 60° Vee
- The parts should either be tack welded or held in position with clamps or fixtures.
-In tack welding, the current can be increased approximately 40% above that for continuous welding.
- A backing strip is usually employed so that the extremely fluid molten aluminium does not escape through the joint faces.
-The backing strip may be of steel or copper and should preferably be provided with a shallow groove, which will allow a small convex underbead to be formed.
- The gap provided between the two plates to be welded may either be in La per or parallel.
-The taper may be of the order of 1.6 mm at the beginning and increasing at a rate of 1.6 mm/300 mm run of weld along the length

of the seam.
-A parallel gap width ranges from 1.6 mm to 3.2 mm or about half the thickness of the metal welded in order to allow the arc to melt both edges simultaneously.

3)MIG WELDING
- An electric arc is struck between an aluminium or aluminium alloy continuously fed electrode (+) pulled from a spool by a wire-feeding mechanism and the job (-). A shielding gas is used to protect the weld pool.MIG welding deposits large quantities of weld metal in a short periodof time.Edge preparation is done by
(i) Sawing (ii) Machining
(iii) Rotary planing (iv) Plasma cutting etc.
- Thicknesses from 3 mm to several mm can be welded by MIG , process

4)RESISTANCE WELDING
- Aluminium and aluminium alloys whether they are cast or wrought, heat-treatable or non-heat-treatable, can be resistance welded, some more readily than others. Resistance welding processes are especially useful in joining the pigh strength heal treatable

5)SOLID STATE WELDING

(a) Cold Welding

- In cold welding coalescence is produced by the external applicalionof mechanical force alone. Butt and lap joints are used. Since intimate contact between joint surfaces is essential to obtain good welds, they must be free from oxide, etc. Depending upon the type of alloy, pressures of 10.5 X 103 to 35 X 103 kglcm2 are required to make a proper weld.Lap welds have been made at room temperature in thicknesses from that of a thin foil to 6 mm plate.- Excellent lap welds are obtained with the lower strength nonheat treatable alloys. Butt cold welds can be made in most aluminium alloys.

(b) Dlffuslon Welding

- Best weld strength and greatest ease of bonding is obtained through the use of an, intermediate layer such as silver, copper,etc. With an Alclad surface, AI-1.6 Cu-2.5 Mg-5.6 Zn-O.3 Cr (%) alloy can be welded in one hour at 163°C (1.68 x 103 kg/ern? pressure).

	(c) Explosion Welding - Explosion welding is mostly applicable to lap welds and to cladding.- Welding will occur in aluminium parts if the plate velocity (under vacuum conditions) is about 15000 em/second and the impact angle is in the range of 2 to 4 degrees. (d) Ultrasonic Welding - Ultrasonic welding is used to join foils as well as sheet gauges of aluminium alloys.- The strength of ultrasonic welds is equal to or more than. that of the resistance spot welds 6)CARBON ARC WELDING - Carbon arc welding is particularly adapted to butt joints in the lighter gauge metals from 0.9 to 2 mm. It can produce welds of quality comparable to oxy-acetylene process. Absence of distortion is a feature of this process. 7)ATOMIC.HYDROGEN WELDING - The high cost of this process is a contributing factor in its limited use today. However, fillet or lap welds can be carried out on some of the aluminium alloys with a greater freedom from cracking or excessive heating of the welds. In general this process resembles oxy-acetylene welding 8)TIG WELDING Its suitability are as follows: -TIG welding is the most commonly used method of welding aluminium today. Thinner gauges of aluminium can be joined without a filler metal. - TIG welding involves striking an arc between a tungsten (alloy) electrode and the workpiece to provide heat for joining. -A separate filler rod is employed when welding thicker workpieces. -TIG welding resembles gas welding because both employ a heat source independent of the filler (metal) electrode. -Gas welding employs a flux whereas TIG welding makes use of an inert gas to prevent any reaction between the molten weld metal and the atmosphere. -Thicknesses of aluminium alloys commonly welded by TIG processrange from 1 to 10 mm for manual welding and from 0.25 mm to 25 mm for automatic welding.		

e)	i)SPATTER Spatter can be minimized by correcting the welding conditions and should be eliminated by grinding when present. ii)INCOMPLETE PENETRATION/ FUSION: Remedies of incomplete fusion Follow correct welding procedure specification Maintain proper electrode position Reposition work, lower current, or increase weld travel speed Clean weld surface prior to welding iii)DISTORTION Reducing the metal weld volume to avoid overfill and consider the use of intermittent welding Minimizing the number of weld runs Positioning and balancing the welds correctly round the axis Using backstep or skip welding techniques, which involves laying short welds in the opposite direction Making allowance for shrinkage by pre-setting the parts to be welded out of position Planning the welding sequence to ensure that shrinkages are counteracted progressively Shortening the welding time iv)OVERLAPPING The overlap can be repaired by grinding off excess weld metal and surface grinding smoothly to the base metal.	**1m each**	**4m**
f)	The main factors to be considered while selecting the soldering joint are: (i) Selection of the proper joint design and clearance. (ii) Selection of the right solder (iii) Adequately cleaning the joint components. (iv) Fluxing and assembling components with proper preplacement or addition of solder. (v) Heating the joint to the right soldering temperature for optimum time.The soldering operation is performed by bringing molten solder in contact with the preheated surfaces and heating the joint area to a good wetting temperature. This is roughly 55 to 8 above the melting point of the solder alloy itself. Under these conditions, good wetting can occur. (I'i) The solder is then left to cool and freeze as quickly as possible in order to avoid disturbing the joint during solidification and causing internal microcracks to form. (I'ii) The soldered joint is then cleaned to remove any undesirable flux residues on the surfaces and to ensure the integrity of the soldered joint.	**1m each point**	**4m**