



# ENGINEERING – MATERIALS AND TECHNOLOGY

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## HIGHER & ORDINARY LEVEL

### MARKING SCHEME

#### Pre-Leaving Certificate Examination 2024

Higher Level:      page 3

Ordinary Level:    page 23





## HIGHER LEVEL

300 marks

## Question 1. Answer 10

(50 marks)

- (a) Environmentally friendly energy sources:
- Solar power
  - Wind energy
  - Grid power derived from renewables

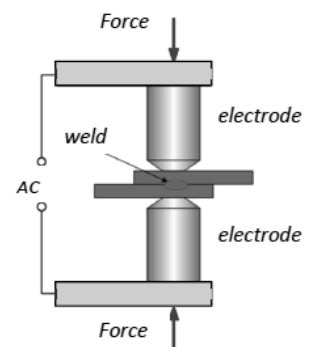
3 + 2

- (b) **Allotropy** is the property of some chemical elements to exist in two or more different forms. Iron exists as a BCC structure up to approximately 910°C. Between 910°C and approximately 1390°C it exists as a FCC structure.

5

- (c) **Resistance spot welding** is a welding process in which work pieces are welded due to a combination of a pressure applied to them and heat generated by a high electric current flowing through the contact area of the weld. Heat produced by the current is sufficient for local melting of the work piece at the contact point and formation of small weld pool called a 'nugget'. The molten metal then solidifies under pressure and joins the pieces. Time, pressure and current, required for the formation of a reliable joint, are determined by the dimensions of the electrodes and the work piece metal type.

**Typical applications include:** car panels, electronics and battery manufacture.



3 + 2

- (d) **Material fatigue** is failure due to on/off loading or cyclic stressing. Fatigue failure begins as a minute crack which grows under the action of fluctuating stress.

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- (e) **Tolerance:** 0.1mm.

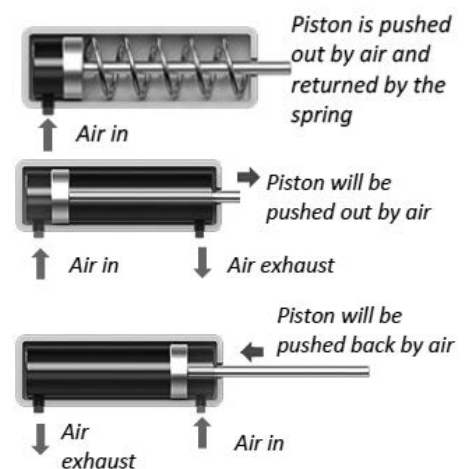
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- (f) **Single-acting pneumatic cylinder**

A single-acting cylinder is one where the thrust or output force is developed in only one direction. The piston is returned by a fitted spring, or by some other external means such as a weight. They have a single port to allow compressed air to enter the cylinder to move the piston to the desired position.

**Double-acting pneumatic cylinder**

In a double-acting pneumatic cylinder air pressure is applied alternately to the opposite ends of the piston. Double-acting cylinders have a port at each end and move the piston forward and back by alternating the port that receives the high-pressure air. These cylinders are necessary when a load must be moved in both directions such as opening and closing a gate.



3+2

**(g) (i) John McCarthy**

John McCarthy (1927 – 2011) was an American computer scientist and cognitive scientist. McCarthy was one of the founders of the discipline of artificial intelligence (AI). It was in the mid-1950s that McCarthy coined the term “Artificial Intelligence” which he would define as “the science and engineering of making intelligent machines”.

**(ii) Eileen Gray**

Irish-born architect and influential furniture designer, Eileen Gray was a pioneer of the modern Movement in Architecture since the 1920's with furniture designs in a range of materials. Her furniture is still in great demand with her Bibendum chair still in production.

**(iii) Christopher Cockerell**

Christopher Cockerell (1910 - 1999) was an English engineer, best known as the inventor of the hovercraft.

**(Any one) 5****(h) Advantages of using pneumatics power:**

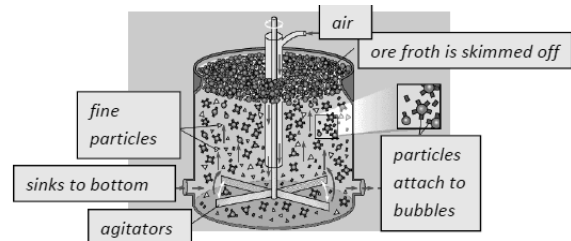
- pneumatic power offers a very clean system, it is suitable for food manufacturing processes and other processes which require no risk of contamination;
- pneumatics offer rapid movement of cylinders;
- available in very small sizes.

**5****(i) Lathes need to operate at different speeds due to:**

- The diameter of the work being turned;
- The type of material being turned;
- Feed rate of the cutting tool;
- The operation being carried out;
- The condition of the machine.

**5****(j) Bronze** is widely used in statues and other outdoor art because of its resistance to corrosion and because it is a very good casting material. It has good machinability also.**3 + 2****(k) Thermoplastics** are plastic materials that are manufactured through addition polymerisation. They can be reheated and reshaped making them easy to work with and excellent for recycling. Acrylic is an example of a thermoplastic material.**3 + 2****(l) Floatation separation:**

The fine particles of ore are swirled around in large tanks with air blown in and flotation agents added. The ore particles attach to the bubbles and float to the surface where this froth is skimmed off.

**3 + 2****(m) Composite materials** such as carbon fibre or fibre glass have a very high strength to weight ratio, they are impact resistant, they can be formed into intricate shapes, design features can be integrated into the frame shape to make each one unique and improve aerodynamic shape, they can be made in a range of colours, etc.**3 + 2**

**Question 2. Answer all of the following****(50 marks)**

- (a) **Hull Design:** Container ships are designed to be fast and efficient both in terms of their voyage from one port to another and the speed at which the cargo is loaded and discharged. For speed and efficiency at sea, they require a hull shape that optimises fuel consumption and enhances hydrodynamic performance. The hull design must also allow for maximum cargo carriage. To achieve this the main body of the hull is rectangular shape whereas the bow (front) and stern (aft) are more curved to ensure a smooth flow of water past and away from the vessel. To ensure efficiency whilst in port there must be easy access to containers both above and below decks. Containers below decks don't require securing as they are kept in place by cell guides. These guides are basically metal structures that run from the bottom of the cargo hold to the top.

**Container ship size:** The growth in container ship size was driven by economies of scale, the more of something you can transport the less the overall cost, hence the reason for 24,000 TEU ships. It is interesting to note that the fuel consumption does not scale up with the ship size. Doubling the amount of cargo she can carry does not double the fuel consumption. On the other hand, increasing ship speed results in a marked increase in fuel consumption. Thus, increasing the ship size rather than ship speed gives greater economy of scale, meaning it becomes cheaper to ship more rather than less, and consequently the desire to have bigger and bigger container ships. There is, however, still a need for container ships of a small size. Larger containerships are restricted to docking at certain ports due to quay (berth) size, cranes and the available depth of water within the port. Smaller ships are employed to connect trade between larger and smaller ports.

**5+5**

- (b) (i) **Ship stability and GM:** A vessel is designed to float upright under normal conditions. If an external force such as wind or waves causes the vessel to heel (lean over) at some angles, it should return to the upright condition. This is what is meant by stability. Stability is the function of two things: The position of the centre of gravity, the higher the centre of gravity the less stable the vessel is. The underwater shape of the hull is the other factor, the bigger the hull the more stable it will be. The term GM is mentioned a lot regarding ship stability. GM is simply how the stability of a vessel is measured. It can be too high, too low or even negative, negative means she falls over (capsizes). Too large a GM & the vessel is considered stiff, meaning it will roll rapidly from side to side. This does not alone cause stress on the ship, it also increases the stresses on the container securing devices and may lead to loss of containers. Too small a GM and the ship is considered tender, meaning it will roll very slowly from side to side and if there are heavy seas, they are more likely to pour over the side and onto the deck. So, the optimum is to find a balance somewhere in the middle. This is achieved by correct stowage of cargo and supplemented with the distribution of ballast water in the ship's ballast tanks i.e., putting weight lower down.

(ii) **Cargo operation:** Planning the cargo operations on a container ship is complex. A planner working ashore will plan which containers are to be loaded or discharged in the various ports along the ship's route. The complexity comes from the numerous ports of call. Containers for the 2nd port of call cannot be loaded onto containers for the 1st port of call. Heavy containers cannot be placed on top of light containers. Refrigerated containers need to be plugged into the ship's power source. Containers carrying dangerous goods can only be placed in certain areas due to their hazardous nature. So, load planning is a combined effort from both ashore and the ship, made easier nowadays thanks to technology.

(iii) **Navigation:** Navigation of the vessel is undertaken from a space onboard known as The Bridge. Modern technologies have transformed the bridge of a ship, making it more efficient, safer, and equipped with advanced navigation, communication, and control systems. Ships also use GPS for position fixing. We even have virtual roundabouts and roadways at sea.

**Any two @ 5+5**

- (c) (i) **Propulsion:** The slow-speed two-stroke engine is unique to ship propulsion. It is a large bore (600 900 mm) and long stroke. There is no clutch or gearbox the engine drives the propeller directly. If the ship needs to go astern the engine is stopped and then started in the reverse direction. 4

(ii) **Steering:** Steering the ship is as important as propulsion and very large forces are required to turn the ship's rudder. This is done by a machine referred to as the steering gear. The rudder is like a vertical hinged paddle behind the propeller. 3

(iii) **Electrical power:** Electrical power is needed throughout the ship to drive motors for all the auxiliary systems and power all other electrical systems. This power is provided by one or more of the following:

1. Diesel alternators; a diesel engine driving an alternator.
2. Turbo alternator; waste heat from the propulsion engine exhaust is used in an exhaust gas boiler to raise steam. The steam drives a steam turbine which drives an alternator.
3. Shaft alternator; the propulsion engine may be used to drive an alternator as well as the propeller. 3

(d) (i) **Pollution of seawater by the ship's operation**

**Ballast Water Management:** Ships take on ballast water for several reasons (stability, ensuring propeller and rudder are immersed and limiting hull structural loading). This ballast water is discharged during loading cargo. The result is water from one coastal zone is taken up and discharged in a different coastal zone. This can result in the introduction of Invasive Aquatic Species (IAS) to coastal zones. The ballast water must be treated to mitigate this risk.

**Oil Water Separation:** Oil-contaminated water has a serious impact on the marine environment. Oil leakage can occur in the machinery spaces, and this contaminates any water in the bilges. It is necessary to separate any oil from bilge water before it is discharged overboard (the maximum limit is currently 15 ppm). Several technologies are employed to achieve this, most are based on the density difference between oil and water. 4

(ii) Air pollution caused by the ship,

**Gaseous Emissions**

The combustion of fuel oil in diesel engines leads to several gaseous emissions:

1. The fuel contains sulphur and combustion leads to oxides of sulphur which, in combination with moisture, form acids. There are international standards limiting the amount of sulphur permitted in marine fuels at sea and in port. Scrubbing systems may use water sprays to reduce this gaseous emission.
2. The high carbon content of fuel oil results in high CO<sub>2</sub> emissions. Several strategies are being employed to reduce these emissions. Improving engine efficiency is an obvious approach but it is technically challenging. Employing alternative fuels with lower carbon content is the main thrust of current research. Liquid Natural Gas (LNG), methanol, ammonia, and hydrogen are all either in current use or planned as future fuels. There are significant technical challenges in the storage, handling, and combustion of these alternative fuels.
3. Combustion of fuel in a diesel engine occurs at high temperatures and this results in the production of NO<sub>x</sub>. This has a much higher impact than CO<sub>2</sub>. Two technologies are in use to reduce NO<sub>x</sub> emissions Exhaust Gas Recirculation (EGR) and Selective Catalytic Reduction (SCR). 3

**(iii) Fire on board the ship**

Fire safety on board ships is a major concern. While at sea the ship crew must be capable of dealing with any fire that occurs. This fire could be in accommodation spaces, machinery spaces, or cargo spaces. Several methods are employed to reduce the risk of fire. Structural boundaries are designed to contain a fire in its place of origin, fire detection systems are designed to detect a fire and its location, and firefighting systems are employed to extinguish the fire.

**Firefighting Systems:**

1. **Fire pumps and fire main:** a dedicated piping system supplies hydrants throughout the ship. Hoses and nozzles are available at each hydrant. The water is supplied from dedicated fire pumps in the engine room and an independent fire pump outside the engine room in case the engine room is affected by the fire.
2. **Total Flooding Systems** are employed to discharge inert gas into areas such as machinery spaces to suppress a fire. This type of system is used in these areas because it may not be possible to fight the fire locally.
3. **Foam systems:** may be installed, particularly where flammable liquids are present.
4. **Water mist systems:** are employed for local protection of key equipment such as diesel engines. These systems differ from conventional sprinkler systems because the water is delivered at high pressure through fine nozzles resulting in a fine mist. Diesel engines have high-pressure fuel systems, and any leak may cause a fire.

3

**(e) Advantages and disadvantages of container ships****Advantages:**

1. Container ships are a key component that enable Global trade.
2. Ensures fast and efficient transport of goods.
3. Versatility as they can carry a range of cargoes.
4. Allows for economies of scale both in terms of the cost of transport and the cost of goods themselves.
5. Security of cargo as containers can be sealed and tracked.
6. They have regular, fixed schedules with predictable delivery dates.

5

**Disadvantages:**

1. As a key component in global trade if it fails, global trade suffers, as evidenced in the MV Ever Given incident in the Suez Canal.
2. Due to operating in a harsh environment, possibilities of damage to containers, damage to the ship, and loss of containers overboard.
3. Component failures onboard can lead to the loss of the ship, temporarily or permanently.
4. Majority of containerships are still relying on fossil fuels for propulsion systems.
5. Due to technologies and communication methods used the industry has suffered from cyberattacks, costing companies millions, and resulting in serious delays and issues within the logistics supply chain.

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## Question 3.

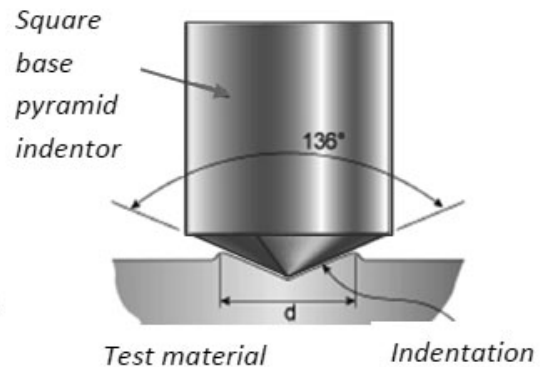
(50 marks)

- (a) (i) **Metal Creep** is the slow deformation of a material over time due to a constant force acting on it. It occurs as a result of long-term exposure to high levels of stress that are below the yield strength of the material. Temperature, time and tensile strength are contributing factors.

6

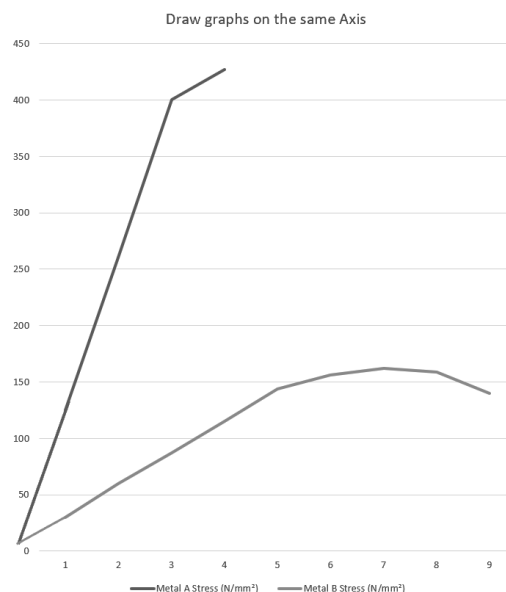
(ii) **Any suitable hardness test**

Vickers test is shown. A hard metal point, called an indenter, is pressed into the surface of the material being tested with a measured force. Softer materials will produce a deeper indentation. The test piece is considerably thicker than the indentation. The test material is placed on a table, which can be adjusted for height. The Vickers hardness test uses a diamond, square-based pyramid indenter. It has a point angle of  $136^\circ$ . The hardness value for a Vickers hardness test is converted from the length of the diagonal produced by the indenter. It is suitable for testing hard materials with a high degree of accuracy.



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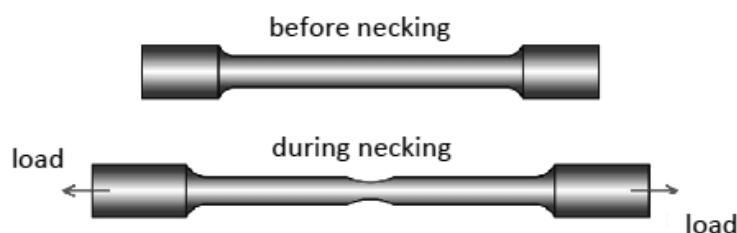
- (b) (i)



10

- (ii) At load value of  $160\text{ N/mm}^2$ , metal B will be in the “necking” phase of the tensile test. This is where the middle of the specimen is noticeably thinner than the rest of the specimen and with a little more stress the piece is going to fracture.

4



- (iii) Young's Modulus of elasticity for metal A =  $260\text{ kN/mm}^2$   
 Young's Modulus of elasticity for metal B =  $60\text{ kN/mm}^2$

2+2

- (c) (i) **Economic benefits of NDT:** Non-destructive testing allows materials to be tested to ensure conformity, metals are not rejected. Tested specimens are not discarded. The test specimens are not broken.

**Safety benefits of NDT:** Components can be tested in use avoiding failure, all components can be tested, damage to other components can be when weaknesses are discovered.

4

(ii) **Magnetic particle testing:**

In ferrous materials, cracks and cavities cause distortions in magnetic fields. This technique involves passing a magnetic field through a ferro magnetic structure or component. Magnetic particles are applied to the magnetised component and any flaw will be shown by a distortion in the resultant magnetic field. Magnetic particle inspection produces clear results, enabling a thorough assessment of the materials and ensuring that safety standards are maintained.

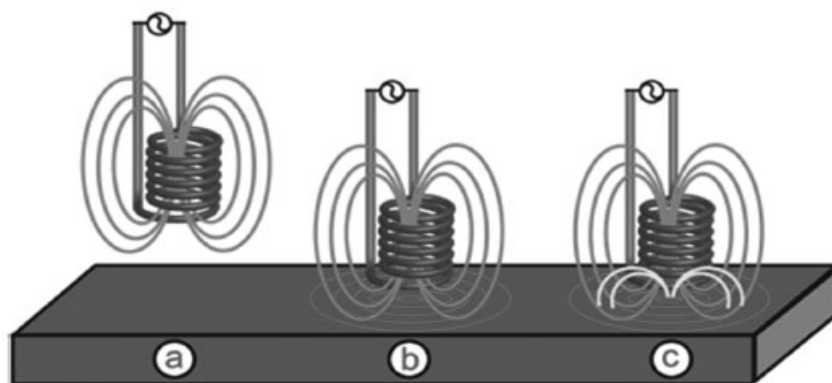
**Liquid penetrant testing:**

A coloured or fluorescent dye, when applied to a clean surface and allowed to dwell for 10 to 20 minutes, will be drawn into the surface flaw by capillary pressure. The excess dye is then removed from the surface and a developer applied. The developer assists in drawing the dye back out to the surface by giving good visual contrast. After a time, usually a minimum of 10 minutes, the surfaces are visually inspected. White light is used for red dyes, ultra-violet light for fluorescent dyes.

2 + 2

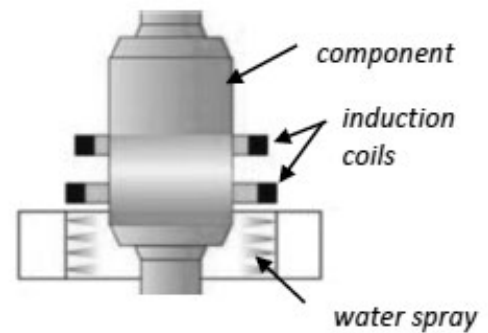
(iii) **Eddy current testing** is the most suitable NDT for non-ferrous metals where the flaw is near the surface. The alternating current flowing through the coil at a chosen frequency generates a magnetic field around the coil (a). When the coil is placed close to an electrically conductive material, eddy currents are induced in the material (b). If a flaw in the conductive material disturbs the eddy current circulation (c), the magnetic field with the probe is changed and a defect signal can be read by measuring the variation.

8



**Question 4.****(50 marks)****(a) (i) Induction hardening**

A coil carries high frequency currents which create a magnetic field which in turn induces eddy currents on the surface of the component causing a rapid rise in temperature. This allows a change to austenite in the surface layers of the component. Water jets then cool the steel, transforming the austenite to martensite. This leaves the outer surface hard while the inner core is tough. The frequency of the current and time it takes to pass the coils determines the depth of heating and the depth of hardening.

**8****(ii) Faults:**

- Incorrect heat settings,
- incorrect speed, not enough time for heat treatment to penetrate,
- inappropriate quenching, too much heating time for the sprockets to become brittle, etc.

**(Any two) @ 4 + 4****(b) (i) X = Upper Critical Temperature Line (UCT) - Austenite to ferrite and austenite transformation, depending on carbon content.**

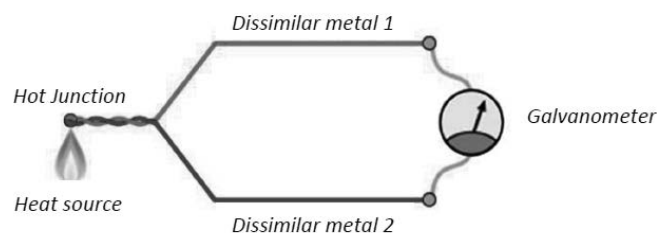
Y = Lower Critical Temperature Line (LCT) - Austenite and cementite to pearlite and cementite transformation, depending on carbon.

**3 + 3**

**(ii)** Point A is called the **eutectoid point**. At this point solid Austenite changes to solid pearlite at approximately 723°C at 0.83% carbon.

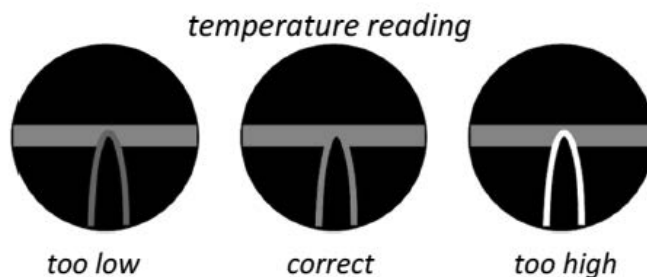
**6****(iii) The heat treatment process which occurs is annealing.**

For annealing of 0.6% carbon content the steel is heated to 1000°C and soaked at this temperature until all of the workpiece is fully heated through. The temperature of the furnace is gradually reduced so that the piece cools very slowly. This causes the steel to become "soft", recrystallises the grains and makes the pieces more machinable and ductile.

**6**

**(c) (i) Thermocouple Pyrometer:**

Two dissimilar metals are joined together with a galvanometer placed at the cold junction. A rise in temperature at the hot junction produces an electrical current which is recorded by the galvanometer. This galvanometer is calibrated to read in degrees of temperature rather than indicating electrical units. This is a very accurate way to measure furnace temperature.

**Optical pyrometer**

The optical pyrometer method compares the intensity of light from the filament of a lamp with the light from the furnace. Current flow from the lamp can be adjusted, using a variable resistor, to match the light from the furnace. There are three possible results with the optical pyrometer: filament too bright, filament not bright enough and filament matching the furnace colour. When the filament seems to 'disappear', the temperature of the filament matches that of the furnace and a reading can thus be taken.

**(ii) Grey cast iron** is named after its grey fractured surface, which occurs because the graphitic flakes deflect a passing crack and initiate countless new cracks as the material breaks. Grey cast iron results from slow cooling and/or high carbon equivalent. The carbon exists as flakes of graphite. It has a grey appearance when fractured and it is the most commonly used cast iron. Grey cast iron has poor tensile strength and shock resistance but has good compressive strength. It is soft and machinable.

**White cast iron** is named after its white surface when fractured, due to its carbide impurities which allow cracks to pass straight through. White cast iron results from fast cooling and/or low carbon equivalent. The carbon is tied up as cementite. It has a white shiny appearance when fractured and it is used in the impellers of slurry pumps, shell liners and in the balls and rings in coal pulverisers. It is hard, brittle and generally not machinable.

**(iii)** The holding of a metal at a suitable heat treatment temperature is called **soaking**. The object of heat treatment is to bring about changes in the properties of a metal. To accomplish this, the metal must be heated to a temperature at which structural changes will take place within the metal as the constituents go into solution. With such slow cooling, grain structure will be refined and internal stresses will be relieved.

Quenching in water will result in an increase in hardness and brittleness with greater prospects of cracking or warping.

**Any two @ 8+8**

## Question 5.

(50 marks)

- (a) (i) As a metal reaches its cooling point, small particles cool first. Solidification takes place in a pattern. Each small particle grows to form a crystal or grain. Crystals grow together to form a solid. This process is known as dendritic growth from Greek word “dendron” for treelike.



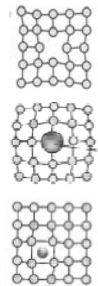
3 + 3

- (ii) **Crystal point defects:**

**Vacancy:** if there is an atom missing from the lattice, the other atoms are forced towards the vacant space.

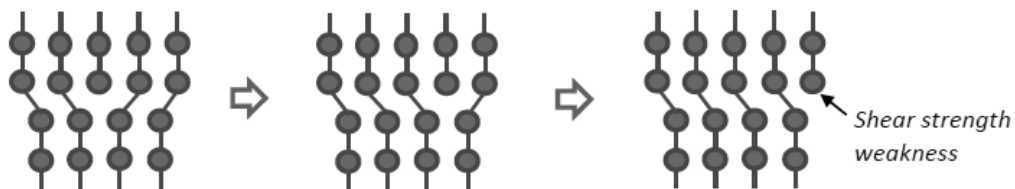
**Substitution:** if atoms from another element have taken the place of atoms of the parent metal. These atoms may not be the same size and may cause a distortion of the lattice.

**Interstitial:** an atom from another element moves into the space between the atoms of the parent metal lattice.



3 + 3

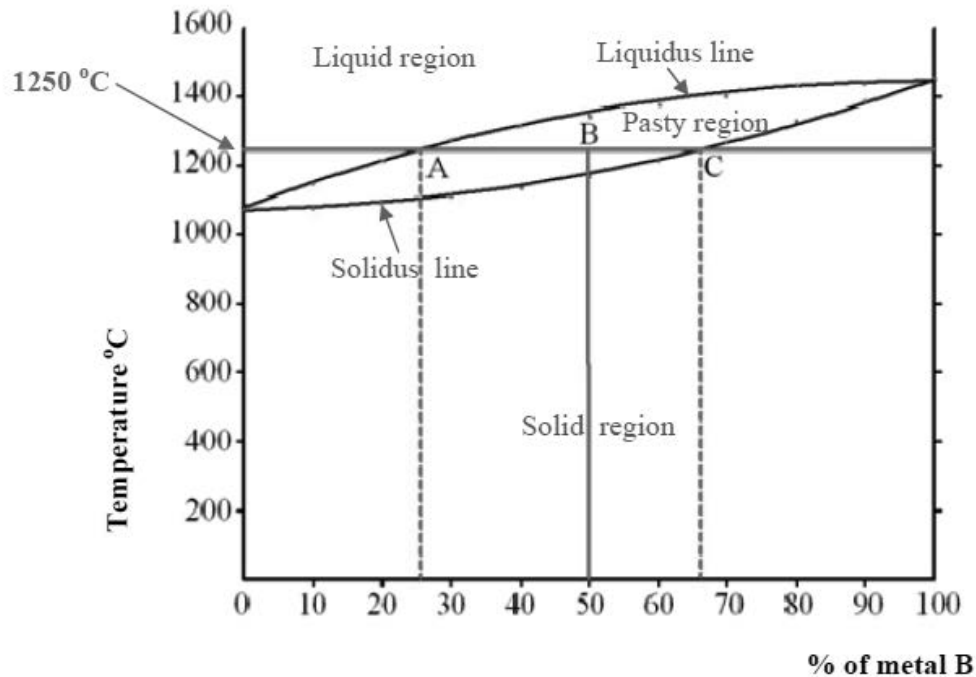
- (iii) Line defects, such as dislocations, are rows of atoms that are spaced irregularly. Line defects can weaken or strengthen solids. Dislocations can move along the densest planes of atoms to the edge of the material, shear strength is reduced. Dislocations may move easily to improve ductility. Work hardening can occur when dislocations impede movement.



*Impact of line defect as it moves to the edge of metal*

2+2

- (b) (i) Draw the thermal equilibrium diagram:



Draw = 8

- (ii) Labels on diagram

Any three @ 2+2+2

- (iii) Ratio of phases at 1250 °C for 50% metal B

Mass of solid is  $50 - 26 = 24$

Mass of liquid  $66 - 50 = 16$

$AB = 24$   $BC = 16$   $C =$

$|AB|/|BC| = 24/16 = 3/2$

4

- (c) (i) In a **solid solution** alloy, the metals are completely soluble in each other in all three states. The solid solution can be substitutional or interstitial in nature.

In a **partial solubility** alloy the metals are completely soluble in the liquid phase. The metals are also soluble in each other (in a solid state) to a limited degree. This is denoted by the Solvus Lines.

- (ii) The possible corrosive effects of the environment on metal objects.

- Ferrous metals (e.g. steel) may rust. This may cause early failure of steel products.
- An oxide layer can form on some metals such as aluminium giving a dull colour.
- Other metals may tarnish due to corrosion e.g. copper can turn a green colour.
- The presence of water (especially acidic water) can initiate electrochemical reactions in some metals e.g. stainless steel and zinc are impacted by seawater.

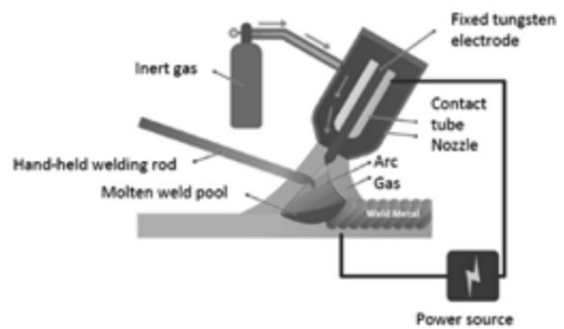
- (iii) **Work hardening** is the internal stressing of a material due to processes such as hammering, filing, drilling and bending, etc.

**Age hardening:** Aluminium alloyed with copper and cooled from a high temperature will increase in hardness over time at room temperature. This is due to the precipitation of  $\text{CuAl}_2$ . Age hardening is a feature of a range of alloys, especially non-ferrous combinations.

(Any two) 8 + 8

**Question 6.****(50 marks)**

- (a) (i) **TIG Welding:** An arc is formed between the non-consumable electrode and the metal being welded. The inert gas shielded arc is used to flux the joint. Argon is often used to prevent oxygen getting to the joint area. A stainless steel filler metal is added manually to the weld pool when necessary. A high frequency generator provides a path for the welding current.

**8**

- (ii) TIG welding is a suitable welding technique for welding the stainless steel exhaust system. It is selected as it produces high-quality, clean welds on stainless steel.

**4+4**

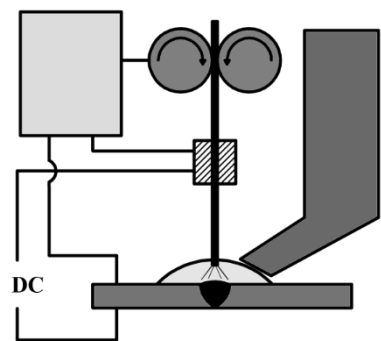
- (b) (i) **Welding defects:**

- Porosity in welding can be caused by the presence of moisture.
- Welds may lack penetration when welder settings are incorrectly adjusted or when the welding torch is moved too quickly.
- Welds may be excessively brittle if over-heated and improperly cooled.
- Slag inclusion can cause weakness also.

- (ii) **Consumable electrodes** get used up in the welding operations such as MMA, MIG and SAW whereas **non-consumable electrodes** do not melt during the welding operation, such as TIG welding, a filler material is required to fill the weld.

- (iii) **Submerged arc welding:**

In submerged arc welding, a bare wire electrode is used. It is fed automatically from a spool and generates an electric arc to heat the metal. The flux, in powder form, is fed from a hopper to completely cover the joint and the tip of the electrode. The arc creates the heat to melt the joint, flux and electrode. A slag is formed to provide a protective coating for the weld. The excess flux powder can be collected and used again. Submerged arc welding is a fully automated process. Applications: used for large-scale straight-line welds such as steel reinforcing beams, shipbuilding and bridge construction.

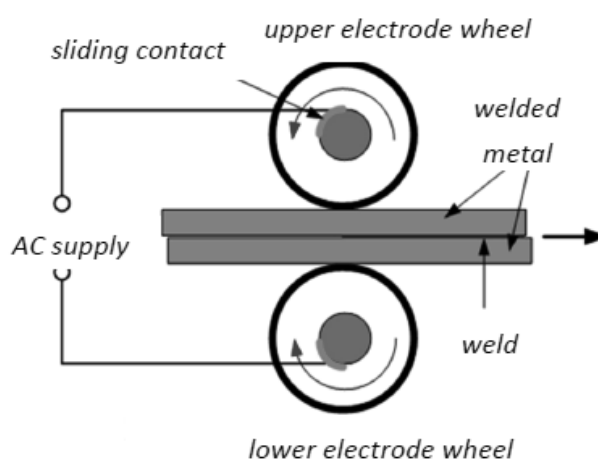
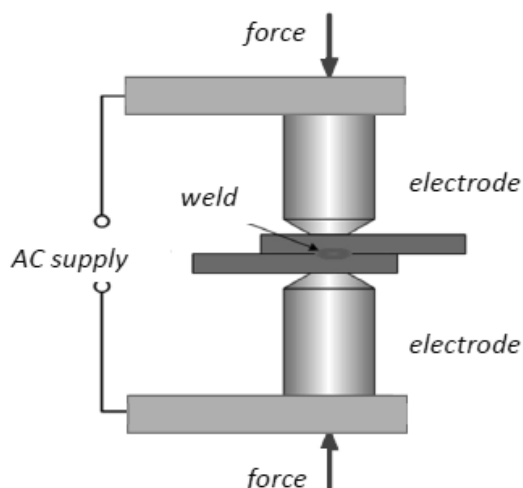


- (iv) Safety features integrated into oxy-acetylene welding equipment:

- The colour coding on the cylinders and the hoses helps prevent any possible mix-up of the gases and connections.
- The oxygen cylinder is usually thinner and taller than the acetylene cylinder.
- The connections for the different gases have either left or right-hand thread forms.
- The flashback arrestors prevent the flame returning to the cylinders.
- Valves allow cylinders to be turned off when finished operating the equipment.

**(Any three) 6 + 6 + 6**

(c)



Resistance spot welding	Resistance seam welding
<b>Electrode shape:</b> The electrode is in the shape of a round bar with tapered ends where it contacts the material.	The electrodes are disc shapes as they need to rotate during the process
<b>Welding procedure:</b> The components to be joined are placed between the electrodes and then pressed together. A nugget weld is achieved as current is passed through the electrodes generating a large heat between the metals. It is very effectively used to join sheet metal together and is recognised by the distinctive circular mark left at the site of the weld.	A form of resistance welding that uses copper roller electrodes to provide a continuous run of overlapping welds as the current is activated at set intervals. One of the electrodes may be driven by an electric motor. The workpiece is moved between the rollers and pulses of current are supplied. Each pulse is set to last long enough to produce a weld.
<b>Applications:</b> Used in the automotive industry for body panel assembly.	Used when continuous watertight weld is required e.g. fuel tanks, drums, domestic radiators.
<b>Safety Considerations:</b> Electrical equipment needs to be maintained. Localised spots of weld will be hot after welding, metal must be handled with care.	Process tends to be more automated allowing sheet metal to move through the machine. A strip of hot metal is created while welding.

16

OR

- (c) (i) The **working envelope** refers to the defined area of space through which a robot can move. The **sensors** are laser controlled inputs to identify the location of items and allow the robot arm will to "see" objects or locates itself.

4 + 4

- (ii) Stepper motors in control of robotic arms provide:
- Incremental movement and allow for precision control of movement
  - Reliability of operation
  - Good power output to give the torque required for operation
  - Stepper motors are driven by control circuits.

4 + 4

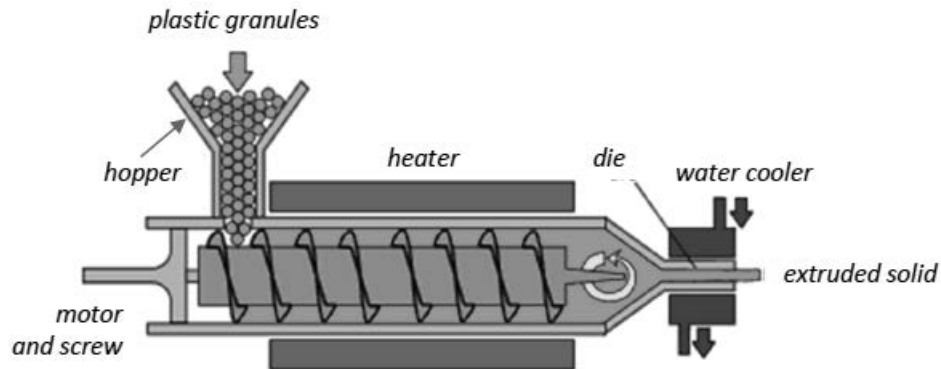


**Question 7.****(50 marks)**

- (a) (i) Thermoplastic tubes – extrusion  
Thermoplastic joints – injection moulding

**2+2**

- (ii) Extrusion



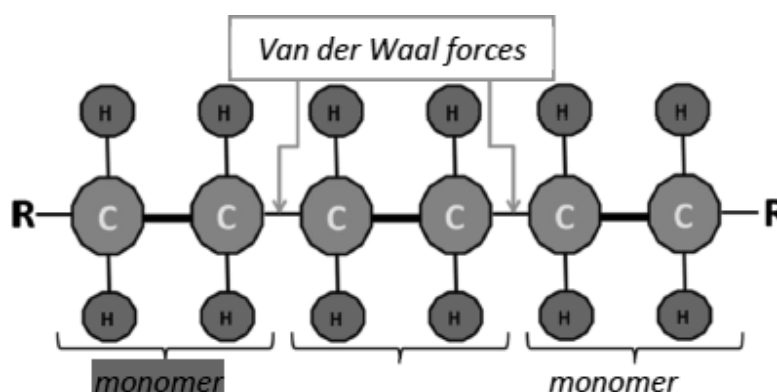
This process is used to produce items of uniform profile such as curtain rails and plumbing pipes. Plastic granules are fed from a hopper through a die by a rotating screw. The plastic is heated in the chamber before it enters the die and cooled by air jets or water as it leaves the die. The extruded products can be cut into lengths or coiled. Thermoplastics such as polythene, PVC and nylon are commonly extruded.

**10**

- (iii) Nylon is strong, difficult to break and lightweight.

**2+2**

- (b) (i) **Ethylene monomers** are added together in the process of Addition Polymerisation: Long chainlike molecules are formed by the addition of large numbers of monomers. The molecules (or mers) consist of a strong and a weak bond between the carbon atoms. A catalyst or a free radical, which has an unpaired electron in its outer shell, is released to the molecules. The weak bond is attached and one of its electrons is taken by the radical leaving the other free. Then those molecules behave like a radical and the process is continuously repeated until termination takes place. Addition polymerisation contains bonds held together by weak van der Waals forces which can be overcome by heat or pressure.



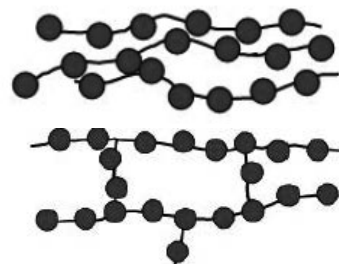
(ii) Most **natural rubber** is produced from a softwood tree native to Brazil, though several other species of trees and shrubs are sources of rubber as well. Natural rubber has a high tensile strength and is resistant to fatigue from wear such as chipping, cutting or tearing. Natural rubber has only moderate resistance to damage from exposure to heat, light and Lubricants make the polymer easier to mould. Various types of waxes are used in small amounts for this purpose. Natural rubber also has tack, which means it can adhere to itself as well as other materials. It adheres particularly well to steel cord, which makes it an excellent material for use in tyres.

**Synthetic rubber** is produced artificially from polymers in different varieties to mimic the different properties of natural rubber. Synthetic rubber offers better resistance to abrasion than natural rubber, as well as superior resistance to heat and the effects of ageing. Many types of synthetic rubber are flame-resistant, so it can be used as insulation for electrical devices. It also remains flexible at low temperatures and is resistant to grease and oil.

(iii) **Thermosetting polymers** are insulators and can withstand high temperatures and cannot be re-softened a second time. They are also rigid and hard materials.

(iv) Products are produced from non-renewable sources. The synthesis of petroleum products also uses large amounts of energy. Some chemical by-products may also be hazardous. Petroleum products are likely to be long-life, presenting a challenge for disposal at end-of life.

(v) **Linear structures** are associated with thermoplastics and addition polymerisation. The polymer chain structures are not linked together.



**Cross-linked structures** are associated with thermosetting polymers and condensation polymerisation. The polymer chains structures are linked together.

(Any three) 6 + 6 + 6

- (c) (i) **Lamination:** Thin layers of materials bonded together. High strength plastics can be produced by layers of paper or cloth coated with resin being bonded together. Heat and pressure can be used.

**Carbon fibre:** The addition of glass or carbon fibre greatly increases the strength of plastic materials, commonly polyester resins are used. Boats and storage tanks are commonly made from these materials.

4+4

- (ii) The honeycomb structure adds strength, stiffness and thickness to the frame structure. The racing bicycle remains light with excellent strength-to-weight properties.

6

**Question 8.****(50 marks)**

- (a) (i) Polycarbonate is transparent, screens can be replaced easily, polycarbonate is tough and will not shatter if struck by loose metals, etc.

**4 + 4**

(ii) **Safety hazards using the centre lathe:**

- Rotating workpieces at high speed - chuck guards need to be used.
- Metals can get hot - use cutting fluids if needed, ensure lathe cutting tools are in good condition.
- Cutting metal swarf is sharp – do not allow to build up and dispose of carefully.
- Rotating shafts can catch loose clothing – ensure guards are in place.
- Inexperienced users need supervision.

**(Any 3) 2+2+2**

- (b) (i) A **magnetic chuck** is traditionally associated with grinding machines, it has been adapted for use with other machines. Used for holding ferromagnetic workpieces, a magnetic chuck consists of an accurately centered permanent magnet face. Electromagnets or permanent magnets are brought into contact with fixed ferrous plates, or pole pieces, contained within a housing. These pole pieces are usually flush with the housing surface. The part (workpiece) to be held forms the closing of the magnetic loop or path, onto those fixed plates, providing a secure anchor for the workpiece.

(ii) The **fixed steady** provides support for lengthy work which needs an intermediate support to prevent whip or wobble. This is useful where long lengths of bar are being machined at either end and need to be securely supported to avoid deflection.

(iii) **Thread rolling** is extensively used to produce screws, bolts and other fasteners. Thread rolling is an automated process suitable for mass production, has a high production rate and has no loss of material. Thread rolling produces a stronger thread than cut threads with increased fatigue resistance due to work hardening. The material grain structure is not cut but strengthened by distorting into the thread shape.

(iv) **Benefits of Tungsten Carbide tips:**

- Tungsten carbide tools will retain their cutting edge at high temperatures more effectively than high speed steel (HSS).
- Experienced operators will ensure longer tool life.
- Tools are not sharpened which is time consuming and dependent on the skill of the operator for effectiveness, inserts are replaced.
- Inserts can have a number of cutting edges integrated into their design.

(v) A **drill bit** is used to cut a round hole in a material. A **reamer** is a type of rotary cutting tool used in metalworking. Precision reamers are designed to enlarge the size of a previously formed hole by a small amount but with a high degree of accuracy to leave smooth sides.

**(Any three) 6 + 6 + 6**

- (c) (i) Water, soluble oils, mineral oils, straight oils, synthetic fluids, semi-synthetic fluids, etc. (Any two) 3 + 3

(ii) Rancidity is caused by bacteria and other microscopic organisms that grow and multiply within the cutting fluid resulting in poor odour and the presence of hazardous bacteria.

6

(iii) **Advantages of using cutting fluids in machining:**

- Extending tool life.
- Making metal cutting more efficient.
- Cooling the cutting tool and the workpiece.
- Reducing friction giving a better surface.
- Removing metal particles from cutting area.
- Protecting the workpiece and the machine tool from corrosion.

(Any two) 3 + 3

OR

- (c) (i) **Impact on productivity:** products can be manufactured precisely at greater speeds than by using traditional technology, less expertise is required, machines will run without interruption, tool changes are automated, etc.

**Reliability:** CNC machines will produce high quality products on a consistent basis, accuracy is assured, etc.

5+5

(ii) **Safety features** incorporated into CNC machines include:

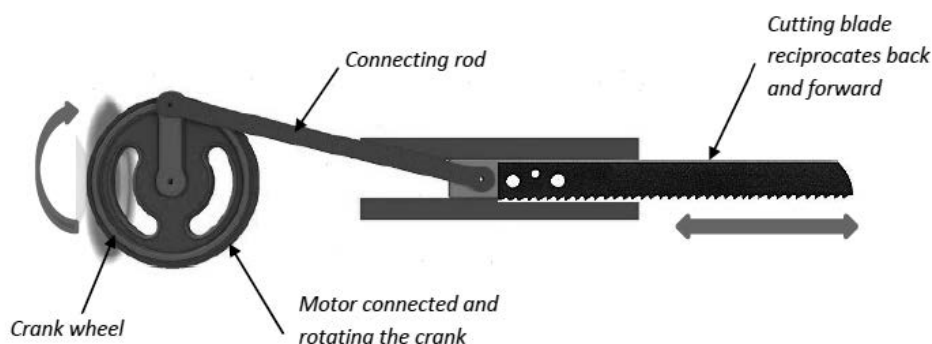
- Work area covered with clear guard.
- Emergency stop buttons.
- Test-run software.
- Interlocking guard.

(Any two) 4+4

## Question 9. (50 marks)

- (a) (i) As the motor rotates the crank wheel the slider will reciprocate back and forward, operating the cutting blade.

8



**(ii) Advantages of cordless power tools:**

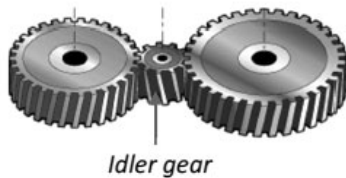
- No cords to worry about.
- Convenience – Cartridges or batteries will often be the power source of the cordless tool, meaning that there's less equipment to carry.
- Portability.
- No need for a power outlet.
- Safety, chance of electric shock reduced.

**Disadvantages of cordless power tools:**

- Less power - As the battery power source becomes depleted, the efficiency of the tool may suffer. This can result in subpar work being done by the tool if the charge falls too low.
- Expensive.
- Less reliable due to battery lifespan.

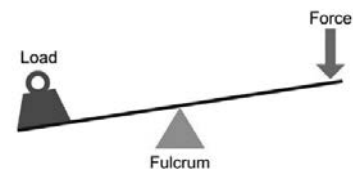
**4+4**

- (b) (i) Idler gears** are used to change the direction of a gear train, it can ensure that driver and driven gears rotate in the same direction.



- (ii)** The gear drive mechanism should be securely housed/guarded to reduce the likelihood of entanglement. Gear wheels need to be securely attached to drive shafts due to high speeds.

- (iii) Fulcrum:** The fulcrum is the point on which the lever pivots. When a force is applied to one end of the lever with a load at the other end, the load will move upward. The position of the fulcrum will determine the lifting power of a lever as well as the class or type of lever.

**(iv) Applications for a universal joint:**

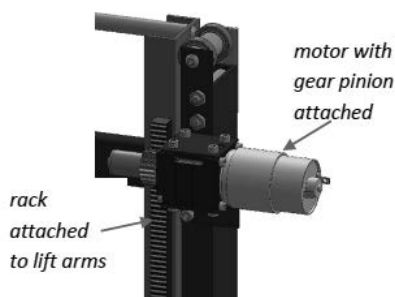
- Steering mechanisms
- Socket sets
- Shafts connecting machinery to tractors
- Shafts that are not in-line.

**(v) Advantages of roller bearings in machinery:**

- Reduced friction.
- Smooth running of parts.
- Power saving on machines
- Reliability.
- Lubrication and labour saving.
- Reduced vibration.

**(Any three) 6+6+6**

- (c) (i) The use of a rack and pinion mechanism would provide a drive mechanism for the platform to be raised and lowered. A worm-wheel could also be used with the gear pinion to prevent the mechanism slipping, the motor would have to drive all movement.  
(Other suitable mechanisms can be used)



8

- (ii) Advantages of single rear wheel design over single front wheel design:

- Greater stability for the vehicle.
- Better under braking performance as weight is to the front.
- Better weight distribution when lifting loads.
- No chance of toppling when cornering.

4+4

OR

- (c) (i) The energy conversion which takes place in a photovoltaic panel is solar energy to electrical energy. Solar battery charging systems can convert solar to chemical energy and then chemical to electrical energy.

8

- (ii) **Advantages of photovoltaic (PV) panels:**

- Electricity produced by solar cells is clean and silent. As these panels do not use fuel other than sunshine, PV systems do not release any harmful air or water pollution into the environment, deplete natural resources, endanger animal or human health.
- Photovoltaic systems are quiet and visually unobtrusive.
- Small-scale solar plants can take advantage of unused space on rooftops of existing buildings.
- Solar energy is a locally available renewable resource.
- Solar energy can be used to charge battery or capacitor systems and release energy when sun is not available.

**Disadvantages of photovoltaic panels:**

- Some toxic chemicals, like cadmium and arsenic, are used in the PV production process. These environmental impacts are minor and can be easily controlled through recycling and proper disposal.
- Solar energy is somewhat more expensive to produce than conventional sources of energy due in part to the cost of manufacturing PV devices and in part to the conversion efficiencies of the equipment.
- Solar power is a variable energy source, with energy production dependent on the sun. Solar facilities may produce no power at all some of the time, which could lead to an energy shortage if too much of a region's power comes from solar power.

4 + 4

## Ordinary Level – 200 marks

Answer any four questions.  
All questions carry equal marks.

**Question 1: Total - 50 Marks.**

Any eight parts @ 6 marks each.  
Award 1 extra mark for each of the first two correctly answered parts.

**Question 2 - 50 marks**

- (a)(i) Three parts @ 4 each (12)
- (b) One @ 10 (10)
- (c) (i) Three @ 3 (9)  
(ii) Three @ 3 (9)
- (d) (i) One @ 5 (5)  
(ii) One @ 5 (5)

**Question 3 - 50 marks**

- (a) Two parts @ 8 each (16)
  - (b) (i) One @ 7 (7)  
(ii) One @ 7 (7)
  - (c) Two @ 4 (8)
  - (d) Two parts @ 6 each (12)
- OR
- (d) (i) Two @ 3 each (6)  
(ii) Two @ 3 each (6)

**Question 4 - 50 marks**

- (a)(i) One part @ 4 &  
Two parts @ 3 each (10)
- (ii) Two parts @ 2 each (4)
- (iii) Two parts @ 2 each (4)
- (b) Three parts @ 4 each (12)
- (c) Three parts @ 4 each (12)
- (d) Two @ 4 each (8)

**Question 5 - 50 marks**

- (a) (i) Two @ 5 each (10)  
(ii) One part @ 8 (8)
- (b) Three parts @ 4 each (12)
- (c) Two parts @ 5 each (10)
- (d) Two @ 5 each (10)

**Question 6 - 50 marks**

- (a) Three parts @ 6 each (18)
  - (b) Two parts @ 6 each (12)  
One part @ 5 (5)
  - (c) Three parts @ 5 each (15)
- OR
- (c) Three parts @ 5 each (15)

**Question 7 - 50 marks**

- (a) Two @ 6 each (12)
  - (b) Four parts @ 5 each (20)
  - (c) Three parts @ 6 each (18)
- OR
- (c) (i) Three parts @ 3 each (9)  
(ii) Three parts @ 3 each (9)

## Question 1:

(50 Marks)

Give **brief** answers to **any eight** of the following:

- (a) Personal Protective Equipment (PPE) must be worn when:  
 (i) Operating machinery such as the lathe / pillar drilling etc.  
 (ii) Using oxygen acetylene gas welding equipment i.e. leather gloves /apron / welding goggles must be worn.  
**3+3 Marks**
- (b) 1. Good conductor of heat/electricity.  
 2. Ductile.  
**3+3 Marks**
- (c) Non-ferrous metals: Non-ferrous metals or alloys do not contain any amounts of iron. Aluminium is a non-ferrous metal as it does not contain iron.  
**6 Marks**
- (d) A chain and sprocket mechanism can be used as part of a driving mechanism in a bicycle.  
**3+3 Marks**
- (e) Solder  
**6 Marks**
- (f) (i) To connect a phone to a charger.  
 (ii) To connect a printer to a computer.  
**3+3 Marks**
- (g) Benefit of using computer aided drawing (CAD) in engineering: Accurate, high-quality drawings can be produced. Easily distributed and amended.  
**6 Marks**
- (h) Wind turbines are a renewable energy source.  
**6 Marks**

(i) **Hot wire strip heater:**

A strip heater is used to form straight or small curvature bends in thermoplastic sheet material. An electric element or hot wire is enclosed in a channel which has an opening at the top. Thermoplastic sheet is placed across supports above the opening.

By adjusting the height of the supports the width of strip to be heated can be altered. The supports are set to a low height for tight bends. If a more gradual bend is required, the heated area is widened by setting the supports higher. Different thicknesses of sheet may be formed by controlling the heating temperature.

Good clear description  
**Total 6 Marks**

**Pop rivet gun:**

A pop riveting gun is used to create a pop riveted joint in sheet metal. A pop rivet is placed into the gun and passed through a pre-drilled hole in the metals to be joined. As the handles of the gun are squeezed, a clamping mechanism grips the shaft of the rivet and draws it back. The enlarged end of the shaft causes the remaining part of the rivet to expand thereby clamping the sheet metal together. When the tensile force on the rivet gets too great the shaft breaks off leaving the pop rivet joint behind.



**Air compressor:**

The compressor shown has an electric motor, a compressor unit, and a storage tank. The electric motor drives the compressor unit which sucks air into a cylinder through an inlet valve. The air is then squashed (compressed) by a piston and forced into the storage tank. As the compressor continues to run, pressure builds up inside the storage tank. When it reaches a set level the electrical motor cuts off, stopping the compressor. The storage tank now stores the compressed air for use. When the pressure drops inside the storage tank, the electric motor starts again to bring up the level of pressure inside the storage tank.

**(j) Virtual reality:**

Virtual reality uses computer-generated graphics to produce a simulation of three-dimensional images or environments which can be interacted with in a seemingly real or physical way by the user. Using special electronic equipment, such as VR headsets/helmets the user feels part of a scene or that they can take part in activities by way of a screen inside the headset. Gloves with sensors are often supplied to enhance the experience.

Good clear description  
**Total 6 Marks**

**Bluetooth:**

Bluetooth is a wireless technology which allows mobile devices to be connected over short distances. Bluetooth is used as a short-range wireless interconnection of mobile phones, computers, sound systems, game controllers, printers, and other electronic devices.

**Micro:bit:**

The Micro:bit is a pocket sized computer that allows a user to control motors or other devices using coding. The micro:bit has an LED light display, buttons, sensors and many input/output features that, when programmed, let it interact with you and your world.

**(k) Electrical insulator:**

An electrical insulator prevents the flow of current (electricity) through it.

**Name:** Plastic / Rubber

Define Award 3  
Name 3  
**Total 6 Marks**

**(l) Blind hole:**

A blind hole refers to a hole that is reamed, drilled, or milled to a specified depth without breaking through to the other side of the workpiece.

Good clear description  
**Total 6 Marks**

**Reamer:**

Reamers are designed to enlarge the size of a previously formed hole by a small amount but with a high degree of accuracy and finish. There are also non-precision reamers which are used for more basic enlargement of holes or for removing burrs.

**Swarf:**

Swarf is the waste material produced when the chip is cut from the workpiece. Swarf is produced when drilling on a drilling machine or turning on the centre lathe.

**(m) Name: Parting-off tool.**

Function: used for cutting of a completed part on a centre lathe.

Name Award 3  
Application Award 3  
**Total 6 Marks**

**Question 2:****(50 Marks)****(a) (i) Charge:**

The charge is the material melted in the furnace. It can be made up of material such as ore, scrap iron/steel, coke, limestone, etc.

**(ii) Carbon electrode:**

Used in the electric arc furnace to transmit electric to the charge. The arc jumps from the rod to the charge creating heat when refining the steel.

**(iii) Refractory lining:**

The refractory lining of a furnace is a protective layer inside the furnace that acts as a form of insulation to withstand high temperatures.

**(iv) Oxygen lance:**

Used in the basic oxygen furnace to blow oxygen onto charge. The oxygen hits the melted charge creating greater heat when refining the steel.

Explain any time  
Award 3 @ 4 Marks  
**Total (12) Marks**

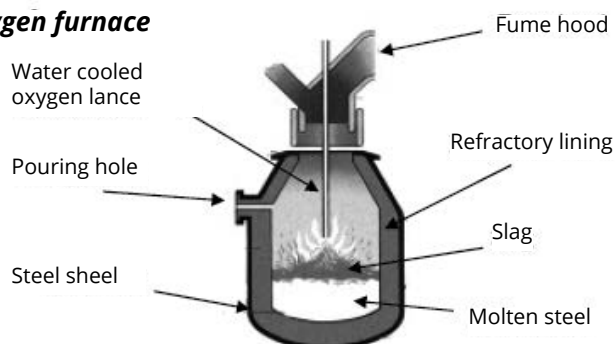
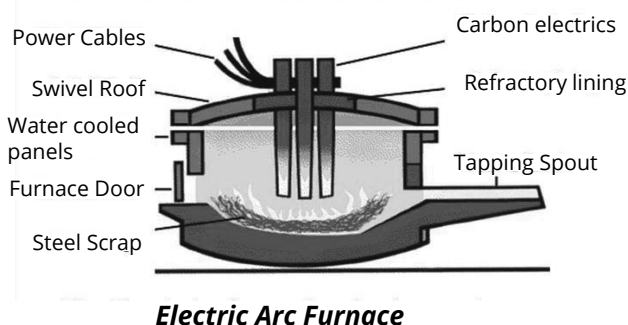
**(b)****Basic Oxygen furnace**

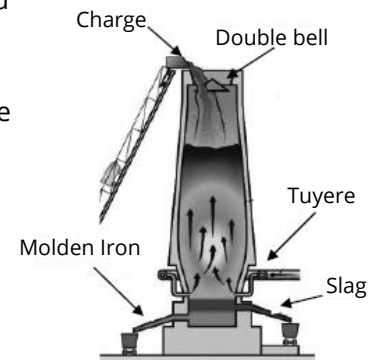
Diagram and parts  
Award 5 Marks  
Description  
Award 5 Marks  
**Total (10) Marks**

**Basic Oxygen Furnace:** The charge consists of scrap iron and steel together with lime and molten pig iron. Oxygen is blown at the surface of the molten charge from a water cooled lance which is lowered through the mouth of the furnace. Impurities in the charge are oxidized and form a slag on the surface. At the end of the blow, the steel is poured off through a tapping hole followed by emptying the slag through the mouth of the furnace.

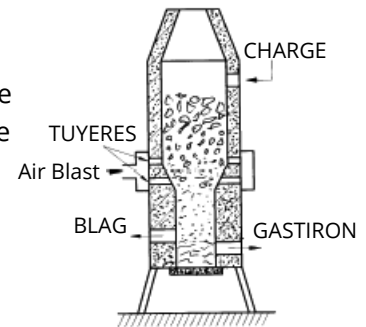
**Electric Arc furnace:** Cold scrap iron or steel make up the majority of the charge together with small amounts of lime and carbon. Heat for this furnace is by an electric arc created between carbon electrodes and the charge. The lime combines with impurities producing slag. When the correct composition of steel is achieved the slag is removed and the steel tapped from the furnace.

**Electric Arc Furnace**

**Blast Furnace:** Iron ore, coke and limestone provide the charge and are fed in through the top of the furnace. As the coke burns, air is blown in through the tuyere increasing the furnace temperature. Carbon monoxide is produced, and combines with the oxygen in the ore, leaving iron. The limestone combines with impurities to form slag. The molten iron falls to the bottom of the furnace where it is tapped off from time to time. The slag floats above the molten iron and is tapped off as required.



**Cupola Furnace:** Pig iron and scrap steel or cast iron, together with other elements are the raw materials. Similar to the blast furnace, the cupola furnace is coke-fired with limestone acting as a flux to trap the impurities into slag. The molten cast iron is tapped from the bottom of the furnace and cast into moulds of different shapes and sizes as required.



(c)

(i) Material:	(ii) Reason:
Frame: Carbon fibre Tubular steel Tubular aluminium	Strong relatively light material that will protect the driver
Seat: Leather Synthetic leather Nylon	Waterproof, hard wearing, driver comfort.
Wheel: Aluminium Rubber Light / will not rust	Gives better grip.

(i) Material  
Award 3 @ 3 Marks  
(ii) Reason  
Award 3 @ 3 Marks  
**Total (18) Marks**

(d) **Ferrous or Non-ferrous**

- (i) Brass – Non-ferrous
- (ii) Aluminium – Non-ferrous
- (iii) Cast iron – Ferrous.

Award 2 @ 5 Marks  
**Total (10) Marks**

**Question 3:****(50 Marks)**

(a)

**(i) Annealing:**

Annealing is a heat treatment process used to soften metals. To anneal steel, it is heated to a cherry red colour and allowed to soak, approx. 900°C. It is then allowed to cool down as slow as possible. This can be achieved by leaving the metal in the furnace while the furnace is cooling down.

Description  
Award 2 @ 8 marks  
**Total (16) Marks**

**(ii) Hardening:**

Hardening a piece of metal creates a hard material which will resist wear, indentation and scratching. Hardening will also increase brittleness. It heated to a cherry red colour and cooled rapidly in water.

**(iii) Tempering:**

The steel is cleaned and polished with emery paper. It is then heated again to allow the coloured oxides to appear. When the correct colour, i.e. light straw, appears at approx. 250° to 350°C the steel is quenched in cold water. This removes some of the hardness and increases toughness.

**(b)****(i) Quenching:**

Quenching is when a hot metal is cooled very quickly i.e., when a cherry red metal is moved about when dipped into cold water.

Explaining  
Award 2 @ 7 Marks  
**Total (14) Marks**

**(ii) Work hardening:**

When a metal is hammered or shaped when cold it becomes hard and brittle at the point where the cold working occurs. Some metals are prone to work hardening, copper and aluminium are typical examples where hardness values can be increased by cold working.

**(iii) Normalising:**

Normalising is a heat treatment process that is used to make a metal more ductile and tough after processes such as thermal or mechanical hardening. Normalising steel involves heating it to a temperature typically in the range of 830°-950° and then cooling in air. The heating and slow cooling changes the microstructure of the steel, altering its mechanical properties.

**(iv) Case hardening:**

Case hardening is a method of making low carbon steel very hard on the outside while leaving its centre tough. Low carbon steel may be case hardened by first increasing the amount of carbon in the outer surface by 'carburising'. Carburising is carried out by heating the steel to a cherry red and allowing it to cool in a carbon rich material. The steel part will now have a skin or 'case' rich in carbon. The part is then heated to a cherry red and quenched, producing a hardened skin with a tough core.

**(c) Safety precautions:**

Wear heat resistant gloves when performing heat treatment of metals.

Do not leave hot metals lying around in case people accidentally pick up the piece, etc.

State  
Award 4+4 Marks  
**Total (8) Marks**

**(d) (i) Brittleness:**

Brittleness is the inability of a material to withstand impact i.e. a brittle material will fracture if subjected to an impact or blow.

**(ii) Malleability:**

The ability of a material to be hammered and/or formed without breaking.

**(iii) Ductility:**

A material is said to be ductile when it can be permanently stretched, without fracture. It must be plastic enough to allow deformation and strong enough not to fracture. A metal must be ductile to enable it to be stretched/ drawn into wire.

Description  
Award 2 @ 6 Marks  
**Total (12) Marks**

**(iv) Compressive strength:**

The ability of a material to withstand being squashed or pushed together, without deforming.

Or

- (d) (i) **Two processes** - Car manufacture & circuit board assembly.
- (ii) **Two advantages** - Accuracy of manufacture, speed of production.

(I) Processes  
Award 2 @ 3 Marks  
(ii) Advantages  
Award 2 @ 3 Marks  
**Total (12) Marks**

**Question 4:****(50 Marks)**

- (a) (i) **Types of flame**
- Oxidising flame
  - Neutral flame
  - Carburising flame

Types of flame  
Award 1 @ 4 Marks  
Award 2 @ 3 Marks  
**Total (10) Marks**

- (ii) **Name of gases**  
Oxygen & Acetylene

Name  
Award 2 @ 2 Marks  
**Total (4) Marks**

- (iii) **Colour of cylinders**
- Oxygen cylinder - Black
  - Acetylene cylinder - Maroon (red)

Colour  
Award 2 @ 2 Marks  
**Total (4) Marks**

- (b) (i) **Chipping hammer**

The chipping hammer is used for the removal of slag after arc welding.

Suitable use  
Award 3 @ 4 Marks  
**Total (12) Marks**

- (ii) **Earth clamp**

The earth clamp forms the circuit when welding. It clamps onto the material being welded and when the electrode creates the arc the clamp completes the circuit.

- (iii) **Welding mask**

A welding mask is required to protect the user from the bright light and heat of the welding process affecting both the eyes and the skin on the face.

- (iv) **Electrode**

An electrode is used to conduct current through a workpiece to fuse two pieces together. Depending upon the process, the electrode is either consumable, in the case of gas metal arc welding (as shown in the question) or shielded metal arc welding, or non-consumable, such as in gas tungsten arc welding.

- (c) (i) **Advantages of spot welding**

- Does not require a high level of skill to use.
- Portable.

- (ii) **Difference between an M5 hole and a Ø5 hole**

An M5 hole is a hole which is threaded to a metric 5mm thread.  
A Ø5 hole is a hole which has been drilled to a diameter 5mm using a 5mm drill.

Descriptions  
Award 3 @ 4 Marks  
**Total (12) Marks**

## (iii) Permanent joint between electronic components

Soldering.

## (iv) Ventilation

Adhesives produce dangerous fumes, ventilation provides a flow of fresh air which helps to dilute the fumes when using adhesives.

## (d) Two safety precautions

- Check the hoses for any damage before you start welding.
- Make sure the gas cylinders are secure and cannot fall over.
- Work in a well ventilated area.

Safety Award 2 @ 4  
Marks  
**Total (8) Marks**

## Question 5:

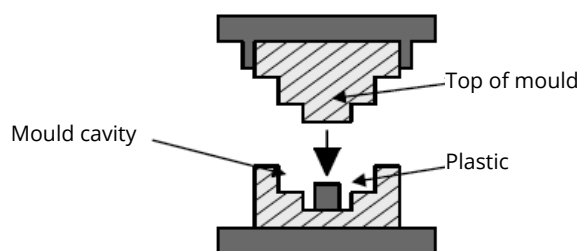
**(50 Marks)**

## (a) (i) Name processes

- A - Compression Forming  
B - Injection Moulding  
C - Blow Moulding

Name of process  
Award 2 @ 5 Marks  
**Total (10) Marks**

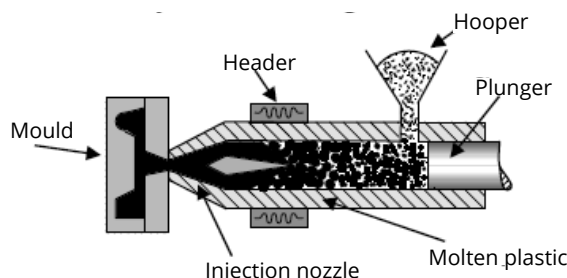
## (ii) Compression moulding

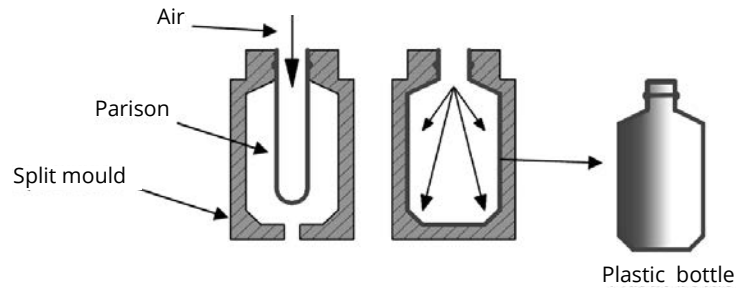


A measured amount of thermosetting plastic polymer is placed into the cavity of the mould. Heat from the mould causes the polymer to melt. The mould cavity is shaped to form the outside of the object. The top half of the mould closes displacing the melted plastic to form the object. Pressure is maintained to allow the plastic to harden. Once solidified the mould is opened and the part is released.

## Injection moulding:

Thermoplastic is softened by heating it inside an injection nozzle. The softened plastic is forced by a plunger into a cold mould where it hardens rapidly. The mould opens and ejects the part.



**Blow Moulding:**

Describe

**8 Marks**

Used to produce articles from a heated thermoplastic tube called a parison. The mould closes around the extruded parison and air is blown inside forcing the parison out against the wall of the mould. The article is moulded by the internal shape of a split mould, taking the shape of the mould cavity. The component is allowed to cool before being removed from the opened mould.

**(b) (i) Thermoplastic:**

Thermoplastic is a plastic which softens when heated.

Answer

Award 3 @ 4 Marks

**Total (12) Marks****(ii) Thermoforming:**

Thermoforming is a manufacturing process where a plastic sheet is heated until the plastic becomes soft and pliable. A strip heater can be used to heat acrylic sheet for thermoforming. The sheet can then be formed to a specific shape and then trimmed to create a usable product.

**(iii) Thermosetting plastic:**

Thermosetting plastic is a plastic which remains hard when heated.

**(iv) Elastic memory:**

Elastic memory describes the ability of a plastic to return to its original shape after being formed. The plastic remembers its original shape and will return to this shape if heated i.e. it is a smart material. Sometimes referred to as springback.

- (c)**
- (i)** Plastic kettle – polypropylene (PP) or polyethylene (LDPE)
  - (ii)** Garden hose pipe - Polyvinylchloride (PVC)
  - (iii)** File handle: Cellulose acetate (CA) / ABS
  - (iv)** Kitchen worktop - Melamine-formaldehyde (MF) / Bakelite

Name

Award 2 @ 5 Marks

**Total (10) Marks****(d) Safety precautions:**

- Do not overheat the object (metal) to be plastic dip coated.
- Use gloves when handling the hot component, etc.

Precautions

Award 2 @ 5 Marks

**Total (10) Marks**

**Question 6:****(50 Marks)**

- (a) A - Headstock  
B - Top Slide,  
C - Carriage,  
D - Tailstock.

Identify  
Award 3 @ 6 Marks  
**Total (18) Marks**

- (b) (i) **Chuck key:**  
Used to open and close a 3 / 4 jaw chuck on a centre lathe.

- (ii) **Cutting speed:**  
Cutting speed is defined as the speed at which the work moves with respect to the tool.

Award 2 @ 6 Marks  
Award 1 @ 5 Marks  
**Total (17) Marks**

- (iii) **Depth of cut:**  
This is the distance the cutting tool is moved into the workpiece when cutting.

- (iv) **Feed:**  
Feed is the amount per revolution at which the drill/cutting tool moves into the material being removed.

- (c) (i) **Centre lathe part:**  
**Name:** Four-way toolpost

- (ii) **Function:** Holds up to 4 tools and allows each to be used as needed by rotating the tool post through 90°.

- (iii) **Safety precautions:**
- Make sure the cutting tool is secured correctly before use.
  - Make sure all tools are on centre when setting up in the tool post.

(c) (i) Name  
Award 5 Marks  
(c) (ii) Function  
Award 5 Marks  
(c) (iii) Precaution  
Award 3+2 marks  
**Total (15) Marks**

**OR**

- (c) **Advantages of a CNC lathe:**
- Easier and quicker to mass produce the piece shown on a CNC lathe.
  - Less chance of errors if made on a CNC lathe.
  - Reduced labour cost.

Advantages  
Award 3 @ 5 Marks  
**Total (15) Marks**

**Question 7:****(50 Marks)**

- (a) (i) **Interference fit:**  
An interference fit produces a tight fit where both parts require force during assembly.

- (ii) **Tolerance:**  
Tolerance is the difference between the upper and lower limits of a component to be manufactured.

- (iii) **Lower Limit:**  
The lower limit is the smallest size a component can be manufactured to and still be acceptable.

Explain  
Award 2 @ 6 Marks  
**Total (12) Marks**



- (b) (i) Nominal diameter of hole: - 26.00 mm.
- (ii) Smallest diameter of the hole: - 25.97mm.
- (iii) Largest diameter of the shaft: - 26.05 mm.
- (iv) Clearance fit.

Calculations  
Award 4 @ 5 Marks  
**Total (20) Marks**

- (c) (i) **Vee block & clamp** - used for holding round bars when drilling or marking out.
- (ii) **Outside calipers** - for gauging the outside diameter of round bars.
- (iii) **Digital micrometer** - for accurate measurement of machine parts.
- (iv) **Engineer's protractor** - Used to accurately measure or mark angles.

Name & Application  
(3+3)  
Award 3 @ 6 Marks  
**Total (18) Marks**

OR

- (c) (i) **Any three circuit symbols:**

Name:



Fixed resistor



Toggle switch



Battery



Motor

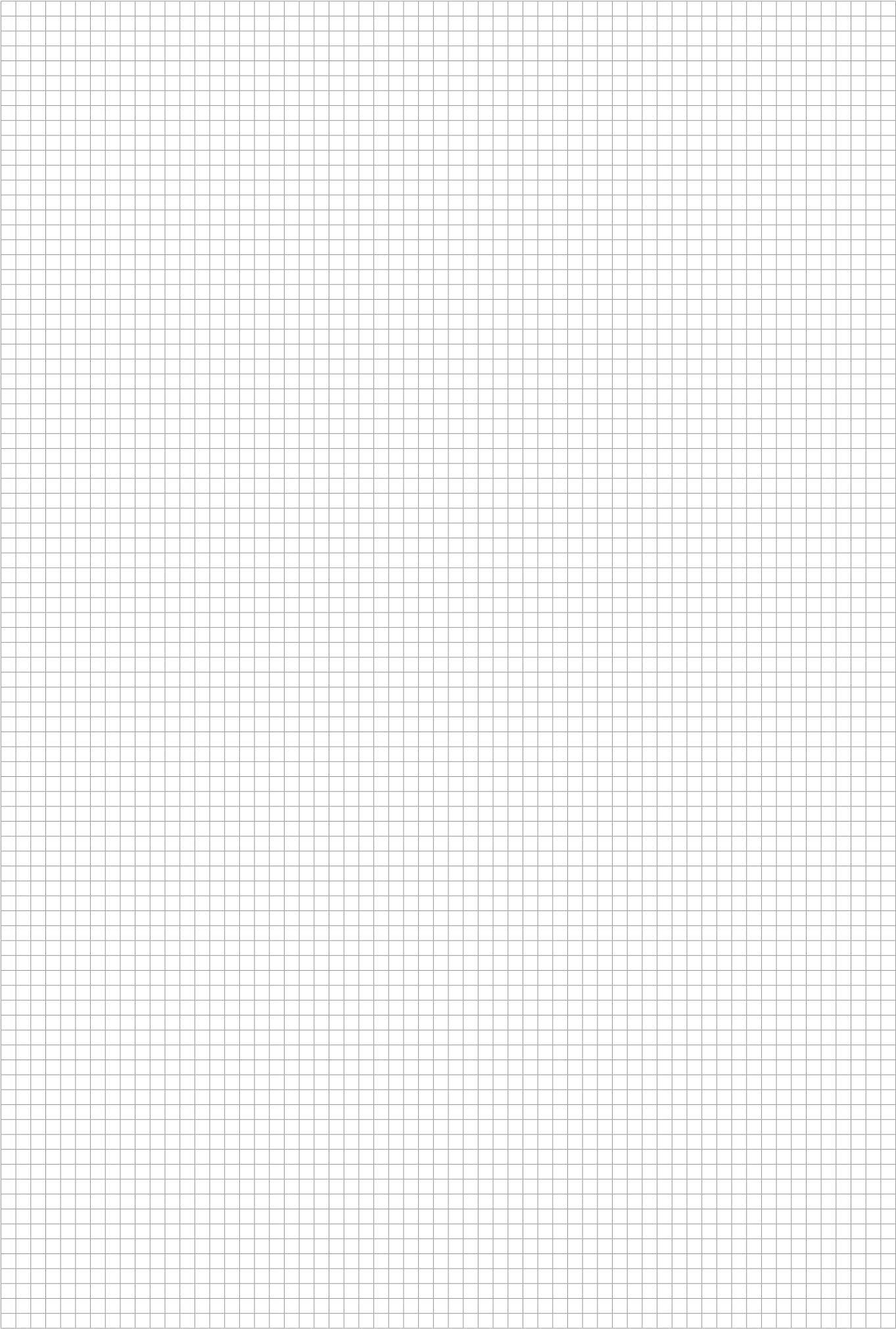


Variable resistor



(c) (i) & (ii)  
Name & Draw Symbol  
(3 + 3)  
Award 3 @ 6 Marks  
**Total (18) Marks**

## NOTES





**Examcraft Group**



89F Lagan Road,  
Dublin Industrial Estate,  
Dublin 11



T: 01 808 1494



F: 01 836 2739



E: [info@examcraft.ie](mailto:info@examcraft.ie)



W: [www.examcraft.ie](http://www.examcraft.ie)