Coimisiún na Scrúduithe Stáit
State Examinations Commission

Scéimeanna Marcála

Innealtóireacht - Ábhair agus Teicneolaíocht

Scrúduithe Ardteistiméireachta, 2004

Ardleibhéal

Marking Scheme

Engineering – Materials and Technology

Leaving Certificate Examination, 2004

Higher level

Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2004

ENGINEERING – MATERIALS AND TECHNOLOGY

(Higher level – 300 marks)

SAMPLE ANSWERS AND MARKING SCHEME

LEAVING CERTIFICATE ENGINEERING

MATERIALS AND TECHNOLOGY

(Higher Level – 300 marks)

Marking Scheme 2004

Answer Question 1, Sections A and B and **Four other questions.**

Question 1 Section A – 50 marks **Any ten @** 5 marks each. (a) 3 + 2 (b) **Any one** @ 5 (c) 4 + 1 (d) 2 + 2 + 1 (e) **Any one** @ 3 + 2 (f) 3 + 2 (g) **Any two** @ 3 + 2 (h) 5 (i) 3 + 2 (j) 3 + 2 (k) 5 (l) 3 + 2 (m) **Any one** @ 5	**Question 1 Section B – 50 marks** Answer **all** of the following. (n) 10 (o) (i) Name 1 + 1 + 1 + 1 (ii) **Any two @** 3 + 3 (p) 10 (q) **Any two** @ 5 + 5 (r) (i) 3 + 2 (ii) 3 + 2	**Question 2 – 50 marks** (a) **Any two** @ 9 + 9 (b) (i) Principle of test 8 (ii) Indenter 5 (iii) One advantage 3 (c) (i) Name 5 (ii) Operation 8 (iii) Application 3

Question 3 – 50 marks (a) (i) Identify 2 + 2 + 2 + 2 (ii) Name 3 + 3 Describe 2 + 2 (b) **Any two @** 9 + 9 (c) 14	**Question 4 – 50 marks** (a) **Any two** @ 8 + 8 (b) (i) 7 (ii) 10: (5 **labels** @ 1 mark each) (5 **descriptions** @ 1 mark each) (iii) 3 (c) Describe 7 Diagram 7	**Question 5 – 50 marks** (a) **Any three** @ 6 + 6 + 6 (b) (i) Name 4 (ii) Operation 10 (iii) Application 4 (c) Description 7 Diagram 7 **OR** (c) Two factors 7 + 7

Question 6 – 50 marks (a) Description 7 Diagram 7 (b) (i) Name 3 Operation 5 (ii) 4 (iii) 2 + 2 + 2 (c) **Any three** @ 6 + 6 + 6	**Question 7 – 50 marks** (a) (i) Name 5 Process 6 (ii) 3 (iii) 3 (b) **Any three** @ 6 + 6 + 6 (c) **Any one** @ Describe 8 Diagram 7 **OR** (c) **Any three** @ 5 + 5 + 5	**Question 8 – 50 marks** (a) **Any one** @ Name 8 Application 8 (b) **Any three** @ 6 + 6 + 6 (c) Operation 10 Function 6 **OR** (c) Identify 6 Operation 10

End

Question 1. ***(100 marks)***

SECTION A - 50 marks

(a) **Pyrometallurgy** is based on the use of heat energy in the separation of ore e.g. during the smelting process in the blast furnace.
Hydrometallurgy involves the use of aqueous solutions to dissolve the ore. This method of ore extraction is called leaching. **3 + 2**

(b) (i) **Gustaf Dahlen:** In 1902 he developed acetylene gas and demonstrated gas welding for the first time.
(ii) **Willhelm Roentgen:** In 1895 he produced X-rays in a high voltage discharge tube. The results have significant importance in engineering and medicine.
(iii) **Henery Maudslay:** In 1780 he used a revolving cutting tool to mill a slot in a lock. He mounted the tool on an arbour and set it up between centres on a lathe. **(Any one) 5**

(c) The crystal Structure is a **Body Centred Cubic** Structure and metals based on this structure include iron, tungsten, chromium, vanadium, sodium, potassium and molybdenum. **4 + 1**

(d) Land Fill, incineration and recycling. **2 + 2 + 1**

(e) (i) **Name:** Square thread. **Application**: Screw jacks.
(ii) **Name:** Acme thread **Application:** Lead screw of lathe **(Any one) 3 + 2**

(f) Main **properties** include ductility, malleability, high melting point, insoluble in water, good conductor of heat and electricity. **3 + 2**

(g) (i) **LCD:** Liquid crystal display. These are special display systems for use with computers and digital watches.

(ii) **CD-ROM:** Compact disc read only memory. This is a strictly read only form of storage having a capacity of about 600 megabytes.

(iii) **ISP:** Internet service provider. This provides the link between the PC operator and all of the internet world. It passed the necessary data to and from sites visited, and e-mail accounts used.

(iv) **DOS:** Disc operating system. This is a program stored in the memory of a computer. It simplifies tasks such as running a program or printing a document. **(Any two) 3 + 2**

(h) Drop forging. **5**

(i) **Crystalline structures** have regular repeating geometrical molecular patterns. **Amorphous structures** have disorganised, irregular molecular patterns. **3 + 2**

(j) **Component name**: Transistor

Purpose: Transistors are semi-conducting devices with three leads. A very small current at one lead can control a much larger current flowing through the other two leads. It can be used as an amplifier or a switch. **3 + 2**

(k) In annealing a component is **"soaked"** when it remains in the furnace at a prescribed temperature and is heated uniformly. This may be achieved by switching off the furnace to allow for very slow cooling. **5**

(l) **Generating** produces a machined surface by the combined movement of the machine sideways, e.g. taperturning, facing.

Forming produces a surface which is determined by the tool profile e.g. parting off tool. **3 + 2**

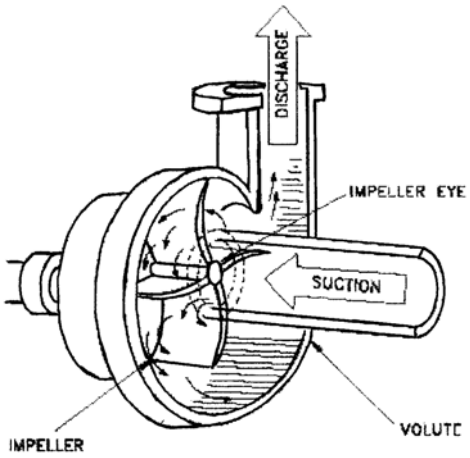
(m) (i) Shuttle valve.

(ii) Flow Control valve.

(iii) Interruptible jet sensor. **(Any one) 5**

SECTION B - 50 marks

(n) In the operation of a centrifugal pump, liquid enters the suction nozzle and then into the eye or centre of a revolving impeller. When the impeller rotates the liquid is thrown outward by centrifugal action. As the liquid leaves the eye of the impeller a low pressure arc is created causing more liquid to flow towards the inlet. The fluid is discharged at pressure from the volute through the discharge nozzle.



10

(o) (i) A: Impeller or Impeller Vane
B: Discharge Nozzle
C: Suction Eye
D: Volute **(Name) 1 + 1 + 1 + 1**

(ii) A – **Impeller:** The impeller is the main rotating element that provides centrifugal acceleration to the fluid.

or

A - **Impeller Vane:** This controls the direction of motion for the liquid. The greater the number of vanes the smoother the motion.

B – **Discharge Nozzle:** This is the exit port where pressurised liquid leaves the centrifugal pump.

C – **Suction Eye:** This is where fluid enters into the impeller.

D – **Volute:** A curved funnel increasing in area to the discharge port. As it's cross-section area increases the volute reduces the speed of the liquid and increases its pressure. **(Any two) 3 + 3**

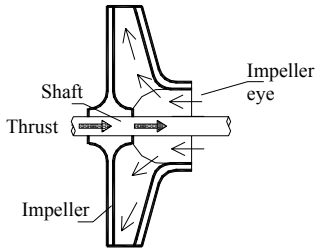
(p) The energy of the electric motor or turbine is first converted into kinetic energy by the impeller . This kinetic energy is converted into pressure energy by the volute. **10**

(q) (i) **Radial Flow** occurs in a centrifugal pump where the pressure is developed completely by centrifugal force.

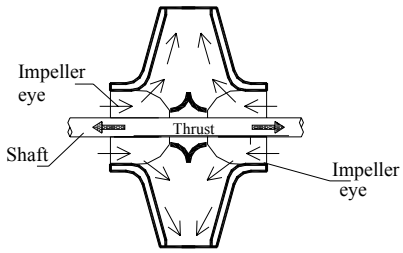
Axial flow occurs in a centrifugal pump where the pressure is developed by the propelling or lifting action of the vanes of the impeller on the liquid.

(ii) **Single suction** refers to pumps with one suction nozzle where liquid enters into the eye of the impeller.

Double suction centrifugal pumps have two suction nozzles.



Single suction



Double suction

(iii) **Open impeller:** No shrouds or wells enclose the vanes. This type of impeller is less likely to clog.

Closed impeller: Shrouds or sidewalls enclose the vanes.

(iv) A **Volute casing** builds up a higher head or pressure and its main purpose is to balance hydraulic pressure on the pump.

Circular casings are used in centrifugal pumps that pump a high liquid volume rather than build a high head or pressure. **(Any two) 5 + 5**

(r) (i)

- Pump liquids with a wide range of properties.
- Can be constructed from a wide range of corrosion-resistant materials.
- Gives a high flow rate for its size. **3 + 2**

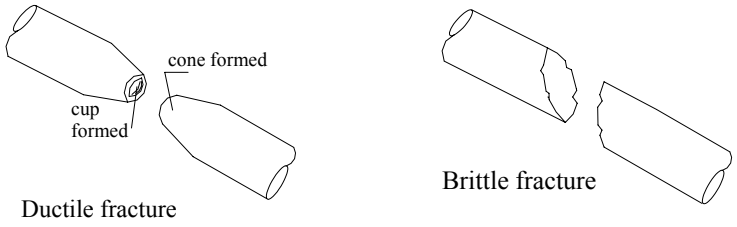
(ii)

- Slurry agitator
- Water pump in the cooling system of an engine.
- Irrigation.
- Industrial water supplies. **3 + 2**

Question 2 *(50 marks)*

(a) (i) **Ductile fracture:** When a ductile material has a gradually increasing stress applied it behaves elastically up to a limiting stress. Beyond this, plastic deformation occurs in the form of necking. As the stress is increased the cross-section area considerably reduces until a fracture occurs. This fracture shows a typical cone and cup formation. A characteristic of ductile fracture is the dull appearance on the surface of the fractured metal.

Brittle fracture: In brittle fracture failure occurs before any significant plastic deformation has occurred. The surface of the fractured material appears bright and granular.



(ii) **Macroscopic examination** is a visual inspection technique. The naked eye or a low powered magnifying glass is used. During macroscopic examination physical manufacturing defects are revealed.

Microscopic examination is inspection with the aid of an optical microscope (with magnification up to 3000x). This allows for more detailed examination of the grain size and some impurities.

(iii) **Fatigue** is failure due to on/off loading or cyclic stressing. Failure begins as a minute crack and grows under the action of fluctuating stress.

Creep is slow deformation of a material over time resulting from a steady force acting on the material. Creep occurs more readily if materials are lso subjected to high temperatures.

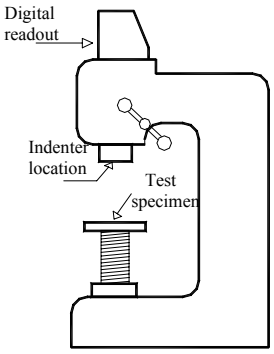
(iv) **Izod** testing involves the following:

- A notched specimen is clamped in a vice at one end;
- A pendulum with a striking energy of 163 Joules strikes and fractures the test piece and continues to swing;
- After fracture the highest point of swing indicates the amount of energy used to fracture the specimen.

Charpy testing is similar to Izod with the following differences:

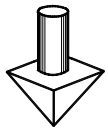
- The notched specimen is held at both ends;
- The notch is facing away from the pendulum;
- The striking energy for Charpy is 300 Joules. **(Any two) 9 + 9**

(b)(i) **Vickers hardness test:** A diamond shaped indenter is forced into the specimen.The diagonal length of the square is measured. This measurement is taken by a special microscope for accuracy. It is then converted into a Vickers hardness number. **8**



Hardness testing machine

(ii) A diamond shaped pyramid indenter is used. It has a point angle of 136º. **5**


Square pyramid indenter

(iii) **Advantages**: Vickers has a wide range of hardness values. Its scale ranges from 114 to 545. It overcomes the limitations associated with Brinell testing. Excellent for components with high hardness, also suitable for testing some finished components due to the small indentation it leaves. **(Advantage) 3**

(c) (i) **Name**: Eddy current testing. **(Name) 5**

(ii) When a coil, energised with high frequency alternating current, is placed close to a conductive material it will produce eddy currents in the material. These currents produce a magnetic field in the test specimen. A search coil used in conjunction with the energised coil can be connected to an electronic recording device. Any defect in the material distorts the magnetic field. This is indicated on the recording device. The magnitude of the distortion reflects the size of the defect. **(Operation) 8**

(iii) A **suitable application** is the detection of surface or subsurface flaws in nonferrous metals of uniform section. **(Application) 3**

Question 3 *(50 marks)*

(a) (i) A: Austenite

B: Liquid

C: Austenite + Cementite

D: Austenite + Liquid. **(Identify) 2+2+2+2**

(ii) E: **Eutetic point.** **(Name) 3**

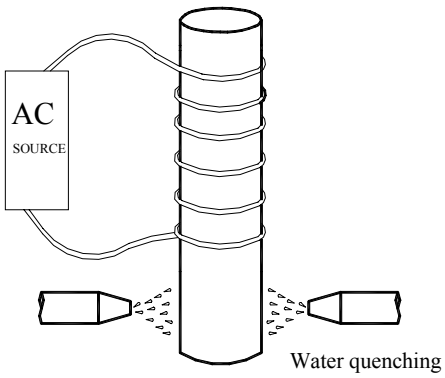
This is in a special change point where a liquid to solid change occurs. This occurs at 1140ºC for the iron carbon alloy with 4.3% carbon. Liquid steel changes to solid austenite and cementite. **(Describe) 2**

F: **Eutectoid point.** **(Name) 3**

This reaction occurs during the solid state. Solid austenite changes to solid pearlite. This occurs at 723ºC for the iron carbon alloy with 0.83% carbon.

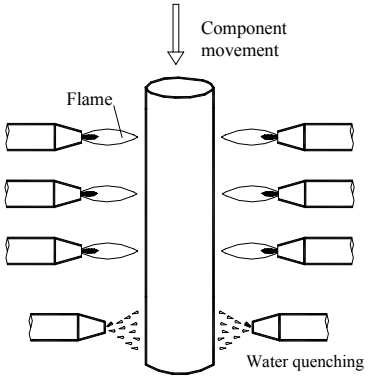
(Describe)2

(b) (i) **Induction hardening:** This process involves placing the steel component within a coil through which a high frequency current is passed. This alternating current induces another alternating current to flow in the surface layers of the steel. The layers are heated to a sufficient temperature causing the surface layers to change to austenite. The water quenching which follows transforms the austenite to martensite which leaves the outer surface hard. The depth of heating and hence the depth of hardening is related to the frequency of the current used.



Induction hardening

(ii) **Flame hardening:** This method involve heating the surface of the steel with an oxy-acetylene flame and then immediately quenching the surface in cold water. The heating transforms the structure of the surface layers to austenite an the quenching changes the austenite to martensite.



Flame hardening

This leaves a hard layer on the outer surface. The depth of hardening depends of the rate of heat supplied, the faster the burner moves over the surface the less the depth of hardening. Flame hardening is usually carried out at temperatures of 850ºC.

(iii) **Carburising:** This is a surface hardening process that involves changing the composition of the surface layers. It involves increasing the carbon content of the surface layers, followed by a quenching process to convert the surface layers to martensite. The process is normally carried out on a steel containing less than 0.2% carbon. There are a number of carburising methods and they include:

- Pack carburising;
- Salt-bath carburising;
- Gas carburising. **(Any two) 9 + 9**

(c) The **allotropy** of iron modifies the solubility of carbon and it is because of this that steel can be hardened. In particular the change from alpha iron (ferrite) which has a bcc crystal to gamma iron (austenite) which has an fcc structure is of fundamental importance in the **hardening of steel**. Up to 1.7% carbon can be accommodated in gamma iron. When carbon steel is cooled from the austenite state to the ferrite some carbon must come out of solution. This is achieved by the formation of a compound of iron and carbon called cementite. The presence of cementite gives hardness to carbon steel. **14**

Question 4 *(50 marks)*

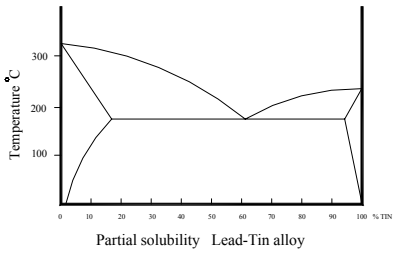
(a) (i) **Vacancy**: A vacancy or vacant site defect is where one atom is missing therefore disturbing the crystal lattice.

Dislocation: An incomplete layer of atoms in a crystal structure is called a dislocation. Dislocations often account for the difference between the estimated and the actual strength of metal crystals.

(ii) **Age hardening:** A. Wilm discovered that when commercial aluminium alloyed with copper is quenched from a relatively high temperature, it increases in hardness over time at room temperature. The ageing occurs due to precipitation of $CuAl_2$.

(iii) In a **bcc** structure atoms are not closely packed therefore slip is less likely to occur due the the lack of slip planes. For atoms to slip or slide over one another a large force is required, often giving rise to rupture and brittleness.

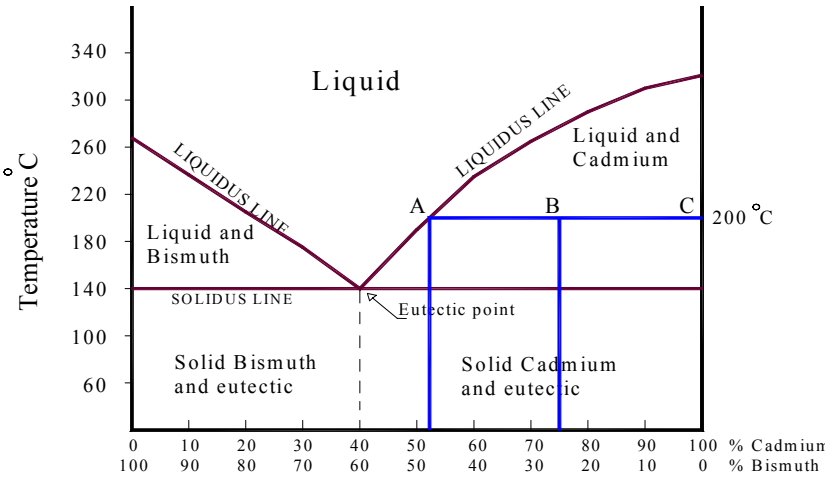
(iv) **Partial solubility:** For this alloy the two metals dissolve in each other to a limited degree. The lead/tin alloy is an example, and is a combination of the solid solution and eutetic alloy systems. With partial solubility A new line exists called the Solvus line.



Partial solubility Lead-Tin alloy

(Any two) 8 + 8

(b) (i)



Equilibrium diagram

(Diagram) 7

(ii) See **labels** on diagram: **(Any five labels) 5 x 1**

Liquidus line: for the cadmium bismuth alloy, this line represents the boundary between the fully liquid state and the beginning of solidification.

Solidus line: The boundary line that determines the end of solidification. Below this line the alloy is completely solid and cooling.

Solid Cadmium and Eutetic and solid Bismith and Eutetic: Below the solidus line there is a mixture of crystals of cadmium and bismuth. Each of the two metals in the solid alloy retains its independent identity.

Liquid region: The two metals are completely soluble in each other in the liquid state.

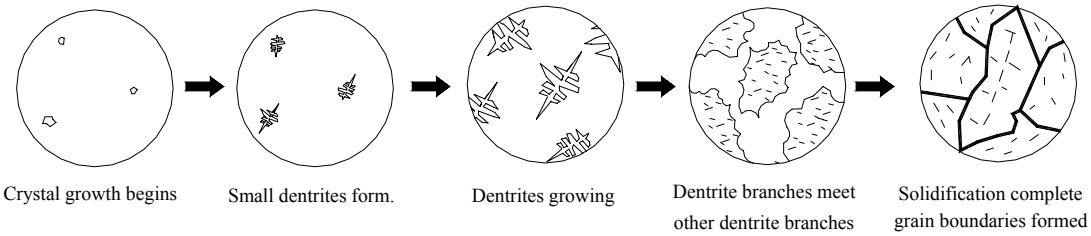
Pasty (Liquid + Bismuth and Liquid + Cadmium): Between the liquidus and solidus lines the alloy system is in a part liquid part solid state.

Eutetic point: This is a special change point at 40% cadmium and 60% bismuth, where liquid changes directly to solid without going through a pasty stage. **(Any five descriptions) 5 x 1**

(iii) The **ratio** of solid to liquid at 200°C for the 75% cadmium alloy is calculated as follows:

$$\frac{\text{Mass of solid}}{\text{Mass of liquid}} = \frac{22.5}{25} = \frac{9}{10} \quad \textbf{3}$$

(c) The stages of crystal solidification of a metal from the liquid phase is known as dentritic growth. Initially the cell forms and grows to form a dendrite. As dendrites grow, they intrude on each other with spike-like formation. This continues until they eventually form a grain boundary. **(Description) 7**



Dendritic growth

(Diagram) 7

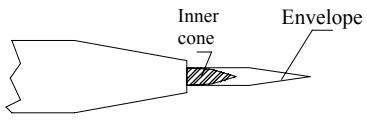
Question 5 *(50 marks)*

(a) (i)

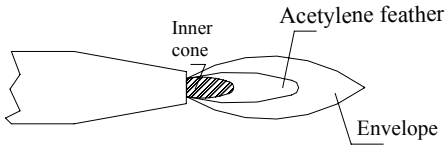
- In manual metal arc welding, fluxing elements of the electrode coating give off a gas which protects the weld from the atmospheric contamination. The slag formed protects the weld during cooling
- In metal inert gas and tungsten inert gas welding and inert gas such as argon shields the weld pool.
- In oxy-acetylene welding the outer envelope of the flame uses oxygen from the surrounding air to burn off the carbon monoxide that results from the combustion of acetylene. Further protection can be achieved with the use of a flux.

(ii) **An oxidising flame** has excess oxygen in its composition. The ratio of oxygen to acetylene is 1.5 parts oxygen to 1 part acetylene. It has a melting temperature of 35000°C. It is used for welding copper and bronze.

A carburising flame has excess acetylene in its composition. The ratio of oxygen to acetylene is 0.9 parts oxygen to 1 part acetylene. It has a melting temperature of 3150°C and can be used to weld aluminium alloys and alloy steel.



Oxidising flame



Carburising flame

(iii) When welding aluminium, the weld pool oxidises extremely quickly.Tungsten inert gas welding uses argon gas to shield the weld pool allowing aluminium to be successfully welded.

(iv) Safety precautions include:

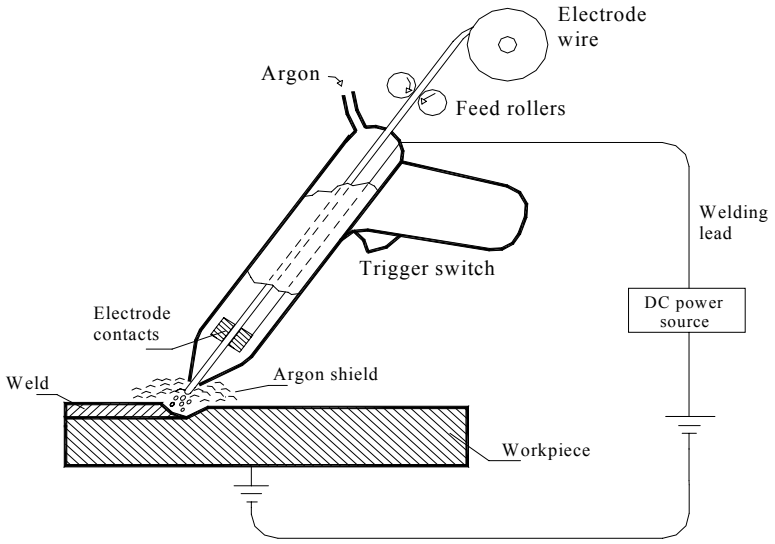
- Ensure that all equipment is properly installed.
- Ensure that all terminals and wires are secure and properly insulated.
- Never weld in damp conditions.
- Make sure equipment is earthed. **(Any three) 6 + 6 + 6**

(b) (i) **Name:** Submerged arc welding. **4**

(ii) **Method of operation:** In submerged arc welding, a bare wire electrode is used. It is fed continuously from a spool and generates the electric arc to heat the joint. Flux is in powder form and is fed from a hopper to completely cover the joint and the end of the electrode. The arc melts the joint, flux and electrode. A slag is formed which provides a protective coating and can be easily removed. Submerged arc welding is a fully automatic process. **10**

(iii) **Applications:** Straight line welds in shipbuilding, bridge construction, large steel reinforcement beams. **4**

(c) **Metal inert gas welding:**



Metal inert gas welding is a semi-automatic process. It operates on principles similar to manual metal arc welding. A consumable bare wire electrode is fed continuously through the welding torch or gun into the weld pool area. Fluxing is

achieved through the use of an inert gas such as argon, the gas exits through the torch nozzle and creates a protective shield around the weld pool The operator sets the feed rate of the electrode and the flow rate of the gas. Once the arc is generated between the electrode and the work, the operator simply guides the torch to complete the weld. **(Description) 7**

(Diagram) 7

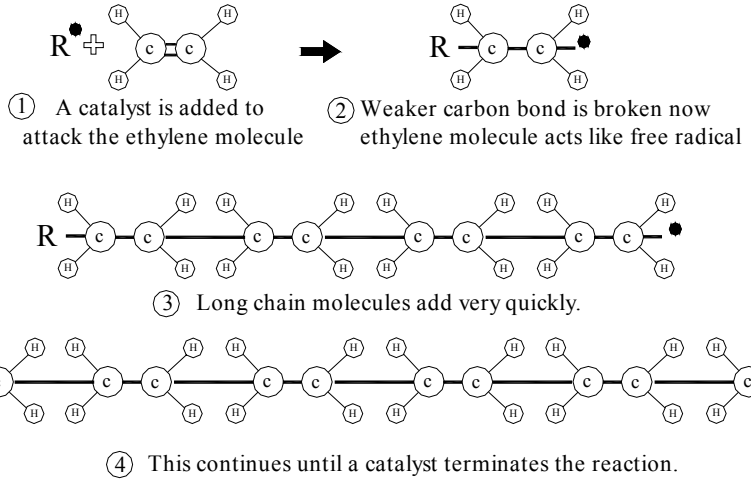
OR

(c) **Factors include:**

- Speed of production;
- Efficiency;
- Cost effectiveness;
- Capability for full automation.
- Heat resistant, robust materials used in manufacture. **(Two factors) 7 + 7**

Question 6 *(50 marks)*

(a) **Addition polymerisation** is a process where long chainlike molecules are formed by the addition of large numbers of mers. Polyethylene is produced by this polymerisation mechanism. The ethylene molecule or mer consists 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 added to the ethylene molecule. The weak bond is attached and one of its electrons is taken by the radical leaving the other free. Now the attached ethylene molecule behaves like a radical and the process is repeated continuously. Long chains bond together in seconds until the reaction is terminated by a chain stopper. Addition polymerisation contains bonds held together by weak Van der Waals forces which are easily overcome by heat or pressure.



(Description) 7

(Diagram) 7

(b) (i) **Name:** Transfer moulding. **(Name) 3**

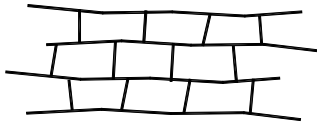
Principle of operation: The moulding powder is placed in a compartment above the mould where it is heated. The plunger forces the molten polymer into a cooled mould cavity. The polymer solidifies in the mould which is then opened and the product is removed. **(Operation) 5**

(ii) Thermosetting products e.g. socket covers, plug tops. **(One component) 4**

(iii) A = Polymer power. B = Plunger. C = Mould. **(Name parts) 2 + 2 + 2**

(c) (i) **Van der Walls forces:** These are the bonding forces between adjacent polymer chains as a result of addition polymerisation. They are weak secondary covalent bonds and may disrupted easily by heat or pressure.

(ii) **Crosslinking:** In condensation, a strong rigid 3-D network is formed by primary covalent bonds between adjacent chains. These bond and are called crosslinks and give the polymer higher tensile strength, rigidity and resistance to heat. Thermosetting plastics are formed due to crosslinking.



(iii) **Co-polymerisation:** The process where two different mers are linked together in the same polymer chain to form a completely new polymer. This new polymer may have a variety of properties.

(iv) **Filler:** These are a range of materials or additives added to polymers to increase their volume or mechanical strength.

(v) **GRP:** Glass reinforced plastic e.g. fibreglass. Reinforced plastic consists of a polymer combined with glass fibre which is a stiff, strong additive. Its effect is to increase the tensile strength of the polymer. **(Any three) 6 + 6 + 6**

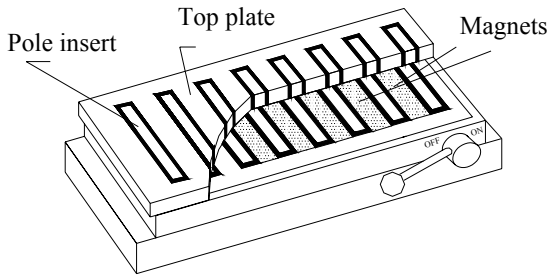
Question 7 *(50 marks)*

(a) (i) **Name:** Surface grinding. **(Name)5**

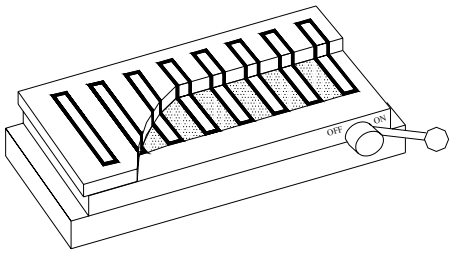
Process: Surface grinding is a metal cutting process. Its function is to produce flat and extremely smooth surfaces. Metal removal is achieved through a combination of motions. The grinding wheel rotates clockwise and the workpiece is fed to and fro continuously. At the end of each stroke, the table is fed across the wheel by small amounts. For new cuts to be taken the wheel head can be lowered by a required depth. **(Process) 6**

(ii) **Workholding:** The magnetic chuck is the most common method of workholding in surface grinding. The chuck consists of a top plate which contains magnetic inserts, a casing which contains permanent magnets, these rest on a base plate. If the chuck is in the on position the magnets move on line with the magnetic inserts, creating a magnetic force through the workpiece, therefore holding it securely in position. If in the off position the magnets move off line and the magnetic force passes through the top plate, thus releasing the component.

(Magnetic chuck diagram)



Chuck in the OFF position as the magnets are out of phase with the top plate.The workpiece is now released.



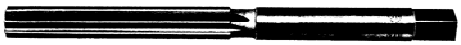
ON position as the magnets have moved in line with the top plate therefore the work is securely held.

Other workholding devices include: Adaptor plates; chuck blocks; the universal vice; the sine chuck. **(One method) 3**

(iii) **Application:** Smooth and polished finishes on components. **3**

(b) (i) **Reaming and drilling:** A reamer accurately finishes an already drilled hole. A reamer contains more flutes than a drill bit.

Twist drill



Reamer

(ii) **Clearance fit:** If the limits on the shaft are always smaller than the limits on the hole a clearance fit exists.

Interference fit: If the limits on the shaft are always larger than the limits on the hole an interference fit exists.

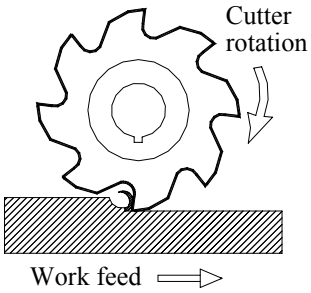
(iii) A **plug gauge** is used to accurately determine if a selected hole is within a specific range of limits.

(iv) Continuous chip.

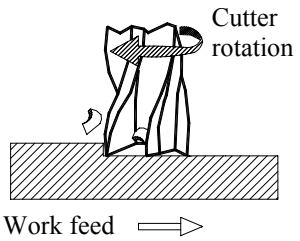
Discontinuous chip.

Discontinuous chip with built up edge. **(Any three) 6 + 6 + 6**

(c) **Peripheral milling:** In peripheral milling the finished surface is produced from the cutting action of teeth on the periphery of the milling cutter. Sometimes referred to as slab milling when a long cylindrical cutter is used. Up cut and down cut milling are other examples of peripheral milling. Cutters are mounted on an arbour.



Peripheral milling



Face milling

Face milling: In face milling the milling cutter operates at right angles to the surface being generated. The face or end of the cutter generates the desired surface on the workpiece. Many of the cutters are chuck mounted.

Any one (Describe) 8

(Diagram) 7

OR

(c) (i) **Incremental dimensioning:** In this system, each dimension is taken relative to the previous position and not from a fixed datum line. (G91)

(ii) **Time Dwell:** This code is entered if the operation required a period of time to execute a tool change. (G04)

(iii) **Canned cycle:** This enables a required number of repetitive operations to be executed by a single program block (G80-G84)

(iv) **CAM:** computer aided manufacture. **(Any three) 5 + 5 + 5**

Question 8 *(50 marks)*

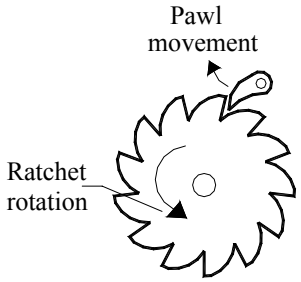
(a) (i) **Name:** Worm and worm wheel.

Application: Used in the dividing head.

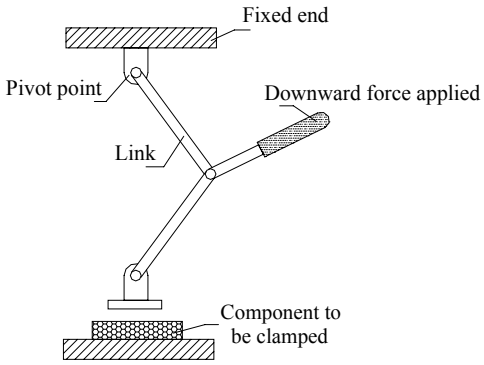
(ii) **Name:** Bevel gears (sometimes called mitre gears)

Application: Connection of two moving shafts which meet at right angles and shafts that do not have parallel access. **(Any one) Name 8**
Application 8

(b) (i) **Ratchet:** A ratchet is a wheel with suitably shaped teeth, which can be moved in circular motion. A ratchet wheel used in conjunction with a pawl allows rotation in one direction only. It is used in socket sets and wire tensioning devices.

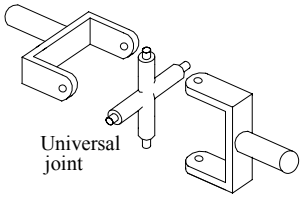


(ii) **Toggle mechanism:** These are used to secure large clamping forces. It consists of two links joined to a common pivot point. One link is secured to a fixed surface and pivoted. The other link has freedom to move. Clamping occurs when a force is applied to the common pivot which pushes the free end downwards. If the links are in a straight line the clamping force is at a maximum. This mechanism is used to clamp vacuum forming sheets, and on prams and buggies.



Toggle mechanism

(iii) **Universal joint:** A universal joint allows one shaft to drive another when their axes are not in line.



(iv) **Throttle valve**: This is used in pneumatic circuts and its function is to restrict the flow of air in both directions.

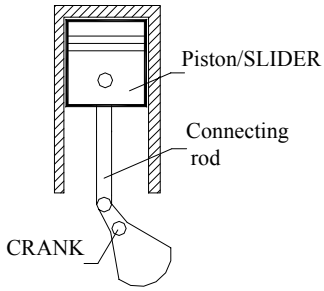
Throttle valve

(v) **Solenoid:** This is an electrical device where a coil of wire wound on a soft

iron core is energised. The magnetic force induced by the current pulls the bar into its centre. When the current is switched off, a spring returns the bar to its original position. **(Any three) 6 + 6 + 6**

(c) **Crank/slider mechanism**

Operation: In the car engine the reciprocating motion of the piston caused by exploding fuel is converted into rotary motion as the con-rod moves the crankshaft around. An air compressor uses this principal in reverse an electric motor turns the crankshaft and the piston moves up and down to compress the air.

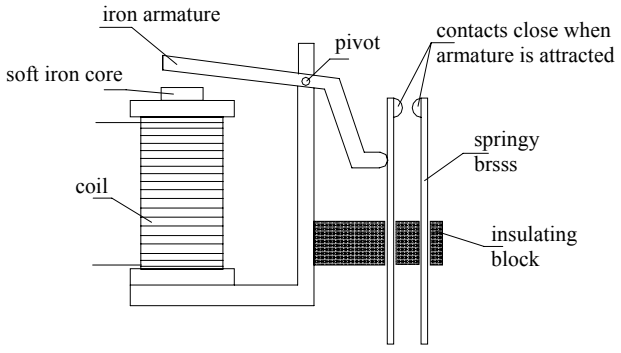


Function: A crank and slider mechanism changes rotary to reciprocal motion or vice-versa. **(Operation) 10 (Function) 6**

OR

(c) **Identification:** Electromechanical relay. **(Identify) 6**

Operation: This is an electromagnetic device that changes switching contacts when it receives an electric signal. It consists of a wire coil with a soft iron core. If a small current is passed through the coil, the iron core is magnetized and a pivoted armature is attracted towards the magnetized core. The movement of the armature closes the contacts and may open other contacts. These contacts can be used to control larger currents or a secondary circuit. The relay is a switch and changes electrical energy into mechanical energy. It is used in an electric motor door chime. **(Operation) 10**



Electrical Relay