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LEAVING CERTFICATE EXAMINATION, 2002.

ENGINEERING – MATERIALS AND TECHNOLOGY

(Higher Level – 300 marks)

<u>Answer Q1 (A&B) and any FOUR others</u>.
Marking Scheme and Solutions

Question 1 Section A: 50 marks.

Any Ten @ 5 marks each.
(a) 5
(b) 3 + 2 + 1
(c) 3 + 2
(d) 5
(e) 5
(f) 5
(g) 3 + 2
(h) 5
(i) 5
(j) 5
(k) 5
(l) 5
(m)5

Question 1 Section B: 50 marks.

Answer all questions
(n) (i) 5
(ii) 5
(o) 3 + 3 + 4
(p) 10
(q) (i) 5
(ii) 5
(ii) 5
(r) (i) 5
(ii) 5

Question Two: 50 marks

(a) (i) 5 + 5 + 5
(ii) 3

(b) Name = 4
Purpose = 6
Proceedure = 3
Results = 3

(c) Principles = 6
Applications = 2 x 2

Question Three: 50 marks

(a) Any Two @ 8 + 8 marks

(b) Any Two @ 8 + 8 marks

(c) Names @ 1 mark each.
Highlight zones = 3 + 3
Distinguish = 3 + 3

Question Four: 50 marks

(a) Any Four @ 4 x 4

(b) 8 + 8 marks.

(c) Copy = 3 marks
Identify = 3 + 3 + 3
Explanation = 2 + 2 + 2

Question Five: 50 marks

(a) (i) Component Names = 2 + 2
(ii) Operation = 5 + 5
(iii) Application = 2 + 2

(b) Any Three @ 8 marks each
(c) Diagram = 4
Description = 4
OR
(c) 8 marks.

Question Six: 50 marks

(a) Any Three @ 6 marks.

(b) (i) Name and Application
3 + 3 marks
(ii) Operation = 6 marks
(c) 10 + 10 marks

Question Seven: 50 marks

(a) Four processes @ 6 each.

(b) Any Three @ 6 marks each.
(c) 8 marks.
OR
(c) 8 marks.

Question Eight: 50 marks

(a) Name = 9 marks
Application = 8 marks

(b) Any Three @ 6 marks each.
(c) Three types
Distinguish = 3
Application = 2
OR
(c) Operation = 10
Application = 5.

1. **(100 marks)**

SECTION A – 50 marks

(a) A point defect is where one atom is missing in the crystal lattice structure. A line defect is where a full line of atoms is missing. Interstitial or Substitutional. **5**

(b) Pressing is used to form the panels for cars. Folding and any plastic forming process.
Spot welding usually controlled by robots is used to join main structures to the chassis. **2 + 2 + 1**

(c) (i) Transistors are used as switches. A small base / emitter current allows for a greater flow of current between the base and collector.
(ii) A Bell or buzzer emits an audible sound when current passes through it.
(iii)A light dependant resistor only allows current to pass through when sufficient light is present. **3 + 2**

(d) The kettle could be manufactured by transfer moulding and the tray by Compression moulding. **5**

(e) When small seed like cells begin to form tree like cells on cooling the process is referred to as dentritic growth. **5**

(f) Any metal that can exist in more than one form is referred to as an allotropic metal. Steel is in the Body centred cubic form at room temperature but changes to Face centred cubic above its critical temperature. **5**

(g) The metallic bond consists of positive atoms surrounded by a sea or cloud of electrons. These free electrons are easily excited resulting in the material being very conductive of heat and electricity. **3 + 2**

(h) The mechanism is a Cam and Follower. The function of the mechanism is to convert the rotary motion of the Cam into reciprocating motion of the follower. **5**

(i) Non metals will only conduct under certain conditions.
Silicon or Germanium are easily doped and are used in the manufacture of transistors and diodes. **5**

(j) The symbol on the left represents a general danger symbol. The second symbol indicates that a substance or an area is highly inflammable and no naked flames should be used in the vicinity. **5**

(k) The dovetail may be measured using precision rollers and then a measurement may be taken directly using a vernier or micrometer. **5**

(l) (i) Laser Development. (ii) Steam Turbine. (iii)Interchangability **5** (m)(i) A Pneumatic sequencer controls steps in a process, step two cannot begin until feedback from step one is received.

(ii) A Pneumatic programmable logic controller is a microprocessor which can be programmed to perform any sequence of operations It can combine both pneumatic and electronic inputs and outputs. **5**

SECTION B – 50 MARKS

(n) (i) The polarity of magnets result in magnetic field lines flowing from north to south poles. If magnetic poles are the same, they repel. If opposite they attract. The attraction of opposite poles is important for the operation of stepper motors. **5**

(ii) When a current is made to flow in a piece of wire it generates a magnetic field about the wire. The direction of the magnetic field will depend on the direction of the current flow in the wire. If we extend greatly this wire into a coil the magnetic fields from each turn of the coils add together making the magnetic field much stronger. A soft iron core concentrates the lines of magnetic field inside the coil. The coil is now an electro-magnet with a north and south pole. The ability to reverse the position of the north and south in an electromagnet is important for the successful operation of stepper motors. **5**

(o) A: Motor housing/ outside casing. **3**
B: Stator (electromagnets) **3**
C: Rotor (permanent magnets) **4**

(p) In fig. 1 the voltage from the stator coil AB is removed and is applied to stator coil CD. Since stator coil AB now has no magnetic attraction the rotor is now attracted to coil CD resulting in ninety degrees of movement. **10**

(q)

(i) In coil one pole A is South and pole B is north, the rotor magnet will line as in the left hand diagram. Unlike poles attract resulting the rotor staying in position, this is referred to as holding torque. **5**

(ii) The rotor revolves within fixed electromagnets called the stator. The rotor is driven round by switching the coils on and off in the correct sequence using electronics. **5**

(r) (i) Permanent Magnet motors (rotors) include Bipolar and Unipolar.
Variable Reluctance motors
Hybrid combines the operational feature of both the above. **5**

(ii) Low cost, less lightly to fail, fewer moving parts, low maintenance do not stall or slip (holding torque).
They use much more current than DC motors, waste more energy, high torque is achieved at low speeds only. **5**

2. **(50 marks)**

(a) (i) A: represents both the proportional period and the elastic range. **5**
B: is the plastic range or ductility period. **5**
C: is where fracture or breakage occurs. **5**

(ii) Fatique is when a material fails due to constant cyclic stress. **3**

(b) (i) The drawing given could represent either the Brinnell hardness or the Rockwell test. Both tests measure the hardness of a material. **4 + 6**

(ii) A hardened steel ball indenter is pressed into the material. **3**

(iii) The Brinnel test is based on the surface area of impression whilst the Rockwell measures the depth of impression. **3**

(c) (i) Ultrasonic: High frequency sound waves are passed through the test piece, any voids will immediately reflect back as an echo and be recorded on a cathode ray tube as a smaller peak than the signal emitted. Used for checking internal faults in welds.

(ii) Radiographic: X – Ray are used to develop a photographic image of the work. Used for checking internal flaws.

(iii) Magnetic: Iron filings are scattered over the work, it is then magnetised and the particles will gather around any surface flaw.

6 + 2 x 2

3. **(50 marks)**

(a) (i) When a piece of high carbon steel is heated to its critical point at 720, the structure begins to change internally. There is little or no increase in temperature as this critical stage begins. The point at which it begins is referred to as the Decalesence point. If allowed to cool slowly the changes occur in reverse and the corresponding point is referred to as Recalesence.

(ii) Annealing: This is a heat treatment process to render a material as soft as is possible.

(iii) The Critical range starts at the point of Decalesence at 720 degrees. During this period the material glows less brightly, contracts dimensionally. A loss of magnetism is also experienced.

(iv) Martensite: A hard needle like structure that results from rapid cooling after the critical temperature. It is also very brittle. **8 + 8**

(b) (i) The component moves at a steady rate through the flames followed by water jets hardening the surface of the work.
The component is placed inside a coil. The high frequency current in the coil induces eddy currents in the work. This in turn causes a rapid rise in the temperature in the outer layers. The component is cooled by water jets.

(ii) Ferrite is almost pure iron, Pearlite is alternate layers of ferrite and cementite. Cementite is a compound of iron and carbon.

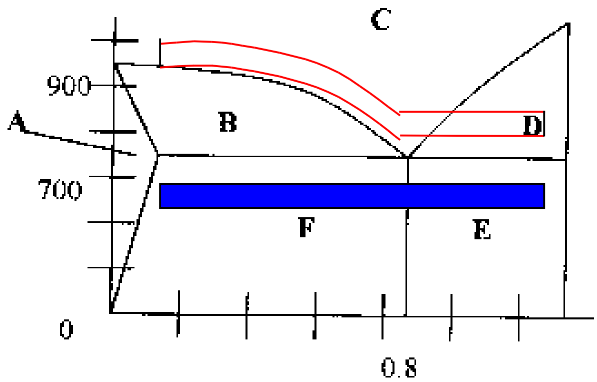
(iii) Grey cast iron has flakes of graphite and is weak in tension and is generally softer than white, it has self-lubricating properties
White cast iron is hard and brittle, the carbon is present in the form of ferrite and cementite.

(iv) Eutectic is a liquid to solid rapid change point where as Eutectoid is a solid to solid change point. **8 + 8**

(c)

(i) A: Ferrite.
B: Austenite and Ferrite.
C: Austenite.
D: Austenite and Cementite.
E: Pearlite and Cementite.
F: Ferrite and Pearlite.

(ii) Blue area: Stress relieving.
Red area: Hardening.



(iv) For a structure with 0.6% carbon when quenched rapidly the carbon In solution will have insufficient time to revert back and is essentially trapped in solution. The resulting structure is a hard needle like form referred to as Martensite.
When cooled slowly all the critical changes occur in reverse and the reverts back to its original form. **18**

4. **(50 marks).**

(a)

(i) The ore used for aluminium is Bauxite.

(ii) Purification and Electrolysis.

(iii) Aluminium self protects by forming an oxide layer.

(iv) Light in weight, does not corrode, a good conductor of electricity and heat. Cheaper to produce than copper. It is malleable, ductile. A good reflector of light and heat and is easily cast. It has a low melting point, 660 C.

(v) At the Aughinish plant, Co.Limerick where aluminium oxide is extracted from Bauxite ore, the Alumina is shipped abroad for electrolysis.

(vi) The Y alloy gets harder over time as the copper slowly comes out of solution. **4 x 4**

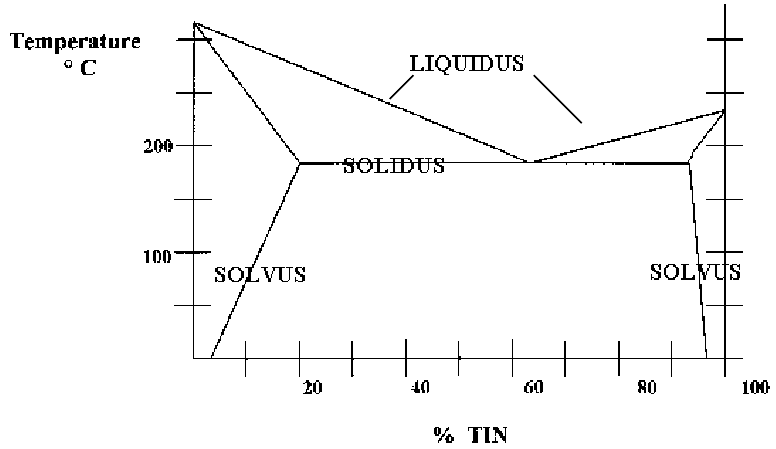
(b) Solid Solution: When two metals are completely soluble in each other in both the liquid and solid states. When the alloy solidifies only one type of crystal is formed and it looks like a pure metal. Copper and nickel form a solid solution of the substitutional form. Simple Eutectic: The two metals are completely soluble in the liquid state but insoluble in the solid state. On cooling two separate types of crystals or grains are formed. **8 + 8**

(c) (i) Liquidus: The line made up of the combination of start of cooling points for different percentage mixes of alloys. Anything above the liquidus line is completely liquid.

(ii) Solidus: Line made up of a combination of derived from the finish of cooling for various percentage alloys. Any combination below this line is completely solid. Between the liquidus and solidus is where the alloys are in a part liquid part solid state.

(iii) Solvus: Lines defining the temperatures at which a solid to solid change of structure occurs.

Explain = 2 x 3
Identification = 3 x 3
Copy = 3



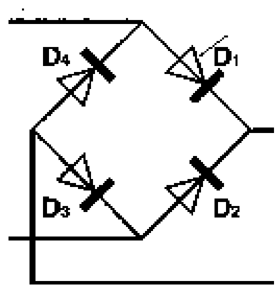
5. **(50 marks)**

(a)

(i) The components represented are the transformer and a rectifier. **4**

(ii) The transformer changes an alternating current into an alternating current at a higher or lower voltage. It consists of an iron core on which two coils of wire are wound. When the primary coil is connected to the electric supply an alternating magnetic field is set up in the iron core. This magnetic field induces an alternating current in the secondary coil. When the secondary coil has a smaller number of turns than the primary coil, the output voltage will be lower than the input voltage but the current will be higher.

The rectifier converts alternating current (AC) to direct current (DC). This is a single phase bridge converter. It uses four diodes during one half cycle of the AC supply, diodes D1 and D3 are conducting. During the next half cycle, diodes D2 and D4 are conducting **5 + 5**



(iii) The main applications of transformers is to step up or down mains voltage. The Rectifier changes AC to DC. **2 + 2**

(b) (i) The electrode coating is a flux which melts and vapourises, the gas produced shields the joint from oxygen in the air. A slag is left on top of the weld bead and protects the weld as it cools.

(ii) Both spot welding and seam welding are based on electrical resistance. Spot welding uses copper electrodes. Pressure is applied and an electric current is passed, the greatest resistance is at the interface and rapid heating results. A nugget of molten metal forms. Common method for joining light gauge sheet metal at different spots.

Seam welding produces continuous welds. One form is referred to as stitch welding which uses a series of overlapping spots. The other method uses rollers instead of electrodes. The rollers allow the workpiece to move through the machine continuosly

(iii) Multi-run welds are superior to single-run welds as each weld run post heats the previous run resulting in more refinement in the materials structure.

(iv) Aluminium self protects itself with an oxide layer. This layer must be penetrated before successful welding can occur. **8 x 3**

(c)

(i) Submerged arc welding is so called because an arc is struck and maintained between a copper-coated bare wire electrode and the workpiece under a blanket of granulated flux. The flux is highly conductive in the molten state and floats to the top to become a protective slag. The welding electrode is fed into the weld area by means of a guide nozzle using two drive rolls.

(ii) Oxyacetylene Welding: This is a fusion welding process. Heat is concentrated on the joint edges until the metal melts and starts to flow. When the molten metal from both of the join edges meets, it fuses. Oxygen and acetylene gas are burned at the tip of a nozzle on the welding torch. Oxidation of the joint faces is prevented by an envelope made up of the products of combustion. A filler metal can be added and is in rod form.

Diagrams = 4
Explanation = 4

(c) Spot welding is most suited to robotic control and is used extensively for welding motor cars. **8**

6. **(50 marks)**

(a)

(i) Stabilisers: help to prevent the degrading effects of heat and ultraviolet light.

(ii) Catalysts: speed up chemical reactions.

(iii) Promoters: Encourage certain chemical reactions to occur with resulting improvements in say flexibility

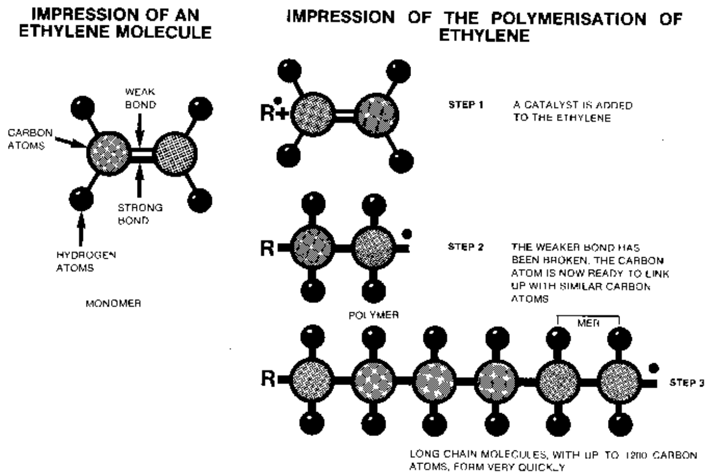
(iv) Inhibitors: Prevent certain chemical combinations from happening or slow down reactions**.** **6 + 6 + 6**

(b)

(i) Compression moulding, Thermosetting Polymers. **3 + 3**

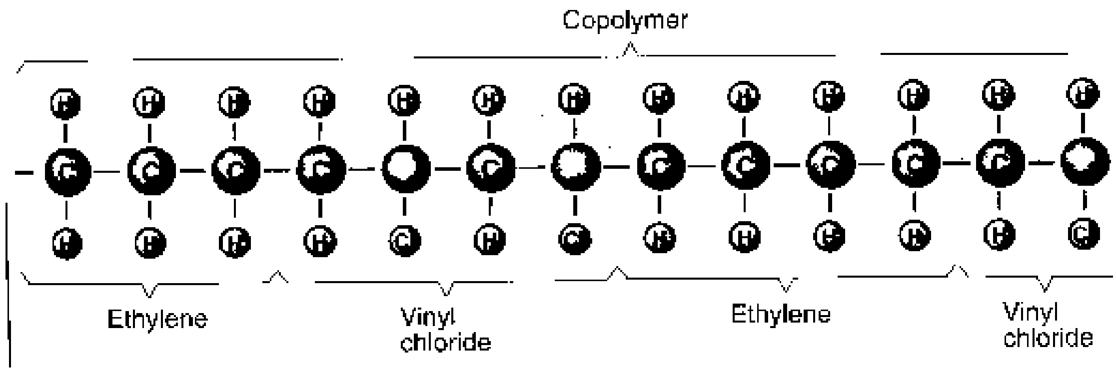
(ii) The polymer is heated and is then forced under pressure into the mould cavity. The cavity in the mould is the required shape of the finished article. A measured amount of the monomer powder is placed in the mould. A punch, which is also shaped like the finished article is forced by a hydraulic ram. The heaters causes the powder to melt and as it sets cross-linking begins to occur. The mould is opened with the aid of guide bars. **6**

(c) Addition polymerisation is the addition of large numbers of mers so that they form into long chains. The formation of polyethylene is a good example.



Copolymerisation: is the process where mers of different kinds are Linked together in the same chain.

An example of Co-polymerisation is Polyvinylchloride Acetate.



10 + 10

7. **(50 marks).**

(a) A:The most appropriate machining process would be milling by means of a tee slot cutter.
B: The dovetail is produced by a dovetail cutter on the milling machine.
C: The tapered barrel is produced by taper turning on the lathe.
D: The hexagonal shape is produced on the milling machine with The dividing head indexing through the correct number of turns.

6 x 4

(b) (i) A wheel becomes loaded when small particles of grit and dust

become trapped in the surface of the wheel. Grinding with a loaded wheel will result in poor cutting and a tendency to overheat and burn.
If worn or dulled abrasive grains fail to break free of the wheel then the wheel has become glazed recognised easily by its shiny appearance. This situation demands immediate dressing with a star wheel dresser.

(ii) Forming utilises tools in the identical shape of the work produced. Generated surfaces are produced by combined movements of Slideways.

(iii) A continuous chip is formed when a ductile metal is machined. Continuous chips tend to become entangled in the work.
A discontinuous chip results when brittle materials are machined. The machining of brass and cast iron produces discontinuous chips.

(iv) Side and face milling cutters have cutting edges on the periphery and on the sides. When three or more of these cutters produce steps and grooves simultaneously, the process is referred to as Gang milling. In straddle milling, two cutters are mounted on the The arbor, so that two surfaces are machined simultaneously.

(v) Direct measurements uses micrometers and vernier calipers as opposed to comparative where gauges like plug and gap, bevel gauges, radius gauges and feeler gauges are used. **6 x 3**

(c) As the shear plane angle is increased (large rake angle) the shear area reduces. **8**

<u>OR</u>

(c) Line 200 rapidly positions the tool to 15mm on the diameter and 1mm out from the end of the workpiece.
Line 210 machines down to 15mm diameter for a length of 20mm, feed rate 75.
Line 220 produces a 5mm chamfer, feed rate 75.
Line 230 positions the tool 10mm from the end of the work and stops the spindle. M02 marks the end of the program. **8**

8. **(50 marks)**

(a) The mechanism at (i) is rack and pinion and may be used in steering mechanisms. The universal coupling is shown at (ii) where drive shafts are not in alignment. **9 + 8**

(b) (i) Heat Pump: The opposite to a refrigerator steals heat from a source and radiates it, leaving the source iced.
(ii) Ratchet Mechanism: Allows wire to be wound tautly on a drum without slippage.

(iii) Flywheel: absorbs all the up and down forces of the pistons and by means of the crankshaft smooths out the forces into a smooth balanced rotary motion.

(iv) Rectifier: Changes Alternating current to Direct current.

(v) A non-return valve: allows a liquid to flow in one direction only.

6 x 3

(c) Two types of locknut devices are shown. The first shows the plain nut and lock nut arrangement to prevent loosening by vibration. The castle or slotted nut can be used in conjunction with a split pin. Wing nuts are tightened or loosened by hand and are quick and easy to use however only suitable when high degrees of tightness is not required. **5 x 3**

<u>OR</u>

(c) The circuit makes use of a BC108 transistor to sense water or damp conditions. In dampness a small current flows through the water. This raises the voltage at the base of the transistor, switching it on and allowing a large current to pass through the LED. In dry conditions The transistor is switched off and hence the LED.
Uses might include a simple moisture sensor or to determine if plants Need **10 + 5.**