Coimisiún na Scrúduithe Stáit
State Examinations Commission

Scéimeanna Marcála	Scrúduithe Ardteistiméireachta, 2007
Innealtóireacht - Ábhair agus Teicneolaíocht	**Ardleibhéal**

Marking Scheme	Leaving Certificate Examination, 2007
Engineering - Materials and Technology	**Higher Level**

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Leaving Certificate Examination, 2007

Engineering – Materials and Technology

(Higher Level – 300 marks)

SAMPLE ANSWERS AND MARKING SCHEME

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

Engineering – Materials and Technology

(Higher Level – 300 marks)

Marking Scheme 2007

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) 5
(c) **Any two** @ 3 + 2
(d) 3 + 2
(e) 3 + 2
(f) **Any one** @ 5
(g) 2 + 2 + 1
(h) **Any two** @ 3 + 2
(i) 5
(j) 5
(k) 3 + 2
(l) **Any one** @ 5
(m) 3 + 2

Question 1 Section B – 50 marks
Answer **all** of the following.

(n) 4 + 3 + 3

(o) (i) 2
(ii) 5
(iii) **Any three** @ 1 + 1 + 1

(p) 5 + 5

(q) (i) 3 + 2
(ii) 5

(r) **Any two** @ 5 + 5

Question 2 – 50 marks

(a) (i) 8 (**Any two** @ 4 + 4)
(ii) 8

(b) (i) 9
(ii) 3 + 3 + 3

(c) (i) 6
(ii) Describe 5
Diagram 5

Question 3 – 50 marks

(a) **Any two** @ 8 + 8

(b) (i) 2 + 2 + 2 + 2
(ii) 4 + 4

(c) (i) Name @ 3 + 3 + 3
Order @ 1
(ii) Outline 4
Diagram 4

Question 4 – 50 marks

(a) **Any two** @ 8 + 8

(b) (i) 9
(ii) 6
(iii) 3

(c) (i) 8
(ii) 8

Question 5 – 50 marks

(a) (i) 15
(ii) 3

(b) **Any three** @ 6 + 6 + 6

(c) **Any one** @ Describe 7
Diagram 7

OR

(c) (i) 4 + 3
(ii) 4 + 3

Question 6 – 50 marks

(a) (i) Name 4
Operation 8
(ii) 4

(b) **Any two** @ 8 + 8

(c) **Any three** @ 6 + 6 + 6

Question 7 – 50 marks

(a) **Any three** @ 6 + 6 + 6

(b) **Any 2** @ 7 + 7

(c) **Any one** @ Describe 9
Diagram 9

OR

(c) **Any three** @ 6 + 6 + 6

Question 8 – 50 marks

(a) **Any one** @ Name 8
Application 8

(b) **Any three** @ 6 + 6 + 6

(c) Describe 8
Diagram 8

OR

(c) (i) Identify @ 2 + 2 + 2 + 2
(ii) 4 + 4

Question1 **(100 Marks)**

Section A – 50 marks

(a) Safety hazards associated with the use of adhesives include:
- Use gloves to avoid contact with skin.
- Apply in a well ventilated area to minimise fumes.
- Avoid inhalation and provide fume extraction.
- Ensure that materials to be joined are adequately supported while the adhesive is curing.
- Wear protective clothing, goggles or face mask.
- Ensure adequate preparation of joining materials. **3 + 2**

(b) The ratio allowed in design between the ultimate stress in a structure and the safe permissible stress in that structure. **5**

(c) **(i)** Casting
(ii) Compression moulding / Injection moulding
(iii) Compression moulding **(Any two) 3 + 2**

(d) **ROM.** Read Only Memory data is fixed at the time of writing and it's contents can be read but not 'written to' or altered by the user.
RAM. Random Access Memory is available for programmes and data, it can be 'read from' and 'written to' by the computer user. **3 + 2**

(e) Metal **creep** is the slow deformation of a metal under a constant load; high temperatures and time are factors that cause creep. Metal **fatigue** can occur when a relatively small load subjects a vibration or cyclical stressing on the metal causing failure. **3 + 2**

(f) **(i)** Push button three port valve.
(ii) Shuttle valve**.** **(Any one) 5**

(g) Recycling.
Incineration.
Reusing.
Landfill. **(Any three) 2 + 2 + 1**

(h) **(i)** unplasticised Poly Vinyl Chloride.
(ii) Integrated circuit.
(iii) Visual display unit.
(iv) Light emitting diode. **(Any two) 3 + 2**

(i) A solvus line dictates the amount of one metal that can dissolve in the second metal of the alloy. **5**

(j) The body centre cubic (BCC) structure is not a close packed arrangement while the face centre cubic structure is close packed, which allows easier activation and movement of atoms across each other. FCC metals are ductile while BCC metals tend to be more brittle**.** **5**

(k) Magnetic properties in magnetic separation.
Specific gravity / weight in gravity concentration.
Differences in surface tension for flotation.
Chemical reaction in amalgamation. **(Any two) 3 + 2**

(l) **(i)** John P. Holland: Irish engineer who invented some of the first submarines.
(ii) Viktor Kaplan: Austrian engineer who invented a water turbine with adjustable blades.
(iii) Eli Whitney: US inventor who patented the cotton gin and then manufactured muskets using power-driven tools to produce interchangeable parts.

(Any one) 5

(m) Name: wire gauge
Application: used to measure the thickness of sheet metal and the diameter of wire. **3 + 2**

Section B – 50 marks

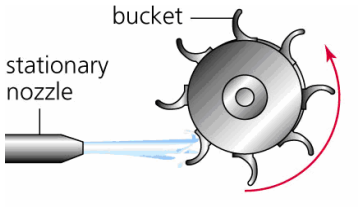
(n) Sources of energy that may include a turbine-based system include:

- Water.
- Wind.
- Gas combustion turbines.
- Steam powered by sources such as geothermal, coal, oil, biomass, etc.
- Fossil fuels. **4 + 3 + 3**

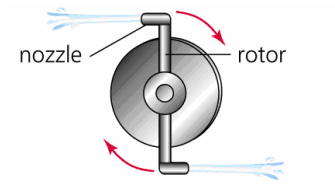
(o) **Name:** Kaplan turbine.
Principle of operation: potential energy, such as water in a reservoir, is stored until the control gate, or valve, is opened. Water flows (kinetic energy) and comes to the turbine, causing them to turn. This rotary movement turns the shaft of an electrical generator.
A – Valve.
B – Turbine blades.
C – Shaft.
D – Generator.

Name 2
Operation 5
Identify parts 1 + 1 + 1

(p) Impulse turbines: jets of water are projected onto the blades of the turbine causing the wheel to rotate. Pelton wheels and de Laval turbines operate on this principle.



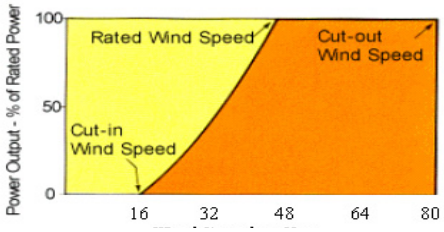
Reaction turbines: jets of water flow from the wheel tangential to its circumference, rather like the action of a water sprinkler. The wheel will then rotate. Francis and Kaplan turbines are reaction turbines.



5 + 5

(q) (i) In **pitch control,** the turbine's controller checks the power output of the turbine regularly. When the power output becomes excessively high, the rotor blades are turned out of the wind. If the wind drops, the blades can be turned back into the wind.
In **stall control,** the turbines are designed to create air turbulence when the wind speed exceeds a specified amount. This turbulence makes the blades less efficient and acts as a brake for the turbine. **3 + 2**

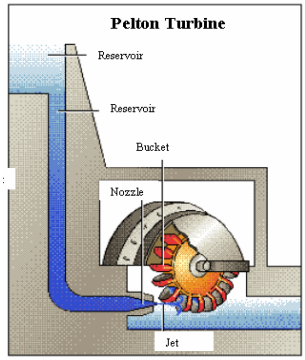
(ii) Wind turbines reach a stage at which they rotate at maximum efficiency. Lower wind speeds produce a sharp drop off in power output and higher wind speeds produce an output that may be less stable. This stage of maximum efficiency is the 'rated wind speed'.



5

(r)(i) Several impellers are turned in a series in a multi-level steam turbine system. Between these impellers are situated idlers, which do not turn. The gas changes direction passing an idler and is directed towards the next impeller. Impellers increase in size due to the expansion of the gas.

(ii) Developed by Lester Pelton around 1870 in California, he took his inspiration from a mining turbine using jets driving a rotating platform with vanes. The invention of the split bucket ensured that the jet always strikes more than one at a time. The conduit bringing the high pressure water to the impulse wheel is called the penstock.



(iii) Some environmental impacts of using renewable sources of energy:

- Wind turbines may be as large as a 20 storey building, creating a visual impact on their location. Sensitive location is important as wind energy is the fastest growing source of generation in the world; it increased at a rate of about 26% each year since the 1990's.
- Some sources, wind and solar, are intermittent sources of power. The use of batteries may need consideration.
- The use of biomass is often linked with a need to grow large tracts of trees for fuel, thus reducing agricultural land. However, household and agricultural waste (straw, corn cobs, etc.) could be used for this purpose.
- Hydro and wind power can have an impact on fish and avian life.
- Noise impact from wind turbines.
- The rise in air quality due to a lessening of pollutants caused by burning of fossil fuels.

(Any two) 5 + 5

Question 2 **(50 marks)**

(a) (i) Mechanical tests are carried out on materials to assess how they might perform when they are put into use. Many of these tests destroy the sample material but are carried out for the following reasons:

- Values for properties such as strength, ductility, hardness, toughness, elasticity, fatigue, creep, etc. can be ascertained;
- Standardisation of components can be achieved;
- Quality control is maintained;
- The success of heat treatments can be measured**.** **(Any two) 4 + 4**

(ii) Both tests involve striking a notched bar with a pendulum from a predetermined height to deliver a specific impact.

Izod Test	**Charpy Test**
167 joules striking energy	300 joules striking energy
Test specimen held vertically	Test specimen held horizontally
Test specimen is clamped at one end	Test specimen is clamped at both ends
Notch on test specimen faces striker	Notch on test specimen faces away from striker

8

(b) (i) The following information can be obtained from a tensile test:

- Youngs Modulus;
- proof or yield stress;
- tensile strength;
- percentage elongation;
- percentage reduction in area;
- properties such as ductility and shear strength can be measured.

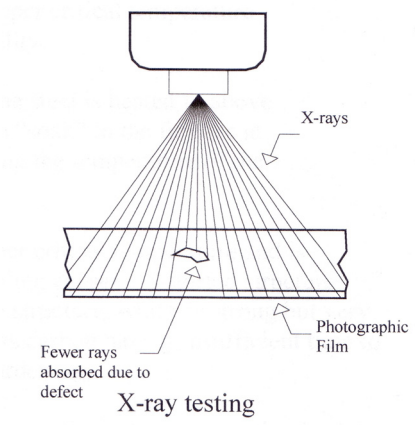
9

(ii) Material A. A small amount of elasticity is exhibited with little ductility. This is a brittle material such as cast iron.
Material B. This material displays good ductility with a definite elastic limit. Low carbon steel exhibits these characteristics.
Material C. This is a very ductile material with stretching over a period with little increase in load. An example is copper. **3 + 3 + 3**

(c) (i) Non-destructive tests are used in the manufacture of engine parts to ensure:

- that these parts can be tested for quality;
- that expensive components need not be destroyed during testing;
- tests can be carried out for flaws at surface level or internally; **6**

(ii) A suitable non-destructive test for assessing welds for internal faults would be **X-ray testing**.



X-ray testing

Radiation from an x-ray tube is passed through the weld. If no defects are present, the amount of absorption is uniform across the area exposed to the x-ray beam. If a defect is present in the weld, a smaller amount of rays is absorbed giving a variation in the intensity of the emergent beam. This can be detected by placing a photographic film on the side of the material opposite the radiation source. On a negative film, the defect shows as a dark spot.

(Describe) 5
(Diagram) 5

Question 3 **(50 marks)**

(a) (i) Methods used to measure furnace temperature include;

- Optical pyrometer
- Thermo-electric pyrometer
- Seger cones.

(ii) Allotopy is the ability of a material to exist in different forms. Allotropy of iron modifies the solubility of carbon which allows some steels to be hardened. The transformation from *alpha iron* (ferrite), which has a bcc crystal structure, to the fcc structure of *gamma iron* (austenite) is the basis for the hardening of steels. Up to 1.7% carbon can be accommodated in gamma iron. When carbon steel is cooled from the austenite state to ferrite, some carbon must come out of solution. A compound of iron and carbon called cementite is formed giving a hardness to carbon steel.

(iii) Annealing is carried out to a metal as soft as possible, it also improves ductility, refines grain size and minimises internal stresses. Annealing essentially involves:
(a) heating slowly to the required temperature,
(b) holding at that temperature for long enough to enable the internal changes to take place and
(c) cooling slowly.
When the temperature is reached the steel is "soaked" to ensure uniform heating and cooling is controlled by reducing the temperature of the furnace gradually. If possible, the object to be annealed is allowed to cool by turning off the furnace making it as soft as possible.

(iv) **Grey cast iron** forms due to slow cooling where carbon is present as graphite flakes. It is soft, weak in tension, casts into intricate shapes and is easy to machine. It has self lubricating and vibration dampening properties making is suitable for casting machine and engine parts.
White cast iron forms under quick cooling conditions. The carbon is present in the form of ferrite and cementite. White cast irons are hard and brittle.

(Any two) 8 + 8

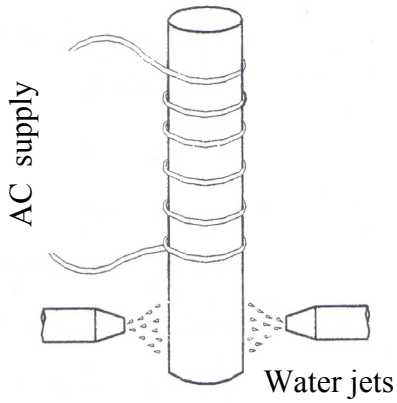
(b) (i) **A** – Liquid
B – Austenite + Liquid
C – Austenite
D – Austenite + Cementite. **(Name) 2 + 2 + 2 + 2**

(ii) **X – Eutectoid point.**
Solid austenite changes to solid pearlite at 723 ^{o}C for the an alloy containing 0.83% carbon. **(Identify & Describe) 2 + 2**
Y – Eutectic point.
A solid to liquid change takes place at 1140 ^{o}C for the alloy with 4.3% carbon. Liquid steel changes to solid austenite and cementite.
(Identify & Describe) 2 + 2

(c) (i) During heat treatment, the metal can be quenched by
- Brine – salt and water mixture for rapid quenching
- Water
- Oil
- Air
- Turn furnace off – slowest form of cooling. **(Name) 3 + 3 + 3**

(Order) 1

(ii) Induction hardening



The steel component is placed inside a coil, which carries a high frequency current. Eddy currents are induced 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. The frequency of the current determines the depth of heating and the depth of hardening. Induction hardening is used on the slideways of a lathe.

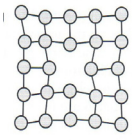
(Outline) 4
(Diagram) 4

Question 4 **(50 marks)**

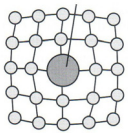
(a) (i) **Crystalline structures** have atoms that are bonded together in a pattern that is repeated. Metals with bcc and fcc unit cells are examples of a crystalline structure.
Amorphous structures do not have a pattern in the arrangement of their atoms but are a more random structure. Pitch, glass and some plastics have this type of structure.

(ii) **Eutectic alloy:** two metals are completely soluble in the liquid state but are insoluble in the solid state. Cadmium/bismuth is an example of a eutectic mixture.
Solid solution alloy: the metals in the alloy are completely soluble in one another. When viewed under a microscope, a solid solution looks like a pure metal. Copper-nickel is an example of this type of alloy.

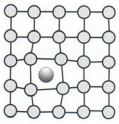
(iii) **Vacancy:** if there is an atom missing from the lattice, the other atoms are forced towards the vacant space.



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.



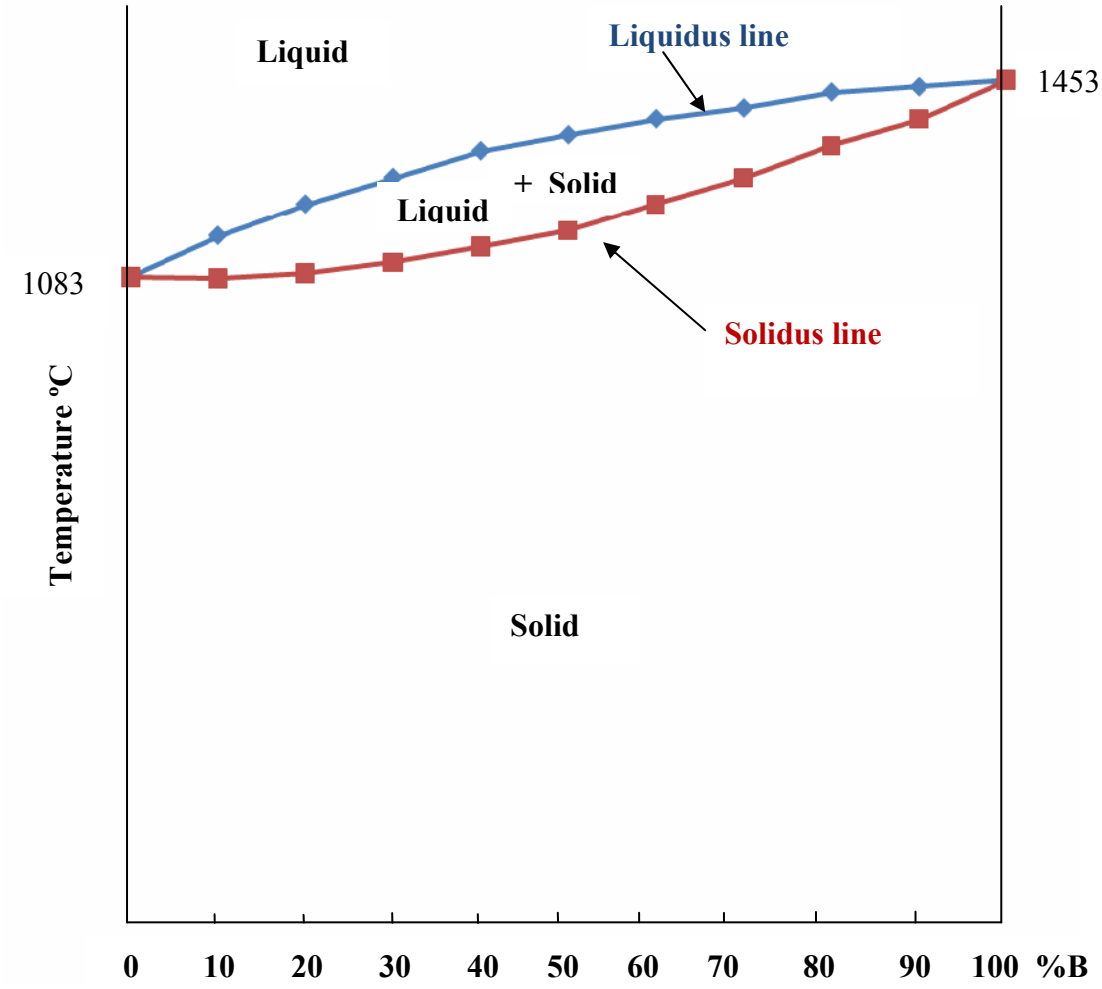
Interstitial: an atom from another element moves into the space between the atoms of the parent metal lattice.



(iv) Age hardening: when the aluminium/copper alloy, duralumin, is quenched from around 375 ^{o}C, it increases in hardness over time at room temperature. The alloy may need to be re-annealed after 4 or 5 days if it needs to be worked on. This occurs due to precipitation of $CuAl_2$.

(Any two) 8 + 8

(b)(i)



(Draw graph) 9

(ii) Liquid: the two metals are soluble in each other in the liquid state.

Liquidus line: the change from fully liquid to pasty state. Above the liquidus line, the alloy is liquid. This is the beginning of solidification.

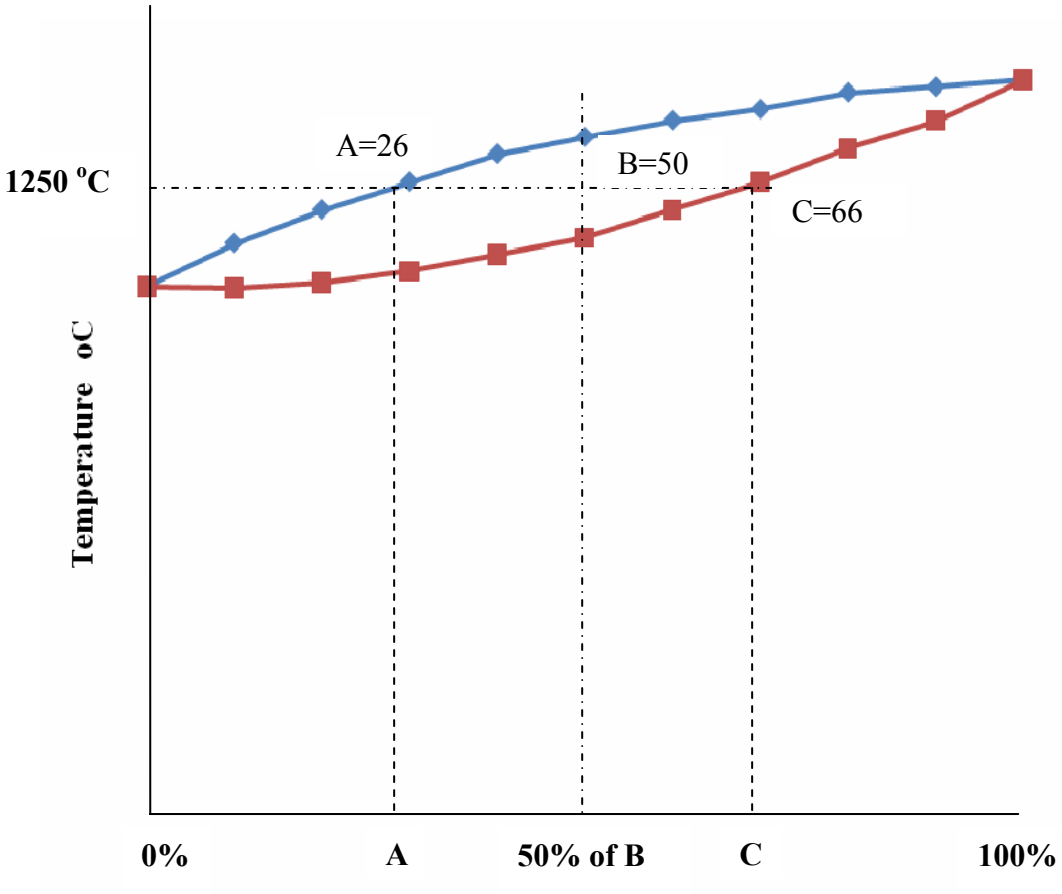
Liquid + solid: the alloy is in a pasty form.

Solidus line: the change from pasty to solid. Below the solidus line, the alloy is cooling and solid. This is the end of solidification.

Solid: alloy is in solid form.

(Any 3 labels) 3
(Any 3 descriptions) 3

(iii)

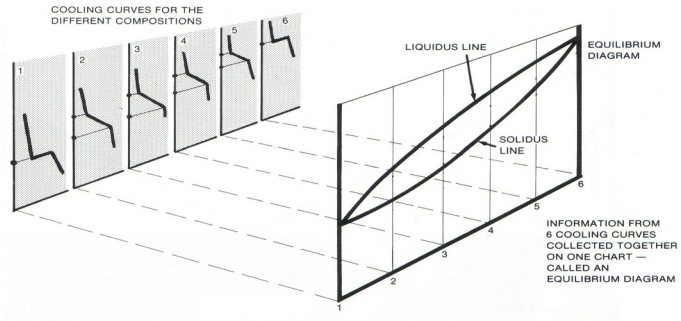


Ratio of phases at 1250°C for 50% B

$$\frac{\text{Mass of solid}}{\text{Mass of liquid}} \text{ is } \frac{50-26}{66-50} = \frac{24}{16} = \frac{3}{2}$$

3

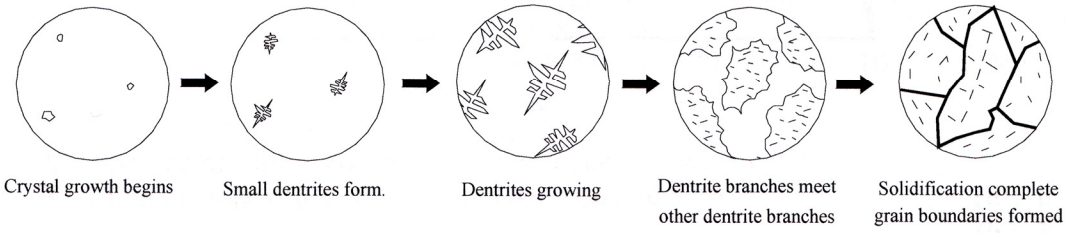
(c) (i) The cooling curve for a combination of metals highlights the start and end of solidification for that particular alloy.



If the information from a range of cooling curves for different combinations of the alloy is collected on one chart, a thermal equilibrium diagram is formed.

8

(ii) The stages of crystal solidification of a metal from the liquid phase are known as dendritic growth. As the metal cools, solidification starts from cells and begin to grow to form a dendrite. These have a tree-like formation with branches reaching out in all directions. Grain boundaries with solid metal crystals are formed.



(Explanation) 4
(Diagram) 4

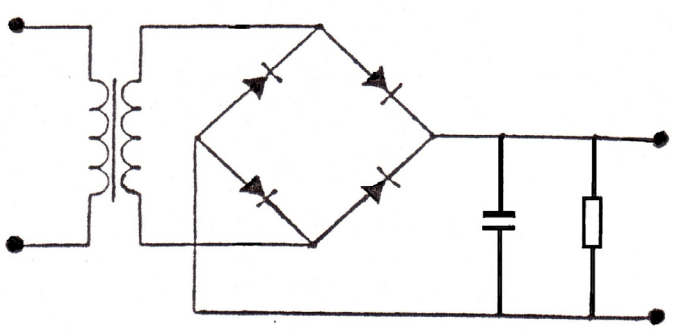
Question 5 **(50 marks)**

(a) (i) 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.

(ii) Applications: used for large scale straight line welds such as steel reinforcing beams, shipbuilding and bridge construction.

(Operation) 15
(Application) 3

(b) (i)



(ii) **A - Step-down transformer.** In this circuit, the transformer takes AC at high voltage and produces AC at a lower voltage. This ensures that the output current will be higher than the input current.
B – Smoothing capacitor. A more uniform direct current is produced by smoothing surges produced by the rectifier.

(iii) Multi-run welds produce a finished weld that is more refined in structure than single run welds. Each run of the weld has a post heating effect on the previous weld.

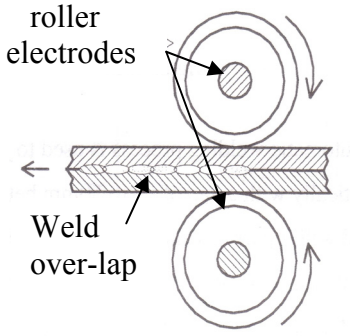
(iv) Safety precautions associated with electric arc welding materials and equipment include:

- Ensure that equipment is well maintained with cables secured and insulated properly to prevent electric shock.
- Materials to be welded need to be cleaned and degreased to minimise fumes while welding. Appropriate ventilation systems should be in place.
- Protective clothing should be worn including leather gloves, apron, etc.
- A good quality welding shield with darkened face plates must be worn to protect the user.
- Appropriate welding curtain or cubicle will ensure that others are not exposed to the UV light emitted from the welding process.
- Ensure that work is appropriately secured.

(Any three) 6 + 6 + 6

(c) (i) **Resistance seam welding**

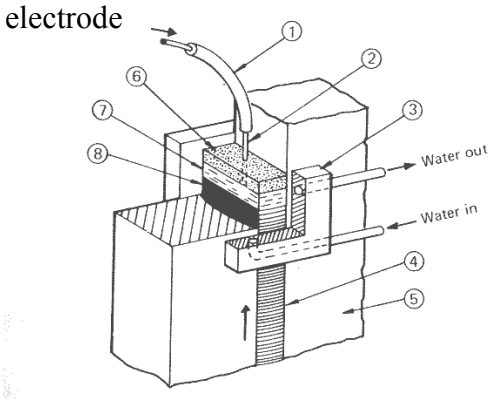
A form of resistance welding that uses copper roller electrodes to provide a continuous run of overlapping spot welds as the current is activated at set intervals. One of the electrodes may be driven by an electric motor.



The workpiece is moved between the rollers and pulses of current are supplied. Each pulse is set to last long enough to produce a spot weld.
The time interval is controlled so that these spots overlap by approx. 40% of their length along the seam.

(ii) Electro-slag welding

Electro-slag welding is automatic welding process used to join thicker plates(5). The gap between the plates to be welded can be quite large as it is filled with molten metal. Water cooled copper shoes(3) prevent this molten metal escaping from the joint. The carriage, shoes and electrode(1) all move together leaving the solidified weld(4) behind.



(Any one) Describe 7
Diagram 7

OR

(c) (i) Advantages of using robots in circuit assembly include:

- Consistent accurate work is produced and repeated.
- Capable of producing intricate work effectively, including ability to work in a number of axes and from multiple axes.
- Cost effective after initial equipment is purchased.
- Circuits are produced quickly.

4 + 3

(ii) Safety factors in robot set-up:

- The base of the robot must be secured anchored to the floor.
- Ensure the working envelope (volume of space) is of adequate size to perform assigned tasks.
- A robotic welding facility will produce intense light, heat and fumes which may not be of danger to the robot but must be deemed a hazard to people working in the area. Proper shielding and ventilation will be needed.

4 + 3

Question 6 **(50 marks)**

(a) (i) **Name:** Compression moulding.
Operation: This process is suitable for thermosetting plastics. It uses a split mould formed to the shape of the object to be moulded. The combination of heat and pressure allows a measured amount of polymer to be shaped. The polymer can be in powder or 'slug' form. As the mould closes, the application of heat triggers the chemical reaction of 'cross-linking' and the object sets (curing). The mould is opened and the object is removed. These mouldings can have a high quality finish requiring only the removal of 'flash'.

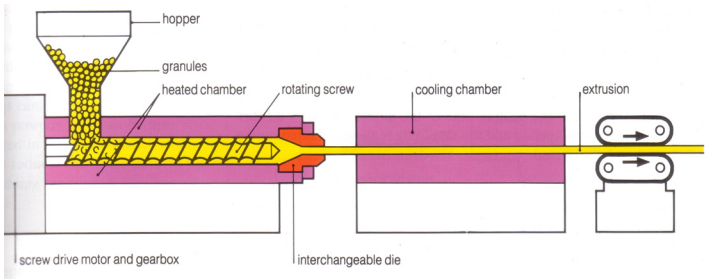
(Name) 4
(Operation) 8

(ii) Electrical fittings (plugs and sockets), saucepan and cutlery handles, bottle tops, etc. are formed by compression moulding. **4**

(b) (i) **Pigments** have the function of giving colour to the polymer.
(ii) **Plasticisers** are added to polymers to improve their flexibility. They achieve this by altering the forces of attraction between molecules of the polymer.
(iii) **Lubricants** make the polymer easier to mould. Various types of waxes are used in small amounts for this purpose. **(Any two) 8 + 8**

(c) (i) **Condensation polymerisation:** Used to produce many thermosetting plastics, condensation polymerisation forms a strong primary bond with cross-links between chains. Two monomers react chemically to form a new molecule with water eliminated as a by-product. This has the effect of producing a cross-linked structure with strong primary bonds. The polymer produced cannot be re-softened, has a high tensile strength and a high melting point. Phenol formaldehyde is an example.

(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. Polythene, PVC and nylon are commonly extruded.

(iii) Elastomers: A group of polymers consisting of linear chains that are coiled, entangled and are subject to minimal cross-linking. This irregular internal structure and bonding arrangement allows these materials to be very elastic at room temperature.

(iv) Van der Waals forces: These are the bonding forces between polymer chains produced by addition polymerisation. They are weak, secondary covalent bonds that may be disrupted by heat or pressure.

(iv) Monomer: This is a molecule of a compound which can react with other molecules to form a polymer.

(Any three) 6 + 6 + 6

Question 7 **(50 marks)**

(a) (i) A centre lathe must incorporate features such as:

- Moving parts must be guarded.
- Stopping controls are to be prominent and accessible.
- A braking system that will stop the chuck quickly.
- Minimal vibration due to robust construction.

(ii) Cutting fluids are used to:

- Wash away cutting chips.
- Keep the cutting tool cool.
- Reduce friction between cutting tool and workpiece.
- Prolong tool life.
- Improve surface finish.

(iii) Small blocks of alloy steel or tungsten carbide that are manufactured in a variety of precise sizes. Slip gauges can be stacked to a specific size. The surface finish is smooth enough for the gauges to wring together. They can be used to check for accuracy or calibrate instruments.

(iv) Orthogonal cutting has two forces, the tangential and axial force acting on the cutting tool.
Oblique cutting consists of a three force system. The radial force is caused by the plan approach angle on the cutting tool. As the radial force increases, the axial force decreases**.**

(v) Forming is when the surface produced is a copy of the tool producing it. Contour work and screwcutting are examples of forming.
Generating moves the tool in various directions until the required surface is machined. Facing and taper turning on the lathe are examples of machining by generation.

(Any three) 6 + 6 + 6

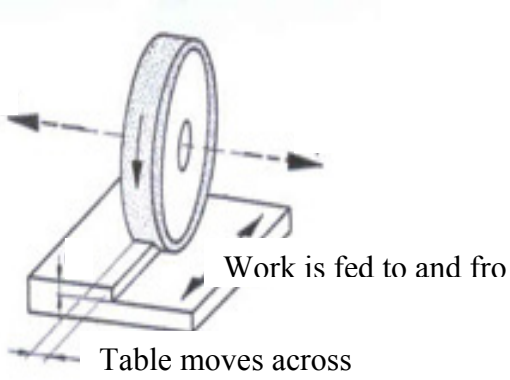
(b) (i) **Dovetail cutter** is used to machine dovetail slides on machine slideways.

(ii) **End mills** have cutting edges along their length as well as on their end and are used to cut flat surfaces and milling slots from the edge of a workpiece.

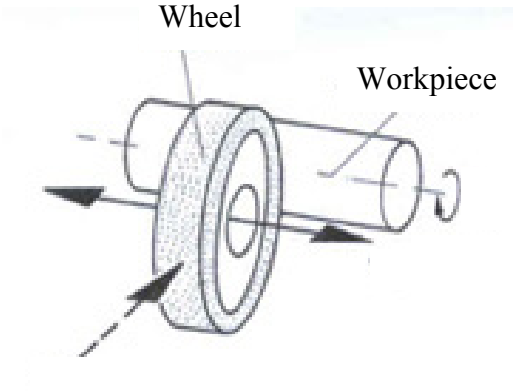
(iii) **Tee-slot cutter** is designed for milling tee slots in machine tables.

(Any two) 7 + 7

(c) (i) **Surface grinding:** A metal cutting process in which flat and extremely smooth surfaces are produced. The grinding wheel rotates and the workpiece, usually held in a magnetic chuck, is fed to and fro continuously. At the end of each stroke, the table is moved across the wheel by a small amount. The grinding wheel can be lowered to take a new cut.



(ii) **Cylinderical grinding:** This is used to produce cylindrical objects. The workpiece is held in a chuck, or between centres, and set to rotate. Then a grinding wheel, when brought into contact with the workpiece, will produce a smooth accurate cylinder. Long workpieces can be ground as the table can reciprocate and the wheel head can move towards the workpiece. Tapered work can also be carried out.



(Any one) Describe 9
Diagram 9

OR

(c) (i) **Safety features** include:

- Large clear guard encloses machining.
- Machine will not run when guard is not in place.
- Emergency stop on the front of the machine.
- Programme must have test run before machining.

(ii) Canned cycle enables a series of repetitive operations to be executed by a single programme block.

(iii) G00 is a code to inform to move as quickly as possible as the machine is not involved in a cutting operation.

(iv) Tool park position is the place where the tool is set in order to start a machining operation.

(Any three) 6 + 6 + 6

Question 8 **(50 marks)**

(a) (i) Rack and pinion converts rotary motion to linear motion. As the pinion rotates, the gear teeth mesh with those on the rack. This allows the rack to be moved in a line. Applications of the rack and pinion include raising and lowering the table of a pillar drill and steering in a car.

(ii) Worm and worm wheel transmit motion at right angles. For every complete turn of the worm shaft, the worm wheel advances only one tooth of its gear. Worm and wheels are commonly used to reduce the speed of electric motors.

(Any one) Name 8
Application 8

(b) (i) Idler gears are inserted between two other gears with the purpose of changing the direction of gear rotation. Idler gears do not have an influence on the gear ratio of the system. They allow the input gear and output gear shafts to rotate in the same direction.

(ii) Universal joint allows one shaft to drive another shaft when their axes are not in line.

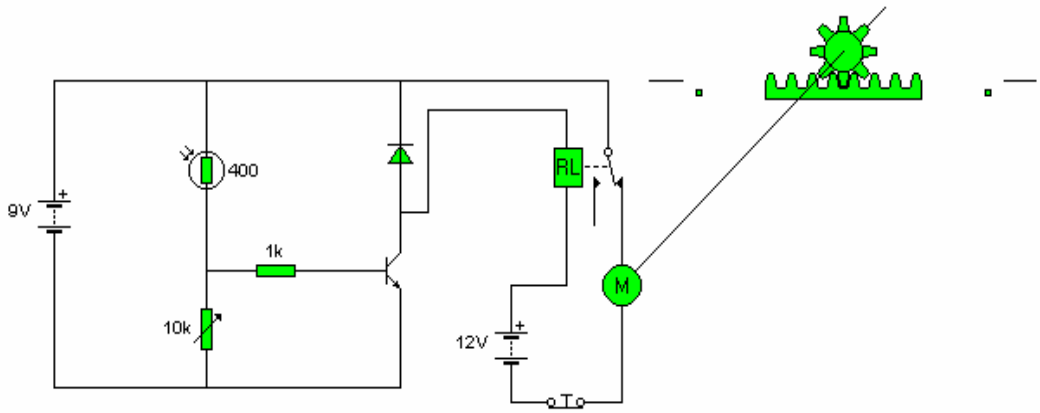
(iii) A **solenoid** is a device where a coil of wire wound on a soft iron core is energised. The magnetic force induced by the current pulls the bar into its centre. When the current is switched off, the bar will return to its original position.

(iv) Pneumatic flow regulator restricts, or regulates, the flow of air in one direction only in a pneumatic circuit.

(v) Solar panels are used to harness energy from the sun and use it to generate electrical energy or to provide hot water and heating for buildings.

(Any three) 6 + 6 + 6

(c) A number of suitable mechanisms for opening a door automatically are possible including rack and pinion, linkages, crank and slider, pulleys, pneumatic control, etc.
A simple suggested solution is to use a rack and pinion mechanism to automate a sliding door.



The motor driving the pinion is driven by the low voltage circuit. When light flow to the light dependent resistor is interrupted, by a person arriving at the doorway, the resistance is reduced. The transistor is activated switching on the relay. The motor circuit is then switched on causing the pinion to move the rack and open the door. The push-to-break switch will prevent the pinion running off the rack.

(Description) 8
(Diagram) 8

OR

(d) (i) A – Light bulb.
B – Transistor.
C – Capacitor (polarised).
D – Resistor.

2 + 2 + 2 + 2

(ii) The transistor will act as an electronic switch, turning the bulb on when it is activated. It will also turn the bulb off when current to the base leg of the transistor is removed.
The capacitor will gather, store and release electrical energy. In this circuit, the size of the capacitor will determine how long the bulbs stay on for.

4 + 4