MARKING GUIDE (MOCK 2026)

5130, Materials Technology and Workshop Processes (Paper 1 & 2)

Subject code: 7130 (Materials Techno. and Work. Proc. 1)																	
Question N°	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Answer	C	A	D	C	D	D	B	B	A	B	B	C	C	B	D	C	A
Question N°	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Answer	A	C	B	D	C	C	A	C	A	D	C	A	B	D	A	C	D
Question N°	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	
Answer	A	A	A	D	C	D	B	B	C	D	D	A	B	D	C	B	

Subject code: 5130 (Materials Technology and Workshop Processes 2)

Question 1: PROPERTIES OF METALS

a- Define the following as regards properties of metals. (0.5mark x 4 = 2 marks)

- Hardness: It's simply the ability of a material to resist penetration or indentation by other hard bodies.
- Strength: It's simply the resistance to the change of the form and breaking of a material.
- Ductility: It's the property of a material enabling it to be drawn into a wire with the application of a tensile Force.
- Hardness: It's the property of a material of breaking of a material with little permanent distortion.

b- Differentiate between physical properties of metals and mechanical properties and give two (02) examples on each case. (3 marks)

Physical properties of metals are those properties that you able to observe with your naked eyes;
Examples: color, size, shape.
While **Mechanical properties** of metal are those which are associated with the ability of the material to resist mechanical forces and load. Examples: strength, ductility, brittleness, etc…

c- The hardness of a metal can be determined by using a series of tests. Name three (03) of them. (1 x 3 = 3 marks)
- Brinell hardness test; - Rockwell hardness test; - Vickers hardness test also called diamond pyramid test;
- Knock hardness test; - Durometer test; - Durability test.

d- The selection of a paper material for engineering purposes is one of the most difficult problems for the designers. State three (03) factors that should be considered while selecting engineering materials. (1mark x 3 = 3 marks)
- Availability of the materials; - Suitability of the material for the working conditions in service;
- The cost of the material.

Question 2: MELTING FURNACES

Figure 1 below represents a type of furnace used in the production of cast iron.

a- Identify the type of furnace below. (1 mark)
Cupola furnace.

b- Briefly explain what happens in the following zones. (1 mark x 3 = 3 marks)

- Reduction zone: Also called protective zone, CO_2 is changed to CO. Temperature falls to about 1200°C at The top of this zone. $CO_2 + C$ (coke) $\longrightarrow$ $2CO$ + Heat.
- Melting zone: The metal charge starts melting and drops down through the coke bed and is collected in the well. $3F_e + 2CO$ $F_{e3}C + CO_2$
- Preheating zone: The charge is preheated from room temperature to about 1090°C before it enters the melting zone.

c- Give the name of zone 4. Which are the exothermic (heat releasing) reactions that take place in this zone? (2 marks)

Zone 4 is combustion zone.
Reactions that take place are: $C + O_2 \longrightarrow CO_2 + Heat;$
$S_i + O_2 \longrightarrow S_iO_2 + Heat;$
$2M_n + O_2 \longrightarrow 2MnO + Heat;$

d- Name two (02) properties of cast iron. (0.5mark x 2 = 1 mark)
- Very brittle and weak in tension; - High compressive strength; -High wear resistance.

e- Complete the table below. (0.5mark x 6 = 3 marks)

Type of cast iron	Percentage of carbon	One application (use) in the vehicle
Grey cast iron	2.5 to 3.8%	Piston rings; cylinder blocs.
Malleable cast iron	2.16 to 2.9%	Differential cases; bearing caps; steering gear housing.
White cast iron	3.2 to 3.6%	Car rim; flanges; pump or impeller.
Spheroidal graphite cast iron	3.2 to 4.2%	Wheels, crankshafts; connecting rod.

Question 3: HEAT TREATMENT OF METALS AND ALLOYS

a- Define heat treatment. (0.75 mark)
It is a controlled process of using heat, soaking and cooling at various staged levels to change or alter the mechanical properties (microstructure) of metals and alloys.

b- Give any three (03) reasons or objectives for carrying out heat treatment on metals. (1.5 mark)
- To help increase their resistance to wear (hardness);
- To help in relieving internal stresses that were induced in the metal or alloy during hot or cold rolling operations.
- To help to improve on their in-built mechanical properties such as their ductility, tensile strength, toughness, malleability, etc…
Others include: - To help improve on their shock resistance abilities; - To help improve on their weld ability;
- To help improve on their machinability; - To help increase on their resistance to heat and corrosion.

c- State precisely the objectives or purposes of the following heat treatment processes on steel. (1mark x 3 = 3 marks)
- Case hardening: Its goal is to render the surface of a metal or an alloy substantially harder than its inner core.
- Annealing: It's carried out on metals for the following reasons: - To reduce their hardness and brittleness;
  - To soften the metal and improve on its machinability or formability;
  - To recrystallize cold-worked (strain-hardened) metals;
  - To relieve residual stresses that were induced by previous processes.
- Tempering: It's a heat treatment process that's applied on hardened steels so as to reduce brittleness, increase ductility and toughness as well as relieve stresses in the steel's martensite structure.

d- Hardening.
i) Name any three (03) methods of carrying out surface hardening on carbon steels. (0.25mark x 3 = 0.75 mark)
- By using a flame (flame hardening); - By induction method (induction hardening); - By nitriding;
- By high-frequency (HF) resistance method; - By carburizing; - etc…

ii) Cite four (04) vehicle components that are subjected to a hardening heat treatment process. (2 marks)
- Gearbox and axle gears; - Valve stems and valve face;
- Crankshaft main journals and crank pins; - Steering ball joints/sockets.
Others include: - Balls, roller, needles of shaft support and wheel hub bearings; - Connecting rods;
- Camshaft (cam lobes), gear selector forks, etc...

e- Carburizing.
i) Define carburizing. (0.5 mark)
It's a surface-hardening heat treatment process whereby a part of low carbon steel is heated in the presence of a carbon-rich atmosphere or environment so that carbon is diffused into the steel's surface that rendering it harder than its inner core.

ii) Name any two (02) methods of carburizing. (0.25mark x 2 = 0.5 mark)
- By surrounding the low-carbon steel with carbonaceous materials such as charcoal or coke packed in a close container with the parts (pack carburizing);
- By using gas (application of hydrocarbon fuels such as propane (C_3H_8) inside a sealed furnace so that carbon can be diffused into the low-carbon steel's surface).

f- What are the differences between nitriding and carbonitriding (or cyaniding)? (1 mark)
Nitriding is a heat treatment process in which nitrogen is diffused into the surfaces of special alloy steels in order to produce a thin hard casing without quenching meanwhile Carbonitriding is a type of heat treatment process in which both carbon and nitrogen are absorbed into the steel's surface as it's heated in a furnace containing both carbon (C) and ammonia.

Question 4: COMPOSITE AND ORGANIC POLYMERS

a- What is a semiconductor? Name two (02) materials used in manufacturing semiconductors. (0.5mark x3= 1.5 mark)
A semiconductor is a solid material which allow electrons to flow through it but it neither a conductor nor an insulator. Material of conductor: Silicon, Germanium, Arsenic, Sulphur, etc…

b- State four (04) properties of a plastic materials. (0.5mark x 4 = 2 marks)
- Light in weight, tough, strength, rigidity; - Less brittle than glass; - Corrosion resistance;
- Good insulator; - Low moisture absorption; -Easily molded; - Easily colour.

c- What is the difference between thermoplastics and thermo-setting? (2 marks)
Thermoplastics are plastics which can easily be softened again and again by heating while Thermo-setting are hardened by heat, effecting a non- reversible chemical charge.
Thermoplastic is recyclable while Thermo-setting is nor recyclable.

d- Give three (03) characteristics each of thermoplastic and thermo-setting. (0.25mark x 6 = 1.5 mark)

Thermoplastic	Thermo-setting
- Soften by heat; - Soft and less strong; - Cannot be used where high temperature is needed; - It's a granular material; Application: toys, lands, toilet goods, insulator, tubs.	- When set are not soften by heat; - Strong and harder; - It can be used where high temperature is needed; - Monomeric or partially polymerized material; Application: electrical plug, TV, camera, circuit breaker.

e- Cite three ways in which thermoplastics can be joined together. (0.5mark x 3 = 1.5 mark)
Thermoplastics are joined together by: - Solvent; - Cement; - Adhesive bonding;
- Welding; - Mechanical fastener.

f- Name three (03) parts in automobile made from composite materials. (0.5mark x 3 = 1.5 mark)
- Clutch disc; - Windscreen; - Face band; - Fuel tank; - Bumpers; - Floor carpets.

Question 5: WELDING

a- Explain the following welding processes:
i) Forge welding process. (0.5 mark)
In this process, the work-pieces are heated to the plastic condition (above 1000°C) and then placed together and while hot.

ii) Friction welding. (0.5 mark)
In this process, the heat for welding is obtained from mechanically induced sliding motion between rubbing surfaces of work-pieces.

b- Give two (02) causes each on the following detects:
i) Lack of penetration. (0.5mark x 2 = 1 mark)
- Inadequate current; - Slogging; - Incorrect edge penetration; - Incorrect welding technique.

ii) Lack of fusion. (0.5mark x 2 = 1 mark)
- Too fast a travel; - Incorrect technique; - Insufficient heat.

iii) Porosity. (0.5mark x 2 = 1 mark)
- Chemical in the metal; - Dampness; - Too rapid cooling of the weld.

c- Name the following parts 1, 2, 3, 4 and 5 in figure 2 above. (0.25mark x 5 = 1.25 mark)

N°	Name	N°	Name
1	Welding torch	4	Base
2	Welding rod or filler rod	5	Solidified weld metal.
3	Molten weld metal		

d- Why is part 2 in figure 2 above necessary in the welding process? (0.5 mark)
- Part 2 is used to build up the seam slightly for greater strength; - To fill the welding gap.

e- Why is flux necessary in welding? (1 mark)
Fluxes are used in welding to remove oxide film and maintain a clean surface.

f- Briefly explain the process of Arc welding and Oxy-acetylene welding process in two lines. (2 marks)
Arc welding uses electric arc to melt and fuse together edges of the parts through an electrode. Gas welding uses heat of combustion of air/gas acetylene to melt or fuse parts together.

g- Which of the above welding process is best used in automobile bodyworks maintenance and why? (1.25 mark)
The gas welding is mostly used on automobile bodywork because thickness of the body is less than 5mm.
It creates a strong and durable bonnet.

SECTION B
PROFESSIONAL CALCULATION AND SCIENCE
(Answer any TWO questions from this section)

Question 6: STRENGTH OF MATERIAL

A rod of 2m long supports a force of 5000N. The rod is in steel for which $R_{Pe} = 100N/mm^2$ and $E = 2 \times 10^5 N/mm^2$.

a- Determine the minimum diameter of the rod. (3 marks)

$G \leq RPe$ $\quad \frac{F}{A} \leq RPe$ $\quad$ with $\quad A = \pi d^2/4$

$\frac{4F}{\pi d2} \leq RPe$ $\quad d^2 \geq \frac{4F}{\pi RPe}$ $\quad d \geq \sqrt{\frac{4F}{\pi RPe}} = \sqrt{\frac{4x5000}{3.14x100}}$

$d \geq \sqrt{\frac{20000}{314}}$ $\quad d \geq \sqrt{63.69}$ $\quad d \geq 7.9$ mm $\quad$ **$d = 8$ mm**

b- Its change in length caused by the force. (3 marks)

$\Delta_L = \frac{FL}{EA}$ with $L = 2m = 2000mm$ and $A = \pi d^2/4 = 3.14 \times 64/4 = 3.14 \times 16 = 50.24mm^2$.

$\Delta_L = \frac{5000\ x\ 2000}{200000 \times 50.24} = \frac{100}{100.48} = 0.99mm$ $\quad$ **$\Delta_L = 0.99$ mm**

c- Deduce the stress rod is undergoing. (2 marks)

$G = \frac{F}{A}$ with $A = \pi d^2/4 = 3.14 \times 64/4 = 3.14 \times 16 = 50.24mm^2$

$G = \frac{5000}{50.24} = 99.52\ N/mm^2$ $\quad$ **$G = 99.52\ N/mm^2$**

d- Check if the condition of resistance is verified. (2 marks)
Since $G \leq RPe$ is condition of resistance, we know that $99.52 \leq 100$; hence it's verified.

Question 7: BASIC MECHANICS

After constructing a tank with the following internal dimensions: length 8m, width 5m, height 2m and the weight of the tank is 500N. The tank is filled with petrol having a density $\rho = 8.8kg/m^3$. Four supports of diameter 32mm each and length of 1600mm. Calculate:

a- The volume of the tank. (2 marks)

V = LWh V = 8 x 5 x 2 = 80 m^3 **V = 80 m^3**

b- The capacity of the tank. (2 marks)

1m^3 = 1000liters C = 80 x 1000 = 80000L **C = 80000 Liters**

c- Mass of the fuel in the tank when full. (2 marks)

$\varphi = \frac{M}{V}$ M = φ.V M = 8.8 x 80 = 528 Kg **M = 704 Kg**

d- The total weight needed to be supported by a constructed steel support. (2 marks)

Total weight = weight of fuel + weight of tank with weight of fuel = M.g and weight of tank = 500N

Total weight = (704 x 9.81) + 500 = 6906.24 + 500 = 7406.24 N **T = 7406.24 N**

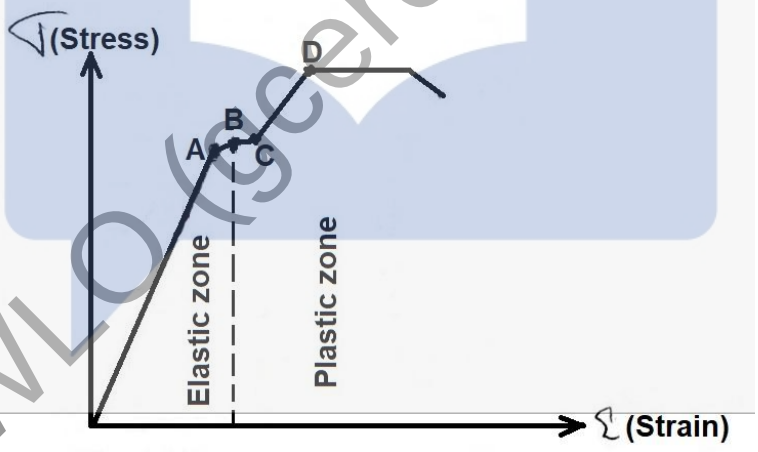
e- The tensile stress of the steel support when carrying the tank full of fuel. (2 marks)

$\delta = \frac{F}{A}$ with F = Total weight and A = π d^2/4 = 3.14 x 1024/4 = 803.84mm^2

$\delta = \frac{7406.24}{803.84} = 9.21 N/mm^2$ **$\delta = 9.21 N/mm^2$**

Question 8: STRESS AND STRAIN

a- Draw the stress/strain graph and indicate the elastic zone. (2 marks)



b- The connecting rod is subjected to a tensile force of 900N, with a diameter of 80mm and the increased length of 28mm due to the tensile strength. Density of the rod ρ = 89kg/m^3, young modulus 3500MPa.
Calculate:

i) Tensile stress. (1 mark)

$\delta = \frac{F}{A}$ with A = π d^2/4 = 3.14 x 80 x 80/4 = 5024 mm^2

$\delta = \frac{900}{5024} = 0.179 N/mm^2$ **$\delta = 0.179 N/mm^2 = 179140.12 N/m^2 = 179140.12 Pa$**

ii) Strain. (1 mark)

$\varepsilon = \frac{\delta}{E}$ $\varepsilon = \frac{0.179 MPa}{3500 MPa} = \frac{0.179}{3500} = 5.11 \times 10^{-5}$ **$\varepsilon = 5.11 \times 10^{-5}$**

iii) Length of the rod. (2 marks)

$\varepsilon = \frac{\Delta L}{L}$ $L = \frac{\Delta L}{\varepsilon}$ $L = 28/5.11 \times 10^{-5} = 5.479 \times 10^{5}$mm

$L = 5.479 \times 10^{5}$mm = 547.9 m

iv) Volume of the rod when being stressed. (2 marks)

$V = (L + \Delta L).A$ with $A = \pi d^2/4 = 3.14 \times 80 \times 80/4 = 5024$ mm^2

$V = (5.479 \times 10^5 + 28) \times 5024 = 2.753 \times 10^9$ mm^3 **$V = 2.753 \times 10^9$ mm^3 = 2.753 m^3**

v) Mass of the rod when being stressed. (2 marks)

$\varphi = \frac{M}{V}$ $M = \varphi.V$ $M = 2.753 \times 10^9 \times 89 = 528$ Kg **$M = 2.45 \times 10^{11}$ Kg**