AQA

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

Level 3 Technical Level Engineering
MATERIALS TECHNOLOGY AND SCIENCE

Unit F/506/5952

Monday 19 June 2017 Afternoon Time allowed: 1 hour 45 minutes

Materials
For this paper you must have:
- pens
- pencils
- simple drawing instruments
- scientific calculator (non-programmable).

Instructions
- Answer all questions on the paper.
- Do not write outside the box around each page or on blank pages.
- Answer to 3 significant figures unless otherwise instructed.

Information
- There are 80 marks available on this paper.

Advice
Do not spend too long on one question. Read all questions thoroughly before starting your answer.

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
TOTAL	

Formula Sheet

Area of a circle $A = \pi r^2$ or $A = \frac{\pi D^2}{4}$	Density $\rho = \frac{m}{V}$
Stress $\sigma = \frac{F}{A}$	Strain $\varepsilon = \frac{\delta L}{L}$
Angular measure $360^\circ \equiv 2\pi$ radians	Newton's second law $F = ma$
Trigonometry $\sin = \frac{opp}{hyp}$, $\cos = \frac{adj}{hyp}$ and $\tan = \frac{opp}{adj}$	Young's modulus $E = \frac{\sigma}{\varepsilon}$
Ohm's law $V = IR$	Electrical power $P = VI$, $P = I^2R$ and $P = \frac{V^2}{R}$
Resistance in series $R_{total} = R_1 + R_2 + R_3$	Resistance in parallel $R_{total} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ .... Two resistors in parallel $R_{total} = \frac{R_1 R_2}{R_1 + R_2}$
Straight line graph $y = mx + c$	Energy $PE = mgh$ and $KE = \frac{mv^2}{2}$
Frequency $f = \frac{1}{T}$ and $f = \frac{\omega}{2\pi}$	Boyle's law $P_1V_1 = P_2V_2$
Charles' law $\frac{V_1}{T_2} = \frac{V_2}{T_2}$	The combined gas laws $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$
The equation of state $\frac{PV}{T} = mR$	The pressure law $\frac{P_1}{T_1} = \frac{P_2}{T_2}$
Torque $T = Fr$	Gear ratio (2 gears) $R = \frac{\omega_{in}}{\omega_{out}} = \frac{N_{out}}{N_{in}}$
Friction $F = \mu N$	Efficiency $\eta = \frac{\text{Output}}{\text{Input}}$ and $\eta_{\%} = \frac{\text{Output}}{\text{Input}} \times 100$
Conversion from bar to Pascal's: $bar \times 101 \times 10^3$ N m^{-2}	The gravitation constant $g = 9.81$ m s^{-2}

Section A

Answer **all** questions in this section.

In the multiple choice questions, only **one** answer per question is allowed.

For each answer completely fill in the circle alongside the appropriate answer.

CORRECT METHOD 

WRONG METHODS 

If you want to change your answer you must cross out your original answer as shown. 

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown. 

0 1 Malleability is the property of a material that allows it to be

A cast into complex shapes easily. ⬭

B beaten into thin sheets. ⬭

C used in a marine environment. ⬭

D welded. ⬭

[1 mark]

0 2 Ductility can best be described as the ability to

A be drawn into long thin wires. ⬭

B withstand heavy loads. ⬭

C withstand high temperatures. ⬭

D be corrosion resistant. ⬭

[1 mark]

0 3 Toughness is best described as

A the ability to resist the corrosive effects of seawater. ○

B the ability to withstand high electrical current. ○

C the ability to withstand scratching. ○

D the ability to withstand the propagation of cracks. ○

[1 mark]

0 4 Hardness is a material's ability to resist

A compressive loading. ○

B repeated hammering. ○

C scratches and abrasions. ○

D tensile loading. ○

[1 mark]

0 5 A material with a low thermal expansion coefficient will

A melt at low temperature. ○

B melt at high temperature. ○

C expand least at high temperature. ○

D expand most at high temperature. ○

[1 mark]

0 6 A material that is low density will give rise to

A high unit weight. ○

B low unit weight. ○

C low unit strength. ○

D high unit strength. ○

[1 mark]

0 7 High tensile strength allows a material to resist being

A twisted. ⬭

B bent. ⬭

C rolled. ⬭

D pulled apart. ⬭

[1 mark]

0 8 Electrical conductivity relies on which material property?

A electrical power ⬭

B resistivity ⬭

C voltage ⬭

D current ⬭

[1 mark]

0 9 Which **one** of the materials listed below has the best corrosion resistance in a sea water environment?

A stainless steel ⬭

B brass ⬭

C low carbon steel ⬭

D medium carbon steel ⬭

[1 mark]

1 0 Compressive strength is measured in units of

A kilograms. ⬭

B N/m. ⬭

C joules. ⬭

D N/m^2. ⬭

[1 mark]

1 1 . 1 Complete **Table 1** below for each material. Carbon Fibre Reinforced Plastic (CFRP) has been completed for you as an example.

Table 1

Material	Class	Example use
Carbon Fibre Reinforced Plastic (CFRP)	Composite	Bicycle frame, fishing rod, car body panel, etc
Stainless Steel		
Rubber		
Tungsten Carbide		

[6 marks]

1 1 . 2 The fuselage (**Figure 1**) of a commercial airliner can be manufactured from which material?

[2 marks]

Figure 1

1 1 . 3 Give **two** reasons why this material is used.

[2 marks]

Reason 1: _____

_____

Reason 2: _____

_____

10

1 2 . 1 Describe how high carbon steel can be hardened enough to make a metal cutting tool.

[4 marks]

_____

_____

_____

_____

_____

_____

_____

_____

Question 12 continues on the next page

1 2 . 2 Brittleness is one unwanted property that is a direct result of the hardening process. Name a heat treatment process that will reduce its effects.

[1 mark]

1 2 . 3 Name the class of material that polyethylene belongs to.

[1 mark]

1 2 . 4 Provide a sketch of the monomer for polyethylene in the space provided.

[2 marks]

Sketch here

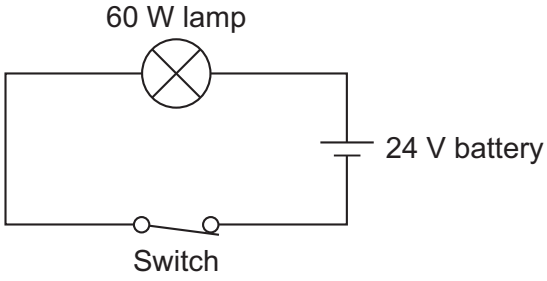
1 2 . 5 Describe the process of polymerisation.

[2 marks]

10

1 3 The electrical circuit, in **Figure 2**, shows a simple electrical lighting system.

Figure 2



1 3 . 1 Determine the current flowing in the circuit, showing the correct units in your answer.

[5 marks]

Question 13 continues on the next page

1 3 . 2 Calculate the resistance of the lamp, showing the correct units in your answer.

[5 marks]

10

1 4 . 1 Describe what is meant by laminar flow in a fluid control system.

[3 marks]

1 4 . 2 Describe, with the aid of a labelled diagram, water flowing past a circular column in a river.

[4 marks]

Sketch here

Description: _____

1 4 . 3 Describe what is meant by heat conduction in metals.

[3 marks]

10

Turn over for Section B

Section B

Answer all three questions in this section.

1 5 The gas in the cylinder of an internal combustion engine at the start of the compression stroke has volume of 0.015 m^3, temperature of 20 $^{\circ}\mathrm{C}$ and pressure of 1.8 bar g.

The piston compresses the gas to 0.005 m^3 and pressure of 8 bar g.

1 5 . 1 By use of the gas laws, determine the final temperature of the gas giving your answer in **absolute values**.

[8 marks]

1 5 . 2 Explain why the temperature changes during compression.

[2 marks]

10

1 6 A method widely used throughout the engineering industry to test metallic materials is the tensile test.

1 6 . 1 Draw the load/extension curve/graph for a typical low carbon steel. Label the following points on your curve/graph:

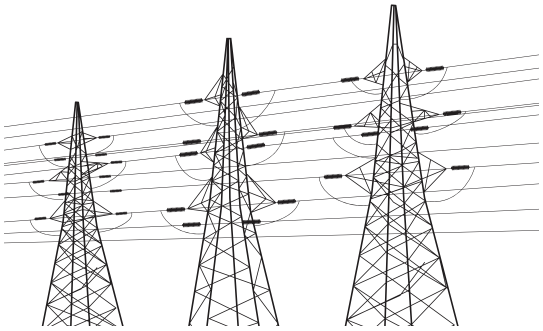
- yield point
- ultimate tensile strength
- total elongation
- the failure point.

[5 marks]

Draw load/extension curve/graph here:

1 6 . 2 A 15 mm diameter carbon steel tie-bar is subjected to a load of 20 kN whilst being used on an electricity pylon. Determine the direct stress produced in this component.

[5 marks]



1 7 Corrosion costs engineering industries a large amount of money each year.

1 7 . 1 Explain why metals corrode.

[4 marks]

10

1 7 . 2 Describe how aluminium and its alloys protect themselves from atmospheric corrosion when being used.

[2 marks]

1 7 . 3 Identify **four** corrosion protection methods used to protect engineering metals whilst in service.

[4 marks]

Corrosion protection method 1: _____

Corrosion protection method 2: _____

Corrosion protection method 3: _____

Corrosion protection method 4: _____

10

END OF QUESTIONS