Level 3 Technical Level
Design Engineering
Mechatronic Engineering

F/506/5952-Unit 1 Materials technology and science
Mark scheme

June 2018

Version/Stage: 1.0 Final

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from aqa.org.uk

Level of response marking instructions

Level of response mark schemes are broken down into levels, each of which has a descriptor. The descriptor for the level shows the average performance for the level. There are marks in each level.

Before you apply the mark scheme to a student's answer read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Step 1 Determine a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different qualities that might be seen in the student's answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level and then use the variability of the response to help decide the mark within the level, ie if the response is predominantly level 3 with a small amount of level 4 material it would be placed in level 3 but be awarded a mark near the top of the level because of the level 4 content.

Step 2 Determine a mark

Once you have assigned a level you need to decide on the mark. The descriptors on how to allocate marks can help with this. The exemplar materials used during standardisation will help. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the example.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the Indicative content to reach the highest level of the mark scheme.

An answer which contains nothing of relevance to the question must be awarded no marks.

Question	Guidance	Mark
01	**Steel is an alloy of** **B** iron and carbon. **1 mark** for the correct answer.	1
02	**Which of the following is not a composite material?** **D** Polyethylene **1 mark** for the correct answer.	1
03	**Photochromic materials** **A** change colour with different lighting conditions. **1 mark** for the correct answer.	1
04	**QTC stands for** **D** quantum-tunnelling composite. **1 mark** for the correct answer.	1
05	**The SI unit of capacitance is the** **C** farad. **1 mark** for the correct answer.	1
06	**Which of the following is a thermosetting polymer?** **A** Polyester resin **1 mark** for the correct answer.	1
07	**The UTS of a material is better known as its** **C** ultimate tensile strength. **1 mark** for the correct answer.	1
08	**Plasticity is a material's ability to be** **B** easily shaped or moulded. **1 mark** for the correct answer.	1

Question	Guidance	Mark
09	**Which of the following does a belt drive rely on to operate?** **D** Friction **1 mark** for the correct answer.	1
10	**Which one of the following engineering materials is the most ductile at room temperature?** **C** Aluminium **1 mark** for the correct answer.	1
	Total marks for questions 1 to 10	**10**

<table>
<tr><th>Question</th><th>Guidance</th><th>Mark</th></tr>
<tr><td>11.1</td><td>Complete Table 1 by entering the class of material and an application.
The top row has been completed for you as an example.

<table>
<tr><th>Material</th><th>Class of material</th><th>Application</th></tr>
<tr><td>Stainless steel</td><td>Ferrous alloy.</td><td>Sinks, knives, forks, washing machines, food preparation equipment etc.</td></tr>
<tr><td>Acrylonitrile butadiene styrene (ABS)</td><td>Thermoplastic polymer.
Accept polymer.
Don’t accept plastic.</td><td>Pipe systems, musical instruments, golf club heads, automotive trim components, automotive bumper bars, enclosures for electrical and electronic assemblies, protective headgear.
Any suitable application.</td></tr>
<tr><td>Brass</td><td>Non-ferrous alloy.
Accept alloy of copper and zinc.
Allow non-ferrous metal.
Allow alloy.</td><td>Water taps, hosepipe connections, bullet cartridges, musical instruments etc.
Any suitable application.</td></tr>
<tr><td>Reinforced concrete</td><td>Composite material.</td><td>Beams, bridges, structures, columns, struts etc.
Any suitable application.</td></tr>
</table>

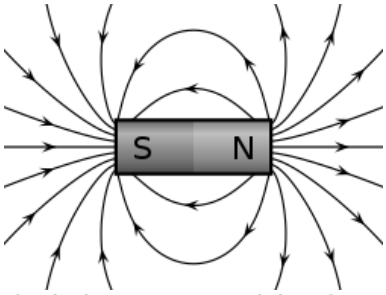
1 mark for each correct answer to a maximum of 6 marks.</td><td>6</td></tr>
<tr><td>11.2</td><td>What material is the blade of the hacksaw shown in Figure 1 made from?

High carbon steel/tool steel
Do not accept low carbon steel.
1 mark for either answer.</td><td>1</td></tr>
<tr><td>11.3</td><td>Explain why this material is used.

The blade can be made hard enough to cut metal by heat treatment.
Hardness, toughness, strength, cost effectiveness relative to other materials, ability to be manufactured are the key properties. Corrosion resistance is acceptable for 1 mark.

1 mark each for up to two identified properties and up to 2 marks for justifications to a maximum of 3 marks in total.</td><td>3</td></tr>
<tr><td colspan="2">Total marks for question 11</td><td>10</td></tr>
</table>

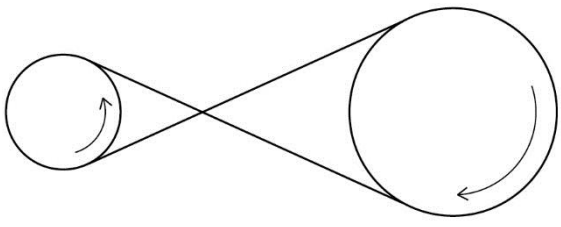
Question	Guidance	Mark
12.1	**Describe how cold working changes the structure of a metal.** Cold working is the plastic deformation of metals below the recrystallisation temperature. In most cases of manufacturing, such cold forming is done at room temperature. • Plastic • Deformation • Below recrystallisation temperature • Done at room temperature • Elongation of grains • Dislocations. • Lattice structure. • Any other suitable response. **1 mark** for each correct point made. **Maximum 4 marks**.	4
12.2	**Name two benefits of cold working on metals.** • No heating required. • Increases strength of material. • Increases hardness of material. • Better dimensional accuracy. • Improve finish (planishing hammers etc) • Or other suitable responses. **1 mark** for any of the correct answers above. **Maximum 2 marks**.	2
12.3	**Explain what is meant by crosslinking within polymers.** Crosslinking is where the polymer chains are chemically joined together in places, by ionic or covalent bonds. The polymer chains cannot slide over each other. This makes materials tougher and less flexible, and they cannot be easily stretched. Crosslinking also gives materials high melting points. Vulcanised rubber has crosslinks. Its polymer molecules are crosslinked by sulphur atoms. It is tough but flexible, and used for making tyres. • Chemically joined; • Ionic or; • Covalent bonds; • Polymer chains can't slide over each other; • Tougher; • Less flexible; and • Higher melting temperature. • Or other suitable responses. **1 mark** for any of the above answers. **Maximum 4 marks.**	4
	Total marks for question 12	**10**

Question	Guidance	Mark
13.1	**Figure 2 shows a bar magnet. Describe the magnetic field with the aid of a sketch around the bar magnet.**  Magnetism refers to physical phenomena arising from the force caused by magnets, objects that produce fields that attract or repel other objects. The motion of electrically charged particles gives rise to magnetism. The force acting on an electrically charged particle in a magnetic field depends on the magnitude of the charge, the velocity of the particle, and the strength of the magnetic field. A magnetic field is the magnetic effect of electric currents and magnetic materials. The magnetic field at any given point is specified by both a direction and a magnitude (or strength); as such it is represented by a vector field. • **2 marks** for a suitable diagram, similar to the one above showing force lines with direction arrows. • **1 mark** for mention of forces. • **1 mark** for attract or repel. • **1 mark** for mention of a vector quantity. **Maximum 5 marks**.	5
13.2	**Describe two applications where magnets are typically used.** • They are used to construct the electrical motors and the generators which convert the electrical energy into mechanical energy and vice versa. • They are also used in the speakers which can convert the electrical energy into sound energy. • They are used in the electrical bells / buzzers. • They are used in the Maglev trains. In the Maglev trains, the super conducting magnets are used on the tracks on which the train floats. These types of the trains are working on the repulsion force of the magnets. • They are also used to sort out the magnetic and nonmagnetic materials from the scrap. • They are used in TV screens, computer screens, telephones and in tape recorders. • They are used in cranes to lift heavy objects. **2 marks** for any of the above or other suitable responses. **Maximum 4 marks**.	4
13.3	**State the function of a transistor.** **Do not accept voltage amplifier.** Transistors are tiny electronic switches and amplifiers. **1 mark** for a similar response.	
	Total marks for question 13	**10**

Question	Guidance	Mark
14.1	**Describe what is meant by thermal radiation.** All objects give out and take in **thermal radiation**, which is also called **infrared radiation**. The hotter an object is, the more infrared radiation it emits. Infrared radiation is a type of electromagnetic radiation that involves waves. No particles are involved, unlike in the processes of conduction and convection, so radiation can even work through the vacuum of space. Thermal radiation (as opposed to particle radiation) is the transfer of internal energy in the form of electromagnetic waves. For most bodies on the Earth, this radiation lies in the infrared region of the electromagnetic spectrum. **1 mark** for electromagnetic. **1 mark** for no particles. **1 mark** for transfer of energy. **1 mark** for infrared. Any other suitable response. **Maximum 4 marks.**	4
14.2	**Describe two applications where heat transfer is influenced by thermal radiation.** • We wear white or light-coloured clothes in summer because they are poor absorbers and good reflectors of heat. This way they keep us cool. On the contrary, we prefer to wear dark-coloured clothes in winters because they absorb most of the heat of sun and keep our body warm. • Radiators of heat in cars, machines and air conditioners are painted black so as to have cooling effect by radiating most heat. • Room (electric) heaters have bright polished surfaces which act as good reflectors of heat. Such surfaces absorb very little heat and reflect towards us most of the heat radiations. These surfaces remain cool even after continuous use of heaters. • The highly polished surfaces of spacecraft reflect most of the heat radiated from the sun. • Base of cooking utensils is made black. Such a black surface absorbs more heat from the surroundings. • If ovens or cavity walls are mentioned allow only one mark per application. **1 mark** for stating the application and **1 mark** for the description of the application. **Maximum 4 marks.**	4
14.3	**Describe the term 'potential energy'.** **Use a diagram to support your answer.** Use of appropriate illustration. The energy possessed by a body by virtue of its position relative to others. **1 mark** for the above or other suitable response. **1 mark** for a suitable illustration. **Maximum 2 marks.**	2
	Total marks for question 14	**10**

Question	Guidance	Mark
15	**In the circuit in Figure 3 if the potential difference between points a and c $V_{ac} = 120$ V, find the charge on capacitors C_1 and C_2.** **C_1 and C_2 are in series:** $\frac{1}{C_{12}} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{60} + \frac{1}{20} = \frac{1}{15} \therefore C_{12} = 15\mu F$ C_{12} and C_3 are in parallel: $C_{123} = C_{12} + C_3 = 15\mu F + 9\mu F = 24\mu F$. Now, C_{123} and C_4 are in series: $\frac{1}{C_{Total}} = \frac{1}{C_{123}} + \frac{1}{C_4} = \frac{1}{24} + \frac{1}{12} \therefore C_{Total} = 8\mu F$. The total charge of the system is: $V_{ac} = \frac{Q_T}{C_{Total}} \therefore Q_T = V_{ac}C_{Total} = 120 \times 8 \times 10^{-6} = 960\mu C$. Or equivalent value. The potential difference between points b and c is: $V_{bc} = \frac{Q_T}{C_4} = \frac{960 \times 10^{-6}}{12 \times 10^{-6}} = 80V$. The potential difference between points a and b is: $V_{ab} = V_{ac} - V_{bc} = 120 - 80 = 40V$. The charge on capacitor C_1 and C_2 $Q_{12} = V_{ab}\, C_{12} = 40 \times 15 \times 10^{-6} = 600\mu C$ or equivalent value. 1 mark for use of series formula. 1 mark for correct transposition. 1 mark for correct value: C_{12}. 1 mark for correct use of parallel formula. 1 mark for correct value: C_{Total}. 1 mark for correct values used: $Q_T = V_{ac}C_{Total}$. 1 mark for correct value: V_{bc}. 1 mark for correct value: V_{ab}. 1 mark for correct values in: $Q_{12} = V_{ab}C_{12}$. 1 mark for correct answer: Q_{12}.	10
	Total marks for question 15	**10**

Question	Guidance	Mark
16.1	**The radius of the applied force is 250 mm.** **Calculate the torque the fitter is applying to the nut.** **Show your answer to 2 decimal places.** Covert mass into force: $F = mg = 5 \times 9.81 = 49.05$ N Using the torque equation from the formulae sheet: $T = Fr = 49.05 \times 0.25 = 12.26$ Nm 2 dp **1 mark** for converting mass to force. **1 mark** for correct torque equation. **1 mark** for correct answer. **1 mark** for correct units. **1 mark** for 2 d.p. **Maximum 5 marks**.	5
16.2	**As a result of tightening the nut, a 10 mm diameter bolt now has a force of 1 kN applied to it.** **Determine the stress in the bolt once tightened. Show your answer in engineering units.** Area of the bolt: $A = \frac{\pi D^2}{4} = \frac{\pi \times 10 \times 10^{-3^2}}{4} = 78.539816\ldots \times 10^{-6} m^2$ **Or** equivalent value / method. The stress in the bolt: $\sigma = \frac{F}{A} = \frac{1000}{78.539816...\times 10^{-6}} = 12.7$ MPa **Or** 12.7 MN m^{-2} **1 mark** for either correct area formula. **1 mark** for correct answer. **1 mark** for correct stress formula. **1 mark** for correct answer. **1 mark** for correct engineering units. **Maximum 5 marks.**	5
	Total marks for question 16	**10**

Question	Guidance	Mark
17.1	**Describe two advantages of using a belt drive as a means of power transfer in engineering systems.** • Belt drives are simple are economical to design, maintain and operate. • They don't need parallel shafts. • Belts drives can be provided with overload and jam protection. • Noise and vibration are damped out. • Machinery life is increased because load fluctuations are shock-absorbed. • They are lubrication-free. They require less maintenance cost. • Belt drives are highly efficient in use (up to 98%, usually 95%). • They are very economical when the distance between shafts is large. **2 marks** each for any of the above or other suitable answer. **Maximum 4 marks.**	4
17.2	**Describe two disadvantages of using a belt drive as a means of power transfer in engineering systems.** • In Belt drives, angular velocity ratio is not necessarily constant or equal to the ratio of pulley diameters, because of slipping and stretching. • Heat build-up occurs. Speed is limited to usually 35 ms^{-1}. • Power transmission is limited to 370 kilowatts. • Operating temperatures are usually restricted to –35 to 85°C. • Slippage of belt made in the power transfer. • Limitations of power transfer compared to some alternative mechanisms ie gears. • Damage to mechanical systems if slip does occur – cam belts on IC engines etc. • Do not accept wear or wearing out and needs changing regularly. **2 marks** for any of the above or other suitable response. **Maximum 4 marks.**	4
17.3	**Show a belt drive arrangement that can change the direction of each pulley.**  Crossed belt drive **1 mark** for 2 pulleys and **1 mark** for cross-over. **2 marks** for this or other suitable image. **Maximum 2 marks.**	2
	Total marks for question 17	**10**

Assessment outcomes coverage

Assessment Outcomes	Marks and % of marks available in section A	Marks and % of marks available in section B	Total Marks
AO1:	12 marks 15%	05 marks 6.25%	17
AO2:	12 Marks 15%	00 marks 00%	12
AO3:	04 Marks 05%	00 marks 00%	04
AO4:	11 Marks 13.75%	10 marks 12.5%	21
AO5:	11 Marks 13.75%	15 marks 18.75%	26
Total Marks	**50**	**30**	**80**

Question	Assessment Outcome 1	Assessment Outcome 2	Assessment Outcome 3	Assessment Outcome 4	Assessment Outcome 5
1	N / A	1	N / A	N / A	N / A
2	N / A	1	N / A	N / A	N / A
3	N / A	1	N / A	N / A	N / A
4	N / A	1	N / A	N / A	N / A
5	N / A	N / A	N / A	1	N / A
6	N / A	1	N / A	N / A	N / A
7	1	N / A	N / A	N / A	N / A
8	1	N / A	N / A	N / A	N / A
9	N / A	N / A	N / A	N / A	1
10	1	N / A	N / A	N / A	N / A
11	3	7	N / A	N / A	N / A
12	6	N / A	4	N / A	N / A
13	N / A	N / A	N / A	10	N / A
14	N / A	N / A	N / A	N / A	10
15	N / A	N / A	N / A	10	N / A
16	05	N / A	N / A	N / A	05
17	N / A	N / A	N/A	N / A	10
Totals	**17**	**12**	**04**	**21**	**26**