



Please write clearly in block capitals.

Centre number

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Candidate number

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Surname

Forename(s)

Candidate signature

Level 3 Technical Level DESIGN ENGINEERING MECHATRONIC ENGINEERING

Unit 1 Materials technology and science

Wednesday 17 January 2018 Afternoon Time allowed: 1 hour 45 minutes

Materials

For this paper you must have:

- pens
- pencils
- simple drawing instruments
- scientific calculator (non-programmable)
- formula sheet.

Instructions

- Use black ink or black ball-point pen. Use pencil only for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this answer book. Cross through any work you do not want to be marked.
- Answer to 3 significant figures unless otherwise instructed.

Information

- The marks for questions are shown in brackets.
- There are 80 marks available on this paper. There are 50 marks for Section A and 30 marks for Section B.
- Both sections should be attempted.

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	
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11	
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16	
17	
TOTAL	



J A N 1 8 F 5 0 6 5 9 5 2 0 1

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Section A

Answer **all** questions in this section.In the multiple choice questions, only **one** answer per question is allowed.

For each question 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

What is steel?

A A mixture of tin and iron.

☐

B A mixture of iron and carbon.

☐

C A mixture of copper and zinc.

☐

D A mixture of aluminium and carbon.

☐

[1 mark]

1

0 2

Which **one** of the following is a thermoplastic?

A Epoxy resin

☐

B Melamine formaldehyde

☐

C Rubber

☐

D Polypropylene

☐

[1 mark]

1



0	3
---	---

A thermo chromic material

A gets harder with increase in temperature.

☐

B gets tougher with decrease in temperature.

☐

C changes colour with change of temperature.

☐

D changes shape with change of temperature.

☐

[1 mark]

1

0	4
---	---

A normalised steel is

A heated up and cooled in air.

☐

B heated up and quenched in oil.

☐

C heated up and quenched in acid.

☐

D heated up and cooled in water.

☐

[1 mark]

1

0	5
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Which **one** of the following elements gives stainless steel its resistance to corrosion?

A Chromium

☐

B Zinc

☐

C Platinum

☐

D Titanium

☐

[1 mark]

1

Turn over ►



0 6

Which of the following is a non-ferrous metal?

A Medium carbon steel

☐

B Cast iron

☐

C Low carbon steel

☐

D Tungsten

☐

[1 mark]

1

0 7

Which of the following best describes plastic deformation?

A Deformation caused by sunlight.

☐

B Reversible deformation.

☐

C Irreversible deformation.

☐

D Deformation that is time dependant.

☐

[1 mark]

1

0 8

Strain is

A mass/density

☐

B change in length/original length

☐

C force/volume

☐

D mass/volume

☐

[1 mark]

1



0	9
---	---

Which **one** of the following classes of engineering materials is the hardest?

A Ceramics

☐

B Elastomers

☐

C Metals

☐

D Polymers

☐

[1 mark]

1

1	0
---	---

Which **one** of the following engineering materials is the least ductile at room temperature?

A Stainless steel

☐

B Tungsten carbide

☐

C Copper

☐

D Medium carbon steel

☐

[1 mark]

1

Turn over for the next question

Turn over ►



1 1 . 1

Complete **Table 1** by entering the material class and a suitable application.

The top row has been completed for you as an example.

[6 marks]**Table 1**

Material	Class	Typical use
Melamine formaldehyde	Thermosetting polymer	Household items – such as glasses, cups, bowls and plates. Toilet seats, light switches and pan handles.
Thermochromic materials		
Polyvinyl chloride (PVC)		
Titanium		

1 1 . 2

Figure 1

The frame of the mountain bike is commonly manufactured from which material?

[2 marks]



1 1 . 3

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

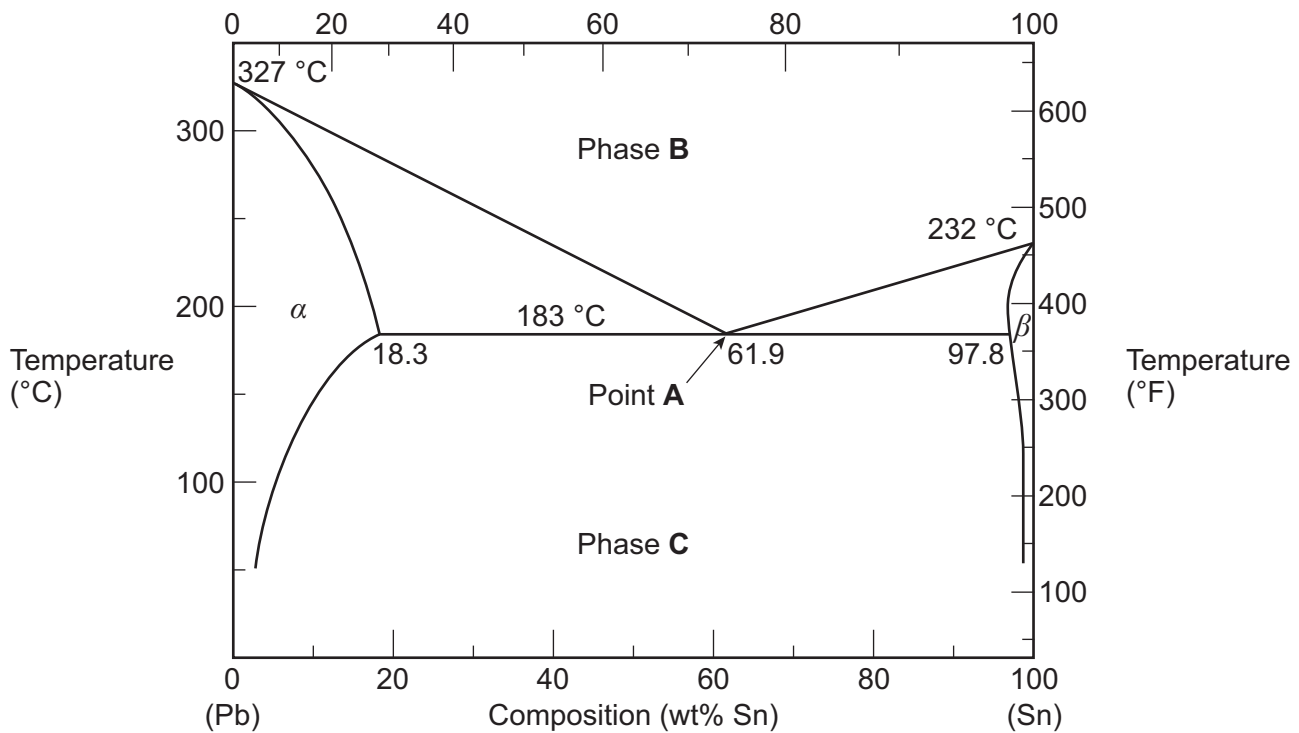
[2 marks]

Reason 1: _____

Reason 2: _____

10

1 2

The tin–lead phase diagram is shown in **Figure 2**.**Figure 2**

1 2 . 1

Name the **three** labelled regions indicated in **Figure 2**.

[3 marks]

Point A _____

Phase B _____

Phase C _____

Turn over ►



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outside the
box*

1 2 . 2

Describe the stages of the process for case hardening of steel.

[7 marks]

10



1 3 . 1

Describe how a diode works in an electronic circuit.

[5 marks]

1 3 . 2

Describe how **electromagnetic induction** is used in a voltage transformer.

[5 marks]

10

Turn over ►



1 4 . 1

Describe what is meant by latent heat of fusion.

[2 marks]

1 4 . 2

Describe in detail the operation of a heat pump using a suitable example.

[6 marks]

An example of a heat pump: _____



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What is the SI unit of thermal energy?

[1 mark]

1	4	.	4
---	---	---	---

What is the SI unit of thermal power?

[1 mark]

10

Turn over for Section B

Turn over ►



Section BAnswer **all** questions in this section.**1 5**

A steel beam is designed to operate in the following temperature's range:
 $-30\text{ }^{\circ}\text{C}$ to $70\text{ }^{\circ}\text{C}$ The beam's length (L_0) is 6.0 m when assembled at $20\text{ }^{\circ}\text{C}$

$$L_t = L_0 (1 + \alpha \Delta T)$$

1 5 . 1

Calculate the length of the beam, L_t , at $70\text{ }^{\circ}\text{C}$ and $-30\text{ }^{\circ}\text{C}$ if
 $\alpha = 16.0 \times 10^{-6} \text{ m m}^{-1} \text{ K}^{-1}$

[7 marks]**1 5 . 2**

State **two mechanical properties** and **one physical property** required for a steel beam.

[3 marks]

Mechanical property 1 _____

Mechanical property 2 _____

Physical property 1 _____

10

1 6

A compound gear train is part of a machine tool gearbox and is shown in **Figure 4**.

Figure 4

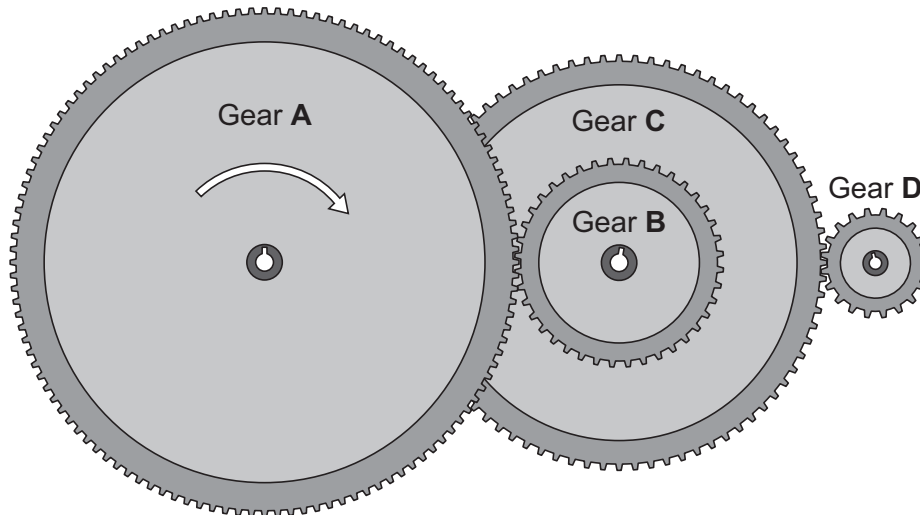


Table 2

Gear A	Gear B	Gear C	Gear D
120 Teeth	40 Teeth	80 Teeth	20 Teeth

If **Gear A** is rotating at 30 RPM in a clockwise direction, determine the speed and direction of **Gear D** using the information from **Table 2**.

[10 marks]

10

Turn over ►



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1 7 . 1

Describe the effects of cold working an aluminium alloy.

[4 marks]



1	7	.	2
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[6 marks]

[illegible]

10



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