Oxford Cambridge and RSA

Cambridge **TECHNICALS LEVEL 3**

ENGINEERING

Cambridge TECHNICALS

Combined feedback on the January 2017 exam paper (including selected exemplar candidate answers and commentary)

Unit 2 – Science for engineering

Version 1

ocr.org.uk/engineering

CONTENTS

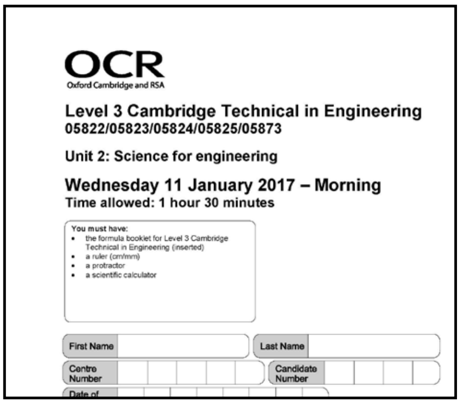
INTRODUCTION

This resource brings together the questions from the January 2017 examined unit (Unit 2), the marking guidance, the examiners comments and the exemplar answers into one place for easy reference.

We've also included candidate exemplar answers with commentaries for Questions 4 and 5.

The marking guidance and the examiner's comments are taken straight from the Report to Centre for this question paper.

The Question Paper, Mark Scheme and the Report to Centre are available from: https://interchange.ocr.org.uk/



OCR
Oxford Cambridge and RSA

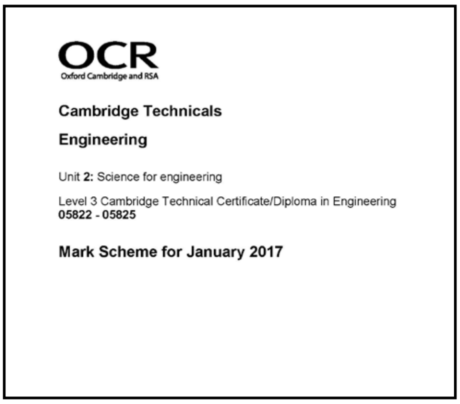
Level 3 Cambridge Technical in Engineering
05822/05823/05824/05825/05873

Unit 2: Science for engineering

Wednesday 11 January 2017 – Morning
Time allowed: 1 hour 30 minutes

You must have:
- the formula booklet for Level 3 Cambridge Technical in Engineering (inserted)
- a ruler (cm/mm)
- a protractor
- a scientific calculator

First Name | Last Name
Centre Number | Candidate Number
Date of



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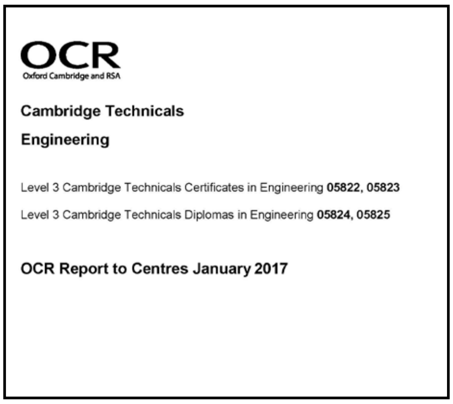
Cambridge Technicals

Engineering

Unit **2:** Science for engineering

Level 3 Cambridge Technical Certificate/Diploma in Engineering
05822 - 05825

Mark Scheme for January 2017



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Engineering

Level 3 Cambridge Technicals Certificates in Engineering **05822, 05823**

Level 3 Cambridge Technicals Diplomas in Engineering **05824, 05825**

OCR Report to Centres January 2017

GENERAL EXAMINER COMMENTS ON THE PAPER

This is a mandatory unit across all qualifications in the Cambridge Technicals in Engineering suite.

Candidates should be reminded that where appropriate calculation questions should be supported with workings. Marks may be awarded for a correct method even if the answer is incorrect. There was evidence this series that because workings were not shown some candidates could not be awarded marks when previous errors were carried through to subsequent calculations.

There were a number of missing or incorrect units being used for numerical answers and candidates need to ensure that they convert values to consistent powers of ten before carrying out any calculation.

Candidates seemed to show greater understanding of learning outcomes 1 to 4 as they performed better in questions 1 to 4, compared to questions 5 and 6.

Question 1

1 (a) Assign the appropriate power of ten to the following prefixes.

µ (micro)	10^{-6}
M (mega)	10^{6}
k (kilo)	10^{3}
m (milli)	10^{-3}

[4]

(b) Define the term relative error in the context of engineering measurements.

Relative error: Ratio of absolute error and true value (given in percentages), OR absolute error divided by true value.

[1]

(c) You are given that $X = 0.002362$.

Find the relative error if X is written to

(i) 3 significant figures,

$(X =)0.00236$;
Relative error $= \Delta X/X = (0.002362 - 0.00236)/0.002362$
Relative error $= 0.00085$ ($= 0.085\%$)

[3]

(ii) 3 decimal places.

$(X =)0.002$;
Relative error $= \Delta X/X = (0.002362 - 0.002)/0.002362 =$
0.153 ($= \pm 15.3\%$)

[2]

Mark scheme guidance

1 (a)

One mark for each correct line of the table.

Accept powers alone i.e. -6, 6,3, -3.

1 (b)

Accept absolute error over true value.

1 (c) (i)

Evidence of correct calculation
Ignore sign (subtraction can be done either way round)

1 (c) (ii)

Ignore sign as above
(2nd mark of (i) could be awarded here if not awarded in (i)

Examiner comments

1 (a)

Candidates generally either knew all these prefixes or very few.

1 (b)

Many candidates were able to define relative error, but a few gave an imprecise definition.

1 (c)

Some candidates did not comprehend the difference between significant figures and decimal places. A fairly common error was to calculate measured value divided by true value rather than error divided by true value.

Question 2

2 Use $g = 9.8\text{ms}^{-2}$ in this question.

(a) A 20kg ball shown in Fig. 1 is suspended in equilibrium from the ceiling on a wire and has a force $F = 80\text{N}$ acting on it in horizontal direction. The wire makes an angle of α with the vertical.

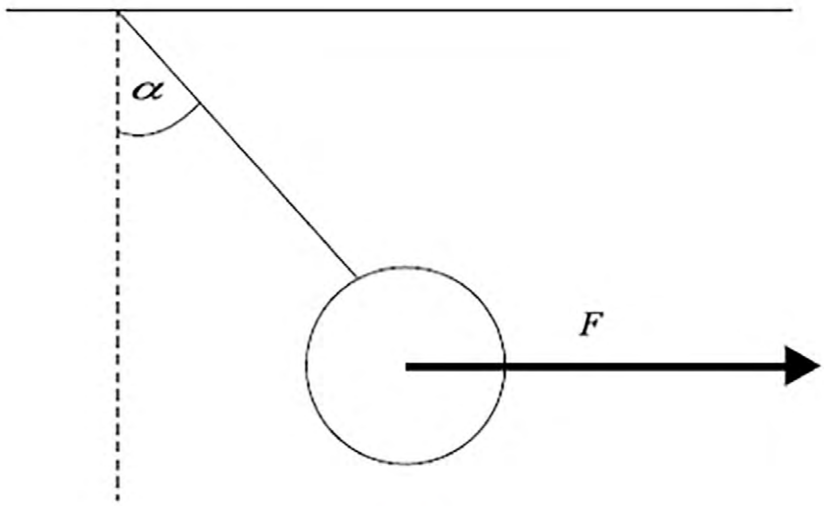

Fig. 1

(i) Calculate the weight of the ball.

$F_g = mg = 20 \times 9.8 = 196$ N

[1]

(ii) Calculate the tension in the wire.

(Using Pythagoras)

$$F_w = \sqrt{F^2 + F_g^2}$$

$$F_w = \sqrt{80^2 + 196^2} = 212\ N\ (= 210\ N)$$

[2]

(iii) Calculate the angle, α, between the vertical and the wire.

EITHER:
Resolving horizontally:
$F_W \sin \alpha = 80$
sin α = 80/212 = 0.377
α = 22(.2)°
OR:
Resolving vertically:
$F_W \cos \alpha = 196$
= 196/212 = 0.925
α = 22(.3)°
OR
tan α = 80/196
tan α = 0.408
α = 22(.2)°

[3]

(b) Fig. 2 shows how the velocity of a moving object changes over a few seconds.

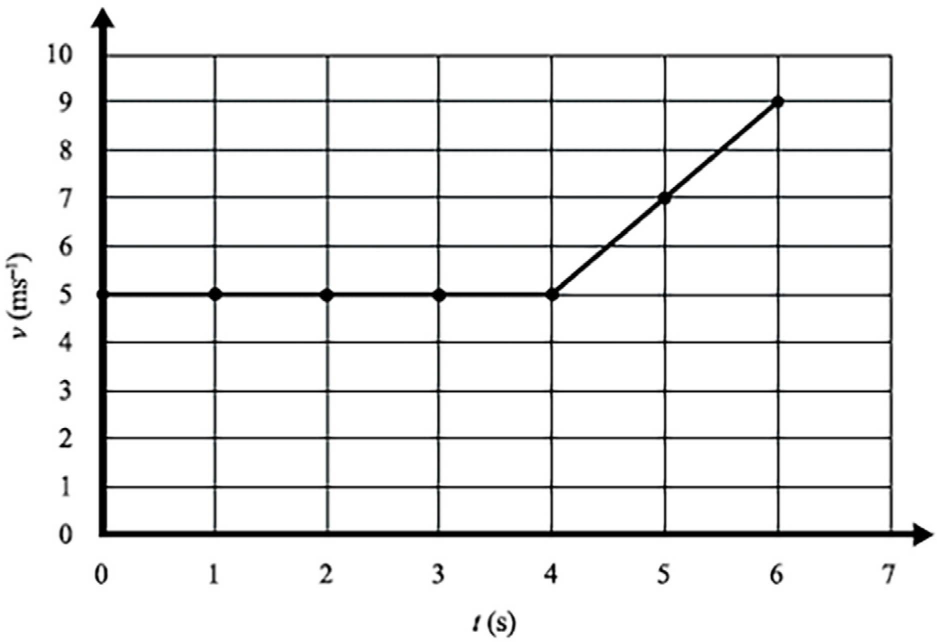

Fig. 2

(i) Calculate the distance covered by the object in the first 4 seconds.

$s = v\,t = 5 \times 4 = 20$ (m)

[1]

(ii) **Calculate the acceleration of the object between 4 and 6 seconds.**

$a = dv/dt = (v - u)/t = (9 - 5)/2 = 4/2 = 2$ <u>m s</u> $^{-2}$ **[1]**

(iii) **From time $t = 6$ seconds the object has constant deceleration, coming to rest in 3 seconds. Find the value of the constant deceleration.**

$a = dv/dt = (v - u)/t = \pm (9 - 0)/3$

$a = \pm 3$ <u>m s</u> $^{-2}$

[2]

Mark scheme guidance

2 (a) (i)
Unit is required. ACCEPT 200 N for 2 sf.

2 (a) (ii)
Allow ecf of incorrect weight from part (i). Need to see unit but only one unit penalty in part (a).

2 (a) (iii)

Allow ecf of incorrect forces from part i) and ii).

Use of $F_W = 210$ N gives α = 21° and use of $F_g = 200$ N as well gives α = 17°. All acceptable if working shown.

2 (b) (i)
Ignore unit. Accept answer to answer to 1 sf.

2 (b) (ii)

Unit is required.
Accept answer given to 1 sf.

2 (b) (iii)
Appropriate substitution into equation.
Unit required but only one unit penalty in (b).

Examiners comments

2 (a)

Some candidates did not understand the difference between mass and weight, and there were also a number of candidates who correctly calculated the weight but omitted or used the incorrect units.

In part (ii) some candidates realised that they needed to use Pythagoras Theorem to find the tension, but used the incorrect values.

In part (iii), instead of using the relatively simple equations for the trigonometric functions for right angled triangles, some candidates attempted to use the cosine rule, and then got confused about which values or force to use. A few candidates attempted to measure the angle from the diagram using a protractor rather than calculate it from the value for the forces.

2 (b)

Many candidates omitted units for the distance in part (i) although this was not penalised in the mark scheme, and some used the unit for velocity instead of acceleration in parts (ii) and (iii). Some candidates were able to calculate the acceleration from the graphical data in part (ii) than the data given in text form in part (iii) and vice versa.

Question 3

3 **(a)** The current flowing through the circuit shown in Fig. 3 is $I = 2$ A.

The potential differences across R_1, R_2 and R_3 are 5V, 2V and 10V respectively.

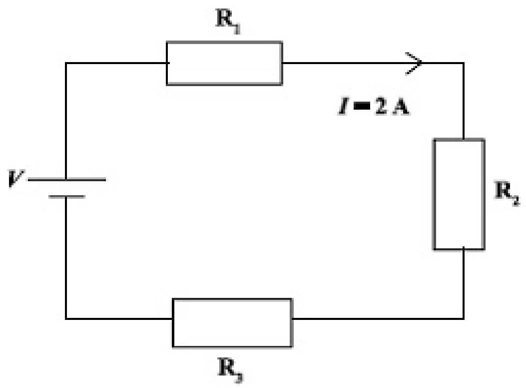

Fig. 3

Calculate

(i) the total voltage supplied to the circuit,

Total Voltage drop is the sum of voltage drops across all resistors
$V_0 = 5 + 2 + 10 = 17$ V **[1]**

(ii) the total resistance in the circuit,

Use of $R = V/I = 17/2$
$R_T = 8.5$ Ω **[2]**

(iii) the resistance of the individual resistors R_1, R_2 and R_3,

$R_1 = 5/2 = 2.5$ Ω
$R_2 = 2/2 = 1$ Ω
$R_3 = 10/2 = 5$ Ω
[3]

(iv) the power lost across resistor R_1.

Use of $P = IV$ or $P = I^2R$ or $P = V^2/R$

$P_1 = 2 \times 5 = 10$ W $P_1 = (2)^2 \times 2.5 = 10$ W $P_1 = 5^2/2.5 = 10$ W **[2]**

(b) (i) State the SI unit for inductance.

Henry (or H) **[1]**

(ii) Which of the following expressions in base SI units is equivalent to the SI unit for inductance?
Put a ring round the correct response.

$kgm^{-2}\,s^{-2}\,A^{-1}$ $kgm^{2}s^{-1}A^{-2}$ $kgm^{2}\,s^{-2}A^{-2}$ $kgm\,s^{-2}A^{-1}$ **[1]**

$kg\,m^{2}\,s^{-2}\,A^{-2}$

Mark scheme guidance

3 (a) (i)

Ignore unit.

3 (a) (ii)

Substitution of any voltage and 2A into equation.
Allow ecf from (i). Unit required.

3 (a) (iii)

Units required at least once in part (ii) and part (iii).
If already penalised unit in part ii ignore unit.
Max 2/3 if not clear which R is which.

These marks can be awarded from working shown in part (ii). This is acceptable for both sections.

3 (a) (iv)

Substituting appropriate values into one of the power equations.
Unit required.

3 (b) (i)

Not h.

3 (b) (ii)

Third answer should be ringed. Accept alternative clear indication of correct response.

Examiners comments

3 (a): Many candidates were able to calculate voltage and resistance in this series circuit, but there were many cases of omitting the unit. Some candidates showed the working for all three resistors in part (iii) but omitted to show which resistor was which. In part (iv) some candidates chose a correct equation to calculate power, but then substituted values for the quantities either for the whole circuit or the incorrect resistor. Some candidates found the total power provided by the supply and then subtracted the power loss from the resistor.

3 (b): Many candidates were able to identify the SI unit for Inductance, but did not know the equivalent in SI base units.

Question 4

4 **(a)** Fig. 4 shows a stress-strain curve for a metal.

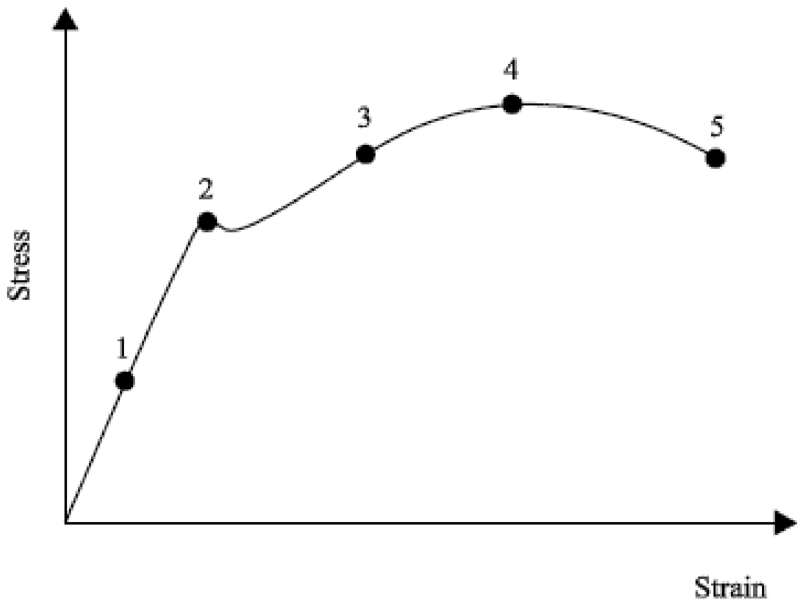

Fig. 4

Complete the table to show which point (1, 2, 3, 4 or 5) represents the features of the stress-strain graph.

Feature	Point number
Ultimate Tensile Stress (UTS)	4
Yield Stress	2
Fracture Point	5
Elastic deformation	1

[4]

(b) Fig. 5 shows a square section beam subjected to a tensile load of 85kN.

The stress normal to section A-A is 105MPa
The strain of the beam is 500 x 10^{-6}.
The yield strength of the material is 210MPa.

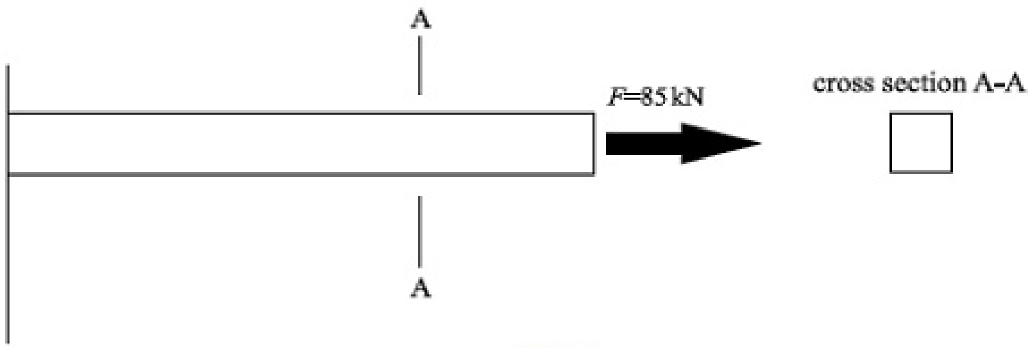

Fig. 5

(i) Calculate the cross sectional area of the beam.

Use of $\sigma = F/A$ hence $A = F/\sigma = 85 \times 10^3 / 105 \times 10^6$

$A = 8.1 \times 10^{-4}$ m² (0.00081 m²)

[2]

(ii) Calculate the load required to plastically deform the beam.

$Fy = \sigma y\, A = (210 \times 10^6) \times (8.1 \times 10^{-4})$

$F = 1.7 \times 10^5$ N (170 kN)

[2]

(iii) Calculate Young's modulus of the material.

$E = \sigma/\varepsilon = 105 \times 10^6 / 500 \times 10^{-6}$

$E = 2.1 \times 10^{11}$ Pa (210 GPa or 210 000 MPa)

[2]

Mark scheme guidance

4 (a)

One mark for each correct line of the table.

4 (b) (i)

Allow values (ignoring POT) substituted into $\sigma = F/A$ for first mark.
Lose second mark for POT errors.
Unit necessary.

4 (b) (ii)

Correct substitution (ignoring POT). Allow ecf from part i).
Lose one mark for POT errors.
Use of σ_y = 105 MPa scores zero.

4 (b) (iii)

Correct substitution (ignoring POT).
Lose one mark for POT errors.
Unit required.

Examiners comments

4 (a)

Some candidates were able to correctly identify the features of a stress strain graph, but there was some confusion between yield stress and elastic deformation.

4 (b)

There were several responses given without units or with the incorrect powers of ten. More candidates were able to calculate the Young Modulus in part (iii) and part (ii) seemed to cause the most problems.

Exemplar candidate work

Question 4 - Low level answer

(a) Fig. 4 shows a stress-strain curve for a metal.

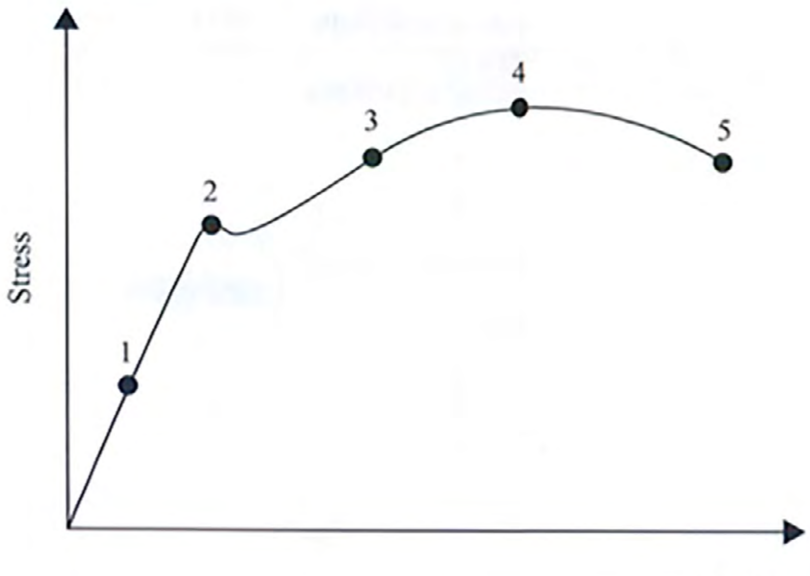

Fig. 4

Complete the table to show which point (1, 2, 3, 4 or 5) represents the features of the stress-strain graph.

Feature	Point number
Ultimate Tensile Stress (UTS)	4 ✓
Yield Stress	~~4~~ 3 ✗
Fracture Point	~~5~~ 5 ✓
Elastic deformation	~~6~~ ~~5~~ 2 ✗

[4]

(b) Fig. 5 shows a square section beam subjected to a tensile load of 85 kN.

The stress normal to section A-A is 105 MPa
The strain of the beam is 500 x 10^{-6}.
The yield strength of the material is 210 MPa.

Stress = 105
Strain = 500 x 10^{-6}
F = 0.085

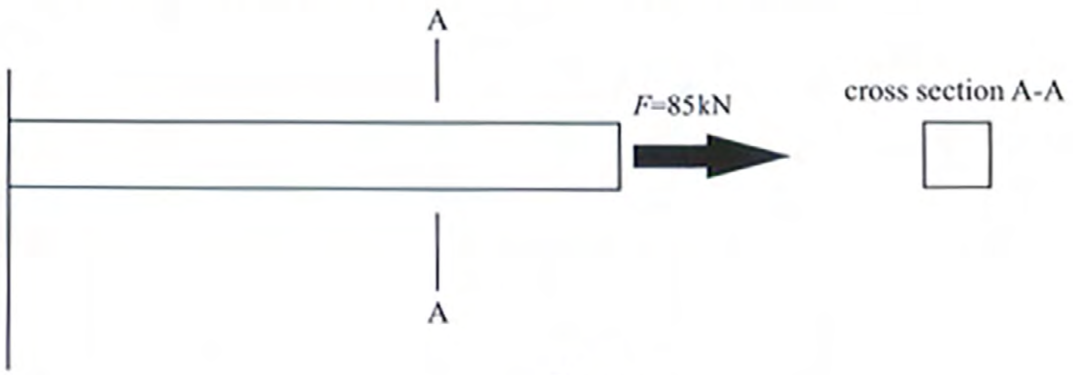

Fig. 5

(i) Calculate the cross sectional area of the beam. [2]

Cross sectional area = axial force / axial stress

∴ Stress = axial force / cross sectional area   85/1000 = 0.085 N ✓

∴ Cross sectional area = 0.085 / 105 = 8.095238095 x 10^{-4} A up |

(ii) Calculate the load required to plastically deform the beam. [2] C

(iii) Calculate Young's modulus of the material. [2]

Young modulus = stress / strain = 105 / 500 x 10^{-6} ✓

= 210000 A up |

Commentary

In part (a) there are only two correct responses.

In part (b) only 2 out of the 3 calculations have been attempted and although these two calculations are correct and all values are to a consistent power of ten, there are no units on either of the final values. Most physical quantities require a unit. Cross sectional area is measured in m^2 and Young Modulus can be measured in N m^{-2} or Pa. Including these units would improve the answer.

Question 4 - Medium level answer

4 (a) Fig. 4 shows a stress-strain curve for a metal.

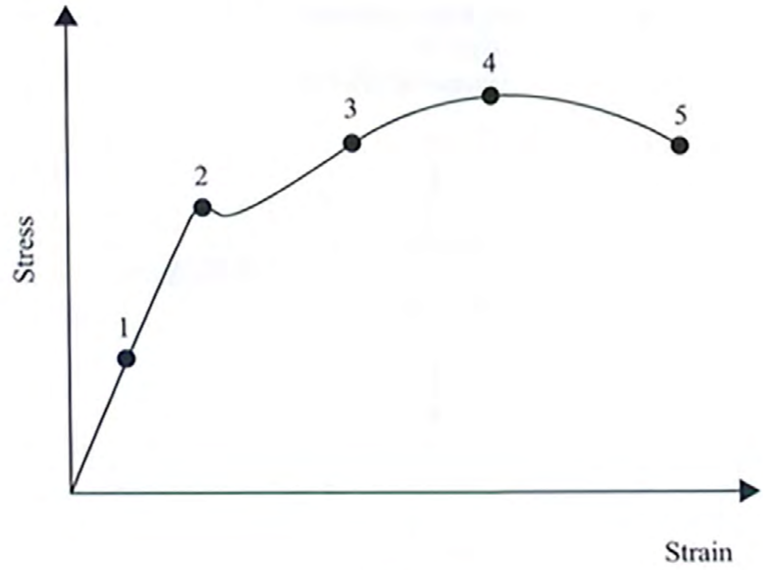

Fig. 4

Complete the table to show which point (1, 2, 3, 4 or 5) represents the features of the stress-strain graph.

Feature	Point number
Ultimate Tensile Stress (UTS)	4 ✓
Yield Stress	2 ✓
Fracture Point	5 ✓
Elastic deformation	1 ✓

[4] 4

(b) Fig. 5 shows a square section beam subjected to a tensile load of 85 kN.

The stress normal to section A-A is 105 MPa
The strain of the beam is 500 x 10^{-6}.
The yield strength of the material is 210 MPa.

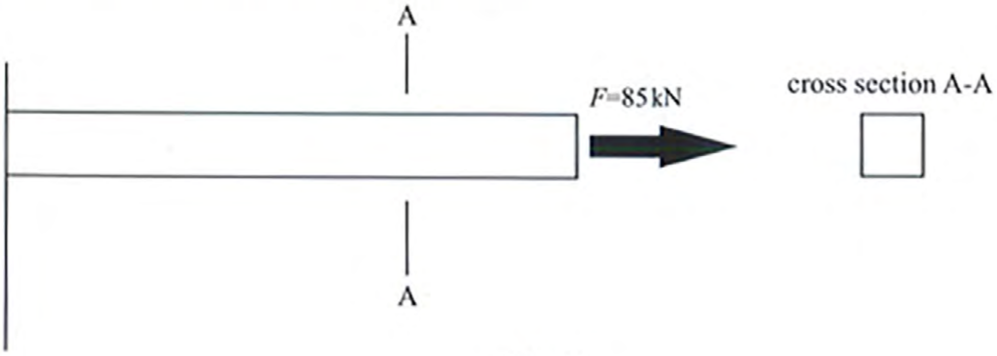

Fig. 5

(i) Calculate the cross sectional area of the beam.

Stress = Force / CSa   CSa = 105×10^6 / 85×10^3

CSa = Force / Stress   CSa = 1235.3 m^2 ✗

[2] 0

(ii) Calculate the load required to plastically deform the beam.

260 kN

Stress = load / area ✗

[2] 0

(iii) Calculate Young's modulus of the material.

Ym = Stress / Strain   Ym = 2.1×10^{11} N m^{-2} ✓

Ym = 105×10^6 / 500×10^{-6} ✓

[2] 2

Commentary

In part (a) all four responses are correct so all four marks are gained.

In part (b)(i) the candidate has selected and rearranged the correct equation: $area = \frac{force}{stress}$, and has used values for force and stress to the correct powers of ten but has then substituted them the wrong way round. This calculation gives an unrealistically high value for the cross-sectional area of a beam which could be spotted by the candidate to realise that a mistake has been made.

In part (b)(ii) the candidate has selected the correct equation to use, but has not completed the calculation. The equation needs to be rearranged to calculate the load using the area value calculated in part (ii) and the yield strength 210×10^6 Pa.

Part (b)(iii) is all correct and gains both marks.

Question 4 - High level answer

4 **(a)** Fig. 4 shows a stress-strain curve for a metal.

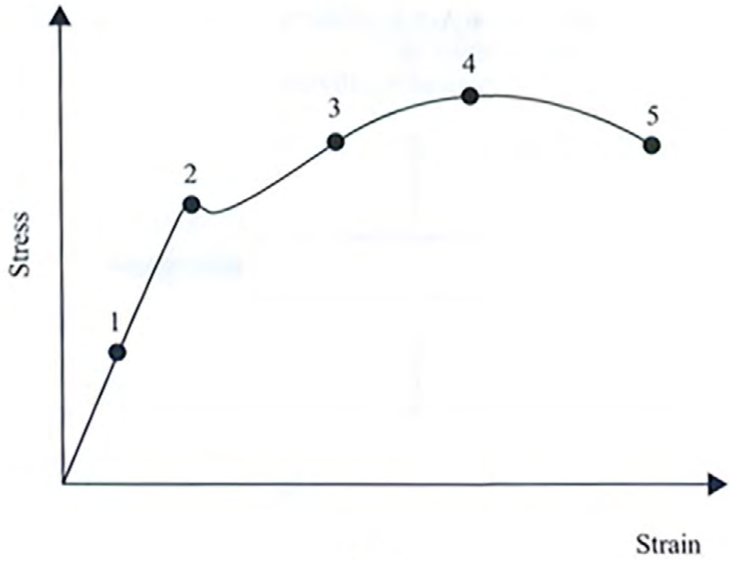

Fig. 4

Complete the table to show which point (1, 2, 3, 4 or 5) represents the features of the stress-strain graph.

Feature	Point number
Ultimate Tensile Stress (UTS)	4
Yield Stress	~~3~~ 2
Fracture Point	5
Elastic deformation	~~3~~ 1

[4] 4 4

(b) Fig. 5 shows a square section beam subjected to a tensile load of 85kN.

The stress normal to section A-A is 105MPa
The strain of the beam is 500 x 10^{-6}.
The yield strength of the material is 210MPa.

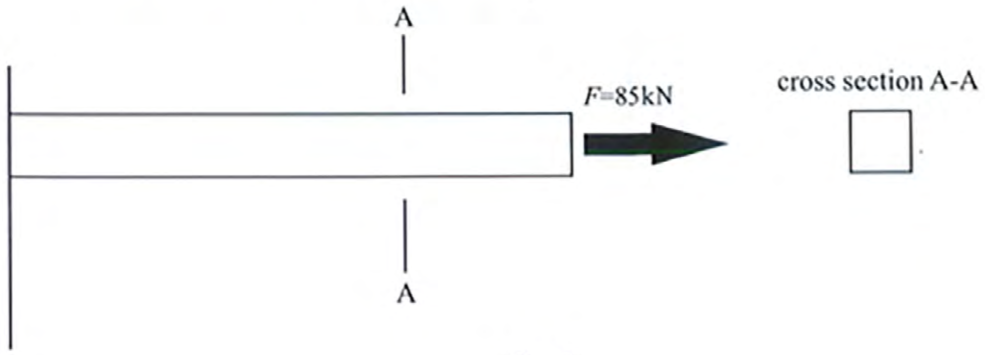

Fig. 5

(i) Calculate the cross sectional area of the beam.

stress = force / cross s area.

CSA = force / stress $\frac{85\times10^3}{105\times10^6}$ = 0.00081 m **[2]**

(ii) Calculate the load required to plastically deform the beam.

210 MPa < Stress = force / 0.00081m.

210×10^6 = force / 0.00081 m. $210\times10^6 \times 0.00081$ = force

< 170100 N. **[2]**

(iii) Calculate Young's modulus of the material.

Ym = stress / strain   Ym = $\frac{105\times10^6}{500\times10^{-6}}$ = 2.1×10^{11} E **[2]**

Commentary

In part (a) all four responses are correct so all 4 marks are gained.

In part (b)(i) the candidate has carried out the calculation correctly with all values to the correct power of ten. However, the unit given is incorrect. Area is measured in m^2.

In part (b)(ii) the candidate has carried out the correct calculation and assigned an appropriate unit to the final value so both marks are gained.

Part (b)(iii) the candidate has carried out the calculation correctly with all values to the correct power of ten. However, the unit given is incorrect. Young Modulus is measured in Pa or N m^{-2}.

Including the correct units in all calculations would make this a 'full mark answer'.

Question 5

5 (a) Define 'viscosity' of a fluid.

Viscosity is a fluid's ability to resist shear forces. [1]

(b) Fluid flow is described as being either laminar or turbulent.

Explain the difference in the behaviour of particles in laminar and turbulent flow.

Laminar flow: particles move in layers/parallel (to direction of flow).

Turbulent flow: particle movement is irregular/chaotic/unpredictable. [2]

(c) Fig. 6 shows a cross section of a tank filled with water, mercury and air.

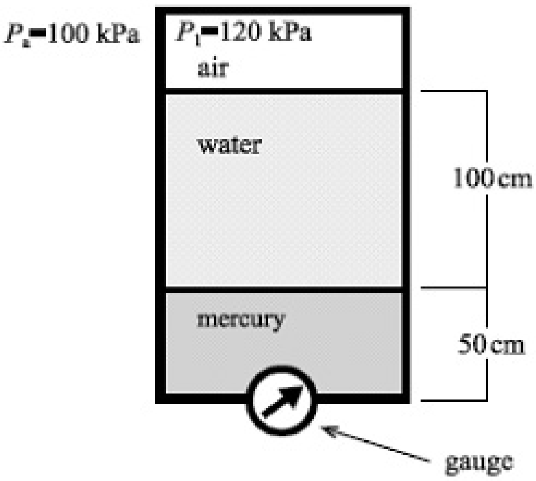

Fig. 6

Density of water $\rho_w = 1000\text{kgm}^{-3}$
Density of mercury $\rho_m = 13500\text{kgm}^{-3}$
Air pressure in the tank = 120kPa

(i) Calculate the hydrostatic pressure due to the column of water in the tank.

$P_w = \rho_w g\, h_w = 1000 \times 9.8 \times h$

$P_w = 1000 \times 9.8 \times 1 = 9800$ Pa or 9.8 kPa [2]

(ii) **Calculate the hydrostatic pressure due to the column of mercury in the tank.**

$P_m = \rho_m g h_m = 13500 \times 9.8 \times 0.5$

$P_m = 6.6 \times 10^4$ Pa (or 66 kPa) **[2]**

(iii) **What is the absolute pressure at the gauge?**

$P_g = 120 + 9.8 + 66 = 196$ (kPa) **[1]**

(iv) **If the atmospheric pressure is 100kPa, what is the gauge pressure?**

$P_g = P_{abs} - P_{atm}$

$P_g = 196 - 100 = 96$ (kPa) **[2]**

Mark scheme guidance

5 (a)

Ignore 'flow'.

5 (b)

IGNORE 'smooth'.

ACCEPT 'random'.

Reference to particles needed at least once for both marks.
Two opposite statements – max one mark awarded.

5 (c) (i)

Substitution of correct values of ρw and g and a value of height for first mark.
Unit required.
Lose one mark for POT errors.

5 (c) (ii)

Correct substitution required.

Unit required but penalise only once in part (c).
Lose one mark for POT errors, but allow same POT error ecf from part (i).

5 (c) (iii)

Accept 200 kPa (to 2 sf). Unit not required but consistent values must be added together.
Allow ecf from part (i) and (ii).

5 (c) (iv)

First mark for quoting equation or correct substitution.
Unit not required but consistent values must be subtracted.
Allow ecf from part (iii).

Examiners comments

5 (a)

Many candidates had difficulties defining 'viscosity'. Many attempted to describe a viscous liquid rather than viscosity, and many explanations were vague.

5 (b)

Candidates performed slightly better here, but there was often a lack of scientific terminology used.

5 (c)

These were again calculations where there were several errors of units or powers of ten. Some candidates added the height of water to the height of mercury in the calculations. There was also some confusion about the terms absolute pressure and gauge pressure.

Exemplar candidate work

Question 5 - Low level answer

5 (a) Define 'viscosity' of a fluid.

Viscosity of a fluid is how 'dence' the liquid is, ~~the a~~ thickness off the fluid, how tightly compact the molecules are. [1]

(b) Fluid flow is described as being either laminar or turbulent.

Explain the difference in the behaviour of particles in laminar and turbulent flow.

lamier is a constant flow, for example ~~watte~~ water out of a jug.

turbulet flow is seen with a thicker fluid which drops in chunks rather than a solid flow. [2]

(c) Fig. 6 shows a cross section of a tank filled with water, mercury and air.

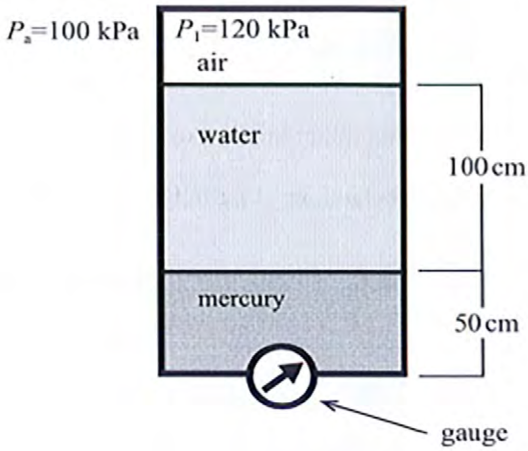

Fig. 6

Density of water $\rho_w = 1000 \text{kgm}^{-3}$
Density of mercury $\rho_m = 13500 \text{kgm}^{-3}$
Air pressure in the tank = 120kPa

(i) Calculate the hydrostatic pressure due to the column of water in the tank.

pressure due to a column of liquid = H × G × d of liquid
= 100cm × ~~9.8~~ 120kpa × 1000kgm⁻³ = 12000000 kpa **[2]**

(ii) Calculate the hydrostatic pressure due to the column of mercury in the tank.

= 50 × 12000000 + 120 × 13500 = 601620000kpa
∴ 6.0162 × 10⁻⁴ kpa **[2]**

(iii) What is the absolute pressure at the gauge?

601620000 + 12000000 = 613620000kpa **[1]**

(iv) If the atmospheric pressure is 100kPa, what is the gauge pressure?

613620100kpa **[2]**

Commentary

The definition in part (a) requires the use of the correct scientific terminology. The only part of this response which is related to viscosity is the word "thickness", but this is too vague a word to use in a definition of viscosity.

In part (b) the question refers to the movement of particles in fluids and this response does not describe how the particles move in either laminar or turbulent flow.

In part (c) the candidate needs to convert all the heights from cm to m in order to carry out the calculations correctly. In part (i) the correct equation has been selected and values for the height and density of the water column substituted, so the first mark is awarded. The value for height remains in cm and also the value for air pressure has been used instead of the gravitational acceleration so the calculation is then incorrect so the second mark cannot be awarded.

In part (ii) the candidate has made the same errors again, so is not penalised twice. Correct values for height and density of mercury are used so both marks are awarded.

In part (iii) the calculation should be the sum of the values calculated in parts (i) and (ii) and the air pressure 120 x 103 Pa.

In part (iv) the calculation is incorrect as the atmospheric pressure should be subtracted from the answer given in part (iii).

Question 5 - Medium level answer

5 (a) Define 'viscosity' of a fluid.

Viscosity is the internal resistance of a fluid, this makes the fluid stick, and hard to get through ✗ **[1]** 0

(b) Fluid flow is described as being either laminar or turbulent.

Explain the difference in the behaviour of particles in laminar and turbulent flow.

In laminar, the particles move in sync, they move together and the same way. turbulent flow moves freely, this makes the fluid more unorganised and it makes it more viscous ✗ **[2]** 0

(c) Fig. 6 shows a cross section of a tank filled with water, mercury and air.

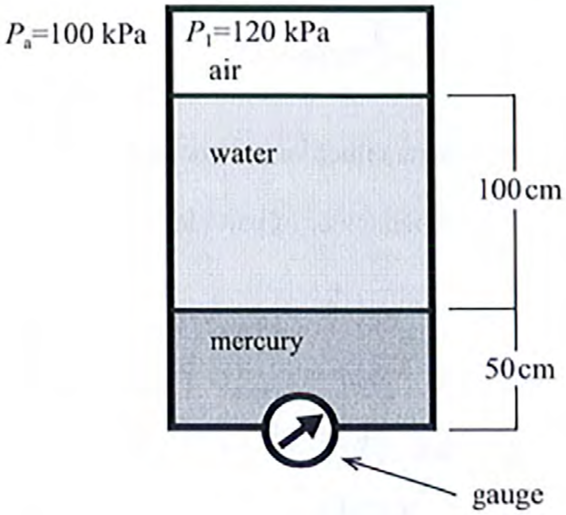

Fig. 6

Density of water $\rho_w = 1000\,\text{kg m}^{-3}$
Density of mercury $\rho_m = 13500\,\text{kg m}^{-3}$
Air pressure in the tank = 120kPa

(i) Calculate the hydrostatic pressure due to the column of water in the tank.

1 x 9.81 x 1000 = 9810 Pa

[2] 2

(ii) Calculate the hydrostatic pressure due to the column of mercury in the tank.

0.5 x 13500 x 9.81 = 66217.5 Pa

[2] 2

(iii) What is the absolute pressure at the gauge?

120000 + 66217.5 + 9810 = 196027.5 Pa **[1]** 1

(iv) If the atmospheric pressure is 100kPa, what is the gauge pressure?

at pre = abs ol pre / gauge pre = 196027.5 / 100000 = gp
gp = 1.96 **[2]** 0

Commentary

In part (a) this response does refer to the resistance, but as there is no mention of shear forces the mark cannot be gained.

In part (b) the description of laminar flow does refer to particles, but it is too imprecise. "…the same way" is not a good enough explanation for "parallel". The description of turbulent flow does not state that particles move in an unorganised way and the mention of increasing viscosity is not relevant so the marks cannot be awarded.

In part (c) the calculations for the first three sections are all correct. The candidate has correctly converted the heights from cm to m, and used the correct values for density and all the final values have units. The first five marks here are all gained. In part (iv) the candidate has carried out an incorrect calculation so does not gain either mark.

Question 5 - High level answer

5 (a) Define 'viscosity' of a fluid.

A ~~[illegible]~~ Fluids ability to resist sheer forces (e.g Friction) **[1]**

(b) Fluid flow is described as being either laminar or turbulent.

Explain the difference in the behaviour of particles in laminar and turbulent flow.

Turbulant flow is where the particles move in irregular patterns whereas in laminar they all ~~[illegible]~~ move in uniform straight movements **[2]**

(c) Fig. 6 shows a cross section of a tank filled with water, mercury and air.

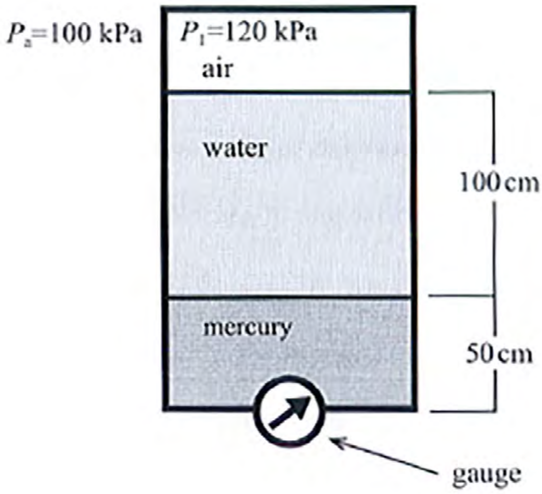

Fig. 6

Density of water ρ_w = 1000 kg m^{-3}
Density of mercury ρ_m = 13500 kg m^{-3}
Air pressure in the tank = 120 kPa

(i) Calculate the hydrostatic pressure due to the column of water in the tank.

~~hx~~ hgρ = 1 × 9.81 × 1000

= 9810 Pa ✓✓ **[2]** 2

(ii) Calculate the hydrostatic pressure due to the column of mercury in the tank.

hgρ = 0.5 × 9.81 × 13500

= 66,217.5 Pa ✓✓ **[2]** 2

(iii) What is the absolute pressure at the gauge?

~~100 + 120 + 9810~~ **[1]** 0

100,000 ✗ + 120,000 + 9810 + 66,217.5 = 296,027.5 Pa

(iv) If the atmospheric pressure is 100 kPa, what is the gauge pressure?

~~gauge - absolute~~

absolute - atmospheric = gauge pressure **[2]** 2

296,027.5 - 100,000 = 196,027.5 Pa

Commentary

In part (a) the candidate has defined viscosity correctly so gains the mark.

In part (b) the candidate's description of turbulent flow is correct with reference to particles moving in an irregular way. However, the description of laminar flow is not good enough; the terms "…uniform straight movement" does not necessarily mean the particles move parallel to one another.

The first two calculations are correct, and the candidate has converted the heights from cm to m, and used correct values for density so the first four marks are all gained.

The calculation in part (iii) is incorrect. The candidate has added an extra term – the atmospheric pressure so does not gain the mark.

In part (iv) the candidate has correctly subtracted the atmospheric pressure from the (incorrect) value for absolute pressure calculated in part (iii) to give a value for gauge pressure and gained both marks.

Question 6

6 A thermally insulated rigid box shown in Fig. 7 contains air at 12°C and pressure P_1=100 kPa.
The internal dimensions of the box are 3m by 3m by 10m.
Heat is supplied to the interior of the box at 1500 W.

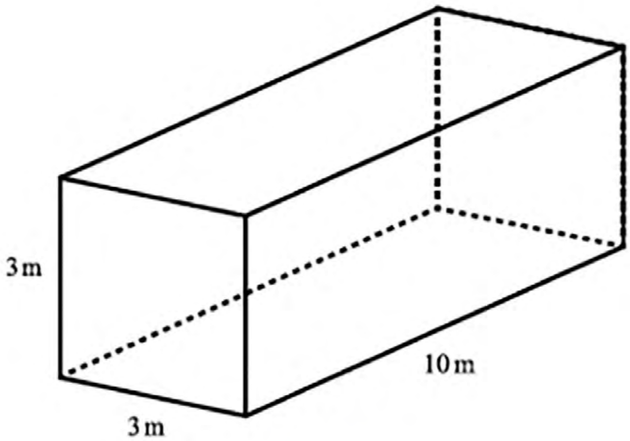

Fig. 7

Specific gas constant R_{air} for air is 287 J kg^{-1} K^{-1}.
Specific heat capacity of air c_{air} = 718 J kg^{-1} K^{-1}.

(i) Show that the mass of air in the box is approximately 110kg.

Volume of box = 3 x 3 x 10 = 90 m^3;
Conversion of 12 °C to 285 K;

Use of $PV = m\mathrm{R}T$; $m = PV/\mathrm{R}T$;

m = (100 x 10^3) x 90)/(287 x 285) [= 110 kg]

[4]

(ii) What is the air pressure in the box once the temperature reaches 300K?

EITHER: Use of $P_1/T_1 = P_2/T_2$ rearranged to give $P_2 = P_1 T_2/T_1$;
P_2 = (100 x 10^3) x 300/285 = 1.05 x 10^5 <u>Pa</u> (or 105 <u>kPa</u>)

OR: Rearrange $PV = m\mathrm{R}T$ to give $P = m\mathrm{R}T/V$;
P = (110 x 287 x 300)/90 = 1.0^5 x 105 <u>Pa</u> (or 105 <u>kPa</u>)

[2]

(iii) Calculate the energy which needs to be supplied to the box to heat the air inside to 300K.

ΔT = 300 - 285 = 15 K;
Energy = $m\, c_v \Delta T$ = 110 x 718 x 15 = 1.2 x 10^6 J

[2]

(iv) **How long will it take to heat up the air to 300K?**

Power = energy/time; time = $1.2 \times 10^6/1500$;

Time = 800 s (= 13 minutes = 0.22 hours)

[2]

Mark scheme guidance

6 (i)

Calculation of volume.
Conversion of temperature to K. If T remains in °C max 2 marks can be awarded.
Correct rearrangement of equation must be shown, but can be after values have been substituted.
Correct substitution and calculation.
No mark for final value as this is a 'show that' question.

6 (ii)

ACCEPT 1.1×10^5 Pa (to 2 sf)
Do not accept ecf of other values for m. Unit required.
Lose one mark for POT errors.
Use of temperatures in °C can score max 1 mark for correct rearrangement. [P = 2500 Pa]

6 (iii)

Correct change in temperature.
Correct substitution and calculation. Ignore unit.
Only allow ecf of an incorrect temperature change. [if T1 = 12, then $\Delta T = 288$ and $E = 2.3 \times 10^7$ J; award 1 mark]

6 (iv)

Substitution of values into equation. Allow ecf of energy from part iii).
Unit required.
Accept 8×10^2 s (1sf).

Examiners comments

6 (i): In a 'show that' question candidates are expected to show all their working to gain full credit and some candidates did not do this clearly. Most candidates were able to calculate the volume of the box but then got stuck and they did not use the correct equation. Some candidates were unable to rearrange the equation and some candidates did not convert the temperature into Kelvin, although this was better than in the previous series.

6 (ii): Some candidates did not show working in this question so may not have gained any credit for an attempt to use the correct equation. Again there were some candidates who did not use temperatures in Kelvin.

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