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OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Wednesday 13 January 2021 – Morning

Level 3 Cambridge Technical in Engineering

05822/05823/05824/05825/05873

Unit 2: Science for engineering

Time allowed: 1 hour 30 minutes plus your additional time allowance

You must have:

the Formula Booklet for Level 3 Cambridge Technical in Engineering (with this document)

a ruler (cm/mm)

a protractor

a scientific calculator

Please write clearly in black ink.

Centre number								
Candidate number								
First name(s)								
Last name								
Date of birth	D	D	M	M	Y	Y	Y	Y

READ INSTRUCTIONS OVERLEAF

INSTRUCTIONS

Use black ink. You can use an HB pencil, but only for graphs and diagrams.

Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.

Answer ALL the questions.

Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

Give your final answers to a degree of accuracy that is appropriate to the context.

The acceleration due to gravity is denoted by $g\,\mathrm{m\,s^{-2}}$. When a numerical value is needed use $g = 9.8$ unless a different value is specified in the question.

INFORMATION

The total mark for this paper is 60.

The marks for each question are shown in brackets [ ].

ADVICE

Read each question carefully before you start your answer.

Answer ALL the questions.

1 (a) Name the measuring instrument used to measure:

(i) mass

______________________________ **[1]**

(ii) electric current

______________________________ **[1]**

(b) Define 'intrinsic error'.

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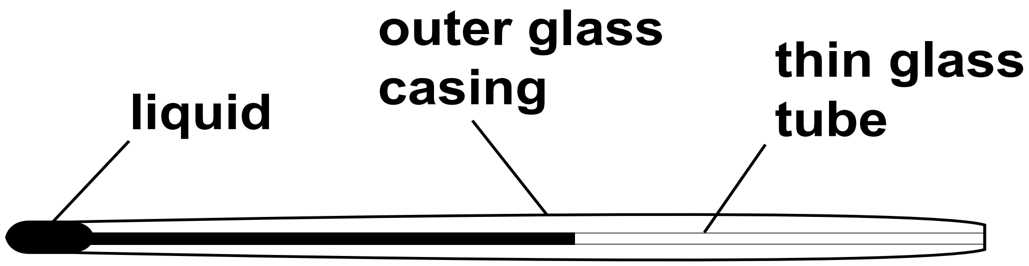
______________________________ **[1]**

(c) A thermometer is made using liquid sealed into a thin glass tube inside an outer glass case, as shown in Fig. 1.

Fig. 1



Explain how to calibrate this thermometer using a different, accurate thermometer.

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____ [3]

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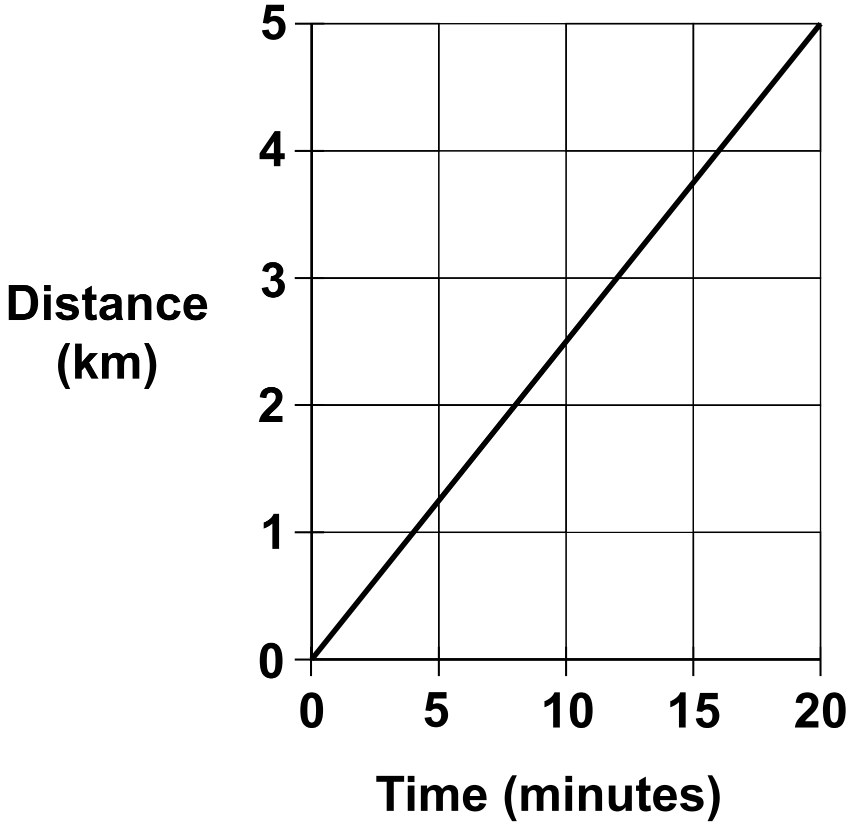
2 A cyclist travels from home to work.
Fig. 2 shows a distance–time graph for the journey.

Fig. 2



(a) (i) Determine the speed of the cyclist in km min^{-1}.

speed = ________________________________ km min^{-1} [2]

(ii) Convert this speed into ms^{-1}.

speed = ________________________________ ms^{-1} [2]

(b) The cyclist returns home at the end of the day.

(i) Explain why the distance travelled by the cyclist is 10 km but their displacement is zero.

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____ [2]

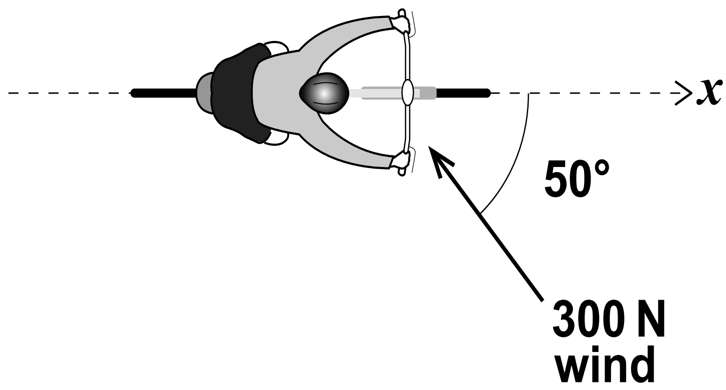
(ii) The cyclist produces an average forward force of 800 N.

Calculate the work done by the cyclist in one day. Include the unit in your answer.

work done = ________________________________ [3]

(c) The next day there is a strong wind in the direction shown in Fig. 3.

Fig. 3



Calculate the component of the wind force in the direction marked x.

wind force component = ________________________ N [2]

3 The engine control unit (ECU) in a car can be damaged by static electricity.

The circuits inside the ECU can be protected with a 0.8 μF capacitor.

(a) Define capacitance.

____

____ [1]

(b) The 0.8 μF capacitor is uncharged. A static discharge delivers 2×10^{-5} C into the capacitor.

Calculate the potential difference across the capacitor.

potential difference = ______________________ V [3]

(c) The capacitor is made from two sheets of foil 0.5 mm apart.

Calculate the electric field strength between the foil sheets when the potential difference across the capacitor is 20 V.

field strength = ______________________ $V m^{-1}$ [2]

(d) The capacitor discharges and a small current flows into the ECU.

To prevent damage to the ECU, the discharge current must flow for at least 1 s.

Calculate the resistance required to make sure the current flows for at least 1 s.

resistance = ______________________________ Ω [3]

4 Many houses in the UK are built using bricks.

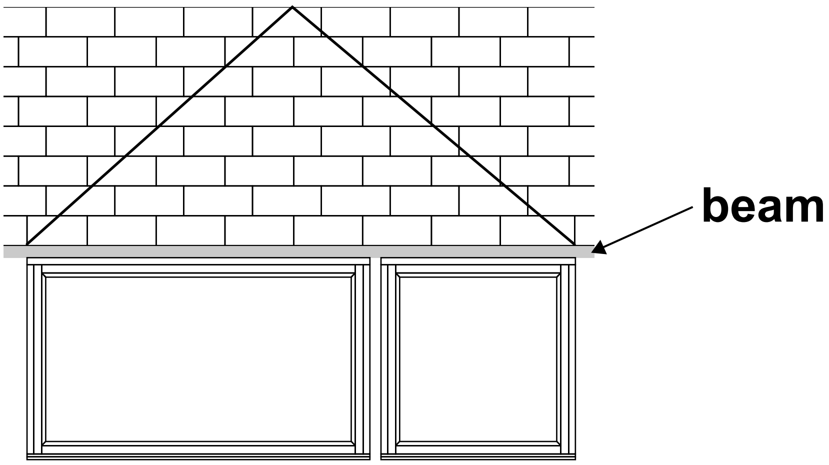
(a) Circle the correct word from the choice of three in each box to complete the sentence. [2]

Brick is a ceramic which is	malleable strong tough	
when subjected to	compressive tensile torsional	forces.

(b) **Bricks above a window opening are laid on a steel beam.**

Structural engineers calculate the load on the beam as the weight of the brickwork in the triangular area above the window as shown in Fig. 4.

Fig. 4



(i) **Each brick has mass 3.5 kg.**

Show that the load on the beam above the window in Fig. 4 is approximately 1100 N.

Use the space below. [3]

(ii) The table in Fig. 5 shows the maximum load of three different beams from a given manufacturer.

Fig. 5

Maximum load (N)		
Beam 1	Beam 2	Beam 3
500	1400	2000

Explain which beam is most suitable for the window opening shown in Fig. 4.

____

____

____ [2]

(iii) If an unsuitable beam is used, the beam may bend over time. This is a form of plastic deformation.

Describe, using ideas about atoms, how plastic deformation happens.

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____ [3]

(iv) To find the maximum load for each beam the manufacturer used destructive testing.

Give ONE reason why destructive testing was used to find the maximum load.

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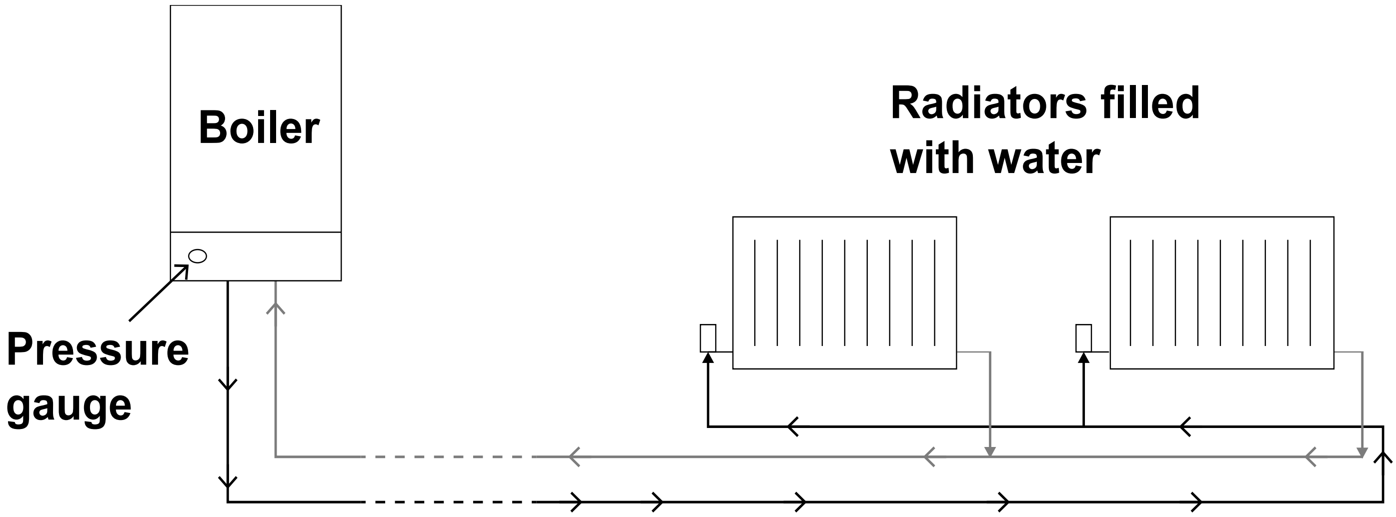
____ [1]

5 Fig. 6 shows a central heating system. Water is heated by a boiler and flows through radiators which transfer energy to warm the surroundings.

Fig. 6



(a) The pressure reading shown on the boiler is gauge pressure.

(i) Explain the difference between gauge and absolute pressure.

____

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____ [2]

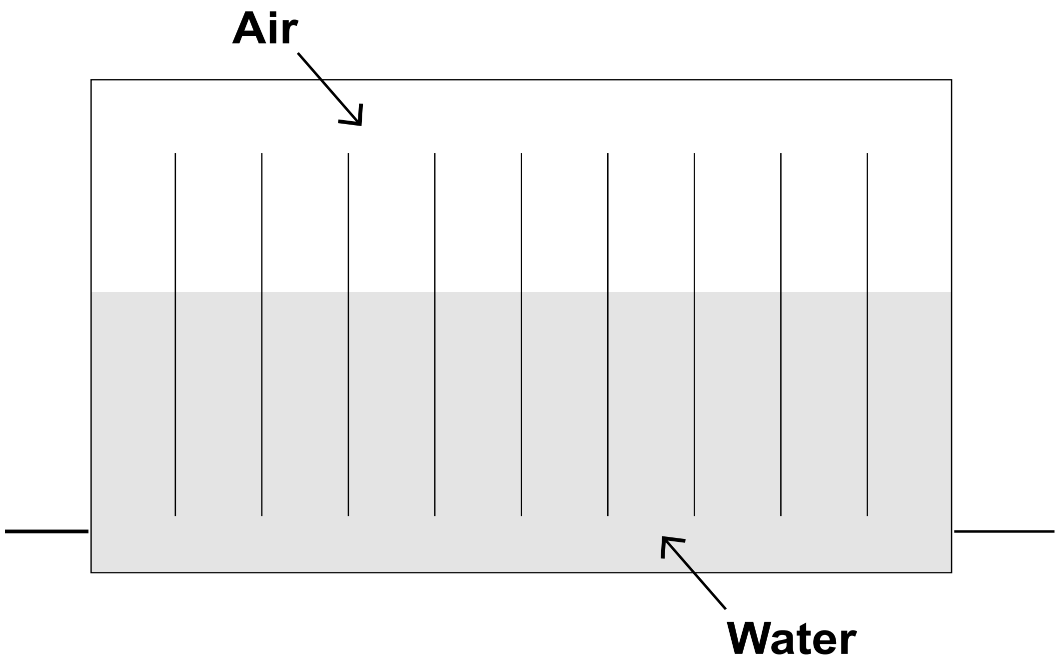
(ii) The pressure gauge reads 1.5 bar (150 kPa). Atmospheric pressure is 1 bar (100 kPa).

State the absolute pressure in the central heating system.

absolute pressure = ________________________ kPa [1]

(b) After maintenance to the system, one of the radiators contains some air as shown in Fig. 7.

Fig. 7



(i) At 15°C, the air has an absolute pressure of 220 kPa.

The temperature of the system increases from 15°C to 55°C.

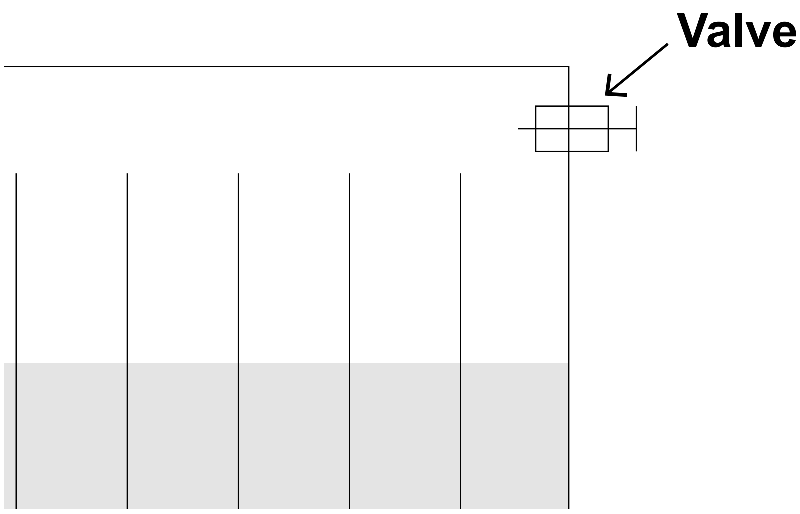
Calculate the new absolute pressure of the air.

absolute pressure = ______________________ kPa [3]

(ii) There is a valve in the top of the radiator. There is a force on the valve due to the air inside the radiator.

Draw an arrow on Fig. 8 below to show the direction of the force. [1]

Fig. 8



(iii) The valve is opened.

Explain why the air in the radiator comes out through the valve.

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____ [2]

(iv) As the air comes out, the water moves up to fill the space.

Explain what will happen to the reading on the boiler's pressure gauge.

____

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____ [2]

(c) The radiators must supply 11000 J of heat energy per second to keep the house at a constant temperature.

Determine the minimum required power output of the boiler and give the unit.

Assume no energy enters the system and no work is done by the system.

power output = ______________________________ [2]

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6 (a) Describe how the internal energy of an object is made up.

Use your ideas about particles.

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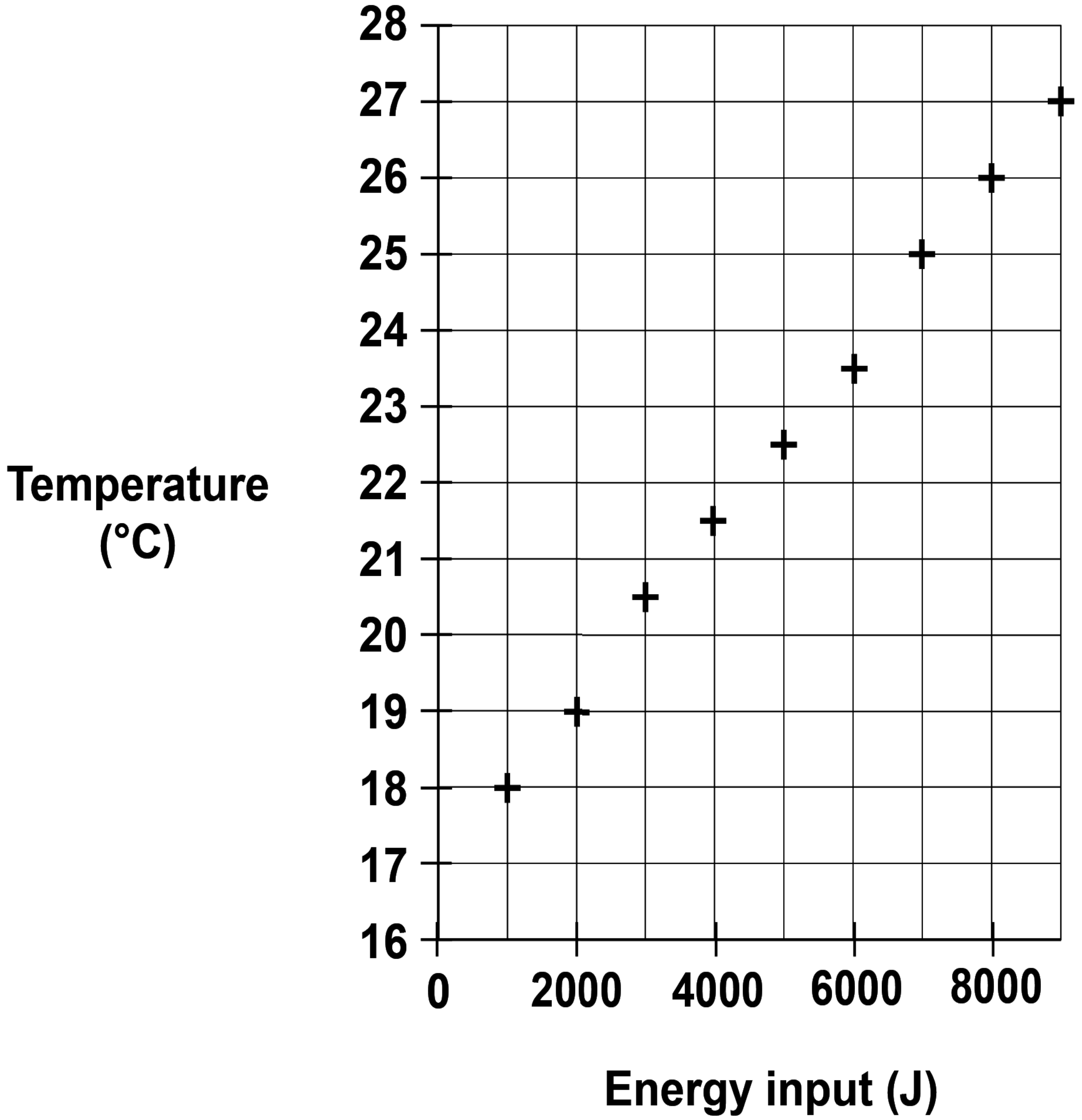
____ [2]

(b) A student is attempting to measure the specific heat capacity of aluminium.

Fig. 9 shows a graph of the results.

Fig. 9



(i) Draw a line of best fit on Fig. 9. [1]

(ii) Determine the specific heat capacity of aluminium from the gradient of the graph.

The student used an aluminium block of mass 1.1 kg.

specific heat capacity = ______________________ J kg^{-1} K^{-1} [3]

(iii) The student read her thermometer to ±0.5 °C.

Calculate the relative error in the measurement of temperature when energy input was 1000 J.

relative error = ______________________________ [2]

(iv) Explain why there is no change in latent heat during the experiment.

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____ [2]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined pages. The question numbers must be clearly shown – for example, 1(c) or 6(a).

Version 3