CAMBRIDGE TECHNICALS

OCR
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CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

ENGINEERING

05822–05825, 05873

Unit 2 January 2023 series

Version 1

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

Unit 2 series overview

Candidates attempted all the questions and there was a good spread of marks across the ability range.

Candidates seemed to find the first two questions in the paper, covering LO1 and LO2, easier and more accessible. This may have been due to the subject matter being more familiar to them.

Many of the calculations were well answered and there were fewer candidates omitting to deal with powers of ten. Some candidates did not seem familiar with some of the equations from the formula booklet. In this year's paper the more challenging questions covered capacitor discharge and LO4.

Candidates found it more difficult to write explanations and complete definitions clearly using the correct scientific terminology.

Candidates who did well on this paper generally did the following:	Candidates who did less well on this paper generally did the following:
• laid out calculations clearly • used appropriate scientific terminology correctly in explanations • labelled and interpreted diagrams carefully.	• had difficulty selecting or rearranging equations in calculation questions • did not use scientific terminology precisely.

Question 1 (a)

1 (a) Draw lines to match the SI prefix to the corresponding power of ten.

One has been completed for you.

centi (c)	10^{-9}
mega (M)	10^{-3}
milli (m)	10^{-2}
nano (n)	10^{6}

[2]

Most candidates answered this question well.

Question 1 (b) (i) and (ii)

(b) A measurement of the diameter of a bolt is 1.565 cm.

The desired true value is 1.500 cm.

(i) Calculate the absolute error.

absolute error = ... cm **[1]**

(ii) Calculate the relative error.

relative error = ... **[2]**

Most candidates correctly calculated the absolute error and then went on to use it correctly to find the relative error. There were only a few mistakes such as dividing by the measured value (1.565) or dividing 1.500 into 1.565.

Question 1 (b) (iii)

(iii) Four more measurements are taken. The mean (average) value is 1.564 cm.

	1	**2**	**3**	**4**	**5**	**Mean ($\bar{x}$)**
Diameter / cm	1.565	1.563	1.566	1.565	1.561	1.564
$x - \bar{x}$						
$(x - \bar{x})^2$						

Calculate the standard deviation.

You may use the rows in the table for your working.

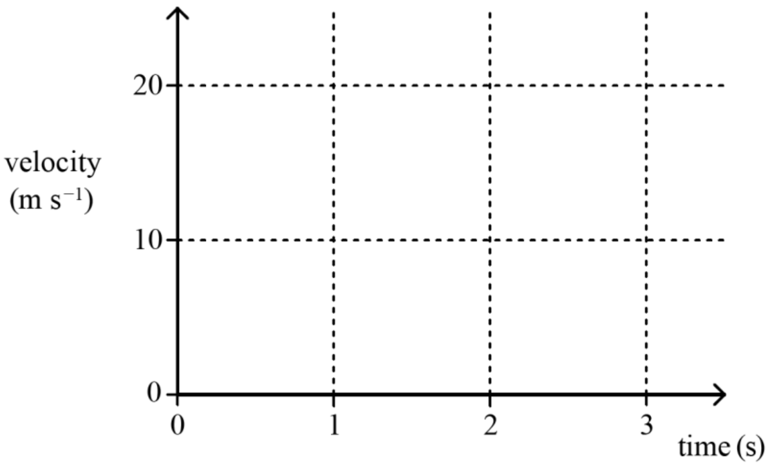
standard deviation = ... **[4]**

Many candidates correctly calculated the standard deviation using a calculator without using the table at all, which gained them full credit. Some candidates completed the table with correct values for $x - \bar{x}$ and $(x - \bar{x})^2$. Some candidates forgot to take the square root of the mean value of $(x - \bar{x})^2$.

Question 2 (a)

2 **(a)** A car sets off from rest with a constant acceleration of 5.0 m s^{-2} for 3.0 s.

Sketch this motion on the velocity–time axes below.



[2]

Most candidates drew an upwards sloping straight line on the graph. A few candidates drew a line from (0,0) to (3,20) instead of (3,15). Some candidates drew a horizontal line showing a constant velocity of 5 m s^{-1}, showing a confusion between acceleration and velocity.

Question 2 (b)

(b) A second car sets off from rest with a constant acceleration of 4.0 m s^{-2}.

Calculate the speed of this car after it has travelled 18 m.

speed = ... m s^{-1} **[3]**

Although many candidates correctly answered this question using $v^2 = u^2 + 2as$, there were many incorrect calculations such as acceleration ÷ distance, or acceleration × distance.

Assessment for learning

The equations of motion with constant acceleration are listed in the formula booklet. Candidates should be familiar with these equations and know which one to use in different scenarios.

Question 2 (c) (i), (ii) and (iii)

(c) Later, this second car is on a motorway travelling at a constant speed of 35 m s^{-1}.

(i) Calculate the time it takes for this car to travel 70 m.

time = ... s **[1]**

(ii) When travelling at this constant speed, the (forward) driving force is 4 kN.

Calculate the work done by this force when the car travels 70 m.

work done = ... J **[2]**

(iii) Calculate the minimum engine power required.

Use your answers from parts **(c)(i)** and **(c)(ii)**.

power = ... W **[2]**

Most candidates correctly calculated both the energy and the power in this question. There were some power of ten errors as candidates omitted to convert 4 kN to 4000 N. A few candidates gave an incorrect value for time in part (i) and some multiplied the energy by the time to find power.

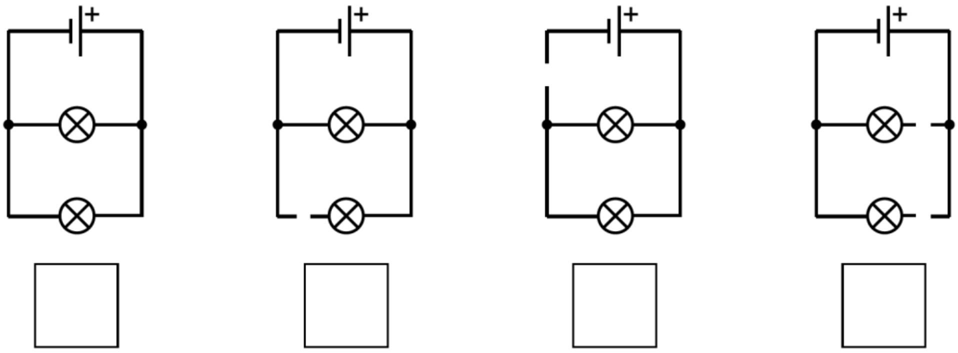
Question 3 (a) (i)

3 An electric car has two headlamps.

(a) Only one of the headlamps is lit. The other headlamp has a failed bulb.

(i) Which circuit best represents this scenario?

Tick **one** box.



[1]

Most candidates answered this question correctly.

Question 3 (a) (ii)

(ii) The resistance of the working bulb is 48 Ω.

The potential difference across the bulb is 12 V.

Calculate the current in the bulb.

current = ... A **[2]**

This calculation was well answered. Only a few candidates did not rearrange the equation correctly to divide the potential difference by the resistance to find the current.

Question 3 (a) (iii)

(iii) The failed bulb is replaced with one of a different type.

The new bulb has resistance 24 Ω.

Calculate the total resistance of the two bulbs in parallel.

resistance = ... Ω **[3]**

Many candidates correctly used the equation to find resistance in parallel circuits. Some candidates omitted the final step of finding the reciprocal of $\frac{1}{48} + \frac{1}{24}$ and gave the answer 0.0625.

Checking a numerical answer makes sense

The total resistance of two resistors in parallel should be smaller than either of the individual resistances, but it should be of similar order of magnitude.

The incorrect answer 0.0625 Ω is smaller than 24 Ω, but it is not of the same order of magnitude.

Question 3 (b)

(b) When there is a current in the bulb, there is a difference between the drift velocity and root mean square (r.m.s.) speed of the electrons.

Which column of the table correctly represents their size relative to one another?

Tick **one** box.

drift velocity	low	low	high	high
r.m.s. speed	low	high	low	high
	☐	☐	☐	☐

[1]

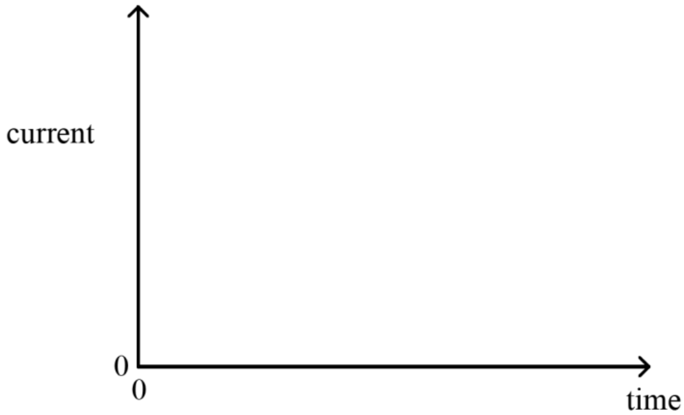
This question was not well answered. Many candidates suggested that the drift velocity was high so the common responses were the third and fourth column.

Question 3 (c) (i)

(c) One limitation of electric cars is the amount of energy that can be stored in the battery.

A proposed alternative power source is a capacitor with a very large capacitance (sometimes called a supercapacitor). A fully charged supercapacitor is tested by discharging through a resistance.

(i) Sketch a graph on the axes below showing how the current in the circuit changes over time.



[2]

Many candidates were unable to draw an exponential curve for showing the discharge of a capacitor. Some candidates recognised that the current would go down over time, but either drew a straight line with negative gradient or did not start the curve at the current axis. There were several graphs with positive gradient.

Question 3 (c) (ii)

(ii) The supercapacitor is fully charged at a potential of 24 V. Its capacitance is 85 F.

The resistance in the discharging circuit is 20 Ω.

Calculate the potential difference across the capacitor after 6 minutes (360 s).

potential difference = ... V **[3]**

Most candidates did not use the correct exponential equation from page 15 of the formula booklet. There were many responses which attempted to use some combination of $V = IR$, $Q = It$, etc. The candidates who did select or remember the correct equation managed to manipulate the equation correctly to give the correct answer.

Question 4 (a)

4 **(a)** Complete the sentence below by writing the correct words in the spaces.

Each word can be used once, more than once or not at all.

attractive **gravitational** **magnetic** **repulsive** **resultant**

The .... force between two atoms in a crystal is the

vector sum of .... and .... forces.

[3]

This question was not well answered. There was a variety of incorrect responses.

Question 4 (b)

(b) State Hooke's law.

....

....

....

.... **[2]**

Several candidates were able to recall that Hooke's law is the extension of a material is proportional to the load, but often they did not include that this was only up to a limit of proportionality or elastic limit. Some candidates described elastic behaviour, so they remembered that this did relate to material properties. However, there were also a number of candidates who described other physical laws or rules.

Question 4 (c)

(c) **Fig. 1** shows the net force–separation graph for two adjacent atoms in a crystal.

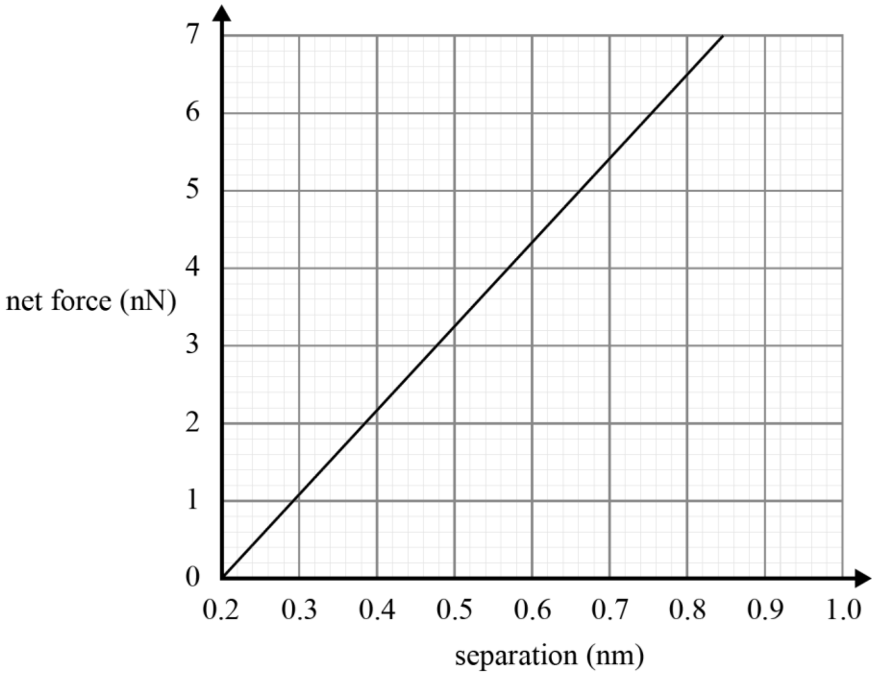


Fig. 1

Calculate the energy stored when the separation of the atoms is increased from 0.2 nm to 0.8 nm.

energy stored = ... J **[4]**

Many candidates used a correct method to calculate energy stored. Common mistakes included using 0.8nm as the extension and omitting the 10^{-9} for both the force and the separation, hence getting a power-of-ten error in their final answer. There were also a number of candidates who used an incorrect equation to calculate the energy, omitting the factor of ½, as the force is not constant throughout the separation.

Question 5 (a)

5 Gases and liquids are both fluids, but they can behave differently.

(a) State what happens to the volume and density of fluids when increased pressure is applied.

Write the words 'increases', 'decreases' or 'stays the same' in each box.

	Volume	**Density**
Gas		
Liquid		

[4]

This question was not as well answered as expected. In the specification 5.1 Fluids at rest, candidates should understand the main differences between gases and liquids. Gases are compressible whereas liquids are not, and that the more a gas is compressed, the smaller its volume will become, and hence density will increase.

Question 5 (b)

(b) **Fig. 2** shows the airflow across an aerofoil section (aeroplane's wing).

Draw lines to join the labels (streamline, laminar flow and turbulent flow) to the correct parts of the diagram.

The wing has been labelled for you.

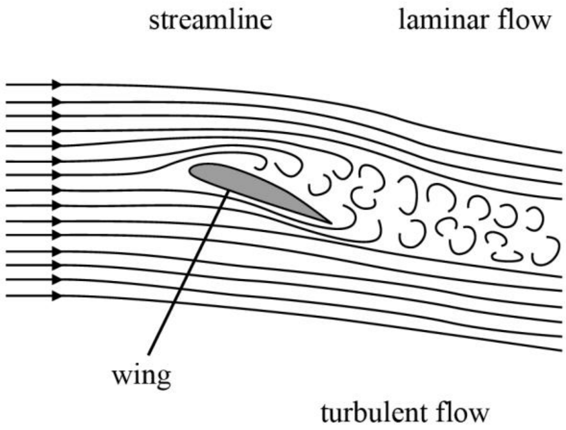


Fig. 2

[3]

Most candidates showed understanding of turbulent and laminar flow, with a small number of candidates getting them the wrong way around. Some candidates could have been more accurate with their label lines, as the line to a streamline often ended in the space between the streamlines.

Question 5 (c)

(c) List these three fluids in order of increasing viscosity.

detergent **treacle** **water**

least viscous ....

....

most viscous ....

[1]

There were a variety of responses to this question. Some candidates answered it correctly, while others had the order reversed. A few candidates thought that detergent was more viscous than treacle.

Question 5 (d)

(d) Water has dynamic viscosity 1.05×10^{-3} Pa s and density 1030 kg m^{-3}.

Calculate the kinematic viscosity.

kinematic viscosity = ... $m^2 s^{-1}$ **[2]**

This question was not well answered. Most candidates just multiplied the two numbers together. Those candidates who recalled that kinematic viscosity is the ratio of dynamic viscosity and density were able to calculate the correct answer here.

Question 6 (a)

6 **(a)** State Boyle's law.

....

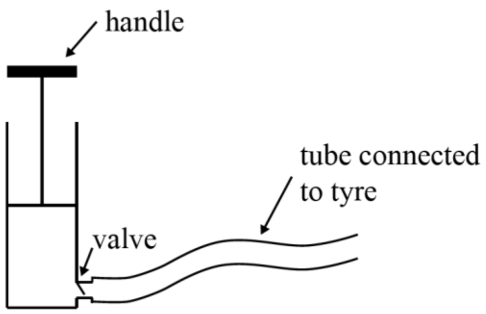
.... **[2]**

Many candidates correctly stated that Boyle's law related to pressure and volume of a gas, but most did not mention that it is only true for an ideal gas at constant temperature. The equation for Boyle's law is stated in the formula booklet so candidates were expected to write the relationship out in words, not just copy the symbol equation from the formula booklet.

Question 6 (b) (i)

(b) A cyclist pumps up a tyre.

A diagram of the pump is shown below.



When the cyclist pushes down on the handle, the pressure inside the pump increases until it is the same as the pressure in the tyre. The valve opens to let air into the tyre.

Initially the volume of air in the pump is 50 cm^3 and the pressure is 100 kPa. The pressure in the tyre is 150 kPa.

The cyclist pushes down on the handle.

(i) Calculate the volume of air in the pump just as the valve opens.

volume = ... cm^3 **[3]**

Many candidates were able to calculate the volume correctly by using the equation for Boyle's law. Some candidates struggled with rearranging the equation to find the required value.

Question 6 (b) (ii)

(ii) The cyclist keeps pumping more air into the tyre.

Explain why the cyclist requires more and more effort as they continue to inflate the tyre.

....

....

....

....

.... **[2]**

Candidates sometimes struggle with explanation questions. Most candidates were able to explain that the pressure inside the tyre would increase, but did not go on to explain that in order to pump more air into the tyre the pressure from the pump would need to be greater than the pressure inside the tyre.

Question 6 (b) (iii)

(iii) The cyclist uses the pump at a faster rate and the air in the pump gets hotter.

Calculate the final temperature of the air in the pump given the following data.

Initial conditions: volume 50 cm^3, pressure 100 kPa, temperature 293 K

Final conditions: volume 25 cm^3, pressure 250 kPa

temperature = ... K **[3]**

Those candidates who correctly selected the combined gas law equation from the formula booklet did well in this question, as long as they were able to rearrange the equation to find the temperature. In this question, as all three variables are given in the question, candidates should realise that they should not use the other gas laws.

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