CAMBRIDGE TECHNICALS

OCR
Oxford Cambridge and RSA

Examiners' report

CAMBRIDGE TECHNICALS LEVEL 3 (2016)

ENGINEERING

OCR Level 3 Cambridge Technical in Engineering Principles

Certificate: 05822

OCR Level 3 Cambridge Technical in Engineering

Extended Certificate: 05823

Foundation Diploma: 05824

Diploma: 05825

Extended Diploma: 05873

Unit 2 Summer 2025 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 Teach Cambridge.

Unit 2 series overview

Unit 2: Science for Engineering is an externally assessed unit of study which is a mandatory part of all the routes through the Cambridge Technical Level 3 Engineering qualifications.

It consists of six questions covering all the learning objectives of the specification using a range of contexts including shipping, fan heating, lift cables, rowing and gasometers. The latter may have been something novel for candidates on this paper.

In this series candidates seemed to perform better on questions on kinematics (Question 2) and electrical circuits (Question 3) and the use of the gas laws (Question 6). They performed in general less well on mechanical properties of materials (Question 4 (a)). Some candidates do not fully understand what the stiffness or Young Modulus actually measures and many did not understand what is meant by the term 'strain energy'.

In numerical questions, candidates seem to be better at writing down the equation as the first step but do still need to lay out the working in a logical method. This helps them make fewer mistakes and is easier for the examiner to follow what they have done. That way they are more likely to gain marks even if they do not have a fully correct response.

Candidates fared less well when they had to state a definition of explain scientific phenomena. They should try to use terminology correctly and structure their response in a logical format.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• recalled definition and were able to write them down correctly • laid out calculations clearly.	• were unable to interpret graphs correctly • used poor terminology, particularly in trying to explain the Young Modulus of steel • were confused about temperatures in °C and Kelvin.

Question 1 (a)

1

(a) Draw lines to match the SI prefixes with their values.

giga (G) •	• 10^{-9}
kilo (k) •	• 10^{-6}
micro (μ) •	• 10^{3}
nano (n) •	• 10^{9}

[3]

This was a relatively straightforward start to the paper for most candidates who got full marks. There was some confusion was between giga, 10^9 and nano, 10^{-9}, and between micro, 10^{-6} and nano, 10^{-9}.

Question 1 (b) (ii)

(ii) The student's result for the wavelength is 541 nm.

The true value of the wavelength for this laser is 557 nm.

Calculate the percentage error in the student's result.

Percentage error = ... % **[2]**

Some candidates struggled with calculating the correct percentage, often this was due to the use of an incorrect denominator and not showing their working.

Question 2 (a)

2

(a) Complete the definition of the newton below.

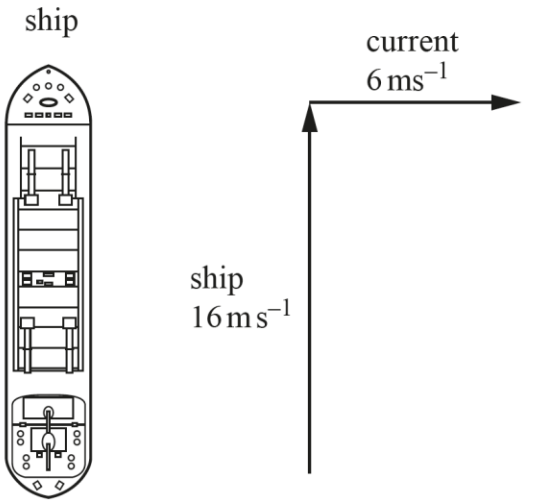
One newton is the force required to ....

.... **[3]**

The definition of the newton is part of the specification within learning objective 2, but many candidates were unable to correctly answer this question. Many candidates did refer to a force causing a mass to move, but often did not specify the mass as being 1kg. Other candidates just recited the equation force = mass x acceleration, without reference to the unit of force, newton.

Question 2 (b) (i)

(b) A container ship is sailing North at a constant $16\,\mathrm{m\,s^{-1}}$. The ship is experiencing a constant ocean current of $6\,\mathrm{m\,s^{-1}}$ East.



NOT TO SCALE

(i) Calculate the magnitude of the resultant velocity of the ship.

Magnitude of resultant velocity = ... $\mathrm{m\,s^{-1}}$ **[2]**

Most candidates were able to add the two perpendicular vectors together correctly. There were a few candidates who just added the two magnitudes algebraically.

Question 2 (b) (ii)

(ii) Earlier in the journey, the resultant force on the ship was 16.7×10^6 N.

The total mass of the ship including load is 1.6×10^8 kg.

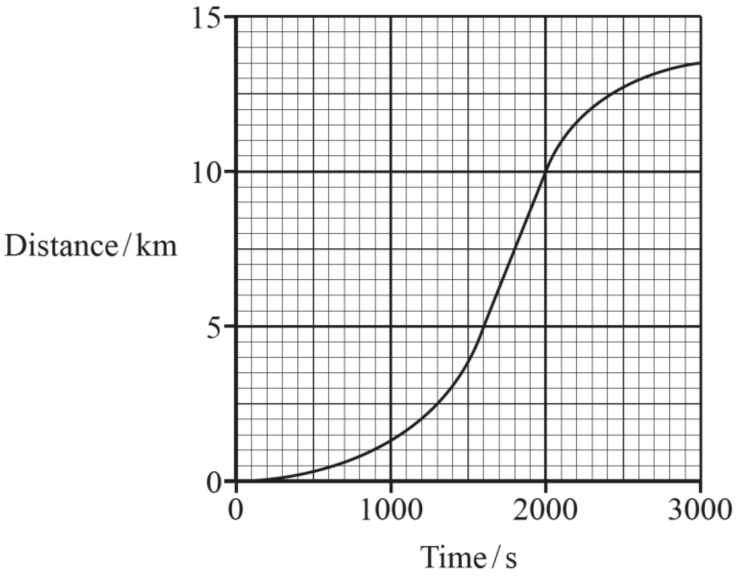
Calculate the acceleration of the ship. Give the unit for your answer.

Acceleration = ... Unit .... **[3]**

This question was answered well with most candidates getting a correct numerical value. More errors were with the unit. Some candidates just put m/s, and another common error was to put m/s^{-2}, so care needs to be used here.

Question 2 (b) (iii)

The graph shows the distance the ship has travelled in the time since leaving port.



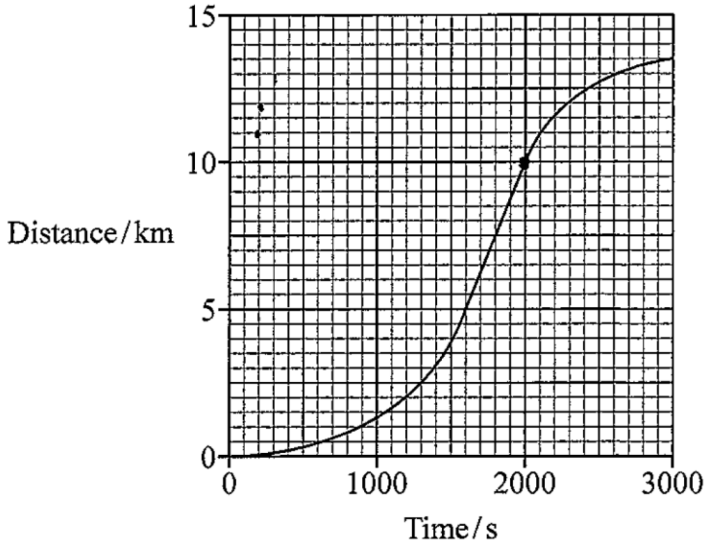
(iii) Use the graph to find the maximum speed of the ship in $m\,s^{-1}$.

Maximum speed = ... $m\,s^{-1}$ **[4]**

Many candidates incorrectly calculated a speed using a pair of coordinates from the graph, typically the end point (3000, 13.5) and gave an answer of 13.5 ÷ 3000 = 4.5 × 10^{-3}, the total distance travelled divided by the total time in km s^{-1}. Some candidates did remember to convert the distance in km to m by multiplying by 1000, but many did not.

Exemplar 1

The graph shows the distance the ship has travelled in the time since leaving port.



~~$s = \frac{1}{2}(u+v)t$~~
~~$13.5 \times 10^3 = \frac{1}{2}(v)3000$~~
~~$13.5 \times 10^3 = 1500v$~~
~~$v = \frac{13.5 \times 10^3}{1500}$~~

(iii) Use the graph to find the maximum speed of the ship in m s^{-1}.

~~$\frac{s-d}{t} = \frac{10 \times 10^3}{2000} = 5$~~

$s = \frac{1}{2}(u+v)t$

$2\left(\frac{s}{t}\right) = u+v$

$2\left(\frac{s}{t}\right) - u = v$

$2\left(\frac{10 \times 10^3}{2000}\right) - 0 = v$
$= 10$

Maximum speed = ~~5~~ 10 m s^{-1} **[4]**

This response gives another fairly typical misconception about how to find the speed from a distance-time graph. This candidate is attempting to use a suvat equation which is inappropriate here as we do not have constant acceleration.

There is some realisation that the steepest section of the graph gives the maximum speed because this candidate changes their mind from using the end point of the graph (3000, 13.5) to the coordinates of a point near the steepest section (2000, 10). They do remember to convert the 10 km to 10 × 103 m.

What this candidate should have done is to use two sets of coordinates from that steepest section of the graph and find the gradient.

Question 3 (a)

3

(a) State Ohm's law.

....

....

....

.... **[2]**

Most candidates were not able to state Ohm's law and the most common response was just to write out the equation V = I R in words or to just substitute 'is directly proportional to' instead of 'equals'. This equation is given in the formula booklet. Of the few candidates who were able to state that potential difference is proportional to current flowing through a resistor, many omitted the part about temperature being constant.

Question 3 (b)

(b) An electric fan heater is used on a building site.

The heater's performance is described using the term **kilowatt-hour**.

State the quantity that can be measured in kilowatt-hours.

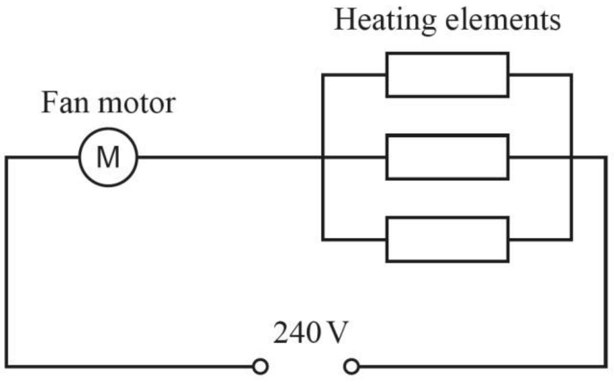
.... **[1]**

A number of candidates correctly stated that the kilowatt-hour is a measure of energy, but many candidates gave the response 'power', and some did not seem to understand the question and gave a numerical value.

Question 3 (c) (i)

(c) The heater contains three identical resistors (heating elements) that turn electrical energy into heat, as well as a fan to blow the hot air into the room.

The circuit diagram for the heater is shown below



Each heating element has resistance 126 Ω.

The current through each element is 1.79 A.

(i) Calculate the power dissipated in **one** heating element.

Power = ... W **[2]**

Most candidates used the correct relationship between power, current and resistance in this question, but some misinterpreted the question and calculated the power dissipated in all three heating elements. Some candidates attempted to use P=VI but did not consider that some of the potential difference would be used up across the motor.

Question 3 (c) (ii)

(ii) What device could be used to measure the current?

.... **[1]**

This was a relatively straight forward question which most candidates were able to answer correctly. It would be better if they were able to spell scientific terminology correctly. In this paper we did allow misspellings such as Ameter, Ampmeter etc.

Question 3 (d)

(d) The fan motor has resistance $5.0\,\Omega$.

Calculate the total resistance in the circuit.

Resistance = ... Ω **[3]**

Many candidates did manage to use the correct equation to find the combined resistance of resistors in parallel but there were a number who then forgot to then find the reciprocal of the added fractions. Some candidates tried to include the resistance of the motor in the parallel resistor calculation rather than just to add it algebraically.

Question 4 (a)

4 This question is about a steel cable used to suspend a lift in a tall building.

(a) The Young's modulus of steel is very high.
Explain why this makes it a good choice of material for a lift cable.

....

....

....

.... **[2]**

This question was not well answered by the majority of candidates. Many candidates suggested that steel was a good choice of material because of its other properties such as high tensile strength, toughness or ductility. Where candidates suggest that a material can withstand a high amount of stress they need to then clarify what they then mean by 'withstand'. A strong material will withstand a high amount of stress before failure; a material will withstand a high amount of stress without showing much strain; a material with a high elastic limit will withstand a high amount of stress before plastically deforming. They are all very different.

Steel is a versatile material because it has many useful properties in addition to having a high Young Modulus. It is strong, tough, has a hight elastic limit, so candidates need to make sure that they answer the question correctly and stick to points relevant to Young Modulus.

Misconception

There is a misconception that the Young Modulus is related to the elastic limit of the material. Young Modulus is a measure of the material's stiffness and is usually calculated as the tensile stress ÷ tensile strain for metals behaving elastically. Having a high Young Modulus means that the material needs a high amount of stress to produce a noticeable amount of strain. The elastic limit is not related. A stiff material could have a relatively low elastic limit.

Exemplar 2

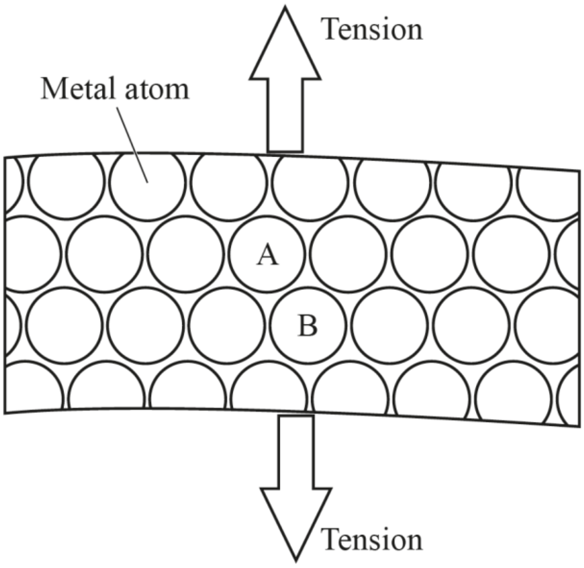
Because a high Young's Modulus means that the material has a higher stiffness so they can store more energy before failure.

This candidate starts off with a correct statement which related to the question. They say that materials with a high Young Modulus are stiff. But then their response describes a different material property. They say that a stiff material can store more energy before failure and that is a good description of a tough material.

Question 4 (b) (i) and (ii)

The diagram shows part of the atomic structure of the metal cable.

Tension is applied to the cable as shown.



(b) State what happens to the separation of the atoms, A and B in the diagram, when

(i) the tension is applied,

.... **[1]**

(ii) the tension is released.

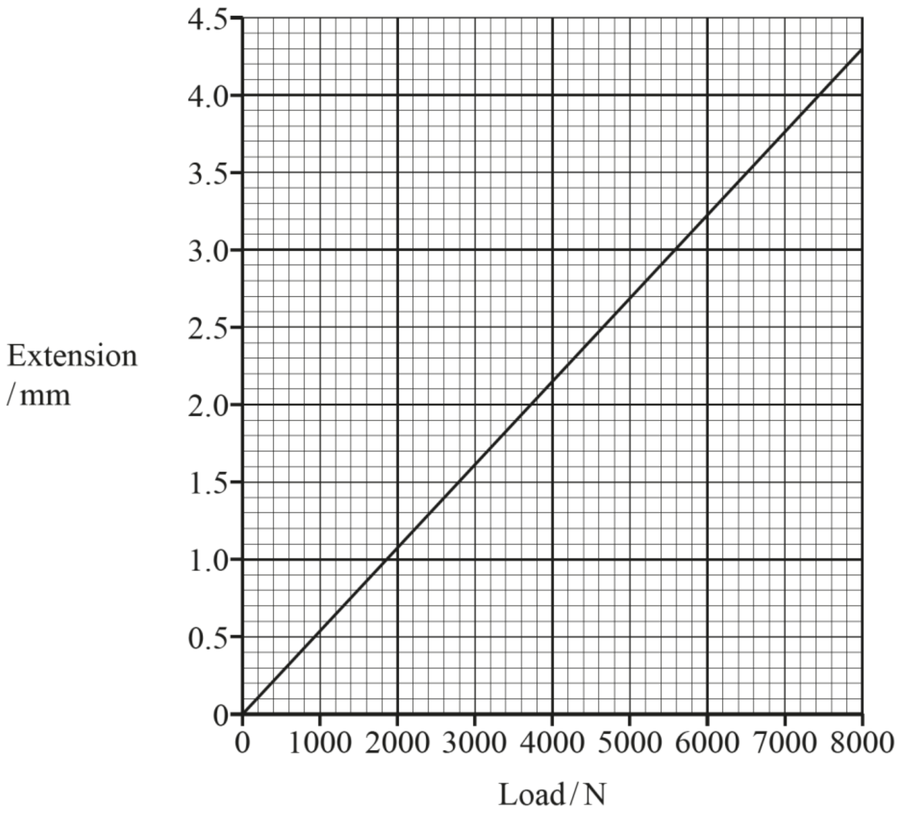
.... **[1]**

Most candidates answered these two questions correctly. Common mistakes included references to the atoms repelling or attracting which is not relevant here. The questions specifically ask about the separation of the atoms.

Question 4 (d)

When the lift is carrying passengers, the cable stretches slightly.

The graph shows the extension of the lift cable for different loads.



(d) Calculate the strain energy in the cable when the load is 6000 N.

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

Most candidates did not answer this question well. Many calculated the strain in the cable. So, most start off okay by reading the strain as 3.2 mm when the load is 6000N. Some candidates remember to convert that to 3.2×10^{-3} m, but many do not. Some candidates realise that energy can be calculated using the equation energy = force × distance moved, but this is only true when the force is constant. The strain energy is the area between the line on the graph and the force axis. The equation for calculating strain energy is not listed in the formula booklet but candidates do still need to understand what is meant by the term 'strain energy' and how to calculate it from a force-extension graph.

Question 4 (e)

(e) The manufacturer uses destructive testing when evaluating its lift cables.

Describe **two** features of destructive testing.

1 ....

....

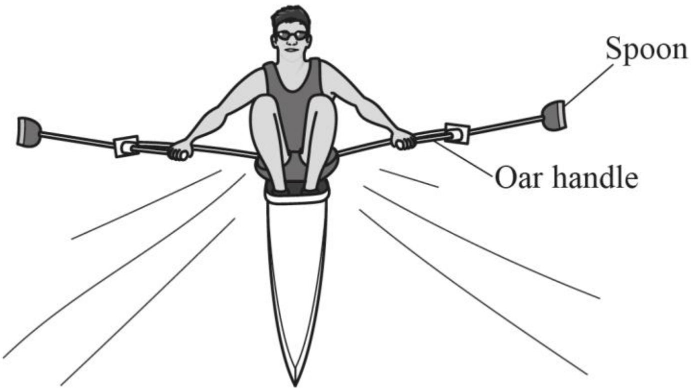
2 ....

....
[2]

Most candidates showed some understanding of destructive testing and common correct responses included the material cannot be used after testing because it has failed or plastically deformed, but few candidates stated that destructive testing was carried out on a sample of a material or manufactured item. Some candidates were able to list several mechanical properties which could be measured using destructive testing, but this is not really a generic feature of it.

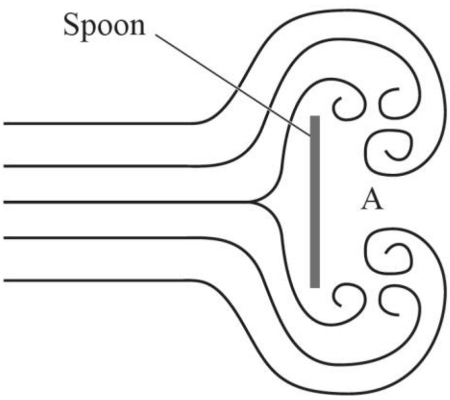
Question 5 (a) and (b)

5 The image shows a person rowing a boat with oars.



The end of the oar, called the spoon, enters the water.

The diagram shows the flow of water around the spoon.



(a) What **one word** describes the flow at point A?

.... **[1]**

(b) Describe the motion of water particles at point A.

....

....

....

.... **[2]**

Most candidates correctly identified the flow around the spoon as turbulent flow in part (a) but were then unable to correctly describe the motion of the water particles in part (b). Many candidates attempted to describe the diagram which is really just a representation of the situation. Random or different directions of travel was more commonly mentioned than random speed or velocity.

Question 5 (c)

(c) Engineers can improve rowing performance by changing the shape of the spoon.

The table shows data for two spoon designs.

	Old Design	New Design
Water pressure / Pa	5740	5960
Spoon area / m^2	0.1150	0.1280

Calculate the increase in force when changing to the new design.

Increase in force = ... N **[4]**

This calculation was relatively straightforward, and many candidates gave a correct response. A few candidates attempted to subtract the different pressure and areas before multiplying them.

Question 5 (d)

(d) The dynamic viscosity of water is 1.31 mPa s at 10 °C.

State how you know that water is **not** an ideal fluid.

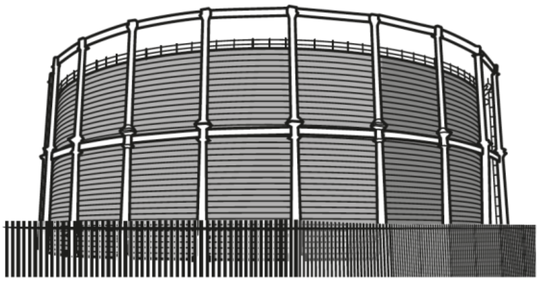
....

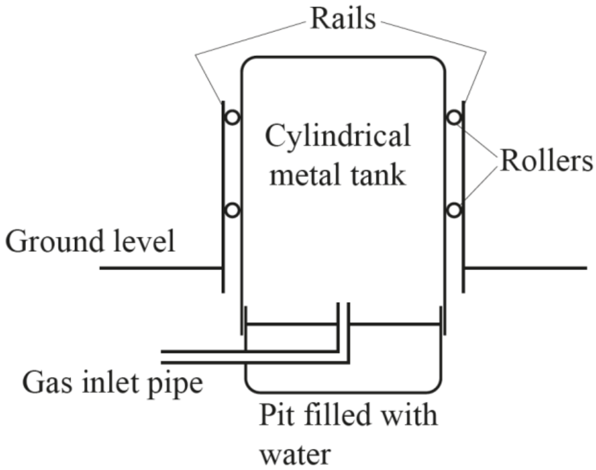
.... **[1]**

Many candidates correctly stated that if the dynamic viscosity of water is not zero then it cannot be an ideal fluid. Some candidates were somewhat vaguer and just said the dynamic viscosity was high or greater than 1 so did not answer the question correctly.

Question 6 (a)

6 Gas storage is important for a country's energy security. In the 20th century, gas was stored in large cylindrical metal tanks called 'gasometers' like the one shown in the image below.





When gas is pumped into the gasometer, the cylindrical metal tank slides up the vertical rails on rollers. When the tank moves, the gas remains sealed inside by a pit of water below ground level.

(a) A gasometer has a volume of 50 000 m^3 and holds gas at pressure 4000 Pa.
The temperature of the gas and surroundings is 15 °C (288 K).
Calculate the number of moles of gas in the tank.

Molar gas constant = 8.31 $J K^{-1} mol^{-1}$

Moles of gas = ... **[3]**

Most candidates correctly calculated the number of moles of gas using the Ideal Gas equation. Some candidates got a power of ten error, and a few decided to try to use the temperature in degrees Celsius instead of 288K.

Question 6 (b)

(b) More gas is added to the tank.
The tank rises and the volume increases.
The pressure does not change because it is caused by the weight of the tank above.

Explain why the volume must increase if gas is added to the tank.
Use the ideal gas law in your explanation.
Assume the outside temperature stays the same.

....

....

....

....

.... **[2]**

Many candidates did not clearly state that the temperature in this situation was remaining constant. Some poorly worded explanations also confused the n and the R in the gas equation.

Question 6 (c)

(c) On a cold day, the gas temperature falls to 5 °C.
The pressure does not change.
Calculate the decrease in volume of the gas.

Decrease in volume = ... m^3 **[4]**

In this part of the question candidates needed to convert the temperature to Kelvin before attempting to use either Charles' Law or the Ideal Gas equation. Another common error was to find the change in volume but then omit to calculate the new volume.

Assessment for learning

Candidates should learn that the gas laws require all temperatures to be in Kelvin. In this question some parts of the question the temperature was given in Kelvin and others not, so candidates need to check each time.

Also, candidates should realise that both temperature scales have the same increments. A temperature difference of 1°C is the same as a temperature difference of 1 K.

Question 6 (d)

(d) On a different cold day, the tank moves downwards by 0.60 m.

The radius of the tank is 25 m.

The amount of gas in the tank remains the same.

The tank in part (a) had volume 50 000 m^3 and temperature 288 K.

Calculate the temperature of the gas in kelvin.

Temperature = ... K **[3]**

This question also required candidates to use Charles' Law relationship between temperature and volume of a gas at constant pressure. The first part of this multistage calculation was to find the change in the volume of the tank but finding the area and multiplying by 0.6m, which some candidates found challenging. Some candidates over complicated this step by finding the original height of the tank from the original volume, then subtracting the change in height before calculating the new volume again. Once they had a value for the new volume, the calculation using either Charles' Law of the Ideal Gas equation was relatively straight forward.

Exemplar 3

(d) On a different cold day, the tank moves downwards by 0.60 m.

The radius of the tank is 25 m.

The amount of gas in the tank remains the same.

The tank in part (a) had volume 50 000 m³ and temperature 288 K.

Calculate the temperature of the gas in kelvin.

$V = \pi \times r^2 \times h$

$50,000 = \pi \times 25^2 \times h$

$50,000 = 625\pi \times h$

$h = 25.5\text{m}$ high tank

$25.5 + 0.6 = 26.1$

$\pi \times 25^2 \times 26.1 = 51,247.23\text{m}^3$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\frac{50,000\text{m}^3}{288\text{k}} = \frac{51,247.23\text{m}^3}{T_2} \qquad T_2 = 295.185...$$

(173.61)

Temperature = 295 K **[3]**

This candidate has clearly laid out their calculations so they are easy to follow. The candidate starts off correctly finding the change in volume, but then they add this to the previous volume instead of subtracting as the tank is moving downwards. The use of Charles' Law equation is clear.

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