CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

ENGINEERING

05822–05825, 05873

Unit 2 Summer 2019 series

Version 1

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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 can be downloaded from OCR.

Paper Unit 2 series overview

Candidates were able to attempt nearly all the questions on this paper, and few appeared to have run out of time. There were some poorly answered recall-type equations showing that some candidates were not learning the definitions of several scientific terms. There was an improvement on the use of units and converting values to SI units since last year.

Candidate who did well:	*Candidates who did less well:*
• laid out calculations clearly • interpreted and/or drew graphs and diagrams correctly • used scientific terminology correctly.	• showed little or poorly laid out working of calculations. • were unable to rearrange equations or use calculators correctly. • omitted converting units or used incorrect conversion factors. • were unable to recall or use standard definitions.

Question 1 (a)

1 **(a)** Three automatic positioning systems are being tested for quality. The results for each system are shown in Fig.1.

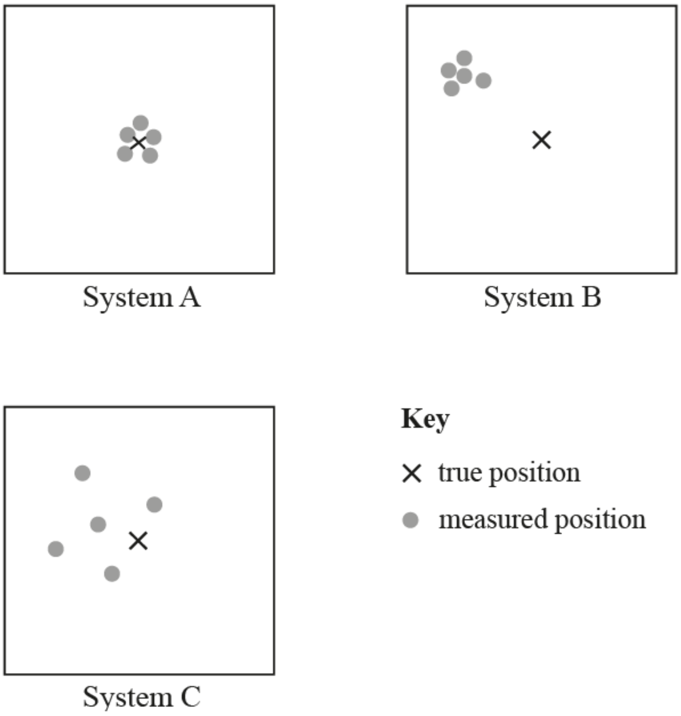


Fig. 1

Put **one** tick (✓) in each row of the table below to indicate the precision of each system.

	Precision	
System	**Precise**	**Imprecise**
A		
B		
C		

[3]

Many candidates answered this question correctly. The most common error was to think that B was imprecise because the data is not close to the actual position.

Question 1 (b)

(b) Complete the statements below. Use the format 10^x, the first one has been done for you.

1 kilowatt is equal to ....**10^3**.................. W

1 metre is equal to .... mm

1 gram is equal to .... Mg

1 litre is equal to .... mm^3

[3]

Most candidates knew that 1 metre is equivalent to 103 mm, but many found the other two conversions more difficult, especially the litre. Some candidates got the sign of the powers incorrect, for example stating that 1 gram is equal to 106 Mg. It can be helpful to think about which unit should be larger than the other, for example a gram is a much smaller value of mass than a Mega-gram.

Question 2 (a) (i) and (ii)

2 **(a)** Fig. 2 shows the cross section of a metal bar of diameter $d = 40\,\text{mm}$ which is subjected to a moment about its centre, $M = 120\,\text{Nm}$.

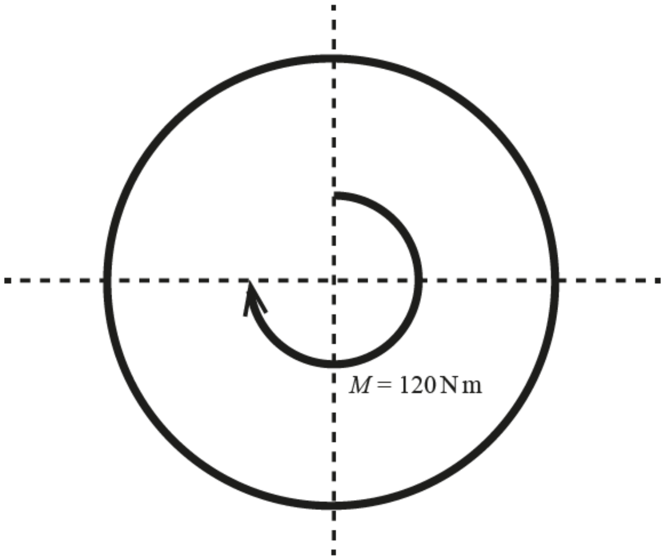


Fig. 2

(i) Calculate the magnitude of the couple needed to act on the surface of the bar to maintain equilibrium.

Magnitude of couple = ... N **[2]**

(ii) Add arrows to Fig. 2 to show the direction of the couple. **[2]**

Candidates seemed to get the terms 'moment' and 'couple' confused. Many managed to get the calculation in part (i) correct by dividing the moment by the diameter, and it was good to see that most of them did successfully convert millimetres correctly to metres before performing the calculation. However, when it came to representing the couple on the diagram in part (ii), many candidates showed little understanding that a couple is a pair of equal parallel forces acting either end of a diameter. Many candidates did recognise that the direction of the applied couple should oppose the motion of the shaft shown in the diagram.

Question 2 (b) (i) and (ii)

(b) Fig. 3 shows an object suspended in equilibrium from two strings.

String A is horizontal and string B is at an angle α to the horizontal axis.

String A and string B are in the same vertical plane.

The weight of the object $W = 3\,\text{kN}$ and the horizontal force $F_A = 4\,\text{kN}$.

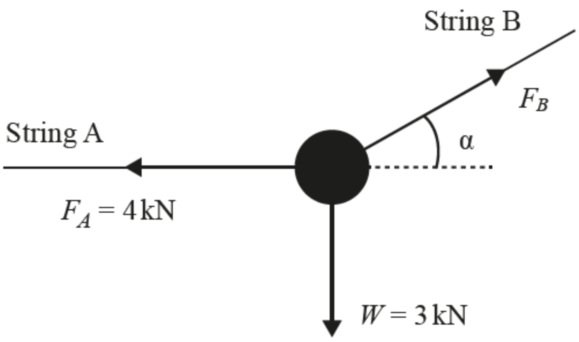


Fig. 3

(i) Calculate the magnitude of the force acting along string B, F_B.

$F_B =$ .... kN **[2]**

(ii) Determine the angle α between the F_B and the horizontal axis.

$\alpha =$ .... ° **[1]**

It was good to see most candidates using Pythagoras' Theorem correctly to calculate the magnitude of the force in part (i). Many were also able to use trigonometry correctly to find the angle in part (ii). Some candidates used sine rather than cosine.

Question 2 (c) (i)

(c) Fig. 4 shows the position of an object as it varies with time while moving along a horizontal plane.

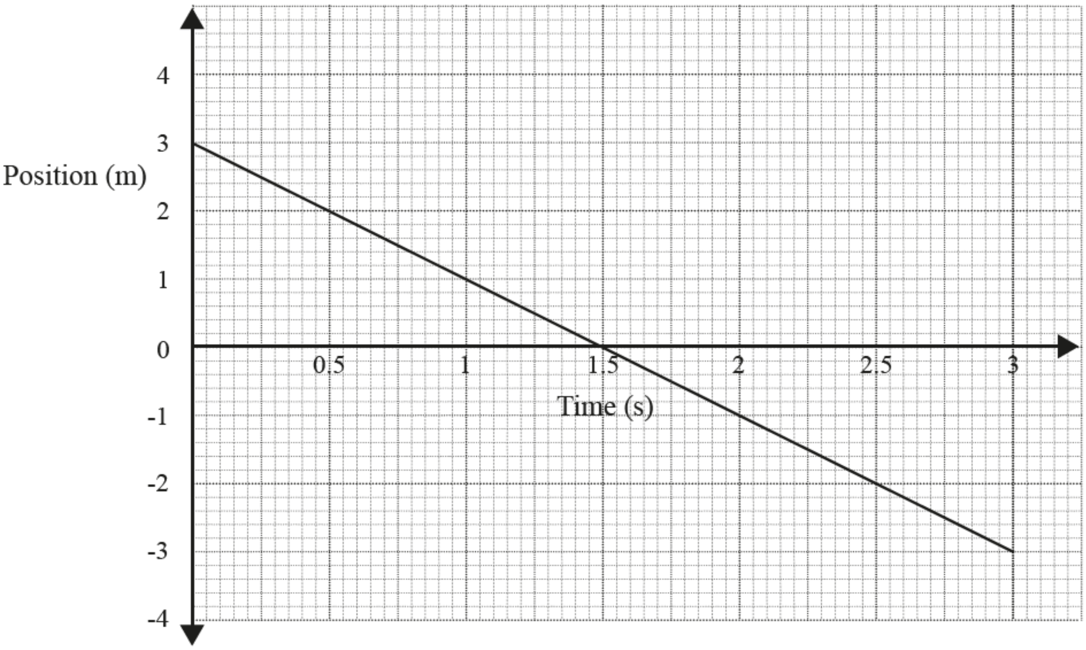
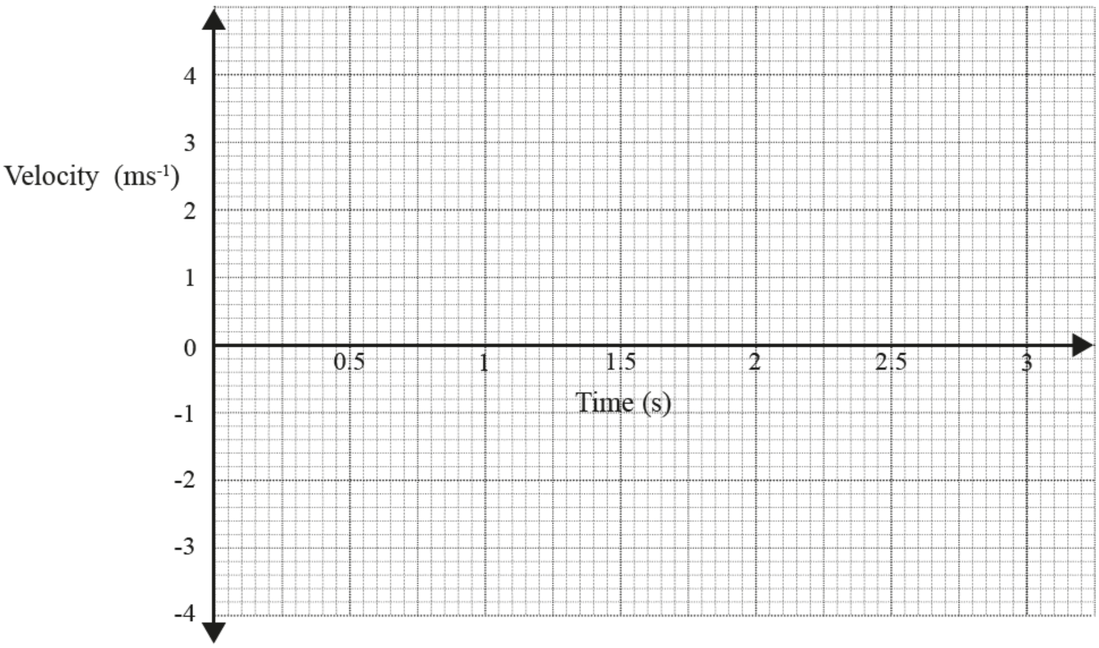


Fig. 4

(i) On the grid below draw the corresponding velocity-time graph for the movement shown in Fig. 4.



[2]

Many candidates realised that the straight line on a position-time graph means that there is constant velocity and drew a horizontal line on the velocity-time graph. Some gave a positive value of velocity, but as the gradient on the position-time graph is negative, this means that the velocity is also negative. Most candidates who drew a horizontal line also had the correct magnitude of 2 m s^{-1}.

Question 2 (c) (ii)

(ii) State and explain the magnitude of acceleration.

....

.... **[1]**

Many candidates realised that there was no acceleration because the velocity-time graph was horizontal or had zero gradient. Those candidates who did not give a horizontal line, were able to state that acceleration was the gradient of the velocity-time graph and were able to gain this mark.

Question 2 (c) (iii)

(iii) A horizontal force acting on the object of 5 kN causes the movement shown in Fig. 4.

Calculate the work done by the force on the object.

Include a unit in your answer.

Work done = ... **[2]**

Many candidates were able to use the correct equation (work done = force × distance moved). Some candidates used an incorrect value for distance moved, with a common error being the use of the value 3 m. The position-time graph shows the motion going from +3 m to -3 m, giving a total distance moved of 6 m. Most candidates used the correct unit of Joules (J), but some candidates did not convert the force of 5 kN to 5000 N. Leaving the force in kN would give the correct answer in kJ.

	AfL	Where a candidate does not get a calculation question fully correct, they will still gain some marks for showing their working. In this question candidates would have gained a mark for writing down the correct equation required: work done = force × distance moved, even if they then inserted an incorrect distance.

Question 3 (a) (i)

3 (a) Fig. 5 shows a resistor circuit.

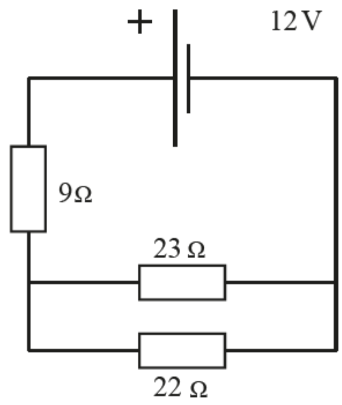


Fig. 5

(i) Show that the total equivalent resistance is approximately 20 Ω.

[3]

This is a 'show that' question meaning candidates are expected to show all their working clearly. Most candidates did know how to calculate the equivalent resistance of resistors in series and parallel but did not show this clearly. An example of what a typical candidate's response might look like is:

$$\frac{1}{22} + \frac{1}{23} = \frac{45}{506} = 11.2$$

$$11.2 + 9 = 20.2$$

The first line of the calculation is algebraically incorrect, so does not gain any marks. The second line is algebraically correct, but does not include any subject for the equation, so does not show clearly what the candidate is trying to calculate.

An answer which would gain all 3 marks might look like this:

$$\frac{1}{R_p} = \frac{1}{22} + \frac{1}{23} = \frac{45}{506}$$

$$R_p = \frac{506}{45} = 11.2$$

$$R_T = 11.2 + 9 = 20.2$$

All three equations have a subject and are algebraically correct, and so it is clear that the candidate is showing that the total resistance is approximately equal to 20Ω.

Question 3 (a) (ii)

(ii) Calculate the current I through the circuit when the supply is 12 V.

$I =$ .... A **[2]**

Most candidates were able to calculate the current in the circuit by dividing the electromotive force (12 V) by the total resistance of 20Ω.

Question 3 (b) (i)

(b) A capacitor of capacitance $C = 12\,\text{mF}$, is fully charged by applying a potential difference $V_0 = 9.0\,\text{V}$.

(i) Calculate the total energy stored by the capacitor.

Energy stored = ... J **[2]**

Some candidates were able to recall the equation $W = \frac{1}{2}CV^2$, and were able to calculate the energy stored in the capacitor. Another way to do this calculation is to use a two-step process using the equations given in the formula booklet, first calculating capacitance, $C = \frac{Q}{V}$ and then using $W = \frac{1}{2}CV$. The capacitance is given in mF so for an answer in J, this needs to be converted into Farads (F) first. Many candidates did not do this and therefore got a power-of-ten error in their final answer.

Question 3 (b) (ii)

The fully charged capacitor is then placed in the RC circuit shown in Fig. 6.

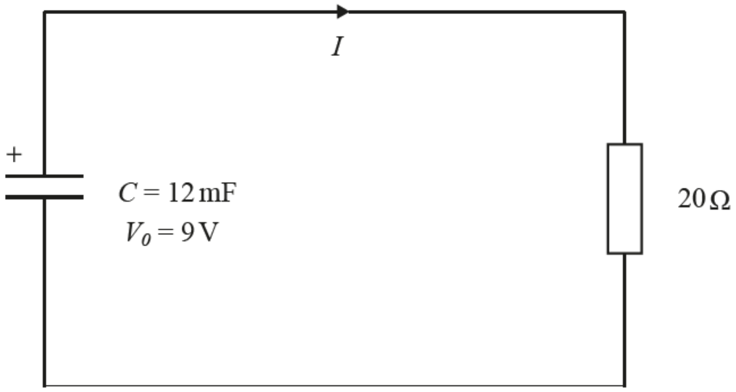


Fig. 6

(ii) Calculate the time constant, τ for the circuit in Fig. 6.

τ = ... s **[2]**

This was a fairly straightforward question relying on the candidate choosing and using the correct equation from the formula booklet, $\tau = RC$. Where a candidate had already been penalised for a missing or incorrect power-of-ten in the value for capacitance, they were credited for bringing that error carried forward.

Question 3 (b) (iii)

(iii) Calculate the potential difference across the capacitor at time t = 0.4 s.
The initial potential difference V_0 = 9.0 V.

$V_{0.4}$ = ... V **[2]**

This question also required candidates to use an equation given in the formula booklet, $V = V_0 e^{\frac{-t}{RC}}$. Candidates who were unable to compute this equation using their calculators were able to gain a mark for substituting the correct values into the equation.

Question 4 (a) (i)

4 **(a)** Fig. 7 shows the stress-strain curve of a metallic material.

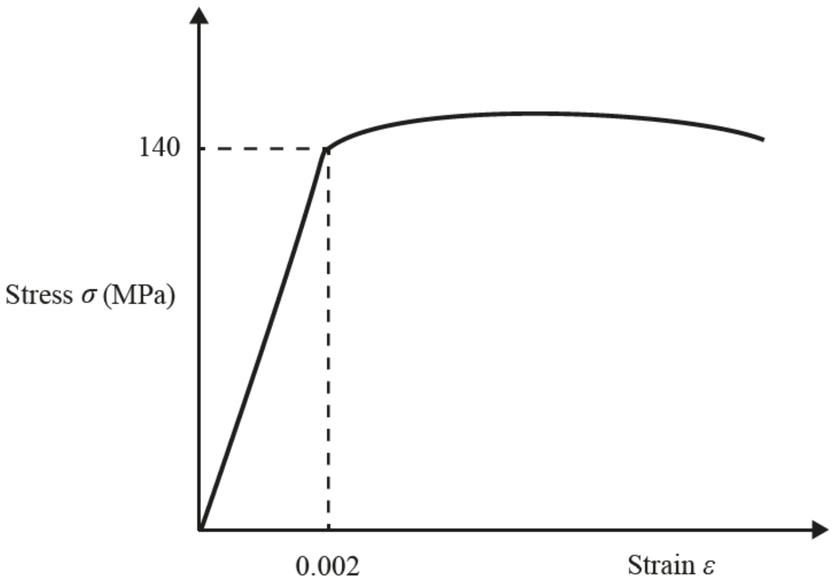


Fig. 7

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

Young's modulus = ... MPa **[2]**

This question was well answered. Most candidates were able to calculate Young's modulus by reading the values of stress and strain from the graph.

Question 4 (a) (ii)

(ii) Draw a cross **(X)** on Fig. 7 to show the ultimate tensile strength of the metallic material. **[1]**

Common errors in this question were to put the cross at the end of the elastic region of the graph or at the failure point. The ultimate tensile strength of the material is the maximum value of stress so the cross should be placed on the highest point on the graph.

Question 4 (a) (iii)

(iii) Metallic materials undergo two types of deformation, both of which are shown in Fig. 7.

State the two types of deformation and explain the key difference between them on both a macroscopic and microscopic level.

.... **[4]**

Most candidates were able to gain 2 marks for this question for stating the two types of deformation, elastic and plastic, and by explaining the difference between them on a macroscopic scale. Only a few candidates were able to describe the types of deformation on a microscopic scale. A number of candidates referred to plastic deformation as the breaking of inter-atomic bonds but did not go on to state that slip occurs because some bonds do break, but then new bonds are made with atoms in the next row or plane of atoms.

Question 4 (b)

(b) Place a tick (✓) against the statement in the table below that describes non-destructive testing.

Statement	**Tick (✓)**
A component is tested for any internal flaws or cracks using ultrasonic waves.	
A tensile test is performed on a specimen of a material to find its strain at failure.	

[1]

Most candidates were able to pick the correct response to describe non-destructive testing.

Question 4 (c)

(c) A vehicle body panel must withstand repeated vibration loading during the life cycle of a car.

It must also be resistant to scratches and abrasions.

State the material properties associated with these requirements.

Repeated vibration: ....

Resistant to scratches and abrasions: ....
[2]

Many candidates struggled to give the correct material properties in this question. More candidates put hardness correctly for the second answer, than endurance for the first answer. Toughness was a common response for both examples, but toughness is a measure of the amount of energy required to plastically deform materials. Resilience was another common incorrect answer for the first answer, but this relates to the elasticity of a material not its ability to withstand cyclical stress or repeated vibration.

Question 5 (a)

5 (a) Define viscosity of a fluid.

....

.... **[1]**

Few candidates were able to recall the definition of viscosity correctly.

Question 5 (b) (i)

(b) Fig. 8 shows a plate submerged in a container filled with ethanol.

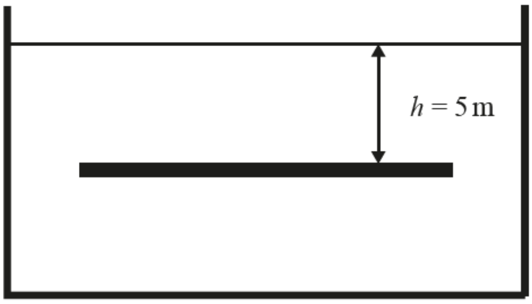


Fig. 8

(i) Draw arrows on Fig. 9 below to show the pressure acting on the plate.

Fig. 9

[2]

This question was not answered particularly well. Pressure should be represented by equally spaced arrows pointing at right angles towards the surface of the plate. Pressure in a liquid is equal in all directions.

Question 5 (b) (ii)

(ii) Calculate the force exerted by the ethanol on the top surface of the plate.

Density of ethanol $\rho_{ethanol} = 790\,\text{kg m}^{-3}$.

The top surface area of the plate is $15\,\text{m}^2$.

Force = ………………………………… N **[3]**

This was a two stage calculation, with many candidates managing to successfully calculate the pressure in the fluid at a depth of 5m, but who then did not go on to use the equation $F = P \times A$ to find the force acting over the top surface of the plate.

Question 5 (b) (iii)

(iii) Calculate the absolute pressure exerted on the plate.

Atmospheric pressure is 101 kPa.

Absolute pressure =………………………………… Pa **[2]**

The unit given on the answer line is Pa, however the unit for atmospheric pressure is kPa. Candidates who used their intermediate answer of pressure found in part (b)(ii) needed to remember to convert it to kPa before adding it to atmospheric pressure to find the absolute pressure. Many candidates tried to add the value of force found in part (ii) to the atmospheric pressure, but if they did not write out the equation used, would have secured no credit here.

Question 5 (iv)

(iv) The upthrust force acting on the submerged plate is 22 kN.

Calculate the thickness of the plate. Include a unit in your answer.

Thickness = ………………………………… **[4]**

Many candidates were able to complete this multi-stage calculation correctly and use the correct units in their final answer. Some candidates found the volume of the plate but did not go on to find the thickness by dividing by the area.

Question 6 (a) (i)

6 **(a)** A gas in an insulated container has the following properties.

$P_1 = 250\,\text{kPa}$,

$T_1 = 300\,\text{K}$,

$V_1 = 0.13\,\text{m}^3$.

(i) Calculate the pressure of the gas if the volume decreases to $V_2 = 0.07\,\text{m}^3$ and the temperature rises to $T_2 = 305\,\text{K}$.

Pressure = ... kPa **[3]**

Many candidates were able to correctly use the combined gas equation to find the new pressure. As the answer line includes the unit kPa and the original pressure is given in kPa there is no need to convert the pressures to Pa and then back again here. Some candidates tried using the pressure law or Charles Law which in this case are not valid as all the variables are changing.

Question 6 (a) (ii)

(ii) Calculate the number of moles in the container.

The ideal gas constant $R_{gas} = 8.3\,\text{J}\,\text{mol}^{-1}\,\text{K}^{-1}$.

Number of moles = ... moles **[3]**

Most candidates were able to use the ideal gas equation correctly, but many forgot to convert the pressure in kPa to Pa before substituting into the equation.

Question 6 (b) (i)

(b) **(i)** Explain what is meant by the 'internal energy' of a system.

....

....

.... **[2]**

This was a recall question which was not well answered. Common incorrect responses included 'energy within a system' or 'energy used by a system'.

Question 6 (b) (ii)

(ii) State the physical significance of absolute zero on the Kelvin scale.

....

.... **[1]**

Some candidates did not correctly answer this question as they just stated that absolute zero is -273°C, instead of stating that it is the temperature at which internal energy of a material is minimum.

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