Calculating errors

Question Paper

Level	International A Level
Subject	Physics
Exam Board	Edexcel
Topic	Lab Skills 2
Sub Topic	Calculating errors
Booklet	Question Paper

Time Allowed: **94 minutes**

Score: **/79**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

Answer ALL questions in the spaces provided.

1 A student determines the circumference C of a glass test tube by wrapping a piece of string around the outside. C is given by

$$C = (x/10) - \pi d$$

where x is the length of string wrapped 10 times around the outside of the test tube and d is the diameter of the string.

(a) (i) She measures the diameter d of the string as 1.70 ± 0.04 mm.

State **one** precaution she should take when using a micrometer screw gauge to make this measurement.

(1)

.....

(ii) She finds $x = 803 \pm 4$ mm.

Use the equation above to calculate a value for C.

(2)

.....

.....

$C =$ .....

(iii) State why the uncertainty in $x/10$ is 0.4 mm.

(1)

.....

.....

(iv) Show that the uncertainty in πd is about 0.13 mm.

(1)

.....

.....

(v) State why the uncertainty in C is obtained by adding together 0.4 mm and 0.13 mm.

(1)

.....

.....

(vi) Calculate the percentage uncertainty in your value for C.

(1)

.....

Percentage uncertainty = ...

(b) (i) Use your value for C to calculate a value for the external cross-sectional area A of the test tube where

$$A = C^2/4\pi$$

(1)

.....

.....

$A =$ .....

(ii) Calculate the percentage uncertainty in your value for A.

(1)

.....

.....

Percentage uncertainty = ...

(c) The student then uses another method to find A by measuring the external diameter D of the test tube using digital callipers. The precision of the callipers is 0.01 mm.

She records the following measurements.

D/mm	23.96	23.86	23.91

(i) State why digital callipers are a suitable choice of measuring instrument.

(1)

.....

.....

(ii) Estimate the percentage uncertainty in her value for A.

(2)

.....

.....

.....

Percentage uncertainty = ...

(Total for Question 1 = 12 marks)

2 A student made measurements to determine the density of a single microscope slide.

(a) The dimensions of the slide were approximately 8 cm long, 3 cm wide and 1 mm thick.

Complete the table below to show the instruments you would use to make these measurements to an appropriate precision.

(4)

Measurement	Instrument	Precision of instrument
length	metre rule	1 mm
width		
thickness		

(b) The student recorded the following measurements.

Measurement	Reading	Mean
length / mm	75.8	75.8
width / mm	25.8	25.8
thickness / mm	1.01	1.00

Use these measurements to estimate the percentage uncertainty in the readings for length and thickness.

(2)

.....

.....

.....

.....

Percentage uncertainty in length = ... %

Percentage uncertainty in thickness = ... %

(c) The mass of the microscope slide is recorded as 4.82 g with an uncertainty of 0.03 g.

(i) Calculate a value for the density of the slide.

(2)

Density = ...

(ii) Estimate the percentage uncertainty in your value for the density.
You may assume the uncertainty in the measurement for the width is negligible.

(2)

Percentage uncertainty = ... %

(iii) The student researched the density of different types of glass and found a value for 'Crown glass' of 2600 ± 100 kg m^{-3}.

Use this information to decide if the slide is made from Crown glass.

(2)

(d) Measuring the thickness of a stack of 10 slides would produce a better value for the thickness of one slide.

Explain why.

(2)

(Total for Question 2 = 14 marks)

3 A student is asked to determine the density of two coins, X and Y, to decide if they are made from the same material. The diameter of each coin is about 25 mm.

(a) (i) She uses vernier callipers to measure the diameter of coin X.

Show that the percentage uncertainty for this measurement is less than 1%.

(1)

.....

.....

(ii) Apart from repeating her readings, state one precaution she could take to ensure each measurement is as accurate as possible.

(1)

.....

.....

(iii) The student measures the thickness of coin X using a micrometer screw gauge. She takes measurements at different points on the coin.

Explain why this would make the mean value for the thickness more accurate.

(1)

.....

.....

(b) She records the following values for coin X:

diameter/mm 25.9, 25.9, 25.9

thickness/mm 1.80, 1.84, 1.82

(i) Use these measurements to calculate the mean value for the volume of coin X.

(2)

.....

.....

.....

.....

.....

Mean value for the volume of coin X = ...

(ii) Use the measurements to estimate the percentage uncertainty in the volume.

(3)

.....

.....

.....

.....

Percentage uncertainty = ...

(c) She measures the mass of coin X as 7.08 g with negligible uncertainty.

Calculate the density of coin X.

(2)

.....

.....

Density of coin X = ...

(d) The student makes the same measurements for coin Y. The value of the density for coin Y is 6900 kg m^{-3}. The percentage uncertainties in the measurements are the same for both coins.

Use these measurements to decide if the coins are made from the same material.

(2)

.....

.....

.....

.....

.....

.....

(Total for Question 3 = 12 marks)

4 A student was asked to determine the density of the metal from which a food can is made.

(a) She calculated the volume of the metal by determining the external volume of the can and subtracting the internal volume.

(i) She measured the external height of the can using a metre rule.

State the precision of a metre rule.

(1)

(ii) She used two set squares and a metre rule to measure the external diameter of the can.

Describe how you would use this apparatus to measure accurately the diameter of a can. Your description should include a diagram.

(2)

(b) The student recorded the following results.

Quantity	Measurements	Mean value
Internal volume / cm^3	391 399 398	396
Height / cm	10.1 10.1 10.1	10.1
External diameter / cm	7.2 7.1 7.3	7.2
Mass / kg	4.982×10^{-2}	

The volume of a cylinder is given by $V = \pi r^2 h$

where r is the radius of the cylinder and h is its height.

(i) Use these measurements to show that the external volume is about 400 cm^3.

(1)

.....

.....

(ii) Hence calculate a value for the volume of the metal.

(1)

.....

Volume of metal = ...

(iii) Hence calculate a value for the density of the metal.

(2)

.....

.....

Density of metal = ...

(c) (i) Use the measurements to estimate the percentage uncertainty in the external volume. You should assume the uncertainty in the height measurement is negligible.

(2)

.....

.....

.....

.....

Percentage uncertainty = ... %

(ii) Use the measurements to estimate the percentage uncertainty in the internal volume.

(1)

.....

.....

Percentage uncertainty = ... %

(iii) The volume of metal was determined by subtracting the internal volume of the can from the external volume. This produces a percentage uncertainty for the volume of metal which is greater than 10%.

Suggest why.

(1)

.....

.....

(Total for Question 4 = 11 marks)

5 A student carried out an experiment to measure how the resistance of a thermistor decreases as the temperature increases.

(a) Draw a diagram of the apparatus that could be used to carry out this experiment in a school laboratory.

(3)

(b) The following readings were recorded.

***T*/°C**	***R*/kΩ**
14	8.16
30	4.03
45	2.29
61	1.32
83	0.65

(i) Suggest why it would be a good idea to take extra readings in the range 14 °C to 45 °C.

(1)

.....

.....

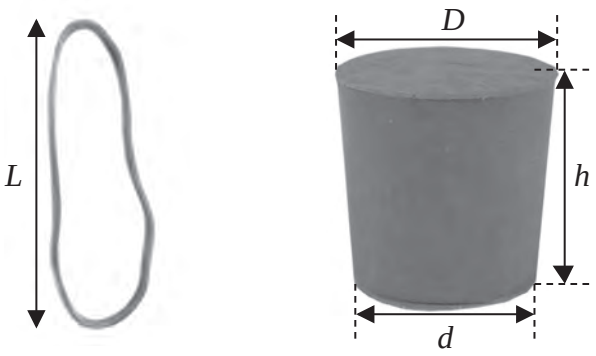
(ii) Suggest how the range of readings could have been increased. **(1)**

.....

.....

(Total for Question 5 = 5 marks)

6 A student investigates the properties of a rubber band and a rubber bung to determine whether they are made from the same type of rubber.



Rubber band Rubber bung

(a) The volume V_1 of the band is given by

$$V_1 = 2Lwt$$

where w is the width of the band and t is the thickness and L is the length shown in the diagram.

(i) The student uses a metre rule to measure L which is approximately 10 cm. Explain why a metre rule is suitable for this measurement.

(2)

.....

.....

.....

.....

(ii) She uses a micrometer screw gauge to measure w and t and records the following readings with negligible uncertainties.

***L*/cm**	***w*/mm**	***t*/mm**
10.0	9.33	1.03

Use these measurements to calculate V_1 in cm^3.

(2)

.....

.....

V_1 = ... cm^3

(b) The volume V_2 of the bung is given by

$$V_2 = \frac{\pi h}{12}\left(D^2 + d^2 + Dd\right)$$

where D, d and h are the dimensions shown on the diagram.
The student uses callipers to take measurements of the bung.

(i) Describe how h should be measured.

(2)

.....

.....

.....

.....

(ii) She records values for the diameters with negligible uncertainty.

$D = 3.45\,\text{cm}$ $d = 3.06\,\text{cm}$

She records the following values for h

h/cm	3.51	3.49	3.53

Use these measurements to calculate V_2 in cm^3.

(2)

.....

.....

V_2 = ... cm^3

(iii) Estimate the percentage uncertainty in V_2.

(1)

.....

.....

.....

.....

Percentage uncertainty = ...

(c) The student uses a top pan balance to record the following readings with negligible uncertainty.

mass of band = 2.23 g mass of bung = 44.48 g

Calculate the densities of the band and the bung.

(3)

.....

.....

.....

.....

.....

.....

Density of band = ...

Density of bung = ...

(d) The percentage uncertainty in the density of the band is 4%.

Use this value and your results to comment on the suggestion that both the band and the bung are made from the same type of rubber.

(2)

.....

.....

.....

.....

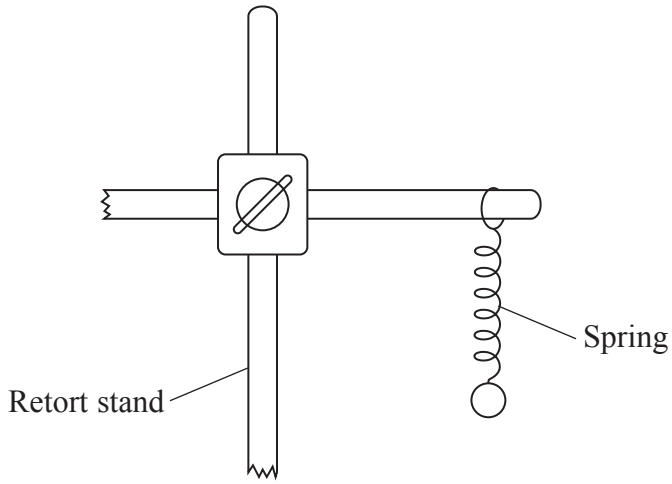
.....

.....

.....

(Total for Question 6 = 14 marks)

7 A student is asked to determine the spring constant for a small spring.



He has the following additional apparatus:

50 g mass hanger with 9 × 50 g masses

stopwatch with a precision of 0.01 s

optical pin.

He is told that the time period T for vertical oscillations of a mass m is

$$T = 2\pi\sqrt{\frac{m}{k}}$$

where k is the spring constant.

The student decides to determine the period of oscillation for different values of mass.

(a) (i) Describe how he could make his readings for the time period as accurate as possible.

(2)

(ii) Describe the graph he should plot to obtain a straight line and how to determine the spring constant from the graph.

(3)

(b) His teacher suggests using a position sensor with a datalogger instead of the stopwatch.

(i) Draw a diagram to show how this apparatus could be used to record the position of the hanging mass.

(2)

(ii) Explain how using a position sensor with a datalogger will improve the measurement of the time period.

(2)

(Total for Question 7 = 9 marks)