

**Cambridge Technicals  
Applied Science**

**Unit 3: Scientific Analysis and Reporting**

Level 3 Cambridge Technical in Applied Science  
**05847 – 05849/05874/05879**

**Mark Scheme for January 2022**

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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Annotations available in RM Assessor

Annotation	Meaning
	Correct response
	Incorrect response
	Omission mark
<b>BOD</b>	Benefit of doubt given
<b>CON</b>	Contradiction
<b>RE</b>	Rounding error
<b>SF</b>	Error in number of significant figures
<b>ECF</b>	Error carried forward
<b>L1</b>	Level 1
<b>L2</b>	Level 2
<b>L3</b>	Level 3
<b>NBOD</b>	Benefit of doubt not given
<b>SEEN</b>	Noted but no credit given
<b>I</b>	Ignore

**Subject-specific Marking Instructions****INTRODUCTION**

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

Question		Answer	Mark	Guidance
1	(a)	Laboratory Technology Reports ✓	1	
	(b)	(i) 2016 ✓	1	
		(ii) 3 (months) ✓	1	
	(c)	Two different addresses/institutions/countries (in the affiliations) / (some authors are in) Germany and (others in) Spain ✓	1	<b>ALLOW</b> reference to groups a and b
	(d)	Germany ✓	1	
	(e)	The paper was available online <b>2 days</b> after it was accepted ✓	1	<b>ALLOW</b> reference to short time period
	(f)	(i) <b>Any two from:</b> Review by other scientists/researchers/experts/teams ✓ Working in the same field ✓ Prior to publication ✓	2	<b>IGNORE</b> 'others' <b>DO NOT ALLOW</b> friends / family (negates the first marking point)
		(ii) <b>Any one from:</b> The <b>findings</b> are checked (before publication) ✓ Ensures the quality/validity of published research/data ✓	1	<b>IGNORE</b> to check for errors/mistakes <b>ALLOW</b> AW for data e.g., results / conclusions / methods
		<b>Total</b>	<b>9</b>	

Question		Answer	Mark	Guidance										
2	(a)	all bars drawn to correct height (and same width) ✓ both axes with appropriate labels ✓ gaps between bars (of equal distance) ✓	3	<b>CHECK</b> every bar <b>ALLOW</b> e.g., percentage / % on y-axis, colour on x-axis										
	(b)	(i) Vertical lines at 450 and 700 nm ✓	1											
		(ii) <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 2px;">A single colour is a range of wavelengths</td> <td style="text-align: center; width: 20px;">✓</td> </tr> <tr> <td style="padding: 2px;">Colour is discontinuous but wavelength is continuous</td> <td></td> </tr> <tr> <td style="padding: 2px;">Colour is continuous but wavelength is discontinuous</td> <td></td> </tr> <tr> <td style="padding: 2px;">Stars emit a range of wavelengths</td> <td style="text-align: center;">✓</td> </tr> <tr> <td style="padding: 2px;">The wavelength ranges are irregular</td> <td></td> </tr> </table>	A single colour is a range of wavelengths	✓	Colour is discontinuous but wavelength is continuous		Colour is continuous but wavelength is discontinuous		Stars emit a range of wavelengths	✓	The wavelength ranges are irregular		2	
A single colour is a range of wavelengths	✓													
Colour is discontinuous but wavelength is continuous														
Colour is continuous but wavelength is discontinuous														
Stars emit a range of wavelengths	✓													
The wavelength ranges are irregular														
		(iii) 550 (x 10 <sup>-9</sup> m) ✓ green ✓	2	<b>ALLOW</b> 1 mark for any correct wavelength colour pair										
		(iv) (It) appears white because it emits the spectrum / full range of visible light ✓	1	<b>ALLOW</b> (it emits) a mixture of colours										
	(c)	(i) M-type stars are the coolest type of star ✓ <b>AND</b> M-type stars emit wavelengths which are in the red colour range so appear red ✓ <b>OR</b> K-type stars are cooler than G-type stars ✓ <b>AND</b> K-type stars emit wavelengths which are at the end of the red colour range so appear red ✓	2	<b>ALLOW</b> e.g., K-stars have more (a peak of) red wavelengths at 4000 °C but G-stars have more (a peak of) blue wavelengths at 5000 °C (= 2 marks)										

Question		Answer	Mark	Guidance
	(ii)	<p><b>Correct</b> because: Most/51% of the stars (in <b>Fig. 2.1</b>) are blue ✓  (<b>Fig. 2.3</b> trend shows) blue is hotter ✓</p> <p><b>Incorrect</b> because: these are the brightest stars (seen from Earth) not the nearest stars (in <b>Fig. 2.1</b>) ✓  there may be nearer stars that are too dim to see/dimmer/not included in data/do not emit visible light ✓</p>	4	<b>ALLOW</b> only 40% / fewer are yellow or red
		<b>Total</b>	<b>15</b>	

Question			Answer	Mark	Guidance
3	(a)	(i)	1.6 OR 1.60 ✓ 1.58 ✓	2	
		(ii)	<b>FIRST CHECK ANSWER ON ANSWER LINE</b> <b>If answer = 1.55 (V) award 3 marks</b>  (M1) 10.87 ✓  (M2) $10.87 \div 7 = 1.5528$ ✓  (M3) = 1.55 (3sf) ✓	3	<b>ALLOW ECF</b> using <b>their</b> value from M1 <b>ALLOW ECF</b> using <b>their</b> value from M2 recorded to 3 s.f.
	(b)		<b>FIRST CHECK ANSWER ON ANSWER LINE</b> <b>If answer for s = and s<sup>2</sup>= award 6 marks</b>  (M1) $(X_i - \bar{X})$ : 0.05, -0.07, 0.02, 0.05, -0.11, 0.03 ✓  (M2) $(X_i - \bar{X})^2$ : 0.0025, 0.0049, 0.0004, 0.0025, 0.0025, 0.0121, 0.0009 ✓  (M3) $\Sigma (X_i - \bar{X})^2 = 0.0258$ ✓  (M4) variance, $s^2$ , = $0.0258 \div 6 = 0.00429$ ✓  (M5) answer M4 recorded as $s^2 = 0.00429$ ✓  (M6) standard deviation, $(s = \sqrt{0.00429}) = 0.06549$ ✓	6	<b>ALLOW their</b> M3÷6 <b>ALLOW their</b> M3÷6 recorded as $s^2$  <b>ALLOW their</b> M5 correctly square-rooted <b>ALLOW</b> calculator value of $s = 0.0655 / 0.066 / 0.07$
	(c)	(i)	Any <b>two</b> batteries from 2, 3 or 6 ✓	1	
		(ii)	other values are similar to original measurements ✓  other values have same increase in precision / other values within 5% / these values more than 5% different ✓	2	<b>ALLOW</b> these values are <b>too</b> different  <b>ALLOW</b> other values are within a narrower range



Question	Answer	Mark	Guidance												
(d)	<table border="0" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left; width: 50%;"><b>term</b></th> <th style="text-align: left; width: 50%;"><b>definition</b></th> </tr> </thead> <tbody> <tr> <td style="border: 1px solid black; padding: 5px;">accuracy</td> <td style="border: 1px solid black; padding: 5px;">the closeness of agreement between measured values obtained by repeated measurements</td> </tr> <tr> <td style="border: 1px solid black; padding: 5px;">measurement error</td> <td style="border: 1px solid black; padding: 5px;">error due to measurements varying in an unpredictable way</td> </tr> <tr> <td style="border: 1px solid black; padding: 5px;">precision</td> <td style="border: 1px solid black; padding: 5px;">error due to measurements differing from the true value by a consistent amount</td> </tr> <tr> <td style="border: 1px solid black; padding: 5px;">random error</td> <td style="border: 1px solid black; padding: 5px;">the closeness of the instrument reading to the true value</td> </tr> <tr> <td style="border: 1px solid black; padding: 5px;">systematic error</td> <td style="border: 1px solid black; padding: 5px;">the difference between a measured value from the true value</td> </tr> </tbody> </table> <p style="text-align: right;">✓✓✓✓✓</p>	<b>term</b>	<b>definition</b>	accuracy	the closeness of agreement between measured values obtained by repeated measurements	measurement error	error due to measurements varying in an unpredictable way	precision	error due to measurements differing from the true value by a consistent amount	random error	the closeness of the instrument reading to the true value	systematic error	the difference between a measured value from the true value	<b>5</b>	
<b>term</b>	<b>definition</b>														
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precision	error due to measurements differing from the true value by a consistent amount														
random error	the closeness of the instrument reading to the true value														
systematic error	the difference between a measured value from the true value														
	<b>Total</b>	<b>19</b>													

Question			Answer	Mark	Guidance
4	(a)	(i)	$h = 2.0$ (cm) <b>AND</b> $t = 79$ (s) ✓	1	
		(ii)	<b>FIRST CHECK ANSWER ON ANSWER LINE</b> If answer = $1.00 \text{ cm}^3 \text{ s}^{-1}$ award 3 marks  $[3.14 \times (7.1^2) \times 2.0] \div [4 \times 79]$ ✓  $1.00$ ✓  $\text{cm}^3 \text{ s}^{-1}$ ✓	3	<b>ALLOW</b> ecf from (a)(i)  <b>ALLOW</b> answer that rounds to 1 (1 s.f.)  <b>ALLOW</b> $\text{cm}^3/\text{s}$ , and other consistent units
		(iii)	( $t_2$ ) ▲ at 14, 330 (s) - using left hand scale ✓  (R) × at 14, $1.00 \text{ (cm}^3 \text{ s}^{-1})$ - using right hand scale ✓	2	<b>ALLOW</b> ECF from (a)(ii)
		(iv)	Range of 3.1 to 3.2 ✓	1	<b>IGNORE</b> units
	(b)		<b>[Level 3]</b> Candidate shows a high level of understanding <b>AND</b> gives a detailed explanation of the evidence from Fig 4.2 and Fig 4.3. <p style="text-align: right;"><b>(5 - 6 marks)</b></p> <b>[Level 2]</b> Candidate shows an understanding <b>AND</b> gives a simple explanation of the evidence from Fig 4.2 and Fig 4.3. <p style="text-align: right;"><b>(3 – 4 marks)</b></p> <b>[Level 1]</b> Candidate shows a basic understanding <b>AND/OR</b> gives a basic explanation of the evidence from Fig 4.2 <b>OR</b> Fig 4.3. <p style="text-align: right;"><b>(1 – 2 marks)</b></p> <b>[Level 0]</b> Candidate response includes <b>fewer than two</b> valid points. <p style="text-align: right;"><b>(0 marks)</b></p>	6	<b>Trend in R (Fig. 4.2)</b> <ul style="list-style-type: none"> <li>• <math>R</math> decreases as <math>h</math> increases (simple)</li> <li>• <math>R</math> decreases as <math>t</math> increases (simple)</li> <li>• <math>R</math> tends to zero as the amount of water in the can decreases to zero (detailed)</li> </ul> <b>Suggested reasons for trend in R (Fig. 4.2)</b> <ul style="list-style-type: none"> <li>• amount of water in the can decreases (simple)</li> <li>• weight / force of water in the can decreases (detailed)</li> <li>• water pressure at the hole decreases (detailed)</li> </ul> <b>Explanation for the inaccuracy in determining the time measurements (Fig. 4.3)</b> <ul style="list-style-type: none"> <li>• the water surface is uneven / has bubbles making it difficult to read the water level (simple)</li> </ul>

Question			Answer	Mark	Guidance								
					<ul style="list-style-type: none"> <li>at 14 cm, the rate is slow, so it is difficult to decide exactly when the water reaches the 14 cm mark / the water level changes little over a long period of time (detailed)</li> <li>reference to taking reading from the bottom of the meniscus / uncertainty in where the meniscus is</li> </ul>								
	(c)		<table border="1"> <tr> <td>Acceleration = change in speed ÷ time</td> <td></td> </tr> <tr> <td>Density = mass ÷ volume</td> <td></td> </tr> <tr> <td>Force = mass x acceleration</td> <td></td> </tr> <tr> <td>Pressure = density x gravitational field strength x depth</td> <td>✓</td> </tr> </table>	Acceleration = change in speed ÷ time		Density = mass ÷ volume		Force = mass x acceleration		Pressure = density x gravitational field strength x depth	✓	1	
Acceleration = change in speed ÷ time													
Density = mass ÷ volume													
Force = mass x acceleration													
Pressure = density x gravitational field strength x depth	✓												
			<b>Total</b>	<b>14</b>									

Question		Answer	Mark	Guidance	
5	(a)	<p><b>Use ticks or crosses with subscript letters to indicate marking points</b></p> <p>y-axis labelled 'time' (s) ✓<sub>y</sub></p> <p>x-axis labelled 'decrease in distance of pendulum bob' (cm) ✓<sub>x</sub></p> <p>appropriate scale labelled at least every third large square ✓<sub>s</sub></p> <p>all points correctly plotted (check and circle the plot furthest from the best fit line) ✓<sub>p</sub></p> <p>outlier identified/circled at (4/200) ✓<sub>o</sub></p> <p>appropriate curved line of best fit for 54 cm pendulum ✓<sub>l</sub></p> <p>appropriate curved line of best fit for 130 cm pendulum disregards outlier ✓<sub>l</sub></p>	7	<p><b>ALLOW</b> 1 mark for mp1 and mp2 if no units  <b>ALLOW</b> 1 mark for mp1 and mp2 if correct but reversed axes  <b>DO NOT ALLOW</b> mp3 if awkward scale e.g 3, 7, 11  <b>PENALISE</b> poor line quality (feathering, tramlines, thickness, discontinuity) once</p>	
	(b)	(i)	207 ✓ 253 ✓	2	<b>ALLOW</b> any equal tolerance either side of 230 for 1 mark e.g. 220 and 240
		(ii)	range bar at 6 cm <b>AND</b> ± 10% from 207 to 253 ✓	1	<b>ALLOW ECF</b> using (b)(i) values

Question		Answer	Mark	Guidance										
	(iii)	<table border="1"> <tr> <td>A larger decrease in the distance from the vertical position with each swing</td> <td>✓</td> </tr> <tr> <td>A smaller decrease in the distance from the vertical position with each swing</td> <td></td> </tr> <tr> <td>The pendulum bob changing direction more quickly</td> <td>✓</td> </tr> <tr> <td>The pendulum bob changing direction more slowly</td> <td></td> </tr> <tr> <td>An increase in the time for one swing of the pendulum bob</td> <td></td> </tr> </table>	A larger decrease in the distance from the vertical position with each swing	✓	A smaller decrease in the distance from the vertical position with each swing		The pendulum bob changing direction more quickly	✓	The pendulum bob changing direction more slowly		An increase in the time for one swing of the pendulum bob		2	
A larger decrease in the distance from the vertical position with each swing	✓													
A smaller decrease in the distance from the vertical position with each swing														
The pendulum bob changing direction more quickly	✓													
The pendulum bob changing direction more slowly														
An increase in the time for one swing of the pendulum bob														
		<b>Total</b>	<b>12</b>											

Question		Answer	Mark	Guidance																
6	(a)	<table border="1"> <thead> <tr> <th>Label</th> <th>Identification</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>acute</td> </tr> <tr> <td>2</td> <td>obtuse</td> </tr> <tr> <td>3</td> <td><i>P. pulcher</i></td> </tr> <tr> <td>4</td> <td>acuminate</td> </tr> <tr> <td>5</td> <td><i>P.perfoliatus</i></td> </tr> <tr> <td>6</td> <td><i>P.robbinsii</i></td> </tr> <tr> <td>7</td> <td><i>P.crispus</i></td> </tr> </tbody> </table> ✓✓✓✓✓✓✓✓	Label	Identification	1	acute	2	obtuse	3	<i>P. pulcher</i>	4	acuminate	5	<i>P.perfoliatus</i>	6	<i>P.robbinsii</i>	7	<i>P.crispus</i>	7	<b>ALLOW</b> species without the <i>P.</i> prefix, for labels 3, 5, 6 and 7
Label	Identification																			
1	acute																			
2	obtuse																			
3	<i>P. pulcher</i>																			
4	acuminate																			
5	<i>P.perfoliatus</i>																			
6	<i>P.robbinsii</i>																			
7	<i>P.crispus</i>																			
	(b)	(i)	(they) share many common features ✓ underwater leaf width has large overlap ✓	2	<b>ALLOW</b> same underwater leaf blade shape <b>ALLOW</b> same floating tip shape <b>ALLOW</b> the only difference is the shape of the underwater leaf tip															
		(ii)	length of underwater leaf / colour of leaf / flower colour / number of petals / stem width / AVP ✓	1	<b>NOT JUST</b> e.g., colour / stem															
	(c)	genus ✓ binomial ✓	2																	

Question		Answer	Mark	Guidance
	(d)	<p><b>Any three from:</b></p> <p>indicator species tell you how polluted the environment is ✓</p> <p>different species tolerate different levels/types of pollution ✓</p> <p>changes in populations indicate changes in water quality ✓</p> <p>changes in populations prompt further chemical analysis/investigations into causes of change ✓</p> <p>pondweed provide a habitat for other species / presence of pondweed indicates that other species may also be present ✓</p>	3	<p><b>ALLOW</b> simple reference to pollution</p> <p><b>ALLOW</b> plants die if the water is polluted</p>
		<b>Total</b>	<b>15</b>	

Question		Answer	Mark	Guidance	
7	(a)	Complex formation	✓	2	
		Density			
		Optometry			
		Redox	✓		
		Spectroscopy			
	(b) (i)	Silver chromate ✓	1		
	(ii)	Red / brown ✓	1		
	(c)	Wear gloves / use goggles / wear a lab coat/PPE / use a fume cupboard ✓	1	<b>IGNORE</b> wear a mask <b>ALLOW</b> protective gear	
	(d)	<b>Any one from:</b> Wash the contaminate off (using cold water) ✓ Contact supervisor / senior technician / H&S officer ✓ Fill in the accident book ✓	1		
	(e) (i)	(Molar mass of AgNO <sub>3</sub> =) 169.9 ✓ (2.125 / 169.9 =) 0.0125 (mol) ✓	2	<b>ALLOW</b> 170 <b>ALLOW ECF</b> using 2.125 ÷ <b>their</b> formula mass <b>ALLOW</b> answer to 2 s.f., 0.013	
	(ii)	(0.0125 / 0.25 =) 0.05 (mol dm <sup>-3</sup> ) ✓	1	<b>ALLOW ECF</b> answer (e)(i) ÷ 0.25	
	(f) (i)	(No. moles Ag <sup>+</sup> in 15.5 cm <sup>3</sup> silver nitrate = 15.5 x 0.1/1000 =) 1.55 × 10 <sup>-3</sup> ✓	1		
	(ii)	(No. moles Cl <sup>-</sup> ions =) 1.55 × 10 <sup>-3</sup> ✓	1	<b>ALLOW ECF</b> using the same answer to (f)(i) <b>ALLOW</b> answer to 2 s.f. e.g. 0.0016	
	(iii)	(Concentration of chloride in diluted sample = 1.55 x10 <sup>-3</sup> / 0.025 =) 0.062 (mol dm <sup>-3</sup> ) ✓	1	<b>ALLOW ECF</b> answer f(ii) ÷ 0.025	



Question		Answer	Mark	Guidance
	(iv)	(Concentration of chloride in undiluted tap water = $5 \times 0.062 =$ $0.31 \text{ (mol dm}^{-3}\text{)} \checkmark$	1	<b>ALLOW ECF</b> answer f(iii) x 5
	(v)	(Yes, because) the concentration of chloride in the sample is more than <b>0.01</b> (mol dm <sup>-3</sup> ) $\checkmark$	1	<b>ALLOW ECF</b> from f(iv). This mark is for a conclusion based on a comparison between answer to (iv) and 0.01
	(g)	Erichrome Black T $\checkmark$  EDTA $\checkmark$	2	
		<b>Total</b>	<b>16</b>	

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