A-level
MATHEMATICS
7357/3

Paper 3

Mark scheme

June 2024

Version: 1.0 Final

2 4 6 A 7 3 5 7 / 3 / M S

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

No student should be disadvantaged on the basis of their gender identity and/or how they refer to the gender identity of others in their exam responses.

A consistent use of 'they/them' as a singular and pronouns beyond 'she/her' or 'he/him' will be credited in exam responses in line with existing mark scheme criteria.

Further copies of this mark scheme are available from aqa.org.uk

Mark scheme instructions to examiners

General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- marking instructions that indicate when marks should be awarded or withheld including the principle on which each mark is awarded. Information is included to help the examiner make his or her judgement and to delineate what is creditworthy from that not worthy of credit
- a typical solution. This response is one we expect to see frequently. However credit must be given on the basis of the marking instructions.

If a student uses a method which is not explicitly covered by the marking instructions the same principles of marking should be applied. Credit should be given to any valid methods. Examiners should seek advice from their senior examiner if in any doubt.

Key to mark types

M	mark is for method
R	mark is for reasoning
A	mark is dependent on M marks and is for accuracy
B	mark is independent of M marks and is for method and accuracy
E	mark is for explanation
F	follow through from previous incorrect result

Key to mark scheme abbreviations

CAO	correct answer only
CSO	correct solution only
ft	follow through from previous incorrect result
'their'	indicates that credit can be given from previous incorrect result
ISW	Ignore subsequent working
AWFW	anything which falls within
AWRT	anything which rounds to
ACF	any correct form
AG	answer given
SC	special case
OE	or equivalent
NMS	no method shown
PI	possibly implied
sf	significant figure(s)
dp	decimal place(s)

AS/A-level Maths/Further Maths assessment objectives

AO		Description
AO1	AO1.1a	Select routine procedures
	AO1.1b	Correctly carry out routine procedures
	AO1.2	Accurately recall facts, terminology and definitions
AO2	AO2.1	Construct rigorous mathematical arguments (including proofs)
	AO2.2a	Make deductions
	AO2.2b	Make inferences
	AO2.3	Assess the validity of mathematical arguments
	AO2.4	Explain their reasoning
	AO2.5	Use mathematical language and notation correctly
AO3	AO3.1a	Translate problems in mathematical contexts into mathematical processes
	AO3.1b	Translate problems in non-mathematical contexts into mathematical processes
	AO3.2a	Interpret solutions to problems in their original context
	AO3.2b	Where appropriate, evaluate the accuracy and limitations of solutions to problems
	AO3.3	Translate situations in context into mathematical models
	AO3.4	Use mathematical models
	AO3.5a	Evaluate the outcomes of modelling in context
	AO3.5b	Recognise the limitations of models
	AO3.5c	Where appropriate, explain how to refine models

Examiners should consistently apply the following general marking principles:

No Method Shown

Where the question specifically requires a particular method to be used, we must usually see evidence of use of this method for any marks to be awarded.

Where the answer can be reasonably obtained without showing working and it is very unlikely that the correct answer can be obtained by using an incorrect method, we must award **full marks**. However, the obvious penalty to students showing no working is that incorrect answers, however close, earn **no marks**.

Where a question asks the student to state or write down a result, no method need be shown for full marks.

Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

Otherwise we require evidence of a correct method for any marks to be awarded.

Diagrams

Diagrams that have working on them should be treated like normal responses. If a diagram has been written on but the correct response is within the answer space, the work within the answer space should be marked. Working on diagrams that contradicts work within the answer space is not to be considered as choice but as working, and is not, therefore, penalised.

Work erased or crossed out

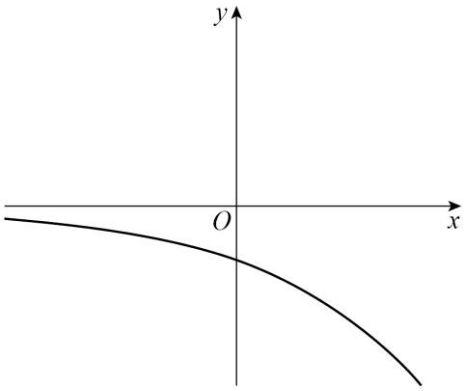
Erased or crossed out work that is still legible and has not been replaced should be marked. Erased or crossed out work that has been replaced can be ignored.

Choice

When a choice of answers and/or methods is given and the student has not clearly indicated which answer they want to be marked, mark positively, awarding marks for all of the student's best attempts. Withhold marks for final accuracy and conclusions if there are conflicting complete answers or when an incorrect solution (or part thereof) is referred to in the final answer.

Q	Marking instructions	AO	Marks	Typical solution
1	Ticks 3rd box	1.1b	B1	$128 - 64 + 32 - 16 + \ldots$
	Question 1 Total		**1**	

Q	Marking instructions	AO	Marks	Typical solution
2	Circles 2nd answer	1.1b	B1	$b = \pm 12$
	Question 2 Total		**1**	

Q	Marking instructions	AO	Marks	Typical solution
3	Ticks 3rd box	2.2a	B1	
	Question 3 Total		**1**	

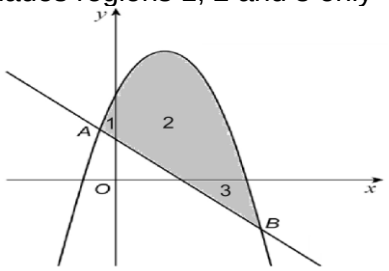
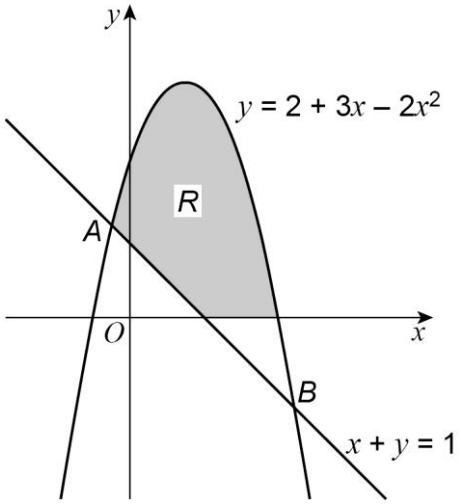
Q	Marking instructions	AO	Marks	Typical solution
4	Obtains one correct term	1.1a	M1	$\frac{dy}{dx} = 4x^3 + 2^x \ln 2$
	Obtains $4x^3 + 2^x \ln 2$ Condone $4x^3 + \ln 2 \times 2^x$ Do not **ISW**	1.1b	A1	
	Question 4 Total		**2**	

Q	Marking instructions	AO	Marks	Typical solution
5	Obtains $\frac{1}{2}\times 18^2\times\frac{\pi}{6}$ or $\frac{1}{2}\times 18^2\sin\frac{\pi}{6}$ Allow 0.5 instead of $\sin\frac{\pi}{6}$ Accept use of degrees eg $\frac{30}{360}\times\pi\times 18^2$ or $\frac{1}{2}\times 18^2\sin 30$	3.1a	M1	$\frac{1}{2}\times 18^2\times\frac{\pi}{6}-\frac{1}{2}\times 18^2\sin\frac{\pi}{6}$ $=27\pi-81$ $=27(\pi-3)\text{ cm}^2$
	Obtains $\frac{1}{2}\times 18^2\times\frac{\pi}{6}$ **and** $\frac{1}{2}\times 18^2\sin\frac{\pi}{6}$ Allow 0.5 instead of $\sin\frac{\pi}{6}$ Accept use of degrees as above	1.1b	A1	
	Completes reasoned argument to obtain $27(\pi-3)\text{ cm}^2$ Must see $27\pi-81$ or $162\left(\frac{\pi}{6}-\frac{1}{2}\right)$ Accept use of degrees as above **ISW** Condone missing units	2.1	R1	
	Question 5 Total		**3**	

Q	Marking instructions	AO	Marks	Typical solution
6(a)	Writes $\frac{1}{\sqrt{x}}$ term as $x^{-\frac{1}{2}}$ **PI** by $\sqrt{x}$ or $x^{\frac{1}{2}}$ in answer	1.1b	B1	$\int\left(6x^2-\frac{5}{\sqrt{x}}\right)\mathrm{d}x=\int\left(6x^2-5x^{-\frac{1}{2}}\right)\mathrm{d}x$ $=2x^3-10x^{\frac{1}{2}}+c$
	Obtains one correctly integrated term May be unsimplified	1.1a	M1	
	Obtains $2x^3-10x^{\frac{1}{2}}+c$ **ISW** Condone omission of $+c$ Must be simplified	1.1b	A1	
	Subtotal		**3**	

Q	Marking instructions	AO	Marks	Typical solution
6(b)	Substitutes x = 4 into their integrated expression from part **6(a)**, with an arbitrary constant **and** sets equal to 90 **PI** by -18	3.1a	M1	$90=2\times4^3-10\times4^{\frac{1}{2}}+c$ $c=-18$ $\therefore y=2x^3-10x^{\frac{1}{2}}-18$
	Obtains $y=2x^3-10x^{\frac{1}{2}}-18$ **CAO** Condone f(x) for y	1.1b	A1	
	Subtotal		**2**	

	Question 6 Total		**5**	

Q	Marking instructions	AO	Marks	Typical solution
7(a)	Shades two of regions 1, 2 or 3 only or shades one of region 1 or 2 or 3 only or shades regions 1, 2 and 3 only  	1.1a	M1	
	Shades the correct regions 1 and 2 only Condone missing label *R*	2.2a	R1	
	Subtotal		**2**	

Q	Marking instructions	AO	Marks	Typical solution
7(b)	Eliminates y or x correctly to obtain a quadratic in x or y	1.1a	M1	$1-x=2+3x-2x^2$ $2x^2-4x-1=0$ $x=\frac{2-\sqrt{6}}{2}$ $y=\frac{\sqrt{6}}{2}$ So $A\left(\frac{2-\sqrt{6}}{2},\frac{\sqrt{6}}{2}\right)$
	Obtains $x=\frac{2-\sqrt{6}}{2}$ or $\frac{2\pm\sqrt{6}}{2}$ Accept **AWFW** [–0.225, –0.22] or obtains $y=\frac{\sqrt{6}}{2}$ or $\pm\frac{\sqrt{6}}{2}$ Accept **AWFW** [1.22, 1.225] May be unsimplified	1.1b	A1	
	Obtains $\left(\frac{2-\sqrt{6}}{2},\frac{\sqrt{6}}{2}\right)$ Accept $x=\frac{2-\sqrt{6}}{2}$ **and** $y=\frac{\sqrt{6}}{2}$ **ISW** Must be simplified	1.1b	A1	
	Subtotal		**3**	

	Question 7 Total		**5**	

Q	Marking instructions	AO	Marks	Typical solution
8(a)	Substitutes $t = 0$ into the model **PI** by 20	3.4	M1	$\theta = 20\left(11-10\mathrm{e}^{0}\right)$ $= 20$
	Obtains 20°C Must have units	3.2a	A1	Room temperature = 20°C
	Subtotal		**2**	

Q	Marking instructions	AO	Marks	Typical solution
8(b)	Replaces e^{-kt} with 0 or substitutes any positive value for kt **PI** by 220	3.4	M1	For large values of t, $\mathrm{e}^{-kt} \to 0$ $T = 20\left(11-10\times 0\right)$ Hence T = 220
	Obtains 220	3.4	A1	
	Subtotal		**2**	

Q	Marking instructions	AO	Marks	Typical solution
8(c)(i)	Forms the equation $86 = 20\left(11-10\mathrm{e}^{-k}\right)$ **PI** by correct answer	3.4	M1	$86 = 20\left(11-10\mathrm{e}^{-k}\right)$ k = 0.4
	Obtains **AWFW** [0.4, 0.4005] or $-\ln 0.67$ **OE**	3.3	A1	
	Subtotal		**2**	

Q	Marking instructions	AO	Marks	Typical solution
8(c)(ii)	Uses their T from part **8(b)** and their k from part **8(c)(i)** correctly to form the equation $T-1 = 20\left(11-10\mathrm{e}^{-kt}\right)$ **PI** by correct answer Condone use of inequality sign	3.4	M1	$220-1 = 20\left(11-10\mathrm{e}^{-0.4t}\right)$ t = 13.2 minutes
	Obtains **AWFW** [13.2, 13.25] mins or **AWFW** [13m 12s, 13m 15s] or 13 mins Condone missing units or $t > 13.2$ or $t \geq 13.2$ **ISW**	1.1b	A1	
	Subtotal		**2**	

	Question 8 Total		**8**	

Q	Marking instructions	AO	Marks	Typical solution
9(a)	Obtains $(x \pm 4)^2 \ldots$ or $(y \pm 6)^2 \ldots$	1.1a	M1	$x^2 + y^2 = 12y - 8x - 27$ $x^2 + 8x + y^2 - 12y = -27$ $(x+4)^2 - 16 + (y-6)^2 - 36 = -27$ $(x+4)^2 + (y-6)^2 = 25$
	Obtains $(x+4)^2 \ldots + (y-6)^2 \ldots$	1.1a	M1	
	Obtains $(x+4)^2 + (y-6)^2 = 25$ Accept 5^2 for 25 Condone $(x - -4)^2 \ldots$ throughout	1.1b	A1	
	Subtotal		**3**	

Q	Marking instructions	AO	Marks	Typical solution
9(b)	States (–4, 6) Follow through their squared brackets from part **9(a)**	1.2	B1F	(–4, 6)
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
9(c)	Substitutes $x = 0$ correctly into the given or their equation of circle to form a quadratic equation in y or uses their right-angled triangle correctly to find vertical distance of Q above P **PI** by $y = 9$ or (0, 9) May be seen on diagram	3.1a	M1	$4^2 + (y-6)^2 = 25$ $y^2 - 12y + 27 = 0$ $y = 3$ or $y = 9$ $\therefore y = 9$
	Obtains 9 Accept (0, 9) Must come from centre (–4, 6)	2.2a	A1	
	Subtotal		**2**	

Q	Marking instructions	AO	Marks	Typical solution
9(d)	Uses distance formula to find *QR* or *PR* **PI** by their 15 for *QR* or their $5\sqrt{10}$ for *PR* **OE** **PI** by correct answer or **AWFW** [71.5, 72]°	1.1a	M1	$PR = \sqrt{(9--4)^2 + (-3-6)^2}$ $= 5\sqrt{10}$ $\cos QPR = \frac{5}{5\sqrt{10}}$ $QPR = 1.25$
	Substitutes all their relevant lengths correctly into an appropriate trigonometric equation **PI** by correct answer or **AWFW** [71.5, 72]°	3.1a	M1	
	Obtains **AWFW** [1.249, 1.25]	1.1b	A1	
	Subtotal		**3**	

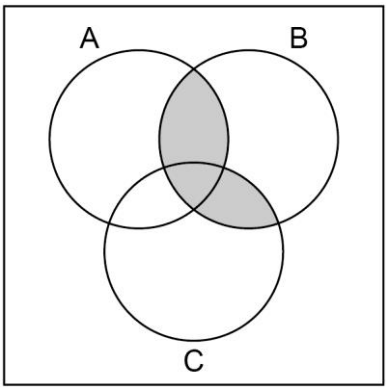
	Question 9 Total		**9**	

Q	Marking instructions	AO	Marks	Typical solution
10	States $5(x+h)^3+(x+h)-(5x^3+x)$ Condone missing brackets	1.1a	M1	
	Expands $(x+h)^3$ correctly Like terms need not be collected Accept all terms multiplied by 5 May be embedded	1.1a	M1	
	Obtains $\frac{15x^2h+15xh^2+5h^3+h}{h}$ correctly eliminating $5x^3$ and x **PI** by $15x^2+15xh+5h^2+1$ having seen a division by h Like terms need not be collected	1.1b	A1	$\frac{f(x+h)-f(x)}{h}=\frac{5(x+h)^3+(x+h)-(5x^3+x)}{h}$ $=\frac{5(x^3+3x^2h+3xh^2+h^3)+h-5x^3}{h}$ $=\frac{15x^2h+15xh^2+5h^3+h}{h}$ $=15x^2+15xh+5h^2+1$
	Obtains $15x^2+15xh+5h^2+1$ by correctly dividing by h Like terms need not be collected	2.1	A1	$f'(x)=\lim_{h\to 0}15x^2+15xh+5h^2+1$ $f'(x)=15x^2+1$
	Completes a reasoned argument using the $\lim_{h\to 0}$ to prove that $f'(x)=15x^2+1$ $f'(x)$ may be seen on the final line or before Do not allow $\frac{dy}{dx}$ for $f'(x)$	2.5	R1	
	Question 10 Total		**5**	

Q	Marking instructions	AO	Marks	Typical solution
11	Equates $\left(x^2-8x\right)\ln x$ to zero **PI** by 1 or 8 or ±108.(2…) May be seen on diagram or integral	3.1a	M1	$\left(x^2-8x\right)\ln x=0$ $x\left(x-8\right)\ln x=0$ $x=8, \ln x=0 \Rightarrow x=1$
	Obtains at least one of x = 1 or x = 8 **PI** by ±108.(2…) May be seen on diagram or integral	1.1b	A1	$\int_1^8\left(x^2-8x\right)\ln x\ \mathrm{d}x$ $u=\ln x \qquad u'=\frac{1}{x}$ $v'=x^2-8x \qquad v=\frac{x^3}{3}-4x^2$
	Deduces the limits are 1 **and** 8 **PI** by ±108.(2…) May be seen on integral or substituted into their integrated expression	2.2a	R1	$\left(\frac{x^3}{3}-4x^2\right)\ln x-\int\left(\frac{x^3}{3}-4x^2\right)\frac{1}{x}\mathrm{d}x$ $=\left(\frac{x^3}{3}-4x^2\right)\ln x-\left(\frac{x^3}{9}-2x^2\right)$
	States $u=\ln x$ and $v'=x^2-8x$ Condone $v=\ln x$ and $u'=x^2-8x$	3.1a	M1	$\int_1^8\left(x^2-8x\right)\ln x\ \mathrm{d}x$ $=\left[\left(\frac{8^3}{3}-4\times8^2\right)\ln 8-\left(\frac{8^3}{9}-2\times8^2\right)\right]$
	Finds $u'=\frac{1}{x}$ and $v=\frac{x^3}{3}-4x^2$	3.1a	A1	
	Applies integration by parts formula correctly by substituting their *u, u' and v* **PI** by $\left(\frac{x^3}{3}-4x^2\right)\ln x-\left(\frac{x^3}{9}-2x^2\right)$ or $-\left(\frac{x^3}{3}+4x^2\right)\ln x+\left(\frac{x^3}{9}-2x^2\right)$ Condone missing brackets	1.1a	M1	$-\left[\left(\frac{1^3}{3}-4\times1^2\right)\ln 1-\left(\frac{1^3}{9}-2\times1^2\right)\right]$ $=-\frac{256}{3}\ln 8+\frac{640}{9}-\frac{17}{9}$ $=\frac{623}{9}-256\ln 2$
	Obtains $\left(\frac{x^3}{3}-4x^2\right)\ln x-\left(\frac{x^3}{9}-2x^2\right)$ **OE** or $-\left(\frac{x^3}{3}+4x^2\right)\ln x+\left(\frac{x^3}{9}-2x^2\right)$ **OE**	1.1b	A1	$\therefore \text{ Area} = -\frac{623}{9}+256\ln 2$

	Substitutes their non-zero limits correctly into their integrated expression (the subtraction does not need to be seen) or obtains exact values for their integrated expression using their non-zero limits eg $-\frac{256}{3}\ln 8+\frac{640}{9}$ and $\frac{17}{9}$	1.1a	M1	
	Obtains $\frac{623}{9}-256\ln 2$ or $\frac{623}{9}-\frac{256}{3}\ln 8$ **ACF** must be exact form with two terms **PI** $-\frac{623}{9}+256\ln 2$	1.1b	A1	
	Completes a reasoned argument to obtain $-\frac{623}{9}+256\ln 2$ To be awarded R1, all marks must be scored	2.1	R1	
	Question 11 Total		**10**	

Q	Marking instructions	AO	Marks	Typical solution
12	Circles 1st answer	1.1b	B1	3
	Question 12 Total		**1**	

Q	Marking instructions	AO	Marks	Typical solution
13	Ticks bottom left box	2.5	B1	
	Question 13 Total		**1**	

Q	Marking instructions	AO	Marks	Typical solution
14(a)	Obtains 2700	1.1b	B1	2700
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
14(b)	Uses the correct formula for standard deviation using their mean **PI** by 400	1.1a	M1	$\sqrt{\frac{2\,607\,500\,000}{350} - 2700^2} = 400$
	Obtains 400	1.1b	A1	
	Subtotal		**2**	

Q	Marking instructions	AO	Marks	Typical solution
14(c)	Concludes correctly in context for the means Comparison must include the word such as 'on average' or 'typically' etc Follow through the correct comparison of 3100 with their mean from part **14(a)**	2.4	E1F	The cost of energy for households in Village A is less on average The variation in cost of energy is higher in Village A.
	Concludes correctly in context for the standard deviations Comparison must include the word such as 'varies', 'spread' 'disperse' 'variation' or 'consistent' etc Follow through the correct comparison of 325 with their standard deviation from part **14(b)** Do not allow comparison that includes 'range' or 'variety'	2.4	E1F	
	Subtotal		**2**	

	Question 14 Total		**5**	

Q	Marking instructions	AO	Marks	Typical solution
15(a)	Obtains 8.4	1.1b	B1	8.4
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
15(b)	Shows how to obtain **6.93** by using the correct formula for variance **AG**	1.1b	B1	Variance = 48 × 0.175 × 0.825 = 6.93
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
15(c)	Obtains **AWFW** [0.674, 0.6742]	1.1b	B1	0.6742
	Subtotal		**1**	

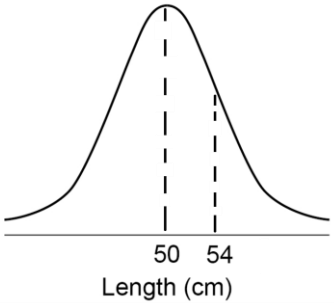
Q	Marking instructions	AO	Marks	Typical solution
15(d)	Finds P($X \leq 5$) = [0.132, 0.133] or P($X \leq 6$) = [0.241, 0.242] or P($X > 6$) = [0.758, 0.759] or P($X \geq 6$) = [0.867, 0.868] **PI** by correct answer Condone incorrect or no labels	1.1a	M1	P ($X \geq 6$) = 1 – P ($X \leq 5$) = 1 – 0.1325 = 0.8675
	Obtains **AWFW** [0.867, 0.868]	1.1b	A1	
	Subtotal		**2**	

Q	Marking instructions	AO	Marks	Typical solution
15(e)	Finds P($X \leq 15$) = [0.994, 0.9941] or P($X \leq 8$) = [0.531, 0.532] **PI** by correct answer Condone incorrect or no labels	1.1a	M1	P ($9 \leq X \leq 15$) = 0.9940 – 0.5317 = 0.4623
	Obtains **AWFW** [0.462, 0.4631]	1.1b	A1	
	Subtotal		**2**	

Q	Marking instructions	AO	Marks	Typical solution
15(f)	States that the model is appropriate because 1. The 48 seats and 17.5% passengers travelling for business match the values of n and p in the model or 2. Only business or non-business passenger 3. Business/non-business passengers occur independently or states that the model is not appropriate because 1. The plane may not be full so n might change or might not be 48 2. The p might change or is not fixed or might not be 0.175 due to eg peak or holiday periods 3. Not independent because passengers might book seats in groups Do not allow probability being independent	3.5b	E1	Model is appropriate because 48 seats and 17.5% passengers travelling for business match the values of n and p. However the plane may not be full so n may not be 48.
	Makes a second non-contradictory comment in context from the list above, about the suitability of the model	3.5b	E1	
	Subtotal		**2**	

	Question 15 Total		**9**	

Q	Marking instructions	AO	Marks	Typical solution
16	States $H_0 : \rho = 0$ $H_1 : \rho < 0$	2.5	B1	$H_0 : \rho = 0$ $H_1 : \rho < 0$ $-0.45 < -0.2787$ Reject H_0 There is sufficient evidence to suggest the student's belief that, in adults, there is a negative correlation between the amount of nicotine in their blood stream and their energy level
	Compares ± 0.45 or $\lvert -0.45 \rvert$ **and** ± 0.2787 May be seen on a diagram	3.5a	M1	
	States $-0.45 < -0.2787$ or $0.45 > 0.2787$ or $\lvert -0.45 \rvert > 0.2787$ or $\lvert -0.45 \rvert > \lvert 0.2787 \rvert$ **and** Infers H_0 rejected Condone accept H_1	2.2b	A1	
	Concludes, from a fully correct comparison, in context by referring to **negative correlation** between the amount of **nicotine** in the blood stream and the **energy** level in adults Conclusion must not be definite, eg use of 'suggest', 'support' etc To be awarded R1, marks M1A1 must be scored as the minimum	3.2a	R1	
	Question 16 Total		**4**	

Q	Marking instructions	AO	Marks	Typical solution
17(a)	Labels 50 on the horizontal axis below the vertex Condone label at the vertex	3.3	B1	
	Labels 54 on the horizontal axis below the right-hand point of inflection Condone label at the right-hand point of inflection	3.3	B1	
	Subtotal		**2**	

Q	Marking instructions	AO	Marks	Typical solution
17(b)	States 0.5	1.2	B1	0.5
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
17(c)	Obtains **AWFW** [0.0668, 0.067]	1.1b	B1	0.0668
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
17(d)	Obtains **AWFW** [0.987, 0.99]	1.1b	B1	0.9876
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
17(e)	Forms $\frac{x-50}{4} = -1.6449$ or forms $50 + 4\times(-1.6449)$ **PI** by correct answer or **AWFW** [56.56, 56.6]cm or 57cm Allow [–4, 4] except ±0.95 or ±0.05 or 0 for –1.6449	3.1b	M1	$\frac{x-50}{4} = -1.6449$ Minimum length is 43.4 cm
	Obtains **AWFW** [43.4, 43.44] cm or 43 cm Condone missing units	1.1b	A1	
	Subtotal		**2**	

Q	Marking instructions	AO	Marks	Typical solution
17(f)	States H_0: $\mu = 50$ H_1: $\mu > 50$	2.5	B1	X = length of new-born baby H_0: $\mu = 50$ H_1: $\mu > 50$ $\bar{x} = 51.5$ $\bar{X} \sim N(50, \frac{4^2}{40})$ $P(\bar{X} > 51.5) = 0.0089$ $0.0089 < 0.1$ Reject H_0 There is sufficient evidence to suggest that the mean length of a new-born baby at the clinic in 2020 has increased compared to 2019.
	Obtains 51.5 **OE**	1.1b	B1	
	States or uses correct model **PI** by normal with mean 50 **and** variance $\frac{4^2}{40}$ or 0.4 or standard deviation $\sqrt{0.4}$ or 0.63 or better **OE** or by correct probability **AWFW** [0.0086, 0.009] or test statistic $(\pm)\frac{51.5-50}{\frac{4}{\sqrt{40}}}$ FT their 51.5 for test statistic or test statistic value **AWFW** (±)[2.37, 2.4] or critical value **AWFW** [50.8, 51]	1.1a	M1	
	Obtains **AWFW** [0.0086, 0.009] or the correct value of the test statistic **AWFW** [2.37, 2.4] or acceptance region ≤ **AWFW** [50.8, 51] allow strict inequality or critical region ≥ **AWFW** [50.8, 51] allow strict inequality or critical value **AWFW** [50.8, 51]	1.1b	A1	

	Correctly compares their value of $P(>$ or $\geq$ their sample mean) with 0.1 or correctly compares their positive test statistic with **AWFW** [1.28, 1.282] or correctly compares 51.5 with their acceptance region or critical region or critical value **FT** their sample mean May be seen on a diagram	3.5a	M1	
	Infers H_0 rejected **FT** their comparison Condone accept H_1	2.2b	A1F	
	Concludes, from a fully correct comparison, in context by referring to an **increase** in the **mean** length of new-born baby at the clinic. Conclusion must not be definite, eg use of 'suggest', 'support' etc To be awarded R1, marks B0B1M1A1M1A1 must be scored as the minimum	3.2a	R1	
	Subtotal		**7**	

	Question 17 Total		**14**	

Q	Marking instructions	AO	Marks	Typical solution
18(a)(i)	Obtains 0.39	1.1b	B1	0.39
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
18(a)(ii)	States or calculates $1 - \text{P}(G \cap H)$ or states 0.07 + 0.18 + 0.54 **PI** by correct answer	1.1a	M1	$1 - 0.21 = 0.79$
	Obtains 0.79	1.1b	A1	
	Subtotal		**2**	

Q	Marking instructions	AO	Marks	Typical solution
18(a)(iii)	States $\text{P}(H \mid G') = \dfrac{\text{P}(H \cap G')}{\text{P}(G')}$ Condone missing $\text{P}(H \mid G')$ or states $\text{P}(H \cap G') = 0.07$ or $\dfrac{0.07}{k}$ seen or states $0.07 + 0.54$ or 0.61 or $\dfrac{k}{0.07+0.54}$ seen **PI** by correct answer	1.1a	M1	$\text{P}(H \mid G') = \dfrac{\text{P}(H \cap G')}{\text{P}(G')}$ $= \dfrac{0.07}{0.61}$ $= \dfrac{7}{61}$
	Obtains $\dfrac{7}{61}$ or **AWFW** [0.11, 0.115]	1.1b	A1	
	Subtotal		**2**	

Q	Marking instructions	AO	Marks	Typical solution
18(b)	States their P(G) from part **18(a)(i)** × 0.28 or compares their P(G) from part **18(a)(i)** with 0.75 or compares their P($H \mid G$) with 0.28 or compares their P($H \mid G'$) from part **18(a)(iii)** with 0.28 or any other valid comparison with one correct probability to at least 2 sf	3.1b	M1	P(G) × P(H) = 0.39 × 0.28 = 0.1092 P($G \cap H$) = 0.21 P($G \cap H$) $\neq$ P(G) × P(H) Hence G and H are not independent
	Completes a reasoned argument and concludes that G and H are **not independent**	2.4	R1	
	Subtotal		**2**	

	Question 18 Total		**7**	

Q	Marking instructions	AO	Marks	Typical solution
19(a)(i)	States $H_0 : p = 0.8$ $H_1 : p \neq 0.8$	2.5	B1	$H_0 : p = 0.8$ $H_1 : p \neq 0.8$
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
19(a)(ii)	States or uses correct model **PI** by calculation of one of P($X \leq x$) where x = [1, 24] or P($X \geq x$) where x = [1, 25] or P($X = x$) where x = 0 or 25 or by critical region of $x \leq 16$ or $x \geq 24$	3.3	B1	$X \sim$ B(25, 0.8) P($X \leq 15$) = 0.0173 < 0.05 P($X \leq 16$) = 0.0468 < 0.05 P($X \leq 17$) = 0.1091 > 0.05 P($X \geq 23$) = 0.0982 > 0.05 P($X \geq 24$) = 0.0274 < 0.05 P($X \geq 25$) = 0.0038 < 0.05 Critical region is $x \leq 16$, $x \geq 24$
	Obtains one of (List 1) [0.017, 0.0174] or [0.046, 0.047] or [0.109, 0.11] or [0.098, 0.0983] or [0.027, 0.0274] or [0.0037, 0.0038] or obtains one of (List 2) [0.982, 0.983] or [0.953, 0.954] or [0.890, 0.891] or [0.901, 0.902] or [0.97, 0.973] or [0.996, 0.9963] **PI** by critical region of $x \leq 16$ or $x \geq 24$ Ignore labels	1.1a	M1	
	Compares one probability from List 1 **with** 0.05 or compares one probability from List 2 **with** 0.95 **PI** by critical region of $x \leq 16$ or $x \geq 24$	1.1a	M1	
	Obtains one of the critical regions of $x \leq 16$ or $x \geq 24$	1.1b	A1	
	Obtains both critical regions $x \leq 16$, $x \geq 24$ Accept critical region of $x < 17$ or $0 \leq x < 17$, $x > 23$ Condone use of any letter for x or stating ≤ 16 or ≥ 24 throughout	3.2a	A1	
	Subtotal		**5**	

Q	Marking instructions	AO	Marks	Typical solution
19(a)(iii)	Concludes correctly in context from a fully correct comparison Conclusion must not be definite, eg use of 'suggest', 'support' etc Follow through the correct comparison of 18 with their critical region from part **19(a)(ii)** The comparison does not need to be seen	2.2b	E1F	There is insufficient evidence to suggest that proportion of diesel cars registered in 2022 with CO emissions less than 0.3 g/km has changed
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
19(b)	States one of the following reasons 1. no **diesel cars** in the LDS have **CO emissions** more than 0.5 g/km 2. Values of **CO emissions** for some **diesel cars** are missing from LDS 3. LDS data is not representative due to only few regions in England or some makes of cars or only two years	2.4	E1	No diesel cars in the LDS have CO emissions more than 0.5 g/km The LDS only uses data from cars in some regions in England but not all
	States a different reason 1. no **diesel cars** in the LDS have **CO emissions** more than 0.5 g/km 2. Values of **CO emissions** for some **diesel cars** are missing from LDS 3. LDS data is not representative due to only few regions in England or some makes of cars or only two years	2.4	E1	
	Subtotal		**2**	

	Question 19 Total		**9**	

	Question Paper Total		**100**	