A-level
MATHEMATICS
7357/3

Paper 3

Mark scheme

June 2020

Version: 1.0 Final Mark Scheme

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.

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
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
ISW	ignore subsequent work
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

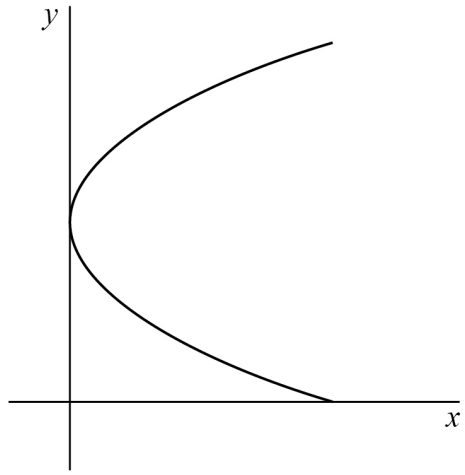
Erased or crossed out work that is still legible and has not been replaced should be marked. Erased or crossed out work that has been replaced can be ignored.

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	Circles correct answer	2.2a	B1	17
	Total		**1**	

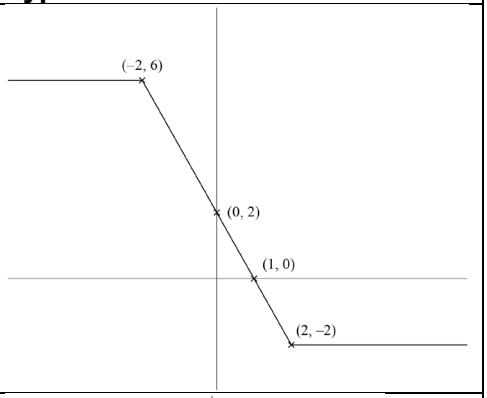
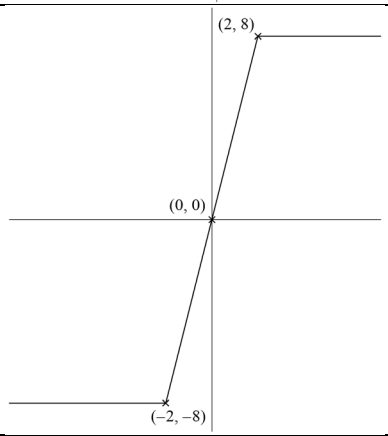
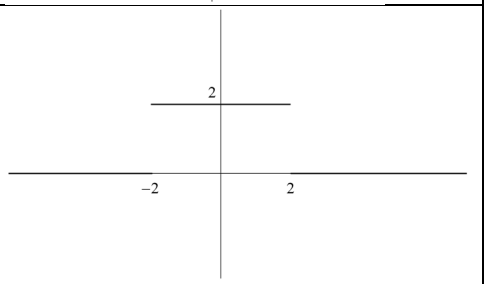
Q	Marking instructions	AO	Marks	Typical solution
2	Circles correct answer	1.1b	B1	10
	Total		**1**	

Q	Marking instructions	AO	Marks	Typical solution
3	Ticks correct box	1.2	B1	
	Total		**1**	

Q	Marking instructions	AO	Marks	Typical solution
4(a)	Substitutes x = 6 into p(x)	1.1a	M1	$p(6) = 4\times6^3 - 15\times6^2 - 48\times6 - 36$ $= 0$ $\therefore x-6$ is a factor of $\mathrm{p}(x)$
	Completes reasoned proof by stating $p(6)=0$ and clearly states that this implies that x - 6 is a factor	2.1	R1	
4(b)(i)	Factorises with at least two terms correct or differentiates $p(x)$ with at least two terms correct	3.1a	M1	$4x^3 - 15x^2 - 48x - 36 = (x-6)(4x^2+9x+6)$ $b^2 - 4ac = 9^2 - 4\times4\times6$ $= -15$ < 0 $\therefore 4x^2 + 9x + 6 = 0$ has no real roots Hence $p(x) = 0$ has exactly one real root.
	Obtains fully correct quadratic factor or obtains fully correct derivative	1.1b	A1	
	Calculates their discriminant or sets their quadratic = 0 or sketches their quadratic **PI** concluding no real root or sets their derivative = 0 and obtains their turning points (x, y) **OE**	1.1a	M1	
	States -15 < 0 and concludes reasoned argument **OE** or states roots are non-real roots and concludes reasoned argument or states correct turning points and concludes reasoned argument	2.1	R1	
4(b)(ii)	States coordinates of point of intersection	1.1b	B1	(6, 0)
	Total		**7**	

Q	Marking instructions	AO	Marks	Typical solution
5(a)	Substitutes t = 15.9 hours and $N = \frac{N_0}{2}$ in the model to find k **OE** **PI** by correct value of k	3.4	M1	$\frac{N_0}{2} = N_0 e^{-15.9k}$ $k = 0.0436$ $0.1 = e^{-0.0436t}$ $t = 52.8\,\text{hours}$ t = 2.2 days
	Obtains correct k **AWFW** [0.043, 0.044] or $-\frac{ln(0.5)}{15.9}$	1.1b	A1	
	Substitutes their value of k and $N = 0.1N_0$ in the model to find t **OE**	3.4	M1	
	Solves their equation correctly to find their t **AWFW** [52.3, 53.6] if correct k used	1.1a	M1	
	Obtains correct t in days **AWRT** 2.2 days Accept [2 days 4 hours, 2 days 6 hours] or 3 days Condone 2 days if 2.2 days seen	3.2a	A1	
5(b)	Substitutes t = 24x7 or 168 and their value of k in the model. Condone omission of N or N_0 or use of N_0 = 1 or 100 **PI** by [0.000616, 0.00073] or correct answer	3.4	M1	$N = N_0 e^{-0.0436\times168}$ $= N_0 \times 0.000658..$ 0.066%
	Obtains correct percentage **AWFW** [0.0616, 0.073] **ISW**	3.2a	A1	
5(c)	Gives a sensible reason relating continuous model for discrete data **OE**	3.2b	E1	The model is continuous but the number of atoms is discrete

5(d)	Explains that the number of atoms will eventually become small or explains that the model will eventually predict less than one atom but never zero atoms **OE**	3.5a	E1	As t gets large the number of atoms predicted by the model will become small so the model will no longer be accurate.
	Total		**9**	

Q	Marking instructions	AO	Marks	Typical solution
6(a)	Sketches correct shape with graph reflected in the y-axis	1.1a	M1	
	Labels all four points correctly Condone omission of (0, 2)	1.1b	A1	
6(b)	Calculates or labels at least two points of (2, 8), (0, 0), (-1, -4) or (-2, -8) correctly	3.1a	M1	
	Sketches correct graph and labels all four points correctly Condone omission of (0,0) or (-1, -4) or both	1.1b	A1	
6(c)	Calculates or obtains gradient 2 for between x = -2 and x = 2 **PI** by line y = 2 or calculates or obtains gradient 0 when x < -2 or when x > 2 **PI** by explaining gradient when x < -2 or x > 2 is zero or by drawing visible solid horizontal lines on the x axis	1.1b	B1	
	Draws a horizontal line on the positive y-axis between x = -2 and x = 2 without extension Ignore any other lines if drawn	1.1a	M1	

	Draws **correct two solid horizontal lines** on the x-axis up to (−2, 0) and from (2, 0) **and their horizontal line** $y = 2$ between $x = -2$ and $x = 2$ Accept explanation that gradient for $x < -2$ and $x > 2$ is zero if no solid horizontal lines are drawn on the x-axis Do not accept solid vertical lines at $x = -2$ or $x = 2$ Follow through their value of positive gradient	1.1b	A1F	
	Total		**7**	

Q	Marking instructions	AO	Marks	Typical solution
7(a)	Substitutes $r = 2$ into given formula and writes out either $n!$ or $(n-2)!$ correctly up to at least three terms Accept $n! = n \times (n-1) \times (n-2)!$ or $(n-2)! = (n-2) \times (n-3) \times (n-4)!$ Condone omission of brackets	1.1a	M1	${}^nC_2 = \frac{n!}{2!(n-2)!}$ $= \frac{n\times(n-1)\times(n-2)\times\ldots}{2\times(n-2)\times\ldots}$ $= \frac{n(n-1)}{2}$
	Completes reasoned argument, eliminating common factors correctly leading to the correct form Must see $\frac{n\times(n-1)}{2}$ **AG**	2.1	R1	
7(b)(i)	Simplifies to obtain ${}^nC_4$ as $\frac{2n(n-1)(n-2)(n-3)}{4!}$ or better	1.1b	B1	$2\times {}^nC_4 = 51\times {}^nC_2$ $\frac{2\,n!}{4!(n-4)!} = \frac{51\,n(n-1)}{2}$
	Writes ${}^nC_4$ and ${}^nC_2$ in terms of n and forms an equation using $2\times {}^nC_4 = 51\times {}^nC_2$ Allow ${}^nC_4 = \frac{2\,n!}{4!(n-4)!}$ or $\frac{2n(n-1)(n-2)(n-3)}{4!}$ or ${}^nC_2 = \frac{n!}{2!(n-2)!}$	3.1a	M1	$\frac{2n(n-1)(n-2)(n-3)}{4!} = \frac{51\times n\times(n-1)}{2}$ $\frac{(n-2)(n-3)}{6} = 51$ $n^2 - 5n + 6 = 306$ $n^2 - 5n - 300 = 0$

	Completes reasoned argument to obtain given result Must see $\frac{(n-2)(n-3)}{6}=51$ or $(n-2)\ (n-3)$ = 306 **OE** **AG**	2.1	R1	
7(b)(ii)	Obtains at least one correct solution to the equation $n^2-5n-300=0$ **PI** by correct answer	1.1a	M1	$n=-15$ or 20 since n > 0, so n = 20
	States n = 20	3.2a	A1	
	Total		**7**	

Q	Marking instructions	AO	Marks	Typical solution
8(a)	Forms an equation for sum to infinity or 2nd term **PI** by correct answer	1.1a	M1	$ar = 18$ $\frac{a}{1-r} = 96$ $r - r^2 = \frac{18}{96}$ $r = \frac{1}{4}$ or $\frac{3}{4}$ $a = 72$ or 24 Since a < 30 $r = \frac{3}{4}$ $a = 24$
	Obtains both correct equations	1.1b	A1	
	Solves their two equations to find two values of a or r **PI** by correct values of a or r	3.1a	M1	
	Obtains two correct values of a= 72 or 24 or obtains two correct values of $r = \frac{1}{4}$ or $\frac{3}{4}$	1.1b	A1	
	Deduces correct pair of a and r Follow through their values of a and r Must have one value of a > *30*	2.2a	A1F	
8(b)(i)	Substitutes their a and r into the expression $u_n = ar^{n-1}$	1.1b	B1F	$u_n = 24 \times \left(\frac{3}{4}\right)^{n-1}$ $= 3 \times 2^3 \times \frac{3^{n-1}}{2^{2(n-1)}}$ $= \frac{3 \times 3^{n-1}}{2^{-3} \times 2^{2(n-1)}}$ $= \frac{3^n}{2^{2n-5}}$
	Writes their a or r in terms of prime numbers fully	3.1a	M1	
	Deduces that $a = 24$ can be written as $2^3 \times 3$ and $r = \frac{3}{4}$ as $\frac{3}{2^2}$ **PI** by expressing all terms in powers of 2 and 3	2.2a	A1	
	Completes reasoned argument by expressing all terms in powers of 2 and 3 and simplifies to show required result **AG**	2.1	R1	
8(b)(ii)	Applies logarithmic subtraction or addition law correctly	1.1a	M1	
	Applies logarithmic power law to obtain either $n \log_3 3$ or $(2n\text{-}5) \log_3 2$ Condone omission of brackets	1.1a	M1	

	Completes reasoned argument by using $n \log_3 3$ and $(2n\text{-}5) \log_3 2$ to show required result **AG** Do not allow recovery of omitted brackets	2.1	R1	$\log_3 u_n = \log_3 \frac{3^n}{2^{2n-5}}$ $= \log_3 3^n - \log_3 2^{2n-5}$ $= n - (2n-5)\log_3 2$ $= n + (5-2n)\log_3 2$ $= n - 2n\log_3 2 + 5\log_3 2$ $= n(1 - 2\log_3 2) + 5\log_3 2$
	Total		**12**	

Q	Marking Instructions	AO	Marks	Typical Solution
9(a)	Uses $\text{cosec}2\theta = \frac{1}{\sin 2\theta}$ and $\cot 2\theta = \frac{\cos 2\theta}{\sin 2\theta}$	1.2	B1	$\frac{1}{\sin 2\theta} + \frac{\cos 2\theta}{\sin 2\theta}$ $= \frac{1+\cos 2\theta}{\sin 2\theta}$
	Uses the identity for $\sin 2\theta = 2\sin\theta\cos\theta$ or an identity for $\cos 2\theta = \cos^2\theta - \sin^2\theta$ *or* $2\cos^2\theta - 1$ or $1 - 2\sin^2\theta$ to commence proof	2.1	M1	$= \frac{1+\cos^2\theta - \sin^2\theta}{2\sin\theta\cos\theta}$ $= \frac{2\cos^2\theta}{2\sin\theta\cos\theta}$
	Uses the identities for $\sin 2\theta$ and $\cos 2\theta$ in correct proof	1.1b	A1	$= \frac{\cos\theta}{\sin\theta} = \cot\theta$
	Completes a reasoned argument leading to a single trigonometric fraction to prove given identity **AG**	2.1	R1	
9(b)	Deduces that when $\cos\theta = 0$ then $\cot\theta$ is defined/zero/exists on LHS but $\text{cosec}2\theta$ or $\cot 2\theta$ or $\frac{1}{2\sin\theta\cos\theta}$ *or* $\frac{1}{\sin 2\theta}$ is undefined on RHS or deduces that LHS is defined but RHS is undefined Must compare both LHS and RHS	2.2a	E1	When $\cos\theta = 0$ the value of $\cot\theta = 0$ on LHS but because the value of $\sin 2\theta = 0$, $\text{cosec}2\theta$ and $\cot 2\theta$ are undefined on RHS.
	Total		**5**	

Q	Marking Instructions	AO	Marks	Typical Solution
10	Circles correct answer	1.1b	B1	0.11
	Total		**1**	

Q	Marking Instructions	AO	Marks	Typical Solution
11	Circles correct answer	1.1b	B1	8.24
	Total		**1**	

Q	Marking Instructions	AO	Marks	Typical Solution
12(a)	Compares correctly the medians and infers that London is greater Must use median only References to values (London 142 and North West 129), if used, must be correct	2.2b	E1	Central tendency Median in London is greater than the median in the North West Spread Range in London is less than the range in the North West
	Compares correctly the ranges and infers that London is less or compares correctly the IQR/SIQR and infers that London's IQR/SIQR is greater Must use range/IQR/SIQR only References to values, range (London 307 and North West 343) /IQR (London 49 and North West 37) /SIQR (London 143.5 and North West 136.5) if used, must be correct	2.2b	E1	
12(b)	Gives one reason why his conclusion may be invalid	2.4	E1	Not all makes of car are included in the database Not all English regions are included
	Gives a second reason why his conclusion may be invalid Other reasons Some values for CO_2 or CO are missing in the LDS LDS has outliers/skewed LDS uses CO_2 or CO from cars only LDS on shows data for cars registered in 2002 and 2016 Values in the LDS were not exact or have been rounded Information not representative of England **OE**	2.4	E1	
	Total		**4**	

Q	Marking Instructions	AO	Marks	Typical Solution
13(a)(i)	Calculates the correct probability **OE**	1.1b	B1	$\frac{18}{25}$

13(a)(ii)	Calculates the correct probability **OE** Allow value truncated to 0.76 or rounded to 0.77 or better	1.1b	B1	$\frac{153}{200}$
13(b)	Finds the total male teachers **PI** if $\frac{56}{200}$ seen or by correct answer	1.1a	M1	9 + 24 + 23 = 56 = $\frac{47}{56}$
	Obtains the correct probability **OE** **AWRT** 0.84	1.1b	A1	
13(c)	Finds P(all three secondary teachers) **PI** by correct answer	3.1b	M1	$\frac{109}{200}\times\frac{108}{199}\times\frac{107}{198}$ = 0.16
	Obtains the correct probability **AWRT** 0.16 Do not allow 0.16 coming from incorrect working	1.1b	A1	
	Total		**6**	

Q	Marking Instructions	AO	Marks	Typical Solution
14	States both hypotheses correctly for two-tailed test Accept **population mean** for μ	2.5	B1	X = waiting times, in hours $H_0: \mu = 4$ $H_1: \mu \neq 4$
	Calculates mean of the sample **PI** in equation Accept $\overline{x}$ = [4.12, 4.13]	1.1a	M1	$\overline{x} = \frac{49.5}{12} = 4.125$
	Formulates the test statistic or uses the correct distribution of their sample mean **PI** by correct test statistic value or calculates probability or identifies acceptance region Condone $4 - 4.125$	1.1a	M1	$\text{Test statistic} = \frac{4.125 - 4}{0.8/\sqrt{12}}$ $= 0.541$ Critical value 1.65 0.541 < 1.65
	Obtains the correct value of the test statistic [0.519, 0.563] or obtains the correct probability [0.286,0.302] or [0.57, 0.604] or obtains the correct acceptance region of [3.62, 4.38]	1.1b	A1	Accept H_0 There is insufficient evidence to suggest that the mean waiting time at this hospital's A&E department has changed
	Compares their value of test statistic [0.519, 0.563] with their critical value [1.64, 1.65] Allow critical value [-4, 4] except ±0.1 or ±0.05 or compares their probability [0.286,0.302] with 0.05 or compares their probability [0.57, 0.604] with 0.10 or compares their sample mean [4.12, 4.13] with their acceptance region [3.62, 4.38] Do not allow negative region	1.1b	B1F	
	Compares values correctly and infers H_0 is not rejected **CSO** Allow reference to H_1	2.2b	A1	
	Concludes correctly in context that there is **insufficient evidence** to suggest that the **mean** waiting **time** at this hospital's A&E department has **changed**	3.2a	R1	

	CSO			
	Total		**7**	

Q	Marking Instructions	AO	Marks	Typical Solution
15(a)	Uses correct proportion to find either category **PI** by correct answer Accept 24 or 25 for 24.9 and 45 or 46 for 45.1	1.1a	M1	$\frac{4735}{13\,300} \times 70 = 24.9$ = 25 under 30 years old $\frac{8565}{13\,300} \times 70 = 45.1$ = 45 above 30 years old
	Obtains the correct number of under 30 years old and 30 years old and over Accept 24 paired with 46 **ISW**	1.1b	A1	
15(b)	Sets up enumerated population using valid numbering stating range used **OE**	2.4	E1	Give each member under 30 years old a number from 1 to 4735 Generate random four-digit integers using a calculator Continue until 25 different numbers have been identified and select the members given those numbers
	Explains how to obtain **random** numbers using **calculator or number generator** Must refer to replacement if using alternative suitable method eg hat or lottery	2.4	E1	
	Explains how to select their amount of people under 30 years old ensuring **different** numbers chosen **OE** Must state ignore repeats if using alternative suitable method eg hat or lottery	2.4	E1F	
	Total		**5**	

Q	Marking Instructions	AO	Marks	Typical Solution
16	States both hypotheses correctly for one-tailed test Do not accept $r = 0$ and $r > 0$ Accept ρ in words eg. H_0:No correlation/coefficient is 0 H_1:Positive correlation/coefficient > 0	2.5	B1	H_0: $\rho = 0$ H_1: $\rho > 0$ 0.379 < 0.4622 Accept H_0 There is insufficient evidence to suggest that there is a positive correlation between the hours of revision and the scores achieved by them in their A level exams
	Compares given critical value 0.4622 with the given correlation 0.379 coefficient Condone 0.462 or 0.46 or 0.5 for 0.4622 Condone 0.38 or 0.4 for 0.379	3.5a	M1	
	Compares given critical value 0.4622 with the given correlation 0.379 coefficient correctly and infers H_0 is not rejected Allow reference to H_1	2.2b	A1	
	Concludes correctly in context that there is **insufficient evidence** to suggest that there is **positive correlation** between the **hours** of revision and the **scores** achieved by them in their A level exams	3.2a	R1	
	Total		**4**	

Q	Marking Instructions	AO	Marks	Typical Solution
17(a)(i)	States correct probability **OE**	1.2	B1	1
17(a)(ii)	Calculates the correct probability **AWFW** [0.817, 0.82]	1.1b	B1	0.818
17(b)	Standardises correctly **PI** by correct answer	3.1b	M1	$\frac{x-\mu}{1.5} = \frac{x-8}{1.5}$
	Obtains correct value of x **AWFW** [6.07, 6.08] **ISW**	1.1b	A1	x = 6.08
17(c)	Obtains z value from inverse normal distribution **AWFW** [0.67, 0.68] or [–0.68, –0.67] **PI** by correct answer or equation	1.1b	B1	z = –0.6745 $\frac{5-7}{\sigma}$ = –0.6745 σ = 2.97
	Uses $\frac{7-5}{\sigma}$ or $\frac{5-7}{\sigma}$ **PI** by correct equation	3.1b	M1	
	Forms an equation using $\frac{7-5}{\sigma}$ or $\frac{5-7}{\sigma}$ and their z value Accept z = [−4, 4] except ±0.25	1.1a	M1	
	Obtains correct value of standard deviation **AWFW** [2.94, 2.99] **CAO** **ISW**	1.1b	A1	
	Total		**8**	

Q	Marking Instructions	AO	Marks	Typical Solution
18(a)(i)	States the binomial distribution with n = 30, p = 0.25 or states $P(X = 5) = P(X \leq 5) - P(X \leq 4)$ or uses the binomial formula with $\binom{30}{5} 0.25^5 0.75^{25}$ **PI** by correct answer	3.3	M1	X ~B(30, 0.25) $P(X = 5) = 0.1047$
	Obtains correct probability **AWRT** 0.105 **ISW**	1.1b	A1	
18(a)(ii)	States the binomial distribution with n = 30, p = 0.40 or states $P(X < 15) = P(X \leq 14)$ **PI** by $P(X \leq 15)$= 0.9029 or by correct answer	3.3	M1	X ~B(30, 0.40) $P(X < 15) = P(X \leq 14)$ =0.8246
	Obtains correct probability **AWRT** 0.825 **ISW**	1.1b	A1	
18(a)(iii)	States the binomial distribution with n = 30, p = 0.70 **PI** by $P(X \leq 19)$= 0.2696 or 0.27 of $P(X \geq 21)$= 0.5888 or by correct answer or states the binomial distribution with n = 30, p = 0.30 **PI** by $P(\mathrm{Y} \geq 10)$ = 0.4112 or 0.41 or $P(\mathrm{Y} \geq 11)$ = 0.2696 or 0.27 or by correct answer	1.1b	B1	X ~B(30, 0.70) $P(X \geq 20) = 1 - P(X \leq 19)$ = 1 – 0.2696 = 0.7304
	Uses B(30, 0.7) to calculate $P(X \leq 19)$= 0.2696 or 0.27 or states $P(X \geq 20) = 1 - P(X \leq 19)$ or uses B(30, 0.3) to calculate $P(\mathrm{Y} \geq 10)$ = 0.4111 or 0.41 or $P(\mathrm{Y} \geq 11)$ = 0.2696 or 0.27	3.4	M1	
	Obtains correct probability **AWFW** [0.73, 0.7304]	1.1b	A1	

18(b)(i)	States binomial distribution with n = 60, p = 0.30 **PI** by finding values of P($X \leq x$) where x = [0, 15] correct to at least 3dp P($X \leq x$) = [0, 0.244], x = [0, 15] **OE**	3.3	B1	X ~B(60, 0.30) P($X \leq 11$) = 0.0295 < 0.05 P($X \leq 12$) = 0.0568 > 0.05 Critical region is $x \leq 11$
	Finds of P($X \leq x$) where x = [0, 15] correct to at least 3dp Do not accept P($X = x$) P($X \leq x$) = [0, 0.244], x = [0, 15] **OE**	1.1a	M1	
	Obtains P($X \leq 12$) = 0.0568 **AWFW** [0.05677, 0.0568] Condone wrong inequality sign if [0.05677, 0.0568] seen	1.1b	A1	
	Obtains P($X \leq 11$) = 0.0295 **AWFW** [0.02947, 0.0295] Condone wrong inequality sign if [0.02947, 0.0295] seen	1.1b	A1	
	Obtains correct critical region x Accept critical region of 0≤ x ≤11 or x <12 or $\{0,1,2,3,4,5,6,7,8,9,10,11\}$	3.2a	R1	
18(b)(ii)	Compares 13 with their critical region from **b(i)** and makes their correct inference or compares $P(X \leq 13)$= 0.09996 (accept **AWRT** 0.1) with 0.05 and infers H_0 is not rejected Allow reference to H_1	2.2b	M1	13 > 11 so accept H_0 There is insufficient evidence to suggest that the proportion of shirts with a fabric defect has decreased.
	Concludes correctly in context that there is **insufficient evidence** to suggest that the **proportion** of **shirts** with a fabric defect has **decreased.** Follow though correct conclusion for their critical region	3.2a	R1F	
	Total		**14**	