Cambridge Assessment International Education

Cambridge International AS & A Level

MATHEMATICS **9709/52**

Paper 5 Probability & Statistics 1 **October/November 2022**

MARK SCHEME

Maximum Mark: 50

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

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Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:
Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:
Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:
Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:
Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

GENERIC MARKING PRINCIPLE 5:
Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

GENERIC MARKING PRINCIPLE 6:
Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

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Mathematics Specific Marking Principles	
1	Unless a particular method has been specified in the question, full marks may be awarded for any correct method. However, if a calculation is required then no marks will be awarded for a scale drawing.
2	Unless specified in the question, answers may be given as fractions, decimals or in standard form. Ignore superfluous zeros, provided that the degree of accuracy is not affected.
3	Allow alternative conventions for notation if used consistently throughout the paper, e.g. commas being used as decimal points.
4	Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored (isw).
5	Where a candidate has misread a number in the question and used that value consistently throughout, provided that number does not alter the difficulty or the method required, award all marks earned and deduct just 1 mark for the misread.
6	Recovery within working is allowed, e.g. a notation error in the working where the following line of working makes the candidate's intent clear.

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Mark Scheme Notes

The following notes are intended to aid interpretation of mark schemes in general, but individual mark schemes may include marks awarded for specific reasons outside the scope of these notes.

Types of mark

M Method mark, awarded for a valid method applied to the problem. Method marks are not lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. Correct application of a formula without the formula being quoted obviously earns the M mark and in some cases an M mark can be implied from a correct answer.

A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated method mark is earned (or implied).

B Mark for a correct result or statement independent of method marks.

DM or **DB** When a part of a question has two or more 'method' steps, the M marks are generally independent unless the scheme specifically says otherwise; and similarly, when there are several B marks allocated. The notation DM or DB is used to indicate that a particular M or B mark is dependent on an earlier M or B (asterisked) mark in the scheme. When two or more steps are run together by the candidate, the earlier marks are implied and full credit is given.

FT Implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A or B marks are given for correct work only.

- A or B marks are given for correct work only (not for results obtained from incorrect working) unless follow through is allowed (see abbreviation FT above).
- For a numerical answer, allow the A or B mark if the answer is correct to 3 significant figures or would be correct to 3 significant figures if rounded (1 decimal place for angles in degrees).
- The total number of marks available for each question is shown at the bottom of the Marks column.
- Wrong or missing units in an answer should not result in loss of marks unless the guidance indicates otherwise.
- Square brackets [ ] around text or numbers show extra information not needed for the mark to be awarded.

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Abbreviations

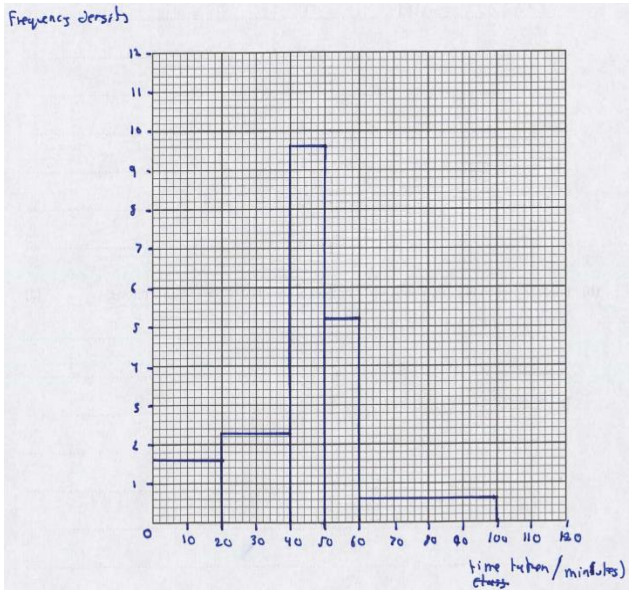
AEF/OE	Any Equivalent Form (of answer is equally acceptable) / Or Equivalent
AG	Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)
CAO	Correct Answer Only (emphasising that no 'follow through' from a previous error is allowed)
CWO	Correct Working Only
ISW	Ignore Subsequent Working
SOI	Seen Or Implied
SC	Special Case (detailing the mark to be given for a specific wrong solution, or a case where some standard marking practice is to be varied in the light of a particular circumstance)
WWW	Without Wrong Working
AWRT	Answer Which Rounds To

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Question	Answer	Marks	Guidance
1(a)	$0.2\times x+0.1\times 2x+0.7\times 0.25=0.235$	**M1**	$0.2\times x+0.1\times 2x+0.7\times 0.25$ or $0.2x + 0.2x + 0.175$ seen.
		M1	Equating *their* 3 term expression (2 terms involving x) to 0.235
	$x=0.15$	**A1**	
		3	
1(b)	$\left[P(car\,\vert not\ late)=\dfrac{P(car\ and\ not\ late)}{P(not\ late)}\right]$ $\dfrac{0.1\times(1-0.3)}{1-0.235}$	**M1**	$0.1\times(1-2\times their\ x)$ or 0.1 × 0.7 as numerator **and** 0.2 × (1 – *their x*) + 0.1 × (1 – 2 × *their x*) + 0.7 × 0.75 with values substituted or 1 – 0.235 or 0.765 as denominator of fraction. Condone 0.2 × (1 – *their x*) + 0.1 × (1 – × *their x*) + 0.7 × 0.75 as denominator consistent with **1(a)**.
	$\left[\dfrac{0.07}{0.765}=\right]0.0915,\dfrac{70}{765},\dfrac{14}{153}$	**A1**	0.091503267 to at least 3SF. If M0 scored **SC B1** for 0.091503267 to at least 3SF.
		2	

Question	Answer	Marks	Guidance
2(a)	[P(X<54.8)] = P($Z < \frac{54.8-55.6}{1.2}$)	**M1**	Use of ± standardisation formula, with 54.8, 55.6 and 1.2 substituted. condone $1.2^2, \sqrt{1.2}$ or continuity correction of 54.75 or 54.85
	[= P($Z < -0.6667$)] $= 1 - 0.7477$	**M1**	Appropriate area Φ, from final process, must be probability.
	= 0.2523	**A1**	$0.252 \leqslant p \leqslant 0.2525$ If A0 scored **S CB1** for $0.252 \leqslant p \leqslant 0.2525$
	[Expected number =] $400 \times 0.2523 = 100.92$ 100 or 101	**B1 FT**	FT *their* 4SF (or better) probability from a normal calculation. Must be a single integer answer.
		4	
2(b)	[P($-\frac{1}{2} < Z < \frac{1}{2}$) = Φ(½) – Φ(−½) =] $2\Phi\left(\frac{1}{2}\right) - 1$ = $2 \times$ *their* 0.6915 − 1 or *their* $0.6915 - (1 - $ *their* $0.6915)$ or $2 \times (0.6915 - 0.5)$	**M1**	{Both ½ and –½ seen as z-values **or** appropriate use of +½ or −½} **and** {no other z-values in part}. Condone $\frac{56.2-55.6}{1.2}$ and $\frac{55[.0]-55.6}{1.2}$ seen as z-values.
		M1	Calculating the appropriate area from stated phis of z-values which must be ± the same number.
	0.383	**A1**	$0.3829 \leqslant z \leqslant 0.383$ If A0 scored **SC B1** for $0.3829 \leqslant z \leqslant 0.383$
		3	

Question	Answer	Marks	Guidance
3(a)	[P(17 or 18) =] $\frac{4}{216}=\frac{1}{54}$,0.0185(185…)	**B1**	May be seen used in calculation.
	P(X = 6) = $\left(\frac{53}{54}\right)^5.\frac{1}{54}$	**M1**	$p(1-p)^5$, $0<p<1$
	0.0169	**A1**	$0.01686 < p \leqslant 0.0169$ If A0 scored **SC B1** for $0.01686 < p \leqslant 0.0169$
		3	
3(b)	[P(X < 8) =] $1-\left(\frac{53}{54}\right)^7$	**M1**	$1-\left(\textit{their}\left(\frac{53}{54}\text{ or }0.98148\right)\text{or correct}\right)^r$, $r=7,8$ $0<\textit{their}\ p<1$
	0.123	**A1**	$0.1225 \leqslant p \leqslant 0.123$
	Alternative method for Question 3(b)		
	[P(X < 8) =] $\left(\frac{1}{54}\right)+\left(\frac{53}{54}\right)\left(\frac{1}{54}\right)+\left(\frac{53}{54}\right)^2\left(\frac{1}{54}\right)+\left(\frac{53}{54}\right)^3\left(\frac{1}{54}\right)+\left(\frac{53}{54}\right)^4\left(\frac{1}{54}\right)+$ $\left(\frac{53}{54}\right)^5\left(\frac{1}{54}\right)+\left(\frac{53}{54}\right)^6\left(\frac{1}{54}\right)$	**M1**	$q+pq+p^2q+p^3q+p^4q+p^5q\left[+p^6q\right]$, $p+q=1,0<p,q<1,q$ $=\textit{their}\ \frac{53}{54}$
	0.123	**A1**	$0.1225 \leqslant p \leqslant 0.123$
		2	

Question	Answer	Marks	Guidance
4(a)	Cw 20 20 10 10 40 Fd 1.6 2.3 9.6 5.2 0.6 	**M1**	At least 4 frequency densities calculated $\frac{f}{cw}$ eg $\frac{32}{20}\left(\text{condone}\ \frac{f}{cw \pm 0.5}\ \text{if unsimplified}\right)$, accept unsimplified, may be read from graph using *their* scale no lower than 1 cm = fd 1
		A1	All bar heights correct on graph, using *their* suitable linear scale with at least 3 values indicated, no lower than 1 cm = fd 2.
		B1	Bar ends at [0,] 20, 40, 50, 60, 100 (at axis), 5 bars drawn $0 \leqslant$ time axis $\leqslant 100$, linear scale with at least 3 values indicated.
		B1	Axes labelled frequency density (fd), time (t) and minutes (mins, m) or appropriate title. (Axes may be reversed).
		4	

Question	Answer	Marks	Guidance
4(b)	Midpoints 10 30 45 55 80	**B1**	At least 4 correct midpoints seen (check data table).
	[Mean = 43.2 given] [Var =] $\frac{32\times10^2+46\times30^2+96\times45^2+52\times55^2+24\times80^2}{250}-43.2^2$ **Or** $\frac{32(10-43.2)^2+46(30-43.2)^2+96(45-43.2)^2+52(55-43.2)^2+24(80-43.2)^2}{250}$	**M1**	Appropriate variance formula with *their* 5 midpoints (not upper bound, lower bound, class width, frequency density, frequency or cumulative frequency). Condone 1 frequency error. If correct midpoints seen accept $\left\{\frac{3200+41400+194400+157300+153600}{250}\ or\ \frac{549900}{250}\right\}$ $-\{43.2^2\ or\ 1866.24\}$.
	$=\left[\frac{549900}{250}-43.2^2=333.36\right]$ Sd = 18.3	**A1**	www, final answer 18.25814887 to at least 3SF. If M0 earned **SC B1** for final answer 18.25814887 to at least 3SF.
		3	

Question	Answer	Marks	Guidance
5(a)	**Method 1: Scenarios identified ignoring unbiased coin**		
	$P(BH_1\ BT_2) = \frac{1}{4}\times\frac{3}{4}=\frac{3}{16}$ $P(BT_1\ BH_2) = \frac{3}{4}\times\frac{1}{4}=\frac{3}{16}$ $P(BH_1\ BH_2) = \frac{1}{4}\times\frac{1}{4}=\frac{1}{16}$	**M1**	All 3 different calculations seen unsimplified.
	$\frac{3}{16}+\frac{3}{16}+\frac{1}{16}=\frac{7}{16}$	**A1**	Clear identification of **all scenarios**, linked probabilities and sum. AG

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Question	Answer	Marks	Guidance
5(a)	**Method 2: Scenarios identified with all 3 coins**		
	$P(H\ BH_1\ BT_2) = \frac{1}{2}\times\frac{1}{4}\times\frac{3}{4}=\frac{3}{32}$ $P(T\ BH_1\ BT_2) = \frac{1}{2}\times\frac{1}{4}\times\frac{3}{4}=\frac{3}{32}$ $P(H\ BT_1\ BH_2) = \frac{1}{2}\times\frac{3}{4}\times\frac{1}{4}=\frac{3}{32}$ $P(T\ BT_1\ BH_2) = \frac{1}{2}\times\frac{3}{4}\times\frac{1}{4}=\frac{3}{32}$ $P(H\ BH_1\ BH_2) = \frac{1}{2}\times\frac{1}{4}\times\frac{1}{4}=\frac{1}{32}$ $P(T\ BH_1\ BH_2) = \frac{1}{2}\times\frac{1}{4}\times\frac{1}{4}=\frac{1}{32}$	**M1**	All 6 different calculations seen unsimplified.
	$P(B) = \frac{1+3+3+1+3+3}{32}=\frac{14}{32}=\frac{7}{16}$	**A1**	Clear identification of **all scenarios**, linked probabilities and sum. AG
	Method 3: 1- $P(BT_1\ BT_2)$ ignoring unbiased coin		
	$1 - P(BT_1\ BT_2) = 1-\left(\frac{3}{4}\right)^2$	**M1**	Calculation seen unsimplified **and** 1 – probability seen.
	$=\frac{7}{16}$	**A1**	Clear identification of scenario used, linked probability and calculation. AG

Question	Answer	Marks	Guidance
5(a)	**Method 4: 1- P(BT_1 BT_2) with all 3 coins**		
	$1 - P(H\ BT_1\ BT_2) - P(T\ BT_1\ BT_2) = 1-\left(\frac{1}{2}\times\frac{3}{4}\times\frac{3}{4}\right)-\left(\frac{1}{2}\times\frac{3}{4}\times\frac{3}{4}\right)$	**M1**	Both calculations seen unsimplified **and** 1 – 2 probabilities seen.
	$= 1-\frac{9}{32}-\frac{9}{32}=\frac{7}{16}$	**A1**	Clear identification of **all scenarios** used, linked probabilities and calculation. AG
		2	
5(b)	$\left[P(A\|B)=\frac{P(A\cap B)}{P(B)}=\right]\ \frac{\frac{1}{2}\times\frac{1}{4}\times\frac{1}{4}}{\frac{7}{16}}=\frac{\frac{1}{32}}{\frac{7}{16}}$	**M1**	*Their* identified P(*HHH*) or correct as numerator **and** *their* identified P(B) or correct as denominator. Either numerical expression acceptable.
	$=\frac{1}{14}$, 0.0714	**A1**	Accept 0.071428… rounded to at least 3SF.
		2	
5(c)	P(1H) = $\frac{1}{2}\times\frac{3}{4}\times\frac{1}{4}+\frac{1}{2}\times\frac{1}{4}\times\frac{3}{4}+\frac{1}{2}\times\frac{3}{4}\times\frac{3}{4}=\frac{15}{32}$ P(2H) = $\frac{1}{2}\times\frac{1}{4}\times\frac{1}{4}+\frac{1}{2}\times\frac{3}{4}\times\frac{1}{4}+\frac{1}{2}\times\frac{1}{4}\times\frac{3}{4}=\frac{7}{32}$ X | 0 | 1 | 2 | 3 $p(X)$ | $\frac{9}{32}$ 0.28125 | $\frac{15}{32}$ 0.46875 | $\frac{7}{32}$ 0.21875 | $\frac{1}{32}$ 0.03125	**B1**	Table with correct X values and at least one probability. Condone any additional X values if probability stated as 0.
		B1	P(1) or P(2) correct, need not be in table, accept unsimplified.
		B1	4 correct probabilities linked with correct outcomes, may not be in table. Decimals correct to at least 3 SF.
			SC B1 for 4 probabilities ($0 < p < 1$) sum to 1 ± 0.005 with P(1) **and** P(2) incorrect.
		3	

Question	Answer	Marks	Guidance
6(a)	[1 – P(10, 11, 12) =] $1-({}^{12}C_{10}\ 0.9^{10}\ 0.1^{2}\ +\ {}^{12}C_{11}\ 0.9^{11}\ 0.1^{1}\ +\ {}^{12}C_{12}\ 0.9^{12}\ 0.1^{0})$ = 1 – (0.230128 + 0.376573 + 0.282430)	**M1**	One term ${}^{12}C_x\ p^x(1-p)^{12-x}$, for $0 < x < 12$, $0 < p < 1$
		A1	Correct expression, accept unsimplified, no terms omitted, leading to final answer.
	0.111	**B1**	Mark the final answer at the most accurate value, $0.1108 < p \leqslant 0.111$ WWW.
	Alternative method for Question 6(a)		
	[P(0,1,2,3,4,5,6,7,8,9) =] ${}^{12}C_0\ 0.9^0\ 0.1^{12}\ +{}^{12}C_1\ 0.9^1\ 0.1^{11}\ +{}^{12}C_2\ 0.9^2\ 0.1^{10}\ +{}^{12}C_3\ 0.9^3\ 0.1^9$ $+{}^{12}C_4\ 0.9^4\ 0.1^8\ +{}^{12}C_5\ 0.9^5\ 0.1^7\ +{}^{12}C_6\ 0.9^6\ 0.1^6\ +{}^{12}C_7\ 0.9^7\ 0.1^5\ +{}^{12}C_8$ $0.9^8\ 0.1^4\ +{}^{12}C_9\ 0.9^9\ 0.1^3)$	**M1**	One term ${}^{12}C_x\ p^x(1-p)^{12-x}$, for $0 < x < 12$, $0 < p < 1$
		A1	Correct expression, accept unsimplified, no terms omitted, leading to final answer. If answer correct condone omission of any 7 of the 8 middle terms.
	0.111	**B1**	Final answer $0.1108 < p \leqslant 0.111$ WWW.
		3	

Question	Answer	Marks	Guidance
6(b)	[Mean = 80×0.9 =] 72, $\left[\text{Variance} = 80 \times 0.9 \times 0.1\right] = 7.2$	**B1**	72 and 7.2 seen, allow unsimplified. May be seen in standardisation formula. ($2.683 \leqslant \sigma < 2.684$ imply correct variance).
	$P(X > 69) = P\left(Z > \frac{69.5 - 72}{\sqrt{7.2}}\right)$	**M1**	Substituting *their* mean and $\sqrt{\textit{their}\ \text{variance}}$ into ±standardisation formula (any number for 69·5), not *their* 7.2, not √*their* 2.683
		M1	Using continuity correction 69·5 or 68·5 in *their* standardisation formula.
	[= $P(Z > -0.9317)$ =] $\Phi(0.9317)$	**M1**	Appropriate area Φ, from final process, must be probability.
	0.824	**A1**	$0.8239 \leqslant p \leqslant 0.8243$ WWW.
		5	
6(c)	$np = 72,\ nq = 8$ Both greater than 5, [so approximation is valid]	**B1**	*np*, *nq* evaluated accurately. **both** *np* & *nq* referenced correctly. > 5 or greater than 5 seen.
		1	

Question	Answer	Marks	Guidance
7(a)	7!	**M1**	$\frac{7!}{b! \times c!}$ *b*,*c* = 1,2 $7! \times \frac{2!}{2!} \times \frac{2!}{2!}$ oe, no further terms present.
	5040	**A1**	
		2	

Question	Answer	Marks	Guidance
7(b)	**Method 1 for first 3 marks: Arrangements of 6 letters including Ls between As**		
	$5! \times 5 \times 2$	**M1**	$5! \times d$, d integer > 1
		M1	$e! \times f \times g$, $e = 5, 6, 7$; $f = 1, 5$; $g = 1, 2$; $f \neq g$, 1 can be implicit.
	1200	**A1**	
	Method 2 for first 3 marks: Number of arrangements of LL^^^^^ – number of arrangements with the Ls split by an A		
	$6! \times 2 - 5! \times 2$	**M1**	$6! \times 2 - h$ h an integer $1 < h < 1440$
		M1	$k - 5! \times 2$ k an integer $k > 240$
	1200	**A1**	
	Method 3 for first 3 marks: Alternative approaches to Method 1		
	^A ^ ^ ^ ^ ^ A $^5P_1 \times {}^1P_1 \times {}^5P_5 \times {}^1P_1 = 600$	**M1**	LL treated as a single unit.
		M1	
	1200	**A1**	

Question	Answer	Marks	Guidance
7(b)	**Final 2 marks of Question 7(b)**		
	[Total number of arrangements =] $\left[\frac{9!}{2!2!} = \right] 90\,720$	**B1**	Accept unsimplified. May be seen as denominator of probability.
	Probability = $\frac{1200}{90\,720}, \frac{5}{378}$, 0.0132	**B1 FT**	$\frac{\textit{their}\,1200}{\textit{their}\,90\,720}$ unsimplified B1 FT if *their* 1200 and *their* 90 720 supported by work in this part.
		5	

Question	Answer	Marks	Guidance
7(c)	**Method 1: Scenarios identified Both As and Ls removed**		
	A _ _ _ _ $^5C_4 = 5$ AA _ _ _ $^5C_3 = 10$ AL _ _ _ $^5C_3 = 10$ AAL _ _ $^5C_2 = 10$	**B1**	1 correct, identified outcome/value for A, AL or AAL scenario, accept unsimplified $^5C_{5-x}$ cannot be used in place of ^5C_x
		M1	Add 4 values of appropriate scenarios, no incorrect scenarios, no repeated scenarios, accept unsimplified, condone use of permutations.
	[Total =] 35	**A1**	Value stated WWW.
	Method 2: 1 A fixed, 1 L removed No other scenarios can be present anywhere in solution		
	A ^ ^ ^ ^ $^7C_4$	**M1**	^7C_h, $3 \leqslant h \leqslant 5$
		B1	$^7C_4$ oe, no other terms, scenario identified.
	[Total =] 35	**A1**	Value stated.
	Method 3: 1 A fixed, both Ls removed		
	A ^ ^ ^ ^ = $^6C_4 = 15$ A L ^ ^ ^ = $^6C_3 = 20$	**B1**	Correct outcome/value for 1 identified scenario, accept unsimplified. WWW
		M1	Add 2 values of appropriate scenarios, no incorrect scenarios, no repeated scenarios, accept unsimplified, condone use of permutations.
	[Total =] 35	**A1**	Value stated.
		3	

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