Question	Answer	Marks	Guidance
2	(see scenario table below)	B1	Expression of the form $^{16}C_x \times {}^{10}C_y$ with $x + y = 6$ linked to a correct identified scenario.
		M1	Two identified outcomes evaluated accurately, accept un-simplified. Identification can be implied by un-simplified expression. Condone consistent use of permutations.
		M1	Sum of *their* values of 3 correct identified scenarios, no incorrect/repeated scenarios. Identification can be implied by un-simplified expression.
	Total = 174 300	A1	If either or both Ms not awarded, **SCB1** for 174 300 WWW.
		4	

Scenario	S(16)	D(10)		
SSSSDD	4	2	$^{16}C_4 \times {}^{10}C_2$	[81900]
SSSDDD	3	3	$^{16}C_3 \times {}^{10}C_3$	[67200]
SSDDDD	2	4	$^{16}C_2 \times {}^{10}C_4$	[25200]

Question	Answer	Marks	Guidance
3(a)	Scenarios: 6W 0M $^9C_6 = 84$ 5W 1M $^9C_5 \times {}^5C_1 = 126 \times 5 = 630$ 4W 2M $^9C_4 \times {}^5C_2 = 126 \times 10 = 1260$	M1	Correct number of ways for either 5 or 4 women, accept unsimplified
		M1	Summing the number of ways for 2 or 3 correct scenarios (can be unsimplified), no incorrect scenarios.
	Total = 1974	A1	
		3	
3(b)	Total number of ways = $^{14}C_6$ (3003) Number with sister and brother = $^{12}C_4$ (495) Number required = $^{14}C_6 -$	M1	$^{14}C_6$ – a value
	$^{12}C_4 = 3003 - 495$	M1	$^{12}C_x$ or $^nC_4$ seen on its own or subtracted from *their* total, $x \leqslant 6$, $n \leqslant 13$
	2508	A1	
	Alternative method for question 3(b)		
	Number of ways with neither = $^{12}C_6 = 924$	M1	$^{12}C_6$ + a value
	Number of ways with either brother or sister (not both) $= {}^{12}C_5 \times 2$ $(= 792 \times 2) = 1584$	M1	$^{12}C_x \times 2$ or $^nC_5 \times 2$ seen on its own or added to *their* number of ways with neither, $x \leqslant 5$, $n \leqslant 12$
	Number required = 924 + 1584 = 2508	A1	
		3	

Question	Answer	Marks	Guidance
5(a)	$^5P_2 \times {}^7P_4$ **or** $5 \times 4 \times 7 \times 6 \times 5 \times 4$	M1	$^5P_x \times {}^7P_y$, $1 \leqslant x \leqslant 4$, $1 \leqslant y \leqslant 6$
	16 800	A1	
		2	

Question	Answer	Marks	Guidance
5(b)	**Method 1** [Identify scenarios]		
	With A and no 5: $8 \times {}^6P_4$ or $(1 \times 4 \times 6 \times 5 \times 4 \times 3) \times 2$ or $4C1 \times 2! \times 6P4 = 2880$ With 5 and no A: $^4P_2 \times 4 \times {}^6P_3$ or $(4 \times 3 \times 1 \times 6 \times 5 \times 4) \times 4$ or $4P2 \times 6C3 \times 4! = 5760$ With A and 5: $8 \times 4 \times {}^6P_3$ or $(4 \times 1 \times 1 \times 6 \times 5 \times 4) \times 8$ or $4C1 \times 2! \times 6C3 \times 4! = 3840$	**M1**	One number of ways correct, accept unsimplified.
		M1	Add 2 or 3 identified correct scenarios only, accept unsimplified.
	[Total =] 12 480	**A1**	CAO
	Method 2 [total number of codes – number of codes with no A or 5]		
	No A or 5 : $(4 \times 3) \times (6 \times 5 \times 4 \times 3) = 4320$	**M1**	$^4P_2 \times {}^6P_4$ or $^4C_2 \times {}^6C_4$ seen, accept unsimplified.
	Required number = *their* **(a)** – *their* 4320	**M1**	*Their* **5(a)** (or correct) – *their* (No A or 5) value.
	12 480	**A1**	
	Method 3 [subtracting **double counting**]		
	With A $^4P_1 \times {}^7P_4 \times 2$ or $^4C_1 \times 2 \times {}^7C_4 \times 4! = 6720$ With 5 $^5P_2 \times {}^6P_3 \times \mathbf{4}$ or $^5C_2 \times 2 \times {}^6C_3 \times 4! = 9600$ With A and 5 = $^4P_1 \times {}^6P_3 \times 8$ or $4C1 \times 2! \times 6C3 \times 4! \times 8 = 3840$	**M1**	One outcome correct, accept unsimplified.
	Required number = 6720 + 9600 – 3840	**M1**	Adding 'with a' to 'with 5' and subtracting 'A and 5'.
	12 480	**A1**	CAO
		3	

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Question	Answer	Marks	Guidance
5(c)	**Method 1** – number of successful codes divided by total		
	$(1 \times)\ 3 \times {}^5P_2$	**M1**	$3 \times {}^5P_n$, $n = 2, 3$. Condone $3 \times {}^5C_2$, no + or –.
	Probability = $\frac{their\ 3 \times 5P2}{their\ 16\,800}$	**M1**	Probability = $\frac{their\ 60}{their\ 16\,800}$.
	$\frac{1}{280}$, 0.00357	**A1**	
	Method 2 – product of probabilities of each part of code		
	$\frac{1}{5} \times \frac{1}{4} \times \frac{1}{7} \times \frac{3}{6}\left(\times \frac{5}{5} \times \frac{4}{4}\right)$ or $\frac{1}{5} \times \frac{1}{4} \times \frac{3 \times 5P2}{7P4}$	**M1**	$\frac{1}{5} \times \frac{1}{4} \times k$ where $0 < k < 1$ for considering letters.
		M1	$t \times \frac{1}{7} \times \frac{3}{6}$ or $t \times \frac{3 \times 5P2}{7P4}$ where $0 < t < 1$.
	$\frac{1}{280}$	**A1**	CAO
		3	

Question	Answer	Marks	Guidance
7(a)	$^{12}C_5 \times {}^7C_4$ [$\times {}^3C_3$]	**M1**	$^{12}C_r \times q$, $r = 3, 4, 5$ q a positive integer > 1, no + or – .
		M1	$^{12}C_s \times {}^{12-s}C_t$ [$\times {}^{12-s-t}C_u$] $s = 3, 4, 5$; $t = 3, 4, 5 \neq s$; $u = 3, 4, 5 \neq s, t$
	Alternative method for question 7(a)		
	$\frac{12!}{5! \times 3! \times 4!}$	**M1**	12! ÷ by a product of three factorials.
		M1	$\frac{n!}{5! \times 3! \times 4!}$
	[792 × 35 =] 27 720	**A1**	CAO
		3	

Question	Answer	Marks	Guidance
7(b)	4! (Lizo) × 6! (Kenny) × 2! (Martin) × 2! (Nantes)	**M1**	Product involving at least 3 of 4!, 6!, 2!, 2!
	× 3! (orders of K, M and N)	**M1**	w × 3! , *w* integer > 1.
	414 720	**A1**	WWW CAO
		3	
7(c)	${}^7C_4$ (adults) × ${}^4C_1$ × ${}^3C_1$	**M1**	${}^7C_4$ × *b*, *b* integer > 1 no + or – .
	420	**A1**	
		2	
7(d)	K not L ${}^5C_3 \times {}^8C_3 = 560$ L not K ${}^5C_3 \times {}^8C_3 = 560$ L and K ${}^5C_2 \times {}^8C_3 = 560$	**M1**	${}^8C_3$(or ${}^8P_3$) × *c* for one of the products or ${}^5C_3$ (or ${}^5P_3$)× *c*, positive integer >1 for first 2 products only.
		M1	Add 2 or 3 correct scenarios only values, no additional incorrect scenarios, no repeated scenarios. Accept unsimplified.
	[Total or Difference=] 1680	**A1**	
	Alternative method for question 7(d)		
	Total no of ways – neither L nor K Total = ${}^7C_4 \times {}^8C_3 = 1960$ Neither K nor L = ${}^5C_4 \times {}^8C_3 = 280$	**M1**	${}^8C_3$ × *c, c* a positive integer >1.
		M1	Subtracting the number of ways with neither from their total number of ways.
	[Total or Difference=] 1680	**A1**	

Question	Answer	Marks	Guidance
7(d)	**Alternative method for question 7(d)**		
	Subtracting K and L from sum of K and L K ${}^6C_3 \times {}^8C_3 = 1120$ L ${}^6C_3 \times {}^8C_3 = 1120$ L and K ${}^5C_2 \times {}^8C_3 = 560$ 1120 + 1120 – 560 = 1680	**M1**	${}^8C_3$ × *c, c* a positive integer >1.
		M1	Subtracting number of ways with both from sum of number of ways with K and number of ways with L.
	[Total or Difference=] 1680	**A1**	
		3	

Question	Answer	Marks	Guidance
6(a)(i)	**Method 1**		
	$6! \times 2^6$	**M1**	$6! \times a$, *a* integer > 1.
		M1	$b \times 2^6$, *b* integer ⩾ 1.
	= 46080	**A1**	Accurate answer required. **SC B1** for 46080 if M0 M0 www.
	Alternative method for question 6(a)(i)		
	$12 \times 10 \times 8 \times 6 \times 4 \times 2$	**M1**	$c \times d \times e \times f \times g \times h$ $2 \leqslant c,d,e,f,g,h$ (different integers) $\leqslant 12$
		M1	Correct unsimplified.
	= 46080	**A1**	Accurate answer required. **SC B1** for 46080 if M0 M0 www.
		3	
6(a)(ii)	$5! \times 5! \times 2 \times 2$	**M1**	$5! \times 5! \times k$, *k* positive integer, 1 may be implied (no adding/subtracting).
	= 57600	**A1**	
		2	

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td rowspan="6">6(b)</td><td colspan="3">Method 1 probabilities of J & K being placed:</td></tr>
<tr><td rowspan="3"><table>
<tr><td>In the group of 5</td><td>$\frac{5}{12}\times\frac{4}{11}$</td><td>$\left[=\frac{20}{132},\frac{5}{33}\right]$</td></tr>
<tr><td>In the group of 4</td><td>$\frac{4}{12}\times\frac{3}{11}$</td><td>$\left[=\frac{12}{132},\frac{1}{11}\right]$</td></tr>
<tr><td>In the group of 3</td><td>$\frac{3}{12}\times\frac{2}{11}$</td><td>$\left[=\frac{6}{132},\frac{1}{22}\right]$</td></tr>
</table></td><td>B1</td><td>Correct probability for one identified scenario.</td></tr>
<tr><td>M1</td><td>Denominator 12×11 for all probabilities, (1, 2 or 3 scenarios).</td></tr>
<tr><td>A1</td><td>3 correct probabilities, accept unsimplified.</td></tr>
<tr><td>$\frac{5}{12}\times\frac{4}{11}+\frac{4}{12}\times\frac{3}{11}+\frac{3}{12}\times\frac{2}{11}$</td><td>M1</td><td>Adding probabilities for 3 correct scenarios.</td></tr>
<tr><td>$\frac{19}{66}$, 0.288</td><td>A1</td><td>0.2878787 to at least 3SF.</td></tr>
</table>

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td rowspan="8">6(b)</td><td colspan="3">Method 2 number of arrangements of J & K being placed:</td></tr>
<tr><td rowspan="2"><table>
<tr><td>In the group of 5</td><td>${}^{10}C_3 \times {}^{7}C_4$</td><td>[= 120 × 35 = 4200]</td></tr>
<tr><td>In the group of 4</td><td>${}^{10}C_2 \times {}^{8}C_5$</td><td>[= 45 × 56 = 2520]</td></tr>
<tr><td>In the group of 3</td><td>${}^{10}C_1 \times {}^{9}C_5$</td><td>[= 10 × 126 = 1260]</td></tr>
</table></td><td>B1</td><td>Correct value of one identified scenario seen, accept unsimplified.</td></tr>
<tr><td>M1</td><td>${}^{12}C_a \times {}^{12-a}C_b$, $a = 3, 4, 5$; $b = 3, 4, 5$ $(a \neq b)$</td></tr>
<tr><td>[Total number of ways of arranging the 3 groups =]
${}^{12}C_5 \times {}^{7}C_4 = 792 \times 35 = 27720$
or ${}^{12}C_3 \times {}^{9}C_4$ or ${}^{12}C_4 \times {}^{8}C_5$</td><td>A1</td><td>27720 Seen alone or as denominator of probability –accept unsimplified.
SC B1 if M0.</td></tr>
<tr><td>4200 + 2520 + 1260 = 7980</td><td>M1</td><td>Values of 3 correct scenarios added, accept unsimplified – or correct.</td></tr>
<tr><td>[Probability =] $\frac{7980}{27720}$, $\frac{19}{66}$, 0.288</td><td>A1</td><td>0.2878787 to at least 3SF.</td></tr>
<tr><td></td><td>5</td><td>Note, alternative arrangement calculations possible e.g.<table>
<tr><td>In the group of 5</td><td>${}^{10}C_3 \times {}^{7}C_4$</td><td>[= 120 × 35 = 4200]</td></tr>
<tr><td>In the group of 4</td><td>${}^{10}C_5 \times {}^{5}C_2$</td><td>[= 252× 10 = 2520]</td></tr>
<tr><td>In the group of 3</td><td>${}^{10}C_5 \times {}^{5}C_4$</td><td>[= 252 × 5 = 1260]</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td rowspan="8">5(a)</td><td>Total number of ways = $\frac{8!}{3!2!}$ (= 3360)</td><td>B1</td><td>Correct unsimplified expression for total number of ways</td></tr>
<tr><td>Number of ways with V and E in correct positions = $\frac{6!}{2!\times2!}$ (= 180)</td><td>B1</td><td>$\frac{6!}{2!\times2!}$ alone or as numerator in an attempt to find the number of ways with V and E in correct positions.
No ×,±</td></tr>
<tr><td>Probability = $\frac{180}{3360}$ $\left(=\frac{3}{56}\right)$ or 0.0536</td><td>B1 FT</td><td>Final answer from their $\frac{6!}{2!\times2!}$ divided by their total number of ways</td></tr>
<tr><td colspan="3">Alternative method for question 5(a)</td></tr>
<tr><td rowspan="2">$\frac{1}{8}\times\frac{3}{7}$</td><td>M1</td><td>$\frac{a}{8}\times\frac{b}{7}$ seen, no other terms (correct denominators)</td></tr>
<tr><td>M1</td><td>$\frac{1}{c}\times\frac{3}{d}$ seen, no other terms (correct numerators)</td></tr>
<tr><td>$\frac{3}{56}$ or 0.0536</td><td>A1</td><td></td></tr>
<tr><td></td><td>3</td><td></td></tr>
</table>

Question	Answer	Marks	Guidance
5(b)	Rs together and Es together: 5! (120)	B1	Alone or as numerator of probability to represent the number of ways with Rs and Es together, no ×, +, –
	Es together: $\frac{6!}{2!}(=360)$	B1	Alone or as denominator of probability to represent the number of ways with Es together, no ×, + or –
	Probability = $\frac{5!}{\frac{6!}{2!}}$	M1	$\frac{\textit{their}\ 5!}{\textit{their}\ \frac{6!}{2!}}$ seen
	$\frac{1}{3}$	A1	OE
	Alternative method for question 5(b)		
	P(Rs together and Es together): $\frac{5!}{\textit{their}\text{ total number of ways}}\left(=\frac{1}{28}\right)$	B1	
	P(Es together): $\frac{\frac{6!}{2!}}{\textit{their}\text{ total number of ways}}\left(=\frac{3}{28}\right)$	B1	Alone or as numerator of probability to represent the P(Rs and Es together), no ×, +, –
	Probability = $\frac{\frac{1}{28}}{\frac{3}{28}}$	M1	Alone or as denominator of probability to represent the P(Es together), no ×, + or –
	$\frac{1}{3}$	A1	OE, $\frac{\textit{their}\ \frac{1}{28}}{\textit{their}\ \frac{3}{28}}$ seen
		4	

Question	Answer	Marks	Guidance
6(a)	$\left[\frac{9!}{2!2!}=\right]$ 90720	B1	
		1	

Question	Answer	Marks	Guidance
6(b)	**Method 1** Total arrangements – arrangements with repeated letters at ends		
	$\frac{9!}{2!2!}-\frac{7!}{2!}\times 2$	M1	$a-\frac{7!}{2!}\times b$ $a=$ *their* 6(a) or correct, $b=1,2$.
		M1	$a-\frac{7!}{c!}\times 2$ $a=$ *their* 6(a) or correct, $c=1,2$.
	85680	A1 FT	ft *their* **6(a)** – 5040.
	Method 2 Adding no of different ways		
	P and S at ends $\quad 2\times 7!=\quad$ 10080 P or S at one end only $\quad 4\times 5\times\frac{7!}{2!}=\quad$ 50400	M1	Finding correct number of ways for one of these correctly identified scenarios.
	Neither P nor S at an end $\quad 5\times 4\times\frac{7!}{2!2!}=\quad$ 25200	M1	Adding no of ways for 3 correctly identified scenarios.
	Total 85680	A1	
	Method 3		
	P at beginning $\quad 7\times\frac{7!}{2!}\quad = 17640$ S at beginning $\quad 7\times\frac{7!}{2!}\quad = 17640$	M1	Finding correct number of ways for one of these correctly identified scenarios.
	Neither P nor S at beginning $\quad 5\times\frac{8!}{2!2!}\quad = 50400$	M1	Adding no of ways for 3 correctly identified scenarios.
	Total 85680	A1	
		3	

Question	Answer	Marks	Guidance
6(c)	**Method 1** arrangements with PP between Ss { S P P S ^ ^ ^ ^ ^ } add arrangements with PP not between Ss { (S ^ ^ S) ^ P P ^ }		
	$6!+5!\times 5\times 4$	**M1**	$6! + d$, d an integer ≥ 1, may be implied.
	$6!+5!\times 5\times 4$	**M1**	$e+5!\times f$, e, f integers ≥ 1, may be implied.
		M1	$e+g!\times\left(5\times 4\,or\,{}^{5}P_{2}\right)$, e an integer ≥ 1, g = 4,5,6.
	[Total]= 3120	**A1**	
	Method 2 - considers the 6 positions for S ^^S		
	Positions 1 and 6 there are 5 $\times 5!$ ways	**M1**	Identifying no of ways if S^^S is in position 1 or 6.
	Positions 2, 3, 4 and 5 there are $4\times 5!$ ways	**M1**	Identifying no of ways if S^^S is in position 2, 3, 4 or 5.
	$2\times 5\times 5!+4\times 4\times 5!$	**M1**	Adding no of ways for 6 scenarios (or 26 × 5!).
	[Total] = 3120	**A1**	SC B1 for 3120 if any method marks are withheld.
		4	

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Question	Answer	Marks	Guidance
6(d)	**Method 1** Either PP in the group of 5 or PP in the group of 4		
	$\frac{{}^{5}C_{3}}{{}^{9}C_{5}}+\frac{{}^{5}C_{2}}{{}^{9}C_{5}}$, $\frac{{}^{5}C_{3}+{}^{5}C_{2}}{{}^{9}C_{5}}$	**M1**	$a\times{}^{5}C_{2}$, $a\times{}^{5}C_{3}$, or ${}^{5}C_{2}+{}^{5}C_{3}$ seen as a numerator of one or two fractions where a is 1 or 2, no extra terms.
		M1	${}^{9}C_{5}\,or\,{}^{9}C_{4}$ seen (no addition, multiplication) as a denominator of one or two fractions.
	Probability = $\frac{20}{126},\frac{10}{63}$, 0.159	**A1**	
	Method 2 Considering the positions of P and then S		
	$\left(\frac{5}{9}\times\frac{4}{8}\times\frac{4}{7}\times\frac{3}{6}\right)+\left(\frac{5}{7}\times\frac{4}{6}\times\frac{4}{9}\times\frac{3}{8}\right)$	**M1**	a × 5 × 4 × 4 × 3 seen as a numerator of a fraction. where a = 1 or 2.
	$\left(\frac{5}{9}\times\frac{4}{8}\times\frac{4}{7}\times\frac{3}{6}\right)+\left(\frac{5}{7}\times\frac{4}{6}\times\frac{4}{9}\times\frac{3}{8}\right)$ $=\frac{10}{63}$	**M1**	9 × 8 × 7 × 6 seen as a denominator of a fraction.
		A1	
		3	

Question	Answer	Marks	Guidance
6(a)	$\frac{9!}{2!2!}$	**M1**	$\frac{h!}{2!\times j!}$, h = 7, 8, 9; j = 1, 2
	90720	**A1**	
		2	
6(b)	**Arrangements with 5 letters between As + Arrangements with 6 letters between As + Arrangements with 7 letters between As**		
	With gap of 5: $\frac{7!}{2!}\times 3$ [= 7560] With gap of 6: $\frac{7!}{2!}\times 2$ [= 5040] With gap of 7: $\frac{7!}{2!}\times 1$ [= 2520]	**M1**	$\frac{7!}{2!}\times k$, k positive integer 1< k < 7
		M1	Add their no of ways for 3 identified correct scenarios, no additional incorrect scenarios, accept unsimplified.
	[Total no = $\frac{7!}{2!}\times 6$ =] 15120	**A1**	
		3	

Question	Answer	Marks	Guidance
6(c)	**Method 1: Summing number of ways**		
	AT _ _ _ $2\times2\times{}^5C_3$ 40 A _ _ _ _ $2\times{}^5C_4$ 10 AATT _ ${}^5C_1$ 5 AAT _ _ $2\times{}^5C_2$ 20 AA _ _ _ ${}^5C_3$ 10 _ _ _ _ _ ${}^5C_5$ 1	B1	Correct no of ways for 4 correctly identified scenarios, accept unsimplified.
		M1	Add no of ways for 5 or 6 identified correct scenarios, no additional incorrect scenarios, no repeated scenarios, accept unsimplified.
	[Total no of ways not containing more Ts than As =] = 40+10+5+20+10+1 [=86]	A1	All correct and added
	Probability = $\frac{86}{{}^9C_5}$	M1	$\frac{their\,86}{9C5\,or\,their\,identified\,total}$ accept numerator unevaluated
	$\frac{86}{126}, \frac{43}{63}$, 0.683	A1	
	Method 2: Subtracting no of ways with more Ts from total		
	T _ _ _ _ $2\times{}^5C_4$ 10 TTA _ _ $2\times{}^5C_2$ 20 TT _ _ _ ${}^5C_3$ 10	B1	Correct no of ways for 2 correctly identified scenarios, no additional incorrect scenarios, no repeated scenarios, accept unsimplified, condone use of permutations
		M1	Add no of ways for 2 or 3 correct scenarios and subtract from their total no of ways All correct and subtracted
	Total no of ways with more Ts than As =40 ${}^9C_5 - 40 = 86$	A1	
	Probability = $\frac{86}{{}^9C_5}$	M1	$\frac{their\,86}{9C5\,or\,their\,identified\,total}$ accept numerator unevaluated

Question	Answer	Marks	Guidance
6(c)	$\frac{43}{63}$, 0.683	A1	
		5	