Question	Answer	Marks	Guidance
7(a)	**Method 1: Total number of arrangements – number of arrangements with Cs together**		
	$\frac{10!}{2!4!} - \frac{9!}{4!}$ [75600-15120]	**M1**	$\frac{10!}{a!b!} - c$, $a \neq b$, $a = 1, 2$, $b = 1, 4$, with c being a positive integer.
		M1	$d - \frac{e!}{4!}$, $e = 8, 9, 10$, with d being a positive integer.
	= 60480	**A1**	Exact value only. **SC B1** for final answer 60480 www.
	Method 2: Arrangements ^ ^ C ^ C ^ ^ ^ ^ ^		
	$\frac{8!}{4!} \times \frac{9 \times 8}{2}$	**M1**	$\frac{8!}{4!} \times f$ seen, with f being a positive integer.
		M1	$g \times \frac{9 \times 8}{h}$, with g being a positive integer, $h = 1, 2$. $g \times {}^9C_2$ and $g \times {}^9P_2$ are acceptable.
	= 60480	**A1**	Exact value only. **SC B1** for final answer 60480 www.
		3	

Question	Answer	Marks	Guidance
7(b)	AC^^^C^^^A $\frac{6!}{2!} \times 4$	**M1**	$\frac{6!}{2!} \times s$, with s being a positive integer.
		M1	$\frac{t!}{r!} \times 4$, $r = 1, 2, 3$ and $t = 8, 7, 6$.
	1440	**A1**	
	Alternative Method for Question 7(b)		
	$\frac{4 \times {}^6P_3 \times 3!}{2!}$	**M1**	$\frac{{}^6P_3}{2!} \times k$, with k being a positive integer.
		M1	$4 \times 3! \times \frac{{}^6P_m}{n!}$, $m = 2, 3$ and $n = 1, 2, 3$.
	1440	**A1**	
		3	

Question	Answer	Marks	Guidance
7(c)	Scenarios AA _ _ _ ${}^5C_3 = 10$ AAA _ _ ${}^5C_2 = 10$ AAAA _ ${}^5C_1 = 5$	**B1**	Correct number of ways for identified scenarios of 2 or 3 As, accept unsimplified, www.
		M1	Add 3 values for 2, 3 and 4 As, no additional, incorrect or repeated scenarios. Accept unsimplified.
	25	**A1**	
	Alternative Method 2 for Question 7(c)		
	Scenarios: AAC _ _ ${}^4C_2 = 6$ AA _ _ _ ${}^4C_3 = 4$ AAAC _ ${}^4C_1 = 4$ AAA _ _ ${}^4C_2 = 6$ AAAAC 1 AAAA _ 4	**B1**	Correct total number of ways for identified scenarios of 2 or 3 As, accept unsimplified, www (e.g., both values for AAC^^ and AA^^^ shown would be fine for 2As).
		M1	Add 6 values of appropriate scenarios only, no additional, incorrect or repeated scenarios. Accept unsimplified.
	25	**A1**	
		3	

Question	Answer	Marks
7(a)	$\frac{9!}{2!2!} = 90\,720$	B1
		1
7(b)	$\frac{6!}{2!}$	M1
	360	A1
		2

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Question	Answer	Marks
7(c)	2 Es together $= \frac{8!}{2!} (= 20160)$	M1
	Es not together $= 90720 - 20160 = 70560$	M1
	Probability $= \frac{70560}{90720}$	M1
	$\frac{7}{9}$ or 0.778	A1
	Alternative method for question 7(c)	
	_^_^_^_^_^_^_^_ $\frac{7!}{2!} \times \frac{8 \times 7}{2} = 70560$	
	$7! \times k$ in numerator, k integer $\geqslant 1$, denominator $\geqslant 1$	M1
	Multiplying by $^8C_2$ OE	M1
	Probability $= \frac{70560}{90720}$	M1
	$\frac{7}{9}$ or 0.778	A1
		4

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Question	Answer	Marks
7(d)	Scenarios are: E L _ _ _ $\quad ^5C_3 \quad 10$ E E L _ _ $\quad ^5C_2 \quad 10$ E _ _ _ _ $\quad ^5C_4 \quad 5$ E E _ _ _ $\quad ^5C_3 \quad 10$	M1
	Summing the number of ways for 3 or 4 correct scenarios	M1
	Total = 35	A1
		3

Question	Answer	Marks	Guidance
3(a)	**Method 1** Total arrangements with Ds at ends – arrangements with Ds at ends and Fs together		
	$\frac{7!}{2!} - 6!$ [= 2520 – 720]	M1	$\frac{7!}{2!}$ seen alone, not multiplied or divided in a calculation nor subtracted from another value.
		M1	$\frac{l!}{m!} - 6!$, $l = 7$, 8 or 9, $m = 1$ or 2
	= 1800	A1	
	Method 2 D ^ ^ ^ ^ ^ D, Fs inserted not next to each other		
	$5! \times \frac{6 \times 5}{2}$	M1	$5! \times a$, $1 \leqslant a \leqslant 30$ 1 can be implied, a is an integer. No other terms added or subtracted.
		M1	$b! \times \frac{6 \times 5}{2}$ *or* $b! \times {}^6C_2$ *or* $b! \times \frac{6P2}{2!}$. Where $b = 5, 6$ or 7.
	= 1800	A1	
		3	

Question	Answer	Marks	Guidance
3(b)	**Method 1**		
	[Number of outcomes with 4 letters between Ds (D ^ ^ ^ ^ D ^ ^ ^)] $\frac{7!}{2!} \times 4$ [= 10080]	M1	Accept $\frac{7!}{2} \times 4$ or 10080 alone or as the numerator or denominator of a fraction.
	[Total number of arrangements =] $\frac{9!}{2!2!}$ [= 90720] seen as denominator in a fraction	M1	Accept 90720 as denominator in a fraction.
	[Probability =] $\frac{10080}{90720}, \frac{1}{9}$, 0.111	A1	WWW.
	Method 2		
	[Total number of outcomes with 4 letters between Ds (D_1 ^ ^ ^ ^ D_2 ^ ^ ^)] 7! × 4 × 2! [= 40320]	M1	Accept 7! × 4 × 2! or 40320 alone or as the numerator or denominator of a fraction.
	[Total number of arrangements of $D_1AF_1F_2OD_2ILS$ =] 9! [=362880] seen as denominator in a fraction.	M1	Accept 362880 as denominator in a fraction.
	[Probability =] $\frac{40320}{362880}, \frac{1}{9}$, 0.111	A1	WWW.

Question	Answer	Marks	Guidance
3(b)	**Method 3**		
	[When 2 F's are not part of the 4 letters between the D's] $\frac{5P4 \times 4!}{2!}$ or $\frac{5! \times 4!}{2!}$ [= 1440] [When 1F is part of the 4 letters between the D's] ${}^5C_3 \times 4! \times 4!$ [=5760] [When 2F's are part of the 4 letters between the D's] $\frac{5C2 \times 4!}{2!} \times 4!$ [=2880] [1440 + 5760 + 2880] = 10080	M1	Accept 10080 alone or as the numerator or denominator of a fraction.
	[Total number of arrangements =] $\frac{9!}{2!2!}$ [= 90720] seen as denominator in a fraction	M1	Accept 90720 as denominator in a fraction.
	[Probability =] $\frac{10080}{90720}$, $\frac{1}{9}$, 0.111	A1	WWW.
		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	

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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 $4C1 \times 2! \times 6P4 = 2880$	M1	One number of ways correct, accept unsimplified.
	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	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 ${}^5P_2 \times {}^6P_3 \times$ **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	

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 = $\frac{\textit{their}\ 3\times 5P2}{\textit{their}\ 16\,800}$	M1	Probability = $\frac{\textit{their}\ 60}{\textit{their}\ 16\,800}$.
	$\frac{1}{280}$, 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	

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

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
7(a)	${}^{12}C_5 \times {}^{7}C_4$ [$\times {}^{3}C_3$]	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
7(a)	**Method 1** Total – A and B together		
	7! – 6! ×2	M1	7! – *k*, *k* an integer ⩾ 1.
		M1	*m* – 6! × *n* : *n* = 1, 2 where *m* an integer > 6! n = 1 can be implied.
	= 3600	A1	
	Method 2 Arrangements of 5 people then Ali and Ben placed		
	5! × 6 × 5	M1	5! × *p* where *p* an integer > 1.
		M1	$q \times 6 \times 5$, $q \times {}^6C_2$, $q \times {}^6P_2$, $q \times \frac{6 \times 5}{2}$, where *q* an integer > 1.
	= 3600	A1	
		3	
7(b)	7! × 4! × 2	M1	7! × *r*, where *r* is an integer, *r* > 1 or 4! × *s*, where *s* is an integer, *s* > 1.
		M1	7! × 4! × *t*, where *t* is an integer, *t* ⩾ 1, *t* = 1 can be implied.
	241920	A1	CAO.
		3	

Question	Answer	Marks	Guidance
7(c)	${}^{11}C_6 \times {}^{5}C_3 \times [{}^{2}C_2]$	M1	${}^{11}C_v \times {}^{11-v}C_u \times [{}^{11-v-u}C_w]$, $u, v, w = 6, 3, 2$ $u \neq v \neq w$.
	$= 4620$	A1	
		2	

Question	Answer	Marks	Guidance
7(d)	**Method 1** Ali, Ben and Charlie must be in the group of 6 or the group of 3.		
	group of 6: ${}^{8}C_3 \times {}^{5}C_3 \times ({}^{2}C_2) = 560$	B1	560 seen, accept un-simplified.
	group of 3: ${}^{8}C_6 (\times {}^{2}C_2 \times {}^{3}C_3) = 28$	B1	28 seen accept un-simplified.
	Probability they are in same group $= \dfrac{560+28}{4620}$	M1	$\dfrac{\textit{their}(560+28)}{\textit{their}\ (c)}$ or $\dfrac{\textit{their}(560+28)}{4620}$
	$= \dfrac{588}{4620}, \dfrac{7}{55}, 0.127$	A1	
	Method 2 Ali, Ben and Charlie must be in the group of 6 or the group of 3.		
	Group of 6: $\dfrac{6}{11} \times \dfrac{5}{10} \times \dfrac{4}{9} \times \dfrac{3}{8} \times \dfrac{2}{7} \times \dfrac{1}{6} \times {}^{8}C_3$ $= \dfrac{1}{462} \times 56 = \dfrac{4}{33}$	B1	$\dfrac{4}{33}$, 0.1212… seen, accept un-simplified.
	Group of 3: $\dfrac{3}{11} \times \dfrac{2}{10} \times \dfrac{1}{9} = \dfrac{1}{165}$	B1	$\dfrac{1}{165}$, $0.00606(06\ldots)$ seen, accept un-simplified.
	Probability they are in same group $= \dfrac{4}{33} + \dfrac{1}{165}$	M1	*their* $\dfrac{4}{33}$ + *their* $\dfrac{1}{165}$.
	$= \dfrac{7}{55}, 0.127$	A1	
		4	

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td rowspan="5">2</td><td rowspan="3">
<table>
<tr><td>Scenario</td><td>S(16)</td><td>D(10)</td><td></td><td></td></tr>
<tr><td>SSSSDD</td><td>4</td><td>2</td><td>${}^{16}C_4 \times {}^{10}C_2$</td><td>[81900]</td></tr>
<tr><td>SSSDDD</td><td>3</td><td>3</td><td>${}^{16}C_3 \times {}^{10}C_3$</td><td>[67200]</td></tr>
<tr><td>SSDDDD</td><td>2</td><td>4</td><td>${}^{16}C_2 \times {}^{10}C_4$</td><td>[25200]</td></tr>
</table>
</td><td>B1</td><td>Expression of the form ${}^{16}C_x \times {}^{10}C_y$ with $x + y = 6$ linked to a correct identified scenario.</td></tr>
<tr><td>M1</td><td>Two identified outcomes evaluated accurately, accept un-simplified.
Identification can be implied by un-simplified expression.
Condone consistent use of permutations.</td></tr>
<tr><td>M1</td><td>Sum of their values of 3 correct identified scenarios, no incorrect/repeated scenarios.
Identification can be implied by un-simplified expression.</td></tr>
<tr><td>Total = 174 300</td><td>A1</td><td>If either or both Ms not awarded, SCB1 for 174 300 WWW.</td></tr>
<tr><td></td><td>4</td><td></td></tr>
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