

AS-Level
Topic : Probability
May 2013-May 2025
Answers

Question 1

<p>(a) $P(W_2) = P(W_1W_2) + P(L_1W_2)$ $= 0.3 \times 0.6 + 0.7 \times 0.15$ $= 0.285$</p> <p>$P(W_1 W_2) = \frac{P(W_1 \cap W_2)}{P(W_2)} = \frac{0.18}{0.285}$ $= 0.632, \frac{12}{19}$</p>	<p>B1 M1</p> <p>A1</p> <p>A1 [4]</p>	<p>0.3 × 0.6 alone as num or denom of a fraction Attempt at P(W₂) as sum of two 2-factor options seen anywhere</p> <p>Correct unsimplified P(W₂) as num or denom of a fraction</p> <p>Correct answer</p>
<p>(b) $x + 4$ oe seen</p> <p>$\frac{10}{15} \times \frac{7}{x+4} = \frac{7}{18}$</p> <p>$x = 8$</p>	<p>B1</p> <p>M1</p> <p>A1</p> <p>A1 [4]</p>	<p>Seen anywhere</p> <p>Mult two probabilities, one containing x and equating to $\frac{7}{18}$</p> <p>Correct unsimplified equation</p> <p>Correct answer</p>

Question 2

<p>$P(\text{at least } 2) = P(2, 3) \text{ or } 1 - P(0, 1)$</p> <p>$= \frac{5}{12} \times \frac{4}{11} \times \frac{7}{10} \times {}_3C_2 + \frac{5}{12} \times \frac{4}{11} \times \frac{3}{10}$</p> <p>$= \frac{4}{11} \text{ (0.364)}$</p> <p>OR $\frac{{}_5C_3 + ({}_5C_2 \times {}_7C_1)}{{}_{12}C_3}$</p>	<p>M1</p> <p>M1</p> <p>M1</p> <p>A1 [4]</p> <p>M1</p> <p>M1</p> <p>M1</p> <p>A1</p>	<p>Summing, or 1–, two different three-factor prob expressions, ${}_3C_2$ not needed</p> <p>12, 11, 10 seen or implied in denominator</p> <p>Mult a prob by ${}_3C_2$ or ${}_3C_1$ oe</p> <p>Correct answer</p> <p>${}_5C_3$ seen added in numerator</p> <p>${}_5C_2$ seen mult alone or in numerator</p> <p>${}_{12}C_3$ seen in denom</p> <p>Correct answer</p>
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Question 3

$$P(Q) = \frac{4}{36} \text{ or } P(S) = \frac{1}{2}$$

$$P(Q \cap S) = \frac{2}{36} \text{ or } P(S|Q) = \frac{1}{2} \text{ or}$$

$$P(Q|S) = \frac{2}{18}$$

$$P(Q \cap S) = P(Q) \times P(S) \text{ or}$$

$$P(S|Q) = P(S) \text{ or } P(Q|S) = P(Q)$$

Independent

B1

oe

B1

oe

M1

Comparing correct pair of terms
 $0 \leq$ all probabilities < 1

A1

[4]

Correct conclusion must have all probs correct

Question 4

(i)	$P(T, B) = \frac{5}{12} \times \frac{2}{10} = \frac{1}{12} \text{ (0.0833)}$	M1		Mult their $P(T)$ by $2/9$ or $2/10$ only								
		A1	[2]	Correct answer								
(ii)	$P(C_S \cap C_A) = \frac{7}{12} \times \frac{4}{10} = \frac{28}{120} \text{ (0.2333)}$	M1		Mult their $P(C_S)$ by $3/9$ or $4/10$ seen as num or denom of a fraction								
	$P(C_A) = \frac{7}{12} \times \frac{4}{10} + \frac{5}{12} \times \frac{3}{10} = \frac{43}{120} \text{ (0.3583)}$	M1		Summing 2 two-factor products to find $P(C_A)$ seen anywhere								
	$P(C_S C_A) = \frac{P(C_S \cap C_A)}{P(C_A)} = \frac{28/120}{43/120}$	A1		Correct unsimplified $P(C_A)$ seen as num or denom of a fraction								
	$= \frac{28}{43} \text{ (0.651)}$	A1	[4]	Correct answer								
(iii)	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="padding: 5px;">x</th> <th style="padding: 5px;">0</th> <th style="padding: 5px;">1</th> <th style="padding: 5px;">2</th> </tr> </thead> <tbody> <tr> <td style="padding: 5px;">Prob</td> <td style="padding: 5px;">7/24</td> <td style="padding: 5px;">19/40</td> <td style="padding: 5px;">7/30</td> </tr> </tbody> </table>	x	0	1	2	Prob	7/24	19/40	7/30	B1		$x = 0, 1, 2$, can be implied from table or working
x	0	1	2									
Prob	7/24	19/40	7/30									
	$P(X = 0) = P(T, B) + P(T, T)$	M1		1 or 2 two-factor products, denoms 12 and 10 or 12 and 9, implied if ans is correct								
	$= \frac{5}{12} \times \frac{2}{10} + \frac{5}{12} \times \frac{5}{10} = \frac{7}{24} \text{ (0.292)}$	A1		One correct unsimplified								
	$P(X = 2) = P(C, C) = \frac{7}{12} \times \frac{4}{10} = \frac{28}{120} \text{ (0.233)}$	B1		One other correct unsimplified								
	$P(X = 1) = 1 - 7/24 - 28/120 = \frac{19}{40} \text{ (0.475)}$	B1ft	[5]	Third correct ft $1 - P(2 \text{ of their probs})$								

Question 5

(i)	number of balls in B is $5 + x + 1 = x + 6$ $P(Y) = x/(x + 6)$ AG	B1	[1]	Sensible reason
(ii)	<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p>box A</p> </div> <div style="text-align: center;"> <p>box B</p> </div> </div>	B1		both correct for box A
		B1		1 correct
		B1		1 correct
		B1	[4]	1 correct
(iii)	$P(W_B) = \frac{6}{x+6} = \frac{1}{3}$ $x = 12$ AG	M1		their $\frac{6}{x+6} = 1/3$ or $x/x+6 = 2/3$
		A1	[2]	Verification or solving legit
(iv)	$P(Y) = \frac{8}{10} \times \frac{12}{18} + \frac{2}{10} \times \frac{13}{18}$ $= \frac{61}{90}$ $P(= (AY BY) = \frac{P(AY \cap BY)}{P(Y)}$ $= \frac{2}{10} \times \frac{13}{18} / \frac{61}{90}$ $= \frac{13}{61} (0.213)$	M1		Attempt at $P(Y)$ involving 2 two-factor fractions, seen anywhere.
		A1		Correct $P(Y)$ seen as num or denom of a fraction
		B1		$(2/10) \times (13/18)$ seen as num or denom of a fraction
		A1	[4]	Correct answer

Question 6

<p>(i) $P(\text{same}) = P(1, 1) + P(3, 3) + P(5, 5)$ $= \frac{2}{9} \times \frac{1}{8} + \frac{4}{9} \times \frac{3}{8} + \frac{3}{9} \times \frac{2}{8}$ $= 5/18 (0.278)$ Alt. method: $\frac{2C_2 + 4C_2 + 3C_2}{9C_2}$ or $\frac{2 \times 1 + 3 \times 4 + 2 \times 3}{9C_2 \times 2}$ oe</p>	<p>M1 M1 A1 3</p>	<p>Summing 3 two-factor options Multiplying terms by one less in the numerator or denominator Correct answer M1 for numerator, M1 for denominator, A1 correct answer</p>								
<p>(ii) $P(5, \bar{5}) + P(\bar{5}, 5)$ $= \frac{3}{9} \times \frac{6}{8} + \frac{6}{9} \times \frac{3}{8} = \frac{36}{72} = \frac{1}{2}$ or 0.5 Alt. method: $\frac{6C_1 \times 3C_1 (\times 2)}{9C_2 (\times 2)}$ oe</p>	<p>M1 M1 A1 3</p>	<p>Mult 2 probs whose numerators sum to 9 o.e. Summing 2 options or mult by 2 (may be 4 options) Correct answer M1 for numerator, M1 for denominator, A1 correct answer</p>								
<p>(iii) $P(5 \cap \bar{5}) = \frac{3}{9} \times \frac{6}{8} = \frac{1}{4}$ $P(\bar{5}) = \frac{1}{4} + \frac{6}{9} \times \frac{5}{8} = 48/72 = 0.6666$ $P(5_1 \bar{5}_2) = \frac{1/4}{48/72} = 3/8 = 0.375$</p>	<p>M1 M1 A1 A1 4</p>	<p>Attempt at P(5 and not 5) seen as numerator or denominator of a fraction Attempt at P(not 5) sum of 2 two-factor terms seen anywhere Correct P($\bar{5}$) as numerator or denominator in fraction Correct answer</p>								
<p>(iv)</p> <table border="1" data-bbox="311 1556 694 1630"> <tr> <td>x</td> <td>0</td> <td>1</td> <td>2</td> </tr> <tr> <td>P(X=x)</td> <td>5/12</td> <td>1/2</td> <td>1/12</td> </tr> </table> <p>$P(0) = P(\bar{5}, \bar{5}) = \frac{6}{9} \times \frac{5}{8} = 30/72 (5/12)$ (0.4166) $P(1) = 0.5$ from part (ii) $P(2) = 6/72 (1/12) (0.0833)$ from part (i)</p>	x	0	1	2	P(X=x)	5/12	1/2	1/12	<p>B1 B1 B1ft 3</p>	<p>Values 0, 1, 2 seen in table with at least 1 prob Correct P(0) unsimplified If $x=0,1,2,(3)$ ft $\Sigma p = 1$, no -ve values, all probabilities <1</p>
x	0	1	2							
P(X=x)	5/12	1/2	1/12							

Question 7

<p>(i) options (3, 4, 4,) or (4, 3, 4) or (4, 4, 3) Probs $(4/10 \times 6/9 \times 5/8) \times 3C1$ $= 360/720$ $= \frac{1}{2}$ AG</p> <p>OR $\frac{{}_6C_2 \times {}_4C_1}{{}_{10}C_3} = \frac{1}{2}$ AG</p>	M1												
	M1												
	A1	[3]	Correct answer										
	M1		One of $6C2$ or $4C1$ seen in num $10C3$ in denom Correct answer										
	M1												
	A1												
(ii)	B1	[4]	9, 10, 11, 12 only seen										
<table border="1"> <thead> <tr> <th>sum</th> <th>9</th> <th>10</th> <th>11</th> <th>12</th> </tr> </thead> <tbody> <tr> <td>Prob</td> <td>24/720</td> <td>216/720</td> <td>360/720</td> <td>120/720</td> </tr> </tbody> </table>	sum	9	10	11	12	Prob	24/720	216/720	360/720	120/720	B1		One correct prob other than P(11), with or without replacement Another correct prob
sum	9	10	11	12									
Prob	24/720	216/720	360/720	120/720									
<p>$P(3, 3, 3) = 4/10 \times 3/9 \times 2/8 = 24/720$ (1/30) $P(3, 3, 4) = 4/10 \times 3/9 \times 6/8 \times 3C1$ $= 216/720$ (3/10) $P(4, 4, 4) = 6/10 \times 5/9 \times 4/8 = 120/720$ (1/6)</p>	B1												
(iii) $P(R) = 0.5$ $P(S) = 0.4$ $P(R \cap S) = 120/720$	B1	[3]	$P(R \cap S) = 120/720$ (1/6) Numerical attempt to compare $P(R$ and $S)$ with $P(R) \times P(S)$ provided $P(R \cap S) \neq 1/5$ Correct conclusion ft wrong $P(R \cap S) \neq 1/5$, $P(S)$ correct										
$P(R \cap S) = 120/720 \neq P(R) \times P(S)$ Not indep	M1												
	A1ft												
(iv) $P(R \cap S) \neq 0$ or there is an overlap between R and S (34,4) Not exclusive $\sum xf / \sum f$	B1ft	[1]	Correct answer following correct reasoning ft wrong non zero $P(R \cap S)$										

Question 8

(i) $P(C \cap < 50) = 0.35 \times 0.2 = 0.07$	B1	[1]	
(ii) $P(C \mid < 50) = \frac{P(C \cap < 50)}{P(< 50)}$	M1	[4]	Summing three 2-factor products seen anywhere (can omit the 1)
$= \frac{0.35 \times 0.2}{0.25 \times 0.3 + 0.35 \times 0.2 + 0.4(\times 1)}$	A1		
$= \frac{0.07}{0.545}$	M1		0.545 (unsimplified) seen as num or denom of a fraction Attempt at $P(C \cap < 50)$ as 2-factor prod only seen as num or denom of a fraction
$= 0.128$ (14/109)	A1		Correct answer

Question 9

<p>(i) if throw H then smallest score is 2 $P(T, 1) = 1/2 \times 1/4 = 1/8$ AG</p>	<p>B1 B1</p>	<p>2</p>	<p>Or equivalent</p>																		
<p>(ii) $P(3)$ from two dice = $2/16$ seen</p> <p>$P(H, 3) = 1/2 \times 2/16 = 2/32$ $P(T, 3) = 1/2 \times 1/4 = 1/8$ So $P(3) = 6/32 = 3/16$ AG</p>	<p>B1 M1 A1 A1</p>	<p>4</p>	<p>From (1, 2) and (2, 1)</p> <p>Summing $P(H, 3)$ and $P(T, 3)$ One correct Correct answer must see clear reasoning</p>																		
<p>(iii)</p> <table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <tr> <td style="padding: 2px;">X</td> <td style="padding: 2px;">1</td> <td style="padding: 2px;">2</td> <td style="padding: 2px;">3</td> <td style="padding: 2px;">4</td> <td style="padding: 2px;">5</td> <td style="padding: 2px;">6</td> <td style="padding: 2px;">7</td> <td style="padding: 2px;">8</td> </tr> <tr> <td style="padding: 2px;">Prob</td> <td style="padding: 2px;"></td> <td style="padding: 2px;">$5/32$</td> <td style="padding: 2px;"></td> <td style="padding: 2px;">$7/32$</td> <td style="padding: 2px;"></td> <td style="padding: 2px;">$3/32$</td> <td style="padding: 2px;"></td> <td style="padding: 2px;"></td> </tr> </table>	X	1	2	3	4	5	6	7	8	Prob		$5/32$		$7/32$		$3/32$			<p>B1 B1 B1</p>	<p>3</p>	<p>One correct prob A second correct prob A third correct prob</p>
X	1	2	3	4	5	6	7	8													
Prob		$5/32$		$7/32$		$3/32$															
<p>(iv) $P(Q \cap R) = 0$ or 'if you throw a tail you can't get a 7'</p> <p>Yes they are exclusive</p>	<p>M1 A1dep</p>	<p>2</p>	<p>Stating $P(Q \cap R) = 0$ or implying by words Dep on previous M</p>																		

Question 10

<p>either $55/90$ ($11/18$) or $95/160$ ($19/32$) seen</p> <p>$P(M \text{ and } 18 - 60) = 0.6 \times 55/90$ $= 0.367$ ($11 / 30$)</p> <p>$P(18 - 60) = 0.6 \times 55/90 + 0.4 \times 95/160$ (= $29/48$ or 0.604)</p> <p>$P(M 18 - 60) = \frac{P(M \cap 18 - 60)}{P(18 - 60)}$ $= 88/145$ (0.607)</p>	<p>B1 M1 M1 A1 A1</p>	<p>5</p>	<p>oe</p> <p>0.6 mult by $55/90$ seen as num / denom of a fraction</p> <p>Summing 2 two-factor products seen anywhere</p> <p>Correct unsimplified answer seen as num/denom of a fraction</p> <p>Correct answer</p>
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Question 11

<p>(i) $P(B \text{ champ}) = 0.7 \times 0.7 = 0.49$</p>	<p>B1</p>	<p>1</p>	
<p>(ii) $P(B \text{ champ})$ $= P(WW) + P(WLW) + P(LWW)$ $= (0.7 \times 0.7) + (0.7 \times 0.3 \times 0.7) + (0.3 \times 0.7 \times 0.7)$ $= 0.49 + 0.147 + 0.147$ $= 0.784$</p>	<p>M1 B1 A1</p>	<p>3</p>	<p>Summing at least 2 options, at least one of which is 3-factor</p> <p>0.147 seen, unsimplified Correct answer</p>
<p>(iii) $P(T2 T) = \frac{P(T2 \cap T)}{P(T)}$ $= \frac{0.3 \times 0.3 + 0.7 \times 0.3 \times 0.3}{0.216}$ $= 0.708$</p>	<p>M1 A1 M1 A1</p>	<p>4</p>	<p>Attempt $P(T2 \cap T)$ seen anywhere sum of 2 terms</p> <p>Correct unsimplified num of a fraction Dividing by their $(1 - \text{(ii)})$ oe Correct answer</p>

Question 12

<p>(i) $P(RR) = 0.6 \times 0.7 = 0.42$ $P(AA) = 0.4 \times 0.75 = 0.3$ $P(2 \text{ sets in match}) = 0.72$</p>	<p>B1 B1 B1✓³</p>	<p>Only 2 factors Only 2 factors ft previous answers</p>
<p>(ii) $\frac{P(A \text{ wins and 2 sets})}{P(2 \text{ sets})} = \frac{P(AA)}{P(2 \text{ sets})}$ $= \frac{0.3}{0.72} = \frac{5}{12} (0.417)$</p>	<p>B1✓² B1✓²</p>	<p>Correct num or correct denom of a fraction ft their (i) Correct answer ft their or recovered AA/their or recovered (i)</p>

Question 13

<p>(i) $P(X \text{ and } P) = \frac{1}{4} \times \frac{4}{9} = \frac{1}{9}$ $P(Y \text{ and } P) = \frac{1}{4} \times \frac{2}{12} = \frac{1}{24}$ $P(Z \text{ and } P) = \frac{1}{2} \times \frac{1}{16} = \frac{1}{32}$ $P(P) = \frac{53}{288} = 0.184$</p>	<p>M1 A1 M1 A1</p>	<p>Mult a playground prob with a P prob One correct prob Summing at least two 2-factor probs Correct answer</p>
<p>(ii) $P(Y C) = \frac{P(Y \cap C)}{P(C)}$ $\frac{\frac{1}{4} \times \frac{1}{12}}{\frac{1}{4} \times \frac{1}{12} + \frac{1}{2} \times \frac{4}{16}}$ $= \frac{1}{48} = \frac{1}{7}$</p>	<p>M1 M1 A1 A1</p>	<p>Attempt at $P(Y \cap C)$ as numerator of a fraction Attempt at $P(C)$ in form of summing two 2-factor products, seen anywhere Correct unsimplified $P(C)$ seen anywhere Correct answer</p>

Question 14

(a) (i) $P(X=3) = P(GRR) + P(RGR)$

$$\frac{2}{4} \times \frac{2}{3} \times \frac{1}{2} + \frac{2}{4} \times \frac{2}{3} \times \frac{1}{2}$$

$$\frac{1}{3} \quad \text{AG}$$

(ii)

X	2	3	4
Prob	$\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{2}$

$$P(X=2) = P(RR) = \frac{2}{4} \times \frac{1}{3} = \frac{1}{6}$$

$$P(X=4) = 1 - \left(\frac{1}{6} + \frac{1}{3} \right) = \frac{1}{2}$$

Or $P(GGRR) + P(RGGR) + P(GRGR)$

$$= \left(\frac{2}{4} \times \frac{1}{3} \times \frac{2}{2} \times \frac{1}{1} \right) \times 3 = \frac{1}{2}$$

M1 Mult 3 probs

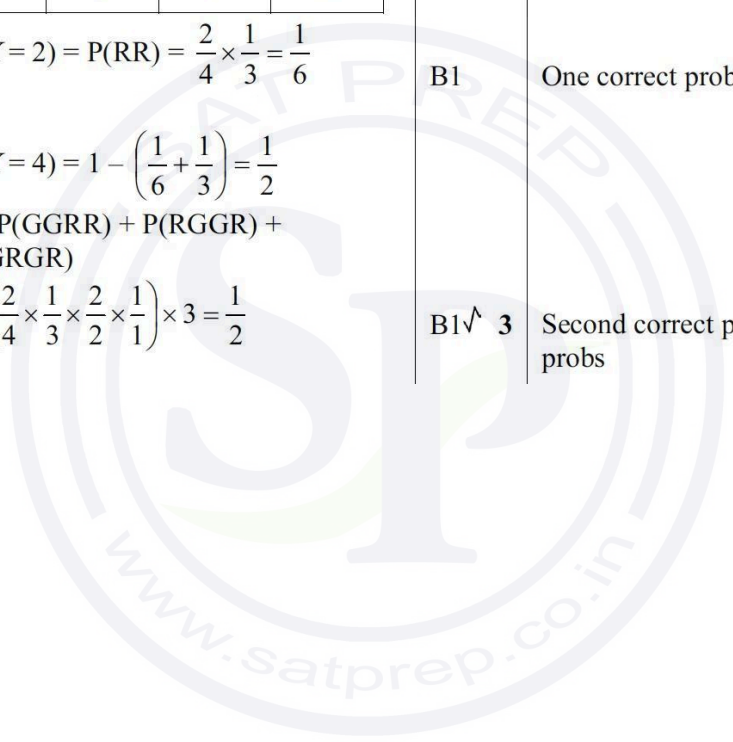
M1 Summing 2 options

A1 3 Correct working with appropriate justification and fraction sequencing

B1 Values 2, 3, 4 only in table
Condone $X=0,1$ if $P(X)=0$ stated

B1 One correct prob other than (i)

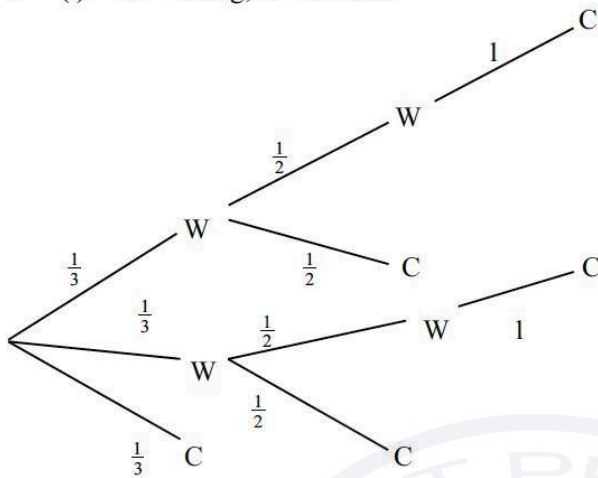
B1[✓] 3 Second correct prob ft 1 – their previous 2 probs



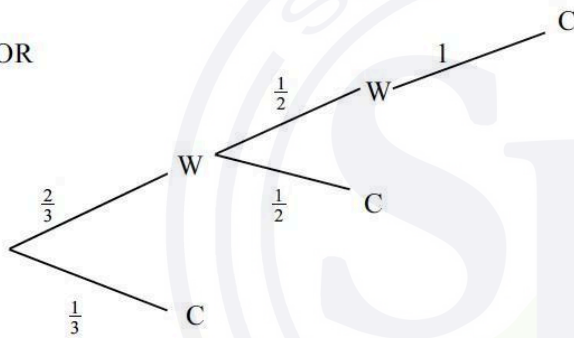
<p>(iii) $P(3 \text{ orange} \mid \text{at least } 2 \text{ O}) = \frac{P(3O)}{P(\text{at least } 2O)}$</p> <p>$P(3 \text{ orange}) = P(OOO)$</p> $= \frac{5}{7} \times \frac{4}{6} \times \frac{3}{5} = \frac{2}{7}$ <p>$P(\text{at least } 2O) = P(YOO) + P(OYO) + P(OOY) + \frac{2}{7}$</p> $= \frac{2}{7} \times \frac{5}{6} \times \frac{4}{5} + \frac{5}{7} \times \frac{2}{6} \times \frac{4}{5} + \frac{5}{7} \times \frac{4}{6} \times \frac{2}{5} + \frac{2}{7}$ $= \frac{6}{7}$ <p>$P(3O \mid \text{at least } 2O) = \frac{2}{7} \div \frac{6}{7} = \frac{1}{3} (0.333)$</p>	M1 A1 M1 A1 A1	Attempt at P(OOO) one three-factor option, not added Correct unsimplified num of a fraction Attempt at P(at least 2O) sum 3 or 4 three-factor options Correct unsimplified answer seen anywhere Correct answer evaluated
<p><u>Alternative 1</u></p> <p>3 Orange = 5C_3</p>	M1 A1	Attempt at combinations for 3 orange oe, not added Correct unsimplified num of a fraction
<p>At least 2 Orange = ${}^5C_2 \times {}^2C_1 + {}^5C_3$</p>	M1 A1	Attempt at combinations for at least 2 orange condone omission of 5C_3 Correct unsimplified answer seen anywhere
<p>$P(3O \mid \text{at least } 2O) = \frac{{}^5C_3}{{}^5C_2 \times {}^2C_1 + {}^5C_3} = \frac{1}{3}$</p>	A1	Correct answer evaluated
<p><u>Alternative 2</u></p> <p>No Yellow = 2C_0</p>	M1 A1	Attempt at combinations for 0 yellow oe, not added Correct unsimplified num of a fraction
<p>No more than 1 Yellow = ${}^2C_1 + {}^2C_0$</p>	M1 A1	Attempt at combinations for no more than 1 yellow. Condone omission of 2C_0 Correct unsimplified answer seen anywhere
<p>$P(3O \mid \text{at least } 2O) = \frac{{}^2C_0}{{}^2C_1 + {}^2C_0} = \frac{1}{3}$</p>	A1	Correct answer evaluated
<p><u>Misread – with replacement</u></p> <p>MR–1 applied to first Accuracy Mark earned</p>	M1 A1	Attempt at P(OOO) one three factor option oe not added Correct unsimplified num of a fraction
<p>$P(3O) = \frac{5}{7} \times \frac{5}{7} \times \frac{5}{7} = \frac{125}{343}$</p>	M1 A1	Attempt at P(at least 2O) sum of 3 or 4 three factor options Correct unsimplified seen anywhere
<p>$P(\text{at least } 2O) = \frac{5}{7} \times \frac{5}{7} \times \frac{2}{7} \times {}^3C_2 + \left(\frac{5}{7}\right)^3$</p>	A1	Answer evaluated
<p>$P(3O \mid \text{at least } 2O) = \frac{5}{11}$</p>	A1	
	max	

Question 15

4 (i) W = wrong, C = correct



OR



(ii)

x	1	2	3
Prob	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$

$$P(1) = P(C) \text{ say } = \frac{1}{3}$$

$$P(2) = P(WC) = \frac{1}{6} \quad P(WC) = \frac{1}{6} \text{ total } P(2) = \frac{1}{3}$$

$$P(3) = P(WWC) = \frac{1}{6} \quad P(WWC) = \frac{1}{6} \text{ total } P(3) = \frac{1}{3}$$

$$E(X) = 1 \times \frac{1}{3} + 2 \times \frac{1}{3} + 3 \times \frac{1}{3} = 2$$

M1 3 branches first qn and 2 by 2 for second qn only

M1 One branch twice for third qn or two branches twice with 0 and 1 seen on branches

B1 Any two of $\frac{1}{3}$, $\frac{1}{2}$ and 1 seen as probs

A1 4 Probs all correct and sensible labels NB SR for 4 outcomes instead of 3, M1 B1 only

M1 2 branches first qn and 1 by 2 for second qn only

M1 One branch once for third qn or two branches with 0 and 1 seen on branches

B1 Any two of $\frac{1}{3}$ or $\frac{2}{3}$, $\frac{1}{2}$ and 1 seen as probs

A1 Probs all correct and sensible labels

B1 1, 2, 3 seen only oe

B1 2 correct probs

B1 3 correct probs

B1 4 Correct answer fit their probs provided $0.999 \leq \Sigma p \leq 1$

Question 16

$P(8) = P(H\ 4\ 4) + P(T\ 2\ 4) + P(T\ 4\ 2)$ $= \frac{1}{3} \times \frac{1}{16} + \frac{2}{3} \times \frac{1}{16} + \frac{2}{3} \times \frac{1}{16}$ $= \frac{5}{48}$ $P(H 8) = \frac{P(H \cap 8)}{P(8)}$ $= \frac{\frac{1}{48}}{\frac{5}{48}} = \frac{1}{5}$	<p>M1</p> <p>M1</p> <p>A1</p> <p>B1</p> <p>A1</p>	<p>$\frac{1}{3}$ or $\frac{2}{3}$ mult by dice related prob, seen anywhere</p> <p>Summing two or three 2-factor probs involving $\frac{1}{3}$ and $\frac{2}{3}$</p> <p>$\frac{5}{48}$ oe seen as num or denom of a fraction</p> <p>$\frac{1}{48}$ oe seen as num or denom of a fraction</p> <p>5 Correct ans</p>
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Question 17

<p>(i)</p> <table border="1" style="margin-left: 20px;"> <thead> <tr> <th></th> <th>Kitchen mess</th> <th>Kitchen not mess</th> <th>Total</th> </tr> </thead> <tbody> <tr> <th>On time</th> <td>1/10</td> <td>1/10</td> <td></td> </tr> <tr> <th>Not on time</th> <td>1/2</td> <td></td> <td>4/5</td> </tr> <tr> <th>Total</th> <td>3/5</td> <td>4/10</td> <td></td> </tr> </tbody> </table>		Kitchen mess	Kitchen not mess	Total	On time	1/10	1/10		Not on time	1/2		4/5	Total	3/5	4/10		<p>B1</p> <p>B1</p> <p>B1</p>	<p>All values may be decimals or %</p> <p>2 probabilities correct</p> <p>2 further probabilities correct</p> <p>[3] 2 further probabilities correct</p>
	Kitchen mess	Kitchen not mess	Total															
On time	1/10	1/10																
Not on time	1/2		4/5															
Total	3/5	4/10																
<p>(ii)</p> $P(\text{not on time given kitchen mess}) = \frac{1/2}{3/5}$ $= 5/6 \text{ o.e.}$	<p>M1</p> <p>A1</p>	<p>A cond prob fraction seen (using corresponding combined outcomes and total)</p> <p>[2] FT from their values, 3sf or better, $<1, 3/5 < 1$</p>																

Question 18

<p>(i)</p> $P(2Es 1O) = \frac{3}{5} \times \frac{2}{4} \times \frac{2}{3} \times {}^3C_2 = \frac{3}{5} (0.6)$ <p>OR</p> $P(2Es 1O) = \frac{{}^3C_2 \times {}^2C_1}{{}^5C_3} = \frac{6}{10}$ $= 0.6$ <p>OR</p> <p>241, 247, 261, 267, 461, 467 = 6 options 124 126 127 146 147 167 246 247 267 467</p> <p>Prob = 6/10</p>	<p>M1 M1 A1 3</p> <p>M1</p> <p>M1 A1</p> <p>M1 M1</p> <p>A1</p>	<p>5×4×3 seen in denom Mult a prob by 3C_2 oe Correct answer</p> <p>3C_x or 3C_2 or 2C_1 oe seen mult by $k \geq 1$ in num</p> <p>5C_3 seen in denom Correct answer</p> <p>List at least 3 of 241, 247, 261, 267, 461, 467 5C_3 or list to get all 10 options in denom see below Correct answer</p>								
<p>(ii)</p> <p>124 126 127 146 147 167 246 247 267 467</p> <table border="1" data-bbox="375 985 829 1052"> <thead> <tr> <th>s</th> <th>1</th> <th>2</th> <th>4</th> </tr> </thead> <tbody> <tr> <td>P(S=s)</td> <td>6/10</td> <td>3/10</td> <td>1/10</td> </tr> </tbody> </table>	s	1	2	4	P(S=s)	6/10	3/10	1/10	<p>M1 A1 B1 B1 B1 5</p>	<p>Attempt at listing with at least 7 correct All correct and no others or all 60 1, 2, 4 only seen in top row Any two correct All correct</p>
s	1	2	4							
P(S=s)	6/10	3/10	1/10							

Question 19

<p>(i)</p> $0.3 \times 0.72 + 0.7 \times x = 0.783$ $x = 0.81$	<p>M1 A1 A1 3</p>	<p>Eqn with sum of two 2-factor probs = 0.783 Correct equation Correct answer</p>
<p>(ii)</p> $P(S \text{ given not like}) = \frac{P(S \cap NL)}{P(NL)}$ $= \frac{0.3 \times 0.28}{0.3 \times 0.28 + 0.7 \times 0.19 \text{ or } 1 - 0.783}$ $= 0.387 (12/31)$	<p>B1 M1 A1 A1 4</p>	<p>0.3×0.28 seen on its own as num or denom of a fraction Attempt at P(NL) either $(0.3 \times p_1) + (0.7 \times p_2)$ or $1 - 0.783$ seen anywhere Correct unsimplified P(NL) as num or denom of a fraction Correct answer</p>

Question 20

<p>(i)</p> $(1-x)0.9 + x \times 0.24 = 0.801$ $x = 0.15$	<p>M1 A1 A1 [3]</p>	<p>Eqn with sum of two 2-factor probs = 0.801 Correct equation Correct answer</p>
<p>(ii)</p> $P(\geq 100 \text{ times given } \leq 3 \text{ views}) = \frac{P(\geq 100 \text{ times} \cap \geq 3 \text{ views})}{P(\geq 3 \text{ views})} =$ $\frac{0.85 \times 0.1}{0.85 \times 0.1 + 0.15 \times 0.76 \text{ or } 1 - 0.801}$ $= 0.427$	<p>B1 M1 A1 A1 [4]</p>	<p>0.85×0.1 seen on its own as num or denom of a fraction Attempt at P(≥ 3 views) either $(0.85 \times p_1 + 0.15 \times p_2)$ or $1 - 0.801$ seen anywhere Correct unsimplified P(≥ 3 views) as num or denom of a fraction Correct answer</p>

Question 21

<p>(i)</p> $P(A) = \frac{1}{3} \times \frac{2}{3} + \frac{2}{3} \times \frac{1}{3} = \frac{4}{9}$ $P(B) = \frac{27}{36} = \frac{3}{4}$ $P(A \cap B) = \frac{12}{36} = \frac{1}{3}$ $P(A) \times P(B) = \frac{4}{9} \times \frac{3}{4} = \frac{1}{3}$ <p>Independent as $P(A \cap B) = P(A) \times P(B)$</p>		<p>M1 M1</p> <p>B1 M1</p> <p>A1 [5]</p>	<p>Sensible attempt at $P(A)$ Sensible attempt at $P(B)$</p> <p>correct $P(A \cap B)$ Cf $P(A \cap B)$ with $P(A) \times P(B)$ need at least 1 correct Correct conclusion following all correct working</p>
<p>(ii)</p>	<p>Not mutually exclusive because $P(A \cap B) \neq 0$ Or give counter example e.g. 1 and 6</p>	<p>B1* [1]</p>	<p>ft their $P(A \cap B)$</p>

Question 22

<p>(i)</p>	$P(S) = \frac{3}{16}$ $P(T) = \frac{4}{16}$ $P(S \cap T) = \frac{2}{16}$ $P(S) \times P(T) = \frac{3}{64} \neq \frac{2}{16}$ <p>Not independent</p>	<p>M1</p> <p>M1</p> <p>B1</p> <p>M1</p> <p>A1 5</p>	<p>Sensible attempt at $P(S)$ Sensible attempt at $P(T)$</p> <p>Correct $P(S \cap T)$ comp $P(S) \times P(T)$ with $P(S \cap T)$ (their values), evaluated Correct conclusion following all correct working</p>
<p>(ii)</p>	<p>not exclusive since $P(S \cap T) \neq 0$ Or counter example e.g. 1 and 3 Or $P(S \cup T) \neq P(S) + P(T)$ with values</p>	<p>B1* 1</p>	<p>FT their $P(S \cap T)$, not obtained from $P(S) \times P(T)$, with value and statement.</p>

Question 23

(i)	$P(X) = \frac{20}{28} \left(\frac{5}{7} \right) (0.714), 71.4\%$	B1	1	oe
(ii)	$P(F) = \frac{20}{28} \times \frac{1}{4} \times \frac{8}{28} \times \frac{6}{10} = \frac{7}{20}$	M1		Summing two 2-factor probs created by One of $\frac{1}{4}$ or $\frac{3}{4}$ multiplied by $\frac{20}{28}$ or $\frac{8}{28}$
		A1	2	Added to $\frac{4}{10}$ or $\frac{6}{10} \times$ altn population prob Correct answer
(iii)	$P(X F) = \frac{5/28}{7/20} = \frac{25}{49} (0.510)$	M1		Their unsimplified country X probability ($\frac{5}{28}$) as num or denom of a fraction Or (their fair hair population) \div (total fair hair pop)
		A1	2	Correct answer

Question 24

(i)	$\frac{1}{4}$	B1	1	
(ii)	$\left(\frac{3}{4} \right)^4 \left(\frac{1}{4} \right) = \frac{81}{1024} = 0.0791$	M1		Expression of form $p^k(1-p)$ only, $p = 1/4$ or $3/4$
		A1	2	Correct answer
(iii)	$P(\text{all diff}) = \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times 4!$ $= \frac{3}{32} (0.0938)$	M1		4! on numerator seen mult by $k \geq 1$ or $3 \times 2 \times 1$ on num oe, must be in a fraction.
	OR $1 \times \frac{3}{4} \times \frac{2}{4} \times \frac{1}{4} = \frac{3}{32}$	M1		4^4 on denom or 4^3 on denom with the $3 \times 2 \times 1$
		A1	3	Correct answer

Question 25

(i)	$P(\text{Abroad given camping})$ $= \frac{P(A \cap C)}{P(A \cap C) + P(H \cap C)}$ $= \frac{0.35 \times 0.15}{0.35 \times 0.15 + 0.65 \times 0.4}$ $= \frac{0.0525}{0.3125}$ $= 0.168$	M1		Attempt at $P(A \cap C)$ seen alone anywhere
		A1		Correct answer seen as num or denom of a fraction
		M1		Attempt at $P(C)$ seen anywhere
		A1		Correct unsimplified answer seen as num or denom of a fraction
		A1	5	Correct answer
(ii)	$(0.65)^n < 0.002$ $n > \lg(0.002) / \lg(0.65)$ $n = 15$	M1		Eqn with 0.65 or 0.35, power n , 0.002 or 0.998
		M1		Attempt to solve their eqn by logs or trial and error need a power
		A1	3	Correct answer

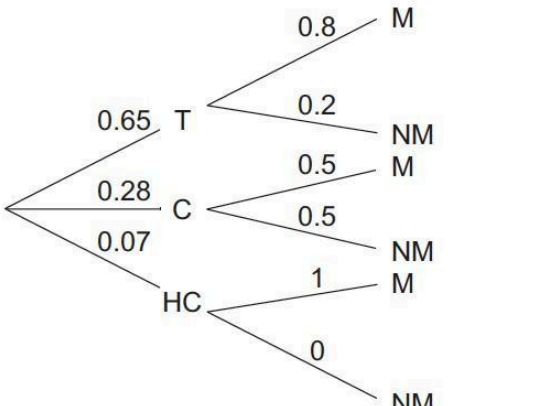
Question 26

(i)	$P(R) [(1, 4), (2, 5), (3, 6), (4, 7), (5, 8)] \times 2/64$ $= 10/64$	M1 A1	List of at least 4 different options or possibility space diagram Correct answer
(ii)	$P(S) = [(3, 8)(3, 7)(4, 8)(4, 7)(4, 6)(4, 5)(5, 8)(5, 7)(5, 6)(6, 8)(6, 7)(7, 8)] \times 2 + (5, 5)(6, 6)(7, 7)(8, 8)$ $= 28/64$	M1 A1	List of at least 14 different options or ticks Correct answer
(iii)	$P(R \cap S) = 4/64$ $4/64 \neq 10/64 \times 28/64$ Events are not independent	B1 M1 A1	Comparing their $P(R \cap S)$ with (i) \times (ii) with values Correct answer

Question 27

(i)	<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th></th> <th>Wears specs</th> <th>Not wears specs</th> <th>Total</th> </tr> </thead> <tbody> <tr> <th>RH</th> <td style="text-align: center;">6</td> <td style="text-align: center;">19</td> <td style="text-align: center;">25</td> </tr> <tr> <th>Not RH</th> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> <td style="text-align: center;">5</td> </tr> <tr> <th>Total</th> <td style="text-align: center;">8</td> <td style="text-align: center;">22</td> <td></td> </tr> </tbody> </table>		Wears specs	Not wears specs	Total	RH	6	19	25	Not RH	2	3	5	Total	8	22		B1 B1	One correct row or col including total other than the Total row/column All correct
	Wears specs	Not wears specs	Total																
RH	6	19	25																
Not RH	2	3	5																
Total	8	22																	
(ii)	$P(X) = 25/30, P(Y) = 8/30$ $P(X) \times P(Y) = 25/30 \times 8/30 = 200/900 = 2/9$ $P(X \cap Y) = 6/30 = 1/5 \neq P(X) \times P(Y)$ Not independent	M1 M1 A1	P(X) or P(Y) from their table or correct from question (denom 30) oe Comparing their $P(X) \times P(Y)$ (values substituted) with their evaluated $P(X \cap Y)$ – not $P(X) \times P(Y)$																

Question 28

(i)		<p>M1</p> <p>A1 [2]</p>	<p>Correct shape with either one branch after HC or 2 branches with 0 prob seen correct Labelled and clear annotation</p> <p>All probs correct</p>
(ii)	$P(C \mid \text{milk}) = \frac{P(\text{coffee} \cap \text{milk})}{P(\text{milk})}$ $= \frac{0.28 \times 0.5}{0.65 \times 0.8 + 0.28 \times 0.5 + 0.07 \times 1}$ $= \frac{0.14}{0.73}$ $= 0.192$	<p>M1</p> <p>M1</p> <p>A1 [3]</p>	<p>Attempt at $P(\text{coffee} \cap \text{milk})$ as a two-factor prod only seen as num or denom of a fraction</p> <p>Summing appropriate three 2-factor products seen anywhere (can omit the 1)</p> <p>Correct answer oe</p>

Question 29

(i)	$P(\text{cup of coffee}) = 0.6 \times 0.9 + 0.4 \times 0.3$ $= 0.66$	<p>M1</p> <p>A1 [2]</p>	<p>Summing two 2-factor probabilities Correct answer accept 0.660</p>
(ii)	$P(\text{Not on time} \mid \text{no cup of coffee})$ $= \frac{P(\text{not on time} \cap \text{no cup})}{P(\text{no cup})} = \frac{0.4 \times 0.7}{1 - 0.66}$ $= \frac{0.28}{0.34} = 0.824$	<p>M1</p> <p>M1</p> <p>A1 [3]</p>	<p>0.4×0.7 seen as num or denom of a fraction</p> <p>Attempt at $P(\text{no cup})$ as $0.1 \times p_1 + 0.7 \times p_2$ or as $1 - (i)$ seen anywhere</p>

Question 30

(i)	64/250, 0.256	B1	[1]	oe
(ii)	190/250, 0.76(0)	B1	[1]	oe

(iii)	$P(X) = 80/250 = 8/25$	M1	attempt at P(X)
	$P(Y) = 100/250 = 2/5$	M1	attempt at P(Y)
	$P(X \cap Y) = 32/250 = 16/125$	B1	oe
	$P(X) \times P(Y) = \frac{8}{25} \times \frac{2}{5} = \frac{16}{125}$	M1	comparing $P(X) \times P(Y)$ and $P(X \cap Y)$ so long as independence has not been assumed
	Since $P(X) \times P(Y) = P(X \cap Y)$ therefore independent	A1	[5] correct answer with all working correct

Question 31

$P(C \text{ given } L) = \frac{P(C \cap L)}{P(L)}$ $= \frac{0.65 \times 0.1}{0.65 \times 0.1 + 0.3 \times 0.15 + 0.05 \times 0.6}$ $= \frac{0.065}{0.14}$ $= 0.464, \frac{13}{28}$	M1	$P(C \cap L)$ seen as num or denom of a fraction
	A1	Correct unsimplified $P(C \cap L)$ as numerator
	M1	Summing three 2-factor products seen anywhere
	A1	0.14 (unsimplified) seen as num or denom of a fraction
	A1	[5] oe

Question 32

(i)	$P(B, B) = 1/4 \times 2/5$	M1	Multiplying two different probs
	$= 1/10$	A1	[2]
(ii)	$P(X=1) = P(R,R) + P(B,B)$	M1	Finding $P(R, R)$ (=3/5)
	$= 3/4 \times 4/5 + 1/10$	M1	Summing two options
	$= 14/20$ (7/10)	A1	[3]
(iii)	$P(B B)$	M1	their (i) seen as num or denom of a fraction
	$= \frac{P(B \cap B)}{P(B)} = \frac{1/10}{3/4 \times 1/5 + 1/4 \times 2/5}$	M1	$\frac{3}{4} \times p_1 + \frac{1}{4} \times p_2$ seen anywhere
		A1	1/4 (unsimplified) seen as num or denom of a fraction, www
	$= 2/5$	A1	[4]

Question 33

5(i)	$P(2) = P(0,2) = 2/10 \times 4/6$					M1	Mult 2 probs seen (or complete listing of all options)												
	$= 2/15$					AG	A1 Correct answer legit obtained												
	Total:						2												
5(ii)	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td>x</td> <td>0</td> <td>1</td> <td>2</td> <td>3</td> <td>5</td> </tr> <tr> <td>$P(X=x)$</td> <td>2/30</td> <td>5/30</td> <td>4/30</td> <td>13/30</td> <td>6/30</td> </tr> </table>					x	0	1	2	3	5	$P(X=x)$	2/30	5/30	4/30	13/30	6/30	B1	Correct values for x in table. Any additional values must have $P(x)=0$ stated
	x	0	1	2	3	5													
	$P(X=x)$	2/30	5/30	4/30	13/30	6/30													
						B1	One correct prob other than $P(2)$ or $P(3)$												
						B1	Correct $P(3)$												
					B1	All correct													
Total:						4													
(iii)	$P(A1 \text{Sum } 3) = \frac{P(A1 \cap \text{Sum } 3)}{P(\text{Sum } 3)} = \frac{5/10 \times 4/6}{13/30}$					M1	Attempt at $P(A1 \cap \text{Sum } 3)$ as num or denom of a fraction, can be by counting												
						M1	Their $P(3)$ from (ii) as num or denom of a fraction												
	$= 10/13(0.769)$					A1													
	Total:						3												

Question 34

$\frac{{}^{12}C_3 \times {}^{28}C_4}{{}^{40}C_7}$		M1	Using combinations with attempt to evaluate 2 terms in num. and 1 in denom.
		M1	Correct numerator or denominator unsimplified
$= 0.242$		A1	
OR			
$P(\text{GGG}) = \frac{12}{40} \times \frac{11}{39} \times \frac{10}{38} \times \frac{28}{37} \times \frac{27}{36} \times \frac{26}{35} \times \frac{25}{34} \times {}^7C_3$		M1	Multiplying 3 green probs with 4 non-green probs, without replacement
		M1	Multiplying by 7C_3
$= 0.242$		A1	
Total:			3

Question 35

(i)	$P(S) = 0.65 \times 0.6 + 0.35 \times 0.75$		M1	Summing two 2-factor probs or $1 - (\text{sum of two 2-factor probs})$
	$= 0.653 (261/400)$		A1	
	Total:			2
(ii)	$P(\text{Std} L) = \frac{P(\text{Std} \cap L)}{P(L)} = \frac{0.35 \times 0.25}{1 - 0.6525} = 0.0875/0.3475$		M1	'P(Std)' \times 'P(L/Std)' as num of a fraction. Could be from tree diagram in 3(i).
			M1	Denominator (1 - their (i)) or their (i) or $0.65 \times 0.4(\text{or } 0.6) + 0.35 \times 0.25(\text{or } 0.75) = 0.26 + 0.0875$ or $P(L)$ from their tree diagram
	$= 0.252 (35/139)$		A1	
Total:			3	

Question 36

$P(6) = 0.3$	B1	SOI
$P(\text{sum is } 9) = P(3, 6) + P(4, 5) + P(5, 4) + P(6, 3)$	M1	Identifying the four ways of summing to 9 (3,6), (6,3) (4,5) and (5,4)
$= (0.03 + 0.02) \times 2$	M1	Mult 2 probs together to find one correct prob of (3,6), (6,3) (4,5) or (5,4) unsimplified
$= 0.1$	A1	OE
Total:	4	

Question 37

(i)	$P(H) = P(BH) + P(SH) = 0.6 \times 0.05 + 0.4 \times 0.75$	M1	Summing two 2-factor probs using 0.6 with 0.05 or 0.95, and 0.4 with 0.75 or 0.25
	$= 0.330$ or $\frac{33}{100}$	A1	Correct final answer accept 0.33
	Total:	2	
(ii)	$P(S H) = \frac{P(S \cap H)}{P(H)} = \frac{0.4 \times 0.75}{0.33} = \frac{0.3}{0.33}$	M1 FT	Their $\frac{P(S \cap H)}{P(H)}$ unsimplified, FT from (i)
	$= \frac{10}{11}$ or 0.909	A1	
	Total:	2	
(iii)	$\text{Var}(B) = 45 \times 0.6 \times 0.4$ $\text{Var}(S) = 45 \times 0.4 \times 0.6$	B1	One variance stated unsimplified
	Variances same	B1	Second variance stated unsimplified and at least one variance clearly identified, and both evaluated <i>or</i> showing equal <i>or</i> conclusion made SR B1 – Standard Deviation calculated Fulfil all the criteria for the variance method but calculated to Standard Deviation
	Total:	2	
(iv)	$1 - P(0, 1)$ $= 1 - [(0.6)^{10} + {}^{10}C_1(0.4)(0.6)^9] = 1 - 0.0464$ OR $P(2, 3, 4, 5, 6, 7, 8, 9, 10)$ $= {}^{10}C_2(0.4)^2(0.6)^8 + \dots + {}^{10}C_9(0.4)^9(0.6) + (0.4)^{10}$	M1 M1	Bin term ${}^{10}C_x p^x (1-p)^{10-x}$ $0 < p < 1$ Correct unsimplified answer
	$= 0.954$	A1	
	Total:	3	

Question 38

$P(\text{score is } 6) = P(3, 3)$	M1	Realising that score 6 is only P(3, 3)
$= r^2 = 1/36$ $r = 1/6$	A1	Correct ans [SR B2 $r = 1/6$ without workings]
$P(2, 3) + P(3, 2) = 1/9$ $qr + rq = 1/9$	M1	Eqn involving qr (OE) equated to $1/9$ (r may be replaced by <i>their</i> 'r value')
$q/6 + q/6 = 1/9$	M1	Correct equation with <i>their</i> 'r value' substituted
$q = 1/3$	A1	Correct answer seen, does not imply previous M's
$p = 1 - 1/6 - 1/3 = 1/2$	B1 FT	FT their p + their r + their $q = 1$, $0 < p < 1$
Total:	6	

Question 39

(i)	$4 \times 5.5 + 3x + 90 = 8 \times 29$	M1	An expression to work out total cost of individual items = $8 \times$ mean, x may be implied.
	$112 + 3x = 232$ $x = 40$	A1	Correct complete unsimplified expression / calculation
	(Cost = \$)40	A1	Units not required
	Total:	3	
(ii)	sd = 0 so all cost the same	M1	Must see comment interpreting sd = 0, OE
	shirts cost $4 \times \$26 = \104 AG	A1	See $4 \times \$26$, $\$130 - \26 OE. Must have a final value of \$104 stated
	Total:	2	

Question 40

(i)		M1	Correct shape i.e. 3 branches then 3 by 3 branches, labelled and clear annotation Condone omission of lines for first match result providing the probabilities are there.
	Total:	2	A1 All correct probs with fully correct shape and probs either fractions or decimals not 1.5/5 etc.
(ii)	$P(L_1 \text{ given } W_2) = \frac{P(L_1 \cap W_2)}{P(W_2)}$	M1	Attempt at $P(L_1 \cap W_2)$ as a two-factor prod only as num or denom of a fraction
	$= \frac{1/5 \times 3/10}{3/5 \times 7/10 + 1/5 \times 1/3 + 1/5 \times 3/10}$	M1	Attempt at $P(W_2)$ as sum of appropriate 3 two-factor probs OE seen anywhere
		A1	Unsimplified correct $P(W_2)$ num or denom of a fraction
	$= \frac{3/50}{41/75} = 9/82 (0.110)$	A1	
Total:	4		

Question 41

$P(R) = 4/36 = 1/9$	M1	Attempt at $P(R)$ by probability space diag or listing more than half the options, must see a prob, just a list is not enough
$P(T) = P(O, E) + P(E, O) = 1/4 + 1/4 = 1/2$ OR $P(R T) = 1/9$	M1	Attempt at $P(T)$ or $P(R T)$ involving more than half the options
$P(R \cap T) = P(3, 4) + P(4, 3) = 2/36 = 1/18$ OR $P(R T) = 1/9$	B1	Value stated, not from $P(R) \times P(T)$ e.g. from probability space diagram
As $P(R) \times P(T) = P(R \cap T)$ OR as $P(R T) = P(R)$	M1	Comparing product values with $P(R \cap T)$, or comparing $P(R T)$ with $P(R)$
The events are independent.	A1	Correct conclusion must have all probs correct
Total:		5

Question 42

(i)		M1	Correct shape
		A1	All correct labels and probabilities
(ii)	$P(F P) = \frac{P(F \cap P)}{P(P)}$ $= \frac{0.15 \times 0.65}{0.85 + 0.15 \times 0.65} \text{ or } \frac{0.15 \times 0.65}{1 - 0.15 \times 0.35}$ $= \frac{0.0975}{0.9475}$ $= \frac{39}{379} = 0.103$	2	
		M1	$P(P)$ consistent with their tree diagram seen anywhere
		A1	Correct unsimplified $P(P)$ seen as num or denom of a fraction
		M1	$P(F \cap P)$ found as correct product or consistent with their tree diagram seen as num or denom of a fraction
		A1	
		4	

Question 43

(i)	$P(4, 2H) = \frac{1}{4} \times {}^4C_2 \times \left(\frac{1}{3}\right)^2 \left(\frac{2}{3}\right)^2$	M1	Multiplying their 2H expression by $\frac{1}{4}$ [P(4)]
		M1	Remaining factor is $\left(\frac{1}{3}\right)^2 \left(\frac{2}{3}\right)^2$ [or $\frac{4}{81}$] multiplied by integer value $k \geq 1$ OE
	$= \frac{2}{27}$ (0.0741)	A1	
		3	
(ii)	$P(3, 3H) = \frac{1}{4} \times \left(\frac{1}{3}\right)^3 = \frac{1}{108}$ (0.00926)	B1	
		1	
(iii)	$P(1, 1H) = \frac{1}{4} \times \frac{1}{3} = \frac{1}{12}$ (0.08333)	M1	Correct expression for 1 of P(1, 1H), P(2, 2H), P(4, 4H) Unsimplified (or better)
	$P(2, 2H) = \frac{1}{4} \times \left(\frac{1}{3}\right)^2 = \frac{1}{36}$ (0.02778)	M1	Summing their values for 3 or 4 appropriate outcomes for the 'game' with no additional outcomes.
	$P(3, 3H) = \frac{1}{4} \times \left(\frac{1}{3}\right)^3 = \frac{1}{108}$ (0.009259)		
	$P(4, 4H) = \frac{1}{4} \times \left(\frac{1}{3}\right)^4 = \frac{1}{324}$ (0.003086)		
	Prob = $\frac{10}{81}$ (0.123)	A1	
		3	

Question 44

(i)		B1	Must see at least 4 probs correct including one with an x in, correct shape
		B1	Shape, clear labels/annotation and all probs correct
		2	
(ii)	$0.82x + 0.18 \times 0.9 = 0.285$	M1	Eqn with x in, two 2-factors on one side
	$x = 0.15$	A1	
		2	
(iii)	$P(E \text{notGNS}) = \frac{P(E \cap \text{notGNS})}{P(\text{notGNS})}$	M1	Attempt at $P(E \cap \text{notGNS})$ seen as num or denom of fraction
		M1	Attempt at $P(\text{notGNS})$ seen anywhere
	$= \frac{0.82 \times 0.85}{1 - 0.285} = 0.975$	A1	Correct answer
		3	

Question 45

3(i)	(10/160 =) 1/16, 0.0625	B1	OE
		1	
(ii)	(90/160) = 9/16, 0.5625	B1	OE
		1	
(iii)	$P(\text{red/hatchback}) = P(\text{red hatchback}) / P(\text{hatchback})$ $= 40/160 / 90/160$	M1	Appropriate probabilities in a fraction
	$= 4/9$	A1	OE
			<i>Alt method: Direct from table</i> <i>M1 for 40/a or b/90, a ≠ 160</i> <i>A1 for 40/90 oe</i>
		2	
3(iv)	<i>EITHER:</i> $P(\text{red}) \times P(\text{hatchback}) = \frac{72}{160} \times \frac{90}{160} \neq \frac{40}{160}$	(M1)	Use correct approach with appropriate probabilities substituted
	Not independent	A1)	Numerical comparison and conclusion stated
	<i>OR:</i> $P(\text{red/hatchback}) = 40/90$ and $\frac{40}{90} \neq \frac{72}{160}$	(M1)	Use correct approach with appropriate probabilities substituted
	Not independent	A1)	Numerical comparison and conclusion stated
		2	

Question 46

(i)	(1-x) and 0.45 (or 0.3)	B1	Seen, either on tree diagram or elsewhere
	Beginners: $0.7 \times x + '0.45' \times '(1-x)' = 0.5$ Or Advanced: $'0.3' \times x + 0.55 \times '(1-x)' = 0.5$ Or $0.7 \times x + '0.45' \times '(1-x)' = '0.3' \times x + 0.55 \times '(1-x)'$	M1	One of the three correct probability equations
	$x = 0.2$ oe	A1	Correct answer
	Total:	3	
(ii)	$P(M A) = \frac{P(M \cap A)}{P(A)} = \frac{0.2 \times 0.3}{0.5}$	M1	'i' × 0.3 as num or denom of a fraction
	$= 0.12 \left(\frac{3}{25} \right)$	A1	Correct answer
	Total:	3	

Question 47

(i)	Method 1 $P(M \cap H) = \frac{3}{4} \times \frac{3}{5} = \frac{9}{20}$ (0.45)	B1	Seen, accept unsimplified	
	$P(F \text{ or } M \cap H) = \frac{1}{4} + \frac{9}{20} = \frac{14}{20}$	M1	Numerical attempt at $P(F) + P(M \cap H)$	
	$= \frac{7}{10}$ (0.7) OE	A1	Correct unsimplified expression	
	Method 2 $P(M \cap H) = \frac{3}{4} \times \frac{2}{5} = \frac{6}{20}$ (0.3)	B1	Correct final answer	
	$P(F \text{ or } M \cap H) = 1 - P(M \cap H)$	M1	Seen, accept unsimplified	
	$= 1 - \frac{3}{4} \times \frac{2}{5}$	M1	Numerical attempt at $1 - P(M \cap H)$	
	$= \frac{7}{10}$ (0.7) OE	A1	Correct unsimplified expression	
(ii)	Method 1 $(P(M) \times P(H)) = \frac{3}{4} \times \text{their } \frac{13}{20} = \frac{39}{80}$ $(P(M \cap H)) = \frac{3}{4} \times \frac{3}{5} = 0.45$	M1	Unsimplified, or better, legitimate numerical attempt at $P(M) \times P(H)$ and $P(M \cap H)$ Descriptors $P(M \cap H)$ and $P(M) \times P(H)$ seen, correct numerical evaluation and comparison, conclusion stated	
	$\frac{39}{80}$ (0.4875) \neq 0.45, not independent	A1		
	Method 2 $P(M H) = \frac{P(M \cap H)}{P(H)} = \frac{\frac{9}{20}}{\text{their } \frac{13}{20}} = \frac{9}{13}$ $P(M) = \frac{3}{4}$	M1	Unsimplified, or better, numerical attempt at $P(H)$ and $P(M \cap H)$, $P(M)$	
	$\frac{9}{13} \neq \frac{3}{4}$, not independent	A1	Descriptors $P(M \cap H)$, $P(H)$ and $P(M)$ OR $P(M H)$ and $P(M)$ seen, numerical evaluation and comparison, conclusion stated Any appropriate relationship can be used, the M is awarded for an unsimplified, or better, numerical attempt at the terms required, the A mark requires the correct descriptors, numerical evaluation and comparison and the conclusion	
			2	

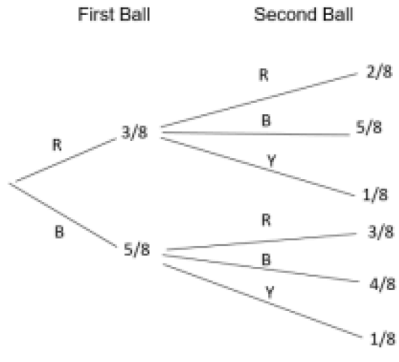
Question 48

(i)	$P(\text{SLL}) = (0.3)(0.55)(0.55) = 0.09075 \left(\frac{363}{4000}\right)$	M1	P(SLL), P(SRR), P(SSL) or P(SSR) seen
	$P(\text{SRR}) = (0.3)(0.15)(0.15) = 0.00675 \left(\frac{27}{4000}\right)$	A1	Two correct options 0.09075 or 0.00675 can be unsimplified
	Total = ${}^3C_1 \times P(\text{SLL}) + {}^3C_1 \times P(\text{SRR})$ = $0.27225 + 0.02025$	M1	Summing 6 prob options not all identical
	Prob = 0.293 accept 0.2925 $\left(\frac{117}{400}\right)$	A1	Correct answer
		4	
(ii)	$P(\text{SSS} \mid \text{all same dir}^n) = \frac{P(\text{SSS and same dir}^n)}{P(\text{same direction})}$	B1	$(0.3)^3$ oe seen on its own as num or denom of a fraction
		M1	Attempt at $P(\text{SSS} + \text{LLL} + \text{RRR})$ seen anywhere
	$= \frac{0.3 \times 0.3 \times 0.3}{(0.15)^3 + (0.55)^3 + (0.3)^3}$	A1	$(0.15)^3 + (0.55)^3 + (0.3)^3$ oe seen as denom of a fraction
	$= 0.137 \left(\frac{108}{787}\right)$	A1	Correct answer
		4	

Question 49

(i)	$P(\text{RB}) + P(\text{BR}) = \frac{4}{12} \times \frac{8}{11} + \frac{8}{12} \times \frac{4}{11}$ oe	M1	Multiply 2 probs together and summing two 2-factor probs, unsimplified, condone replacement								
	$P(\text{diff colours}) = \frac{64}{132} \left(\frac{16}{33}\right)$ (0.485) oe	A1	Correct answer								
	Method 2 $1 - P(\text{BB}) - P(\text{RR}) = 1 - \frac{4}{12} \times \frac{3}{11} - \frac{8}{12} \times \frac{7}{11}$	M1	Multiply 2 probs together and subtracting two 2-factor probs from 1, unsimplified, condone replacement								
	$P(\text{diff colours}) = \frac{64}{132} \left(\frac{16}{33}\right)$ oe	A1	Correct answer								
	Method 3 $P(\text{diff colours}) = \frac{{}^4C_1 \times {}^8C_1}{{}^{12}C_2}$	M1	Multiply 2 combs together and dividing by a combination								
	$= \frac{16}{33}$	A1	Correct answer								
		2									
(ii)	<table border="1" style="display: inline-table; vertical-align: middle;"> <thead> <tr> <th>Number of red socks</th> <th>0</th> <th>1</th> <th>2</th> </tr> </thead> <tbody> <tr> <td>Prob</td> <td>$\frac{14}{33}$</td> <td>$\frac{16}{33}$</td> <td>$\frac{3}{33}$</td> </tr> </tbody> </table>	Number of red socks	0	1	2	Prob	$\frac{14}{33}$	$\frac{16}{33}$	$\frac{3}{33}$	B1	Prob distribution table drawn, top row correct, condone additional values with $p = 0$ stated
Number of red socks	0	1	2								
Prob	$\frac{14}{33}$	$\frac{16}{33}$	$\frac{3}{33}$								
		B1	$P(0)$ or $P(2)$ correct to 3sf (need not be in table)								
		B1	All probs correct to 3sf, condone $P(0)$ and $P(2)$ swapped if correct								
		3									
(iii)	$E(X) = 1 \times \frac{16}{33} + 2 \times \frac{3}{33} = \frac{16}{33} + \frac{6}{33} = \frac{22}{33} \left(\frac{2}{3}\right)$	B1ft	fit their table if 0, 1, 2 only, $0 < p < 1$								
		1									

Question 50

(i)		B1 Fully correct labelled tree and correct probabilities for 'First Ball'
		B1 Correct probabilities (with corresponding labels) for 'Second Ball'
		2
(ii)	$P(RR) + P(BB) = 3/8 \times 2/8 + 5/8 \times 4/8 = 3/32 + 5/16$	M1 Correct unsimplified expression from their tree diagram, $\Sigma p = 1$ on each branch
	$= 13/32 \text{ (0.406)}$	A1 Correct answer
		2
(iii)	$P(RB) = 3/8 \times 5/8 = 15/64$	M1 $P(\text{1st ball red}) \times P(\text{2nd ball blue})$ from their tree diagram seen unsimplified as numerator or denominator of a fraction Allow $\Sigma p \neq 1$ on each branch
	$P(B) = 3/8 \times 5/8 + 5/8 \times 4/8 = 35/64$	M1 Correct unsimplified expression for $P(B)$ from their tree diagram seen as denominator of a fraction. Allow $\Sigma p \neq 1$ on each branch
	$P(R B) = P(RB) / P(B) = (15/64) \div (35/64) = 3/7 \text{ (0.429)}$	A1 Correct answer
		3

Question 51

$P(SS) = \frac{4}{11} \times \frac{3}{10} = \frac{12}{110} \text{ (= 0.10911)}$	B1 One of $P(SS)$, $P(PP)$ or $P(II)$ correct, allow unsimplified
$P(PP) = \frac{2}{11} \times \frac{1}{10} = \frac{2}{110} \text{ (= 0.01818)}$ $P(II) = \frac{4}{11} \times \frac{3}{10} = \frac{12}{110} \text{ (= 0.10911)} \frac{4}{11} \times \frac{3}{10}$	M1 Sum of probabilities from 3 appropriate identifiable scenarios (either by labelling or of form $\frac{4}{11} \times \frac{a}{b} + \frac{2}{11} \times \frac{c}{b} + \frac{4}{11} \times \frac{a}{b}$ where $a = 4 \text{ or } 3$, $b = 11 \text{ or } 10$, $c = 2 \text{ or } 1$)
$\text{Total} = \frac{26}{110} = \frac{13}{55} \text{ oe (0.236)}$	A1 Correct final answer

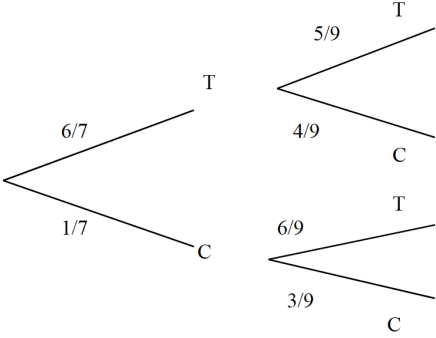
Question 54

(i)		B1	Fully correct labelled tree with correct probabilities for 'Send'
		B1	Fully correct labelled branches with correct probabilities for the 'reply'
		2	
(ii)	$P(\text{email} \text{NR}) = \frac{P(\text{email} \cap \text{NR})}{P(\text{NR})} = \frac{0.2 \times 0.85}{0.3 \times 0.6 + 0.2 \times 0.85 + 0.5 \times 0.4}$	M1	P(email) × P(NR) seen as numerator of a fraction, consistent with <i>their</i> tree diagram
	$= \frac{0.17}{0.18 + 0.17 + 0.2} = \frac{0.17}{0.55}$	M1	Summing three appropriate 2-factor probabilities, consistent with <i>their</i> tree diagram, seen anywhere 0.55 oe (can be unsimplified) seen as denom of a fraction
	$= 0.309, \frac{17}{55}$	A1	
		A1	Correct answer
		4	

Question 55

$P(S) = \frac{1}{2}$	B1	
$P(T) = \frac{16}{36} \left(\frac{4}{9} \right)$	B1	
$P(S \cap T) = \frac{10}{36} \left(\frac{5}{18} \right)$	M1	P(S ∩ T) found by multiplication scores M0 M1 awarded if <i>their</i> value is identifiable in their sample space diagram or Venn diagram or list of terms or probability distribution table (oe)
$P(S T) = \frac{10}{16}$ or $P(T S) = \frac{10}{18}$ $P(S T) \neq P(S)$ or $P(T S) \neq P(T)$ so not independent	A1	Either 18/36, 10/16, P(S) and P(S T) seen in workings and correct conclusion stated, www Or 16/36, 10/18, P(T) and P(T S) seen in workings and correct conclusion stated, www
	4	

Question 56

(i)		<p>B1 First pair of branches labels and probs correct (6/7 and 1/7 or rounding to 0.857 and 0.143) (Labelling must be logically... e.g. (T and T) or (T and Not T) would be acceptable)</p> <p>B1 Either of second top pair or bottom of branches labels and probs correct</p> <p>B1 Both second pairs of branches labels and probs correct. No additional / further branches.</p>								
3										
(ii)	<table border="1" style="width: 100%; text-align: center;"> <tr> <td>No of toffees taken (T)</td> <td>0</td> <td>1</td> <td>2</td> </tr> <tr> <td>prob</td> <td>$\frac{3}{63}$, 0.0476(2)</td> <td>$\frac{30}{63}$, 0.476(2)</td> <td>$\frac{30}{63}$, 0.476(2)</td> </tr> </table>	No of toffees taken (T)	0	1	2	prob	$\frac{3}{63}$, 0.0476(2)	$\frac{30}{63}$, 0.476(2)	$\frac{30}{63}$, 0.476(2)	<p>B1 P(1) correct</p> <p>B1 P(0) or P(2) correct</p> <p>B1 FT Correct values in table, any additional values of T have stated probability of zero. For FT $\Sigma p = 1$,</p>
No of toffees taken (T)	0	1	2							
prob	$\frac{3}{63}$, 0.0476(2)	$\frac{30}{63}$, 0.476(2)	$\frac{30}{63}$, 0.476(2)							
3										
(iii)	$E(X) = \frac{90}{63} \left(\frac{10}{7}\right) (1.43)$	<p>B1 Not FT</p>								
1										
(iv)	$P(1^{st} C 2^{nd} T) = \frac{P(C \cap T)}{P(T)} = \frac{\frac{1}{7} \times \frac{6}{9}}{\frac{1}{7} \times \frac{6}{9} + \frac{6}{7} \times \frac{5}{9}} = \frac{6}{36}$	<p>B1 $P(C \cap T)$ attempt seen as numerator of a fraction, consistent with <i>their</i> tree diagram or correct</p> <p>M1 Summing 2 appropriate two-factor probabilities, consistent with <i>their</i> tree diagram or correct seen anywhere</p> <p>A1 $\frac{36}{63}$ oe or correct unsimplified expression seen as numerator or denominator of a fraction</p>								
	$\frac{1}{6}$ oe	<p>A1 Final answer</p>								
4										

Question 57

Jameel: $P(\text{plum}) = \frac{5}{8}$, Rosa: $P(\text{plum}) = \frac{x}{x+6}$	<p>M1 <i>Their</i> 2 probabilities for P(plum) multiplied and equated to 1/4</p>	
$\frac{5}{8} \times \frac{x}{x+6} = \frac{1}{4}$	<p>A1 Correct equation oe</p>	
(x =) 4	<p>A1 SC correct answer with no appropriate equations i.e. common sense B1</p>	
3		

Question 58

$P(X) = \frac{3}{36} \left(\frac{1}{12} oe \right)$	B1	
$P(Y) = \frac{12}{36} \left(\frac{1}{3} oe \right)$	B1	
$P(X \cap Y) = \frac{1}{36}$	M1	Independent method to find $P(X \cap Y)$ without multiplication, either stated or by listing or circling numbers on a probability space diagram. OR conditional prob with a single fraction numerator
$P(X) \times P(Y) = P(X \cap Y)$, independent	A1	Numerical comparison and conclusion, www
	4	

Question 59

(i) $\frac{120}{300} = 0.4$	B1	OE
	1	
(ii) $P(\text{male}) \times P(\text{not piano}) = \frac{160}{300} \times \frac{225}{300} \left(\frac{8}{15} \times \frac{3}{4} \right) = \frac{2}{5}$	M1	$P(M) \times P(P')$ seen Can be unsimplified but the events must be named in a product
As $P(\text{male} \cap \text{not piano})$ also = $\frac{120}{300} = \frac{2}{5}$	A1	Numerical comparison and correct conclusion
The events are Independent		

Question 60

(i) $\frac{120}{300} = 0.4$	B1	OE
	1	
(ii) $P(\text{male}) \times P(\text{not piano}) = \frac{160}{300} \times \frac{225}{300} \left(\frac{8}{15} \times \frac{3}{4} \right) = \frac{2}{5}$	M1	$P(M) \times P(P')$ seen Can be unsimplified but the events must be named in a product
As $P(\text{male} \cap \text{not piano})$ also = $\frac{120}{300} = \frac{2}{5}$	A1	Numerical comparison and correct conclusion
The events are Independent		

Question 61

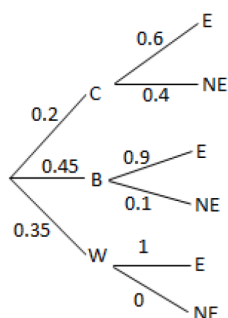
(i) $0.4x + 0.6 \times 2x = 0.36$ or $0.4(1-x) + 0.6(1-2x) = 0.64$	M1	$0.4a + (1-0.4)b = 0.36$ or 0.64 , a, b terms involving x
$1.6x = 0.36$ $x = 0.225$	A1	Fully justified by algebra AG
	2	
(ii) $P(H L) = \frac{0.4(1-x)}{1-0.36} = \frac{0.4 \times (1-0.225)}{0.64} = \frac{0.4 \times 0.775}{0.4 \times 0.775 + 0.6 \times 0.55}$	M1	Correct numerical numerator of a fraction. Allow unsimplified.
	M1	Denominator 0.36 or 0.64. Allow unsimplified.
$\frac{31}{64}$ or 0.484	A1	
	3	

Question 62

(a)	<p>Box A: Red $\frac{7}{8}$, Blue $\frac{1}{8}$</p> <p>Box B: Red $\frac{10}{15}$, Blue $\frac{5}{15}$ (from Red); Red $\frac{9}{15}$, Blue $\frac{6}{15}$ (from Blue)</p>	<p>B1 Both correct probs, box A</p> <p>B1 2 probs correct for box B</p> <p>B1 All correct probs for box B</p>
3		
(b)	$\frac{7}{8} \times \frac{5}{15} + \frac{1}{8} \times \frac{9}{15}$	<p>M1 Two 2 factor terms added, correct or FT <i>their 6(a)</i>.</p>
	$= \frac{44}{120} \left[\frac{11}{30} \text{ or } 0.367 \right]$	<p>A1 OE</p>
2		
(c)	$P(A \text{ blue} B \text{ blue}) = \frac{P(A \text{ blue} \cap B \text{ blue})}{P(B \text{ blue})}$ $= \frac{\frac{1}{8} \times \frac{6}{15}}{\frac{7}{8} \times \frac{5}{15} + \frac{1}{8} \times \frac{6}{15}} = \frac{\frac{1}{20}}{\frac{41}{120}}$	<p>M1 <i>their</i> $\frac{1}{8} \times \frac{6}{15}$ seen as numerator or denom of fraction</p> <p>M1 <i>their</i> $\frac{7}{8} \times \frac{5}{15} + \frac{1}{8} \times \frac{6}{15}$ seen</p> <p>M1 <i>their</i> $\frac{7}{8} \times \frac{5}{15} + \frac{1}{8} \times \frac{6}{15}$ seen as denominator</p>
	$= \frac{6}{41} \text{ or } 0.146$	<p>A1</p>
4		

Question 63

(a)



Fully correct labelled tree for method of transport with correct probabilities.

B1

Fully correct labelled branches with correct probabilities for lateness with either 1 branch after W or 2 branches with the probability 0.

B1

2

(b)

$$P(C|E) = \frac{P(C \cap E)}{P(E)} = \frac{0.2 \times 0.6}{0.2 \times 0.6 + 0.45 \times 0.1 + 0.35 \times 1}$$

M1

Summing three appropriate 2-factor probabilities

M1

$$\frac{0.12}{0.515}$$

A1

$$0.233 \text{ or } \frac{12}{515}$$

A1

4

Question 64

(a)

$$\frac{56}{500} \text{ or } \frac{14}{125} \text{ or } 0.112$$

B1

1

(b)

$$P(D|S) = \frac{P(D \cap S)}{P(S)} = \frac{120}{280}$$

M1

$$\frac{120}{280} \text{ or } \frac{3}{7}$$

A1

2

(c)

$$P(\text{hockey}) = \frac{220}{500} = 0.44$$

M1

$$P(\text{Amos or Benn}) = \frac{242}{500} = 0.484$$

$$P(\text{hockey} \cap \text{A or B}) = \frac{104}{500} = 0.208$$

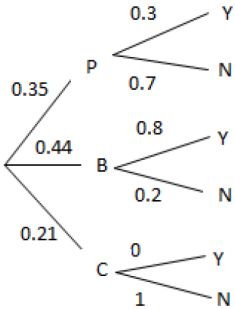
$P(H) \times P(A \cup B) = P(H \cap (A \cup B))$ if independent

$$\frac{220}{500} \times \frac{242}{500} = \frac{1331}{6250} \text{ so not independent}$$

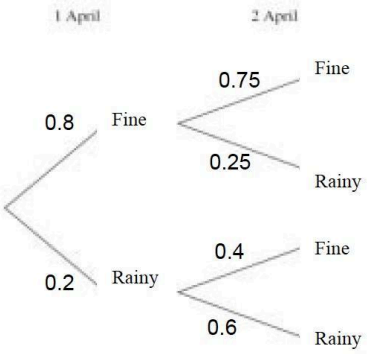
A1

2

Question 65

(a)	 <p>Fully correct labelled tree for method of transport with correct probabilities.</p>	B1
	Fully correct labelled branches with correct probabilities for lateness with either 1 branch after W or 2 branches with the prob 0	B1
		2
(b)	$0.35 \times 0.3 + 0.44 \times 0.8 (+ 0)$ 0.457	M1 A1
		2
(c)	$P(\text{not B} \text{not fruit}) = \frac{P(B' \cap F')}{P(F')}$ $\frac{0.35 \times 0.7 + 0.21 \times 1}{1 - \text{their (b)}}$ $\frac{0.455}{0.543}$ <p>(M1 for 1 - their (b) or summing three appropriate 2-factor probabilities, correct or consistent with their tree diagram as denominator)</p> $0.838 \text{ or } \frac{455}{543}$	M1 M1 M1 A1
		4

Question 66

(a)		<p>B1 All probabilities correct, may be on branch or next to 'Fine/Rainy' Ignore additional branches.</p>
		1

(b)	$0.8 \times 0.75 + 0.2 \times 0.4$ ($= 0.6 + 0.08$)	M1	Correct or FT from <i>their</i> diagram unsimplified, all probabilities $0 < p < 1$. Partial evaluation only sufficient when correct. Accept working in 4(b) or by the tree diagram.
	$0.68, \frac{17}{25}$	A1	From supporting working
		2	
(c)	$0.8 \times 0.75 \times 0.25 + 0.8 \times 0.25 \times 0.6$	M1	$a \times b \times c + a \times 1 - b \times d, 0 < c, d \leq 1$, a, b consistent with <i>their</i> tree diagram or correct, no additional terms
	$0.15 + 0.12$	A1	At least one term correct, accept unsimplified
	0.27	A1	Final answer
		3	
(d)	$P(Y) = \text{their (c)} + 0.2 \times 0.4 \times 0.25 + 0.2 \times 0.6 \times 0.6$ ($= 0.362$)	B1 FT	<i>their (c)</i> + $e \times f \times g + e \times (1-f) \times h, 0 < g, h \leq 1, e, f$ consistent with <i>their</i> tree diagram, or correct
	$P(X Y) = \frac{\text{their (c)}}{\text{their } P(Y)} = \frac{0.27}{0.362}$	M1	<i>their 4(c)</i> (or correct)/ <i>their</i> previously calculated and identified $P(Y)$ or a denominator involving 3 or 4 3-factor probability terms consistent with <i>their</i> tree diagram & third factor $0 < p < 1$
	$0.746, \frac{373}{500}$ or $\frac{135}{181}$	A1	(0.7458...)
		3	

Question 67

(a)	<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th colspan="2" rowspan="2"></th> <th colspan="6">Red</th> </tr> <tr> <th>1</th> <th>2</th> <th>3</th> <th>4</th> <th>5</th> <th>6</th> </tr> </thead> <tbody> <tr> <th rowspan="6" style="writing-mode: vertical-rl; transform: rotate(180deg);">Blue</th> <th>1</th> <td>2</td> <td>3</td> <td>4</td> <td>5</td> <td>6</td> <td>7</td> </tr> <tr> <th>2</th> <td>3</td> <td>4</td> <td>5</td> <td>6</td> <td>7</td> <td>8</td> </tr> <tr> <th>3</th> <td>4</td> <td>5</td> <td>6</td> <td>7</td> <td>8</td> <td>9</td> </tr> <tr> <th>4</th> <td>5</td> <td>6</td> <td>7</td> <td>8</td> <td>9</td> <td>10</td> </tr> <tr> <th>5</th> <td>6</td> <td>7</td> <td>8</td> <td>9</td> <td>10</td> <td>11</td> </tr> <tr> <th>6</th> <td>7</td> <td>8</td> <td>9</td> <td>10</td> <td>11</td> <td>12</td> </tr> </tbody> </table>			Red						1	2	3	4	5	6	Blue	1	2	3	4	5	6	7	2	3	4	5	6	7	8	3	4	5	6	7	8	9	4	5	6	7	8	9	10	5	6	7	8	9	10	11	6	7	8	9	10	11	12	M1	Complete outcome space or or listing A and B outcomes or listing $A \cap B$ outcomes
				Red																																																								
		1	2	3	4	5	6																																																					
Blue	1	2	3	4	5	6	7																																																					
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	6	7	8	9	10	11	12																																																					
	$P(A \cap B) = \frac{5}{36}$	A1	With evidence																																																									
		2																																																										
(b)	$P(A) \times P(B) = \frac{1}{3} \times \frac{10}{36}$	M1	<i>Their</i> $\frac{1}{3} \times \text{their } \frac{10}{36}$ seen																																																									
	$\frac{5}{54} \neq \frac{5}{36}$ so not independent	A1	$\frac{5}{54}, \frac{5}{36}, P(A) \times P(B)$ and $P(A \cap B)$ seen in workings and correct conclusion stated Condone $\frac{5}{36}$ being stated in (a)																																																									

Question 68

(a)(i)	$\left[\frac{104+31}{400} = \frac{135}{400}, \frac{27}{80}, 0.3375 \right]$	B1	Evaluated, exact value.
		1	
(a)(ii)	Method 1		
	$P(M) = \frac{180}{400}, 0.45$ $P(S) = \frac{135}{400}, 0.3375$ $P(M \cap S) = \frac{31}{400}, 0.0775$ $\frac{180}{400} \times \frac{135}{400} = \frac{243}{1600}, 0.151875 \neq \frac{31}{400}$ so NOT independent	M1	Their $P(M) \times$ their $P(S)$ seen, accept unsimplified.
		A1	$P(M)$, $P(S)$ and $P(M \cap S)$ notation seen, numerical comparison and correct conclusion, WWW.
	Method 2		
	$P(M \cap S) = \frac{31}{400}$ $P(S) = \frac{135}{400}$ $P(M) = \frac{180}{400}$ $P(M S) = \frac{\frac{31}{400}}{\frac{135}{400}} = \frac{31}{135}, 0.2296... \neq \frac{180}{400}$ so NOT independent	M1	$[P(M S) =] \frac{\text{their } P(M \cap S)}{\text{their } P(S)}$ (oe) seen, accept unsimplified.
		A1	$P(M)$, $P(S)$ and $P(M \cap S)$ notation seen, numerical comparison and correct conclusion, WWW.
		2	
(b)(i)	Method 1 $[1 - P(0,1,2)]$		
	$= 1 - ({}^{10}C_0 0.3^0 0.7^{10} + {}^{10}C_1 0.3^1 0.7^9 + {}^{10}C_2 0.3^2 0.7^8)$	M1	${}^{10}C_x p^x (1-p)^{10-x}$ for $0 < x < 10$, $0 < p < 1$, any p .
	$= 1 - (0.028248 + 0.121061 + 0.233474)$	A1	Correct expression, accept unsimplified, condone omission of final bracket, condone recovery from poor notation.
	$= 0.617$	A1	Accept $0.61715 \leq p \leq 0.61722$, WWW.
	Method 2 $[P(3,4,5,6,7,8,9,10) =]$		
	${}^{10}C_3 0.3^3 0.7^7 + {}^{10}C_4 0.3^4 0.7^6 + {}^{10}C_5 0.3^5 0.7^5 + {}^{10}C_6 0.3^6 0.7^4 + {}^{10}C_7 0.3^7 0.7^3 + {}^{10}C_8 0.3^8 0.7^2 + {}^{10}C_9 0.3^9 0.7^1 + {}^{10}C_{10} 0.3^{10} 0.7^0$	M1	${}^{10}C_x p^x (1-p)^{10-x}$ for $0 < x < 10$, $0 < p < 1$, any p .
		A1	Correct unsimplified expression.
	$= 0.617$	A1	Accept $0.61715 \leq p \leq 0.61722$, WWW.
		3	
(b)(ii)	$[p = 0.3]$ Mean $= 0.3 \times 90 = 27$; variance $= 0.3 \times 90 \times 0.7 = 18.9$	B1	Correct mean and variance, allow unsimplified. Condone $\sigma = 4.347$ evaluated.
	$P(X < 32) = P\left(z < \frac{31.5 - 27}{\sqrt{18.9}}\right)$	M1	Substituting their μ and σ (not σ^2 , $\sqrt{\sigma}$) into the \pm standardising formula with a numerical value for '31.5'.
		M1	Using either 31.5 or 32.5 within a \pm standardising formula with numerical values for their μ and σ (condone σ^2 , $\sqrt{\sigma}$).
	$= \Phi(1.035)$	M1	Appropriate area Φ , from standardisation formula $P(z < \dots)$ in final solution, must be probability.
	$= 0.850$	A1	Allow $0.8495 < p \leq 0.85(0)$, final answer WWW.
		5	

Question 69

(a)	$0.2[\times 1] + 0.45 \times 0.4 + 0.35 \times 0.3$	M1	$0.2[\times 1] + 0.45 \times b + 0.35 \times c, b = 0.4, 0.6 c = 0.3, 0.7$
	0.485 or $\frac{97}{200}$	A1	
		2	
(b)	$P(Y \bar{H}) = \frac{P(Y \cap \bar{H})}{P(\bar{H})} = \frac{0.35 \times 0.7}{1 - \text{their(a)}} = \frac{0.245}{0.515}$	B1	0.35×0.7 or 0.245 seen as numerator or denominator of fraction.
		M1	0.515 or $1 - \text{their (a)}$ or $[0.3 \times 0 +] 0.45 \times d + 0.35 \times e$, where $d = \text{their } b'$, $e = \text{their } c'$ seen as denominator of fraction.
	0.476 or $\frac{49}{103}$	A1	$0.4757 \leq p \leq 0.476$
		3	

Question 70

(a)(i)	$\frac{40}{800}$ or $\frac{1}{20}$ or 0.05	B1	
		1	
(a)(ii)	$\frac{177}{223 + 177 + 40}$	M1	<i>Their</i> $223 + 177 + 40$ seen as denominator of fraction in the final answer, accept unsimplified
	$\frac{177}{440}$ or 0.402	A1	CAO
Alternative method for Question 7(a)(ii)			
	$P(G S) = \frac{P(G \cap S)}{P(S)} = \frac{\frac{177}{800}}{\frac{223 + 177 + 40}{800}} = \frac{177}{440} = \frac{177}{800} = \frac{11}{20}$ or 0.55	M1	<i>Their</i> $P(S)$ seen as denominator of fraction in the final answer, accept unsimplified
	$\frac{177}{440}$ or 0.402	A1	CAO
		2	
(b)(i)	$P(0, 1, 2) = {}^{10}C_0 (0.35)^0 (0.65)^{10} + {}^{10}C_1 (0.35)^1 (0.65)^9 + {}^{10}C_2 (0.35)^2 (0.65)^8$	M1	One term: ${}^{10}C_x p^x (1-p)^{10-x}$ for $0 < x < 10$, any $0 < p < 1$
	$0.013463 + 0.072492 + 0.17565$	A1	Correct unsimplified expression, or better
	0.262	A1	
		3	
(b)(ii)	Mean = $120 \times 0.35 [= 42]$ Variance = $120 \times 0.35 \times 0.65 [= 27.3]$	B1	Correct mean and variance seen, allow unsimplified
	$P(X > 32) = P(Z > \frac{32.5 - 42}{\sqrt{27.3}}) = P(Z > -1.818)$	M1	Substituting <i>their</i> mean and variance into \pm standardisation formula (any number), condone σ^2 or $\sqrt{\sigma}$
		M1	Using continuity correction 31.5 or 32.5
	$\Phi(1.818)$	M1	Appropriate area Φ , from final process, must be probability
	0.966	A1	$0.965 \leq p \leq 0.966$
		5	

Question 71

(a)	$P(\text{not late}) = 0.4 \times 0.45 + 0.35 \times 0.3 + 0.25 \times (1-x)$ or $P(\text{late}) = 0.4 \times 0.55 + 0.35 \times 0.7 + 0.25x$	M1	$0.4 \times p + 0.35 \times q + 0.25 \times r$, $p = 0.45, 0.55, q = 0.3, 0.7$ and $r = (1-x), x$
	$0.18 + 0.105 + 0.25(1-x) = 0.48$ or $0.22 + 0.245 + 0.25x = 0.52$	A1	Linear equation formed using sum of 3 probabilities and 0.48 or 0.52 as appropriate. Accept unsimplified.
	$x = 0.22$	A1	Final answer
			3
(b)	$\left[P(\text{train} \text{late}) = \frac{P(\text{train} \cap \text{late})}{P(\text{late})} \right]$ $= \frac{0.35 \times 0.7}{1-0.48} \text{ or } \frac{0.35 \times 0.7}{0.4 \times 0.55 + 0.35 \times 0.7 + 0.25 \times \text{their } 0.22}$	B1	0.35×0.7 or 0.245 seen as numerator of fraction
	$= 0.471 \text{ or } \frac{49}{104}$	A1	P(late) seen as a denominator with <i>their</i> probability as numerator (Accept $\frac{\text{their } p}{0.52}$ or $\frac{\text{their } p}{0.22 + 0.245 + 0.25 \times \text{their } 0.22}$)
			3

Question 72

(a)		B1	Fully correct labelled tree diagram for each pair of branches clearly identifying written and practical, pass and fail for each intersection (no additional branches)
		B1	'One written test' branch all probabilities (or %) correct
		B1	'Two written tests' branch all probabilities (or %) correct, condone additional branches after W2F with probabilities 1 for PF and 0 for PP
			3
(b)	$[P(W1P) \times P(PP) + P(W1F) \times P(W2P) \times P(PP)]$ $0.8 \times 0.3 + 0.2 \times 0.6 \times 0.3$	M1	Consistent with <i>their</i> tree diagram or correct
	$0.276 \text{ or } \frac{69}{250}$	A1	
			2
(c)	$P(W1 P) = \frac{P(W1 \cap \text{Practical})}{P(\text{getting place})} = \frac{0.8 \times 0.3}{\text{their}(b)} \left[= \frac{0.24}{0.276} \right]$	M1	Correct expression or FT <i>their</i> (b)
	$\frac{20}{23} \text{ or } 0.87[0]$	A1	
			2

Question 73

(a)	Probabilities: $\frac{x+1}{x+10}, \frac{9}{x+10}, \frac{x}{x+10}, \frac{10}{x+10}$	B1	One probability correct in correct position.
		B1	Another probability correct in correct position.
		B1	Other two probabilities correct in correct positions.
			3
(b)	$\frac{4}{10} \times \text{their } \frac{10}{x+10}$	M1	Method consistent with <i>their</i> tree diagram.
	$\frac{4}{x+10}$	A1	AG
			2

(c)	$\frac{4}{x+10} = \frac{1}{6}$ $x+10=24, x=14$	B1	Find value of x . Can be implied by correct probabilities in calculation.
	$P(\text{A Red} \text{B Red}) = P(\text{A Red} \cap \text{B Red}) \div P(\text{B Red})$ $\frac{\frac{6}{10} \times \text{their} \frac{x+1}{x+10}}{\frac{6}{10} \times \text{their} \frac{x+1}{x+10} + \frac{4}{10} \times \text{their} \frac{x}{x+10}} = \frac{\frac{6}{10} \times \frac{15}{24}}{\frac{6}{10} \times \frac{15}{24} + \frac{4}{10} \times \frac{14}{24}} = \frac{\frac{3}{8}}{\frac{73}{120}}$	B1 FT	$\frac{6}{10} \times \text{their} \frac{x+1}{x+10}$ as numerator or denominator of fraction.
		M1	$\frac{6}{10} \times \text{their} \frac{x+1}{x+10} + \frac{4}{10} \times \text{their} \frac{x}{x+10}$ seen anywhere.
		A1 FT	Seen as denominator of fraction.
	$\frac{45}{73}, 0.616[4\dots]$	A1	If B0 M0: SC B1 for $\frac{3}{73}$ or $\frac{0.375}{0.6083}$ SC B1 $\frac{45}{73}$ or 0.616. $\frac{3}{120}$
		5	

Question 74

(a)	$\frac{82}{180}, \frac{41}{90}, 0.456$	B1	
		1	
(b)	$\left[P(M D) = \frac{P(M \cap D)}{P(D)} \right] = \frac{\frac{11}{180}}{\frac{20}{180} + \frac{11}{180}} = \frac{0.6011}{0.1722}$	M1	Their identified $\frac{P(M \cap D)}{P(D)}$ or from data table $\frac{11}{20+11}$, accept unsimplified, condone $\times 180$.
	$\frac{11}{31}, 0.355$	A1	Final answer.
		2	
(c)	$P(F) = \frac{100}{180}, \frac{5}{9}, 0.5556$ OE $P(G) = \frac{82}{180}, \frac{41}{90}, 0.4556$ OE $P(F \cap G) = \frac{38}{180}, \frac{19}{90}, 0.2111$ OE $P(F) \times P(G) = \frac{100}{180} \times \frac{82}{180} = \frac{41}{162}, 0.2531$ OE $\left[\neq \frac{38}{180} \right]$ Not independent	M1	Their identified $P(F) \times$ their identified $P(G)$ or correct seen, can be unsimplified.
		A1	$\frac{41}{162}, \frac{38}{180}, P(F \cap G)$ and $P(F) \times P(G)$ seen with correct conclusion, WWW. Values and labels must be seen.

Question 75

$\left[P(T B') = \frac{P(T \cap B')}{P(B')} \right]$ $P(B') = 0.45 \times 0.7 + 0.35 \times 0.4 + 0.2 \times 1$ $\left[= 0.655, \frac{131}{200} \right]$	M1	$0.45 \times a + 0.35 \times b + 0.2[\times 1], a = 0.7, 0.3b = 0.4, 0.6$, seen anywhere.
	A1	Correct, accept unsimplified.
$P(T \cap B') = 0.35 \times 0.4 \left[= 0.14, \frac{7}{50} \right]$	M1	Seen as numerator or denominator of a fraction.
$P(T B') = \frac{\text{their } 0.14}{\text{their } 0.655}$	M1	Values substituted into conditional probability formula correctly. Accept unsimplified. Denominator sum of 3 two-factor probabilities (condone omission of 1 from final factor). If clearly identified, condone from incomplete denominator.
$0.214, \frac{28}{131}$	A1	If 0 marks awarded, SC B1 0.214 WWW.
	5	

Question 76

(a)	$\left[\text{Probability of lemon} = \frac{3}{15} = \frac{1}{5} \right]$ $\left[\left(\frac{4}{5} \right)^6 \times \frac{1}{5} = \frac{4096}{78125}, 0.0524 \right]$	B1	0.0524288 rounded to more than 3SF if final answer
		1	
(b)	$\left(1 - \frac{1}{5} \right)^6$	M1	or $\left(\frac{4}{5} \right)^6$. FT <i>their</i> $\frac{1}{5}$ or correct. From final answer Condone $\left(\frac{4}{5} \right)^5$ or $\left(\frac{1}{5} \right) \times \left(\frac{4}{5} \right)^5 + \left(\frac{4}{5} \right)^6$
	$\frac{4096}{15625}, 0.262$	A1	0.262144 rounded to more than 3SF
Alternative method for question 6(b)			
	$[1 - P(1,2,3,4,5,6)] =$ $1 - \left(\frac{1}{5} + \frac{4}{5} \times \frac{1}{5} + \left(\frac{4}{5} \right)^2 \times \frac{1}{5} + \left(\frac{4}{5} \right)^3 \times \frac{1}{5} + \left(\frac{4}{5} \right)^4 \times \frac{1}{5} + \left(\frac{4}{5} \right)^5 \times \frac{1}{5} \right)$	M1	From final answer Condone omission of $\left(\frac{4}{5} \right)^5 \times \frac{1}{5}$
	$\frac{4096}{15625}, 0.262$	A1	0.262144 rounded to more than 3SF
		2	
(c)	$\frac{10}{15} \times \frac{9}{14} \times \frac{8}{13}$	M1	$\frac{a}{15} \times \frac{a-1}{14} \times \frac{a-2}{13}$, no additional terms
	$\frac{24}{91}, 0.264$	A1	0.263736 rounded to more than 3SF
Alternative method for question 6(c)			
	$\frac{3}{15} \times \frac{2}{14} \times \frac{1}{13} + 3 \times \frac{3}{15} \times \frac{2}{14} \times \frac{7}{13} + 3 \times \frac{3}{15} \times \frac{7}{14} \times \frac{6}{13} + \frac{7}{15} \times \frac{6}{14} \times \frac{5}{13}$	M1	[3Ls + 2Ls1S + 1L2Ss + 3Ss] Condone one numerator error. Condone no multiplications seen if tree diagram complete with probabilities on each branch, scenarios listed and attempt at evaluation
	$\frac{24}{91}, 0.264$	A1	0.263736 rounded to more than 3SF
Alternative method for question 6(c)			
	$1 - \left(\frac{5}{15} \times \frac{4}{14} \times \frac{3}{13} + 3 \times \frac{5}{15} \times \frac{4}{14} \times \frac{10}{13} + 3 \times \frac{5}{15} \times \frac{10}{14} \times \frac{9}{13} \right)$	M1	1 - P(3,2,1 oranges) Condone one numerator error.
	$\frac{24}{91}, 0.264$	A1	0.263736 rounded to more than 3SF
Alternative method for question 6(c)			
	$\frac{{}^{10}C_3}{{}^{15}C_3}$	M1	
	$\frac{24}{91}, 0.264$	A1	0.263736 rounded to more than 3SF
		2	

(d)	$\frac{7}{15} \times \frac{5}{14} \times \frac{3}{13} \times 3!$	M1	All probabilities of the form: $\frac{7}{a} \times \frac{5}{b} \times \frac{3}{c}$, $13 \leq a, b, c \leq 15$
		M1	$\frac{e}{f} \times \frac{g}{h} \times \frac{i}{j} \times 3!$ e, f, g, h, i, j positive integers forming probabilities or 6 identical probability calculations or values added, no additional terms
	$\frac{3}{13}$, 0.231	A1	0.230769 rounded (not truncated) to more than 3SF
Alternative method for question 6(d)			
	$\frac{{}^3C_1 \times {}^5C_1 \times {}^7C_1}{{}^{15}C_3}$	M1	$\frac{{}^3C_1 \times {}^5C_1 \times {}^7C_1}{k}$, k integer > 1 Condone use of permutations
		M1	$\frac{{}^3C_a \times {}^5C_b \times {}^7C_c}{{}^{15}C_3}$, $0 < a < 3$, $0 < b < 5$, $0 < c < 7$, Condone use of permutations
	$\frac{3}{13}$, 0.231	A1	0.230769 rounded (not truncated) to more than 3SF
(e)	$\frac{7}{15} \times \frac{6}{14} \times \frac{5}{13} + \frac{3}{15} \times \frac{7}{14} \times \frac{6}{13} \times 3$ <i>their (c)</i> $\left[= \frac{14}{65} + \frac{24}{91} \right]$	3	
		B1	$\frac{3}{15} \times \frac{7}{14} \times \frac{6}{13} \times 3$ seen (SSL, SLS, LSS) SC B1 $\frac{3}{65} \times 3$, $\frac{126}{2730} \times 3$ seen
		B1	$\frac{7}{15} \times \frac{6}{14} \times \frac{5}{13}$ seen in numerator (SSS) SCB1 $\frac{210}{2730} \cdot \frac{1}{13}$ seen in numerator
		M1	Fraction with <i>their (c)</i> or correct in denominator $\left(\frac{720}{2730}, \frac{24}{91}, 0.263736 \right)$
		A1	Accept 0.816
	$= \frac{49}{60}$, 0.817		
Alternative method for question 6(e)			
	$\frac{{}^7C_2 \times {}^3C_1 + {}^7C_3}{{}^{10}C_3}$	B1	${}^7C_2 \times {}^3C_1$ seen (SSL, SLS, LSS) SCB1 21×3 seen or use of permutations
		B1	7C_3 seen in numerator (SSS) SCB1 35 seen in numerator or use of permutations
		M1	Fraction with ${}^{10}C_3$ or consistent with <i>their</i> numerator of 6(c) in denominator
	$= \frac{49}{60}$, 0.817	A1	Accept 0.816
		4	

Question 77

(a)	$[P(>2) = 1 - P(0,1,2) =]$ $1 - ({}^7C_0 \cdot 0.18^0 \cdot 0.82^7 + {}^7C_1 \cdot 0.18^1 \cdot 0.82^6 + {}^7C_2 \cdot 0.18^2 \cdot 0.82^5)$	M1	One term ${}^7C_x p^x (1-p)^{7-x}$, $0 < p < 1, 0 < x < 7$
	$= 1 - (0.249285 + 0.383048 + 0.252251)$ $= 1 - 0.88458$	A1	Correct unsimplified expression or better Condone omission of brackets if recovered
	0.115	B1	WWW. $0.115 \leq p < 0.1155$ not from wrong working
		3	
(b)	$[P(\text{at least 1 day of rain}) = 1 - P(0) = 1 - (0.82)^7 =] 0.7507$	B1	AWRT 0.751 seen
	$[P(\text{exactly 2 periods}) =] 0.7507^2 \times (1 - 0.7507) \times 3$	M1	FT <i>their</i> $1 - p^7$ or <i>their</i> 0.7507 if identified, not 0.18, 0.82 Accept $\times {}^3C_r$, $r=1,2$ or $\times {}^3P_1$ for $\times 3$ Condone $\times 2$
	0.421	A1	Accept $0.421 \leq p \leq 0.4215$ SC B1 if 0/3 scored for final answer only $0.421 \leq p \leq 0.4215$
		3	

Question 78

(a)		B1 First and second jumps correct with probabilities and outcomes identified.
		B1 Third jump correct with probabilities and outcomes identified.
		2
(b)	SFF $0.2 \times 0.7 \times 0.9 = 0.126$ FSF $0.8 \times 0.1 \times 0.7 = 0.056$ FFS $0.8 \times 0.9 \times 0.1 = 0.072$	M1 Two or three correct 3 factor probabilities added, correct or FT from part 6(a). Accept unsimplified.
	[Total = probability of 1 success =] $0.254 \left(\frac{127}{500} \right)$	A1 Accept unsimplified.
	[Probability of at least 1 success = $1 - 0.8 \times 0.9 \times 0.9 = 0.352 \left(\frac{44}{125} \right)$	B1 FT Accept unsimplified.
	P(exactly 1 success at least 1 success) = $\frac{\text{their } 0.254}{\text{their } 0.352}$	M1 Accept unsimplified.
	$0.722, \frac{127}{176}$	A1 $0.7215 < p \leq 0.722$
		5
(c)	$0.8 \times 0.9 \times 0.9 \times 0.1 \times 0.3 \times 0.3 = 0.005832$ [FFFSSS] $0.2 \times 0.3 \times 0.3 \times 0.7 \times 0.9 \times 0.9 = 0.010206$ [SSSFFF]	M1 $a \times b \times c \times d \times e \times f$ FT from <i>their</i> tree diagram. Either a, b and c all = 0.8 or 0.9 (at least one of each) and d, e and f all = 0.1 or 0.3 (at least one of each). Or $a, b, c = 0.2$ or 0.3 (at least one of each) and $d, e, f = 0.7$ or 0.9 (at least one of each).
		A1 Either correct. Accept unsimplified.
	[Total =] 0.0160[38]	A1
		3

Question 79

(a)	$\left[\left(\frac{5}{6} \right)^7 \times \frac{1}{6} \right] = 0.0465, \frac{78125}{1679616}$	B1 $0.0465 \leq p < 0.04652$
		1
(b)	$P(X < 6) = 1 - \left(\frac{5}{6} \right)^5$ or $\frac{1}{6} + \left(\frac{5}{6} \right) \left(\frac{1}{6} \right) + \left(\frac{5}{6} \right)^2 \left(\frac{1}{6} \right) + \left(\frac{5}{6} \right)^3 \left(\frac{1}{6} \right) + \left(\frac{5}{6} \right)^4 \left(\frac{1}{6} \right)$	M1 $1 - p^n, 0 < p < 1, n = 4, 5, 6$ or sum of 4, 5 or 6 terms $p \times (1-p)^n$ for $n = 0, 1, 2, 3, 4(5)$.
	$0.598, \frac{4651}{7776}$	A1
		2
(c)	[Probability of total less than 4 is] $\frac{3}{36}$ or $\frac{1}{12}$	B1 SOI
	$[1 - P(0, 1, 2)]$ $= 1 - \left({}^{10}C_0 \left(\frac{1}{12} \right)^0 \left(\frac{11}{12} \right)^{10} + {}^{10}C_1 \left(\frac{1}{12} \right)^1 \left(\frac{11}{12} \right)^9 + {}^{10}C_2 \left(\frac{1}{12} \right)^2 \left(\frac{11}{12} \right)^8 \right)$	M1 One term ${}^{10}C_x p^x (1-p)^{10-x}$, for $0 < x < 10, 0 < p < 1$.
	$1 - (0.418904 + 0.380822 + 0.155791)$	A1 FT Correct expression. Accept unsimplified.
	0.0445	A1 $0.04448 \leq p \leq 0.0445$
		4

Question 80

(a)	<p>YYY: $\frac{5}{12} \times \frac{4}{11} \times \frac{3}{10} = \frac{60}{1320}, \frac{1}{22}$</p> <p>OOO: $\frac{4}{12} \times \frac{3}{11} \times \frac{2}{10} = \frac{24}{1320}, \frac{1}{55}$</p> <p>RRR: $\frac{3}{12} \times \frac{2}{11} \times \frac{1}{10} = \frac{6}{1320}, \frac{1}{220}$</p>	<p>M1 Either $12 \times 11 \times 10$ in denominator or $a \times (a-1) \times (a-2)$, $a = 5, 4, 3$ in numerator seen in at least one expression.</p> <p>A1 One expression $\frac{a}{12} \times \frac{a-1}{11} \times \frac{a-2}{10}$, $a = 5, 4, 3$ (consistent in expression). Correct order of values in the numerator is essential.</p> <p>M1 $\frac{5}{12} \times \frac{4}{d} \times \frac{3}{e} + \frac{4}{12} \times \frac{3}{d} \times \frac{2}{e} + \frac{3}{12} \times \frac{2}{d} \times \frac{1}{e}$, either $d = 11, e = 10$ or $d = 12, e = 12$. Condone $\frac{1}{22} + \frac{1}{55} + \frac{1}{220}$ OE</p>
	<p>[Total =] $\frac{90}{1320}, \frac{3}{44}, 0.0682$</p>	<p>A1 0.06818. Dependent only upon the second M mark.</p>
(a)	<p>Alternative method for question 7(a)</p> <p>YYY: $\frac{{}^3C_3}{{}^{12}C_3} = \frac{10}{220}, \frac{1}{22}$</p> <p>OOO: $\frac{{}^4C_3}{{}^{12}C_3} = \frac{4}{220}, \frac{1}{55}$</p> <p>RRR: $\frac{{}^3C_3}{{}^{12}C_3} = \frac{1}{220}$</p>	<p>M1 Either ${}^{12}C_3$ in denominator or aC_3 in numerator seen in at least one expression.</p> <p>A1 One expression $\frac{{}^aC_3}{{}^{12}C_3}$, $a = 5, 4, 3$</p> <p>M1 $\frac{{}^5C_3 + {}^4C_3 + {}^3C_3}{{}^{12}C_3 + {}^{12}C_3 + {}^{12}C_3}$ Condone $\frac{1}{22} + \frac{1}{55} + \frac{1}{220}$ OE</p>
	<p>[Total =] $\frac{90}{1320}, \frac{3}{44}, 0.0682$</p>	<p>A1 0.06818. Dependent only upon the second M mark.</p>
	<p>4</p>	
(b)	<p>[P(YYY all same colour) =] $\frac{60}{1320} \div \frac{90}{1320}$</p>	<p>M1 <i>their</i> $P(YYY)$ or $\frac{60}{1320}$ or $\frac{1}{22}$ <i>their</i> 7(a) or $\frac{90}{1320}$ or $\frac{3}{44}$</p>
	<p>$\frac{2}{3}, 0.667$</p>	<p>A1 OE</p>
	<p>2</p>	
(c)	<p>In each method, the M mark requires the scenarios to be identifiable. This may be implied by a list of scenarios and then the calculations which will be assumed to be in the same order. A correct value/expression will be condoned as identifying the connected scenario.</p>	
	<p>Method 1</p> <p>[1 – no orange =] $1 - \frac{8}{12} \times \frac{7}{11} \times \frac{6}{10}$ or $1 - \frac{{}^8C_3}{{}^{12}C_3} = 1 - \frac{14}{55}$</p>	<p>B1 $\frac{8}{12} \times \frac{7}{11} \times \frac{6}{10}$ or $\frac{{}^8C_3}{{}^{12}C_3}$ seen, condone $\frac{336}{1320}$ or $\frac{56}{220}$ only, not OE.</p> <p>M1 $1 - \frac{f}{12} \times \frac{g}{d} \times \frac{h}{e}$ Either $d = 11, e = 10$ or $d = 12, e = 12$ or $1 - \frac{{}^8C_3}{{}^{12}C_3}$. Condone $1 - \frac{14}{55}$ OE (not $\frac{41}{55}$).</p>
	<p>$\frac{41}{55}$</p>	<p>A1 $0.745 \leq p \leq 0.74545$ If M0 scored SC B1 $0.745 \leq p \leq 0.74545$.</p>

(c)

Method 2	
$P(1 O) = \left(\frac{4}{12} \times \frac{3}{11} \times \frac{2}{10} + \frac{4}{12} \times \frac{5}{11} \times \frac{4}{10} + \frac{2}{12} \times \frac{4}{11} \times \frac{3}{10} \right) \times 3 = \frac{672}{1320}$ $P(2 O) = \frac{4}{12} \times \frac{3}{11} \times \frac{8}{10} \times 3 = \frac{288}{1320}$ $P(3 O) = \frac{24}{1320}$	<p>B1 P(1 O) or P(2 O) correct, accept unsimplified.</p> <p>M1 3 correct scenarios added, with at least one 3-term product of form $\frac{f}{12} \times \frac{g}{d} \times \frac{h}{e}$ seen, either $d = 11, e = 10$ or $d = 12, e = 12$.</p>
$[\text{Total}] = \frac{984}{1320} = \frac{41}{55}, 0.745$	<p>A1 $0.745 \leq p \leq 0.74545$ If M0 scored SC B1 $0.745 \leq p \leq 0.74545$.</p>
Method 3	
$\begin{aligned} O Y R &= {}^4C_1 \times {}^5C_1 \times {}^3C_1 &= 60 \\ O R R &= {}^4C_1 \times {}^3C_2 &= 12 \\ O Y Y &= {}^4C_1 \times {}^3C_2 &= 40 \\ O O Y &= {}^4C_2 \times {}^5C_1 &= 30 \\ O O R &= {}^4C_2 \times {}^3C_1 &= 18 \\ O O O &= {}^4C_3 &= 4 \\ \text{Total} &&= 164 \\ \text{Prob} &= \frac{164}{{}^{12}C_3} \end{aligned}$	<p>B1 Number of ways either 1 or 2 orange sweets obtained correctly (112 or 48). Accept unsimplified Note ${}^4C_1 \times {}^8C_2 = 112$ or ${}^4C_2 \times {}^8C_1 = 48$ are correct alternatives.</p> <p>M1 3 correct scenarios (1, 2 or 3 orange sweets) added on numerator, denominator ${}^{12}C_3$</p>
$\frac{984}{1320} = \frac{41}{55}, 0.745$	<p>A1 $0.745 \leq p \leq 0.74545$ If M0 scored SC B1 $0.745 \leq p \leq 0.74545$.</p>
Method 4	
$\begin{aligned} P(R R O) &= \frac{3}{12} \times \frac{2}{11} \times \frac{4}{10} = \frac{1}{55} \\ P(R O) &= \frac{3}{12} \times \frac{4}{11} = \frac{1}{11} \\ P(R Y O) &= \frac{3}{12} \times \frac{5}{11} \times \frac{4}{10} = \frac{1}{22} \\ P(O) &= \frac{4}{12} = \frac{1}{3} \\ P(Y R O) &= \frac{5}{12} \times \frac{3}{11} \times \frac{4}{10} = \frac{1}{22} \\ P(Y O) &= \frac{5}{12} \times \frac{4}{11} = \frac{5}{33} \\ P(Y Y O) &= \frac{5}{12} \times \frac{4}{11} \times \frac{4}{10} = \frac{2}{33} \end{aligned}$	<p>B1 $P(R \wedge \wedge) = \frac{17}{110}$ or $P(Y \wedge \wedge) = \frac{17}{66}$. Accept unsimplified.</p> <p>M1 3 correct scenarios added, with at least one 3-term product of form $\frac{f}{12} \times \frac{g}{d} \times \frac{h}{e}$ seen, either $d = 11, e = 10$ or $d = 12, e = 12$.</p>
$\frac{984}{1320} = \frac{41}{55}, 0.745$	<p>A1 $0.745 \leq p \leq 0.74545$ If M0 scored SC B1 $0.745 \leq p \leq 0.74545$.</p>

(c)

Question 81

(a)	$0.6 + 0.4 \times 0.3 = 0.72$ or $1 - 0.4 \times 0.7 = 0.72$	B1	Clear identified calculation AG
		1	
(b)	$0.72 \times (0.4 + 0.6 \times 0.2)$	M1	$0.72 \times u, 0 < u < 1$
		M1	$v \times (0.4 + 0.6 \times 0.2)$, or $v \times (1 - 0.6 \times 0.8) 0 < v \leq 1$ no additional terms SC B1 for $0.72 \times (0.4 + 0.12)$ or $0.72 \times (1 - 0.48)$
	0.3744	A1	WWW. Condone 0.374. SC B1 for 0.3744 only
		3	
Alternative method for question 6(b)			
	$[p(P1P2) + p(F1P1P2) + p(P1F2P2) + p(F1P1F2P2)] =$ $0.6 \times 0.4 + 0.4 \times 0.3 \times 0.4 + 0.6 \times 0.6 \times 0.2 + 0.4 \times 0.3 \times 0.6 \times 0.2$	M1	Any two terms unsimplified and correct
		M1	Summing 4 appropriate scenarios by listing or on a tree diagram SC B1 for $0.24 + 0.048 + 0.072 + 0.0144$
	0.3744	A1	WWW. Condone 0.374. SC B1 for 0.3744 only
		3	
(c)	$P(\text{fails first or second level} \text{finishes game}) = \frac{P(\text{fails first or second level} \cap \text{finishes game})}{\text{their (b)}}$ Numerator = $P(SF) + P(FS) = 0.6 \times 0.6 \times 0.2 + 0.4 \times 0.3 \times 0.4 = 0.072 + 0.048 = 0.12$ Required probability = $\frac{0.12}{\text{their (b)}}$	M1	Either $0.6 \times 0.6 \times 0.2$ or $0.4 \times 0.3 \times 0.4$ seen Condone 0.072 or 0.048 if seen in (b)
		A1	Both correct accept unsimplified expression. No additional terms
		M1	Their sum of two 3-term probabilities as numerator their (b) or correct
	0.321 or $\frac{25}{78}$	A1	$0.3205 < p \leq 0.321$
		4	

Question 82

(a)	$[P(SRTR) + P(SWTR)] = \frac{3}{8} \times \frac{2}{7} + \frac{5}{8} \times \frac{3}{7}$	M1	$\frac{3}{8} \times \frac{2}{7} + k$ or $l + \frac{5}{8} \times \frac{3}{7} 0 < k, l < 1$
	$= \frac{21}{56} + \frac{15}{56}, 0.375$	A1	SC B1 for $\frac{3}{8}$ with no explanation.
		2	
(b)	[RRWR, WRRR, WRWR] $\frac{3}{8} \times \frac{2}{7} \times \frac{5}{6} \times \frac{1}{5} + \frac{5}{8} \times \frac{3}{7} \times \frac{2}{6} \times \frac{1}{5} + \frac{3}{8} \times \frac{4}{7} \times \frac{2}{6} \times \frac{1}{5}$ $[= \frac{1}{56} + \frac{1}{56} + \frac{1}{14}]$	M1	$\frac{m}{8} \times \frac{n}{7} \times \frac{o}{6} \times \frac{q}{5} 1 \leq m, n, o, q \leq 5, m \neq n \neq o \neq q$
	$= \frac{180}{1680} + \frac{3}{28}, 0.107$	A1	Probability for one scenario correct, accept unsimplified. SC B1 for $3/28$ with inadequate explanation.
		M1	Adding probabilities for 3 correct scenarios and no incorrect.
(c)	$[P(\text{S first disc R} T_2)] = \frac{\frac{30}{28} \times \frac{1}{3}}{\frac{56}{28}} = \frac{1}{3}$	M1	their $P(RRWR)$ or $\frac{3}{8} \times \frac{2}{7} \times \frac{5}{6} \times \frac{1}{5}$ their 7(b) – must be a prob or $\frac{3}{28}$
	$\frac{1}{6}, 0.167$	A1	
		2	

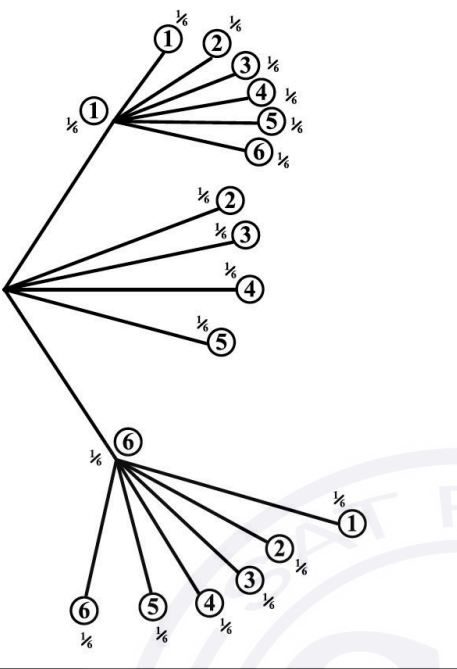
Question 83

(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 <i>their</i> 3 term expression (2 terms involving x) to 0.235
	$x = 0.15$	A1	
		3	
(b)	$\left[\frac{P(\text{car} \text{not late}) = \frac{P(\text{car and not late})}{P(\text{not late})}}{\frac{0.1 \times (1 - 0.3)}{1 - 0.235}} \right]$	M1	$0.1 \times (1 - 2 \times \text{their } x)$ or 0.1×0.7 as numerator and $0.2 \times (1 - \text{their } x) + 0.1 \times (1 - 2 \times \text{their } x) + 0.7 \times 0.75$ with values substituted or $1 - 0.235$ or 0.765 as denominator of fraction. Condone $0.2 \times (1 - \text{their } x) + 0.1 \times (1 - \times \text{their } x) + 0.7 \times 0.75$ as denominator consistent with 1(a) .
	$\left[\frac{0.07}{0.765} = \right] 0.0915, \frac{70}{765}, \frac{14}{153}$	A1	0.091503267 to at least 3SF. If M0 scored SC B1 for 0.091503267 to at least 3SF.
		2	

Question 84

(a)	Method 1: Scenarios identified ignoring unbiased coin		
	$P(\text{BH}_1 \text{ BT}_2) = \frac{1}{4} \times \frac{3}{4} = \frac{3}{16}$ $P(\text{BT}_1 \text{ BH}_2) = \frac{3}{4} \times \frac{1}{4} = \frac{3}{16}$ $P(\text{BH}_1 \text{ BH}_2) = \frac{1}{4} \times \frac{1}{4} = \frac{1}{16}$	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
(b)	$\left[P(A B) = \frac{P(A \cap B)}{P(B)} = \right] \frac{\frac{1}{2} \times \frac{1}{4} \times \frac{1}{4}}{\frac{7}{16}} = \frac{1}{7}$	M1	<i>Their</i> identified $P(\text{HHH})$ or correct as numerator and <i>their</i> 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	

Question 85

<p>(a)</p> 	<p>B1 1st throw fully correct with probabilities and outcomes identified. (Probabilities $\left(\text{all } \frac{1}{6}\right)$ and outcomes (1,2,3,4,5,6) on branches).</p> <p>B1 2nd throw fully correct with probabilities and outcomes identified. (Probabilities $\left(\text{all } \frac{1}{6}\right)$ and outcomes (1,2,3,4,5,6) on branches).</p>	<p>2</p>
<p>(b)</p> <p>5 comes from 1+4 or 5: $P(5) = \frac{1}{6} \times \frac{1}{6} + \frac{1}{6} = \frac{7}{36}$</p> <p>6 comes from 1+5: $P(6) = \frac{1}{6} \times \frac{1}{6} = \frac{1}{36}$</p> <p>7 comes from 1+6 or 6+1: $P(7) = \frac{1}{6} \times \frac{1}{6} + \frac{1}{6} \times \frac{1}{6} = \frac{2}{36}$</p> <p>8 comes from 6+2: $P(8) = \frac{1}{6} \times \frac{1}{6} = \frac{1}{36}$</p> <p>9 comes from 6+3: $P(9) = \frac{1}{6} \times \frac{1}{6} = \frac{1}{36}$</p>	<p>B1 P(5) or P(7) identified and correct unsimplified, accept if supported by correct scenarios shown or from tree diagram .</p>	<p>2</p>
<p>$P(A) = \frac{7}{36} + \frac{1}{36} + \frac{2}{36} + \frac{1}{36} + \frac{1}{36}$</p>	<p>M1 Adding only the values from 5 correct scenarios.</p>	<p>3</p>
<p>$= \frac{12}{36} = \frac{1}{3}$</p>	<p>A1 Scenarios identified (may be on tree diagram in 5(a)), all probabilities seen, WWW AG.</p>	<p>3</p>
<p>(c) $P(B) = \frac{1}{3}, P(A \cap B) = \frac{6}{36}$</p>	<p>M1 Both identified and evaluated, consistent with <i>their</i> tree diagram or correct.</p>	<p>2</p>
<p>$P(A)P(B) = \frac{1}{3} \times \frac{1}{3} = \frac{1}{9}$</p> <p>$\frac{6}{36} \neq \frac{1}{9}$, so not independent</p>	<p>A1 $P(A) \times P(B)$ seen and evaluated, all notation present and correct. Correct conclusion WWW.</p>	<p>2</p>
<p>(d) $P(B A') = \frac{P(B \cap A')}{P(A')} = \frac{\text{their } \frac{6}{36}}{\frac{2}{3}}$</p>	<p>B1 $\frac{6}{36}$ oe as numerator of a fraction.</p> <p>M1 $\frac{\text{their } \frac{6}{36}}{\text{their } 1 - \frac{1}{3}}$ or correct seen, consistent with <i>their</i> tree diagram.</p>	<p>2</p>
<p>$\frac{1}{4}, 0.25$</p>	<p>A1</p>	<p>3</p>

Question 86

$$(1-x) \times 0.7 \times 0.9 = 0.36$$

	M1	$(1-x) \times a \times b = 0.36$, $a = 0.7$ or 0.3 , $b = 0.9$ or 0.1
	B1	$(1-x) \times 0.7 \times 0.9 = 0.36$, $(1-x) \times 0.63 = 0.36$, $0.63 - 0.63x = 0.36$ or $1 - x = \frac{0.36}{0.63}$ seen. Condone recovery from omission of brackets.
$x = \frac{3}{7}$	A1	Accept 0.428571 to at least 3 sf. Condone 0.4285 rounding to 0.429 . If M0 awarded, SC B1 for $x = \frac{3}{7}$ or 0.428571 to at least 3 sf.
	3	

Question 87

$$P(A) = \frac{1}{2}, \quad P(B) = \frac{8}{24} = \frac{1}{3}$$

$$P(A \cap B) = \frac{1}{6}$$

$$P(A) \times P(B) = \frac{1}{2} \times \frac{1}{3} = \frac{1}{6}$$

so events are independent

	B1	Both stated, accept unsimplified.
	M1	Evidence that independence properties not used.
	A1	Evaluated and conclusion stated. $P(A) \times P(B)$ and $P(A \cap B)$ seen.
	3	

Question 88

(a)

$$P(A) = \frac{10}{36}$$

$$P(B) = \frac{24}{36}$$

$$P(A \cap B) = \frac{8}{36}$$

$$\frac{10}{36} \times \frac{24}{36}$$

$$= \frac{5}{27}, 0.185 \left[\neq \frac{8}{36} \right]$$

Events are not independent

	B1	Accept $P(A) = \frac{10}{36}, 0.278$ and $P(B) = \frac{24}{36}, 0.667$.
	B1	
	M1	Their $P(A) \times$ their $P(B)$ seen numerically, $0 \leq$ their $P(A)$, $P(B) \leq 1$.
	A1 FT	Multiplication evaluated correctly and compared with intersection that is not a product of multiplication, conclusion stated, notation $P(A)$, $P(B)$ and $P(A \cap B)$ used.
	4	

(b)

$$\left[\frac{P(B \cap A')}{P(A')} = \right]$$

$$\frac{\frac{16}{36}}{\left(1 - \frac{10}{36}\right)}$$

$$= \frac{8}{13}$$

	M1	$\left[\frac{P(B \cap A')}{P(A')} = \right] \frac{16}{36}, 0.4444$ or their $P(B)$ – their $P(A \cap B)$ seen as numerator or denominator of conditional probability fraction.
	M1	$\left[P(A') = \right] \left(1 - \frac{10}{36}\right), \frac{26}{36}, 0.7222$ or $1 -$ their $P(A)$ seen as denominator of conditional probability fraction.
	A1	Final answer $\frac{16}{26} \cdot \frac{8}{13}, 0.6153846$ to at least 3SF.

Alternative Method for Question 5(b): Direct from outcome tables

$$\left[\frac{P(B|A') = \frac{\text{Number of outcomes } (B \cap A')}{\text{Number of outcomes } (A')}} = \right]$$

$$\frac{16}{26}$$

	M1	$\left[\text{Number of outcomes } (B \cap A') = \right] 16$ seen as numerator or denominator of conditional probability fraction.
	M1	$\left[\text{Number of outcomes } (A') = \right] 26$ seen as denominator of conditional probability fraction.
	A1	Final answer $\frac{16}{26} \cdot \frac{8}{13}, 0.6153846$ to at least 3SF.
	3	

Question 89

(a)	$[P(WW) = P(AWW) + P(BWW) =]$ $\frac{2}{6} \times \frac{8}{15} \times \frac{7}{14} + \frac{4}{6} \times \frac{6}{15} \times \frac{5}{14}$ $\left[= \frac{56}{630} + \frac{60}{630} = \frac{4}{45} + \frac{2}{21} \right] = \frac{58}{315} \text{ or } 0.184$	<p>M1 Either $\frac{2}{6} \times \frac{8}{15} \times \frac{7}{14}$ or $\frac{4}{6} \times \frac{6}{15} \times \frac{5}{14}$ seen, accept unsimplified.</p> <p>M1 $\frac{q}{6} \times \frac{r}{15} \times \frac{r-1}{14} + \frac{6-q}{6} \times \frac{s}{15} \times \frac{s-1}{14}$ seen, no additional terms, accept unsimplified. Condone $\frac{q}{6} \times \frac{r}{15} \times \frac{r}{15} + \frac{6-q}{6} \times \frac{s}{15} \times \frac{s}{15}$, $1 \leq q \leq 5, 1 < r, s < 9$.</p> <p>A1 SC B1 for 58/315 if either M mark withheld.</p>
		3
(b)	$[P(B WR \text{ or } RW) = \frac{P(W \& R \text{ from bag B})}{P(W \text{ and } R)} =]$ $\frac{\frac{4}{6} \times \frac{6}{15} \times \frac{7}{14} + \frac{4}{6} \times \frac{7}{15} \times \frac{6}{14}}{\frac{2}{6} \times \frac{8}{15} \times \frac{4}{14} + \frac{2}{6} \times \frac{4}{15} \times \frac{8}{14} + \frac{4}{6} \times \frac{6}{15} \times \frac{7}{14} + \frac{4}{6} \times \frac{7}{15} \times \frac{6}{14}}$ $\text{or } \frac{2 \times \frac{4}{6} \times \frac{6}{15} \times \frac{7}{14}}{2 \times \frac{2}{6} \times \frac{8}{15} \times \frac{4}{14} + 2 \times \frac{4}{6} \times \frac{6}{15} \times \frac{7}{14}}$	<p>B1 P(W & R from bag B) $= \frac{2}{3} \times \frac{6}{15} \times \frac{7}{14} + \frac{2}{3} \times \frac{7}{15} \times \frac{6}{14}$ or $2 \times \frac{2}{3} \times \frac{6}{15} \times \frac{7}{14}$ [= $\frac{4}{15}$ or 0.267] Seen alone or as numerator/denominator of conditional probability.</p> <p>M1 P(WR or RW) = P(W & R from bag A) + P(W & R from bag B) $= a \times \frac{2}{6} \times \frac{8}{15} \times \frac{4}{14} + a \times \frac{4}{6} \times \frac{6}{15} \times \frac{7}{14}$ or $= a \times \frac{2}{6} \times \frac{8}{15} \times \frac{4}{14} + \text{their } P(W \& R \text{ from bag B})$ $a = 1 \text{ or } 2$. [expect $\frac{116}{315}$ or 0.368] Seen alone or as numerator/denominator of conditional probability.</p>
	$\frac{168}{630} \div \frac{232}{630} = \frac{4}{15} \times \frac{116}{315}$	<p>M1 $\frac{\text{their identified } P(W \& R \text{ from bag B})}{\text{their identified } P(WR \text{ or } RW)}$ Accept unsimplified.</p>
	$= \frac{168}{232}, \frac{21}{29} \text{ or } 0.724$	<p>A1 0.7241379 to at least 3SF.</p>
		4

Question 90

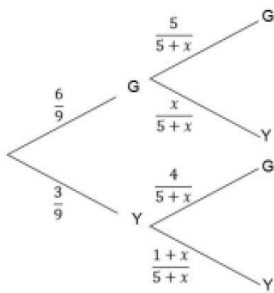
(a)		<p>B1 1st column, 2 branches identified X, Y with probabilities $\frac{1}{2}, \frac{1}{2}$ indicated.</p> <p>B1 2nd column (1st marble pick) of 4 branches identified R B R B (oe) and probabilities $\frac{7}{10}, \frac{3}{10}, \frac{4}{10}, \frac{6}{10}$ indicated appropriately.</p> <p>B1 3rd column (2nd marble pick) of 8 branches identified R B R B R B [B] (oe) and probabilities $\frac{7}{10}, \frac{3}{10}, \frac{6}{10}, \frac{4}{10}, \frac{3}{10}, \frac{5}{10}, \frac{4}{10}, \frac{1}{10}$.</p> <p>Condone omission of YBB branch if YBR branch is fully correct.</p> <p>Ignore any additional columns of branches.</p> <p>If separate tree diagrams for bags X and Y, B0B1B1 max if bags clearly identified.</p>
		3

(b)	$P(\text{both same colour}) = P(\text{BB}) + P(\text{RR}) = P(\text{XBB}) + P(\text{XRR}) + P(\text{YRR}) =$ $\frac{1}{2} \times \frac{3}{10} \times \frac{2}{10} + \frac{1}{2} \times \frac{7}{10} \times \frac{7}{10} + \frac{1}{2} \times \frac{4}{5} \times \frac{4}{5}$ $\left[= \frac{6}{200} + \frac{49}{200} + \frac{16}{50}, 0.03 + 0.245 + 0.32 \right]$	B1 FT	$[P(\text{BB}) =] \left[\frac{1}{2} \times \frac{3}{10} \times \frac{2}{10} \left[+ \frac{1}{2} \times \frac{1}{5} \times 0 \right] \right] = \frac{6}{200}$ <p>seen. Accept unsimplified. FT from 6(a) unsimplified only with 3 term probabilities.</p>
		B1 FT	<p>Either $P(\text{XRR}) = \frac{1}{2} \times \frac{7}{10} \times \frac{7}{10}$ or $P(\text{YRR}) = \frac{1}{2} \times \frac{4}{5} \times \frac{4}{5}$ seen. FT from 6(a) unsimplified only with 3 term probabilities.</p>
		M1	$[P(\text{BB}) + P(\text{XRR}) + P(\text{YRR}) =]$ <p>their $\frac{6}{200} + \text{their } \frac{49}{200} + \text{their } \frac{16}{50}$ Accept unsimplified, consistent with tree diagram if not clearly identified by notation.</p>
	$= \frac{119}{200}, 0.595$	A1	
		4	<p>Special case: if $\frac{1}{2}$ omitted consistently in the tree diagram and the calculation (i.e., no probability for picking the bags), no FT. SC B1 $P(\text{BB}) = \frac{3}{10} \times \frac{2}{10} \left[+ \frac{1}{5} \times 0 \right]$ SC B1 $P(\text{RR}) = \frac{7}{10} \times \frac{7}{10} + \frac{4}{5} \times \frac{4}{5}$ SC B1 $\frac{3}{10} \times \frac{2}{10} \left[+ \frac{1}{5} \times 0 \right] + \frac{7}{10} \times \frac{7}{10} + \frac{4}{5} \times \frac{4}{5}$</p>
(c)	$P(\text{bag } Y \mid \text{different colours}) = \left(\frac{P(\text{bag } Y \cap \text{different colours})}{P(\text{different colours})} \right)$ $\frac{\frac{1}{2} \times \frac{4}{5} \times \frac{1}{5} + \frac{1}{2} \times \frac{1}{5} \times \frac{1}{5} [\times 1]}{1 - \text{their } \left(\frac{119}{200} \right)}$ <p>or</p> $\frac{\frac{1}{2} \times \frac{4}{5} \times \frac{1}{5} + \frac{1}{2} \times \frac{1}{5} \times \frac{1}{5} [\times 1]}{\frac{1}{2} \times \frac{7}{10} \times \frac{3}{10} + \frac{1}{2} \times \frac{3}{10} \times \frac{8}{10} + \frac{1}{2} \times \frac{4}{5} \times \frac{1}{5} + \frac{1}{2} \times \frac{1}{5} \times \frac{1}{5} [\times 1]}$	M1	<p>FT from their 6(a) and their 6(b) with 3 term probabilities unsimplified only or correct. Accept $\frac{4}{50} + \frac{1}{10}, \frac{2}{25} + \frac{1}{10}, \frac{0.08 + 0.1}{200}, \frac{0.405}{200}$.</p>
	$= \left[\frac{9}{50} \right] = \frac{4}{9}, 0.444$	A1	Accept $\frac{36}{81}, 0.4$.
		2	<p>Special case: if $\frac{1}{2}$ omitted consistently in the tree diagram and the calculation (ie no probability for picking the bags), no FT. SC B1 $\frac{\frac{4}{5} \times \frac{1}{5} + \frac{1}{5} \times \frac{1}{5} [\times 1]}{1 - \text{their } 6(b)}$, or $\frac{\frac{4}{5} \times \frac{1}{5} + \frac{1}{5} \times \frac{1}{5} [\times 1]}{\frac{7}{10} \times \frac{3}{10} + \frac{3}{10} \times \frac{8}{10} + \frac{4}{5} \times \frac{1}{5} + \frac{1}{5} \times \frac{1}{5} [\times 1]}$.</p>

Question 91

(a)	$\left[\frac{3}{12} \times \frac{2}{11} \right] = \frac{1}{22}$	B1	Accept $\frac{6}{132}, 0.04545\dots$ to at least three significant figures.
		1	
(b)	$P(\text{B1} \mid \text{R2}) = \frac{\frac{9}{12} \times \frac{3}{12}}{\frac{9}{12} \times \frac{3}{12} + \frac{3}{12} \times \frac{2}{11}}$	M1	$\frac{9}{12} \times \frac{3}{12} = \frac{27}{144}, \frac{3}{16}, 0.1875$ seen as numerator or denominator of a fraction.
		M1	$\text{Their } \frac{9}{12} \times \frac{3}{12} + \text{their } \left(\frac{3}{12} \times \frac{2}{11} \right)$ or $\text{their } \frac{27}{144} + \text{their } \frac{1}{22}$ seen as denominator of a fraction. FT from part (a).
	$\left[= \frac{\frac{3}{16}}{\frac{3}{16} + \frac{1}{22}} \right] = \frac{33}{41}, 0.805$	A1	Accept $\frac{4752}{5904}$ oe, 0.804878... rounded to at least three significant figures. If A0, SC B1 for correct final answer www.
		3	

Question 92

(a)	<div style="display: flex; justify-content: space-around; margin-bottom: 10px;"> <div style="border: 1px solid black; padding: 2px 5px;">Box A</div> <div style="border: 1px solid black; padding: 2px 5px;">Box B</div> </div> 	<p>B1 Correct structure and probabilities for Box A branches.</p> <p>B1 Completely correct structure and one correct probability for a Box B branch including label for G or Y.</p> <p>B1 Completely correct structure and second correct probability on a Box B branch including label G or Y.</p> <p>B1 Completely correct structure and remaining two probabilities correct on Box B branches, including labels for G or Y. SC B1 if correct shape diagram but only four correct algebraic probs for GG, GY, YG and YY.</p>
		4
(b)	$P(\text{same colour}) = \frac{6}{9} \times \frac{5}{5+x} + \frac{3}{9} \times \frac{1+x}{5+x}$	<p>M1 $P(GG) + P(YY) =$ $\left(\frac{6}{9} \text{ or } \frac{3}{9}\right) \times \text{their} \left(\frac{5}{5+x}\right) + \left(\frac{3}{9} \text{ or } \frac{6}{9}\right) \times \text{their} \left(\frac{1+x}{5+x}\right)$</p>
	$\frac{6}{9} \times \frac{5}{5+x} + \frac{3}{9} \times \frac{1+x}{5+x} = \frac{8}{15} \text{ and arrange as a linear equation}$	<p>M1 $15(x+11) = 24(x+5)$ OE Accept sum of their products equated to $\frac{8}{15}$ and rearranged to form a linear equation.</p>
	Solve: $x = 5$	A1
		3

Question 93

(a)	Method 1	
	$P(HR) + P(TR) + P(TBR)$ $\frac{1}{3} \times \frac{4}{9} + \frac{2}{3} \times \frac{4}{9} + \frac{2}{3} \times \frac{5}{9} \times \frac{4}{8}$ <p>or</p> $P(HR) + (P(TRR) + P(TRB)) + P(TBR)$ $\frac{1}{3} \times \frac{4}{9} + \left(\frac{2}{3} \times \frac{4}{9} \times \frac{3}{8} + \frac{2}{3} \times \frac{4}{9} \times \frac{5}{8}\right) + \frac{2}{3} \times \frac{5}{9} \times \frac{4}{8}$	<p>B1 Two of the calculations for P(HR), P(TBR), either P(TR) or P(TRR) + P(TRB) unsimplified, ignore any identification. Condone $\frac{4}{8} = \frac{1}{2}$ in the unsimplified calculation. Condone use of tree diagram to show calculation if values correct at end.</p> <p>M1 Values of all correct identified scenarios added. Correct branches may be identified on the tree diagram.</p> <p>A1 0.6296..., 0.630 If M0 scored SC B1 for acceptable answers, WWW.</p>
	$\left[\frac{4}{27} + \frac{8}{27} + \frac{5}{27}\right] = \frac{17}{27}$	
	Method 2	
	$1 - P(HB) - P(TBB) = 1 - \left(\frac{1}{3} \times \frac{5}{9} + \frac{2}{3} \times \frac{5}{9} \times \frac{4}{8}\right) = \left[1 - \frac{5}{27} - \frac{5}{27}\right]$	<p>(B1) One calculation of P(HB), P(TBB), unsimplified, ignore any identification. 1 - probability must be seen. Condone use of tree diagram to show calculation if values correct at end.</p> <p>(M1) 1 - values of two correct identified scenarios subtracted. Correct branches may be identified on the tree diagram.</p> <p>(A1) 0.6296..., 0.630 If M0 scored SC B1 for acceptable answers, WWW.</p>
	$= \frac{17}{27}$	
(a)	Method 3	
	$P(HR) + P(T, (1 - \text{no R})) =$ $\frac{1}{3} \times \frac{4}{9} + \frac{2}{3} \left(1 - \left(\frac{5}{9} \times \frac{4}{8}\right)\right) =$ $\left[\frac{4}{27} + \frac{2}{3} \left(1 - \frac{20}{27}\right)\right]$	<p>(B1) Calculation for P(T, (1 - no R)) seen unsimplified. Condone use of tree diagram to show calculation if values correct at end.</p> <p>(M1) Values of two correct identified scenarios added. Correct branches may be identified on the tree diagram.</p> <p>(A1) 0.6296..., 0.630 If M0 scored SC B1 for acceptable answers, WWW.</p>
	$= \frac{17}{27}$	
		3

(b)	Method 1		
	$P(\text{head} \mid \text{no reds}) = \frac{P(\text{head} \cap \text{no reds})}{P(\text{no reds})}$ $= \frac{\frac{1}{3} \times \frac{5}{9}}{1 - \frac{17}{27}} = \frac{\frac{5}{27}}{\frac{10}{27}} = \frac{5}{10} = \frac{1}{2}$	M1 $\frac{d}{1 - \text{their(a)}} \text{ or } \frac{d}{1 - \frac{17}{27}} \text{ or } \frac{d}{\frac{10}{27}}, 0 < d < 1.$ Condone $\frac{10}{27} = 0.3704$ or more accurate.	
	$= \frac{1}{2}$	A1	OE Condone 0.499[9...].
	Method 2		
	$P(\text{head} \mid \text{no reds}) = \frac{P(\text{head} \cap \text{blue})}{P(\text{HB}) + P(\text{TBB})}$ $= \frac{\frac{1}{3} \times \frac{5}{9}}{\frac{1}{3} \times \frac{5}{9} + \frac{2}{3} \times \frac{5}{9} \times \frac{4}{8}} = \frac{\frac{5}{27}}{\frac{10}{27}} = \frac{5}{10} = \frac{1}{2}$	(M1) $\frac{d}{\frac{1}{3} \times \frac{5}{9} + \frac{2}{3} \times \frac{5}{9} \times \frac{4}{8}} \text{ or } \frac{d}{\frac{10}{27}}, 0 < d < 1.$ Condone $\frac{10}{27} = 0.3704$ or more accurate.	
	$= \frac{1}{2}$	(A1)	OE Condone 0.499[9...].
		2	

Question 94

(a)	Method 1		
	$[\text{Probability of 4 in 3 throws is}] 1 - \left(\frac{3}{4}\right)^3 = \frac{37}{64}$	M1 $1 - (s)^3, s = \frac{3}{4} \text{ or } \frac{1}{4}.$	
		A1	AG
	Method 2		
	$[\text{Probability of 4 in 3 throws is}] \frac{1}{4} + \frac{1}{4} \times \frac{3}{4} + \frac{1}{4} \times \left(\frac{3}{4}\right)^2 = \frac{37}{64}$	(M1) $t + t(1-t) + t(1-t)^2, t = \frac{1}{4} \text{ or } \frac{3}{4}.$	
		(A1)	AG
	Method 3		
	${}^3C_1 \times \frac{1}{4} \times \left(\frac{3}{4}\right)^2 + {}^3C_2 \times \left(\frac{1}{4}\right)^2 \times \frac{3}{4} + {}^3C_3 \times \left(\frac{1}{4}\right)^3 = \frac{37}{64}$	(M1)	
		(A1)	AG
		2	

(b)	Method 1		
	$\left(1 - \frac{37}{64}\right)^4 = 0.0317$	BIFT $(1 - \text{their(a)})^4, \text{ accept unsimplified.}$	
		1	
	Method 2		
	$[\text{Probability no 4s is}] \left(\frac{3}{4}\right)^6 \times \left(\frac{3}{4}\right)^6 = 0.0317$	(BIFT) Accept unsimplified.	
		1	
(c)	$\begin{array}{l} \text{X3} \\ \text{Y1} \end{array} \left(\frac{37}{64}\right)^3 \times \frac{37}{64} \times \left(\frac{27}{64}\right)^2 \times 3 \quad [= 0.059645]$	B1 Correct probability for 1 identified scenario. Accept unsimplified.	
	$\begin{array}{l} \text{X2} \\ \text{Y0} \end{array} \left(\frac{37}{64}\right)^2 \times \frac{27}{64} \times \left(\frac{27}{64}\right)^3 \times 3 \quad [= 0.03176]$	M1 Add values of 2 correct scenarios. Identification may be implied by correct unsimplified expressions (condone omission of $\times 3$). Values may not be probabilities.	
	Probability = 0.0914	A1	If A0 scored, SC B1 for 0.0914 WWW.
		3	

Question 95

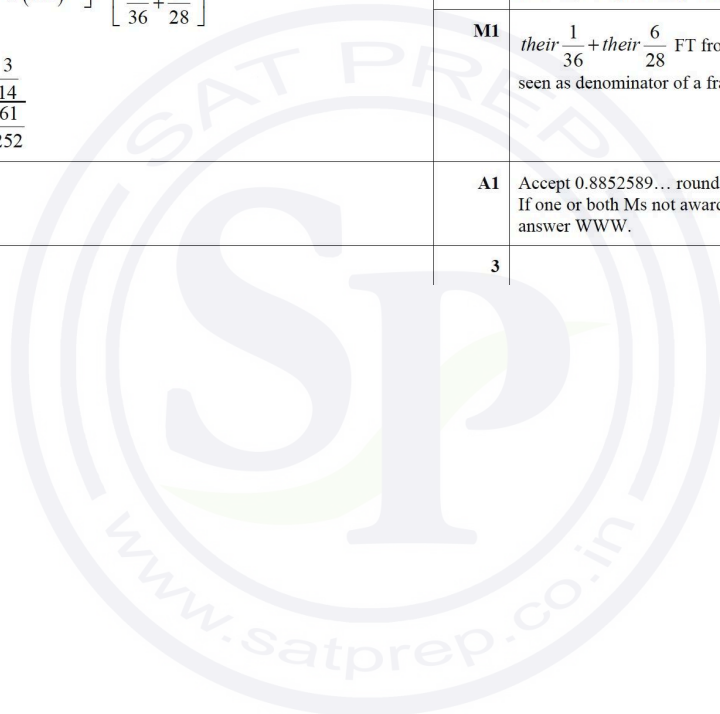
(a)	$0.3^3 + 0.7^3$ or $1 - (3 \times 0.3^2 \times 0.7 + 3 \times 0.3 \times 0.7^2) = [1 - 0.63]$	M1 $p^3 + q^3, p + q = 1, p, q > 0$ or $1 - (3 \times p^2 \times q + 3 \times p \times q^2),$ $p + q = 1, p, q > 0.$
	0.37[0]	A1 $\frac{37}{100}$
		2

Question 96

(a)	$P(X N) = \frac{12}{40}$	B1 $0.3, \frac{3}{10}, 30\% \text{ OE.}$
		1
(b)	$P(N X) = \frac{12}{50}$	B1 $0.24, \frac{6}{25} \text{ OE.}$
		1
(c)	$P(N \cap X) = \frac{12}{120}, P(N) = \frac{40}{120}, P(X) = \frac{50}{120}$ $\frac{40}{120} \times \frac{50}{120} = \frac{5}{36}, 0.138[8\dots] \neq \frac{12}{120}, 0.1 \text{ Not independent}$	B1 $P(N), P(X)$ and $P(N \cap X)$ or $P(N \text{ and } X)$ notation seen and equated to the values for $P(N), P(X)$ and $P(N \cap X)$ or $P(N \text{ and } X)$. Calculation stated and evaluated. Not independent clearly stated. $\frac{5}{36} \neq \frac{12}{120}$ does not need to be stated. All values OE. Condone consistent use of A, B etc. If values for $P(N), P(X)$ stated, accept $P(N) \times P(X) = \frac{5}{36}$
		1
(d)	Method 1 $[P(0, 1, 2) =] (0.85)^8 + {}^8C_1(0.85)^7(0.15) + {}^8C_2(0.85)^6(0.15)^2$ $[= 0.27249 + 0.38469 + 0.23760]$ $= 0.895$	M1 One term of form ${}^8C_x (p)^x (1-p)^{8-x}$. With $0 < p < 1, x \neq 0$ or 8. A1 Correct unsimplified expression, no terms omitted leading to final answer. B1 $0.8945 \leq p \leq 0.895.$
	Method 2 $[P(0, 1, 2) =] 1 - \{ {}^8C_3(0.85)^5(0.15)^3 + {}^8C_4(0.85)^4(0.15)^4 + {}^8C_5(0.85)^3(0.15)^5 + {}^8C_6(0.85)^2(0.15)^6 + {}^8C_7(0.85)(0.15)^7 + (0.15)^8 \}$	M1 One term of form ${}^8C_x (p)^x (1-p)^{8-x}$ With $0 < p < 1, x \neq 0$ or 8. A1 Correct unsimplified expression. Condone omission of final bracket '}'. If other brackets omitted, allow recovery if $1 - 0.1052[...]$ seen.
	$= 0.895$	B1 $0.8945 \leq p \leq 0.895.$
		3

Question 97

<p>(a)</p> $P(\text{HRR}) = \frac{1}{4} \times \frac{4}{6} \times \frac{4}{6} = \frac{16}{144}, \frac{4}{36}$ $P(\text{TRR}) = \frac{3}{4} \times \frac{3}{7} \times \frac{2}{6} = \frac{18}{168}, \frac{3}{28}$ $P(\text{HBB}) = \frac{1}{4} \times \frac{2}{6} \times \frac{2}{6} = \frac{4}{144}, \frac{1}{36}$ $P(\text{TBB}) = \frac{3}{4} \times \frac{4}{7} \times \frac{3}{6} = \frac{36}{168}, \frac{6}{28}, \frac{3}{14}$	<p>B1 2 clearly identified unsimplified probabilities from P(HRR), P(TRR), P(HBB) and P(TBB) correct.</p>
$\frac{4}{36} + \frac{3}{28} + \frac{1}{36} + \frac{6}{28}$	<p>M1 Sum of 4 correct scenarios, may be identified by the unsimplified probability calculations.</p>
$= \frac{29}{63} \text{ or } 0.460$	<p>A1 (0.460317... to at least 3SF).</p>
	<p>3</p>
<p>(b)</p> $P(\text{T BB}) = \frac{P(\text{T} \cap \text{BB})}{P(\text{BB})} = \left[\frac{\frac{3}{4} \times \frac{4}{7} \times \frac{3}{6}}{\frac{1}{36} + \frac{6}{28}} \right]$ $\frac{3}{14} \div \frac{61}{252} \text{ or } \frac{14}{61}$	<p>M1 $\frac{3}{4} \times \frac{4}{7} \times \frac{3}{6}, \frac{36}{168}$ or, $\frac{3}{14}$, 0.2142857... seen as numerator of a fraction, accept unsimplified, FT <i>their</i> P(TBB) from 4(a)</p> <p>M1 <i>their</i> $\frac{1}{36} + \text{their}$ $\frac{6}{28}$ FT from 4(a) or correct, 0.24206..., seen as denominator of a fraction, accept unsimplified.</p>
$\frac{54}{61} \text{ or } 0.885$	<p>A1 Accept 0.8852589... rounded to at least 3SF. If one or both Ms not awarded, SC B1 for correct final answer WWW.</p>
	<p>3</p>



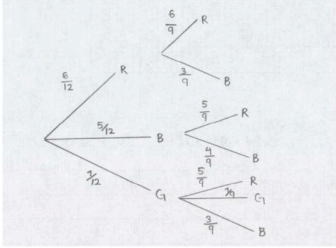
Question 98

(a)	$P(\text{WWW}) = \frac{8}{16} \times \frac{7}{15} \times \frac{6}{14} \left[= \frac{336}{3360}, \frac{1}{10} \right] \text{ or } \frac{{}^8C_3}{{}^{16}C_3}$ $P(\text{BBB}) = \frac{5}{16} \times \frac{4}{15} \times \frac{3}{14} \left[= \frac{60}{3360}, \frac{1}{56} \right] \text{ or } \frac{{}^5C_3}{{}^{16}C_3}$ $P(\text{SSS}) = \frac{3}{16} \times \frac{2}{15} \times \frac{1}{14} \left[= \frac{6}{3360}, \frac{1}{560} \right] \text{ or } \frac{{}^3C_3}{{}^{16}C_3}$	M1 1 outcome seen as the product of 3 fractions with 8, 7, 6 or 5, 4, 3 or 3, 2, 1 as numerators and 16, 15, 14 or 16, 16, 16 as denominators Or 1 outcome correct in terms of combinations.
	$\frac{402}{3360}, \frac{67}{560}, 0.120$	M1 Sum of 3 correct identified scenarios (may be identified by correct unsimplified numerator values).
		A1 $0.1195 < p \leq 0.120$.
		3
(b)	3 cases to consider: WBW, WBB, WBS $P(\text{WBW}) = \frac{8}{16} \times \frac{5}{15} \times \frac{7}{14} \times 3 \left(= \frac{840}{3360}, \frac{1}{4} \right)$ $P(\text{WBB}) = \frac{8}{16} \times \frac{5}{15} \times \frac{4}{14} \times 3 \left(= \frac{480}{3360}, \frac{5}{42} \right)$ $P(\text{WBS}) = \frac{8}{16} \times \frac{5}{15} \times \frac{3}{14} \times 6 \left(= \frac{720}{3360}, \frac{3}{14} \right)$ Or $P(\text{WBW}) = \frac{{}^8C_2 \times {}^5C_1}{{}^{16}C_3} \left(= \frac{140}{560} \right)$ $P(\text{WBB}) = \frac{{}^8C_1 \times {}^5C_2}{{}^{16}C_3} \left(= \frac{80}{560} \right)$ $P(\text{WBS}) = \frac{{}^8C_1 \times {}^5C_1 \times {}^3C_1}{{}^{16}C_3} \left(= \frac{120}{560} \right)$	M1 One outcome seen as the product of 3 fractions with correct numerators and n , $(n - 1)$, $(n - 2)$ only as denominator, where $8 \leq n \leq 16$ (condone omission of $\times 3$ or $\times 6$) Or 1 outcome correct in terms of combinations with mC_3 as denominator where $8 \leq m \leq 16$. Must be a probability, no additional 'divisions' leading to final answer.
	$\frac{2040}{3360}, \frac{17}{28}, 0.607$	A1 1 identified outcome fully correct (accept unsimplified).
		M1 Sum of 3 correctly identified scenarios (may be identified by correct unsimplified numerator values).
		A1 If 1 or more M mark not scored, SC1 for $\frac{2040}{3360}, \frac{17}{28}, 0.607$ WWW.
	Method 2 1 – {P(WSS)+P(WWS)+P(WWW)+P(BSS)+P(BBS)+P(BBB)+P(SSS)}	
	$P(\text{WSS}) = \frac{8}{16} \times \frac{3}{15} \times \frac{2}{14} \times 3 \left(= \frac{144}{3360}, \frac{3}{70} \right)$ $P(\text{WWS}) = \frac{8}{16} \times \frac{7}{15} \times \frac{3}{14} \times 3 \left(= \frac{504}{3360}, \frac{3}{20} \right)$ $P(\text{WWW}) = \frac{8}{16} \times \frac{7}{15} \times \frac{6}{14} \left(= \frac{336}{3360}, \frac{1}{10} \right)$	M1 Two outcomes seen as the product of 3 fractions with correct numerators and n , $(n - 1)$, $(n - 2)$ only as denominator, where $8 \leq n \leq 16$ (condone omission of $\times 3$). Attempt at $1 - p$ must be present. Must be a probability, no additional 'divisions' leading to final answer.
		A1 2 identified outcomes fully correct (accept unsimplified).
(b)	$P(\text{BSS}) = \frac{5}{16} \times \frac{3}{15} \times \frac{2}{14} \times 3 \left(= \frac{90}{3360}, \frac{3}{112} \right)$ $P(\text{BBS}) = \frac{5}{16} \times \frac{4}{15} \times \frac{3}{14} \times 3 \left(= \frac{180}{3360}, \frac{3}{56} \right)$ $P(\text{BBB}) = \frac{5}{16} \times \frac{4}{15} \times \frac{3}{14} \left(= \frac{60}{3360}, \frac{1}{56} \right)$ $P(\text{SSS}) = \frac{3}{16} \times \frac{2}{15} \times \frac{1}{14} \left(= \frac{6}{3360}, \frac{1}{560} \right)$	M1 1 – sum of 7 correctly identified scenarios (may be identified by correct unsimplified numerator values).
	$\frac{2040}{3360}, \frac{17}{28}$	A1 If 1 or more M mark not scored, SC1 for $\frac{2040}{3360}, \frac{17}{28}, 0.607$ WWW.
		4

Question 99

(a)	$[0.55 \times 0.3 \times 0.15 \times 3! =] 0.1485, \frac{297}{2000}$	B1	Accept $\frac{148500}{1000000}$, condone 0.149.
		1	
(b)	Method 1		
	$[1 - P(10, 11, 12) =]$ $1 - \{ {}^{12}C_{10} 0.55^{10} 0.45^2 + {}^{12}C_{11} 0.55^{11} 0.45 + 0.55^{12} \} =$ $[1 - (0.0338529 + 0.0075229 + 0.0007662) =]$	M1	One term of the form ${}^{12}C_x (p)^x (1-p)^{12-x}$, $0 < p < 1, x \neq 0$ or 12.
		A1	Correct unsimplified expression, no terms omitted leading to final answer. Condone omission of last bracket '}' only.
	= 0.958	B1	$0.9575 < p \leq 0.958$.
	Method 2		
	$[P(0, 1, 2, 3, 4, 5, 6, 7, 8, 9) =]$ $0.45^{12} + {}^{12}C_1 0.55^1 0.45^{11} + \dots + {}^{12}C_9 0.55^9 0.45^3$	M1	One term of the form ${}^{12}C_x (p)^x (1-p)^{12-x}$, $0 < p < 1, x \neq 0$ or 12.
		A1	Correct unsimplified expression, no more than 7 'middle' terms omitted leading to final answer.
	= 0.958	B1	$0.9575 < p \leq 0.958$.
		3	
(c)	[Mean = $140 \times 0.15 =] 21$ [Variance = $140 \times 0.15 \times 0.85 =] 17.85$	B1	21 and 17.85 (or $17\frac{17}{20}$) seen, allow unsimplified. May be in standardisation formula. $(\sigma = \sqrt{17.85}, 4.224926\dots)$ to at least 4SF implies correct variance). Withhold mark if variance clearly identified as standard deviation, condone $N(21, \sqrt{17.85})$ if standardisation formula correct or variance/standard deviation correctly stated as well.
	$P(X > 24) = P\left(Z > \frac{24.5 - 21}{\sqrt{17.85}}\right)$	M1	Substituting <i>their</i> μ and <i>their</i> σ into the \pm standardisation formula (any number for 24.5), allow σ^2 or $\sqrt{\sigma}$.
		M1	Use continuity correction 23.5 or 24.5 in <i>their</i> standardisation formula. Note: If no working $\pm\left(\frac{3.5}{\sqrt{17.85}}\right)$ or $\pm\left(\frac{3.5}{4.225}\right)$ seen gains M2 BOD.
	$[P(Z > 0.8284) = 1 - \Phi(0.8284)]$ $1 - 0.7961$	M1	Appropriate area Φ , from final process, must be a probability. May be implied by a sketch of the required probability area. Note: correct final answer implies this M1. Expect final answer < 0.5 .
	= 0.204	A1	Final answer AWRT.
		5	

Question 100

<p>(a)</p>  <p>Probabilities for Bag A selection R,B,G ($\frac{6}{12}, \frac{5}{12}, \frac{1}{12}$)</p> <p>Probabilities for Bag B selection: $\frac{6}{9}, \frac{3}{9}, [0]$ $\frac{5}{9}, \frac{4}{9}, [0]$ $\frac{5}{9}, \frac{3}{9}, \frac{1}{9}$</p>		<p>B1 Correct structure and probabilities for Bag A branches which must be the first set of branches, including labels R, B, G.</p> <p>B1 Correct structure and probabilities for one Bag B branch, including labels R, B, [G]. Condone inclusion of branches with 0 probability.</p> <p>B1 Correct structure and probabilities for remaining Bag B branches, including labels R, B, [G]. Condone inclusion of branches with 0 probability.</p> <p>Additional branches without a probability of zero lose this mark.</p>
	3	
<p>(b)</p> $[P(RR) + P(BB) + P(GG)] = \frac{6}{12} \times \frac{6}{9} + \frac{5}{12} \times \frac{4}{9} + \frac{1}{12} \times \frac{1}{9}$ $= \frac{57}{108}, \frac{19}{36}$		<p>M1 Correct or FT tree diagram probabilities with all 3 (R, B and G) branches. Note: working may be by tree diagram.</p> <p>A1 Accept 0.5278, 0.528.</p>
	2	
<p>(c)</p> $P(\text{A blue} \text{B blue}) = \frac{\frac{5}{12} \times \frac{4}{9}}{\frac{6}{12} \times \frac{3}{9} + \frac{5}{12} \times \frac{4}{9} + \frac{1}{12} \times \frac{3}{9}}$		<p>M1 $\frac{5}{12} \times \frac{4}{9}$ or $\frac{20}{108}$ or $\frac{5}{27}$ or their P(BB) from Q5(b) seen as a numerator of a single fraction. FT tree diagram with values from only 2 bags.</p> <p>B1 FT $\frac{6}{12} \times \frac{3}{9} + \frac{5}{12} \times \frac{4}{9} + \frac{1}{12} \times \frac{3}{9}$ seen as the denominator of a single fraction. $\frac{5}{27}$ or their P(BB) may be seen from Q5b in place of $\frac{5}{12} \times \frac{4}{9}$ FT tree diagram with values from only 2 bags.</p>
$= \frac{20}{41}$		<p>A1 Accept 0.488, 0.4878. SCB1 if either M or B mark not scored $\frac{20}{41}$ or 0.4878.</p>
	3	

Question101

(a)	$[P(\text{both same colour}) = \frac{4}{16} \times \frac{4}{16} + \frac{12}{16} \times \frac{11}{15}]$	<p>M1 OE. $\frac{4}{16} \times \frac{4}{16}$ and either $\frac{12}{16} \times \frac{11}{15}$ or $\frac{12}{16} \times \frac{11}{16}$ seen. Decimals to 4SF but condone $\frac{11}{15} = 0.733$. No additional terms.</p>
	$= \frac{49}{80}, 0.6125$	<p>A1 ISW. CAO, (0.6125, $\frac{49}{80}$ must be seen). If M mark not scored, SCB1 for $\frac{49}{80}, 0.6125$ WWW.</p>
		2
(b)	$\left[P(1B 2R) = \frac{P(1B \cap 2R)}{P(2R)} \right]$ $= \frac{\frac{4}{16} \times \frac{12}{16}}{\frac{4}{16} \times \frac{12}{16} + \frac{12}{16} \times \frac{11}{15}}$	<p>M1 $\frac{4}{16} \times \frac{12}{16}$ seen as a numerator of a single fraction. If 0.1875 or $\frac{3}{16}$ is seen as the numerator, the calculation must be seen in the working for the denominator – or in 3(a), including by the tree diagram. The question will need to be linked if the work is in 3(a).</p> <p>M1 $\left\{ \text{their } \left(\frac{4}{16} \times \frac{12}{16} \right) \text{ or correct} \right\}$ $+ \left\{ \text{their } \left(\frac{12}{16} \times \frac{11}{15} \right) \text{ from part (a)} \right\}$ or 0.7375 or $\frac{59}{80}$ or correct seen as the denominator of a single fraction.</p>
	$\frac{15}{59}, 0.254$	<p>A1 0.254237... to at least 3 SF. If one or more M not scored SCB1 for $\frac{15}{59}, 0.254237...$ to at least 4 SF WWW.</p>
		3