AS-Level

Topic : Probability

May 2013-May 2023

Answers

Question 1

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

Question 2

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

Question 3

$P(Q) = \frac{4}{36}$ or $P(S) = \frac{1}{2}$	B1		oe
$P(Q \cap S) = \frac{2}{36}$ or $P(S\|Q) = \frac{1}{2}$ or $P(Q\|S) = \frac{2}{18}$	B1		oe
$P(Q \cap S) = P(Q) \times P(S)$ or $P(S\|Q) = P(S)$ or $P(Q\|S) = P(Q)$	M1		Comparing correct pair of terms $0 \leq$ all probabilities < 1
Independent	A1	[4]	Correct conclusion must have all probs correct

Question 4

(i)	$P(T,B) = \frac{5}{12} \times \frac{2}{10} = \frac{1}{12}$ (0.0833)	M1 A1	[2]	Mult their P(T) by 2/9 or 2/10 only Correct answer
(ii)	$P(C_S \cap C_A) = \frac{7}{12} \times \frac{4}{10} = \frac{28}{120}$ (0.2333)	M1		Mult their P(C_S) by 3/9 or 4/10 seen as num or denom of a fraction
	$P(C_A) = \frac{7}{12} \times \frac{4}{10} + \frac{5}{12} \times \frac{3}{10} = \frac{43}{120}$ (0.3583)	M1		Summing 2 two-factor products to find P(C_A) seen anywhere
	$P(C_S\|C_A) = \frac{P(C \cap C)}{P(C_A)} = \frac{28/120}{43/120}$	A1		Correct unsimplified P(C_A) seen as num or denom of a fraction
	$= \frac{28}{43}$ (0.651)	A1	[4]	Correct answer
(iii)				

x	0	1	2
Prob	7/24	19/40	7/30

B1 — $x = 0, 1, 2$, can be implied from table or working

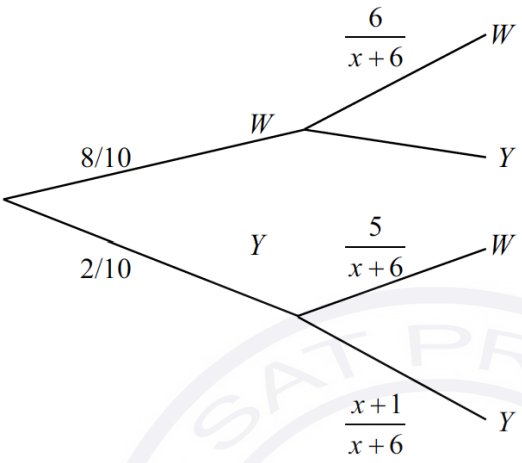
$P(X = 0) = P(T, B) + P(T, T)$ — M1 — 1 or 2 two-factor products, denoms 12 and 10 or 12 and 9, implied if ans is correct

$= \frac{5}{12} \times \frac{2}{10} + \frac{5}{12} \times \frac{5}{10} = \frac{7}{24}$ (0.292) — A1 — One correct unsimplified

$P(X = 2) = P(C, C) = \frac{7}{12} \times \frac{4}{10} = \frac{28}{120}$ (0.233) — B1 — One other correct unsimplified

$P(X = 1) = 1 - 7/24 - 28/120 = \frac{19}{40}$ (0.475) — B1ft — [5] — Third correct ft 1 – P(2 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)	box A box B  	B1 B1 B1 B1	 **[4]**	both correct for box A 1 correct 1 correct 1 correct
(iii)	$P(W_B) = \frac{6}{x+6} = \frac{1}{3}$ $x = 12$ **AG**	M1 A1	 **[2]**	their $\frac{6}{x+6}$ = 1/3 or $x/x+6 = 2/3$ Verification or solving legit
(iv)	$P(Y) = \frac{8}{10}\times\frac{12}{18}+\frac{2}{10}\times\frac{13}{18}$ $= \frac{61}{90}$ $P(=(AY \mid BY) = \frac{P(AY \cap BY)}{P(Y)}$ $= \frac{2}{10}\times\frac{13}{18} / \frac{61}{90}$ $= \frac{13}{61}(0.213)$	M1 A1 B1 A1	 **[4]**	Attempt at $P(,Y)$ involving 2 two-factor fractions, seen anywhere. Correct P(Y) seen as num or denom of a fraction (2/10) × (13/18) seen as num or denom of a fraction Correct answer

Question 6

(i)	P(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: $\frac{2C2+4C2+3C2}{9C2}$ or $\frac{2\times1+3\times4+2\times3}{9C2\times2}$ *oe*	M1 M1 A1	**3**	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
(ii)	$P(5,\bar{5}) + P(\bar{5},5)$ $= \frac{3}{9}\times\frac{6}{8}+\frac{6}{9}\times\frac{3}{8}=\frac{36}{72}=$ ½ or 0.5 Alt. method: $\frac{6C1\times3C1(\times2)}{9C2(\times2)}$ *oe*	M1 M1 A1	**3**	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
(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 $P(5_1 \mid \bar{5}_2) = \frac{1/4}{48/72} = 3/8$ = 0.375	M1 M1 A1 A1	**4**	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
(iv)	<table><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> $P(0) = P(\bar{5},\bar{5}) = \frac{6}{9}\times\frac{5}{8}=$ 30/72 (5/12) (0.4166) P(1) = 0.5 from part (ii) P(2) = 6/72 (1/12) (0.0833) from part (i)	B1 B1 B1ft	**3**	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

Question 7

(i) options (3, 4, 4,) or (4, 3, 4) or (4, 4, 3)
Probs (4/10 × 6/9 × 5/8) ×3C1
= 360/720
= ½ AG

M1 Summing three 3-factor options oe
M1 10 × 9 × 8 seen in denom
A1 **[3]** Correct answer

OR $\frac{{}_6C_2 \times {}_4C_1}{{}_{10}C_3} = \frac{1}{2}$ AG

M1 One of 6C2 or 4C1 seen in num
M1 10C3 in denom
A1 Correct answer

(ii)

sum	9	10	11	12
Prob	24/720	216/720	360/720	120/720

B1 **[4]** 9, 10, 11, 12 only seen

B1 One correct prob other than P(11), with or without replacement

B1 Another correct prob

P(3, 3, 3) = 4/10 × 3/9 × 2/8 = 24/720 (1/30)
P(3, 3, 4) = 4/10 × 3/9 × 6/8 × 3C1
= 216/720 (3/10)
P(4, 4, 4) = 6/10 × 5/9 × 4/8 = 120/720(1/6)

B1 Σ all 4 probs = 1

(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)

P($R \cap S$) = 120/720 ≠ P(R) × P(S)

M1 Numerical attempt to compare P(R and S) with P(R) × P(S) provided P($R \cap S$) ≠ 1/5

Not indep

A1ft Correct conclusion ft wrong P($R \cap S$) ≠ 1/5, P(S) correct

(iv) P($R \cap S$) ≠ 0 or there is an overlap between R and S (34,4)
Not exclusive Σxf/Σf

B1ft **[1]** Correct answer following correct reasoning ft wrong non zero P($R \cap S$)

Question 8

(i) P(C ∩ < 50) = 0.35 × 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 0.545 (unsimplified) seen as num or denom of a fraction

$= \frac{0.07}{0.545}$

M1 Attempt at P(C ∩ < 50) as 2-factor prod only seen as num or denom of a fraction

= 0.128 (14/109)

A1 Correct answer

Question 9

(i)	if throw H then smallest score is 2 P(T, 1) = 1/2 × 1/4 = 1/8 **AG**	B1 B1	**2**	Or equivalent
(ii)	P(3) from two dice = 2/16 seen P(H, 3) = 1/2 × 2/16 = 2/32 P(T, 3) = 1/2 × 1/4 = 1/8 So P(3) = 6/32 = 3/16 **AG**	B1 M1 A1 A1	 **4**	From (1, 2) and (2, 1) Summing P(H, 3) and P(T, 3) One correct Correct answer must see clear reasoning
(iii)				

X	1	2	3	4	5	6	7	8
Prob		5/32		7/32		3/32		

B1		One correct prob
B1		A second correct prob
B1	**3**	A third correct prob

(iv)	P($Q \cap R$) = 0 or 'if you throw a tail you can't get a 7'	M1		Stating P($Q \cap R$) = 0 or implying by words
	Yes they are exclusive	A1dep	**2**	Dep on previous M

Question 10

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

Question 11

(i)	P(B champ) = 0.7× 0.7 = 0.49	B1	**1**	
(ii)	P (B champ) = P(WW) + P(WLW) + P(LWW) = (0.7×0.7) + (0.7×0.3×0.7) + (0.3×0.7×0.7) = 0.49 + 0.147 + 0.147 = 0.784	M1 B1 A1	 **3**	Summing at least 2 options, at least one of which is 3-factor 0.147 seen, unsimplified Correct answer
(iii)	$P(T2 \mid T) = \dfrac{P(T2 \cap T)}{P(T)}$ $= \dfrac{0.3\times0.3 + 0.7\times0.3\times0.3}{0.216}$ = 0.708	M1 A1 M1 A1	 **4**	Attempt P(T2∩T) seen anywhere sum of 2 terms Correct unsimplified num of a fraction Dividing by their (1 – **(ii)** $\surd$) oe Correct answer

Question 12

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

Question 13

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

Question 14

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

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

$\frac{1}{3}$ **AG**

M1 Mult 3 probs

M1 Summing 2 options

A1 **3** Correct working with appropriate justification and fraction sequencing

(ii)

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

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

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

B1 One correct prob other than (i)

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

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

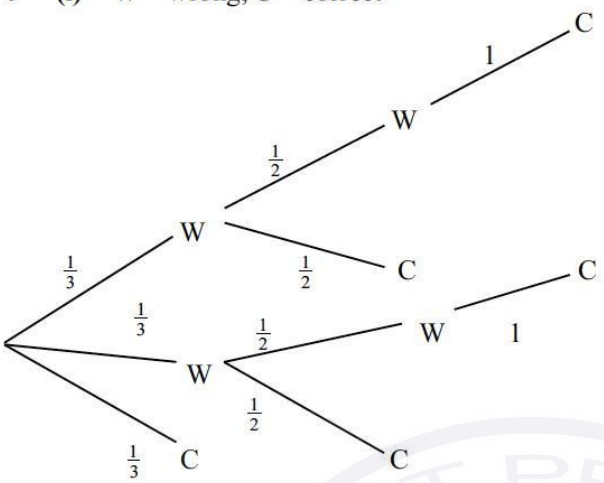
$= \left(\frac{2}{4} \times \frac{1}{3} \times \frac{2}{2} \times \frac{1}{1}\right) \times 3 = \frac{1}{2}$

B1√ **3** Second correct prob ft 1 – their previous 2 probs

(iii)	P(3 orange | at least 2 O) = $\frac{P(3O)}{P(at\ least\ 2O)}$		
	P(3 orange) = P(OOO)	M1	Atttempt at P(OOO) one three-factor option, not added
	$= \frac{5}{7}\times\frac{4}{6}\times\frac{3}{5}=\frac{2}{7}$	A1	Correct unsimplified num of a fraction
	P(at least 2O) = P(YOO) + P(OYO) + P(OOY) + $\frac{2}{7}$		
	$=\frac{2}{7}\times\frac{5}{6}\times\frac{4}{5}+\frac{5}{7}\times\frac{2}{6}\times\frac{4}{5}+\frac{5}{7}\times\frac{4}{6}\times\frac{2}{5}+\frac{2}{7}$	M1	Attempt at P(at least 2O) sum 3 or 4 three-factor options
	$=\frac{6}{7}$	A1	Correct unsimplified answer seen anywhere
	P(30 | at least 2O) = $\frac{2}{7}\div\frac{6}{7}=\frac{1}{3}(0.333)$	A1 **5**	Correct answer evaluated
Alternative 1			
3 Orange = $^5C_3$		M1	Attempt at combinations for 3 orange oe, not added
		A1	Correct unsimplified num of a fraction
At least 2 Orange = $^5C_2 \times {}^2C_1 + {}^5C_3$		M1	Attempt at combinations for at least 2 orange condone omission of $+{}^5C_3$
		A1	Correct unsimplified answer seen anywhere
P(3O | at least 2O) = $\frac{{}^5C_3}{{}^5C_2\times{}^2C_1+{}^5C_3}=\frac{1}{3}$		A1 **5**	Correct answer evaluated
Alternative 2			
No Yellow = $^2C_0$		M1	Attempt at combinations for 0 yellow oe, not added
		A1	Correct unsimplified num of a fraction
No more than 1 Yellow = $^2C_1 + {}^2C_0$		M1	Attempt at combinations for no more than 1 yellow. Condone omission of +2C0
		A1	Correct unsimplified answer seen anywhere
P(3O | at least 2O) = $\frac{{}^2C_0}{{}^2C_1+{}^2C_0}=\frac{1}{3}$		A1 **5**	Correct answer evaluated
Misread – with replacement			
MR–1 applied to first Accuracy Mark earned		M1	Attempt at P(OOO) one three factor option oe not added
P(3O) = $\frac{5}{7}\times\frac{5}{7}\times\frac{5}{7}=\frac{125}{343}$		A1	Correct unsimplified num of a fraction
P(at least 2O) = $\frac{5}{7}\times\frac{5}{7}\times\frac{2}{7}\times{}^3C_2+\left(\frac{5}{7}\right)^3$		M1	Attempt at P(at least 2O) sum of 3 or 4 three factor options
		A1	Correct unsimplified seen anywhere
P(3O | at least 2O) = $\frac{5}{11}$		A1 **4 max**	Answer evaluated

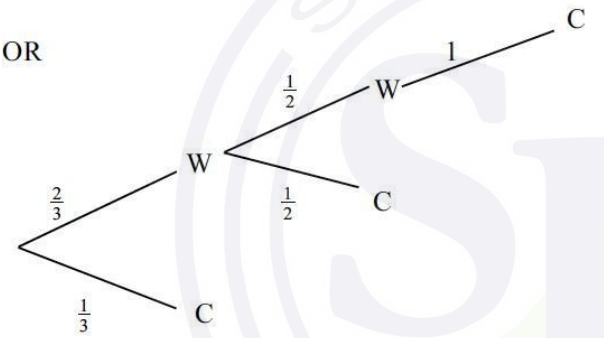
Question 15

4 (i) W = wrong, C = correct



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

OR



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

(ii)

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

B1		1, 2, 3 seen only oe
B1		2 correct probs

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

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

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

B1		3 correct probs

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

B1✓	**4**	Correct answer ft their probs provided $0.999 \leqslant \Sigma p \leqslant 1$

Question 16

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

Question 17

(i)

	Kitchen mess	Kitchen not mess	Total
On time	1/10	1/10	
Not on time	1/2		4/5
Total	3/5	4/10	

All values may be decimals or %		
B1		2 probabilities correct
B1		2 further probabilities correct
B1	**[3]**	2 further probabilities correct

(ii) P(not on time given kitchen mess) $= \frac{1/2}{3/5}$

= 5/6 o.e.

M1		A cond prob fraction seen (using corresponding combined outcomes and total)
A1	**[2]**	FT from their values, 3sf or better, <1, 3/5ft<1

Question 18

(i)	$P(2Es\ 1O) = \frac{3}{5}\times\frac{2}{4}\times\frac{2}{3}\times{}^3C_2 = \frac{3}{5}$ (0.6)	M1		5×4×3 seen in denom
		M1		Mult a prob by ${}^3C_2$ oe
		A1	**3**	Correct answer
	OR			
	$P(2Es\ 1O) = \frac{{}^3C_2\times{}^2C_1}{{}^5C_3} = \frac{6}{10}$	M1		${}^3C_x$ or ${}^yC_2$ or ${}^2C_1$ oe seen mult by $k \geqslant 1$ in num
	$= 0.6$	M1		${}^5C_3$ seen in denom
		A1		Correct answer
	OR			
	241, 247, 261, 267, 461, 467 = 6 options 124 126 127 146 147 167 246 247 267 467	M1		List at least 3 of 241, 247, 261, 267, 461, 467
		M1		${}^5C_3$ or list to get all 10 options in denom see below
	Prob = 6/10	A1		Correct answer
(ii)	124 126 127 146 147 167 246 247 267 467	M1		Attempt at listing with at least 7 correct
		A1		All correct and no others or all 60
		B1		1, 2, 4 only seen in top row
		B1		Any two correct
		B1	**5**	All correct

s	1	2	4
P(S =s)	6/10	3/10	1/10

Question 19

(i)	$0.3\times0.72 + 0.7\times x = 0.783$	M1		Eqn with sum of two 2-factor probs =0.783
		A1		Correct equation
	$x = 0.81$	A1	**3**	Correct answer
(ii)	P(S given not like) $= \frac{P(S\cap NL)}{P(NL)}$	B1		0.3×0.28 seen on its own as num or denom of a fraction
	$= \frac{0.3\times0.28}{0.3\times0.28 + 0.7\times0.19\ or\ 1-0.783}$	M1		Attempt at P(NL) either $(0.3\times p_1) + (0.7\times p_2)$ or 1 – 0.783 seen anywhere
		A1		Correct unsimplified P(NL) as num or denom of a fraction
	$= 0.387\ (12/31)$	A1	**4**	Correct answer

Question 20

(i)	$(1-x)0.9 + x\times0.24 = 0.801$	**M1**		Eqn with sum of two 2-factor probs = 0.801
		A1		Correct equation
	$x = 0.15$	**A1**	**[3]**	Correct answer
(ii)	P($\geqslant$100 times given $\leqslant$ 3 views)	**B1**		0.85×0.1 seen on its own as num or denom of a fraction
	$\frac{P(\geqslant 100\ \text{times}\cap\geqslant 3\ \text{views})}{P(\geqslant 3\ \text{views})} =$	**M1**		Attempt at P($\geqslant$ 3 views) either $(0.85\times p_1 + 0.15\times p_2)$ or 1 – 0.801 seen anywhere
	$\frac{0.85\times0.1}{0.85\times0.1 + 0.15\times0.76\ \text{or}\ 1-0.801}$	**A1**		Correct unsimplified P($\geqslant$ 3 views) as num or denom of a fraction
	$= 0.427$	**A1**	**[4]**	Correct answer

Question 21

(i)	$P(A) = \frac{1}{3} \times \frac{2}{3} + \frac{2}{3} \times \frac{1}{3} = \frac{4}{9}$ $P(B) = \frac{27}{36} = \frac{3}{4}$ $P(A \cap B) = \frac{12}{36} = \frac{1}{3}$ $P(A) \times P(B) = \frac{4}{9} \times \frac{3}{4} = \frac{1}{3}$ Independent as $P(A \cap B) = P(A) \times P(B)$	**M1** **M1** **B1** **M1** **A1 [5]**	Sensible attempt at $P(A)$ Sensible attempt at $P(B)$ 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
(ii)	Not mutually exclusive because $P(A \cap B) \neq 0$ Or give counter example e.g. 1 and 6	**B1√ [1]**	ft their $P(A \cap B)$

Question 22

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

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** **A1**	 2	Summing two 2-factor probs created by One of ¼ or ¾ multiplied by 20/28 or 8/28 Added to 4/10 or 6/10 × altn population prob Correct answer
(iii)	$P(X \mid F) = \frac{5/28}{7/20} = \frac{25}{49}(0.510)$	**M1** **A1**	 2	Their unsimplified country X probability (5/28) as num or denom of a fraction Or (their fair hair population) ÷ (total fair hair pop) 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** **A1**	 2	Expression of form $p^4(1-p)$ only, $p = 1/4$ or $3/4$ Correct answer
(iii)	P(all diff) $= \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times 4!$ $= \frac{3}{32}$ (0.0938) OR $1 \times \frac{3}{4} \times \frac{2}{4} \times \frac{1}{4} = \frac{3}{32}$	**M1** **M1** **A1**	 3	4! on numerator seen mult by k ⩾ 1 or 3×2×1 on num oe, must be in a fraction. 4^4 on denom or 4^3 on denom with the 3× 2× 1 Correct answer

Question 25

(i)	P(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** **A1** **M1** **A1** **A1**	 5	Attempt at $P(A \cap C)$ seen alone anywhere Correct answer seen as num or denom of a fraction Attempt at $P(C)$ seen anywhere Correct unsimplified answer seen as num or denom of a fraction Correct answer
(ii)	$(0.65)^n < 0.002$ $n > \lg(0.002)/\lg(0.65)$ $n = 15$	**M1** **M1** **A1**	 3	Eqn with 0.65 or 0.35, power n, 0.002 or 0.998 Attempt to solve their eqn by logs or trial and error need a power Correct answer

Question 26

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

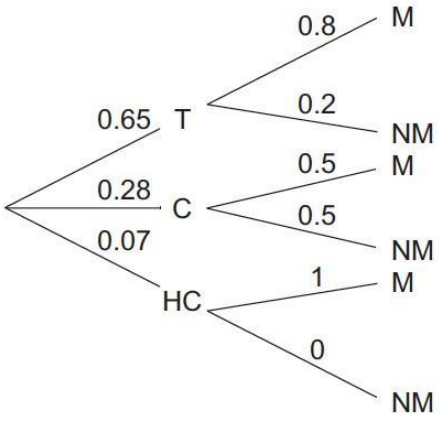
Question 27

(i)				

	Wears specs	Not wears specs	Total
RH	6	19	25
Not RH	2	3	5
Total	8	22	

		B1		One correct row or col including total other than the Total row/column
		B1	[2]	All correct
(ii)	P(X) = 25/30, P(Y) = 8/30	**M1**		P(X) or P(Y) from their table or correct from question (denom 30) oe
	P(X) × P(Y) = 25/30 × 8/30 = 200/900 = 2/9 P(X∩Y) = 6/30 = 1/5 ≠ P(X) × P(Y)	**M1**		Comparing their P(X) × P(Y) (values substituted) with their evaluated P(X∩Y) – not P(X)×P(Y)
	Not independent	**A1**	[3]	

Question 28

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

Question 29

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

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) × P(Y) and P($X \cap Y$) so long as independence has not been assumed
	Since P(X) × P(Y) = P ($X \cap Y$) therefore independent	**A1**	[5]	correct answer with all working correct

Question 31

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

Question 32

(i)	P(B, B) = 1/4 ×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 × 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**		¾ × p_1 + ¼ × 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)	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
		B1	One correct prob other than P(2) or P(3)
		B1	Correct P(3)
		B1	All correct
	Total:	**4**	
(iii)	$P(A1 \mid \text{Sum } 3) = \frac{P(A1 \cap \text{Sum3})}{P(\text{Sum3})} = \frac{5/10 \times 4/6}{13/30}$	**M1**	Attempt at P($A1\cap$ 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		
$P(GGG) = \frac{12}{40} \times \frac{11}{39} \times \frac{10}{38} \times \frac{28}{37} \times \frac{27}{36} \times \frac{26}{35} \times \frac{25}{34} \times {}^{7}C_3$	**M1**	Multiplying 3 green probs with 4 non-green probs, without replacement
	M1	Multiplying by ${}^{7}C_3$
= 0.242	**A1**	
Total:	**3**	

Question 35

(i)	P(S) = 0.65 × 0.6 + 0.35 × 0.75	**M1**	Summing two 2-factor probs or 1 – (sum of two 2-factor probs)
	= 0.653 (261/400)	**A1**	
	Total:	**2**	
(ii)	$P(Std \mid L) = \frac{P(Std \cap L)}{P(L)} = \frac{0.35 \times 0.25}{1 - 0.6525} = 0.0875/0.3475$	**M1**	'P(Std)' × '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 × 0.4(or 0.6) + 0.35 × 0.25(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(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) × 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) = 0.6×0.05 + 0.4×0.75	**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)	Var (B) = 45×0.6×0.4 Var (S)= 45×0.4×0.6	**B1**	One variance stated unsimplified
	Variances same	**B1**	Second variance stated unsimplified **and** at least one variance clearly identified, **and** both evaluated *or* showing equal *or* 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) = ${}^{10}C_2(0.4)^2(0.6)^8 + \ldots + {}^{10}C_9(0.4)^9(0.6) + (0.4)^{10}$	**M1** **M1**	Bin term ${}^{10}C_x p^x(1-p)^{10-x}$ $0 < p < 1$ Correct unsimplified answer
	= 0.954	**A1**	
	Total:	**3**	

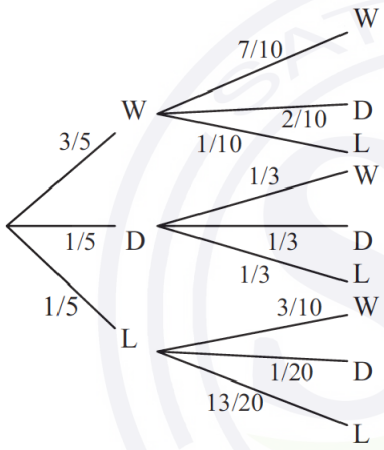
Question 38

P(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 *their* 'r value')
$q/6 + q/6 = 1/9$	**M1**	Correct equation with *their* '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 × 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**	

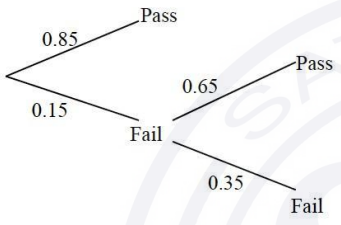
Question 40

(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.
		A1	All correct probs with fully correct shape and probs either fractions or decimals not 1.5/5 etc.
	Total:	**2**	
(ii)	$P(L_1 \text{ given } W_2) = \frac{P(L_1 \cap W_2)}{P(W_2)}$	**M1**	Attempt at P(L1∩W2) 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(W2) as sum of appropriate 3 two-factor probs OE seen anywhere
		A1	Unsimplified correct P(W2) 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 $P(R \mid T) = 1/9$	**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 $P(R \mid T) = 1/9$	**B1**	Value stated, not from P(R) × P(T) e.g. from probability space diagram
As $P(R) \times P(T) = P(R \cap T)$ OR as $P(R \mid T) = P(R)$	**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**	

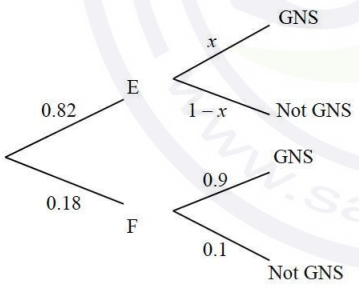
Question 42

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

Question 43

(i)	$P(4, 2H) = \frac{1}{4} \times {}^4C_2 \times (\frac{1}{3})^2(\frac{2}{3})^2$	**M1**	Multiplying their 2H expression by ¼ [P(4)]
		M1	Remaining factor is $(\frac{1}{3})^2(\frac{2}{3})^2$ [or $\frac{4}{81}$] multiplied by integer value $k \geqslant 1$ OE
	$= \frac{2}{27}$ (0.0741)	**A1**	
		3	
(ii)	$P(3, 3H) = \frac{1}{4} \times (\frac{1}{3})^3 = \frac{1}{108}$ (0.00926)	**B1**	
		1	
(iii)	$P(1, 1H) = \frac{1}{4} \times \frac{1}{3} = \frac{1}{12}$ (0.08333) $P(2, 2H) = \frac{1}{4} \times (\frac{1}{3})^2 = \frac{1}{36}$ (0.02778) $P(3, 3H) = \frac{1}{4} \times (\frac{1}{3})^3 = \frac{1}{108}$ (0.009259) $P(4, 4H) = \frac{1}{4} \times (\frac{1}{3})^4 = \frac{1}{324}$ (0.003086)	**M1**	Correct expression for 1 of P(1, 1H), P(2, 2H), P(4, 4H) Unsimplified (or better)
		M1	Summing their values for 3 or 4 appropriate outcomes for the 'game' with no additional outcomes.
	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)	$P(E \mid notGNS) = \frac{P(E \cap notGNS)}{P(notGNS)}$	**M1**	Attempt at P(E∩not GNS) seen as num or denom of fraction
		M1	Attempt at P(not GNS) 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(red/hatchback) = P(red hatchback) / P(hatchback) = 40/160 / 90/160	**M1**	Appropriate probabilities in a fraction
	= 4/9	**A1**	OE *Altn method: Direct from table* *M1 for 40/*a *or* b*/90,* a ≠ *160* *A1 for 40/90 oe*
		2	
3(iv)	*EITHER:* P(red) × P(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
	OR: P(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)	$P(M \mid A) = \frac{P(M \cap A)}{P(A)} = \frac{0.2\times0.3}{0.5}$	**M1**	'i' × 0.3 as num or denom of a fraction
		M1	0.5 (or (1 – 'i') × 0.55 + 'i' × 0.3 unsimplified) seen as 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 $P(F) + P(M \cap H)$
		A1	Correct unsimplified expression
	$= \frac{7}{10}$ (0.7) OE	**A1**	Correct final answer
	Method 2 $P(M \cap H') = \frac{3}{4} \times \frac{2}{5} = \frac{6}{20}$ (0.3)	**B1**	Seen, accept unsimplified
	$P(F \text{ or } M \cap H) = \mathbf{1} - P(M \cap H')$	**M1**	Numerical attempt at $1 - P(M \cap H')$
	$= 1 - \frac{3}{4} \times \frac{2}{5}$	**A1**	Correct unsimplified expression
	$= \frac{7}{10}$ (0.7) OE	**A1**	Correct final answer
(ii)	**Method 1** $(P(M) \times P(H) =) \frac{3}{4} \times \textit{their} \frac{13}{20} = \frac{39}{80}$ $(P(M \cap H) =) \frac{3}{4} \times \frac{3}{5} = 0.45$	**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 $P(M \mid H) = \frac{P(M \cap H)}{P(H)} = \frac{\frac{9}{20}}{\text{their } \frac{13}{20}} = \frac{9}{13}$ $P(M) = \frac{3}{4}$	**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** $P(M \mid H)$ **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	

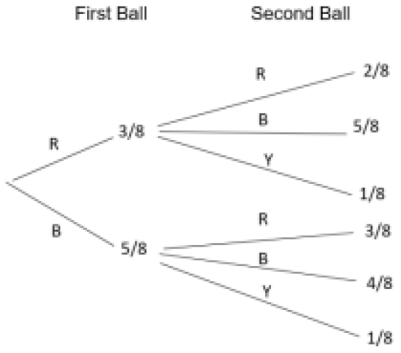
Question 48

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

Question 49

(i)	P(RB) + P(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(diff colours) = $\frac{64}{132}$ $(\frac{16}{33})$ (0.485) oe	A1	Correct answer
	Method 2 1 – P(BB) – P(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(diff colours) = $\frac{64}{132}$ $(\frac{16}{33})$ oe	A1	Correct answer
	Method 3 P(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><tr><td>Number of red socks</td><td>0</td><td>1</td><td>2</td></tr><tr><td>Prob</td><td>$\frac{14}{33}$</td><td>$\frac{16}{33}$</td><td>$\frac{3}{33}$</td></tr></table>	B1	Prob distribution table drawn, top row correct, condone additional values with $p = 0$ stated
		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)	$E(X) = 1 \times \frac{16}{33} + 2 \times \frac{3}{33} = \frac{16}{33} + \frac{6}{33} = \frac{22}{33}$ $(\frac{2}{3})$	B1ft	ft 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 × 2/8 + 5/8 × 4/8 = 3/32 + 5/16	**M1**	Correct unsimplified expression from their tree diagram, Σp = 1 on each branch
	= 13/32 (0.406)	**A1**	Correct answer
		2	
(iii)	P(RB) = 3 / 8 × 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 Σp ≠ 1 on each branch
	P(B) = 3/8 × 5/8 + 5/8 × 4/8 = 35/64	**M1**	Correct unsimplified expression for P(B) from their tree diagram seen as denominator of a fraction. Allow Σp ≠ 1 on each branch
	P(R|B) = P(RB) / P(B) = (15/64) ÷ (35/64) = 3/7 (0.429)	**A1**	Correct answer
		3	

Question 51

$P(SS) = \frac{4}{11} \times \frac{3}{10} = \frac{12}{110}$ (= 0.10911)	**B1**	One of P(SS), P(PP) or P(II) correct, allow unsimplified
$P(PP) = \frac{2}{11} \times \frac{1}{10} = \frac{2}{110}$ (= 0.01818) $P(II) = \frac{4}{11} \times \frac{3}{10} = \frac{12}{110}$ (= 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 *or* 3, b = 11 *or* 10, c = 2 *or* 1)
Total = $\frac{26}{110} = \frac{13}{55}$ oe (0.236)	**A1**	Correct final answer

Question 52

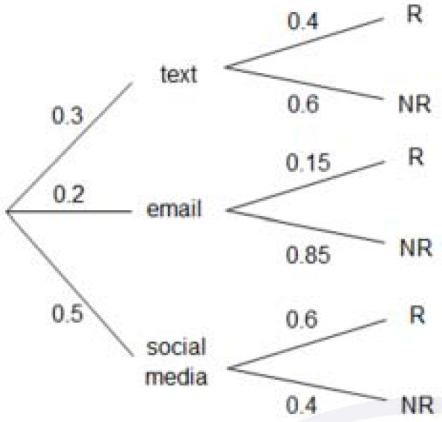
(i)	52/160 = 13/40, 0.325	**B1**	oe
		1	
(ii)	P(boy) = 96/160: P(Music) = 52/160 P(boy and Music) = 40/160	**M1**	Use of P(B) × P(M) = P(B∩M), appropriate probabilities used
	96/160 × 52/160 ≠ 40/160: Not independent	**A1**	Numerical comparison and conclusion stated
		2	
(iii)	**Method 1**		
	P(not Music/girl) = P(not Music and girl)/P(girl) (27/160) / (64/160)	**M1**	Appropriate probabilities in a fraction
	$= \frac{27}{64}$	**A1**	Correct answer www implies method
	Method 2		
	Direct from table	**M1**	*27/a or b/64, a ≠ 160*
	$\frac{27}{64}$	**A1**	Correct answer www implies method
		2	
(iv)	P(B M) × P(B NM) × P(G NM) **or** P(G M) × P(B NM) ×P(B NM)	**M1**	One scenario identified with 3 probs multiplied
	40/160 × 56/159 × 52/158 **or** 12/160 × 56/159 × 55/158	**A1**	One scenario correct (ignore multiplying factor)
	× 3! × 3!/2!	**B1**	Both multiplying factors correct
	0.17387 0.02759 P = 0.17387 + 0.02759	**M1**	Both cases attempted and added (multiplying factor not required), accept unsimplified
	= 0.201 Note: If score in this part is 0, award SCB1 for $\frac{1}{160}\times\frac{1}{159}\times\frac{1}{158}\times k$, for positive integer *k*, seen	**A1**	Correct answer, oe

Question 53

(i)	0.6 × 0.2 + 0.4 × 0.32	**M1**	Addition of 2 two-factor terms 0.6 × *a* + 0.4 × *b*
	= 0.248, $\frac{31}{125}$	**A1**	CAO
		2	
(ii)	**Method 1**		
	P(GS|Not Red socks) = $\frac{0.4\times0.68}{1-\textbf{\textit{(i)}}}$	**B1**	Correct [unsimplified] numerator seen in fraction
		M1	1 – their **(i)** as denominator in fraction
	= 0.362, $\frac{17}{47}$	**A1**	
	Method 2		
	P(GS|Not Red socks) = $\frac{0.4\times0.68}{0.6\times0.8+0.4\times0.68}$	**B1**	Correct [unsimplified] numerator seen in fraction
		M1	Correct or (their **(i)**)' as denominator in fraction
	= 0.362, $\frac{17}{47}$	**A1**	
		3	

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)

$$P(email|NR) = \frac{P(\text{email} \cap \text{NR})}{P(\text{NR})} = \frac{0.2 \times 0.85}{0.3 \times 0.6 + 0.2 \times 0.85 + 0.5 \times 0.4}$$

M1	P(email) × P(NR) seen as numerator of a fraction, consistent with *their* tree diagram
M1	Summing three appropriate 2-factor probabilities, consistent with *their* tree diagram, seen anywhere 0.55 oe (can be unsimplified) seen as denom of a fraction
A1	
A1	Correct answer
4	

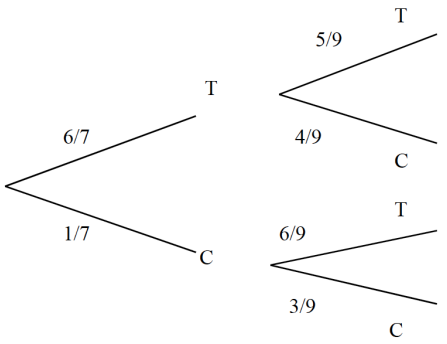
$= \frac{0.17}{0.18 + 0.17 + 0.2} = \frac{0.17}{0.55}$

$= 0.309, \frac{17}{55}$

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**	$P(S \cap T)$ found by multiplication scores M0 M1 awarded if *their* 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)		**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)
		B1	Either of second top pair or bottom of branches labels and probs correct
		B1	Both second pairs of branches labels and probs correct. No additional / further branches.
		3	
(ii)	<table><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>	**B1**	P(1) correct
		B1	P(0) or P(2) correct
		B1	**FT** Correct values in table, any additional values of T have stated probability of zero. For FT $\Sigma p = 1$,
		3	
(iii)	$E(X) = \frac{90}{63}$ $(\frac{10}{7})$ (1.43)	**B1**	Not FT
		1	
(iv)	$P(1^{st}\ C \mid 2^{nd}\ T) = \frac{P(C \cap T)}{P(T)} = \frac{\frac{1}{7}\times\frac{6}{9}}{\frac{1}{7}\times\frac{6}{9}+\frac{6}{7}\times\frac{5}{9}} = \frac{\frac{6}{63}}{\frac{36}{63}}$	**B1**	P(C ∩ T) attempt seen as numerator of a fraction, consistent with *their* tree diagram or correct
		M1	Summing 2 appropriate two-factor probabilities, consistent with *their* tree diagram or correct seen anywhere
		A1	$\frac{36}{63}$ oe or correct unsimplifed expression seen as numerator or denominator of a fraction
	$\frac{1}{6}$ oe	**A1**	Final answer
		4	

Question 57

Jameel: P(plum) = $\frac{5}{8}$, Rosa: P(plum) = $\frac{x}{x+6}$ $\frac{5}{8}\times\frac{x}{x+6}=\frac{1}{4}$	**M1**	*Their* 2 probabilities for P(plum) multiplied and equated to 1/4
	A1	Correct equation oe
(x =) 4	**A1**	**SC** correct answer with no appropriate equations i.e. common sense **B1**
	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 condititional 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(male) × P(not piano) = $\frac{160}{300} \times \frac{225}{300}$ $\left(\frac{8}{15} \times \frac{3}{4}\right) = \frac{2}{5}$	**M1**	P(M) × P(P ') seen Can be unsimplified but the events must be named in a product
	As P(male ∩ not piano) also = $\frac{120}{300} = \frac{2}{5}$ The events are **Independent**	**A1**	Numerical comparison and correct conclusion

Question 60

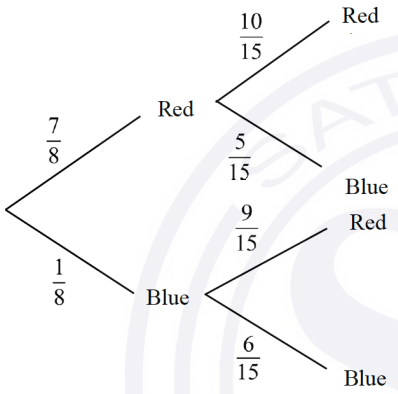
(i)	$\frac{120}{300} = 0.4$	**B1**	OE
		1	
(ii)	P(male) × P(not piano) = $\frac{160}{300} \times \frac{225}{300}$ $\left(\frac{8}{15} \times \frac{3}{4}\right) = \frac{2}{5}$	**M1**	P(M) × P(P ') seen Can be unsimplified but the events must be named in a product
	As P(male ∩ not piano) also = $\frac{120}{300}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

Question 61

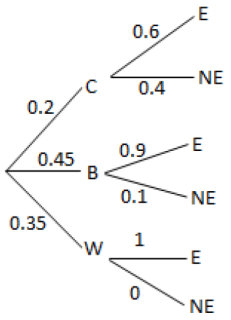
(i)	$0.4x + 0.6 \times 2x = 0.36$ or $0.4(1 - x) + 0.6(1 - 2x) = 0.64$	**M1**	$0.4a + (1 - 0.4)b = 0.36$ or 0.64, a, b terms involving x
	$1.6x = 0.36$ $x = 0.225$	**A1**	Fully justified by algebra AG
		2	

(ii)	$P(H \mid L') = \frac{0.4(1-x)}{1-0.36} = \frac{0.4\times(1-0.225)}{0.64} = \frac{0.4\times0.775}{0.4\times0.775+0.6\times0.55}$	**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)	Box A Box B  	**B1**	Both correct probs, box A
		B1	2 probs correct for box B
		B1	All correct probs for box B
		3	
(b)	$\frac{7}{8}\times\frac{5}{15}+\frac{1}{8}\times\frac{9}{15}$	**M1**	Two 2 factor terms added, correct or FT *their* **6(a)**.
	$=\frac{44}{120}$ $\left[\frac{11}{30}\text{ or }0.367\right]$	**A1**	OE
		2	
(c)	$P(\text{A blue} \mid \text{B blue}) = \frac{P(\text{A blue} \cap \text{B blue})}{P(\text{B blue})}$ $= \frac{\frac{1}{8}\times\frac{6}{15}}{\frac{7}{8}\times\frac{5}{15}+\frac{1}{8}\times\frac{6}{15}} = \frac{\frac{1}{20}}{\frac{41}{120}}$	**M1**	*their* $\frac{1}{8}\times\frac{6}{15}$ seen as numerator or denom of fraction
		M1	*their* $\frac{7}{8}\times\frac{5}{15}+\frac{1}{8}\times\frac{6}{15}$ seen
		M1	*their* $\frac{7}{8}\times\frac{5}{15}+\frac{1}{8}\times\frac{6}{15}$ seen as denominator
	$=\frac{6}{41}$ or 0.146	**A1**	
		4	

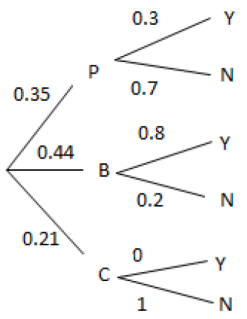
Question 63

(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 or $\frac{12}{515}$	**A1**
		4

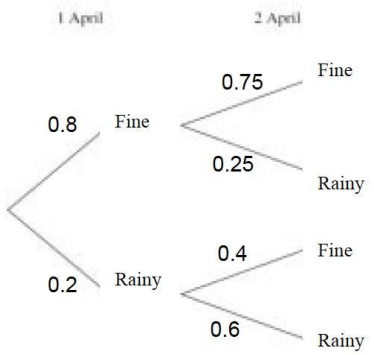
Question 64

(a)	$\frac{56}{500}$ or $\frac{14}{125}$ or 0.112	**B1**
		1
(b)	$P(D\|S) = \frac{P(D \cap S)}{P(S)} = \frac{120}{280}$	**M1**
	$\frac{120}{280}$ or $\frac{3}{7}$	**A1**
		2
(c)	$P(\text{hockey}) = \frac{220}{500} = 0.44$ $P(\text{Amos or Benn}) = \frac{242}{500} = 0.484$ $P(\text{hockey} \cap \text{A or B}) = \frac{104}{500} = 0.208$ $P(H) \times P(A \cup B) = P(H \cap (A \cup B))$ if independent	**M1**
	$\frac{220}{500} \times \frac{242}{500} = \frac{1331}{6250}$ so not independent	**A1**
		2

Question 65

(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 prob 0	**B1**
		2
(b)	$0.35\times0.3+0.44\times0.8\,(+0)$	**M1**
	0.457	**A1**
		2
(c)	P(not B|not fruit) = $\dfrac{P(B'\cap F')}{P(F')}$	**M1**
	$\dfrac{0.35\times0.7+0.21\times1}{1-their\,(\mathbf{b})}$	**M1**
	$\dfrac{0.455}{0.543}$ (**M1** for 1 – *their* **(b)** or summing three appropriate 2-factor probabilities, correct or consistent with *their* tree diagram as denominator)	**M1**
	0.838 or $\dfrac{455}{543}$	**A1**
		4

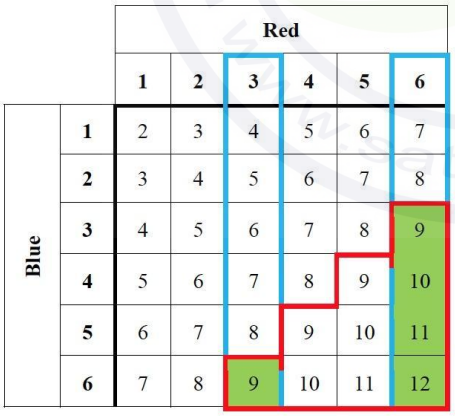
Question 66

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

(b)	$0{\cdot}8 \times 0{\cdot}75 + 0{\cdot}2 \times 0{\cdot}4$ $(= 0{\cdot}6 + 0{\cdot}08)$	**M1**	Correct or FT from *their* 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)	$0{\cdot}8 \times 0{\cdot}75 \times 0{\cdot}25 + 0{\cdot}8 \times 0{\cdot}25 \times 0{\cdot}6$	**M1**	$a \times b \times c + a \times 1\text{-}b \times d$, $0 < c, d \leqslant 1$, a, b consistent with *their* tree diagram or correct, no additional terms
	$0{\cdot}15 + 0{\cdot}12$	**A1**	At least one term correct, accept unsimplified
	0.27	**A1**	Final answer
		3	
(d)	P(Y) = *their* **(c)** $+ 0{\cdot}2 \times 0{\cdot}4 \times 0{\cdot}25 + 0{\cdot}2 \times 0{\cdot}6 \times 0{\cdot}6$ $(= 0{\cdot}362)$	**B1 FT**	*their* **(c)** $+ e \times f \times g + e \times (1\text{-}f) \times h$, $0 < g, h \leqslant 1$, e, f consistent with *their* tree diagram, or correct
	$P(X|Y) = \frac{\textit{their}(c)}{\textit{their}\,P(Y)} = \frac{0.27}{0.362}$	**M1**	*their* **4(c)** (or correct)/*their* previously calculated and identified P(Y) or a denominator involving 3 or 4 3-factor probability terms consistent with *their* tree diagram & third factor $0 < p < 1$
	$0{\cdot}746, \frac{373}{500}$ or $\frac{135}{181}$	**A1**	(0.7458…)
		3	

Question 67

(a)		**M1**	Complete outcome space or or listing A and B outcomes or listing A∩B outcomes
	$P(A \cap B) = \frac{5}{36}$	**A1**	With evidence
		2	
(b)	$P(A) \times P(B) = \frac{1}{3} \times \frac{10}{36}$	**M1**	*Their* $\frac{1}{3} \times$ *their* $\frac{10}{36}$ seen
	$\frac{5}{54} \neq \frac{5}{36}$ so not independent	**A1**	$\frac{5}{54}, \frac{5}{36}$, P(A) × P(B) and P(A∩B) seen in workings and correct conclusion stated Condone $\frac{5}{36}$ being stated in **(a)**

Question 68

'(a)(i)	$\left[\frac{104+31}{400}=\right]\frac{135}{400}, \frac{27}{80}$, 0·3375	**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) × *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		
	$P(M\cap S)=\frac{31}{400}$ $P(S)=\frac{135}{400}$ $P(M)=\frac{180}{400}$ $P(M\|S)=\frac{\frac{31}{400}}{\frac{135}{400}}=\frac{31}{135}$, $0.2296\ldots\neq\frac{180}{400}$ so NOT independent	**M1**	$[P(M\|S)=]\frac{\textit{their}\,P(M\cap S)}{\textit{their}\,P(S)}$ (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 $0{\cdot}61715 \leqslant p \leqslant 0{\cdot}61722$, 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 $0{\cdot}61715 \leqslant p \leqslant 0{\cdot}61722$, WWW.
		3	
'(b)(ii)	[p = 0·3] Mean = 0·3 × 90 = 27; variance = 0·3 × 90 × 0·7 = 18·9	**B1**	Correct mean and variance, allow unsimplified. Condone σ = 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 ±standardising formula with a numerical value for '31·5'.
		M1	Using either 31·5 or 32·5 within a ±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<…) in final solution, must be probability.
	= 0·850	**A1**	Allow $0{\cdot}8495 < p \leqslant 0{\cdot}85(0)$, final answer WWW.
		5	

Question 69

(a)	$0.2[\times 1]+0.45\times 0.4+0.35\times 0.3$	**M1**	0·2 [× 1] + 0·45 × b + 0·35 × c, b = 0·4, 0·6 c = 0·3, 0·7
	0·485 or $\frac{97}{200}$	**A1**	
		2	
(b)	$P(Y \mid \overline{H}) = \frac{P(Y \cap \overline{H})}{P(\overline{H})} = \frac{0.35\times 0.7}{1-\textit{their}\textbf{(a)}} = \frac{0.245}{0.515}$	**B1**	0·35 × 0·7 or 0·245 seen as numerator or denominator of fraction.
		M1	0·515 or 1 – *their* **(a)** or [0·3 × 0 +] 0·45 × d + 0·35 × e, where d = *their b′*, e = *their c′* seen as denominator of fraction.
	0·476 or $\frac{49}{103}$	**A1**	$0.4757 \leqslant p \leqslant 0.476$
		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**	*Their* 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)		
	$P(\mathrm{G} \mid \mathrm{S}) = \frac{P(G \cap S)}{P(S)} = \frac{\frac{177}{800}}{\frac{223+177+40}{800}} = \frac{\frac{177}{800}}{\frac{440}{800}} = \frac{\frac{177}{800}}{\frac{11}{20}}$ or 0.55	**M1**	*Their* 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 *their* mean and variance into ±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**	$0.965 \leqslant p \leqslant 0.966$
		5	

Question 71

(a)	P(not late) = 0.4 × 0.45 + 0.35 × 0.3 + 0.25 × (1 – x) or P(late) = 0.4 × 0.55 + 0.35 × 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)	$\left[P(train\|late)=\frac{P(train\cap late)}{P(late)}\right]$ $=\frac{0.35\times0.7}{1-0.48}$ or $\frac{0.35\times0.7}{0.4\times0.55+0.35\times0.7+0.25\times their\,0.22}$	B1	0.35×0.7 or 0.245 seen as numerator of fraction
		M1	P(late) seen as a denominator with *their* probability as numerator (Accept $\frac{their\ p}{0.52}$ or $\frac{their\ p}{0.22+0.245+0.25\times their\,0.22}$)
	= 0.471 or $\frac{49}{104}$	A1	
		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) × P(PP) + P(W1F) × P(W2P) × P(PP)] 0.8×0.3 + 0.2×0.6×0.3	M1	Consistent with *their* tree diagram or correct
	0.276 or $\frac{69}{250}$	A1	
		2	
(c)	$P(W1\|P)=\frac{P(W1\cap\text{Practical})}{P(\text{getting place})}=\frac{0.8\times0.3}{their(b)}\left[=\frac{0.24}{0.276}\right]$	M1	Correct expression or FT *their* **(b)**
	$\frac{20}{23}$ 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)	$\frac{4}{10}\times their\frac{10}{x+10}$	**M1**	Method consistent with *their* tree diagram.
	$\frac{4}{x+10}$	**A1**	AG
		2	

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

Question 74

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

Question 75

$\left[\text{P}(T\|B')=\frac{\text{P}(T\cap B')}{\text{P}(B')}\right]$ $\text{P}(B')=0.45\times0.7+0.35\times0.4+0.2\times1$ $\left[=0.655, \frac{131}{200}\right]$	**M1**	$0.45\times a+0.35\times b+0.2[\times1], a=0.7, 0.3b=0.4, 0.6$, seen anywhere.
	A1	Correct, accept unsimplified.
$\text{P}(T\cap B')=0.35\times0.4$ [= 0.14, $\frac{7}{50}$]	**M1**	Seen as numerator or denominator of a fraction.
$\text{P}(T\mid B')=\frac{their\,0.14}{their\,0.655}$	**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

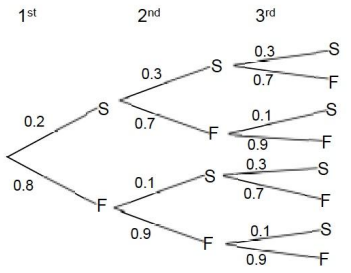
(a)	[Probability of lemon = $\frac{3}{15}=\frac{1}{5}$] $\left[\left(\frac{4}{5}\right)^6\times\frac{1}{5}=\right]\frac{4096}{78125}, 0.0524$	**B1**	0.0524288 rounded to more than 3SF if final answer
		1	
(b)	$\left(1-\frac{1}{5}\right)^6$	**M1**	or $\left(\frac{4}{5}\right)^6$. FT *their* $\frac{1}{5}$ 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
	$\frac{24}{91}, 0{\cdot}264$	**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
	$\frac{24}{91}, 0{\cdot}264$	**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.
	$\frac{24}{91}, 0{\cdot}264$	**A1**	0.263736 rounded to more than 3SF
	Alternative method for question 6(c)		
	$\frac{{}^{10}C_3}{{}^{15}c_3}$	**M1**	
	$\frac{24}{91}, 0{\cdot}264$	**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: $\frac{7}{a}\times\frac{5}{b}\times\frac{3}{c}$, $13 \leqslant a,b,c \leqslant 15$
		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
		3	
(e)	$\frac{\frac{7}{15}\times\frac{6}{14}\times\frac{5}{13}+\frac{3}{15}\times\frac{7}{14}\times\frac{6}{13}\times 3}{their(c)}$ $\left[=\frac{14}{65}\div\frac{24}{91}\right]$	**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** $\frac{210}{2730}, \frac{1}{13}$ seen in numerator
		M1	Fraction with *their* **(c)** or correct in denominator $\left(\frac{720}{2730}, \frac{24}{91}, 0.263736\right)$
	$=\frac{49}{60}$, 0·817	**A1**	Accept 0.81$\dot{6}$
	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 *their* numerator of **6(c)** in denominator
	$=\frac{49}{60}$, 0·817	**A1**	Accept 0.81$\dot{6}$
		4	

Question 77

(a)	[P(>2) = 1 – P(0,1,2) =] $1-({}^7C_0\ 0.18^0\ 0.82^7+{}^7C_1\ 0.18^1\ 0.82^6+{}^7C_2\ 0.18^2\ 0.82^5)$	**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. $0{\cdot}115 \leqslant p < 0{\cdot}1155$ not from wrong working
		3	
(b)	[P(at least 1 day of rain) = 1 – P(0) = $1-(0.82)^7$ =] 0.7507	**B1**	AWRT 0.751 seen
	[P(exactly 2 periods) =] $0.7507^2\times(1-0.7507)\times 3$	**M1**	FT *their* $1-p^7$ or *their* 0.7507 if identified, not 0.18, 0.82 Accept $\times{}^3C_r$, r=1,2 or $\times{}^3P_1$ for ×3 Condone ×2
	0.421	**A1**	Accept $0.421 \leqslant p \leqslant 0.4215$ **SC B1** if 0/3 scored for final answer only $0.421 \leqslant p \leqslant 0.4215$
		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 $0.2\times0.7\times0.9 = 0.126$ FSF $0.8\times0.1\times0.7 = 0.056$ FFS $0.8\times0.9\times0.1 = 0.072$	**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 = $1-0.8\times0.9\times0.9=$]$0.352\left(\frac{44}{125}\right)$	**B1 FT**	Accept unsimplified.
	P(exactly 1 success | at least 1 success)= $\frac{\textit{their}\,0.254}{\textit{their}\,0.352}$	**M1**	Accept unsimplified.
	$0.722, \frac{127}{176}$	**A1**	$0.7215 < p \leqslant 0.722$
		5	
(c)	$0.8\times0.9\times0.9\times0.1\times0.3\times0.3 = 0.005832$ [FFFSSS] $0.2\times0.3\times0.3\times0.7\times0.9\times0.9 = 0.010206$ [SSSFFF]	**M1**	$a \times b \times c \times d \times e \times f$ FT from *their* 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**	$0.0465 \leqslant p < 0.04652$
		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**	$0.04448 \leqslant p \leqslant 0.0445$
		4	

Question 80

(a)	YYY: $\frac{5}{12}\times\frac{4}{11}\times\frac{3}{10} = \frac{60}{1320},\frac{1}{22}$ OOO: $\frac{4}{12}\times\frac{3}{11}\times\frac{2}{10} = \frac{24}{1320},\frac{1}{55}$ RRR: $\frac{3}{12}\times\frac{2}{11}\times\frac{1}{10} = \frac{6}{1320},\frac{1}{220}$	**M1**	**Either** $12\times11\times10$ in denominator **or** $a\times(a-1)\times(a-2)$, $a = 5, 4, 3$ in numerator seen in at least one expression.
		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.
		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
	[Total =] $\frac{90}{1320},\frac{3}{44},0.0682$	**A1**	0.06818. Dependent only upon the second M mark.
(a)	**Alternative method for question 7(a)**		
	YYY: $\frac{{}^5C_3}{{}^{12}C_3} = \frac{10}{220},\frac{1}{22}$ OOO: $\frac{{}^4C_3}{{}^{12}C_3} = \frac{4}{220},\frac{1}{55}$ RRR: $\frac{{}^3C_3}{{}^{12}C_3} = \frac{1}{220}$	**M1**	Either ${}^{12}C_3$ in denominator or ${}^aC_3$ in numerator seen in at least one expression.
		A1	One expression $\frac{{}^aC_3}{{}^{12}C_3}$ $a = 5, 4, 3$
		M1	$\frac{{}^5C_3}{{}^{12}C_3}+\frac{{}^4C_3}{{}^{12}C_3}+\frac{{}^3C_3}{{}^{12}C_3}$ Condone $\frac{1}{22}+\frac{1}{55}+\frac{1}{220}$ OE
	[Total =] $\frac{90}{1320},\frac{3}{44},0.0682$	**A1**	0.06818. Dependent only upon the second M mark.
		4	
(b)	[P(YYY | all same colour) =] $\frac{60}{1320}\div\frac{90}{1320}$	**M1**	$\frac{\textit{their}\,\mathrm{P(YYY)}\text{ or }\frac{60}{1320}\text{ or }\frac{1}{22}}{\textit{their}\,7(\mathrm{a})\text{ or }\frac{90}{1320}\text{ or }\frac{3}{44}}$
	$\frac{2}{3}$, 0.667	**A1**	OE
		2	
'(c)	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.		
	Method 1		
	[1 – no orange =] $1-\frac{8}{12}\times\frac{7}{11}\times\frac{6}{10}$ or $1-\frac{{}^8C_3}{{}^{12}C_3} = 1-\frac{14}{55}$	**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.
		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 $\frac{41}{55}$).
	$\frac{41}{55}$	**A1**	$0.745 \leqslant p \leqslant 0.74545$ If M0 scored **SC B1** $0.745 \leqslant p \leqslant 0.74545$.

'(c)	**Method 2**		
	$P(1\ O)=\left(\frac{4}{12}\times\frac{3}{11}\times\frac{2}{10}+\frac{4}{12}\times\frac{5}{11}\times\frac{4}{10}+2\times\frac{4}{12}\times\frac{5}{11}\times\frac{3}{10}\right)\times 3=\frac{672}{1320}$ $P(2O)=\frac{4}{12}\times\frac{3}{11}\times\frac{8}{10}\times 3=\frac{288}{1320}$ $P(3O)=\frac{24}{1320}$	**B1**	P(1 O)or P(2 O) correct, accept unsimplified.
		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 $d = 12$, $e = 12$.
	[Total =] $\frac{984}{1320}=\frac{41}{55}$, 0.745	**A1**	$0.745 \leqslant p \leqslant 0.74545$ If M0 scored **SC B1** $0.745 \leqslant p \leqslant 0.74545$.
	Method 3		
	$O\ Y\ R = {}^4C_1\times{}^5C_1\times{}^3C_1 = 60$ $O\ R\ R = {}^4C_1\times{}^3C_2 = 12$ $O\ Y\ Y = {}^4C_1\times{}^5C_2 = 40$ $O\ O\ Y = {}^4C_2\times{}^5C_1 = 30$ $O\ O\ R = {}^4C_2\times{}^3C_1 = 18$ $O\ O\ O = {}^4C_3 = 4$ Total = 164 $\text{Prob} = \frac{164}{{}^{12}C_3}$	**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.
		M1	3 correct scenarios (1, 2 or 3 orange sweets) added on numerator, denominator ${}^{12}C_3$
	$\frac{984}{1320}=\frac{41}{55}$, 0.745	**A1**	$0.745 \leqslant p \leqslant 0.74545$ If M0 scored **SC B1** $0.745 \leqslant p \leqslant 0.74545$.
'(c)	**Method 4**		
	$P(R\ R\ O)=\frac{3}{12}\times\frac{2}{11}\times\frac{4}{10}=\frac{1}{55}$ $P(R\ O\ )=\frac{3}{12}\times\frac{4}{11}=\frac{1}{11}$ $P(R\ Y\ O)=\frac{3}{12}\times\frac{5}{11}\times\frac{4}{10}=\frac{1}{22}$ $P(O\ )=\frac{4}{12}=\frac{1}{3}$ $P(Y\ R\ O)=\frac{5}{12}\times\frac{3}{11}\times\frac{4}{10}=\frac{1}{22}$ $P(Y\ O\ )=\frac{5}{12}\times\frac{4}{11}=\frac{5}{33}$ $P(Y\ Y\ O)=\frac{5}{12}\times\frac{4}{11}\times\frac{4}{10}=\frac{2}{33}$	**B1**	$P(R\ ^\wedge\ ^\wedge)=\frac{17}{110}$ or $P(Y\ ^\wedge\ ^\wedge)=\frac{17}{66}$. Accept unsimplified.
		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 $d = 12$, $e = 12$.
	$\frac{984}{1320}=\frac{41}{55}$, 0.745	**A1**	$0.745 \leqslant p \leqslant 0.74545$ If M0 scored **SC B1** $0.745 \leqslant p \leqslant 0.74545$.

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 $v \times (1 - 0.6 \times 0.8)$ $0 < v \leqslant 1$ 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)	$P(\text{fails first or second level} \mid \text{finishes game}) = \dfrac{P(\text{fails first or second level} \cap \text{finishes game})}{\textit{their}\ \textbf{(b)}}$	**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)**
	Numerator = P(S SF) + P(FS S) = $0.6 \times 0.6 \times 0.2 + 0.4 \times 0.3 \times 0.4 = 0.072 + 0.048 = 0.12$	**A1**	Both correct accept unsimplified expression. No additional terms
	Required probability = $\dfrac{0.12}{\textit{their}\ \textbf{(b)}}$	**M1**	$\dfrac{\textit{Their}\ \text{sum of two 3-term probabilities as numerator}}{\textit{their}\ \textbf{(b)}\ \text{or correct}}$
	0.321 or $\dfrac{25}{78}$	**A1**	$0.3205 < p \leqslant 0.321$
		4	

Question 82

(a)	[P(SR TR) + P(SW TR) =] $\dfrac{3}{8} \times \dfrac{2}{7} + \dfrac{5}{8} \times \dfrac{3}{7}$	**M1**	$\dfrac{3}{8} \times \dfrac{2}{7} + k$ or $l + \dfrac{5}{8} \times \dfrac{3}{7}$ $0 < k,l < 1$
	$= \dfrac{21}{56}, \dfrac{3}{8}, 0.375$	**A1**	**SC B1** for $\dfrac{3}{8}$ with no explanation.
		2	
(b)	[RRWR, WRRR, WRWR] $\dfrac{3}{8} \times \dfrac{2}{7} \times \dfrac{5}{6} \times \dfrac{1}{5} + \dfrac{5}{8} \times \dfrac{3}{7} \times \dfrac{2}{6} \times \dfrac{1}{5} + \dfrac{5}{8} \times \dfrac{3}{7} \times \dfrac{4}{6} \times \dfrac{2}{5}$ $[= \dfrac{1}{56} + \dfrac{1}{56} + \dfrac{1}{14}]$	**M1**	$\dfrac{m}{8} \times \dfrac{n}{7} \times \dfrac{o}{6} \times \dfrac{q}{5}$ $1 \leqslant m,n,o,q \leqslant 5$, $m \neq n \neq o \neq q$
		A1	Probability for one scenario correct, accept unsimplified.
		M1	Adding probabilities for 3 correct scenarios and no incorrect.
	$= \dfrac{180}{1680}, \dfrac{3}{28}, 0.107$	**A1**	Or 0.1071428… to 4SF or better. **SC B1** for 3/28 with inadequate explanation.
		4	
(c)	[P(S first disc R |T2) =] $\dfrac{\frac{30}{1680}}{\frac{3}{28}} = \dfrac{\frac{1}{56}}{\frac{3}{28}}$	**M1**	$\dfrac{\textit{their}\ P(RRWR)\ or\ \frac{3}{8} \times \frac{2}{7} \times \frac{5}{6} \times \frac{1}{5}}{\textit{their}\ 7(\mathbf{b})\ - \textit{must be a prob or}\ \frac{3}{28}}$
	$\dfrac{1}{6}, 0.167$	**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 *their* 3 term expression (2 terms involving x) to 0.235
	$x = 0.15$	**A1**	
		3	
(b)	$\left[P(car \mid not\ late) = \dfrac{P(car\ and\ not\ late)}{P(not\ late)}\right]$ $\dfrac{0.1 \times (1 - 0.3)}{1 - 0.235}$	**M1**	$0.1 \times (1 - 2 \times \textit{their}\ x)$ or 0.1×0.7 as numerator **and** $0.2 \times (1 - \textit{their}\ x) + 0.1 \times (1 - 2 \times \textit{their}\ x) + 0.7 \times 0.75$ with values substituted or $1 - 0.235$ or 0.765 as denominator of fraction. Condone $0.2 \times (1 - \textit{their}\ x) + 0.1 \times (1 - \times \textit{their}\ x) + 0.7 \times 0.75$ as denominator consistent with **1(a)**.
	$\left[\dfrac{0.07}{0.765} =\right] 0.0915, \dfrac{70}{765}, \dfrac{14}{153}$	**A1**	0.091503267 to at least 3SF. If M0 scored **SC B1** for 0.091503267 to at least 3SF.
		2	

Question 84

(a) **Method 1: Scenarios identified ignoring unbiased coin**

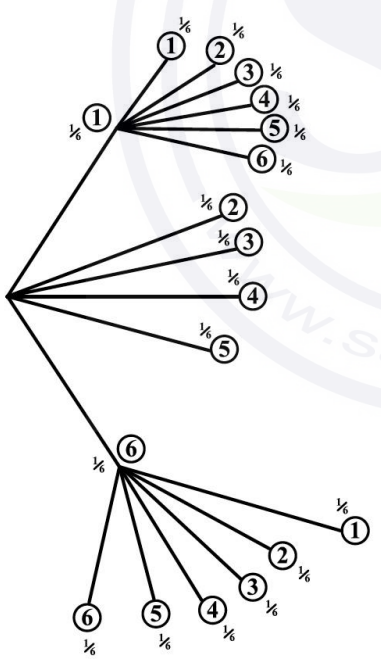
$P(BH_1\ BT_2) = \frac{1}{4}\times\frac{3}{4}=\frac{3}{16}$ $P(BT_1\ BH_2) = \frac{3}{4}\times\frac{1}{4}=\frac{3}{16}$ $P(BH_1\ BH_2) = \frac{1}{4}\times\frac{1}{4}=\frac{1}{16}$	**M1**	All 3 different calculations seen unsimplified.
$\frac{3}{16}+\frac{3}{16}+\frac{1}{16}=\frac{7}{16}$	**A1**	Clear identification of **all scenarios**, linked probabilities and sum. AG

(b)

$\left[P(A\|B)=\frac{P(A\cap B)}{P(B)}=\right]\ \frac{\frac{1}{2}\times\frac{1}{4}\times\frac{1}{4}}{\frac{7}{16}}=\frac{\frac{1}{32}}{\frac{7}{16}}$	**M1**	*Their* identified P(*HHH*) or correct as numerator **and** *their* identified P(B) or correct as denominator. Either numerical expression acceptable.
$=\frac{1}{14}$, 0.0714	**A1**	Accept 0.071428… rounded to at least 3SF.
	2	

Question 85

(a)



	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).
	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).
	2	

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

Question 86

$(1-x)\times 0.7\times 0.9=0.36$	**M1**	$(1-x)\times a\times b=0.36,\ a=0.7\text{ or }0.3,\ b=0.9\text{ or }0.1$
	B1	$(1\text{-}x)\times 0.7\times 0.9=0.36$, $(1\text{-}x)\times 0.63=0.36$, $0.63-0.63x=0.36$ 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

$P(A)=\frac{1}{2}$, $P(B)=\frac{8}{24}=\frac{1}{3}$,	**B1**	Both stated, accept unsimplified.
$P(A\cap B)=\frac{1}{6}$	**M1**	Evidence that independence properties not used.
$P(A)\times P(B)=\frac{1}{2}\times\frac{1}{3}=\frac{1}{6}$ so events are independent	**A1**	Evaluated and conclusion stated. $P(A)\times P(B)$ and $P(A\cap B)$ seen.
	3	

Question 88

(a)	$P(A) = \frac{10}{36}$ $P(B) = \frac{24}{36}$	**B1**	Accept $P(A) = \frac{10}{36}, \frac{5}{18}, 0.278$ and $P(B) = \frac{24}{36}, \frac{2}{3}, 0.667$.
	$P(A \cap B) = \frac{8}{36}$	**B1**	
	$\frac{10}{36} \times \frac{24}{36}$	**M1**	*Their* $P(A) \times$ *their* $P(B)$ seen numerically, $0 \leqslant$ their $P(A), P(B) \leqslant 1$.
	$= \frac{5}{27}, 0.185 \left[\neq \frac{8}{36} \right]$ Events are not independent	**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	

i(b)	$\left[P(B\|A') = \frac{P(B \cap A')}{P(A')} = \right]$ $\frac{16}{36} \Big/ \left(1 - \frac{10}{36}\right)$	**M1**	$\left[P(B \cap A') = \right] \frac{16}{36}, 0.4444$ 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.
	$= \frac{8}{13}$	**A1**	Final answer $\frac{16}{26}, \frac{8}{13}, 0.6153846$ to at least 3SF.
	Alternative Method for Question 5(b): Direct from outcome tables		
	$\left[P(B\|A') = \frac{\text{Number of outcomes}(B \cap A')}{\text{Number of outcomes}(A')} = \right]$ $\frac{16}{26}$	**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 $\frac{16}{26}, \frac{8}{13}, 0.6153846$ to at least 3SF.
		3	