Question	Answer	Marks	Guidance
6(a)	$p+q+0.65=1$	**B1**	Sum of probabilities = 1.
	$p+2q+0.15=0.55$	**B1**	Use given information.
	Solve 2 linear equations	**M1**	Either a single expression with one variable eliminated formed or two expressions with both variables on the same side seen with at least one variable value stated.
	$p=0.3, \frac{3}{10}, \quad q=0.05, \frac{1}{20}$	**A1**	CAO, both WWW If **M0** with correct answers **SC B1**.
		4	
6(b)	Var (X) = *their* $0.3+4\times$*their* $0.05+9\times0.05-0.55^2$	**M1**	Appropriate variance formula including $(E(X))^2$, accept unsimplified.
	$0.6475 \left[\frac{259}{400}\right]$	**A1**	CAO (must be exact).
		2	
6(c)	$1-P(0, 1, 2) = 1-({}^{12}C_0\, 0.3^0\, 0.7^{12} + {}^{12}C_1\, 0.3^1\, 0.7^{11} + {}^{12}C_2\, 0.3^2\, 0.7^{10})$	**M1**	One correct term: ${}^{12}C_x\, p^x\, (1-p)^{12-x}$ for $0<x<12$, $0<p<1$.
	$1-(0.01384+0.07118+0.16779)$	**A1FT**	Correct unsimplified expression, or better in final answer. Unsimplified expression must be seen to **FT** *their p* from **6(a)** or correct.
	0.747	**A1**	
		3	
6(d)	$(0.95)^8\times0.05 = 0.0332$ or $0.95^8-0.95^9=0.0332$	**B1**	Evaluated.
		1	

Question	Answer	Marks	Guidance
2	$p+p+0.1+q+q=1$	**B1**	Sum of probabilities = 1
	$0.1+2q=3(2p)$	**B1**	Use given information
	Attempt to solve two correct equations in p and q	**M1**	**Either** use of Substitution method to form a single equation in either p or q and finding values for both unknowns. **Or** use of Elimination method by writing both equations in same form (usually $ap+bq=c$) and + or – to find an equation in one unknown and finding values for both unknowns.
	$p=\frac{1}{8}$ or 0.125 and $q=\frac{13}{40}$ or 0.325	**A1**	CAO, both WWW
		4	

Question	Answer	Marks	Guidance
4(a)	x: 0, 1, 2, 3, 4 P($X=x$): $\frac{3}{16}$, $\frac{1}{16}$, $\frac{3}{16}$, $\frac{5}{16}$, $\frac{4}{16}$ 0.1875, 0.0625, 0.1875, 0.3125, 0.25 Accept: 0.188, 0.0625, 0.188, 0.313, 0.25	**B1**	Table with correct x values and one correct probability.
		B1	2 more probabilities correct linked to the correct x value, need not be in table, accept un-simplified.
		B1	5 correct probabilities linked with correct outcomes. **SCB1** 5 non-zero probabilities (not all 1/5) summing to 1 placed in a probability distribution table with correct x values if only one of the first two **B** marks are scored.
		3	

Question	Answer	Marks	Guidance
4(b)	$[\mathrm{E}(X) =]\ [0]+1\times\frac{1}{16}+2\times\frac{3}{16}+3\times\frac{5}{16}+4\times\frac{4}{16}$ $\left[=\frac{[0]+1+6+15+16}{16}\right]$ $\left[=\frac{38}{16}=\frac{19}{8}\right]$	**M1FT**	Accept un-simplified or bold expression with probabilities ($0 < p < 1$) that add to 1. May be calculated in variance. **FT** *their* table with 4 or 5 probabilities adding to 1.
	$\mathrm{Var}(X) = \frac{1+3\times2^2+5\times3^2+4\times4^2}{16}-\left(\frac{19}{8}\right)^2$ $\left[=\frac{1+3\times4+5\times9+4\times16}{16}-\frac{361}{64}\right]$ $\left[=\frac{122}{16}-\left(\frac{19}{8}\right)^2\right]$	**M1FT**	Appropriate variance formula using *their* $(\mathrm{E}(X))^2$ value. **FT** *their* table with 4 or more probabilities ($0 < p < 1$) which need not sum to 1 or with an expression no more evaluated than shown.
	$=\frac{127}{64}, 1\frac{63}{64}, 1.98$	**A1**	Accept 1.984375 to 3 or more SF. **SCB1** for 1.98 if **M0 M1** scored.
		3	

Question	Answer	Marks	Guidance
4(c)	**Method 1**		
	$1-\left(\frac{3}{4}\right)^7$	**M1**	$1-\left(\frac{3}{4}\right)^n$ with n = 6, 7, 8.
	= 0.867	**A1**	= 0.8665 to 4SF.
	Method 2		
	$[\mathrm{P}(X < 8) =]\ \frac{1}{4}+\left(\frac{3}{4}\right)\left(\frac{1}{4}\right)+\left(\frac{3}{4}\right)^2\left(\frac{1}{4}\right)+\left(\frac{3}{4}\right)^3\left(\frac{1}{4}\right)+\left(\frac{3}{4}\right)^4\left(\frac{1}{4}\right)+\left(\frac{3}{4}\right)^5\left(\frac{1}{4}\right)+\left(\frac{3}{4}\right)^6\left(\frac{1}{4}\right)$	**M1**	Condone extra term $\left(\frac{3}{4}\right)^7\left(\frac{1}{4}\right)$ *or* the term $\left(\frac{3}{4}\right)^6\left(\frac{1}{4}\right)$ missing.
	= 0.867	**A1**	
		2	

Question	Answer	Marks	Guidance
3(a)	$[\mathrm{P}(X=4) = 3\mathrm{P}(X=2)]$ $4k(4+a) = 3\times2k(2+a)$ $16k + 4ak = 12k + 6ak$	**M1**	Using $\mathrm{P}(X=4) = 3\mathrm{P}(X=2)$ to form an equation in a and k.
	$a = 2$	**A1**	If M0 scored, **SC B1** for $a = 2$ www.
	$3k + 8k + 15k + 24k = 1$	**M1**	Using sum of probabilities = 1 to form an equation in k: $k(1 + a) + 2k(2 + a) + 3k(3 + a) + 4k(4 + a) = 1$.
	$k = \frac{1}{50}$	**A1**	If M0 scored, **SC B1** for $k = \frac{1}{50}$ www.
		4	
3(b)	X: 1, 2, 3, 4 $\mathrm{P}(X)$: $\frac{3}{50}$, 0.06; $\frac{8}{50}$, 0.16; $\frac{15}{50}$, 0.3; $\frac{24}{50}$, 0.48	**B1 FT**	X: 1, 2, 3, 4 $\mathrm{P}(X)$: $k(1 + a)$, $2k(2 + a)$, $3k(3 + a)$, $4k(4 + a)$ $0 < p < 1$ for all outcomes, must be numerical.
		1	
3(c)	$\mathrm{Var}(X) = \frac{3}{50}\times1+\frac{8}{50}\times2^2+\frac{15}{50}\times3^2+\frac{24}{50}\times4^2-3.2^2$	**M1**	Correct formula for variance method from their probability distribution table, $0 \leqslant$ *their* $\mathrm{P}(x) \leqslant 1$. Accept $\frac{3+32+135+384}{50}-\frac{256}{25}$.
	$[= 11.08 - 3.2^2 =]\ 0.84[0],\ \frac{21}{25}$	**A1**	If M0 score **SC B1** for 0.84 www.
		2	

Question	Answer	Marks	Guidance
2(a)	x | 1 | 2 | 3 | 4 | 6 P($X=x$) | $\frac{6}{36}$ | $\frac{12}{36}$ | $\frac{6}{36}$ | $\frac{6}{36}$ | $\frac{6}{36}$ | $\frac{1}{6}$ | $\frac{1}{3}$ | $\frac{1}{6}$ | $\frac{1}{6}$ | $\frac{1}{6}$ | 0.167 | 0.333 | 0.167 | 0.167 | 0.167	**B1**	Table with correct x values and at least one correct probability linked with the correct x-value. Values need not be in order, lines may not be drawn, may be vertical, x and P(X) may be omitted. Condone any additional x values if probability stated as 0.
		B1	4 correct probabilities linked with the correct x-values, need not be in table, accept unsimplified.
		B1	5 correct probabilities linked with correct x-values, may not be in table. Decimals correct to at least 3 SF. **SC B1** 4 or 5 probabilities summing to 1 placed in a probability distribution table with 4 or 5 x-values between 1 and 6 inclusive.
		3	
2(b)	$[\mathrm{E}(X)=\frac{1}{36}(6+24+18+24+36)=]\ 3$	**B1 FT**	FT *their* table with 4 or 5 probabilities ($0 < p < 1$) summing to 1.
		1	

Question	Answer	Marks	Guidance
1(a)	$2k+6k+12k+20k=1,\ \left[k=\frac{1}{40}\right]$	**M1**	Using sum of probabilities = 1 to form an equation in k. Accept $1\times2\times k+2\times3\times k+3\times4\times k+4\times5\times k=1$.
	X | 1 | 2 | 3 | 4 P(X) | $\frac{2}{40}$ | $\frac{6}{40}$ | $\frac{12}{40}$ | $\frac{20}{40}$ | 0.05 | 0.15 | 0.3 | 0.5	**M1**	X | 1 | 2 | 3 | 4 P(X) | $2k$ | $6k$ | $12k$ | $20k$ Two correctly linked, accurate probabilities. May be in terms of k. May not be in a table.
		A1	Table with correct X values and correct probabilities.
		3	
1(b)	$[\mathrm{E}(X)=]\ [\mathrm{E}(X)=\frac{1\times2+2\times6+3\times12+4\times20}{40}]\ \frac{2+12+36+80}{40}$	**M1**	$[\mathrm{E}(X)=1\times2k+2\times6k+3\times12k+4\times20k=130k]$ Accept unsimplified expression. May be calculated in variance. FT *their* table with 3 or more probabilities summing to 1 ($0 < p < 1$). If there are outcomes in the table without probabilities, condone and treat as $p = 0$.
	$\left[\mathrm{Var}(X)=\frac{1^2\times2+2^2\times6+3^2\times12+4^2\times20}{40}-(\textit{their}\ \mathrm{E}(X))^2=\right]$ $\frac{1\times2+4\times6+9\times12+16\times20}{40}-\left(\textit{their}\frac{13}{4}\right)^2$ $\left[\frac{2+24+108+320}{40}-\left(\textit{their}\frac{13}{4}\right)^2\right]$	**M1**	$[\mathrm{Var}(X)=\ 1^2\times2k+2^2\times6k+3^2\times12k+4^2\times20k-(130k)^2]$ Appropriate variance formula using *their* $(\mathrm{E}(X))^2$ value. FT *their* table with 3 or more probabilities ($0 < p < 1$) which need not sum to 1 and the highlighted calculation (or less simplified) seen, Note: if table is correct, $\frac{454}{40}\left(\text{or}\ \frac{227}{20}\ \text{or any calculation}\right)-(\textit{their}\,\mathrm{E}(X))^2$ implies M1.
	$\mathrm{E}(X)=\frac{13}{4},3\frac{1}{4},3.05\ \ \mathrm{Var}(X)=\frac{63}{80},0.7875$	**A1**	Answers for E(X) and Var(X) must be identified. E(X) may be identified by correct use in variance. Condone E, V, μ, σ etc. If A0 earned, **SC B1** for identified correct final solutions.
		3	

Question	Answer	Marks
4(a)	<table><tr><td>−1</td><td>0</td><td>0</td><td>1</td></tr><tr><td>0</td><td>1</td><td>1</td><td>2</td></tr><tr><td>2</td><td>3</td><td>3</td><td>4</td></tr></table>	
	<table><tr><td>x</td><td>−1</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td></tr><tr><td>Probability</td><td>$\frac{1}{12}$</td><td>$\frac{3}{12}$</td><td>$\frac{3}{12}$</td><td>$\frac{2}{12}$</td><td>$\frac{2}{12}$</td><td>$\frac{1}{12}$</td></tr></table>	
	Probability distribution table with correct scores with at least one probability	**B1**
	At least 4 probabilities correct	**B1**
	All probabilities correct	**B1**
		3
4(b)	$E(X)=\frac{-1+0+3+4+6+4}{12}=\frac{16}{12}=\frac{4}{3}$	**B1**
	$Var(X)=\frac{1+0+3+8+18+16}{12}-\left(\frac{4}{3}\right)^2$	**M1**
	$\frac{37}{18}$ $(=2.06)$	**A1**
		3

Question	Answer	Marks	Guidance
6(a)	Scenarios: HHT: $\frac{2}{3}\times\frac{2}{3}\times\frac{1}{5}=\frac{4}{45}$ HTH: $\frac{2}{3}\times\frac{1}{3}\times\frac{4}{5}=\frac{8}{45}$ THH: $\frac{1}{3}\times\frac{2}{3}\times\frac{4}{5}=\frac{8}{45}$	**M1**	One 3 factor probability with 3, 3, 5 as denominators
		M1	3 factor probabilities for 2 or 3 correct scenarios added, no incorrect scenarios
	Total $=\frac{20}{45}=\frac{4}{9}$	**A1**	AG, Total of 3 products with clear context
		3	
6(b)	<table><tr><td>x</td><td>0</td><td>1</td><td>2</td><td>3</td></tr><tr><td>Prob.</td><td>$\frac{1}{45}$</td><td>$\frac{8}{45}$</td><td>$\frac{20}{45}$</td><td>$\frac{16}{45}$</td></tr></table>	**B1**	Probability distribution table with correct outcomes with at least one probability, allow extra outcome values if probability of zero stated'
		B1	2 of P(0), P(1) and P(3) correct
		B1 FT	3 or 4 probabilities sum to 1 with P(2) correct
		3	
6(c)	$Var(X)=\frac{0^2\times1+1^2\times8+2^2\times20+3^2\times16}{45}-\left(\frac{32}{15}\right)^2$ $=\frac{8}{45}+\frac{80}{45}+\frac{144}{45}-\left(\frac{32}{15}\right)^2$	**M1**	Substitute *their* attempts at scores in correct variance formula, must have '– mean^2' (FT if calculated) (condone probs not summing to 1); must be at least 2 non-zero values
	$\frac{136}{225}$ or 0.604	**A1**	
		2	