Question	Scheme	Marks
4(a)	$\frac{r+4}{r(r+1)(r+2)} \equiv \frac{A}{r}+\frac{B}{r+1}+\frac{C}{r+2}$	B1
	$\Rightarrow r+4 \equiv A(r+1)(r+2)+Br(r+2)+Cr(r+1)\ ;\ r=0 \Rightarrow A=\ldots$	M1
	Two of $A=2,\ B=-3,\ C=1$	A1
	$\frac{r+4}{r(r+1)(r+2)} \equiv \frac{2}{r}-\frac{3}{r+1}+\frac{1}{r+2}$	A1
		(4)
(b)	$\sum_{r=1}^{n}\frac{r+4}{r(r+1)(r+2)}=\sum_{r=1}^{n}\frac{2}{r}-\frac{3}{r+1}+\frac{1}{r+2}$ $=\left(\frac{2}{1}-\frac{3}{2}+\frac{1}{3}\right)$ $+\left(\frac{2}{2}-\frac{3}{3}+\frac{1}{4}\right)$ $+\left(\frac{2}{3}-\frac{3}{4}+\frac{1}{5}\right)$ $+\ldots$ $+\left(\frac{2}{n-1}-\frac{3}{n}+\frac{1}{n+1}\right)$ $+\left(\frac{2}{n}-\frac{3}{n+1}+\frac{1}{n+2}\right)$	M1A1
	$=\left(\frac{2}{1}-\frac{1}{2}\right)+\left(-\frac{2}{n+1}+\frac{1}{n+2}\right)$ o.e.	A1
	$=\frac{3}{2}-\frac{2}{n+1}+\frac{1}{n+2}=\frac{3(n+1)(n+2)-4(n+2)+2(n+1)}{2(n+1)(n+2)}=\ldots$	M1
	$=\frac{n(3n+7)}{2(n+1)(n+2)}$	A1
	All marks can be awarded if working in terms of r and then replaced at the end. If no replacement made, then deduct the final A mark	
		(5)
		(9 marks)

Notes:

(a)

B1: Correct form for the partial fractions attempted. **Note:** some candidates may start with $\frac{r+4}{r(r+1)(r+2)} \equiv \frac{A}{r(r+1)}+\frac{B}{(r+1)(r+2)}$ and proceed to split further into four partial fractions, equivalent to the form stated. If in doubt about this method, please send to review.

M1: Method to find at least one of the coefficients, may be the cover-up rule

A1: Two correct coefficients

A1: Fully correct partial fractions found (not just stating the values), but accept if seen in (b) if only the coefficients are found in (a).

(b)

M1: Applies the method of differences, with at least three of the given brackets evaluated, and showing some evidence of appropriate cancellation of terms on the 'diagonal' e.g. $\frac{1}{3}-\frac{3}{3}+\frac{2}{3}$ etc

A1: Shows sufficient terms in the method of differences to establish complete cancellation of terms on the main diagonal (so e.g. at least 3 terms at start and 2 terms at the end or for 2 terms at the start and 3 terms at the end)

Alt: establishes the correct non-cancelling numeric (accept e.g. 3/2 for the numeric terms) **OR** algebraic terms (which would imply M1A1)

A1: Correct non-cancelling terms extracted.

M1: Puts over the correct common denominator for their remaining terms and attempts to simplify the numerator to achieve a quadratic of the form an^2+bn but accept an^2+bn+c with $a\neq 0$

A1: Correct answer or values for P, Q, R and S.

Allow recovery if the terms are given in terms of r instead of n and recovered at the end. If no recovery, then score final A0.

Alt for the first 3 marks in (b)

Re-writing the PFs $\frac{2}{r}-\frac{3}{r+1}+\frac{1}{r+2}$ as $\frac{2}{r}-\frac{2}{r+1}+\frac{-1}{r+1}+\frac{1}{r+2}$ and then using method of differences on two separate sums

(b) Alt	$\sum_{r=1}^{n}\left[\frac{2}{r}-\frac{2}{r+1}\right]+\sum_{r=1}^{n}\left[-\frac{1}{r+1}+\frac{1}{r+2}\right]$ $=\left(\frac{2}{1}-\frac{2}{2}\right)+\left(-\frac{1}{2}+\frac{1}{3}\right)$ $+\left(\frac{2}{2}-\frac{2}{3}\right)+\left(-\frac{1}{3}+\frac{1}{4}\right)+\cdots$ $+\left(\frac{2}{n-1}-\frac{2}{n}\right)+\left(-\frac{1}{n}+\frac{1}{n+1}\right)$ $+\left(\frac{2}{n}-\frac{2}{n+1}\right)+\left(-\frac{1}{n+1}+\frac{1}{n+2}\right)$	**M1A1**
	$=\frac{2}{1}-\frac{2}{n+1}-\frac{1}{2}+\frac{1}{n+2}$	**A1**
	$=\frac{3}{2}-\frac{2}{n+1}+\frac{1}{n+2}=\frac{3(n+1)(n+2)-4(n+2)+2(n+1)}{2(n+1)(n+2)}=\ldots$	**M1**
	$=\frac{n(3n+7)}{2(n+1)(n+2)}$	**A1**
		(5)

Notes:
(b) **M1:** Applies the method of differences, for both summations, with at least two of the brackets evaluated for both, and some evidence of cancellation of terms on the 'diagonal' **A1:** Shows sufficient terms in the method of differences for the cancelling of terms on the main diagonal (e.g. first two and last, or first and last two etc) **Alt:** correct non-cancelling numeric OR algebraic terms extracted (which would imply M1A1) **A1:** Correct non-cancelling terms extracted. **M1:** Puts over the correct common denominator for their remaining terms and attempts to simplify, to achieve a quadratic of the form $an^2 + bn$ but accept $an^2 + bn + c$ with $a \neq 0$ **A1:** Correct answer or values for P, Q, R and S. Allow recovery if the terms are given in terms of r instead of n and recovered at the end. If no recovery, then score final A0.