**1.** The adult population of a town is 25 000 at the end of Year 1.

A model predicts that the adult population of the town will increase by 3% each year, forming a geometric sequence.

(a) Show that the predicted adult population at the end of Year 2 is 25 750.

**(1)**

(b) Write down the common ratio of the geometric sequence.

**(1)**

The model predicts that Year $N$ will be the first year in which the adult population of the town exceeds 40 000.

(c) Show that

$$(N - 1)\log 1.03 > \log 1.6$$

**(3)**

(d) Find the value of $N$.

**(2)**

At the end of each year, each member of the adult population of the town will give £1 to a charity fund.

Assuming the population model,

(e) find the total amount that will be given to the charity fund for the 10 years from the end of Year 1 to the end of Year 10, giving your answer to the nearest £1000.

**(3)**
**(Total 10 marks)**

**2.** A car was purchased for £18 000 on 1st January.

On 1st January each following year, the value of the car is 80% of its value on 1st January in the previous year.

(a) Show that the value of the car exactly 3 years after it was purchased is £9216.

**(1)**

The value of the car falls below £1000 for the first time $n$ years after it was purchased.

(b) Find the value of $n$.

**(3)**

An insurance company has a scheme to cover the maintenance of the car. The cost is £200 for the first year, and for every following year the cost increases by 12% so that for the 3rd year the cost of the scheme is £250.88

(c) Find the cost of the scheme for the 5th year, giving your answer to the nearest penny.

**(2)**

(d) Find the total cost of the insurance scheme for the first 15 years.

**(3)**
**(Total 9 marks)**

**3.** The third term of a geometric sequence is 324 and the sixth term is 96

(a) Show that the common ratio of the sequence is $\frac{2}{3}$

**(2)**

(b) Find the first term of the sequence.

**(2)**

(c) Find the sum of the first 15 terms of the sequence.

**(3)**

(d) Find the sum to infinity of the sequence.

**(2)**
**(Total 9 marks)**

**4.** The first three terms of a geometric series are $(k + 4)$, k and $(2k – 15)$ respectively, where $k$ is a positive constant.

(a) Show that $k^2 – 7k – 60 = 0$.

**(4)**

(b) Hence show that $k = 12$.

**(2)**

(c) Find the common ratio of this series.

**(2)**

(d) Find the sum to infinity of this series.

**(2)**
**(Total 10 marks)**

**5.** A geometric series has first term 5 and common ratio $\frac{4}{5}$.

Calculate

(a) the 20th term of the series, to 3 decimal places,

**(2)**

(b) the sum to infinity of the series.

**(2)**

Given that the sum to $k$ terms of the series is greater than 24.95,

(c) show that $k > \dfrac{\log 0.002}{\log 0.8}$,

**(4)**

(d) find the smallest possible value of $k$.

**(1)**
**(Total 9 marks)**

**6.** The fourth term of a geometric series is 10 and the seventh term of the series is 80.

For this series, find

(a) the common ratio,

**(2)**

(b) the first term,

**(2)**

(c) the sum of the first 20 terms, giving your answer to the nearest whole number.

**(2)**
**(Total 6 marks)**

**7.** A trading company made a profit of £50 000 in 2006 (Year 1).

A model for future trading predicts that profits will increase year by year in a geometric sequence with common ratio $r$, $r > 1$.

The model therefore predicts that in 2007 (Year 2) a profit of £50 000$r$ will be made.

(a) Write down an expression for the predicted profit in Year $n$.

**(1)**

The model predicts that in Year $n$, the profit made will exceed £200 000.

(b) Show that $n > \dfrac{\log 4}{\log r} + 1$.

**(3)**

Using the model with $r = 1.09$,

(c) find the year in which the profit made will first exceed £200 000,

**(2)**

(d) find the total of the profits that will be made by the company over the 10 years from 2006 to 2015 inclusive, giving your answer to the nearest £10 000.
**(3)**
**(Total 9 marks)**

**8.** A geometric series is $a + ar + ar^2 + ...$

(a) Prove that the sum of the first $n$ terms of this series is given by

$$S_n = \frac{a(1-r^n)}{1-r}.$$

**(4)**

(b) Find

$$\sum_{k=1}^{10} 100(2^k).$$

**(3)**

(c) Find the sum to infinity of the geometric series

$$\frac{5}{6} + \frac{5}{18} + \frac{5}{54} + .....$$

**(3)**

(d) State the condition for an infinite geometric series with common ratio $r$ to be convergent.
**(1)**
**(Total 11 marks)**

**9.** A geometric series has first term $a$ and common ratio $r$.
The second term of the series is 4 and the sum to infinity of the series is 25.

(a) Show that $25r^2 - 25r + 4 = 0$.
**(4)**

(b) Find the two possible values of $r$.
**(2)**

(c) Find the corresponding two possible values of $a$.

**(2)**

(d) Show that the sum, $S_n$, of the first $n$ terms of the series is given by

$$S_n = 25(1 - r^n).$$

**(1)**

Given that $r$ takes the larger of its two possible values,

(e) find the smallest value of $n$ for which $S_n$ exceeds 24.

**(2)**
**(Total 11 marks)**

**10.** The first term of a geometric series is 120. The sum to infinity of the series is 480.

(a) Show that the common ratio, $r$, is $\frac{3}{4}$.

**(3)**

(b) Find, to 2 decimal places, the difference between the 5th and 6th term.

**(2)**

(c) Calculate the sum of the first 7 terms.

**(2)**

The sum of the first $n$ terms of the series is greater than 300.

(d) Calculate the smallest possible value of $n$.

**(4)**
**(Total 11 marks)**

**11.** (a) A geometric series has first term $a$ and common ratio $r$. Prove that the sum of the first $n$ terms of the series is

$$\frac{a(1-r^n)}{1-r}.$$

**(4)**

Mr King will be paid a salary of £35 000 in the year 2005. Mr King's contract promises a 4% increase in salary every year, the first increase being given in 2006, so that his annual salaries form a geometric sequence.

(b) Find, to the nearest £100, Mr King's salary in the year 2008.

**(2)**

Mr King will receive a salary each year from 2005 until he retires at the end of 2024.

(c) Find, to the nearest £1000, the total amount of salary he will receive in the period from 2005 until he retires at the end of 2024.

**(4)**
**(Total 10 marks)**

**12.** The cost of Brian's new car was £$P$. He accepted an interest-free loan of £$P$, which he agreed to repay by monthly instalments. The first instalment was £120. The instalments were increased by £5 per month so that the second and third instalments were £125 and £130 respectively.

Given that the loan was repaid in $n$ instalments, and that the final instalment was £325,

(a) show that $n = 42$,

**(2)**

(b) find the value of $P$.

**(3)**

The value of Brian's car at the end of the first year was £7200. After the first year, the value of the car depreciated, each month, by 2% of its value at the start of that month.

(c) Calculate, to the nearest £, the value of Brian's car at the end of the third year.

**(3)**
**(Total 8 marks)**

**13.** The second and fourth terms of a geometric series are 7.2 and 5.832 respectively.

The common ratio of the series is positive.

For this series, find

(a) the common ratio,
**(2)**

(b) the first term,
**(2)**

(c) the sum of the first 50 terms, giving your answer to 3 decimal places,
**(2)**

(d) the difference between the sum to infinity and the sum of the first 50 terms, giving your answer to 3 decimal places.
**(2)**
**(Total 8 marks)**

**14.** The first term of a geometric series is $a$. The fourth and fifth terms of the series are 12 and –8 respectively.

(a) Find the value of the common ratio of the series.
**(2)**

(b) Show that $a = -40\frac{1}{2}$.
**(2)**

(c) Find the sum to infinity of this series.
**(3)**
**(Total 7 marks)**

**15.** A geometric series is $a + ar + ar^2 + \ldots$

(a) Prove that the sum of the first $n$ terms of this series is

$$S_n = \frac{a(1-r^n)}{1-r}.$$

**(4)**

The first and second terms of a geometric series $G$ are 10 and 9 respectively.

(b) Find, to 3 significant figures, the sum of the first twenty terms of $G$.

**(3)**

(c) Find the sum to infinity of $G$.

**(2)**

Another geometric series has its first term equal to its common ratio. The sum to infinity of this series is 10.

(d) Find the exact value of the common ratio of this series.

**(3)**
**(Total 12 marks)**

**16.** A geometric series has first term 1200. Its sum to infinity is 960.

(a) Show that the common ratio of the series is $-\frac{1}{4}$.

**(3)**

(b) Find, to 3 decimal places, the difference between the ninth and tenth terms of the series.

**(3)**

(c) Write down an expression for the sum of the first $n$ terms of the series.

**(2)**

Given that $n$ is odd,

(d) prove that the sum of the first $n$ terms of the series is

$$960(1 + 0.25^n).$$

**(2)**
**(Total 10 marks)**

**17.** The second and fifth terms of a geometric series are 9 and 1.125 respectively.

For this series find

(a) the value of the common ratio,
**(3)**

(b) the first term,
**(2)**

(c) the sum to infinity.
**(2)**
**(Total 7 marks)**

**1.** (a) $25\,000 \times 1.03 = 25750$

$\left\{25000 + 750 = 25750, \text{ or } \ 25000\dfrac{(1-0.03^2)}{1-0.03} = 25750\right\}$ (*) B1 1

(b) $r = 1.03$ Allow $\dfrac{103}{100}$ or $1\dfrac{3}{100}$ but no other alternatives B1 1

(c) $25000r^{N-1} > 40000$ (Either letter $r$ or their $r$ value) Allow ' = ' or '<' M1

$r^M > 1.6 \Rightarrow \log r^M > \log 1.6$ Allow ' = ' or '<' (<u>See below</u>)

OR (by change of base), $\log_{1.03} 1.6 < M \Rightarrow \dfrac{\log 1.6}{\log 1.03} < M$ M1

$(N-1)\log 1.03 > \log 1.6$ (Correct bracketing required) (*) A1 cso

Accept work for part (c) seen in part (d) 3

**<u>Note</u>**

2nd M: Requires $\dfrac{40000}{25000}$ to be dealt with, and 'two' logs introduced.
With, say, $N$ instead of $N - 1$, this mark is still available.

| |
|---|
| <u>Jumping</u> straight from $1.03^{N-1} > 1.6$ to $(N - 1)\log 1.03 > \log 1.6$ can score only M1 M0 A0.<br>(The intermediate step $\log 1.03^{N-1} > \log 1.6$ must be seen). |

<u>Longer methods</u> require correct log work throughout for 2nd M, e.g.:

$\log(25000r^{N-1}) > \log 40000 \quad \Rightarrow \quad \log 25000 + \log r^{N-1} > \log 40000$
$\Rightarrow \quad \log r^{N-1} > \log 40000 - \log 25000 \quad \Rightarrow \quad \log r^{N-1} > \log 1.6$

(d) Attempt to evaluate $\dfrac{\log 1.6}{\log 1.03} + 1$ {or $25000(1.03)^{15}$ <u>and</u> $25000(1.03)^{16}$ } M1

$N = 17$ (<u>not</u> 16.9 and not e.g. $N \geq 17$) Allow '17th year' A1
Accept work for part (d) seen in part (c) 2

**<u>Note</u>**

Correct answer with no working scores both marks.

Evaluating $\log\left(\dfrac{1.6}{1.03}\right)$ + 1 does <u>not</u> score the M mark.

(e) Using formula $\frac{a(1-r^n)}{1-r}$ with values of $a$ and $r$, and $n$ = 9, 10 or 11 M1

$\frac{25000(1-1.03^{10})}{1-1.03}$ A1

287 000 (<u>must</u> be rounded to the nearest 1 000) Allow 287000.00 A1 3

**<u>Note</u>**

M1 can also be scored by a "year by year" method, <u>with terms added.</u>
(Allow the M mark if there is evidence of adding 9, 10 or 11 terms).
1st A1 is scored if the 10 correct terms have been added (allow terms to be to the nearest 100).
To the nearest 100, these terms are:
25000, 25800, 26500, 27300, 28100, 29000, 29900, 30700, 31700, 32600

<u>No</u> working shown: Special case: 287 000 scores 1 mark, scored on ePEN as 1, 0, 0. (Other answers with no working score no marks).

**[10]**

**2.** (a) $18000 \times (0.8)^3$ =£9216 * [may see $\frac{1}{4}$ or 80% or equivalent]. B1cso 1

**<u>Note</u>**

B1 NB Answer is printed so **need working**. May see as above or ×0.8 in three steps giving 14400, 11520, 9216.
Do not need to see £ sign but should see 9216 .

(b) $18000 \times (0.8)^n < 1000$ M1

$n \log(0.8) < \log\left(\frac{1}{18}\right)$ M1

$n > \frac{\log\left(\frac{1}{18}\right)}{\log(0.8)} = 12.952......$ so $n = 13$. A1 cso 3

**<u>Note</u>**

1st M1 for an attempt to use nth term and 1000.
Allow $n$ or $n - 1$ and allow > or =

2nd M1 for use of logs to find $n$ Allow $n$ or $n - 1$ and allow > or =

A1 Need $n = 13$ This is an accuracy mark and must follow award of both M marks but should not follow incorrect work using $n - 1$ for example.

Condone slips in inequality signs here.

Alternative Methods

Trial and Improvement

See 989.56 (or 989 or 990) identified with 12, 13 or 14 years for **first M1**

See 1236.95 (or 1236 or 1237) identified with 11, 12 or 13 years for second **M1**

Then $n = 13$ is **A1 (needs both Ms)**

**Special case** $18000\,(0.8)^n < 1000$ so $n = 13$ as $989.56 < 1000$ is M1M0A0 (not discounted $n = 12$)

(c) $u_5 = 200 \times (1.12)^4$, $= £314.70$ or $£314.71$ M1 A1 2

**Note**

M1 for use of their a and r in formula for 5th term of GP

A1 cao need one of these answers – answer can imply method here

NB 314.7 – A0

Alternative Methods

May see the terms 224, 250.88, 280.99, 314.71 with a small slip for M1 A0, or done accurately for M1A1

(d) $S_{15} = \dfrac{200(1.12^{15} - 1)}{1.12 - 1}$ or $\dfrac{200(1.12^{15})}{1 - 1.12}$, $= 7455.94......$
awrt £7460 M1A1 A1 3

**Note**

M1 for use of sum to 15 terms of GP using their $a$ and their $r$ (allow if formula stated correctly and one error in substitution, but must use $n$ not $n - 1$)

1st A1 for a fully correct expression (not evaluated)

Alternative Methods

Adds 15 terms 200 + 224 + 250.88+… + (977.42) **M1**

Seeing 977… is **A1**

Obtains answer 7455.94 **A1** or awrt £7460 NOT 7450

**[9]**

**3.** (a) $324r^3 = 96$ or $r^3 = \frac{96}{324}$ or $r^3 = \frac{8}{27}$ M1

$r = \frac{2}{3}$ (*) A1cso 2

**<u>Note</u>**

M1 for forming an equation for $r^3$ based on 96 and 324 (e.g. $96r^3 = 324$ scores M1).
The equation must involve multiplication/division rather than addition/subtraction.

A1 Do not penalise solutions with working in decimals, providing these are correctly rounded or truncated to at least 2dp <u>and</u> the final answer 2/3 is seen.

<u>Alternative</u>: (verification)

M1 Using $r^3 = \frac{8}{27}$ and multiplying 324 by this (or multiplying by $r = \frac{2}{3}$ three times).

A1 Obtaining 96 (cso). (A conclusion is not required).

$324 \times \left(\frac{2}{3}\right)^3 = 96$ (no real evidence of calculation) is not quite enough and scores M1 A0.

(b) $a\left(\frac{2}{3}\right)^2 = 324$ or $a\left(\frac{2}{3}\right)^5 = 96$ $a = ...,$ 729 M1, A1 2

**<u>Note</u>**

M1 for the use of a correct formula or for 'working back' by dividing by $\frac{2}{3}$ (or by their $r$) twice from 324 (or 5 times from 96).

Exceptionally, allow M1 also for using $ar^3 = 324$ or $ar^6 = 96$ instead of $ar^2 = 324$ or $ar^5 = 96$, or for dividing by $r$ three times from 324 (or 6 times from 96)… but no other exceptions are allowed.

(c) $S_{15} = \dfrac{729\left(1-\left[\frac{2}{3}\right]^{15}\right)}{1-\frac{2}{3}}$, $= 2182.00...$ (AWRT 2180) M1A1ft, 3

**Note**

M1 for use of sum to 15 terms formula with values of $a$ and $r$. If the wrong power is used, e.g. 14, the M mark is scored only if the correct sum formula is stated.

1st A1ft for a correct expression or correct ft their $a$ with $r = \dfrac{2}{3}$.

2nd A1 for awrt 2180, even following 'minor inaccuracies'.

Condone missing brackets round the $\dfrac{2}{3}$ for the marks in part (c).

Alternative:

M1 for adding 15 terms and 1st A1ft for adding the 15 terms that ft from their $a$ and $r = \dfrac{2}{3}$.

(d) $S_\infty = \dfrac{729}{1-\frac{2}{3}}$, $= 2187$ M1, A1 2

**Note**

M1 for use of correct sum to infinity formula with their $a$. For this mark, if a value of $r$ different from the given value is being used, M1 can still be allowed providing $|r| < 1$.

**[9]**

**4.** (a) Initial step: Two of: $a = k + 4$, $ar = k$, $ar^2 = 2k - 15$

Or one of: $r = \dfrac{k}{k+4}$, $r = \dfrac{2k-15}{k}$, $r = \dfrac{2k-15}{k+4}$ M1

Or $k = \sqrt{(k+4)(2k-15)}$ or even $k^3 = (k + 4)k(2k - 15)$

$k^2 = (k + 4)(2k - 15)$, so $k^2 = 2k^2 + 8k - 15k - 60$ M1, A1

Proceed to $k^2 - 7k - 60 = 0$ (*) A1 4

**Note**

**M1**: The 'initial step', scoring the first M mark, may be implied by next line of proof
**M1**: Eliminates $a$ and $r$ to give valid equation in k only. Can be awarded for equation involving fractions.
**A1**: need some correct expansion and working and answer equivalent to required quadratic but with uncollected terms. Equations involving fractions do not get this mark.
(No fractions, no brackets – could be a cubic equation)
**A1**: as answer is printed this mark is for cso (Needs = 0)
**All four marks must be scored in part (a)**

(b) $(k-12)(k+5) = 0$ $k = 12$ (*) M1 A1 2

**Note**

**M1**: Attempt to solve quadratic

**A1**: This is for correct factorisation or solution and $k = 12$. Ignore the extra solution ($k = -5$ or even $k = 5$), if seen.
Substitute and verify is **M1 A0**
**Marks must be scored in part (b)**

(c) Common ratio: $\frac{k}{k+4}$ or $\frac{2k-15}{k} = \frac{12}{16}\left(= \frac{3}{4} \text{ or } 0.75\right)$ M1 A1 2

**Note**

**M1**: Complete method to find $r$ Could have answer in terms of $k$
**A1**: 0.75 or any correct equivalent
**Both Marks must be scored in (c)**

(d) $\frac{a}{1-r} = \frac{16}{\left(\frac{1}{4}\right)} = 64$ M1 A1 2

**Note**

**M1**: Tries to use $\frac{a}{1-r}$, (even with $r > 1$). Could have an answer still in terms of $k$. **A1**: This answer is 64 cao.

**[10]**

**5.** (a) $T_{20} = 5 \times \left(\frac{4}{5}\right)^{19} = 0.072$ (Accept awrt) Allow $5 \times \frac{4^{19}}{5}$ for M1 M1 A1 2

M: Requires use of the correct formula $ar^{n-1}$.

(b) $S_\infty = \frac{5}{1-0.8} = 25$ M1A1 2

M: Requires use of the correct formula $\frac{a}{1-r}$

(a) and (b): Correct answer without working scores both marks.

| | | | |
|---|---|---|---|
| (c) $\frac{5(1-0.8^k)}{1-0.8} > 24.95$ | (Allow with = or <) | M1 | |
| $1 - 0.8^k > 0.998$ (or equiv., see below) | (Allow with = or <) | A1 | |
| $k \log 0.8 < \log 0.002$ or $k > \log_{0.8} 0.002$ | (Allow with = or <) | M1 | |
| $k > \frac{\log 0.002}{\log 0.8}$ (*) | | A1cso | 4 |

1st M: The sum may have already been 'manipulated' (perhaps wrongly), but this mark can still be allowed.

1st A: A 'numerically correct' version that has dealt with (1 – 0.8) denominator,
e.g. $1-\left(\frac{4}{5}\right)^k > 0.998$, $5(1-0.8^k) > 4.99$,
$25(1-0.8^k) > 24.95$, $5-5(0.8^k) > 4.99$.
In any of these, $\frac{4}{5}$ instead of 0.8 is fine, and condone $\frac{4^k}{5}$ if correctly treated later.

2nd M: Introducing logs and using laws of logs correctly (this must include dealing with the power $k$ so that $p^k = k \log p$).

2nd A: An <u>incorrect</u> statement (including equalities) at any stage in the working loses this mark (this is often identifiable at the stage $k \log 0.8 > \log 0.002$).

(So a fully correct method with inequalities is required.)

(d) $k = 28$ (Must be this integer value) <u>Not</u> $k > 27$, or $k < 28$, or $k > 28$ B1 1

**[9]**

**6.** (a) Complete method, using terms of form $ar^k$, to find r M1
[e.g. **Dividing** $ar^6 = 80$ by $ar^3 = 10$ to find r; $r^6 - r^3 = 8$ is M0]
$r = 2$ A1 2

M1: Condone errors in powers, e.g. $ar^4 = 10$ and/or $ar^7 = 80$,
A1: For $r = 2$, allow even if $ar^4 = 10$ and $ar^7 = 80$ used (just these)
(M mark can be implied from numerical work, if used correctly)

(b) Complete method for finding a M1
[e.g. Substituting value for $r$ into equation of form $ar^k = 10$ or 80 and finding a value for $a$.]
$(8a = 10)$ $a = \frac{5}{4} = 1\frac{1}{4}$ (equivalent single fraction or 1.25) A1 2

M1: Allow for numerical approach: e.g. $\frac{10}{r_c^3} \leftarrow \frac{10}{r_c^2} \leftarrow \frac{10}{r_c} \leftarrow 10$

In (a) and (b) correct answer, with no working, allow both marks.

| | | | | |
|---|---|---|---|---|
| | (c) | Substituting their values of $a$ and $r$ into **correct** formula for sum. | M1 | |
| | | $S = \dfrac{a(r^n - 1)}{r - 1} = \dfrac{5}{4}(2^{20} - 1)$ (= 1310718.75) 1 310 719 (only this) | A1 | 2 |
| | | Attempt 20 terms of series and add is M1 (correct last term 655360)<br>If formula **not** quoted, errors in applying their $a$ and/or $r$ is M0<br>Allow full marks for correct answer with no working seen. | | |
| | | | | **[6]** |
| **7.** | (a) | $50\,000r^{n-1}$ (or equiv.) (Allow $ar^{n-1}$ if $50\,000r^{n-1}$ is seen in (b)) | B1 | 1 |
| | (b) | $50\,000r^{n-1} > 200\,000$<br>(Using answer to (a), which must include $r$ and $n$, and 200 000)<br>(Allow equals sign or the wrong inequality sign)<br>(Condone 'slips' such as omitting a zero) | M1 | |
| | | $r^{n-1} > 4 \Rightarrow (n-1)\log r > \log 4$ M1<br>(Introducing logs and dealing correctly with the power)<br>(Allow equals sign or the wrong inequality sign) | | |
| | | $n > \dfrac{\log 4}{\log r} + 1$ (*) | A1cso | 3 |
| | | <u>Incorrect</u> inequality sign at any stage loses the A mark.<br>Condone missing brackets if otherwise correct,<br>e.g. $n - 1 \log r > \log 4$. | | |
| | | <u>A common mistake:</u> $50\,000r^{n-1} > 200\,000$ M1<br>$(n-1)\log 50\,000r > \log 200\,000$ M0<br>('Recovery' from here is not possible). | | |
| | (c) | $r = 1.09$: $n > \dfrac{\log 4}{\log 1.09} + 1$ or $n - 1 > \dfrac{\log 4}{\log 1.09}$ ($n > 17.086...$) (Allow equality) | M1 | |
| | | Year 18 or 2023 (If one of these is correct, ignore the other) | A1 | 2 |
| | | Correct answer with no working scores full marks.<br>Year 17 (or 2022) with no working scores M1A0.<br>Treat other methods (e.g. "year by year" calculation) as if there is no working. | | |

(d) $S_n = \dfrac{a(1-r^n)}{1-r} = \dfrac{50\,000(1-1.09^{10})}{1-1.09}$ M1A1

£760 000 (Must be this answer... nearest £10000) A1 3

M1: Use of the correct formula with $a$ = 50000, 5000 or 500000, and $n$ = 9, 10, 11 or 15.

M1 can also be scored by a "year by year" method, <u>with terms added</u>.
(Allow the M mark if there is evidence of adding 9, 10, 11 or 15 terms).
1st A1 is scored if 10 correct terms have been added (allow "nearest £100").
(50000, 54500, 59405, 64751, 70579, 76931, 83855, 91402, 99628, 108595)

<u>No</u> working shown: Special case: 760 000 scores 1 mark, scored as 1, 0, 0.
(Other answers with no working score no marks.)

**[9]**

**8.** (a) $\{S_n = \}\ a + ar + \ldots + ar^{n-1}$ B1

$\{rS_n = \}\ ar + ar^2 + \ldots + ar^n$ M1

$(1 - r)S_n = a(1 - r^n)$ **d**M1

$S_n = \dfrac{a(1-r^n)}{1-r}$ (*) A1cso 4

$S_n$ not required. The following must be seen: at least one + sign, $a$, $ar^{n-1}$ and one other intermediate term. No extra terms (usually $ar^n$). B1

Multiply by $r$; $rS_n$ not required.
At least 2 of their terms on RHS correctly multiplied by $r$. M1

Subtract both sides: LHS must be $\pm(1 - r)S_n$, RHS must be in the form $\pm a(1 - r^{pn+q})$.
Only award this mark if the line for $S_n = \ldots$ or the line for $rS_n = \ldots$ contains a term of the form $ar^{cn+d}$
Method mark, so may contain a slip but not awarded if last term of their $S_n$ = last term of their $rS_n$. dM1

Completion c.s.o.
N.B. Answer given in question A1cso

$S_n$ not required. The following must be seen: at least one + sign,
$a$, $ar^{n-1}$ and one other intermediate term. No extra terms (usually $ar^n$). B1

On RHS, multiply by $\frac{1-r}{1-r}$
Or Multiply LHS and RHS by $(1 - r)$ M1
Multiply by $(1 - r)$ convincingly (RHS) and take out factor of $a$.
Method mark, so may contain a slip. dM1

Completion c.s.o. N.B. Answer given in question A1cso

(b) $a = 200$, $r = 2$, $n = 10$, $S_{10} = \frac{200(1-2^{10})}{1-2}$ M1, A1
$= 204{,}600$ A1 3

Substitute $r = 2$ with $a = 100$ or $200$ and $n = 9$ or $10$ into formula for $S_n$. M1

$\frac{200(1-2^{10})}{1-2}$ or equivalent. A1

204,600 A1

Alternative method: adding 10 terms

(i) Answer only: full marks. (M1 A1 A1)

(ii) 200 + 400 + 800 + … {+ 102,400} = 204,600 or
100(2 + 4 + 8 + … {+ 1,024)} = 204,600

M1 for two correct terms (as above o.e.) and an indication that the
sum is needed (e.g. + sign or the word sum). M1

102,400 o.e. as final term. Can be implied by a correct final answer. A1

204,600. A1

(c) $a = \frac{5}{6}, r = \frac{1}{3}$ B1

$S_\infty = \frac{a}{1-r}, S_\infty = \frac{\frac{5}{6}}{1-\frac{1}{3}}$ M1

$= \frac{5}{4}$ o.e. A1 3

N.B. $S_\infty = \dfrac{a}{1-r}$ is in the formulae book.

$r = \dfrac{1}{3}$ seen or implied anywhere. B1

Substitute $a = \dfrac{5}{6}$ and their $r$ into $\dfrac{a}{1-r}$.
Usual rules about quoting formula. M1

$\dfrac{5}{4}$ o.e. A1

(d) $-1 < r < 1$ (or $|r| < 1$) B1 1

N.B. $S_\infty = \dfrac{a}{1-r}$ for $|r| < 1$ is in the formulae book.

$-1 < r < 1$ or $|r| < 1$ In words or symbols.
Take symbols if words and symbols are contradictory. Must be $<$ not $\leq$. B1

**[11]**

**9.** (a) $ar = 4$, $\dfrac{a}{1-r} = 25$ (These can be seen elsewhere) B1, B1

$a = 25(1 - r)$ $25r(1 - r) = 4$ M: Eliminate $a$ M1

$25r^2 - 25r + 4 = 0$ A1cso 4

*The M mark is not dependent,*
*but both expressions must contain both a and r.*

(b) $(5r - 1)(5r - 4) = 0$ $r = \ldots$, $\dfrac{1}{5}$ or $\dfrac{4}{5}$ M1,A1 2

*<u>Special case:</u>*
*One correct r value given, with no method*
*(or perhaps trial and error): B1 B0.*

(c) $r = \ldots \Rightarrow a = \ldots$, 20 or 5 M1,A1 2

*M1: Substitute one r value back to find a value of a.*

(d) $S_n = \dfrac{a(1-r^n)}{1-r}$, but $\dfrac{a}{1-r} = 25$, so $S_n = 25(1 - r^n)$ B1 1

*Sufficient here to verify with just one pair of values of a and r.*

(e) $25(1 - 0.8^n) > 24$ and proceed to $n = ..$
(or >, or <) with no unsound algebra. M1

$\left(n > \dfrac{\log 0.04}{\log 0.8} \ (=14.425)\right)$ $n = 15$ A1 2

*Accept "=" rather than inequalities throughout, and also allow the wrong inequality to be used at any stage.*

*M1 requires use of their larger value of r.*

*A correct answer with no working scores both marks.*

*For "trial and error" methods, to score M1, a value of n between 12 and 18 (inclusive) must be tried.*

**[11]**

**10.** (a) $\dfrac{a}{1-r} = 480$ M1

$\dfrac{120}{1-r} = 480 \Rightarrow 120 = 480(1-r)$ M1

$1 - r = \frac{1}{4} \Rightarrow \underline{r = \frac{3}{4}}$ * A1cso 3

(b) $u_5 = 120 \times (\frac{3}{4})^4$ [= 37.96875] either M1

$u_6 = 120 \times (\frac{3}{4})^5$ [= 28.4765625]

Difference = $\underline{9.49}$ (allow ±) A1 2

(c) $S_7 = \dfrac{120(1-(0.75)^7)}{1-0.75}$ M1

= 415.9277... (AWRT)$\underline{416}$ A1 2

(d) $\dfrac{120(1-(0.75)^n)}{1-0.75} > 300$ M1

$1 - (1.75)^n > \dfrac{300}{480}$ (or better) A1

$n > \dfrac{\log(0.375)}{\log(0.75)}$ (= 3.409 ...) M1

$\underline{n = 4}$ A1cso 4

**[11]**

| | | | | |
|---|---|---|---|---|
| (a) | 1st M1 for use of $S_\infty$ | | | <u>For Information</u> |
| | 2nd M1 | substituting for $a$ and moving $(1 - r)$ to form linear equation in $r$. | | $u_1 = 120$<br>$u_2 = 90$ |
| (b) | M1 | for some correct use of $ar^{n-1}$. [$120(\frac{3}{4})^5 - 120(\frac{3}{4})^6$ is M0]<br>$u_4 = 50.625$ | | $u_3 = 67.5$ |
| (c) | M1 | for a correct expression (need use of $a$ and $r$) | | $S_2 = 210$ |
| (d) | 1st M1 | for attempting $S_n > 300$ [or = 300]<br>(need use of a and some use of r) | | $S_3 = 277.5$ |
| | 2nd M1 | for valid attempt to solve $r^n = p(r, p < 1)$, must give linear eqn in $n$<br>Any correct log form will do. | | $S_4 = 328.125$<br>$S_5 = 366.09$ ... |

Trial 1st M1 for attempting at least 2 values of $S_n$, one $n$ <4 and one $n \geq 4$.

& 2nd M1 for attempting $S_3$ and $S_4$.

Imp. 1st A1 for both values correct to 2 s.f. or better.

2nd A1 for $n = 4$.

**11.** (a) $(S =)\ a + ar + \ldots + ar^{n-1}$ B1

*"S =" not required.*
*Addition required*

$(rS =)\ ar + ar^2 + \ldots + ar^n$ M1

*"rS =" not required*
*(M: Multiply by r)*

$S(1 - r) = a(1 - r^n)$ $\quad S = \dfrac{a(1-r^n)}{1-r}$ M1 A1cso 4

*(M: Subtract and factorise) (*)*

*B1: At least the 3 terms shown above, and no extra terms.*

*A1: Requires a completely correct solution.*

*<u>Alternative for the 2 M marks:</u>*
*M1: Multiply numerator and denominator by 1 – r.*
*M1: Multiply out numerator convincingly, and factorise.*

(b) $ar^{n-1} = 35000 \times 1.04^3 = 39\,400$ M1 A1 2

*(M: Correct a and r, with n = 3, 4 or 5).*

*M1 can also be scored by a "year by year" method.*
*Answer only: 39 400 scores full marks, 39 370 scores M1 A0.*

(c) $n = 20$ B1

*Seen or implied*

$S_{20} = \dfrac{35\,000(1-1.04^{20})}{(1-1.04)}$ M1 A1ft

*(M1: Needs any r value, a = 35 000, n = 19, 20 or 21).*
*(A1 ft: ft from n = 19 or n = 21, but r must be 1.04).*

$= 1\,042\,000$ A1 4

*M1 can also be scored by a "year by year" method, with terms added.*
*In this case the B1 will be scored if the correct number of years is considered.*
*Answer only: Special case: 1 042 000 scores 2 B marks, scored as 1, 0, 0, 1 (Other answers score no marks).*

*Failure to round correctly in (b) and (c):*
*Penalise once only (first occurrence).*

**[10]**

**12.** (a) Applying correct formula [325 = 120 +5(n – 1)] M1
Solving to give $n = 42$ (*) (or verifying in correct equation) A1 2

(b) Using formula for sum of AP: S = $\dfrac{42}{2}\{240 + 5(42 - 1)\}$

or use $\frac{n}{2}\{a + l\}$ M1A1
= 9345 A1 3

(c) Recognising GP with $r = 0.98$ M1
Value ( in £ ) = 7200 ( 0.98)$^{24}$ M1
= 4434 ( only this value) A1 3

**[8]**

**13.** (a) $ar$ 7.2, $ar^3 = 5.832 \Rightarrow r^2 = \dfrac{5.832}{7.2}$ (= 0.81) M1

$r = 0.9$ A1 2

(b) $a = \dfrac{7.2}{(a)}, = 8$ M1, A1 2

| | | | | |
|---|---|---|---|---|
| | (c) | $s_{50} = \dfrac{8(1-(0.9)^{50})}{1-0.9}$ | M1 | |
| | | $= \underline{79.588}$ (3*dp*) | A1 c.a.o | 2 |
| | (d) | $s_\infty = \dfrac{8}{1-0.9}$ (= 80) | M1 | |
| | | $s_\infty - s_{50} = 80 - (c) = 0.412$ | A1 f.t. | 2 |

**[8]**

| | | | | |
|---|---|---|---|---|
| **14.** | (a) | $ar^3 = 12 \quad ar^4 = -8 \quad r = \ldots,\ -\dfrac{2}{3}$ (or exact equivalent) | M1, A1 | 2 |
| | (b) | Using $r$ with $ar^3 = 12$ or $ar^4 = -8$ to find $a = \ldots$ | M1 | |
| | | $a = -40\ 1/2$ | A1 | 3 |
| | (c) | $\dfrac{a}{1-r} = \dfrac{-40\frac{1}{2}}{1-\left(-\frac{2}{3}\right)}, \quad = -24.3 \left(-24\dfrac{3}{10} \text{ or } -\dfrac{243}{10}\right)$ | M1 A1ft, A1 | 3 |
| | | *A1ft requires $\lvert r \rvert < 1$* | | |

**[7]**

| | | | | |
|---|---|---|---|---|
| **15.** | (a) | $(S =)\ a + ar + \ldots + ar^{n-1}$ | B1 | |
| | | *"S =" not required. Addition required.* | | |
| | | $(rS = )\ ar + ar^2 + \ldots + ar^n$ | M1 | |
| | | *"rS =" not required (M: Multiply by r)* | | |
| | | $S(1-r) = a(1-r^n)\ S = \dfrac{a(1-r^n)}{1-r}$ | M1 A1 | 4 |
| | | *(M: Subtract and factorise each side) (*)* | | |
| | (b) | $r = 0.9$ | B1 | |
| | | $S_{20} = \dfrac{10(1-0.9^{20})}{1-0.9} = 87.8$ | M1 A1 | 3 |
| | (c) | Sum to infinity $= \dfrac{a}{1-r} = \dfrac{10}{1-0.9} = 100$ | M1 A1ft | 2 |
| | | *(ft only for $\lvert r \rvert < 1$)* | | |

(d) $\frac{a}{1-r} = \frac{r}{1-r} = 10$ (Put $a = r$ in the formula from (c), and equate to 10) M1

$r = 10(1 - r)$ $r = \ldots$ $\frac{10}{11}$ (or exact equivalent) M1, A1 3

**[12]**

**16.** (a) $\frac{a}{1-r} = \frac{1200}{1-r} = 960$ M1 A1

$960\,(1 - r) = 1200$ $r = -\frac{1}{4}$ (*) A1

(b) $T_9 = 1200 \times (-0.25)^8$ (or $T_{10}$) M1

Difference $= T_9 - T_{10} = 0.0183105\ldots - (-0.0045776\ldots)$ M1

$= 0.023$ (or $-0.023$) A1

(c) $S_n = \frac{1200\left(1-(-0.25)^n\right)}{1-(-0.25)}$ M1 A1

(d) Since $n$ is odd, $(-0.25)^n$ is negative, M1

so $S_n = 960\,(1 + 0.25^n)$ (*) A1

**[10]**

**17.** (a) $ar = 9$

$ar^4 = 1.125$ M1

Dividing gives $r^3 = \frac{1.125}{9} = \frac{1}{8}$ M1

So $r = \frac{1}{2}$ A1 3

(b) Using $ar = 9$, $a = \frac{9}{\frac{1}{2}} = 18$ M1, A1 2

(c) $S_\infty = \frac{a}{1-r} = \frac{18}{1-\frac{1}{2}} = 36$ M1 A1 2

**[7]**

**1.** Parts (a) and (b) of this geometric sequence question were usually correctly answered, although 0.03 instead of 1.03 was occasionally seen as the common ratio.

In part (c), lack of confidence in logarithms was often apparent. Some candidates failed to get started, omitting the vital step $25000r^{N-1} > 40000$, while others tried to use the sum formula rather than the term formula. Often the working was insufficiently convincing to justify the progression to $(N-1)\log 1.03 > \log 1.6$. Showing each step in the working is important when, as here, the answer is given.

There was much more success in part (d), where the result of part (c) had to be used (although other methods such as 'trial and improvement' were possible). Manipulation of the inequality often gave $N > 16.9$, but it was disappointing that many candidates lost a mark by giving 16.9 rather than 17 as the value of $N$.

The majority of candidates interpreted the requirement of part (e) correctly as the sum of a geometric series. A few used $ar^{n-1}$ instead of the sum formula, but in general there were good attempts to find the total sum of money. It was, of course, possible to avoid the sum formula by calculating year by year amounts, then adding, but those who used this inefficient approach tended to make mistakes. Rounding to the nearest £1000 was required, but some candidates ignored this or rounded incorrectly, losing the final mark.

**2.** (a) This was an easy introduction into this question and most candidates showed that $18000 \times 0.8^3 = 9216$. Some did this in one step, which was sufficient, while others multiplied by 0.8 three times and gave the intermediate answers of 14400, 11520 and finally 9216

(b) Although a majority of candidates found $n = 13$, it was rare to see a well set out, completely correct method of solution. Many considered $ar^{n-1}$ instead of $ar^n$ in their working. The log work was usually good, but use of inequalities usually led to errors, as it was rare for students to appreciate that the inequality had to change when dividing by log 0.8, a negative number. Trial and improvement methods were allowed, but required evidence that $n = 13$ and $n = 14$ had been evaluated and compared with 1000.

(c) This part was usually understood and the method was executed correctly. Some did not give their answers to the nearest penny as asked in the question.

(d) Most attempted this using the sum of a GP as required. The answer was usually correct although some made errors evaluating their fraction. A few very weak candidates reverted to A.Ps for this part of the question.

**3.** There were many excellent solutions to this question. When problems did occur, these were frequently in part (a), where some candidates showed insufficient working to establish the given common ratio and others confused common ratio and common difference, treating the sequence as arithmetic.

Most of those who were confused in part (a) seemed to recover in part (b). In both part (a) and part (b), some candidates used the formula $ar^{n-1}$ and others successfully used the method of repeatedly multiplying or dividing by the common ratio.
Formulae and methods for the sum to 15 terms and the sum to infinity were usually correct in parts (c) and (d). Just a few candidates found the 15th term instead of the sum in part (c) and just a few resorted to finding all 15 terms and adding.

**4.** Part (a) was a good discriminator. There were a few cases of "fudging" attempts to yield the printed answer using $(k + 4)(2k – 15) = 0$ or similar. Cancelling was often ignored by those using $(k + 4) \times (k/(k + 4))^2 = (2k – 15)$ resulting in cubic equations – generally incorrectly expanded.

Finding the printed answer in (b) was straightforward and most were successful at solving the quadratic equation. Some used verification and lost a mark.

Finding the common ratio in part (c) was answered well, though some candidates found $r = 4/3$ however.

The sum to infinity in (d) was answered well. Using 12 for "a" was the frequent error here.

**5.** Parts (a) and (b) of this question were very well done and the majority of candidates gained full marks here. A few, however, found the sum of 20 terms in part (a) rather than the 20th term.

Only the very best candidates achieved full marks in part (c). The main difficulty was in dealing correctly with the inequality throughout the working. Often there were mistakes in manipulation and the division by log 0.8 (a negative value) rarely resulted in the required 'reversal' of the inequality sign. Another common mistake was to say that $5 \times 8^k = 4^k$. Despite these problems, many candidates were still able to score two or three marks out of the available four.

A surprising number of candidates made no attempt at part (d) and clearly did not realise they simply had to evaluate the expression in (c). Many failed to appreciate that $k$ had to be an integer.

**6.** This was a straightforward geometric series question and, as the mark scheme was quite generous in parts (a) and (b), most candidates were able to gain some marks. In part (a), the solution of the equations $ar^6 = 80$ and $ar^3 = 10$ often displayed poor algebraic skills, with results such as $ar^3 = 8$, $r^6 - r^3 = 8$ and $r^3 = 70$ too common. The vast majority of candidates stated or used a correct formula in (c), although sometimes $n = 19$ was substituted, and quite often the final answer was not corrected to the nearest integer.

Candidates who found $r = \frac{1}{2}$ in (a) usually went on to find $a = 80$, the same value as seventh term; a quick check of the work might easily have produced more marks.

**7.** Responses to this question were very mixed, with many candidates scoring marks in only one or two parts and with much misunderstanding of logarithms.
In part (a), most managed to write down $50000r^{n-1}$ as the predicted profit in Year $n$, although $50000r^n$ was a popular alternative. In part (b), showing the result $n > \frac{\log 4}{\log r} + 1$ proved difficult for the average candidate. Sometimes this was simply not attempted, sometimes candidates tried to 'work backwards' and sometimes there were mistakes in logarithmic theory such as $50000r^{n-1} > 200000 \Rightarrow (n-1)\log 500000r > \log 200000$.
Disappointingly, many candidates failed to use the given result from part (b) in their solutions to part (c). Some worked through the method of part (b) again (perhaps successfully) but others used the sum formula for the geometric series, scoring no marks. Even those who correctly achieved $n > 17.08...$ tended to give the answer as 'Year 17' or '2022' instead of 'Year 18' or 2023.

After frequent failure in parts (b) and (c), many candidates recovered to score two or three marks in part (d), where they had to use the sum formula for the geometric series. Occasionally here the wrong value of $n$ was used, but more often a mark was lost through failure to round the final answer to the nearest £10 000.

**8.** In part (a), as was found the last time this was tested in June 2005, a number of candidates failed to demonstrate complete understanding of the required proof. Common errors included giving the $n$th term as $ar^n$ rather than $ar^{n-1}$ and rewriting the sum in reverse order rather than multiplying by $r$. In part (b) many candidates appreciated the link with part (a) and attempted to use the correct formula. However, the first term of the series was often stated incorrectly as 100 and occasionally $r = 100$ was seen. A number of candidates wrote out terms and added them on their calculators which usually resulted in the correct answer being given. The majority of candidates answered part (c) correctly. Some had difficulty finding $r$, often resulting in an answer of $r = 3$. These candidates showed a lack of understanding of the condition for a sum to infinity to exist even though $|r| < 1$ is stated in the formula book. A similar problem occurred in part (d). A substantial number of candidates gave no answer to this part. Common incorrect answers included $r > 0$, $r < 1$ and $0 < r < 1$.

**9.** While most candidates were able to produce $ar = 4$ and $\frac{a}{1-r} = 25$, either in part (a) or elsewhere, many had difficulty in establishing the given result $25r^2 - 25r + 4 = 0$ Often the solution to the quadratic equation was seen in part (a) rather than part (b), but candidates usually acknowledged that what they had found was, indeed, the answer for (b). Careless (and sometimes very bad) algebra was not uncommon, but otherwise many correct solutions to parts (b) and (c) were seen. The main difficulties in this question came in the last two parts. In part (d), justification of $S_n = 25(1-r)^n$ was often omitted or unconvincing, and the general proof of the sum formula for a geometric series occasionally appeared. It was common to see the result obtained falsely by adding the $r$ values to get 1, adding the $a$ values to get 25, substituting these hybrid values into the correct formula and ignoring the zero denominator. In part (e), although some candidates used logarithmic or 'trial and improvement' methods very efficiently, others were inclined to produce algebra such as $25(1-8.0)^n = 25 - 20^n$ Some successfully obtained the value $n = 14.4$, but failed to realise that $n$ had to be an integer, or chose $n = 14$ instead of $n = 15$. Some wasted time on lengthy, inaccurate algebra that was leading nowhere.

**10.** Most students made very good progress with the first 3 parts of this question but part (d) caused dome problems. The proof in part (a) was usually carried out successfully with a minority of candidates choosing to verify rather than derive the result, they sometimes lost a mark for failing to provide a closing statement that $r = \frac{3}{4}$. Part (b) was answered well too with very few cases of students trying to use $ar^n$ for the $n^{\text{th}}$ term and only a handful failing to give the answer to the required accuracy. In part (c) a correct expression was usually given but some students struggled with the evaluation of $\left(\frac{3}{4}\right)^7$ and others ignored the bracket to get $120 \times 1 - \left(\frac{3}{4}\right)^7$ but the vast majority of the candidates were successful here. In part (d) most were able to write down a correct inequality or equation but the simplification to a form with $r^n <$ (or $=$), and then a correct use of logarithms proved more challenging and under 40% of the candidates obtained the correct answer. A common error was to replace $120 \times \left(\frac{3}{4}\right)^n$ with $(90)^n$. Some avoided the challenges of inequalities, indices and logarithms by simply evaluating $S_3$ and $S_4$ and correctly deducing the answer. On this occasion that was a sensible strategy but it is not a tactic that is likely to work in the future!

**11.** Those who were familiar with the required proof of the sum formula for the geometric series were able to produce good solutions to part (a), but all too many failed to demonstrate complete understanding of what they were trying to show, losing one or two marks. Many candidates were unable to produce anything worthy of marks here. Whether working with the term formula for a geometric series or otherwise, most candidates managed to score at least the method mark in part (b). Common mistakes included finding the third term (instead of the fourth) and failing to round to the nearest £100. In part (c), those who were unable to find the correct common ratio (using perhaps 0.04 or 1.4, or even 4) were limited to just one mark. An extremely popular mistake was to use $n = 19$ (found by subtracting the years 2024 and 2005) rather than 20. Just a few candidates laboriously calculated the total salary by finding and adding the salaries for all 20 years.

**12.** Parts (a) and (b) were answered very well, with many candidates gaining full marks on these parts. The most common mistakes were to use $S_n$=325 rather than $U_n$ in part (a), and to use the wrong formula in (b) e.g. n/2(a+(n-1)d)

(c) This caused major problems, and very few candidates had this correct. Many tried to use a GP with r=0.02, Those who did decide that r=0.98 tried to use the Sum formula, or use 7200(0.98) to the power of 23, 35, 36, 2 or 3. Some candidates who had the correct answer failed to give it to the nearest £ to gain full marks. Sadly, some candidates didn't use any formulae at all, and calculated all values in all three parts – often coming up with the right answer, but it must have taken a very long time!

**13.** Apart from the small minority who had little idea how a geometric series was defined most made good progress with this question. Part (a) caused the most problems with many candidates taking very circuitous routes, often involving finding the first or third term, to reach $r = 0.9$. Some forgot to square root and used $r = 0.81$ throughout the question. Part (b) caused few problems and apart from a few candidates who used 49 instead of 50 in their formula for the sum in part (c) the only difficulty here was confusion between 3 d.p. and 3 s.f., but the mark scheme allowed many to gain full marks in part (d). Part (d) was answered well, although candidates with incorrect values of $r$ (and $|r| > 1$) had no qualms about using the $S_\infty$ formula.

**14.** There were many excellent solutions to this question. Most candidates showed good understanding of the geometric series in parts (a) and (b), the given answer in part (b) no doubt helping to reduce the likelihood of using $ar^n$ instead of $ar^{n-1}$ as the $n$th term. A "step by step" approach was often seen in part (b), using the fourth term and common ratio to work back to the first term of the series. In part (c), the formula for the sum to infinity was occasionally wrongly quoted and there were sometimes calculation mistakes, but many candidates were able to achieve the correct answer.

**15.** Attempts at the standard proof of the sum formula for the geometric series often showed a lack of understanding. While some candidates had clearly rehearsed this well and scored all four marks very easily, others had no idea how to start, or perhaps confused this with the arithmetic series proof and began by "reversing the terms". The most common mistake in the proof was to write the last term as $ar^n$. Parts (b), (c) and (d) however, were often very well done. In part (b), most found the correct common ratio and used the sum formula accurately, but there were a few who gave $r = \frac{10}{9}$, and those who were thinking of an arithmetic series and gave $r = -1$.

The sum to infinity formula was usually well remembered in part (c), and then in part (d), although some candidates had no idea how to start or never equated $a$ and $r$, it was encouraging that many did form and solve an equation in $r$ to find an exact solution.

**16.** In part (a), most candidates remembered the formula for the sum to infinity of a geometric series and were able to show, sometimes by verification, that the common ratio was $-\frac{1}{4}$. There was rather less success in part (b), however, where numerical mistakes were common. Often sign errors occurred in the calculated value of $1200 \times \left(-\frac{1}{4}\right)^8$ or $1200 \times \left(-\frac{1}{4}\right)^9$, while a few candidates used either the sum formula or $ar^n$ as the *n*th term. A popular suggestion for the 10th term was (±) 4.577…, showing a lack of understanding of the calculator "standard form" display. Also some candidates gave their answer to 3 significant figures rather than 3 decimal places.

Since the requirements of part (c) were somewhat vague, parts (c) and (d) were combined for the purpose of marking. While many candidates were able to use the correct sum formula with the appropriate values of *a* and *r*, and to justify the 960 factor in 960(1+0.25 ), few completed the proof in (d) by showing that, for an odd value of *n*, $(-0.25)^n = -(0.25)^n$.

**17.** No Report available for this question.