1(a). The value of a car £V is given by

$$V = 20\,000 \times 0.9^t$$

where t is the age of the car in complete years.

Write down the value of V when $t = 0$.

£ _____ [1]

(b). What is the value of V when $t = 3$?

£ _____ [2]

(c). After how many complete years will the car's value drop below £10 000?

(c) _____ [2]

2(a). Here are the interest rates for two accounts.

Account A	Account B
Interest: 3% per year compound interest.	Interest: 4% for the first year, 3% for the second year and 2% for the third year.
No withdrawals until the end of three years.	Withdrawals allowed at any time.

Derrick has £10 000 he wants to invest.

Calculate which account would give him most money if he invests his money for 3 years.
Give the difference in the interest to the nearest penny.

Account _____ by _____ p **[5]**

(b). Explain why he might **not** want to use Account A.

---**[1]**

3. On 1st January 2014, Harry invested £5720 at a compound interest rate of 4% per year.

On 1st January of which year will his investment exceed £7000?
Show clearly all your working.

---

[3]

4. Mehdi invests £4000 at a rate of 2% compound interest each year.
Calculate how much the investment is worth after 3 years.

£_____ [3]

5. Noah invested £3000 in a bank at a fixed annual compound interest rate.
In 2013, the bank used this calculation to work out how much the investment was worth.

$$3000 \times 1.025^{16}$$

(i) What rate of interest was given?

(i) _____ % **[1]**

(ii) In which year did Noah originally invest the money?

(ii) _____ **[2]**

6(a). The number of bacteria present in a culture is observed.

This number of bacteria, N, is given by the formula

$N = 15\,000 \times 2^{-t}$

where t is the time, in hours, after the observation starts.

How many bacteria are present 3 hours after the observation starts?

_____ [1]

(b). After how many hours from the start of the observation will the bacteria have disappeared? That is, after how many hours will the number of bacteria first fall below 1?

_____ hours [2]

7. On Finch Island there are bullfinches and chaffinches.
In the spring of 2013:

- the population of bullfinches was 6700 and was **decreasing** by 3% each year
- the population of chaffinches was 4800 and was **increasing** by 4% each year.

In the spring of which year will the population of chaffinches first be greater than that of the bullfinches?
Show your working clearly.

_____ **[4]**

8. Chris has £2500 to invest for 3 years.

He finds this information about two savings accounts paying compound interest.

BONUS ACCOUNT	FIXED RATE ACCOUNT
3.5% interest for first year then 3% interest per year	3.25% interest per year fixed rate for 3 years

Advise Chris which account he should choose, and find how much money he will have at the end of the 3 years.

_____ account

£ _____ **[5]**

9(a). The population, P, of an island t years after the start of 2010 is given by $P = 9200 \times 0.96^t$.

Write down the population of the island at the start of 2010.

_____ [1]

(b). Work out the population of the island at the start of 2013.

_____ [2]

(c). The population continues to decrease at the same rate.

At the start of which year is the population first below half of its level at the start of 2010?

_____ [3]

10. Emma invests £5760 in a savings account.
The account pays a fixed rate of 2.4% per year compound interest.

Calculate how much money is in the account at the end of 3 years.

£ _____ [3]

11(a) On 1st November 2015 there were 4200 trees planted in a wood.

. On 1st November 2016, only 3948 of these trees were still alive.

It is assumed that the number of trees still alive is given by

$$N = ar^t$$

where N is the number of trees still alive t years after 1st November 2015.

Write down the value of a.

_____ [1]

(b). Show that r is 0.94. [2]

(c). Show that on 1st November 2030 the number of trees still alive is predicted to have decreased by over 60% compared with 1st November 2015. [3]

12(a) Rashid invests money into an account which pays a fixed rate of compound interest each year.

The value, £V, of his investment after t years is given by the formula

$$V = 1250 \times 1.03^{t}.$$

How much money did Rashid invest?

£ _____ [1]

(b). What rate of compound interest is paid each year?

_____ % [1]

13(a) Amelia buys a new car.

. The expected future value of this car, £V, is given by

$$V = 16000 \times 0.75^t$$

where t is the age of the car in complete years.

(i) Write down the value of the car when new.

(i) £ ---------- [1]

(ii) Write down the annual percentage decrease in the expected value of the car.

(ii) ---------- % [1]

(iii) Show that the expected value of the car when 2 years old is £9000. [2]

(b). Amelia assumes that her car will have no value at all after 20 years.

Explain why her assumption is mathematically incorrect.

---[1]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Part marks and guidance	
1	a		£20 000	1		
	b		£14 580 or £14 600	2	**M1** for $20\,000 \times 0.9^3$	
	c		7 years	2	**M1** for 2 trials shown	
			Total	**5**		
2	a		(Account) A (by) 103[p]	5	**B2** for 10 927.27 and **B2** for 10 926.24 or **B1** for 10 400 or 10 712 If zero scored **M1** for 1.03^3 **oe** used **M1** for 1.04, 1.03 and 1.02 used **oe**	
	b		He may not want to leave it there for 3 years	1	Accept any valid reason	
			Total	**6**		

Question			Answer/Indicative content	Marks	Part marks and guidance	
3			2020 with some correct supportive working e.g at least two correct values from table	3	**M1** for each of two correct values from the table given which can be rot to at least 3 figures (they do not have to be linked to a number / year) **Note:** Answer of 2020 with no correct supportive working scores **SC1** Answer of 2020 with only the correct value for 2020 scores **SC2**	2015 5948.800 2016 6186.752 2017 6434.222 2018 6691.591 2019 6959.255 2020 7237.625 Alternative method if seen: $5720 \times 1.04^n = 7000$ $1.04^n = 7000 \div 5720$ or 1.223... scores **M1** n = log(their 1.223...) ÷ log 1.04 or 5.14… scores **M1** Examiner's Comments This was answered well with accurate working shown by the majority of candidates. There has been a significant improvement in the use of calculators in these types of questions. The main error was to add on the same amount each year in a similar way as the use of simple interest.
			Total	3		
4			4244.83 or 4245	3	**M2** for 4000×1.02^3 oe **Or M1** for 4000×1.02 oe After zero scored **SC1** for answer 4240	Examiner's Comments This was answered well with many candidates using the more direct method rather than a step-by-step approach. Some answers were spoiled by not being given to an appropriate degree of accuracy.
			Total	3		

Question			Answer/Indicative content	Marks	Part marks and guidance	
5		i	2.5	1		
		ii	1997	2	**M1** for 2013 – 16 oe **Examiner's Comments** There were many fully correct answers to all parts of this question. Common wrong answers to part (i) were 1.025, 0.25, 25 or 1.48 (from 1.025^{16}). (ii) was invariably correct.	
			Total	**3**		
6	a		1875	1	**Examiner's Comments** This was usually correct. Candidates were confident in using their calculators.	
	b		13.88 to 14	2	**M1** for evidence of at least 2 values of t substituted. **Examiner's Comments** There were many correct answers as well. Often an answer appeared with no working shown. Probably candidates thought it unnecessary to write down their trials. On the other hand, a few wrote down numerous trials. The question was sometimes misread and candidates found **any** time when the number fell below 1 rather than the **first** time.	
			Total	**3**		

Question			Answer/Indicative content	Marks	Part marks and guidance	
7			2018 with correct calculations of two further years for both species	4	**B3** for correctly calculating both species for two additional years e.g. 2014 and 2016 **or** **B2** for correctly calculating both species for one additional year e.g. 2014 or one species correct for two additional years **or** **B1** for correctly calculating one species for 2014 or another year the figures need only be **rot** to at least 2 sf e.g. 6499 could be 6400 or 6500 but do not **FT** their incorrect rounding <u>Examiner's Comments</u> The layout and presentation of this question was not always logical and clear. Calculations were seen all over the page and few attached a year to their figures. Surprisingly, there were very few candidates who drew a table. The common errors were to divide rather than multiply, so for example, 6700 ÷ 1.03 (or 0.97) was seen. There were a few who thought that the increase would be the same each year, so they subtracted 201 from the bullfinches and added 192 to the chaffinches for each further year.	2013 6700 4800 2014 6499 4992 2015 6304.03 5191.68 2016 6114.909 5399.347 2017 5931.462 5615.321 2018 5753.518 5839.934 2019 5580.912 6073.531 ignore extras like 'Spring' in their answer condone the wrong labels for the years
			Total	4		

Question			Answer/Indicative content	Marks	Part marks and guidance	
8			Fixed rate account, £2751.76 or £2751.75 With fully correct calculations for both accounts shown, clearly laid out and annotated. This may be either total amount in each account or total interest for both accounts linked with account name	5	Bonus account After 1 year: 2500 × 1.035 = 2587.50 After 3 years: 2587.5 × 1.03^2 = 2745.08 or 2745.07[875] Fixed rate account: After 3 years: 2500 × 1.0325^3 = 2751.76 or 2751.75[7695]	
			4a Correct calculations for both accounts linked with account names with incorrect conclusion eg interest rather than total **4b** Correct conclusion with totals found for both accounts but no calculations or calculations not linked with account names **4c** Clearly laid out and annotated work with one error in calculations or with rounding errors which lead to 2745 (Bonus) and 2751 or 2752 (Fixed) or better and correct FT conclusion	4–3	**3a** Correct amount in one account after 3 years stated or correct calculation for one account seen with account clearly identified **3b** Total interest for both accounts seen not necessarily linked with account names, [£]245.08 and [£]251.76 **3c** Totals for both accounts seen, correct to at least nearest pound, not linked with account names	

Question			Answer/Indicative content	Marks	Part marks and guidance	
			2a One correct total seen [£]2751.76 or [£]2745.08, correct to at least nearest pound **2b** Attempt at **compound** interest calculation for 3 years for one account **2c** Correct calculations seen for totals in both accounts after at least one year: 2500 × 1.035 **oe** and 2500 × 1.0325 **oe** **2d** Simple interest calculations for both accounts seen linked withcorrect accounts and answer Fixed Rate, £2743.75	2–1	**1a** Attempt at correct calculation for one account for at least one year: 2500 × 1.035 **oe** or 2500 × 1.0325 **oe** seen **1b** Attempt to find interest for both accounts for at least one year seen or implied: 3.5% of 2500 or 87.5 or 3% of 2500 or 75 **and** 3.25% of 2500 or 81.25 Alternative method: Bonus account after 3 years $1.035 \times 1.03^2 = 1.098[0315]$ Fixed rate account after 3 years $1.0325^3 = 1.100[703078]$	
			No worthwhile work attempted **Statements are minimum requirement for each mark**	0	Fixed rate is more with $2500 \times 1.0325^3 = £2751.76$ **Examiner's Comments** This question tested the candidates' quality of written communication so they were expected to identify their calculations by more than numerical values and to present them in a logical form leading to a clear conclusion. On the whole presentation is improving in this type of question. Some candidates gained five marks with a minimum of effort producing complete, but concise, working with correct annotation. Many candidates understood that compound interest calculations were	

Question			Answer/Indicative content	Marks	Part marks and guidance	
					required and multiplier methods generally led to correct answers, but in some cases marks were lost because these calculations were not linked with accounts. Candidates who used step-by-step methods to calculate the amounts in the accounts each year often lost marks due to arithmetic slips or miscopying of numbers. Candidates found it harder to deal with the changing interest rate of the Bonus Account than the constant rate in the Fixed Rate Account. Some incorrect application of the interest rates was seen, with, for example, 1.35 used in place of 1.035. Some candidates worked with simple interest rather than compound interest which meant that a maximum of two marks would be awarded. Other candidates tried to use non-calculator methods to find the percentages which is inappropriate on a calculator paper and seldom led to more than one mark for finding the interest correctly for one year. A number of candidates subtracted the interest from the investment or did not give answers to the nearest penny, demonstrating a lack of understanding of functional mathematics.	
			Total	5		

Question			Answer/Indicative content	Marks	Part marks and guidance	
9	a		9200	1	Examiner's Comments In this part the majority of candidates did not realise that the start of 2010 was when $t = 0$, and found the population when $t = 1$ which was 8832.	
	b		8140 or 8139	2	**M1** for 9200×0.96^3 Examiner's Comments Many candidates however knew that they were required to substitute $t = 3$ into the equation in this part and gained at least partial credit here. To gain both marks, candidates were required to realise that a population had to be an integer but rounding or truncating to 8139 or 8140 were both acceptable.	M1 implied by 8139.5 to 8139.6 seen

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th colspan="2">Part marks and guidance</th></tr>
<tr><td></td><td>c</td><td></td><td>2027</td><td>3</td><td>B2 for answer 17 or 2026 or 2028 Or B1 for answer 16 or 18

OR

M1 for correct trial seen with $t > 9$ correct to at least 3 s.f.

AND

M1 for second better trial seen correct to at least 3 s.f.

Examiner's Comments

In this part, many candidates realised that they needed to use a trial and improvement approach to find when the population reached half of its original value. Problems occurred when they tried to relate their value of t to the actual year, so, after seeing correct trials, it was not uncommon to see answers such as 2017 or 2018. Method marks were often awarded for clear trials with the correct outcome shown. Although this was a question on a difficult topic, overall performance was good, with candidates demonstrating good calculator skills.</td><td>Trials finding P
<table><tr><td>t</td><td>P</td><td></td><td>t</td><td>P</td></tr><tr><td>10</td><td>6116</td><td></td><td>15</td><td>4987</td></tr><tr><td>11</td><td>5871</td><td></td><td>16</td><td>4787</td></tr><tr><td>12</td><td>5636</td><td></td><td>17</td><td>4596</td></tr><tr><td>13</td><td>5411</td><td></td><td>18</td><td>4412</td></tr><tr><td>14</td><td>5194</td><td></td><td>19</td><td>4235</td></tr></table>Trials finding 0.96^t
<table><tr><td>t</td><td>0.96^t</td><td></td><td>t</td><td>0.96^t</td></tr><tr><td>10</td><td>0.6648</td><td></td><td>15</td><td>0.5421</td></tr><tr><td>11</td><td>0.6382</td><td></td><td>16</td><td>0.5204</td></tr><tr><td>12</td><td>0.6127</td><td></td><td>17</td><td>0.4996</td></tr><tr><td>13</td><td>0.5882</td><td></td><td>18</td><td>0.4796</td></tr><tr><td>14</td><td>0.5647</td><td></td><td>19</td><td>0.4604</td></tr></table>
Allow year seen in trials in place of t (= t + 2010)</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>6</td><td colspan="2"></td></tr>
</table>

Question			Answer/Indicative content	Marks	Part marks and guidance	
10			6184.75 or 6184.74 or 6184.76 final answer	3	**M2** for 5760×1.024^3 **oe** OR **M1** for 5760×1.024^n **oe** Or for $5760 \times$ *their* 1.024^3 **oe** After **M0**, **SC1** for answer 6174.72 **Examiner's Comments** Candidates were more successful in carrying out the compound interest calculation. Those who used the formula generally reached the correct answer. Candidates who approached the solution using less efficient year-on-year calculations sometimes used incorrect or inappropriate rounding of intermediate values or had transcription errors in their working which led to an inaccurate final answer. This method often included breaking down the percentage into 10%, 2% and 0.4% which led to errors. Some candidates used an incorrect multiplier of 0.24, 1.24 or 2.4 and others used simple interest rather than compound interest. A small number of candidates carried out a percentage reduction calculation. In this question if candidates had checked whether their answer was reasonable it would have	Implied by answer 6184.74 to 6184.8 Allow **M2** for step by step method for total after exactly 3 years Where $n \geq 1$, $n \neq 3$ **M1** implied by 5898.24 seen Where $1 <$ *their* $1.024 < 2$

Question			Answer/Indicative content	Marks	Part marks and guidance	
					led many to realise that they must have made an error as an answer of £5355.15 is clearly wrong as it is less than the starting amount and an answer of £79 626.24 is clearly wrong as it is far too large.	
			Total	3		

Question			Answer/Indicative content	Marks	Part marks and guidance	
11	a		4200	1	Examiner's Comments This part was generally well answered, however sometimes 3948 or 4200–3948 = 252 were seen as answers.	
	b		3948 = 4200*r* oe 3948 ÷ 4200 = 0.94	B1 B1	Can be implied by e.g. second statement Examiner's Comments In this part, it was allowed for candidates to verify the answer rather than to derive it.	
	c		[0].4[0] × 4200 or 1680 4200 × ([0].94)^{15} or 1660[. …] 1660[. …] and1680 oe	M1 M1 A1	accept any correct method e.g. **M1** for 4200 × 0.94^{15} or 1660[. …] **M1** for 1660[. ...] ÷ 4200 [×100] implied by .395[…] or 39.5 to 39.6 **A1** for 60.4 to 60.5[…] or 39.5 to 39.6 with a suitable comment Alternatives: **M2** for 0.94^{15} = .395[…] **A1** for 60.4 to 60.5[…] Examiner's Comments	

Question			Answer/Indicative content	Marks	Part marks and guidance	
					The preferred method in this part was to find the assumed number of trees still alive in 2030 by taking $t = 30–15 = 15$ to obtain 4200×0.94^{15}, which is roughly 1660. Candidates then found 60% of the original 4200, giving them a total of 2520, however this is the number predicted to have died, whereas the 1660 is the number predicted to still be alive. Many just gave these two answers as if this was all that was required, whereas in fact they needed to have subtracted this 2520 from the original 4200, giving 1680. This can then be compared with the 1660 to show that the given prediction was correct. Some candidates, after finding the 1660, expressed this as a % of the original 4200, which came to 39.52%, which they approximated to 40%; they should then have subtracted this result from 100. The question does say over 60%, so they needed to give answers correct to at least one decimal place.	
			Total	6		
12	a		1250	1		
	b		3	1		
			Total	2		

Question			Answer/Indicative content	Marks	Part marks and guidance	
13	a	i	16000	1	Examiner's Comments Many candidates were able to interpret the given formula to provide correct answers to parts (a)(i) and (a)(ii). A few thought that a calculation was required rather than a deduction from the elements in the formula.	
		ii	25	1	Examiner's Comments Many candidates were able to interpret the given formula to provide correct answers to parts (a)(i) and (a)(ii). A few thought that a calculation was required rather than a deduction from the elements in the formula.	

Question			Answer/Indicative content	Marks	Part marks and guidance	
		iii	16000×0.75^2 **oe** with no subsequent error	**M2** **2**	**M1** for $16\,000 \times 0.75^2$ with subsequent error or $16\,000 \times 0.75$ **oe** or for *their* $12\,000 \times 0.75$ | M1 implied by 12000 Examiner's Comments Part (a)(iii) was done very well by those that recognised that 75% was $\frac{3}{4}$ and then either did this in two stages or by multiplying 16 000 by $\left(\frac{3}{4}\right)^2$ A number evaluated $16\,000 \times 0.752$ by long multiplication of decimals which was fine provided they reached 9000 but there was often an arithmetic error in the processing which prevented full marks being awarded.	

Question			Answer/Indicative content	Marks	Part marks and guidance	
	b		If you calculate a value for a 20 year-old car it is greater than 0 **oe**	1	Accept 'the graph will never reach the x-axis' oe, It will have scrap value The answer is always positive etc Condone additional 'opinion based' information Examiner's Comments In part (c), candidates were expected to explain that the car's value was always greater than zero. A few did this but many gave answers that did not include the greater than zero element.	
			Total	5		