1. (a) Given that

$$2\log_3(x - 5) - \log_3(2x - 13) = 1,$$

show that $x^2 - 16x + 64 = 0$.

(5)

(b) Hence, or otherwise, solve $2\log_3 (x - 5) - \log_3 (2x - 13) = 1$.

(2)
(Total 7 marks)

2. (a) Find the positive value of x such that

$$\log x\ 64 = 2$$

(2)

(b) Solve for x

$$\log_2(11 - 6x) = 2\log_2(x - 1) + 3$$

(6)
(Total 8 marks)

3. Given that $0 < x < 4$ and

$$\log_5(4 - x) - 2\log_5 x = 1,$$

find the value of x.

(Total 6 marks)

4. Given that a and b are positive constants, solve the simultaneous equations

$$a = 3b,$$

$$\log_3 a + \log_3 b = 2.$$

Give your answers as exact numbers.

(Total 6 marks)

5. (i) Write down the value of $\log_6 36$.

(1)

(ii) Express $2 \log_a 3 + \log_a 11$ as a single logarithm to base a.

(3)
(Total 4 marks)

6. Solve

(a) $5^x = 8$, giving your answers to 3 significant figures,

(3)

(b) $\log_2(x + 1) – \log_2 x = \log_2 7$.

(3)
(Total 6 marks)

7. Find, giving your answer to 3 significant figures where appropriate, the value of x for which

(a) $3^x = 5$,

(3)

(b) $\log_2 (2x + 1) – \log_2 x = 2$.

(4)
(Total 7 marks)

8. Given that $\log_5 x = a$ and $\log_5 y = b$, find in terms of a and b,

(a) $\log_5\left(\frac{x^2}{y}\right)$,

(2)

(b) $\log_5(25x\sqrt{y})$.

(3)

It is given that $\log_5\left(\frac{x^2}{y}\right) = 1$ and that $\log_5(25x\sqrt{y}) = 1$.

(c) Form simultaneous equations in a and b.

(1)

(d) Show that $a = –0.25$ and find the value of b.

(2)

Using the value of a and b, or otherwise,

(e) calculate, to 3 decimal places, the value of x and the value of y.

(3)
(Total 11 marks)

9. Given that $\log_2 x = a$, find, in terms of a, the simplest form of

(a) $\log_2 (16x)$,

(2)

(b) $\log_2\left(\frac{x^4}{2}\right)$

(3)

(c) Hence, or otherwise, solve

$$\log_2 (16x) - \log_2\left(\frac{x^4}{2}\right) = \frac{1}{2},$$

giving your answer in its simplest surd form.

(4)
(Total 9 marks)

10. (a) Simplify $\dfrac{x^2 + 4x + 3}{x^2 + x}$.

(2)

(b) Find the value of x for which $\log_2 (x^2 + 4x + 3) - \log_2 (x^2 + x) = 4$.

(4)
(Total 6 marks)

11. Solve

$$2 \log_3 x - \log_3 (x - 2) = 2, \; x > 2.$$

(Total 6 marks)

1. (a) $2\log_3(x-5) = \log_3(x-5)^2$ B1

$\log_3(x-5)^2 - \log_3(2x-13) = \log_3 \frac{(x-5)^2}{2x-13}$ M1

$\log_3 3 = 1$ seen or used correctly B1

$\log_3\left(\frac{P}{Q}\right) = 1 \Rightarrow P = 3Q \quad \left\{\frac{(x-5)^2}{2x-13} = 3 \Rightarrow (x-5)^2 = 3(2x-13)\right\}$ M1

$x^2 - 16x + 64 = 0$ (*) A1 cso 5

Note

Marks may be awarded if equivalent work is seen in part (b).

1st M: $\log_3 (x-5)^2 - \log_3 (2x-13) = \frac{\log_3 (x-5)^2}{\log_3 (2x-13)}$ is M0

$2\log_3 (x-5) - \log_3 (2x-13) = 2\log \frac{x-5}{2x-13}$ is M0

2nd M: After the first mistake above, this mark is available only if there is 'recovery' to the required

$\log_3 \left(\frac{P}{Q}\right) = 1 \Rightarrow P = 3Q$. Even then the final mark (cso) is lost.

'Cancelling logs', e.g. $\frac{\log_3 (x-5)^2}{\log_3 (2x-13)} = \frac{(x-5)^2}{2x-13}$ will also lose the 2nd M.

A typical wrong solution:

$\log_3 \frac{(x-5)^2}{2x-13} = 1 \Rightarrow \log_3 \frac{(x-5)^2}{2x-13} = 3(*) \Rightarrow \frac{(x-5)^2}{2x-13} = 3$

$\Rightarrow (x-5)^2 = 3(2x-13)$

(*) Wrong step here

This, with no evidence elsewhere of $\log_3 3 = 1$, scores B1 M1 B0 M0 A0

However, $\log_3 \frac{(x-5)^2}{2x-13} = 1 \Rightarrow \frac{(x-5)^2}{2x-13} = 3$ is correct and could lead to full marks.

(Here $\log_3 3 = 1$ is implied).

No log methods shown:

It is not acceptable to jump immediately to $\frac{(x-5)^2}{2x-13} = 3$. The only mark this scores is the 1st B1 (by generous implication).

(b) $(x-8)(x-8)=0 \;\Rightarrow\; x=8$ Must be seen in part (b). M1 A1

Or: Substitute $x = 8$ into original equation and verify.
Having additional solution(s) such as $x = -8$ loses the A mark. 2
$x = 8$ with no working scores both marks.

Note

M1: Attempt to solve the given quadratic equation (usual rules), so the factors $(x – 8)(x – 8)$ with no solution is M0.

[7]

2. (a) $\log_x 64 = 2 \;\Rightarrow\; 64 = x^2$ M1

So $x = 8$ A1 2

Note

M1 for getting out of logs

A1 Do not need to see $x = –8$ appear and get rejected. Ignore $x = –8$ as extra solution. $x= 8$ with no working is M1 A1

Alternatives

Change base : (i) $\dfrac{\log_2 64}{\log_2 x} = 2$, so $\log_2 x = 3$ and $x = 2^3$, is M1 or

(ii) $\dfrac{\log_{10} 64}{\log_{10} x} = 2, \log x = \tfrac{1}{2} \log 64$ so $x = 64^{\frac{1}{2}}$ is M1 then $x = 8$ is A1

BUT $\log x = 0.903$ so $x = 8$ is M1A0 (loses accuracy mark)

(iii) $\log_{64}x=\tfrac{1}{2}$ so $x=64^{\frac{1}{2}}$ is M1 then $x = 8$ is A1

(b) $\log_2(11–6x)=\log_2(x–1)^2 + 3$ M1

$\log_2\left[\dfrac{11-6x}{(x-1)^2}\right]=3$ M1

$\dfrac{11-6x}{(x-1)^2}=2^3$ M1

$\{11 – 6x = 8(x^2 –2x+1)\}$ and so $0 = 8x^2 – 10x – 3$ A1

$0=(4x+1)(2x–3) \;\Rightarrow x =...$ dM1

$x=\dfrac{3}{2},\left[-\dfrac{1}{4}\right]$ A1 6

Note

1st M1 for using the $n\log x$ rule

2nd M1 for using the $\log x - \log y$ rule or the $\log x + \log y$ rule as appropriate

3rd M1 for using 2 to the power– need to see 2^3 or 8
(May see $3 = \log_2 8$ used)

If all three M marks have been earned and logs are still present in equation **do not give** final M1. So solution stopping at

$\log_2\left[\frac{11-6x}{(x-1)^2}\right] = \log_2 8$ would earn M1M1M0

1st A1 for a correct 3TQ

4th dependent M1 for attempt to solve or factorize their 3TQ to obtain $x =$… (mark depends on three previous M marks)

2nd A1 for 1.5 (ignore –0.25)

s.c 1.5 only – no working – is 0 marks

[8]

3.	$2\log_5 x = \log_5 (x^2)$,	$\log_5 (4-x) - \log_5 (x^2) = \log_5 \frac{4-x}{x^2}$	B1 M1	
	$\log\left(\frac{4-x}{x^2}\right) = \log 5$	$5x^2 + x - 4 = 0$ **or** $5x^2 + x = 4$ **o.e.**	M1 A1	
	$(5x-4)(x+1) = 0$ $\quad x = \frac{4}{5}$	$(x = -1)$	dM1 A1	6

Alternative 1

$\log_5 (4-x) - 1 = 2\log_5 x$ so $\log_5 (4-x) - \log_5 5 = 2\log_5 x$ — M1

$\log_5 \frac{4-x}{5} = 2\log_5 x$ — M1

then could complete solution with $2\log_5 x = \log_5(x^2)$ — B1

$\left(\frac{4-x}{5}\right) = x^2$ $\quad 5x^2 + x - 4 = 0$ — A1

Then as in first method $(5x-4)(x+1) = 0$ $\quad x = \frac{4}{5}$ $\quad (x = -1)$ — dM1 A1 — 6

Notes

B1 is awarded for $2\log x = \log x^2$ anywhere.

M1 for correct use of $\log A - \log B = \log \frac{A}{B}$

M1 for replacing 1 by $\log_k k$. **A1** for correct quadratic

$(\log(4 - x) - \log x^2 = \log 5 \;\Rightarrow\; 4 - x - x^2 = 5$ is **B1M0M1A0 M0A0)**

dM1 for attempt to solve quadratic with usual conventions. (Only award if previous two **M** marks have been awarded)

A1 for 4/5 or 0.8 or equivalent (Ignore extra answer).

Special cases

Complete trial and error yielding 0.8 is **M3** and **B1** for 0.8 **A1, A1** awarded for each of two tries evaluated. i.e. 6/6
Incomplete trial and error with wrong or no solution is 0/6
Just answer 0.8 with no working is **B1**
If log base 10 or base e used throughout – can score **B1M1M1A0M1A0**

[6]

4. Method 1 (Substituting a = 3b into second equation at some stage)

Using a law of logs correctly (anywhere)	e.g. $\log_3 ab = 2$	M1	
Substitution of $3b$ for a (or a/3 for b)	e.g. $\log_3 3b^2 = 2$	M1	
Using base correctly on **correctly derived** $\log_3 p = q$	e.g. $3b^2 = 3^2$	M1	
First correct value	$b = \sqrt{3}$ (allow $3^{½}$)	A1	
Correct method to find other value (dep. on at least first M mark)			
Second answer	$a = 3b = 3\sqrt{3}$ or $\sqrt{27}$	A1	

Method 2 (Working with two equations in $\log_3 a$ and $\log_3 b$)

"Taking logs" of first equation and "separating"	$\log_3 a = \log_3 3 + \log_3 b$ $(= 1 + \log_3 b)$	M1	
Solving simultaneous equations to find $\log_3 a$ or $\log_3 b$ $[\log_3 a = 1½, \log_3 b = ½]$			M1
Using base correctly to find a or b		M1	
Correct value for a or b $a = 3\sqrt{3}$ or $b = \sqrt{3}$		A1	
Correct method for second answer, dep. on first M; correct second answer		M1; A1	6

[Ignore negative values]

Answers must be exact; decimal answers lose both A marks
There are several variations on **Method 1**, depending on the stage at which $a = 3b$ is used, but they should all mark as in scheme.
In this method, the first three method marks on Epen are for

(i) First M1: correct use of log law,

(ii) Second M1: substitution of $a = 3b$,

(iii) Third M1: requires using base correctly on correctly derived $\log_3 p = q$

<u>Three examples of applying first 4 marks in Method 1:</u>

(i) $\log_3 3b + \log_3 b = 2$ gains second M1
$\log_3 3 + \log_3 b + \log_3 b = 2$ gains first M1
($2 \log_3 b = 1$, $\log_3 b = ½$) no mark yet
$b = 3^{½}$ gains third M1, and if correct A1

(ii) $\log_3 (ab) = 2$ gains first M1
$ab = 3^2$ gains third M1
$3b^2 = 3^2$ gains second M1

(iii) $\log_3 3b^2 = 2$ has gained first 2 M marks
$\Rightarrow 2 \log_3 3b = 2$ or similar type of error
$\Rightarrow \log_3 3b = 1 \Rightarrow 3b = 3$ does not gain third M1, as $\log_3 3b = 1$ not derived correctly

[6]

5. (i) 2 B1 1

(ii) $2\log 3 = \log 3^2$ (or $2\log p = \log p^2$) B1

$\log_a p + = \log_a 11 = \log_a 11p = \log_a 99$ (Allow e.g. $\log_a(3^2 \times 11)$) M1,A1 3

Ignore 'missing base' or wrong base.
The correct answer with no working scores full marks
$\log_a 9 \times \log_a 11 = \log_a 99$, or similar mistakes, score M0 A0.

[4]

6. (a) $\log 5^x = \log 8$ or $x = \text{lo}_5\, 8$ M1

Complete method for finding x: $x = \dfrac{\log 8}{\log 5}$ or $\dfrac{\ln 8}{\ln 5}$ M1

= 1.29 only A1 3

	(b)	Combining two logs: $\log_2 \dfrac{(x+1)}{x}$ or $\log_2 7x$	M1	
		Forming equation in x (eliminating logs) legitimately	M1	
		$x = \dfrac{1}{6}$ or $0.1\dot{6}$	A1	3
				[6]
7.	(a)	$\log 3^x = \log 5$	M1	
		$x = \dfrac{\log 5}{\log 3}$ or $x \log 3 = \log 5$	A1	
		$= \underline{1.}46$	A1 cao	3
	(b)	$\log_2 (\dfrac{2x+1}{x}) = 2$	M1	
		$\dfrac{2x+1}{x} = 2^2$ or 4	M1	
		$2x + 1 = 4x$	M1	
		$x = \dfrac{1}{2}$ or 0.5	A1	4
				[7]
8.	(a)	$\log_5 x^2 - \log_5 y$; $= 2\log_5 x - \log_5 y = \mathbf{2a - b}$	M1A1	2
	(b)	$\log_5 25 = 2$ or $\log_5 y$	B1	
		$\log_5 25 + \log_5 x + \log_5 y^{\frac{1}{2}}$; $= \mathbf{2 + a + ½\, b}$	M1;A1	3
	(c)	$2a - b = \mathbf{1}$, $2 + a + ½\, b = \mathbf{1}$ (must be in a and b)	B1 ft	1
	(d)	Using both **correct** equations to show that $a = -0.25$ (*)	M1	
		$b = -1.5$	B1	2
		[Mark for (c) can be gained in (d)]		
	(e)	Using correct method to find a value for x or a value of y:	M1	
		$x = 5^{-0.25} = \mathbf{0.669}$, $y = 5^{-1.5} = \mathbf{0.089}$	A1 A1 ft	3
		[max. penalty –1 for more than 3 d.p.]		
				[11]

9.	(a)	$\log_2 (16x) = \log_2 16 + \log_2 x$	M1	
		$= \underline{4 + a}$	A1 c.a.o	2
		M1 Correct use of $\log(ab) = \log_a + \log_b$		
	(b)	$\log_2\left(\frac{x^4}{2}\right) = \log_2 x^4 - \log_2 2$	M1	
		$= 4 \log 2x - \log_2 2$	M1	
		$= \underline{4a - 1}$ (accept $4 \log_2 x - 1$)	M1	3
		M1 Correct use of $\log\left(\frac{a}{b}\right) = \ldots$		
		M1 Use of $\log x^n = n \log x$		
	(c)	$\frac{1}{2} = 4 + a - (4a - 1)$	M1	
		$a = \frac{3}{2}$	A1	
		$\log_2 x = \frac{3}{2} \quad \Rightarrow \quad x = 2^{\frac{3}{2}}$	M1	
		$\underline{x = \sqrt{8}\ \textit{or}\ \sqrt{2^3}\ \text{or}\ (\sqrt{2})^3}$	A1	4
		M1 Use their (a) & (b) to form equ in a		
		M1 Out of logs: $x = 2^a$		
		A1 Must write x *in surd form, follow through their rational* a.		

[9]

10.	(a)	$\frac{x^2 + 4x + 3}{x^2 + x} = \frac{(x+3)(x+1)}{x(x+1)}$	M1	
		Attempt to factorise numerator or denominator		
		$= \underline{\frac{x+3}{x}}$ or $1 + \frac{3}{x}$ or $(x + 3)x^{-1}$	A1	2

(b) LHS = $\log_2\left(\dfrac{x^2+4x+3}{x^2+x}\right)$ M1 (*)

Use of log a – log b

RHS = 2^4 or 16 B1

$x + 3 = 16x$ M1 (*)

Linear or quadratic equation in x

(*) *dep*

$x = \frac{3}{15}$ or $\frac{1}{5}$ or 0.2 A1 4

[6]

11. $\log_3 x^2 - \log_3 (x-2) = 2$

Use of log x^n rule M1

$\log_3\left(\dfrac{x^2}{x-2}\right) = 2$

Use of log a – log b rule M1

$\dfrac{x^2}{x-2} = 3^2$

Getting out of logs M1

$x^2 - 9x + 18 = 0$

Correct 3TQ = 0 A1

$(x-6)(x-3) = 0$

Attempt to solve 3TQ M1

$x = 3, 6$ Both A1

[6]

1. In part (a), while some candidates showed little understanding of the theory of logarithms, others produced excellent solutions. The given answer was probably helpful here, giving confidence in a topic that seems to be demanding at this level. It was important for examiners to see full and correct logarithmic working and incorrect statements such as

$\log(x-5)^2 - \log(2x-13) = \dfrac{\log(x-5)^2}{\log(2x-13)}$ were penalised, even when there was apparent 'recovery' (helped by the given answer). The most common reason for failure was the inability to deal with the 1 by using $\log_3 3$ or an equivalent approach.

From $\log_3 \dfrac{(x-5)^2}{(2x-13)} = 1$, it was good to see candidates using the base correctly to obtain $\dfrac{(x-5)^2}{(2x-13)} = 3^1$, from which the required equation followed easily.

Even those who were unable to cope with part (a) often managed to understand the link between the parts and solve the quadratic equation correctly in part (b). It was disappointing, however, that some candidates launched into further logarithmic work.

2. (a) Generally, both marks were scored easily with most candidates writing $x^2 = 64$ and $x = 8$. Some included the –8 value as well, indicating that they were not always reading the finer details of the questions. However, quite a few attempts proceeded to $2^x = 64$ leading to the most common incorrect answer seen of $x = 6$. A small group squared 64. Very few students attempted to change base in this part of the question.

(b) Most candidates scored the first M mark by expressing $2\log_2(x-1)$ as $\log_2 (x-1)^2$ but many then failed to gain any further marks. It was not uncommon for scripts to proceed from $\log_2(11-6x) = \log_2(x-1)^2 + 3$ to $(11-6x) = (x-1)^2 + 3$, resulting in the loss of all further available marks.

A significant number of candidates seem to be completely confused over the basic log rules. Working such as $\log_2(11-6x) = \log_2 11/\log_2 6x$ following $\log_2(11-6x) = \log_2 11 - \log_2 6x$ was seen on many scripts. Most candidates who were able to achieve the correct quadratic equation were able to solve it successfully, generally by factorisation, although some chose to apply the quadratic formula. There were a good number of completely correct solutions but the $x = -¼$ was invariably left in, with very few candidates appreciating the need to reject it. Fortunately they were not penalised this time.

3. The better candidates produced neat and concise solutions but many candidates seem to have little or no knowledge of the laws of logs. Those who didn't deal with the 2logx term first usually gained no credit.

A significant minority dealt successfully with log theory to arrive at $\log \dfrac{4-x}{x^2} = 1$ but were let down by basic fraction algebra, "cancelling" to obtain log {4/x} = 1, and even going on "correctly" thereafter to 4/x = 5, x = 4/5!

Another group were unable to proceed from log {(4 – x)/x2} = 1, usually just removing the "log" and solving the resulting quadratic. Making the final M mark dependent on the previous two very fairly prevented this spurious solution gaining unwarranted credit.

A few obtained the answer with trial and improvement or merely stated the answer with no working presumably by plugging numbers into their calculator. Neither of these latter methods is expected or intended however.

4. This was a more unusual question on logarithms, and whilst many full marks were gained by good candidates, this proved taxing for many candidates and one or two marks were very common scores. The vast majority of candidates used the first method in the mark scheme. The most common errors seen were, log3b + logb = log4b and $\log 3b^2 = 2\log 3b$, and marks were lost for not giving answers in exact form. Some candidates made the question a little longer by changing the base.

5. In part (i), some candidates thought that $\log_6 36$was equal to 6, but there were many correct answers, sometimes following 'change of base' and the use of a calculator. Part (ii) caused more problems, the most common mistakes being to express $2\log_a 3 + \log_a 11$ as either $2\log_a 33$ or $2\log_a 14$ Sometimes a correct first step ($\log_a 9$) was followed by the answer $\log_a 20$. In general, responses from weaker candidates suggested a poor understanding of the theory of logarithms.

6. **Pure Mathematics P2**

Most candidates found this question quite accessible.

(a) A minority chose to solve this part using trial and improvement. Quite a few did not round to 3 significant figures. Candidates who started with the form $\log_5 8$ were often not able to progress beyond this.

(b) This was often started well, but there was some confusion when it came to forming an equation without logarithms. This process often took several more steps than necessary. A small, but significant proportion made no attempt at all. Lines such as "log (x + 1) = (log x)log(1) = 0 since log(1) = 0" and "log(x + 1) = log$x$ +log1" were popular options amongst the weaker candidates.

Core Mathematics C2

Most candidates were able to solve $5^x = 8$ correctly in part (a), although the answer was sometimes not rounded to 3 significant figures as required. The usual method was to use $x = \dfrac{\log 8}{\log 5}$, but trial and improvement approaches were sometimes seen.

Part (b) was a more demanding test of understanding of the theory of logarithms. Those who began by using log(x + 1) – log x = $\log\dfrac{x+1}{x}$ were often successful, but common mistakes such as log(x + 1) – log x = $\dfrac{\log(x+1)}{\log x}$ and log(x +1) = log x + log 1 usually prevented the candidate from scoring any marks. Confused working, including 'cancelling' of logs, was often seen here, and there were many attempts involving an unnecessary change of base.

7. Part (a) was usually answered well although some only got as far as $x = \log_3 5$ and either couldn't evaluate it, or failed to read the instruction to give to their answer to 3 significant figures. Some who did evaluate successfully then rounded cumulatively to obtain 1.465 leading to 1.47 but many candidates scored full marks here. A number of candidates used a trial and improvement approach in part (a). Whilst the answer could be obtained in this case it is not a recommended procedure for this type of question. Part (b) was one of the most discriminating parts of the paper. Whilst a reassuringly high proportion of candidates did achieve full marks here many incorrect procedures were seen. Log($2x$ +1) = log$2x$ + log1 was quite common and a number of students drifted from $\log_2\left(\frac{2x+1}{x}\right)$ to $\frac{\log_2(2x+1)}{\log_2 x}$ apparently believing them to be equal.

8. Although many candidates had problems in dealing with parts (a) and (b), it was good to see a significant number of candidates gain full marks. The most common errors by candidates who had some idea how to proceed were: in part (a) to convert $\log x^2 - \log y$ to $a^2 - b$, and in part (b) not to be able to deal with $\log_5 25$ or $\log_5 25x$. Even with wrong equations in (a) and (b) it was possible for candidates to gain 5 of the 6 remaining marks and it was good to see that that was frequently the case. It was particularly pleasing to see many correct solutions to part (e), although some candidates often did not take the most direct route. As always when answers are given they usually emerge however irrelevant the previous working has been. In part (d), for example, most candidates who had the correct answer to part (a) realised that b must be –1.5, and that is fine. Some candidates then manufactured a second equation, such as $-7a + ½b = 1$, so that, when solved simultaneously with $2a - b = 1$, $a = -0.25$ emerged. They did not gain the method mark for part (d)!

9. This question proved to be an effective discriminator. Many weaker candidates barely got started whilst the stronger ones usually made good progress with all 3 parts. In part (a) many were defeated by the $\log_2 16$ term, and a significant minority equated to a and attempted to solve. Part (b) was generally found more straightforward. Both log laws were often used correctly and more candidates seemed to be able to simplify $\log_2 2$, even though they failed to deal with $\log_2 16$ in part (a).

Those who used indices or tried to change the base were less successful. Common errors in part (c) were to forget the bracket on the ($4a$ – 1) term; to reach $a = \frac{3}{2}$ and stop; or to use the "or otherwise" approach and be unable to simplify and score the final 2 marks.

10. Part (a) was a straightforward start to the paper with most candidates able to factorise and simplify perfectly. A few attempted to use long division but this often led to errors, and some weaker candidates simply cancelled the x^2 in the numerator and denominator of the expression.

The second part of this question turned out to be more testing, and it was clear that a number of candidates were not fully familiar with the rules of logarithms. Simply crossing out $\log_2$ was sometimes seen and a large number of candidates thought that $\log a - \log b \equiv \frac{\log a}{\log b}$. Those successfully reaching $\log_2\left(\frac{x+3}{x}\right)$ then had difficulty relating the base 2 with the 4 and common errors included $4^2 \log_2 4$, 4 log e. Even those who successfully arrived at $15x = 3$ were not yet home and dry, as a surprising number concluded that $x = 5$.

11. No Report available for this question.