1.6 Pure: Exponentials and Logarithms

EDEXCEL 9MA0 · Calculator allowed · about 230 minutes · Write-in edition

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Solve $3^x = 81$.

(Total for Question 1 is 1 mark)

2 Write down the value of $\ln(e^5)$.

(Total for Question 2 is 1 mark)

3 This question tests index and logarithm notation. Do not use a calculator.

(a) Write $\log_5(125) = 3$ in index form. **(1)**

(b) Simplify $\log_3(45) - \log_3(5)$, giving your answer as an integer. **(2)**

(c) Solve $4^x = 64$, showing your method clearly. **(2)**

(d) Express $2\log_a(3) + \log_a(5)$ as a single logarithm. **(2)**

(Total for Question 3 is 7 marks)

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4 Simplify $\log_4(8) + \log_4(2)$, giving your answer as an integer.

(Total for Question 4 is 1 mark)

5 Solve $5^{2x} = 125$.

(Total for Question 5 is 2 marks)

6 Solve $2^{3x-1} = 32$.

(Total for Question 6 is 2 marks)

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7 This question tests basic index and logarithm equations.

(a) Solve $2^x = 32$, without using a calculator. **(2)**

(b) Solve $3^{x-1} = 9$, without using a calculator. **(2)**

(c) Express $3\ln(2) - \ln(4)$ as a single logarithm in its simplest exact form. **(2)**

(d) Solve $\log_5(2x + 3) = 2$. **(3)**

(Total for Question 7 is 9 marks)

8 Solve the following equations, using logarithms where necessary and giving each answer to 3 significant figures.

(a) Solve $5^x = 30$. **(3)**

(b) Solve $3^{2x+1} = 50$. **(4)**

(c) Solve $7^x = 4^{x+1}$. **(4)**

(Total for Question 8 is 11 marks)

9 Solve $4^x = 20$, giving your answer to 3 significant figures.

(Total for Question 9 is 2 marks)

10 Solve $e^{2x} = 15$, giving your answer to 3 significant figures.

(Total for Question 10 is 2 marks)

11 The number of bacteria in a culture is modelled by $N = 200 * e^{0.4t}$, where N is the number of bacteria present t hours after the culture is first observed. Find the time taken for the number of bacteria to first exceed 5000, giving your answer to 3 significant figures.

(Total for Question 11 is 3 marks)

12 Using the substitution $y = e^x$, solve the equation $e^{2x} - 4e^x - 5 = 0$, giving your answer as an exact value of x.

(Total for Question 12 is 3 marks)

13 A scientist believes that two variables x and y are related by the equation $y = A*x^n$, where A and n are constants. Taking logarithms gives $\log_{10}(y) = n*\log_{10}(x) + \log_{10}(A)$. A graph of $\log_{10}(y)$ against $\log_{10}(x)$ is a straight line passing through the points (0, 1.2) and (2, 3.6). Find the value of n and the value of A, giving A to 3 significant figures.

(Total for Question 13 is 4 marks)

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14 An investment grows according to the model $V = 4000 * (1.06)^t$, where V pounds is the value of the investment after t complete years. Find the value of the investment after 10 years, giving your answer to the nearest pound, and find the number of complete years after which the value of the investment first exceeds £9000.

(Total for Question 14 is 4 marks)

15 Solve the following equations involving natural logarithms.

(a) Solve $e^{3x} = 20$, giving your answer to 3 significant figures. **(3)**

(b) Solve $\ln(2x - 1) = 4$, giving your answer to 3 significant figures. **(3)**

(c) Solve $\ln(x) + \ln(x + 3) = \ln(10)$, stating why one of the solutions of the resulting quadratic must be rejected. **(4)**

(Total for Question 15 is 10 marks)

16 A radioactive isotope decays according to the model $m = m0 * e^{-\lambda * t}$, where m0 grams is the initial mass, t is the time in years and λ is a positive constant. A sample initially has mass 80 g. After 50 years the mass has reduced to 65 g.

(a) Show that $\lambda = (1/50) * \ln(80/65)$, giving the value of λ to 3 significant figures. **(3)**

(b) Find the half-life of the isotope, giving your answer to 3 significant figures. **(3)**

(c) Find the time taken for the mass to reduce to 10% of its initial value, giving your answer to the nearest year. **(3)**

(Total for Question 16 is 9 marks)

17 A microbiologist called Priya is growing a culture of bacteria. The number of bacteria, N, present t hours after the culture is first observed is modelled by $N = 200 * e^{0.15*t}$.

(a) State the number of bacteria present when the culture is first observed. **(1)**

(b) Find the number of bacteria present after 8 hours, giving your answer to the nearest whole number. **(2)**

(c) Find the time taken for the number of bacteria to reach 1000, giving your answer to 3 significant figures. **(3)**

(d) Show that $dN/dt = 30*e^{0.15*t}$, and hence find the rate of increase of the number of bacteria when t = 8, giving your answer to 3 significant figures. **(4)**

(e) Comment on a limitation of this model for large values of t. **(1)**

(Total for Question 17 is 11 marks)

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18 Solve the simultaneous equations $\log_2(x) + \log_2(y) = 5$ and $\log_2(x) - \log_2(y) = 1$, giving x and y as exact values.

(a) Solve the simultaneous equations, giving x and y as exact values. **(6)**

(Total for Question 18 is 6 marks)

19 Rebecca collects data on two variables x and y, which she believes are related by the equation $y = A*x^n$, where A and n are constants. She plots $\log_{10}(y)$ against $\log_{10}(x)$ and obtains a straight line passing through the points (0, 1.20) and (2, 3.60).

(a) Show that taking logarithms of $y = A*x^n$ gives $\log_{10}(y) = n*\log_{10}(x) + \log_{10}(A)$, and explain why this represents a linear relationship between $\log_{10}(y)$ and $\log_{10}(x)$. **(2)**

(b) Find the value of n. **(2)**

(c) Find the value of A, giving your answer to 3 significant figures. **(3)**

(d) Hence write down the equation connecting y and x. **(1)**

(Total for Question 19 is 8 marks)

20 Solve the equation $(\log_2(x))^2 - 5(\log_2(x)) + 6 = 0$, giving your answers as exact values of x.

(a) Solve the equation, giving your answers as exact values of x. **(6)**

(Total for Question 20 is 6 marks)

21 Jamal owns a rare coin. The value, V pounds, of the coin t years after purchase is modelled by $V = 250*e^{k*t}$, where k is a positive constant. The value of the coin doubles every 12 years.

(a) Show that $k = \ln(2)/12$, giving the value of k to 3 significant figures. **(4)**

(b) Find the value of the coin after 20 years, giving your answer to the nearest pound. **(3)**

(c) Find the number of complete years after purchase before the coin's value first exceeds £1000, justifying your answer carefully. **(4)**

(Total for Question 21 is 11 marks)

22 Solve $\log_5(x + 116) + \log_5(x + 16) = 5$.

(a) Show that the equation can be written as a quadratic and find the quadratic. **(3)**

(b) Hence solve the equation, rejecting any invalid root, and give a reason. **(4)**

(Total for Question 22 is 7 marks)

23 Solve the equation $3^{2x} - 10(3^x) + 24 = 0$, giving your answers in terms of logarithms to base 3, and as decimals to 3 significant figures.

(a) Show that the equation can be written as a quadratic in 3^x. **(2)**

(b) Hence solve the equation. **(4)**

(Total for Question 23 is 6 marks)

24 Solve $\log_2(x - 10) + \log_2(x - 11) = 1$.

(a) Show that the equation can be written as a quadratic and find the quadratic. **(3)**

(b) Hence solve the equation, rejecting any invalid root, and give a reason. **(4)**

(Total for Question 24 is 7 marks)

25 Solve $\log_3(x + 15) + \log_3(x - 11) = 3$.

(a) Show that the equation can be written as a quadratic and find the quadratic. **(3)**

(b) Hence solve the equation, rejecting any invalid root, and give a reason. **(4)**

(Total for Question 25 is 7 marks)

26 The activity, R, of a radioactive sample t days after it is first measured is modelled by $R = A e^{kt}$. Initially the activity is 375, and after 5 days it is 281.25.

(a) Write down the value of A, and show that $k = (1/5) \ln(3/4)$. **(3)**

(b) Find the value of k to 3 significant figures, and interpret its sign. **(3)**

(c) Find the time at which the activity is 1/8 times its initial value, giving your answer to 3 significant figures. **(3)**

(Total for Question 26 is 9 marks)

27 The variables x and y are related by $y = ax^n$, where a and n are constants. A graph of log10 y against log10 x is a straight line with gradient 0.6 and vertical intercept 1.2.

(a) Show that log10 y = n log10 x + log10 a. **(2)**

(b) State the values of n and log10 a, and hence find a to 3 significant figures. **(3)**

(c) Use the model, with your unrounded value of a, to find y when x = 6, to 3 significant figures. **(2)**

(Total for Question 27 is 7 marks)

28 Solve the equation $2^{2x} - 6(2^x) + 8 = 0$, giving your answers in terms of logarithms to base 2, and as decimals to 3 significant figures.

(a) Show that the equation can be written as a quadratic in 2^x. **(2)**

(b) Hence solve the equation. **(4)**

(Total for Question 28 is 6 marks)

29 The value, V pounds, of a machine t years after purchase is modelled by $V = A e^{kt}$. Initially the value is 76, and after 4 years it is 25.3333.

(a) Write down the value of A, and show that $k = (1/4) \ln(1/3)$. **(3)**

(b) Find the value of k to 3 significant figures, and interpret its sign. **(3)**

(c) Find the time at which the value is 1/10 times its initial value, giving your answer to 3 significant figures. **(3)**

(Total for Question 29 is 9 marks)

30 This question tests manipulation of logarithms.

(a) Given that $\log_2(x) = p$, express $\log_2(4x^3)$ in terms of p. **(3)**

(b) Solve the equation $\log_3(x + 5) - \log_3(x - 1) = 2$, stating clearly any restriction on the value of x. **(5)**

(Total for Question 30 is 8 marks)

31 A curve C has equation $y = 2\ln(x - 1) + 3$, for $x > 1$. State the equation of the asymptote of C, and find the exact x-coordinate of the point where C crosses the x-axis.

(Total for Question 31 is 4 marks)

Mark scheme · 1.6 Pure: Exponentials and Logarithms

Question 1

4 cao **B1**

Answer: x = 4

Question 2

5 cao **B1**

Answer: 5

Question 3

(a) $5^3 = 125$ stated correctly **B1**

(a) Answer: $5^3 = 125$

(b) combines using $\log_3(45) - \log_3(5) = \log_3(45/5) = \log_3(9)$ **M1**

(b) 2 cao **A1**

(b) Answer: 2

(c) writes 64 as 4^3 (or takes logs of both sides) **M1**

(c) x = 3 cao **A1**

(c) Answer: x = 3

(d) rewrites $2\log_a(3)$ as $\log_a(9)$ **M1**

(d) $\log_a(45)$ oe cao **A1**

(d) Answer: $\log_a(45)$

Question 4

2 cao **B1**

Answer: 2

Question 5

writes 125 as 5^3 and equates powers, 2x = 3 **M1**

x = 1.5 cao **A1**

Answer: x = 1.5

Question 6

writes 32 as 2^5 and equates powers, 3x - 1 = 5 **M1**

x = 2 cao **A1**

Answer: x = 2

Question 7

(a) writes 32 as 2^5 **M1**

(a) x = 5 cao **A1**

(a) Answer: x = 5

(b) writes 9 as 3^2 and equates exponents x-1 = 2 **M1**

(b) x = 3 cao **A1**

(b) Answer: x = 3

(c) writes 3ln(2) as ln(8) and combines to ln(8/4) **M1**

(c) ln(2) cao **A1**

(c) Answer: ln(2)

(d) writes $2x + 3 = 5^2$ **M1**

(d) rearranges to isolate x **M1**

(d) x = 11 cao **A1**

(d) Answer: x = 11

Question 8

(a) takes logs (or ln) of both sides: x ln(5) = ln(30) **M1**

(a) rearranges to x = ln(30)/ln(5) **M1**

(a) x = awrt 2.11 **A1**

(a) Answer: x = awrt 2.11

(b) takes logs of both sides: (2x+1)ln(3) = ln(50) **M1**

(b) rearranges to 2x + 1 = ln(50)/ln(3) **M1**

(b) correctly isolates x **M1**

(b) x = awrt 1.28 **A1**

(b) Answer: x = awrt 1.28

(c) takes logs of both sides: x ln(7) = (x+1) ln(4) **M1**

(c) expands the right-hand side: x ln(7) = x ln(4) + ln(4) **M1**

(c) collects x terms and factorises: x(ln(7) - ln(4)) = ln(4) **M1**

(c) x = awrt 2.48 **A1**

(c) Answer: x = awrt 2.48

Question 9

takes logs of both sides, x ln4 = ln20 **M1**

awrt 2.16 **A1**

Answer: x = 2.16 (3 s.f.)

Question 10

takes natural logs of both sides, 2x = ln15 **M1**

awrt 1.35 **A1**

Answer: x = 1.35 (3 s.f.)

Question 11

sets up the equation $200e^{0.4t} = 5000$, leading to $e^{0.4t} = 25$ **M1**

takes natural logs of both sides, 0.4t = ln25 **M1**

awrt 8.05 **A1**

Answer: t = 8.05 hours (3 s.f.)

Question 12

substitutes to form the quadratic $y^2 - 4y - 5 = 0$ **M1**

factorises (y - 5)(y + 1) = 0 and rejects y = -1 since $e^x > 0$ **M1**

x = ln5 cao (exact) **A1**

Answer: x = ln5

Question 13

finds the gradient n = (3.6 - 1.2)/(2 - 0) **M1**

n = 1.2 cao **A1**

identifies the y-intercept $\log_{10}(A) = 1.2$ and forms $A = 10^{1.2}$ **M1**

awrt 15.8 **A1**

Answer: n = 1.2, A = 15.8 (3 s.f.)

Question 14

substitutes t = 10 into the model **M1**

£7163 cao (nearest pound) **A1**

sets up the inequality $1.06^t > 2.25$ and takes logs to find t > 13.9 (3 s.f.) **M1**

t = 14 cao **A1**

Answer: Value after 10 years is £7163; the value first exceeds £9000 after 14 complete years

Question 15

(a) takes ln of both sides: $3x = \ln(20)$ **M1**

(a) rearranges $x = \ln(20)/3$ **M1**

(a) x = awrt 0.999 **A1**

(a) Answer: x = awrt 0.999

(b) writes $2x - 1 = e^4$ **M1**

(b) rearranges to $x = (e^4 + 1)/2$ **M1**

(b) x = awrt 27.8 **A1**

(b) Answer: x = awrt 27.8

(c) combines logs: $\ln(x(x+3)) = \ln(10)$ **M1**

(c) forms the quadratic $x^2 + 3x - 10 = 0$ **M1**

(c) factorises to give x = 2 or x = -5 **A1**

(c) rejects x = -5 since ln(x) is undefined for $x \leq 0$; x = 2 cao **B1**

(c) Answer: x = 2

Question 16

(a) forms the equation $65 = 80 * e^{-50*\lambda}$ **M1**

(a) takes ln of both sides and rearranges to $\lambda = (1/50)\ln(80/65)$, cso **M1**

(a) λ = awrt 0.00415 **A1**

(a) Answer: $\lambda = (1/50)\ln(80/65)$ = awrt 0.00415

(b) sets $0.5 = e^{-\lambda*T}$ using the half-life condition **M1**

(b) rearranges to $T = \ln(2)/\lambda$ **M1**

(b) T = awrt 167 (years), using the unrounded value of λ **A1**

(b) Answer: T = awrt 167 years

(c) sets $0.1 = e^{-\lambda*t}$ **M1**

(c) rearranges to $t = \ln(10)/\lambda$ **M1**

(c) t = awrt 554 (years), using the unrounded value of λ **A1**

(c) Answer: t = awrt 554 years

Question 17

(a) N = 200 **B1**

(a) Answer: 200

(b) substitutes t = 8 into the model **M1**

(b) N = awrt 664 **A1**

(b) Answer: N = awrt 664

(c) sets $1000 = 200*e^{0.15*t}$ and simplifies to $5 = e^{0.15*t}$ **M1**

(c) rearranges to $t = \ln(5)/0.15$ **M1**

(c) t = awrt 10.7 (hours) **A1**

(c) Answer: t = awrt 10.7 hours

(d) differentiates N with respect to t using the chain rule **M1**

(d) $dN/dt = 200*0.15*e^{0.15*t} = 30*e^{0.15*t}$, cso **A1**

(d) substitutes t = 8 into dN/dt **M1**

(d) rate = awrt 99.6 bacteria per hour **A1**

(d) Answer: $dN/dt = 30e^{0.15t}$; rate at t=8 is awrt 99.6 per hour

(e) any valid limitation, e.g. the model predicts unlimited growth, but in reality growth would be restricted by limited nutrients, space or competition **B1**

(e) Answer: the model assumes unrestricted exponential growth, which is unrealistic over long periods as resources are finite

Question 18

(a) combines first equation: $\log_2(xy) = 5$, so xy = 32 **M1**

(a) combines second equation: $\log_2(x/y) = 1$, so x/y = 2, i.e. x = 2y **M1**

(a) substitutes x = 2y into xy = 32 to form $2y^2 = 32$ **M1**

(a) y = 4 cao **A1**

(a) x = 8 cao **A1**

(a) rejects y = -4 since $\log_2(y)$ requires y > 0 **B1**

(a) Answer: x = 8, y = 4

Question 19

(a) takes $\log_{10}$ of both sides correctly: $\log_{10}(y) = \log_{10}(A) + n*\log_{10}(x)$ **B1**

(a) identifies this as linear in the form Y = mX + c, with $Y = \log_{10}(y)$, $X = \log_{10}(x)$, gradient n and intercept $\log_{10}(A)$ **B1**

(a) Answer: $\log_{10}(y) = n*\log_{10}(x) + \log_{10}(A)$, which is linear with gradient n and intercept $\log_{10}(A)$

(b) calculates the gradient of the line using the two given points **M1**

(b) n = 1.20 cao **A1**

(b) Answer: n = 1.20

(c) identifies the y-intercept of the line as $\log_{10}(A) = 1.20$ **M1**

(c) rearranges to $A = 10^{1.20}$ **M1**

(c) A = awrt 15.8 **A1**

(c) Answer: A = awrt 15.8

(d) $y = 15.8*x^{1.2}$, ft from parts (b) and (c) **B1ft**

(d) Answer: $y = 15.8x^{1.2}$

Question 20

(a) uses the substitution $u = \log_2(x)$ to form $u^2 - 5u + 6 = 0$ **M1**

(a) factorises as (u-2)(u-3) = 0 **M1**

(a) u = 2 and u = 3 **A1**

(a) converts back to x using $\log_2(x) = u$ **M1**

(a) x = 4 (exact) **A1**

(a) x = 8 (exact) cao **A1**

(a) Answer: x = 4 or x = 8

Question 21

(a) forms the equation $500 = 250*e^{12k}$ using the doubling condition **M1**

(a) simplifies to $2 = e^{12k}$ and takes ln of both sides **M1**

(a) k = ln(2)/12 cso, answer printed **A1**

(a) k = awrt 0.0578 **B1**

(a) Answer: k = ln(2)/12 = awrt 0.0578

(b) substitutes t = 20 into $V = 250*e^{k*t}$ using the unrounded value of k **M1**

(b) evaluates e^{20k} correctly **M1**

(b) V = awrt 794 (pounds) **A1**

(b) Answer: V = awrt £794

(c) sets up $1000 = 250*e^{k*t}$, simplifying to $4 = e^{k*t}$ **M1**

(c) solves using k = ln(2)/12 to obtain $t*\ln(2)/12 = \ln(4) = 2\ln(2)$ **M1**

(c) t = 24 (exact), the time at which V equals exactly 1000 **A1**

(c) concludes the value first exceeds £1000 at t = 25 complete years, since at t = 24 the value equals exactly 1000, not more **B1**

(c) Answer: 25 complete years

Question 22

(a) uses log a + log b = log(ab) **M1**

(a) converts to index form: $(x + 116)(x + 16) = 5^5 = 3125$ **M1**

(a) $x^2 + 132x - 1269 = 0$ **A1**

(a) Answer: $x^2 + 132x - 1269 = 0$

(b) solves the quadratic **M1**

(b) x = 9 or x = -141 **A1**

(b) x = -141 makes the argument of a logarithm negative or zero, so it is rejected **B1**

(b) x = 9 **A1**

(b) Answer: x = 9

Question 23

(a) uses $3^{2x} = (3^x)^2$ **M1**

(a) $y^2 - 10y + 24 = 0$ where $y = 3^x$ (cso) **A1**

(a) Answer: $y^2 - 10y + 24 = 0$, $y = 3^x$

(b) solves the quadratic in y by factorising **M1**

(b) y = 4 or y = 6 **A1**

(b) takes logarithms of each root **M1**

(b) $x = \log_3(6)$ or $x = \log_3(4)$, i.e. x = 1.26 or 1.63 **A1**

(b) Answer: $x = \log_3(6)$ or $x = \log_3(4)$, i.e. x = 1.26 or 1.63

Question 24

(a) uses log a + log b = log(ab) **M1**

(a) converts to index form: (x - 10)(x - 11) = 2 **M1**

(a) $x^2 - 21x + 108 = 0$ **A1**

(a) Answer: $x^2 - 21x + 108 = 0$

(b) solves the quadratic **M1**

(b) x = 12 or x = 9 **A1**

(b) x = 9 makes the argument of a logarithm negative or zero, so it is rejected **B1**

(b) x = 12 **A1**

(b) Answer: x = 12

Question 25

(a) uses log a + log b = log(ab) **M1**

(a) converts to index form: $(x + 15)(x - 11) = 3^3 = 27$ **M1**

(a) $x^2 + 4x - 192 = 0$ **A1**

(a) Answer: $x^2 + 4x - 192 = 0$

(b) solves the quadratic **M1**

(b) x = 12 or x = -16 **A1**

(b) x = -16 makes the argument of a logarithm negative or zero, so it is rejected **B1**

(b) x = 12 **A1**

(b) Answer: x = 12

Question 26

(a) A = 375 **B1**

(a) substitutes t = 5: $375\,e^{5k} = 281.25$ **M1**

(a) $e^{5k} = 3/4$, so $k = (1/5)\ln(3/4)$ (cso) **A1**

(a) Answer: A = 375, $k = (1/5)\ln(3/4)$

(b) $k = \ln(3/4)/5$ **M1**

(b) k = -0.0575 **A1**

(b) k < 0 means decay **B1**

(b) Answer: k = -0.0575

(c) forms $e^{kt} = 1/8$ **M1**

(c) takes natural logs: $t = \ln(1/8)/k$ **M1**

(c) t = 36.1 days **A1**

(c) Answer: 36.1 days

Question 27

(a) takes logs of both sides of $y = ax^n$ **M1**

(a) log10 y = log10 a + n log10 x (cso) **A1**

(a) Answer: log10 y = n log10 x + log10 a

(b) n = 0.6 **B1**

(b) $\log10\ a = 1.2$, so $a = 10^{1.2}$ **M1**

(b) a = 15.8 **A1**

(b) Answer: n = 0.6, a = 15.8

(c) $y = a \times 6^{0.6}$ with the unrounded $a = 10^{1.2}$ **M1**

(c) y = 46.4 **A1**

(c) Answer: y = 46.4

Question 28

(a) uses $2^{2x} = (2^x)^2$ **M1**

(a) $y^2 - 6y + 8 = 0$ where $y = 2^x$ (cso) **A1**

(a) Answer: $y^2 - 6y + 8 = 0$, $y = 2^x$

(b) solves the quadratic in y by factorising **M1**

(b) y = 2 or y = 4 **A1**

(b) takes logarithms of each root **M1**

(b) $x = \log_2(4)$ or $x = \log_2(2)$, i.e. x = 1.00 or 2.00 **A1**

(b) Answer: $x = \log_2(4)$ or $x = \log_2(2)$, i.e. x = 1.00 or 2.00

Question 29

(a) A = 76 **B1**

(a) substitutes t = 4: $76\,e^{4k} = 25.3333$ **M1**

(a) $e^{4k} = 1/3$, so $k = (1/4)\ln(1/3)$ (cso) **A1**

(a) Answer: A = 76, $k = (1/4)\ln(1/3)$

(b) $k = \ln(1/3)/4$ **M1**

(b) k = -0.275 **A1**

(b) k < 0 means decay **B1**

(b) Answer: k = -0.275

(c) forms $e^{kt} = 1/10$ **M1**

(c) takes natural logs: $t = \ln(1/10)/k$ **M1**

(c) t = 8.38 years **A1**

(c) Answer: 8.38 years

Question 30

(a) splits $\log_2(4x^3)$ as $\log_2(4) + \log_2(x^3)$	**M1**
(a) uses $\log_2(4) = 2$ and $\log_2(x^3) = 3p$	**M1**
(a) 2 + 3p oe cao	**A1**

(a) Answer: 2 + 3p

(b) combines logs: $\log_3((x+5)/(x-1)) = 2$	**M1**
(b) removes the log: $(x+5)/(x-1) = 9$	**M1**
(b) solves the resulting linear equation	**M1**
(b) x = 7/4 oe cao	**A1**
(b) states restriction x > 1 (required for both logs to be defined), consistent with x = 7/4	**B1**

(b) Answer: x = 7/4, with restriction x > 1

Question 31

asymptote x = 1	**B1**
sets y = 0 and rearranges to $\ln(x - 1) = -1.5$	**M1**
takes exponentials of both sides, $x - 1 = e^{-1.5}$	**M1**
$x = 1 + e^{-1.5}$ cao (exact)	**A1**

Answer: Asymptote x = 1; curve crosses the x-axis at $x = 1 + e^{-1.5}$