1 State or imply $4 - 2^x = -10$ and 10 — B1

Use correct method for solving equation of form $2^x = a$ — M1

Obtain 3.81 — A1 [3]

2 **(i)** Either: Obtain correct (unsimplified) version of x or x^2 term from $(1-4x)^{\frac{1}{2}}$ — M1

Obtain $1 + 2x$ — A1

Obtain $+ 6x^2$ — A1

Or: Differentiate and evaluate f(0) and f′(0) where f′$(x) = k(1-4x)^{-\frac{3}{2}}$ — M1

Obtain $1 + 2x$ — A1

Obtain $+ 6x^2$ — A1 [3]

(ii) Combine both x^2 terms from product of $1 + 2x$ and answer from part **(i)** — M1

Obtain 5 — A1 [2]

3 **(i)** Substitute $x = 2$ and equate to zero, or divide by $x - 2$ and equate constant remainder to zero, or equivalent — M1

Obtain $a = 4$ — A1 [2]

(ii) **(a)** Find further (quadratic or linear) factor by division, inspection or factor theorem or equivalent — M1

Obtain $x^2 + 2x - 8$ or $x + 4$ — A1

State $(x-2)^2(x+4)$ or equivalent — A1 [3]

(b) State any two of the four (or six) roots — B1√

State all roots ($\pm\sqrt{2}$, $\pm 2\mathrm{i}$), provided two are purely imaginary — B1√ [2]

4 **(i)** Either: Expand $(1 + 2\mathrm{i})^2$ to obtain $-3 + 4\mathrm{i}$ or unsimplified equivalent — B1

Multiply numerator and denominator by $2 - \mathrm{i}$ — M1

Obtain correct numerator $-2 + 11\mathrm{i}$ or correct denominator 5 — A1

Obtain $-\frac{2}{5} + \frac{11}{5}\mathrm{i}$ or equivalent — A1

Or: Expand $(1 + 2\mathrm{i})^2$ to obtain $-3 + 4\mathrm{i}$ or unsimplified equivalent — B1

Obtain two equations in x and y and solve for x or y — M1

Obtain final answer $x = -\frac{2}{5}$ — A1

Obtain final answer $y = \frac{11}{5}$ — A1 [4]

(ii) Draw a circle — M1

Show centre at relatively correct position, following their u — A1√

Draw circle passing through the origin — A1 [3]

5 **(i)** Differentiate to obtain $4\cos\frac{1}{2}x - \frac{1}{2}\sec^2\frac{1}{2}x$ B1

Equate to zero and find value of $\cos\frac{1}{2}x$ M1

Obtain $\cos\frac{1}{2}x = \frac{1}{2}$ and confirm $\alpha = \frac{2}{3}\pi$ A1 [3]

(ii) Integrate to obtain $-16\cos\frac{1}{2}x \ldots$ B1

$\ldots + 2\ln\cos\frac{1}{2}x$ or equivalent B1

Using limits 0 and $\frac{2}{3}\pi$ in $a\cos\frac{1}{2}x + b\ln\cos\frac{1}{2}x$ M1

Obtain $8 + 2\ln\frac{1}{2}$ or exact equivalent A1 [4]

6 **(i)** Obtain $2y\frac{\mathrm{d}y}{\mathrm{d}x}$ as derivative of y^2 B1

Obtain $-4y - 4x\frac{\mathrm{d}y}{\mathrm{d}x}$ as derivative of $-4xy$ B1

Substitute $x = 2$ and $y = -3$ and find value of $\frac{\mathrm{d}y}{\mathrm{d}x}$

(dependent on at least one B1 being earned and $\frac{\mathrm{d}(45)}{\mathrm{d}x} = 0$) M1

Obtain $\frac{12}{7}$ or equivalent A1 [4]

(ii) Substitute $\frac{\mathrm{d}y}{\mathrm{d}x} = 1$ in an expression involving $\frac{\mathrm{d}y}{\mathrm{d}x}$, x and y and obtain $ay = bx$ M1

Obtain $y = x$ or equivalent A1

Uses $y = x$ in original equation and demonstrate contradiction A1 [3]

7 Separate variables correctly and attempt integration on at least one side M1

Obtain $\frac{1}{3}y^3$ or equivalent on left-hand side A1

Use integration by parts on right-hand side (as far as $axe^{3x} + \int be^{3x}\,\mathrm{d}x$) M1

Obtain or imply $2xe^{3x} + \int 2e^{3x}\,\mathrm{d}x$ or equivalent A1

Obtain $2xe^{3x} - \frac{2}{3}e^{3x}$ A1

Substitute $x = 0$, $y = 2$ in an expression containing terms Ay^3, Bxe^{3x}, Ce^{3x}, where ABC ≠ 0, and find the value of c M1

Obtain $\frac{1}{3}y^3 = 2xe^{3x} - \frac{2}{3}e^{3x} + \frac{10}{3}$ or equivalent A1

Substitute $x = 0.5$ to obtain $y = 2.44$ A1 [8]

8 **(i)** Either Obtain $\pm\begin{pmatrix}2\\-1\\-15\end{pmatrix}$ for vector PA (where A is point on line) or equivalent B1

Use scalar product to find cosine of angle between PA and line M1

Obtain $\frac{42}{\sqrt{14\times230}}$ or equivalent A1

Use trigonometry to obtain $\sqrt{104}$ or 10.2 or equivalent A1

Or 1 Obtain $\pm\begin{pmatrix}2n+2\\n-1\\3n-15\end{pmatrix}$ for PN (where N is foot of perpendicular) B1

Equate scalar product of PN and line direction to zero
Or equate derivative of PN^2 to zero
Or use Pythagoras' theorem in triangle PNA to form equation in n M1
Solve equation and obtain $n = 3$ A1

Obtain $\sqrt{104}$ or 10.2 or equivalent A1

Or 2 Obtain $\pm\begin{pmatrix}2\\-1\\-15\end{pmatrix}$ for vector PA (where A is point on line) B1

Evaluate vector product of PA and line direction M1

Obtain $\pm\begin{pmatrix}12\\-36\\-4\end{pmatrix}$ A1

Divide modulus of this by modulus of line direction and obtain $\sqrt{104}$ or 10.2 or equivalent A1

Or 3 Obtain $\pm\begin{pmatrix}2\\-1\\-15\end{pmatrix}$ for vector PA (where A is point on line) B1

Evaluate scalar product of PA and line direction to obtain distance AN M1

Obtain $3\sqrt{14}$ or equivalent A1

Use Pythagoras' theorem in triangle PNA and obtain $\sqrt{104}$ or 10.2 or equivalent A1

Or 4 Obtain $\pm\begin{pmatrix}2\\-1\\-15\end{pmatrix}$ for vector PA (where A is point on line) B1

Use a second point B on line and use cosine rule in triangle ABP to find angle A or angle B or use vector product to find area of triangle M1
Obtain correct answer (angle $A = 42.25\ldots$) A1
Use trigonometry to obtain $\sqrt{104}$ or 10.2 or equivalent A1 [4]

(ii) Either Use scalar product to obtain a relevant equation in a, b, c, e.g. $2a + b + 3c = 0$ or $2a - b - 15c = 0$ M1
State two correct equations in a, b and c A1√
Solve simultaneous equations to obtain one ratio M1
Obtain $a : b : c = -3 : 9 : -1$ or equivalent A1
Obtain equation $-3x + 9y - z = 28$ or equivalent A1

Or 1 Calculate vector product of two of $\begin{pmatrix}2\\1\\3\end{pmatrix}$, $\begin{pmatrix}2\\-1\\-15\end{pmatrix}$ and $\begin{pmatrix}8\\2\\-6\end{pmatrix}$ or equiv M1
Obtain two correct components of the product A1√
Obtain correct $\begin{pmatrix}-3\\9\\-1\end{pmatrix}$ or equivalent A1
Substitute in $-3x + 9y - z = d$ to find d or equivalent M1
Obtain equation $-3x + 9y - z = 28$ or equivalent A1

Or 2 Form a two-parameter equation of the plane M1
Obtain $\mathbf{r} = \begin{pmatrix}1\\3\\-4\end{pmatrix} + s\begin{pmatrix}2\\1\\3\end{pmatrix} + t\begin{pmatrix}2\\-1\\-15\end{pmatrix}$ or equivalent A1√
State three equations in x, y, z, s, t A1
Eliminate s and t M1
Obtain equation $3x - 9y + z = -28$ or equivalent A1 [5]

9 State or imply form $A + \frac{B}{2x+1} + \frac{C}{x+2}$ B1
State or obtain $A = 2$ B1
Use correct method for finding B or C M1
Obtain $B = 1$ A1
Obtain $C = -3$ A1
Obtain $2x + \frac{1}{2}\ln(2x+1) - 3\ln(x+2)$ [Deduct B1√ for each error or omission] B3√
Substitute limits in expression containing $a\ln(2x + 1) + b\ln(x + 2)$ M1
Show full and exact working to confirm that $8 + \frac{1}{2}\ln 9 - 3\ln 6 + 3\ln 2$, or an equivalent expression, simplifies to given result $8 - \ln 9$ A1 [10]

[SR: If A omitted from the form of fractions, give B0B0M1A0A0 in (**i**); B0√B1√B1√M1A0 in (**ii**).]

[SR: For a solution starting with $\frac{M}{2x+1} + \frac{Nx}{x+2}$ or $\frac{Px}{2x+1} + \frac{Q}{x+2}$, give B0B0M1A0A0 in (**i**); B1√B1√B1√, if recover correct form, M1A0 in (**ii**).]

[SR: For a solution starting with $\frac{B}{2x+1} + \frac{Dx+E}{x+2}$, give M1A1 for one of $B = 1$, $D = 2$, $E = 1$ and A1 for the other two constants; then give B1B1 for $A = 2$, $C = -3$.]

[SR: For a solution starting with $\frac{Fx+G}{2x+1} + \frac{C}{x+2}$, give M1A1 for one of $C = -3$, $F = 4$, $G = 3$ and A1 for the other constants or constant; then give B1B1 for $A = 2$, $B = 1$.]

10 **(i)** Use correct identity for $\tan 2x$ and obtains $at^4 + bt^3 + ct^2 + dt = 0$, where b may be zero — M1
Obtain correct horizontal equation, e.g. $4t + 5t^2 - 5t^4 = 0$ — A1
Obtain $kt(t^3 + et + f) = 0$ or equivalent — M1
Confirm given results $t = 0$ and $t = \sqrt[3]{t + 0.8}$ — A1 [4]

(ii) Consider sign of $t - \sqrt[3]{t + 0.8}$ at 1.2 and 1.3 or equivalent — M1
Justify the given statement with correct calculations (–0.06 and 0.02) — A1 [2]

(iii) Use the iterative formula correctly at least once with $1.2 < t_n < 1.3$ — M1
Obtain final answer 1.276 — A1
Show sufficient iterations to justify answer or show there is a change of sign in interval (1.2755, 1.2765) — A1 [3]

(iv) Evaluate $\tan^{-1}$ (answer from part **(iii)**) to obtain at least one value — M1
Obtain –2.24 and 0.906 — A1
State $-\pi$, 0 and π — B1 [3]
[SR If A0, B0, allow B1 for any 3 roots]