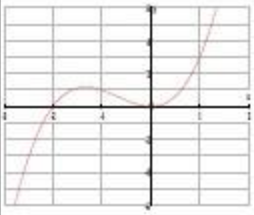
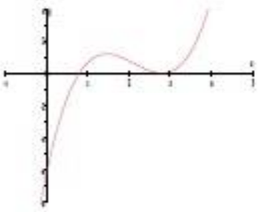
Question 1

Question	Scheme	Marks
(a)	$[y = x^3 + 2x^2]$ so $\dfrac{dy}{dx} = 3x^2 + 4x$	M1A1 (2)
(b)	 Shape 	B1
	Touching x-axis at origin	B1
	Through and not touching or stopping at -2 on x-axis. Ignore extra intersections.	B1 (3)
(c)	At $x = -2$: $\dfrac{dy}{dx} = 3(-2)^2 + 4(-2) = 4$	M1
	At $x = 0$: $\dfrac{dy}{dx} = 0$ (Both values correct)	A1 (2)
(d)	 Horizontal translation (touches x-axis still)	M1
	$k-2$ and k marked on positive x-axis	B1
	$k^2(2-k)$ (o.e) marked on negative y-axis	B1 (3)
		10 marks

	Notes
(a)	M1 for attempt to multiply out and then some attempt to differentiate $x^n \to x^{n-1}$ Do not award for $2x(x+2)$ or $2x(1+2)$ etc
Prod Rule	Award M1 for a correct attempt: 2 products with a + and at least one product correct A1 for both terms correct. (If $+c$ or extra term is included score A0)
(b)	1st B1 for correct shape (anywhere). Must have 2 clear turning points. 2nd B1 for graph touching at origin (not crossing or ending) 3rd B1 for graph passing through (not stopping or touching at) -2 on x axis and -2 marked on axis
SC	B0B0B1 for $y = x^3$ <u>or</u> cubic with straight line between $(-2,0)$ and $(0,0)$
(c)	M1 for attempt at $y'(0)$ or $y'(-2)$. Follow through their 0 or -2 and their $y'(x)$ <u>or</u> for a <u>correct</u> statement of zero gradient for an identified point on their curve that touches x-axis A1 for both correct answers
(d)	For the M1 in part (d) ignore any coordinates marked – just mark the shape. M1 for a horizontal translation of their (b). Should still touch x – axis if it did in (b) <u>Or</u> for a graph of correct shape with min. and intersection in correct order on +ve x-axis 1st B1 for k and $k-2$ on the positive x-axis. Curve must pass through $k-2$ and touch at k 2nd B1 for a correct intercept on negative y-axis in terms of k. Allow $(0, 2k^2 - k^3)$ (o.e.) seen in script if curve passes through –ve y-axis

Question 2

Question	Scheme	Marks
(a)	$\left(\frac{1}{2}, 0\right)$	B1 (1)
(b)	$\frac{dy}{dx} = x^{-2}$	M1A1
	At $x = \frac{1}{2}$, $\frac{dy}{dx} = \left(\frac{1}{2}\right)^{-2} = 4 \quad (= m)$	A1
	Gradient of normal $= -\frac{1}{m} \quad \left(= -\frac{1}{4}\right)$	M1
	Equation of normal: $y - 0 = -\frac{1}{4}\left(x - \frac{1}{2}\right)$	M1
	$2x + 8y - 1 = 0 \quad (*)$	A1cso (6)
(c)	$2 - \frac{1}{x} = -\frac{1}{4}x + \frac{1}{8}$	M1
	$[= 2x^2 + 15x - 8 = 0]$ <u>or</u> $[8y^2 - 17y = 0]$	
	$(2x-1)(x+8) = 0$ leading to $x = \ldots$	M1
	$x = \left[\frac{1}{2}\right]$ or -8	A1
	$y = \frac{17}{8}$ (or exact equivalent)	A1ft (4)
		11 marks
	Notes	
(a)	B1 accept $x = \frac{1}{2}$ if evidence that $y = 0$ has been used. Can be written on graph. Use ISW	
(b)	1st M1 for kx^{-2} even if the '2' is not differentiated to zero. If no evidence of $\frac{dy}{dx}$ seen then 0/6 1st A1 for x^{-2} (o.e.) only 2nd A1 for using $x = 0.5$ to get $m = 4$ (correctly) (or $m = 1/0.25$) To score final A1cso must see at least one intermediate equation for the line after $m = 4$ 2nd M1 for using the perpendicular gradient rule on their m coming from their $\frac{dy}{dx}$ Their m must be a value not a letter. 3rd M1 for using a changed gradient (based on y') and their A to find equation of line 3rd A1cso for reaching printed answer with no incorrect working seen. Accept $2x + 8y = 1$ or equivalent equations with $\pm 2x$ and $\pm 8y$ Trial and improvement requires sight of first equation.	
(c)	1st M1 for attempt to form a suitable equation in one variable. Do not penalise poor use of brackets etc. 2nd M1 for simplifying their equation to a 3TQ and attempting to solve. May be $\Rightarrow$ by $x = -8$ 1st A1 for $x = -8$ (ignore a second value). If found y first allow ft for x if $x < 0$ 2nd A1ft for $y = \frac{17}{8}$ Follow through their x value in line or curve provided answer is > 0 This second A1 is dependent on <u>both</u> M marks	

Question 3

Question Number	Scheme	Marks
(a)	$y = 5x^3 - 6x^{\frac{4}{3}} + 2x - 3$ $\left\{\frac{dy}{dx} =\right\}\ 5(3)x^2 - 6\left(\frac{4}{3}\right)x^{\frac{1}{3}} + 2$ $= 15x^2 - 8x^{\frac{1}{3}} + 2$	M1 A1 A1 A1 [4]
(b)	$\left\{\frac{d^2y}{dx^2} =\right\}\ 30x - \frac{8}{3}x^{-\frac{2}{3}}$	M1 A1 [2] 6
	Notes	
(a)	**M1**: for an attempt to differentiate $x^n \to x^{n-1}$ to one of the first three terms of $y = 5x^3 - 6x^{\frac{4}{3}} + 2x - 3$. So seeing either $5x^3 \to \pm\lambda x^2$ or $-6x^{\frac{4}{3}} \to \pm\mu x^{\frac{1}{3}}$ or $2x \to 2$ is M1. **1st A1**: for $15x^2$ only. **2nd A1**: for $-8x^{\frac{1}{3}}$ or $-8\sqrt[3]{x}$ only. **3rd A1**: for $+2$ ($+c$ included in part (a) loses this mark). **Note**: $2x^0$ is A0 unless simplified to 2.	
(b)	**M1**: For differentiating $\frac{dy}{dx}$ again to give **either** • a correct follow through differentiation of their x^2 term • or for $\pm\alpha x^{\frac{1}{3}} \to \pm\beta x^{-\frac{2}{3}}$. **A1**: for any *correct* expression *on the same line* (accept un-simplified coefficients). For powers: $30x^{2-1} - \frac{8}{3}x^{\frac{1}{3}-1}$ is A0, but writing powers as one term eg: $(15\times 2x) - \frac{8}{3}x^{-\frac{4}{6}}$ is ok for A1. **Note**: Candidates leaving their answers as $\left\{\frac{dy}{dx} =\right\} 15x^2 - \frac{24}{3}x^{\frac{1}{3}} + 2$ and $\left(\frac{d^2y}{dx^2} =\right)\ 30x - \frac{24}{9}x^{-\frac{2}{3}}$ are awarded M1A1A0A1 in part (a) and M1A1 in part (b). **Be careful**: $30x - \frac{8}{3}x^{-\frac{1}{3}}$ will be A0. **Note**: For an extra term appearing in part (b) on the same line, ie $30x - \frac{8}{3}x^{-\frac{2}{3}} + 2$ is M1A0 **Note**: If a candidate writes in part (a) $15x^2 - 8x^{\frac{1}{3}} + 2 + c$ and in part (b) $30x - \frac{8}{3}x^{-\frac{2}{3}} + c$ then award (a) M1A1A1A0 (b) M1A1	

Question 4

Question Number	Scheme		Marks
	$C: y = 2x - 8\sqrt{x} + 5, \quad x \geqslant 0$		
(a)	So, $y = 2x - 8x^{\frac{1}{2}} + 5$		
	$\frac{dy}{dx} = 2 - 4x^{-\frac{1}{2}} + \{0\} \qquad (x > 0)$		M1 A1 A1
			[3]
(b)	(When $x = \frac{1}{4}$, $y = 2(\frac{1}{4}) - 8\sqrt{(\frac{1}{4})} + 5$ so) $\quad y = \frac{3}{2}$		B1
	(gradient $= \frac{dy}{dx} =$) $2 - \frac{4}{\sqrt{(\frac{1}{4})}}$ $\{= -6\}$		M1
	Either: $y - "\frac{3}{2}" = "-6"(x - \frac{1}{4})$	**or**: $y = "-6"x + c$ and $"\frac{3}{2}" = "-6"(\frac{1}{4}) + c \Rightarrow c = "3"$	dM1
	So $\underline{y = -6x + 3}$		A1
			[4]
(c)	Tangent at Q is parallel to $2x - 3y + 18 = 0$		
	($y = \frac{2}{3}x + 6 \Rightarrow$) Gradient $= \frac{2}{3}$. so tangent gradient is $\frac{2}{3}$		B1
	So, $"2 - \frac{4}{\sqrt{x}}" = "\frac{2}{3}"$	Sets their gradient function = their numerical gradient.	M1
	$\Rightarrow \frac{4}{3} = \frac{4}{\sqrt{x}} \Rightarrow x = 9$	Ignore extra answer $x = -9$	A1
	When $x = 9$, $y = 2(9) - 8\sqrt{9} + 5 = -1$	Substitutes their found x into equation of curve.	dM1
		$y = -1$.	A1
			[5]
			12 marks

	Notes
(a)	**M1**: Evidence of differentiation, so $x^n \to x^{n-1}$ at least once so $x^1 \to 1$ or x^0 or $x^{\frac{1}{2}} \to x^{-\frac{1}{2}}$ not just $5 \to 0$
	A1: Any two of the three terms correct – do not need to see zero – the 5 disappearing is sufficient; need not be simplified.
	A1: $2 - 4x^{-\frac{1}{2}}$ Both terms correct, and simplified. Do not need to include domain $x > 0$
(b)	**B1**: Obtaining $y = 3/2$ or fractional or decimal equivalent (no working need be seen)
	M1: An attempt to substitute $x = \frac{1}{4}$ into $\frac{dy}{dx}$ to establish **gradient**. This may be implied by -6 or $m = -6$ but not $y = -6$. Can earn this M mark if they go on to use $m = \frac{1}{6}$ or use their numerical value of $\frac{dy}{dx}$.
	dM1: This depends on previous method mark. Complete method for obtaining the equation of the tangent, using their **tangent** gradient and their value for y_1 (obtained from $x = ¼$, allow slip) i.e.
	$y - y_1 = m_T(x - \frac{1}{4})$ with their tangent gradient and their y_1
	or uses $y = mx + c$ with $(\frac{1}{4}$, their $y_1)$ and their tangent gradient.
	A1: $y = -6x + 3$ or $y = 3 - 6x$ or $a = -6$ and $b = 3$
(c)	**B1**: For the value 2/3 **not** $2/3\,x$ **not** $-3/2$
	M1: Sets their gradient function dy/dx = their numerical gradient
	A1: Obtains $x = 9$
	dM1: Substitutes their x (from gradient equation) into original equation of curve C i.e. original expression $y =$
	A1: $(9, -1)$ or $x = 9$, $y = -1$, or just $y = -1$
	Special Cases: In (b) Finds normal could get B1 M1 M0 A0 i.e. max of 2/4
	In (c) Uses **perpendicular** instead of **parallel** then award B0 M1 A0 M1 A0 i.e max 2/5 – see over

Question 5

Question Number	Scheme		Marks
(a)	$(3-x^2)^2 = 9-6x^2+x^4$	An attempt to expand the numerator obtaining an expression of the form $9 \pm px^2 \pm qx^4$, $p,q \neq 0$	M1
	$9x^{-2}+x^2$	Must come from $\dfrac{9+x^4}{x^2}$	A1
	-6	Must come from $\dfrac{-6x^2}{x^2}$	A1
	Alternative 1: Writes $\dfrac{(3-x^2)^2}{x^2}$ as $(3x^{-1}-x)^2$ and attempts to expand = M1 then A1A1 as in the scheme.		
	Alternative 2: Sets $(3-x^2)^2 = 9+Ax^2+Bx^4$, expands $(3-x^2)^2$ and compares coefficients = M1 then A1A1 as in the scheme.		
			(3)
	$(\text{f}'(x) = 9x^{-2}-6+x^2)$		
(b)	$-18x^{-3}+2x$	M1: $x^n \to x^{n-1}$ on separate terms at least once. Do not award for $A \to 0$ (Integrating is M0) A1ft: $-18x^{-3}+2\text{"}B\text{"}x$ with a numerical B and no extra terms. (A may have been incorrect or even zero)	M1 A1ft
			(2)
(c)	$\text{f}(x) = -9x^{-1}-6x+\dfrac{x^3}{3}(+c)$	M1: $x^n \to x^{n+1}$ on separate terms at least once. (Differentiating is M0) A1ft: $-9x^{-1}+Ax+\dfrac{Bx^3}{3}(+c)$ with numerical A and B, $A, B \neq 0$	M1A1ft
	$10 = \dfrac{-9}{-3}-6(-3)+\dfrac{(-3)^3}{3}+c$ so c = ...	Uses x = -3 and y =10 in what they think is f(x) (They may have differentiated here) but it must be a changed function i.e. not the original $\text{f}'(x)$, to form a linear equation in c and attempts to find c. No + c gets M0 and A0 unless their method implies that they are correctly finding a constant.	M1
	c = -2	cso	A1
	$(\text{f}(x) =) -9x^{-1}-6x+\dfrac{x^3}{3}$ + their c	Follow through their c in an otherwise (possibly un-simplified) **correct expression.** Allow $-\dfrac{9}{x}$ for $-9x^{-1}$ or even $\dfrac{9x^{-1}}{-1}$.	A1ft
	Note that if they integrate in (b), no marks there but if they then go on to use their integration in (c), the marks for integration are available.		
			(5)
			[10]

Question 6

Question Number	Scheme		Marks
(a)	$\left(-\frac{3}{4}, 0\right)$. Accept $x=-\frac{3}{4}$		B1
			(1)
(b)	$y=4$	B1: One correct asymptote	B1B1
	$x=0$ or 'y-axis'	B1: Both correct asymptotes and no extra ones.	
	Special case $x \neq 0$ **and** $y \neq 4$ scores B1B0		
			(2)
(c)	$\frac{dy}{dx}=-3x^{-2}$	$\frac{dy}{dx}=kx^{-2}$ (Allow $\frac{dy}{dx}=kx^{-2}+4$)	M1
	At $x=-3$, gradient of curve = $-\frac{1}{3}$	Cao (may be un-simplified but must be a fraction with no powers) e.g. $-3(-3)^{-2}$ scores A0 unless evaluated as e.g. $\frac{-3}{9}$ or is implied by their normal gradient.	A1
	Gradient of normal = -1/m	Correct perpendicular gradient rule applied to a numerical gradient that must have come from substituting x = -3 into their derivative. **Dependent on the previous M1.**	dM1
	Normal at P is $(y-3)=3(x+3)$	M1: Correct straight line method using (-3, 3) and a "changed" gradient. A wrong equation with no formula quoted is M0. **Also dependent on the first M1.** A1: Any correct equation	dM1A1
			(5)
(d)	(-4, 0) and (0, 12).	Both correct (May be seen on a sketch)	B1
	So AB has length $\sqrt{160}$ or AB^2 has length 160	M1: Correct use of Pythagoras for their A and B one of which lies on the x-axis and the other on the y-axis, obtained from their equation in (c). A correct method for AB^2 or AB. A1: $\sqrt{160}$ or better e.g. $4\sqrt{10}$ **with no errors seen**	M1 A1cso
			(3)
			[11]

Question 7

Question Number	Scheme	Notes	Marks
	$y = x^3 + 4x + 1 \Rightarrow \frac{dy}{dx} = 3x^2 + 4(+0)$	M1: $x^n \to x^{n-1}$ including $1 \to 0$ A1: Correct differentiation (Do not allow $4x^0$ unless $x^0 = 1$ is implied by later work)	M1A1
	substitute $x = 3 \Rightarrow$ gradient $= 31$	M1: Substitutes $x = 3$ into their $\frac{dy}{dx}$ (not y) Substitutes $x = 3$ into a "changed" function. They may even have integrated. A1: cao	M1A1
			[4]

Question 8

Question Number	Scheme	Marks
	(a) $(1-2x)^2 = 1-4x+4x^2$	M1
	$\frac{d}{dx}(1-2x)^2 = \frac{d}{dx}(1-4x+4x^2) = -4+8x$ o.e.	M1A1
		(3)
	Alternative method using chain rule: Answer of -4 ($1-2x$)	M1M1A1 (3)
	(b) $\frac{x^5+6\sqrt{x}}{2x^2} = \frac{x^5}{2x^2} + 6\frac{\sqrt{x}}{2x^2}, = \frac{1}{2}x^3 + 3x^{-\frac{3}{2}}$	M1,A1
	Attempts to differentiate $x^{-\frac{3}{2}}$ to give $k\,x^{-\frac{5}{2}}$	M1
	$= \frac{3}{2}x^2 - \frac{9}{2}x^{-\frac{5}{2}}$ o.e.	A1
	Quotient Rule (May rarely appear) – See note below	(4)
		(7 marks)

Notes

(a) M1 Attempt to multiply out bracket. Must be 3 or 4 term quadratic and **must have constant term 1**

M1 $x^n \to x^{n-1}$. Follow through on any term in an incorrect expression. Accept a constant $\to 0$

A1 $-4+8x$ Accept -4 ($1-2x$) or equivalent. This is not cso and may follow error in the constant term Following correct answer by $-2+4x$ – apply isw

Correct answer with no working – assume chain rule and give M1M1A1 i.e. 3/3

Common errors: $(1-2x)^2 = 2-4x+4x^2$ is M0, then allow M1A1 for $-4+8x$

$(1-2x)^2 = 1-4x^2$ is M0 then $-8x$ earns M1A0 or $(1-2x)^2 = 1-2x^2$ is M0 then $-4x$ earns M1A0

Use of Chain Rule:

M1M1: first M1 for complete method so $2\times(\pm2)(1-2x)$ second M1 for ($1-2x$) (as power reduced)

Then A1 for -4 ($1-2x$) or for $-4+8x$

So (i) $2(1-2x)$ gets M0 M1A0 for reducing power and (ii) $2\times2(1-2x)$ gets M1 M1A0

(b) M1 An attempt to divide by $2x^2$ first. This can be implied by the sight of the following

Some correct working e.g. $\frac{x^5}{2x^2} + 6\frac{\sqrt{x}}{2x^2}$ or $(x^5+6\sqrt{x})(2x^2)^{-1}$ **leading to** ax^p+bx^q in either case

or can be implied by $\frac{1}{2}x^3+3x^p$ (after no working) i.e. both coefficients correct and power 3 correct

Common error: $(x^5+6\sqrt{x})2x^{-2}$ is M0 (may earn next M mark for the differentiation $x^{-\frac{3}{2}} \to x^{-\frac{5}{2}}$)

A1 Writing the given expression as $\frac{1}{2}x^3+3x^{-\frac{3}{2}}$ or $0.5x^3+\frac{6}{2}x^{-\frac{3}{2}}$ or $0.5x^3+\frac{6}{2}x^{-1\frac{1}{2}}$ or etc…

M1 $x^{-\frac{3}{2}} \to x^{-\frac{5}{2}}$ A1 Cao $\frac{3}{2}x^2 - \frac{9}{2}x^{-\frac{5}{2}}$ o.e. e.g. $\frac{3}{2}x^2 - \frac{9}{2x^2\sqrt{x}}$ then isw. Allow factorised form. Do not penalise $+-\frac{9}{2}x^{-\frac{5}{2}}$ used instead of $-\frac{9}{2}x^{-\frac{5}{2}}$

Use of Quotient Rule : M1,A1:Reaching $\frac{2x^2(5x^4+3x^{-\frac{1}{2}}) - 4x(x^5+6x^{\frac{1}{2}})}{4x^4}$, $= \frac{6x^6-18x^{\frac{3}{2}}}{4x^4}$

Send to review if doubtful M1A1: Simplifying (e.g.dividing numerator and denominator by 2) to reach $\frac{3x^6-9x^{\frac{3}{2}}}{2x^4}$ o.e.

Question 9

Question Number	Scheme	Marks
(a)	Substitutes $x = 2$ into $y = 20 - 4 \times 2 - \frac{18}{2}$ and gets 3	B1
	$\frac{dy}{dx} = -4 + \frac{18}{x^2}$	M1 A1
	Substitute $x = 2 \Rightarrow \frac{dy}{dx} = \left(\frac{1}{2}\right)$ then finds negative reciprocal (-2)	dM1
	Method 1: States or uses $y - 3 = -2(x-2)$ or $y = -2x + c$ with their (2, 3) / Method 2: Or: Check that (2, 3) lies on the line $y = -2x + 7$	dM1
	Method 1: to deduce that $y = -2x + 7$ * / Method 2: Deduce equation of normal as it has the **same gradient** and passes through **a common point**	A1*
		(6)
(b)	Put $20 - 4x - \frac{18}{x} = -2x + 7$ and simplify to give $2x^2 - 13x + 18 = 0$	M1 A1
	Or put $y = 20 - 4\left(\frac{7-y}{2}\right) - \frac{18}{\left(\frac{7-y}{2}\right)}$ to give $y^2 - y - 6 = 0$	
	$(2x-9)(x-2) = 0$ so $x =$ or $(y-3)(y+2) = 0$ so $y =$	dM1
	$x = \frac{9}{2}$, $y = -2$	A1, A1
		(5)
		(11 marks)

PTO for notes on this question.

Question 10

Question Number	Scheme		Marks
(a)	$(x^2+4)(x-3)=x^3-3x^2+4x-12$	Attempt to multiply out the numerator to get a cubic with 4 terms and at least 2 correct	M1
	$\dfrac{x^3-3x^2+4x-12}{2x}=\dfrac{x^2}{2}-\dfrac{3}{2}x+2-6x^{-1}$	M1: Attempt to divide each term by $2x$. The powers of x of at least two terms must follow from their expansion. Allow an attempt to multiply by $2x^{-1}$ A1: Correct expression. May be un-simplified but powers of x must be combined e.g. $\dfrac{x^2}{2}$ not $\dfrac{x^3}{2x}$	M1A1
	$\dfrac{dy}{dx}=x-\dfrac{3}{2}+\dfrac{6}{x^2}$ oe e.g. $\dfrac{2x^3-3x^2+12}{2x^2}$	ddM1: $x^n \to x^{n-1}$ or $2 \to 0$ **Dependent on both previous method marks.** A1: $x-\dfrac{3}{2}+\dfrac{6}{x^2}$ oe and isw Accept $1x$ or even $1x^1$ but not $\dfrac{2x}{2}$ and not x^0. If they lose the previous A1 because of an **incorrect constant only** then allow recovery here and in part (b) for a correct derivative.	ddM1A1
			(5)
	See appendix for alternatives using product/quotient rule		
(b)	At $x=-1,\ y=10$	Correct value for y	B1
	$\left(\dfrac{dy}{dx}=\right)-1-\dfrac{3}{2}+\dfrac{6}{1}=3.5$	M1: Substitutes $x=-1$ into their expression for dy/dx A1: 3.5 oe cso	M1A1
	$y-'10'='3.5'(x--1)$	Uses their **tangent** gradient **which must come from calculus** with $x=-1$ and their numerical y with a correct straight line method. If using $y=mx+c$, this mark is awarded for correctly establishing a value for c.	M1
	$2y-7x-27=0$	$\pm k(2y-7x-27)=0$ cso	A1
			(5)
			(10 marks)

Appendix

(a)

Way 2 Quotient	$(x^2+4)(x-3)=x^3-3x^2+4x-12$	Attempt to multiply out the numerator to get a cubic with 4 terms and at least 2 correct	M1
	$\dfrac{dy}{dx}=\dfrac{2x\left(3x^2-6x+4\right)-2\left(x^3-3x^2+4x-12\right)}{(2x)^2}$	M1: Correct application of quotient rule A1: Correct derivative	M1A1
	$=\dfrac{4x^3}{4x^2}-\dfrac{6x^2}{4x^2}+\dfrac{24}{4x^2}=x-\dfrac{3}{2}+\dfrac{6}{x^2}$ oe e.g. $\dfrac{2x^3-3x^2+12}{2x^2}$	M1: Collects terms and divides by denominator. **Dependent on both previous method marks.** A1: $x-\dfrac{3}{2}+\dfrac{6}{x^2}$ oe and isw Accept $1x$ or even $1x^1$ but not $\dfrac{2x}{2}$ and not x^0.	ddM1A1
Way 3 Product	$y=\left(\dfrac{x}{2}+\dfrac{2}{x}\right)(x-3)$ or $\left(x^2+4\right)\left(\dfrac{1}{2}-\dfrac{3}{2x}\right)$	Divides one bracket by $2x$	M1
	$\dfrac{dy}{dx}=(x-3)\left(\dfrac{1}{2}-\dfrac{2}{x^2}\right)+\left(\dfrac{x}{2}+\dfrac{2}{x}\right)$ or $\dfrac{dy}{dx}=\left(x^2+4\right)\dfrac{3}{2x^2}+2x\left(\dfrac{1}{2}-\dfrac{3}{2x}\right)$	M1: Correct application of product rule A1: Correct derivative	M1A1
	$=\dfrac{3}{2}+\dfrac{6}{x^2}+x-3=x-\dfrac{3}{2}+\dfrac{6}{x^2}$ oe e.g. $\dfrac{2x^3-3x^2+12}{2x^2}$	M1: Expands and collects terms. **Dependent on both previous method marks.** A1: $x-\dfrac{3}{2}+\dfrac{6}{x^2}$ oe and isw Accept $1x$ or even $1x^1$ but not $\dfrac{2x}{2}$ and not x^0.	ddM1A1

Way 4 Product	$(x^2+4)(x-3)=x^3-3x^2+4x-12$	Attempt to multiply out the numerator to get a cubic with 4 terms and at least 2 correct	M1
	$\frac{\mathrm{d}y}{\mathrm{d}x}=\left(x^3-3x^2+4x-12\right)\times-\frac{1}{2}x^{-2}+\frac{1}{2}x^{-1}\left(3x^2-6x+4\right)$ M1: Correct application of product rule A1: Correct derivative		M1A1
	$\frac{\mathrm{d}y}{\mathrm{d}x}=-\frac{x}{2}+\frac{3}{2}-\frac{2}{x}+\frac{6}{x^2}+\frac{3x}{2}-3+\frac{2}{x}=x-\frac{3}{2}+\frac{6}{x^2}$ ddM1: Expands and collects terms **Dependent on both previous method marks.** A1: $x-\frac{3}{2}+\frac{6}{x^2}$ oe e.g. $\frac{2x^3-3x^2+12}{2x^2}$ and isw. Accept $1x$ or even $1x^1$ but not $\frac{2x}{2}$ and not x^0.		ddM1A1
Way 5	$y=\left(\frac{x}{2}+\frac{2}{x}\right)(x-3)$ or $\left(x^2+4\right)\left(\frac{1}{2}-\frac{3}{2x}\right)$	Divides one bracket by $2x$	M1
	$=\frac{x^2}{2}-\frac{3}{2}x+2-6x^{-1}$	M1: Expands	M1A1
		A1: Correct expression	
	$\frac{\mathrm{d}y}{\mathrm{d}x}=x-\frac{3}{2}+\frac{6}{x^2}$ oe e.g. $\frac{2x^3-3x^2+12}{2x^2}$	ddM1: $x^n\to x^{n-1}$ or $2\to 0$ **Dependent on both previous method marks.**	ddM1A1
		A1: $x-\frac{3}{2}+\frac{6}{x^2}$ oe and isw Accept $1x$ or even $1x^1$ but not $\frac{2x}{2}$ If they lose the previous A1 because of an **incorrect constant only** then allow recovery here for a correct derivative.	

Question 11

Question Number	Scheme		Marks
(a)	$y = 2x^3 + kx^2 + 5x + 6$		
	$\left(\frac{dy}{dx} = \right) 6x^2 + 2kx + 5$	M1: $x^n \to x^{n-1}$ for one of the terms including $6 \to 0$ A1: Correct derivative	M1 A1
			[2]
(b)	Gradient of given line is $\frac{17}{2}$	Uses or states $\frac{17}{2}$ or equivalent e.g. 8.5. Must be stated or used in (b) and not just seen as part of $y = \frac{17}{2}x + \frac{1}{2}$.	B1
	$\left(\frac{dy}{dx}\right)_{x=-2} = 6(-2)^2 + 2k(-2) + 5$	Substitutes $x = -2$ into their derivative **(not the curve)**	M1
	$"24 - 4k + 5" = "\frac{17}{2}" \Rightarrow k = \frac{41}{8}$	dM1: Puts their expression = their $\frac{17}{2}$ (Allow BOD for 17 or -17 but **not** the normal gradient) and solves to obtain a value for k. **Dependent on the previous method mark.** A1: $\frac{41}{8}$ or $5\frac{1}{8}$ or 5.125	dM1 A1
	Note: $6x^2 + 2kx + 5 = \frac{17}{2}x + \frac{1}{2}$ scores no marks on its own but may score the first M mark if they substitute x = -2 into the lhs. If they rearrange this equation and then substitute x = -2, this scores no marks.		
			[4]
(c)	$y = -16 + 4k - 10 + 6 = 4"k" - 20 = \frac{1}{2}$	M1: Substitutes $x = -2$ and their numerical k into $y = \ldots$ A1: $y = \frac{1}{2}$	M1 A1
	Allow the marks for part (c) to be scored in part (b).		
			[2]
(d)	$y - "\frac{1}{2}" = "\frac{17}{2}"(x - {}^{-}2) \Rightarrow -17x + 2y - 35 = 0$ or $y = "\frac{17}{2}"x + c \Rightarrow c = \ldots \Rightarrow -17x + 2y - 35 = 0$ or $2y - 17x = 1 + 34 \Rightarrow -17x + 2y - 35 = 0$	M1: Correct attempt at linear equation with their 8.5 gradient (not the normal gradient) using x = -2 and their $\frac{1}{2}$ A1: cao (allow any integer multiple)	M1 A1
			[2]
			10 marks

Question 12

Question Number	Scheme		Marks
	$y=\sqrt{x}+\dfrac{4}{\sqrt{x}}+4=x^{\frac{1}{2}}+4x^{-\frac{1}{2}}+4$		
	$x^n \to x^{n-1}$	Decreases any power by 1. Either $x^{\frac{1}{2}} \to x^{-\frac{1}{2}}$ or $x^{-\frac{1}{2}} \to x^{-\frac{3}{2}}$ or $4 \to 0$ or $x^{\text{their } n} \to x^{\text{their } n-1}$ for fractional n.	M1
	$\left(\dfrac{dy}{dx}=\right)\dfrac{1}{2}x^{-\frac{1}{2}}+4\times -\dfrac{1}{2}x^{-\frac{3}{2}}$ $\left(=\dfrac{1}{2}x^{-\frac{1}{2}}-2x^{-\frac{3}{2}}\right)$	Correct derivative, simplified or un-simplified including indices. E.g. allow $\frac{1}{2}-1$ for $-\frac{1}{2}$ and allow $-\frac{1}{2}-1$ for $-\frac{3}{2}$	A1
	$x=8 \Rightarrow \dfrac{dy}{dx}=\dfrac{1}{2}8^{-\frac{1}{2}}+4\times -\dfrac{1}{2}8^{-\frac{3}{2}}$	Attempts to substitute $x = 8$ into their 'changed' (even integrated) expression that is clearly not y. If they attempt algebraic manipulation of their dy/dx before substitution, this mark is still available.	M1
	$=\dfrac{1}{2\sqrt{8}}-\dfrac{2}{\left(\sqrt{8}\right)^3}=\dfrac{1}{2\sqrt{8}}-\dfrac{2}{8\sqrt{8}}=\dfrac{1}{8\sqrt{2}}=\dfrac{1}{16}\sqrt{2}$	B1: $\sqrt{8}=2\sqrt{2}$ seen or implied anywhere, including from substituting $x = 8$ into y. May be seen explicitly or implied from e.g. $8^{\frac{3}{2}}=16\sqrt{2}$ or $8^{\frac{5}{2}}=128\sqrt{2}$ or $4\sqrt{8}=8\sqrt{2}$ A1: cso $\dfrac{1}{16}\sqrt{2}$ or $\dfrac{\sqrt{2}}{16}$ and allow rational equivalents for $\dfrac{1}{16}$ e.g. $\dfrac{32}{512}$ Apply isw so award this mark as soon as a correct answer is seen.	B1A1
			(5 marks)

Question 13

Question Number	Scheme		Marks
(a)(i)	$k=(-5)^2\times 3=75$	M1: Attempts to find the 'y' intercept. Accept as evidence $(-5)^2\times 3$ with or without the bracket. If they expand f(x) to polynomial form here **then they must then select their constant to score this mark**. May be implied by sight of 75 on the diagram.	M1A1
		A1: $k=75$. Must clearly be identified as k. Allow this mark even from an incorrect or incomplete expansion as long as the constant $k=75$ is obtained. Do not isw e.g. if 75 is seen followed by $k=$ -75 score M1A0.	
(ii)	$c=\frac{5}{2}$ only	$c=\frac{5}{2}$ oe (and no other values). Do not award just from the diagram – must be stated as the value of c.	B1
			(3)
(b)	$\mathrm{f}(x)=(2x-5)^2(x+3)=\left(4x^2-20x+25\right)(x+3)=4x^3-8x^2-35x+75$ Attempts f(x) as a cubic polynomial by attempting to square the first bracket and multiply by the linear bracket or expands $(2x-5)(x+3)$ and then multiplies by $2x-5$ **Must be seen or used in (b) but may be done in part (a).** Allow poor squaring e.g. $(2x-5)^2=4x^2\pm 25$		M1
	$(\mathrm{f}'(x)=)12x^2-16x-35$*	M1: Reduces powers by 1 in **all** terms including any constant $\to 0$	M1A1*
		A1: Correct proof. Withhold this mark if there have been any errors including missing brackets earlier e.g. $(2x-5)^2(x+3)=4x^2-20x+25(x+3)=\ldots$	
			(3)

(c)	$f'(3) = 12\times3^2 - 16\times3 - 35$	Substitutes $x = 3$ into **their** $f'(x)$ **or the given** $f'(x)$. Must be a changed function i.e. not into $f(x)$.	M1
	$12x^2 - 16x - 35 = '25'$	Sets **their** $f'(x)$ **or the given** $f'(x) =$ their $f'(3)$ with a consistent f'. **Dependent on the previous method mark.**	**dM1**
	$12x^2 - 16x - 60 = 0$	$12x^2 - 16x - 60 = 0$ or equivalent 3 term quadratic e.g. $12x^2 - 16x = 60$. (A correct quadratic equation may be implied by later work). **This is cso so must come from correct work – i.e. they must be using the <u>given</u>** $f'(x)$.	A1 cso
	$(x-3)(12x+20) = 0 \Rightarrow x = \ldots$	Solves 3 term quadratic by suitable method – see General Principles. **Dependent on both previous method marks.**	**ddM1**
	$x = -\frac{5}{3}$	$x = -\frac{5}{3}$ oe clearly identified. If $x = 3$ is also given and not rejected, this mark is withheld. (allow -1.6 recurring as long as it is clear i.e. a dot above the 6). **This is cso and must come from correct work – i.e. they must be using the <u>given</u>** $f'(x)$.	A1 cso
			(5)
			(11 marks)
Alt (b) Product rule.	$f(x) = (2x-5)^2(x+3) \Rightarrow f'(x) = (2x-5)^2 \times 1 + (x+3)\times 4(2x-5)$ M1: Attempts product rule to give an expression of the form $p(2x-5)^2 + q(x+3)(2x-5)$ M1: Multiplies out and collects terms A1: $f'(x) = 12x^2 - 16x - 35$*		M1 M1A1*