1	(c)(i)	$(y \pm 6)(y \pm 8)$		2	M1	
			$(y-8)(y+6)$		A1	
	(c)(ii)		8, −6	1	B1	**must** ft from their factors in (c)(i)

2	$\dfrac{\left(\frac{X+4}{2}\right)}{X}\left(=\dfrac{X+4}{2X}\right)$ **or** $\dfrac{\left(\frac{X+4}{2}\right)-1}{X-1}\left(=\dfrac{X+2}{2X-2}\right)$	eg, where b = number of blue counters $\dfrac{b}{2b-4}$ **or** $\dfrac{b-1}{2b-5}$	eg, where r = number of red counters $\dfrac{r+4}{2r+4}$ **or** $\dfrac{r+3}{2r+3}$			M1	for making a correct start by finding the probability of the first counter being blue for their method
	eg $\dfrac{X+4}{2X}\times\dfrac{X+2}{2X-2}$	eg $\dfrac{b}{2b-4}\times\dfrac{b-1}{2b-5}$	eg $\dfrac{r+4}{2r+4}\times\dfrac{r+3}{2r+3}$			M1	oe correct calculation for 2 blue (using one variable)
	eg $8(X^2+6X+8) = 3(4X^2-4X)$	eg $8b(b-1) = 3(2b-4)(2b-5)$	eg $8(r+4)(r+3) = 3(2r+4)(2r+3)$			M1	dep for a correct equation with no algebraic fractions eg could have $X^2+6X+8=\frac{3}{8}(4X^2-4X)$
	Eg $4X^2-60X-64\ (=0)$ **or** $X^2-15X-16\ (=0)$ oe	eg $4b^2-46b+60\ (=0)$ **or** $2b^2-23b+30\ (=0)$ oe	eg $4r^2-14r-60\ (=0)$ **or** $2r^2-7r-30\ (=0)$ oe			M1	for rearranging their equation to a correct 3 term quadratic
				16	5	A1	cao dep on M4
							Total 5 marks

3	$(x \pm 9)(x \pm 4)$	$\dfrac{-(-5)\pm\sqrt{(-5)^2-4\times1\times(-36)}}{2\times1}$ **or** $\dfrac{5\pm\sqrt{25+144}}{2}$			M1	**or** $(x+a)(x+b)$ where $ab=-36$ **or** $a+b=-5$ **OR** correct substitution into quadratic formula (condone one sign error in a, b or c) (if + rather than ± shown then award M1 only unless recovered with answers)
	$(x-9)(x+4)$	$\dfrac{5\pm\sqrt{169}}{2}$ **or** $\dfrac{5\pm13}{2}$			M1	**or** $\dfrac{5\pm\sqrt{169}}{2}$ **or** $\dfrac{5\pm13}{2}$
			9, −4	3	A1	dep on at least M1
						Total 3 marks

4	$(v=)\ 3t^2+2\times4t-5$				M1	2 out of 3 terms differentiated correctly
	$3T^2+8T-5=V$ **OR** $3T^2+8T-5-V=0$				A1	correct equation
	$3(T^2+\frac{8}{3}T)-5$ **OR** $3(T^2+\frac{8}{3}T-\frac{5}{3})$	$(T=)\ \dfrac{-8\pm\sqrt{8^2-4\times3\times(-5-V)}}{2\times3}$			M1	attempt to complete the square **OR** use quadratic formula (condone one sign error in a, b or c and ft their quadratic with mistake in a or b) (condone + instead of ±)
	$\left(T+\frac{4}{3}\right)^2=\left(\frac{4}{3}\right)^2+\frac{V+5}{3}$	$(T=)\ \dfrac{-8\pm\sqrt{124+12V}}{6}$			M1	sight of this method mark implies the previous M1 (condone + instead of ±) (ft their quadratic with mistake in a or b)
	$T=\frac{-4}{3}\pm\frac{1}{3}\sqrt{16+3V+15}$	$(T=)\ \dfrac{-8\pm2\sqrt{31+3V}}{6}$			M1	(condone + instead of ±) (ft their quadratic with mistake in a or b)
			$\dfrac{-4+\sqrt{31+3V}}{3}$	6	A1	accept $k=31$ and $m=3$
						Total 6 marks

		Working	Answer	Mark	Notes
5	(b)	$\left(\frac{dV}{dx}=\right)16-2x+\left(3\times -2x^2\right)$ oe		5	M1 for the correct differentiation of at least 2 correct terms from 16 **or** $-2x$ **or** $(3\times -2x^2)$
		$\left(\frac{dV}{dx}=\right)16-2x-6x^2$ oe			A1 for a correct differentiated expression
		'$16-2x-6x^2$' $=0$ oe			M1 (dep on M1) for equating their differentiated expression to zero
		E.g. $(x=)\ \frac{-2\pm\sqrt{2^2-4\times 6\times -16}}{2\times 6}$ oe (accept + in place of ±) or E.g. $6\left(\left(x+\frac{1}{6}\right)^2-\left(\frac{1}{6}\right)^2\right)-16(=0)$ oe			M1 (dep on M1) for a complete method to solve their 3-term quadratic equation (allow one sign error and some simplification – allow as far as $\frac{-2\pm\sqrt{4+384}}{12}$)
			1.47		A1 dep on M1 for answer in range 1.47 – 1.5 from correct working (Must reject −1.80 to −1.81 if calculated)

	Working		Answer	Mark	Notes
6	gradient of $JK = -0.5$ **or** $m\times 2=-1$			6	M1 for finding the gradient of JK using $m_1\times m_2=-1$
	$\frac{k-15}{6-j}=-\frac{1}{2}$ **or** $2k-j=24$ **or** $j=2k-24$ **or** $k=\frac{j+24}{2}$ oe				M1 for expressing the gradient of JK in terms of j and k or a correct equivalent equation
	$(j-6)^2+(k-15)^2=80$ oe **or** $\left(\frac{j+6}{2},\frac{k+15}{2}\right)$ oe **or** $(j+4)^2+196=100+(k-1)^2$ oe				M1 for finding equation of JK in terms of j and k **or** for finding the midpoint of M **or** for equating length HJ with length HK
	eg $3k^2-78k+495=0$ oe **or** $5j^2-60j-140=0$ oe **or** $5k^2-150k+1045=0$ oe **or** $3j^2-12j-36=0$ **oe** **or** gradient HM: eg $\frac{\frac{k+15}{2}-1}{\frac{j+6}{2}+4}=2$ **or** $k=2j+15$ **or** $j=\frac{k-15}{2}$ oe				M1 (dep on M3) writing a correct quadratic expression in the form $ax^2+bx+c\ (=0)$ (allow $ax^2+bx=c$) **or** A correct equation for the gradient of HM in terms of j and k or a correct equivalent equation
	eg $(k-15)(k-11)(=0)$ **or** $\frac{78\pm\sqrt{(-78)^2-4\times 3\times 495}}{2\times 3}$ **or** $(k-13)^2-169+165(=0)$	eg $(j-6)(j+2)(=0)$ **or** $\frac{12\pm\sqrt{(-12)^2-4\times 3\times -36}}{2\times 3}$ **or** $(j-2)^2-4-12(=0)$			M1 (dep on M3) for a complete method to solve their 3-term quadratic equation (allow one sign error in the use of the quadratic formula) **or** a correct method to eliminate either j or k eg $2k-24=\frac{k-15}{2}$ oe **or** $\frac{j+24}{2}=2j+15$ oe
			$j=-2,\ k=11$		A1
					Total 6 marks

		Working		Answer	Mark	Notes
6 ALT		$\left(\frac{j+6}{2},\frac{k+15}{2}\right)$ oe			6	M1 for finding the midpoint of M
		$\frac{\frac{k+15}{2}-1}{\frac{j+6}{2}+4}=2$ **or** $k-2j=15$ **or** $k=2j+15$ **or** $j=\frac{k-15}{2}$ oe				M1 for expressing the gradient of JK in terms of j and k or a correct equivalent equation
		$(j-6)^2+(k-15)^2=80$ oe **or** $(j+4)^2+196=100+(k-1)^2$ oe				M1 for finding the length of JK in terms of j and k **or** for equating length HJ with length HK
		E.g. $5j^2-12j-44=0$ **or** $3j^2+48j+84=0$ oe	E.g. $5k^2-174k+1309=0$ **or** $3k^2+6k-429=0$ oe			M1 (dep on M3) writing the correct quadratic expression in form $ax^2+bx+c\ (=0)$ allow $ax^2+bx=c$
		E.g. $(5j-22)(j+2)(=0)$ **or** $\frac{12\pm\sqrt{(-12)^2-4\times 5\times -44}}{2\times 5}$ **or** $(j+8)^2-64+28(=0)$	E.g. $(5k-119)(k-11)(=0)$ **or** $\frac{174\pm\sqrt{(-174)^2-4\times 5\times 1309}}{2\times 5}$ **or** $(k+1)^2-1-143(=0)$			M1 (dep on M3) for a complete method to solve their 3-term quadratic equation (allow one sign error in the use of the quadratic formula)
				$j=-2,\ k=11$		A1
						Total 6 marks

7 (b)	$(x \pm 8)(x \pm 5)$	$\frac{-(-3) \pm \sqrt{(-3)^2 - 4 \times 1 \times (-40)}}{2 \times 1}$ or $\frac{3 \pm \sqrt{9+160}}{2}$			M1	**or** $(x + a)(x + b)$ where $ab = -40$ **or** $a + b = -3$ **OR** correct substitution into quadratic formula (condone one sign error in a, b or c and missing brackets) (if + rather than ± shown then award M1 only unless recovered with answers)
	$(x - 8)(x + 5)$	$\frac{3 \pm \sqrt{169}}{2}$ **or** $\frac{3 \pm 13}{2}$			M1	$\frac{3 \pm \sqrt{169}}{2}$ **or** $\frac{3 \pm 13}{2}$
			8, −5	3	A1	dep on at least M1 for correct values

8	(i)	$(x \pm 6)(x \pm 4)$		2	M1	or $(x + a)(x + b)$ where $ab = -24$ **or** $a + b = 2$
		Working not required, so correct answer scores full marks	$(x + 6)(x - 4)$		A1	
	(ii)	*Answer must come from the factors in (i) as the questions says 'Hence solve…'*	−6, 4	1	B1ft	**Must** follow through from their factors in (i), so even if the answers 4 and −6 are given the mark can only be awarded if it follows from the factorisation in (i) (dep on 2 factors)
						Total 3 marks
					NB:	Some students may show the whole of their working in the space for (i) or (ii). Please award the marks for (i) and (ii) so long as there is no ambiguity.

9	$x^2 + (3 - 2x)^2 = 18$	$\left(\frac{3-y}{2}\right)^2 + y^2 = 18$		5	M1	substitution of linear equation into quadratic
	$5x^2 - 12x - 9[=0]$ oe	$5y^2 - 6y - 63[=0]$ oe			M1	simplified to a correct 3 term quadratic
	$(5x + 3)(x - 3)$ [= 0] $\frac{-(-12) \pm \sqrt{(-12)^2 - 4 \times 5 \times (-9)}}{2 \times 5}$ $5[(x - \frac{12}{10})^2 - \frac{144}{100}] - 9 = 0$ oe	$(5y - 21)(y + 3)$ [= 0] $\frac{-(-6) \pm \sqrt{(-6)^2 - 4 \times 5 \times (-63)}}{2 \times 5}$ $5[(y - \frac{6}{10})^2 - \frac{36}{100}] - 63 = 0$ oe			M1ft	dep on M1 for solving *their* 3 term quadratic equation using any correct method (if factorising, allow brackets which expanded give 2 out of 3 terms correct) (if using formula allow one sign error and some simplification – allow as far as $\frac{12 \pm \sqrt{144+180}}{10}$ or $\frac{6 \pm \sqrt{36+1260}}{10}$)(if completing the square allow as far as shown)
			$x = -0.6$ **and** $x = 3$ **OR** $y = 4.2$ **and** $y = -3$		A1	oe dep on M2 for both x-values **OR** both y-values
	Working must be shown		$x = -0.6$, $y = 4.2$ $x = 3$, $y = -3$		A1	oe dep on M2 (must be clearly shown as correct pairs), accept answers given as coordinates
						Total 5 marks

10	eg $\frac{\left(\frac{N+3}{2}\right)}{N}\left(=\frac{N+3}{2N}\right)$	eg where b = number of black pens $\frac{b}{2b-3}$ **or** $\frac{b}{N}$ **and** $N = 2b-3$ (or $b = \frac{N+3}{2}$)	eg where r = number of red pens $\frac{r+3}{2r+3}$ **or** $\frac{r+3}{N}$ **and** $N = 2r+3$ (or $r = \frac{N-3}{2}$)		5	M1	for making a correct start by finding the probability of the first pen being black for their method. If in 2 variables, one must also be defined in terms of the other. (any letter may be used for the variable)
	eg $\frac{N+3}{2N}\times\frac{N-3}{2(N-1)}=\frac{9}{35}$	eg $\frac{b}{2b-3}\times\frac{b-3}{2b-4}=\frac{9}{35}$ **or** $\frac{b}{N}\times\frac{b-3}{N-1}=\frac{9}{35}$	eg $\frac{r+3}{2r+3}\times\frac{r}{2r+2}=\frac{9}{35}$ **or** $\frac{r+3}{N}\times\frac{r}{N-1}=\frac{9}{35}$ **and** $N=2r+3$			M1	oe dep on previous M1 for a correct equation for black, red – must be in one variable or if 2 variables, one must be defined in terms of other.
	eg $35(N+3)(N-3)$ $= 9(2N(2N-2))$ **or** $35(N^2-9) = 9(4N^2-4N)$	eg $35(b^2-3b) = 9(4b^2-14b+12)$	eg $35(r^2+3r) = 9(4r^2+10r+6)$			M1	dep on previous marks for a correct equation in one variable with no algebraic fractions – brackets may or may not be expanded
	eg $N^2-36N+315$ (= 0)	eg $b^2-21b+108$ (= 0)	eg $r^2-15r+54$ (= 0)			M1	For correctly rearranging their equation to a 3 term quadratic
	Working must be seen			21, 15		A1	cao dep on M4
							Total 5 marks

11	eg $(x \pm 20)(x \pm 1)$	$\frac{-(-21)\pm\sqrt{(-21)^2-4\times1\times20}}{2\times1}$ **or** $\left(x-\frac{21}{2}\right)^2-\left(\frac{21}{2}\right)^2+20=0$		3	M1	If factorising, allow brackets which expanded give 2 out of 3 terms correct – if using formula or completing the square allow one sign error and some simplification – allow as far as eg $\frac{21\pm\sqrt{441-80}}{2}$ or e $\left(x-\frac{21}{2}\right)^2-\frac{361}{4}=0$ oe
	$(x-20)(x-1)$	eg $\frac{21\pm\sqrt{441-80}}{2}$ or $\frac{21\pm\sqrt{361}}{2}$ or $\frac{21\pm19}{2}$ **or** $x=\pm\sqrt{\frac{361}{4}}+\frac{21}{2}$ oe			M1	dep on M1 for correct factorisation, or a correct expression for x if completing the square. or a correct substitution into quadratic formula with some processing.
			1, 20		A1	for both correct values, dep on 1st M1 with no incorrect working.
						Total 3 marks

12 (b)	$(x-10)^2+6=x^2+6$			3	M1	Using f(x – 10) and setting equal to x^2+6
	$x^2-10x-10x+100$ oe				M1	for $(x-10)^2$ expanded correctly.
			5		A1	dep 1st M1

13	$\frac{5}{x+2}+\frac{3}{x(x+2)}$ (= 2) or $\frac{5x}{x^2+2x}+\frac{3}{x^2+2x}$ (= 2)			5	M1	Factorising x^2+2x in correct expression on LHS or for writing the two fractions over a common denominator.
	$\frac{5x+3}{x(x+2)}=2$ **or** $\frac{5x+3}{x^2+2x}=2$ **or** $5x+3=2x(x+2)$ oe **or** $5x+3=2x^2+4x$ oe				M1	Correct simplified single fraction = 2 or correct equation with no fractions.
	$2x^2-x-3$ (= 0)				M1	Correct 3 term quadratic
	$(2x-3)(x+1)$ (=0) **or** $\frac{--1\pm\sqrt{(-1)^2-4\times2\times(-3)}}{2\times2}$ **or** $\left(x-\frac{1}{4}\right)^2-\frac{1}{16}-\frac{3}{2}=0$ oe				M1ft	independent For solving *their* 3 term quadratic equation using any correct method. If factorising, allow brackets which expanded give 2 out of 3 terms correct (if using formula or completing the square allow one sign error and some simplification – allow as far as eg $\frac{1\pm\sqrt{1+24}}{4}$ or eg $\left(x-\frac{1}{4}\right)^2=\frac{25}{16}$ oe
		1.5 and –1			A1	oe dep on M3
						Total 5 marks

Alternative Mark Scheme for question 13 (obtaining a cubic)					
13	$\frac{5(x^2+2x)+3(x+2)}{(x^2+2x)(x+2)}$ (=2) oe		5	M1	Correct fraction over a common denominator (may be 2 separate fractions)
	eg $5(x^2+2x)+3(x+2)=2(x^2+2x)(x+2)$ oe			M1	Correct equation with no fractions.
	$2x^3+3x^2-5x-6 \quad (=0)$			M1	Correct cubic
	$(x+1)(2x-3)(x+2) \quad (=0)$			M1	For product of 3 correct linear factors.
		1.5 and −1		A1	oe dep on M3 Do not award A mark if extra solution (−2) given.
					Total 5 marks

14	(b)(i)	$(x \pm 9)(x \pm 4)$		2	M1	for $(x \pm 9)(x \pm 4)$ **or** for $(x + a)(x + b)$ where $ab = -36$ or $a + b = 5$
			$(x + 9)(x - 4)$		A1	
	(ii)		−9, 4	1	B1	ft from (b)(i)

15		$(v =)\ 3t^2 + 10t - 8$		5	M1	For at least 2 terms differentiated correctly
		$3t^2 + 10t - 8 = 0$			M1	Their $v = 0$ dep on M1 could be implied by correct values
		$(3t - 2)(t + 4)\ (= 0)$ $(t =)\ \frac{2}{3}$ or $(t =)\ -4$			M1	dep on M1 for correct values for t or for $t = \frac{2}{3}$ or correct method to solve their 3 term quadratic equation: If factorising, allow brackets which when expanded give 2 out of 3 terms correct (If using formula or completing the square allow one sign error and some simplification – allow as far as eg $\frac{-10 \pm \sqrt{100+96}}{6}$ oe $3(t+\frac{5}{3})^2 - \frac{48}{3} = 0$)
		$(s =)\left(\frac{2}{3}\right)^3 + 5\times\left(\frac{2}{3}\right)^2 - 8\times\frac{2}{3} + 10$			M1	For $\frac{2}{3}$ (only) substituted into formula for s or for selecting the value from this substitution or for an answer of 7.185…
			$\frac{194}{27}$		A1	oe but numerator and denominator must be integers.
						Total 5 marks

16	(b)(i)			2	M1	for $(x \pm 9)(x \pm 1)$ **or** for $(x+a)(x+b)$ with $ab = -9$ or $a+b=8$
			$(x+9)(x-1)$		A1	for correct factors
	(ii)		−9, 1	1	B1	ft dep on factorising in the form $(x+p)(x+q)$

17	$\frac{5}{x}\times\frac{(x-4)}{x}$ oe **or** $\frac{(x-5)}{x}\times\frac{6}{x}$ oe		5	M1	for a correct expression for P(R,G) or P(G,R)
	$\frac{5}{x}\times\frac{(x-4)}{x} + \frac{(x-5)}{x}\times\frac{6}{x}$ oe			M1	for a correct expression for P(R,G) + P(G,R)
	$19x^2 - 352x + 1600\ (= 0)$ oe **or** $19x^2 - 352x = -1600$ oe			M1	for a correct equation in the form $ax^2 + bx + c\ (= 0)$ oe **or** $ax^2 + bx = -c$ oe
	$(x - 8)(19x - 200)\ (= 0)$ **or** $(x =)\frac{--352 \pm \sqrt{(-352)^2 - (4\times19\times1600)}}{2\times19}$ **or** $19\left[\left(x-\frac{176}{19}\right)^2 - \left(\frac{176}{19}\right)^2\right] + 1600 (= 0)$			M1	for solving their 3-term quadratic equation using any correct method - if factorising, allow brackets which expanded give 2 out of 3 terms correct (if using formula or completing the square allow one sign error and some simplification – allow as far as $\frac{352 \pm \sqrt{123904 - 121600}}{38}$ oe **or** $19\left(x-\frac{176}{19}\right)^2 - \frac{576}{19} (= 0)$ oe)
		8		A1	cao, dep on M2. Do not award if non−integer solution also given. 8 must come from correct working.
					Total 5 marks

18	(i)	$(x \pm 3)(x \pm 8)$		2	M1	or $(x + a)(x + b)$ where $ab = -24$ **or** $a + b = 5$
			$(x - 3)(x + 8)$		A1	
	(ii)		3, −8	1	B1ft	Must ft from their answer to (i) ft from their incorrect factors in the form $(x + a)(x + b)$
						Total 3 marks

19	$(2x + 3)(x - 1) < 75$		5	B1	For writing the correct inequality sign with a correct calculation or correct value – this could be initially or saying that $x < 6$ at the end
	$2x^2 + x - 78 < 0$			M1	rearranged to form correct quadratic < 0 (allow = 0 or other incorrect inequality sign) oe
	$(x - 6)(2x + 13)\ (< 0)$ **or** $x = \frac{-1 \pm \sqrt{(1)^2 - (4 \times 2 \times -78)}}{2 \times 2}$ **or** $2\left(x + \frac{1}{4}\right)^2 - 2\left(\frac{1}{4}\right)^2 - 78 = 0$			M1	first step to find critical values from the correct quadratic
		$x = 6$		A1	$x = 6$ identified as critical value, ignore −6.5 if given
		$1 < x < 6$		A1	correct inequality
					Total 5 marks

20	$(v =)\ 12t^2 - 27\ (= 0)$		5	M1	Correct differentiation
	$t^2 = \frac{27}{12}\ \left(= \frac{9}{4}\right)$ oe **or** $(3)(2t + 3)(2t - 3)\ (= 0)$			M1	dep M1 first stage to solve $v = 0$ by rearranging, factorising, quadratic formula, or completing the square
	$\sqrt{\frac{9}{4}}$ oe $\left(= \frac{3}{2}\right)$ **or** $\pm\sqrt{\frac{9}{4}}$ oe $\left(= \pm\frac{3}{2}\right)$			A1	Correct value of t (allow ±)
	$(a =)\ 24t$			M1	dep 1st M1 for differentiating v
		36		A1	correct answer
					Total 5 marks

21 (a)		$3c^2(6cd^2-7)$	2	B2	fully correct **or** B1 for a correct partial factorisation with at least two terms outside the bracket ie $3c(6c^2d^2-7c)$ or $c^2\left(18cd^2-21\right)$ **or** the fully correct factor outside the bracket with two terms inside the bracket and at most one mistake $3c^2(...........)$
(b) (i)	eg $(y\pm6)(y\pm3)$ or $y(y+3)-6(y+3)$ or $y(y-6)+3(y-6)$		2	M1	or $(y+a)(y+b)$ where $ab=-18$ **or** $a+b=-3$ or factorisation which expands to give 2 out of 3 correct terms
	[allow use of x rather than y]	$(y-6)(y+3)$		A1	
(ii)		6, −3	1	B1	ft must come from their factors in (b)(i)
					Total 5 marks

21(b) As we have always done, (ii) must ft from (i)
If they do nothing in (i) and then factorise and give the solutions in (ii) can we give marks retrospectively – yes, as long as nothing in (i) – this could gain M1A1B1 (correct factorisation and correct solutions) or M1A0B1 (factorisation worthy of the method mark, but not correct and ft solutions from incorrect factorisation) or M0A0B1 (incorrect factorisation that is worthy of no marks and then answers which ft from their incorrect factorisation)
What do we do if they give the incorrect factorisation in (i) and then start again in (ii), showing the correct factors and give the correct answers from their factorisation in (ii) as answers? Award M0A0 in (i) and then B1 in (ii)
What do we do if nothing is done in (i) and then we see they have used the quadratic formula and got the answers from this in (ii)? No marks at all M0A0B0
What do we do if the student has got the correct factorisation in (i) and the correct answers in (ii) but also has the quadratic formula shown in (ii)? We award M1A1B1 – assuming that the quadratic formula is a check
What if they factorise and solve in part (i) with nothing in (ii)
M1A1B1 if fully correct or M1A0B1(allowable factorisation) or M0A0B1 (ft from incorrect factorisation that is not allowable)
What if they factorise in (i) and give the correct answers for (ii) in (i) and then a different answer for the solution in (ii)
Award M1A1 in (i) and B0 in (ii)
What if they factorise correctly and then expand and give the original expression on the answer line – award full marks; the student knows how to factorise and is checking and gives their check as the answer.

22	$(V=)\pi x^2\left(\frac{800}{\pi x}-x\right)$ or $800x-\pi x^3$ oe		5	M1 for volume of cylinder (in terms of one variable, e.g. x or r)
	$\left(\frac{dV}{dx}=\right)800-3\pi x^2$			M1ft for differentiating an expression in one variable to find 800 **or** $\pm3\pi x^2$ (must come from a cubic in the form $800x\pm\pi x^3$ or $800x\pm ax^3$ or $bx\pm\pi x^3$ where $a\neq0$ and $b\neq0$)
	$"800-3\pi x^2"=0$			M1ft dep on previous M1 for equating their $\frac{dV}{dx}$ to zero (must be a quadratic in the form $800\pm ax^2$ or $b\pm3\pi x^2$ where $a\neq0$ and $b\neq0$)
	$(x=)\sqrt{\frac{800}{3\pi}}\left(=\sqrt{84.8(8263...)}\right)$ or $\frac{\sqrt{9600\pi}}{6\pi}$ or 9.2(13177…)			A1 for a correct value of x Allow use of quadratic formula
	Award marks within the range from correct working	4914		A1 accept 4910 – 4914
				Total 5 marks

23	(b)	$12x^2 + 2x - 20 = 4$ oe		4	M1	ft, for equating their dy/dx to 4
		$12x^2 + 2x - 24$ (= 0) **or** $6x^2 + x - 12$ (= 0)			M1	(dep on M1) ft their dy/dx in the form $ax^2 + bx$ (+ c)
		eg $(6x - 8)(2x + 3)$ (= 0) **or** $(3x - 4)(2x + 3)$ (= 0) **or** $x = \frac{-2 \pm \sqrt{(2)^2 - (4 \times 12 \times -24)}}{2 \times 12}$			M1	for solving their three-term quadratic equation using any correct method - if factorising, allow brackets which expanded give 2 out of 3 terms correct (if using formula or completing the square allow one sign error and some simplification – allow as far as eg $\frac{-2 \pm \sqrt{4 + 1152}}{24}$ oe)
		Working required	$\frac{4}{3}, -\frac{3}{2}$		A1	(dep on M2) oe, allow 1.33(3...) for $\frac{4}{3}$, both values – isw any attempt to find y coordinates

24	(b)	(gh(x)=) $\frac{11}{2(x^2+4)-5}$ (= 1)		3	M1	
		$11 - 3 = 2x^2$ oe eg $x^2 = 4$ **or** $2x^2 - 8 = 0$ **or** $x^2 - 4 = 0$			M1	correct expansion and rearrangement with x term on one side and number terms the other side **or** all terms on one side in an equation
		Correct answer scores full marks (unless from obvious incorrect working)	2		A1	cao, an answer of ±2 gains M2 only If no other marks awarded, award SCB1 for answer of 2.2 oe