	Give 1 mark for each •	Illustration(s) for awarding each mark
1(a)	ans: $2y - x = -2$ (3 marks)	
	•[1] finds midpoint of BC	•[1] midpoint BC: (10,4)
	•[2] establishes gradient of AM	•[2] $m_{AM} = \frac{4+2}{10+2} = \frac{1}{2}$
	•[3] substitutes in general equation	•[3] $y - 4 = \frac{1}{2}(x - 10)$ $y = \frac{1}{2}x - 1$
(b)	ans: D(4,1) (3 marks)	
	•[1] realising $y = 1$	•[1] $y = 1$
	•[2] substitutes into equation	•[2] $2(1) - x = -2;\ x = 4$
	•[3] states coordinates of D	•[3] D(4,1)
(c)	ans: proof (3 marks)	
	•[1] finds gradient of BD	•[1] $m_{BD} = -2$
	•[2] knows condition for perp. lines	•[2] $m_1 \times m_2 = -1$ [stated or implied]
	•[3] makes statement re perpendicular	•[3] $\frac{1}{2} \times -2 = -1$ so AM and BD are perp.
2(a)	ans: $P(1, -\frac{25}{2})$ (4 marks)	
	•[1] knows to take derivative and equate to 0	•[1] $\frac{dy}{dx} = 0$
	•[2] takes derivative	•[2] $3x^2 - 15x + 12 = 0$
	•[3] solves to find x - coordinate	•[3] $x = 1$ [or 4]
	•[4] substitutes to find y - coordinate	•[4] $y = 1^3 - \frac{15}{2}(1) + 12(1) - 18 = -\frac{25}{2}$
(b)	ans: Q(6,0) (3 marks)	
	•[1] knows to make $y = 0$	•[1] $y = 0$
	•[2] uses synthetic division to find x	•[2] $\begin{array}{c\|cccc} 6 & 1 & -\frac{15}{2} & 12 & -18 \\ & & 6 & -9 & 18 \\ \hline & 1 & -\frac{3}{2} & 3 & 0 \end{array}$
	•[3] states coordinates of Q	•[3] Q(6,0)

	Give 1 mark for each •	Illustration(s) for awarding each mark
3(a)	**ans: 32·6 gigatonnes** **(3 marks)**	
	• 1 correct multiplier • 2 completes calculation • 3 calculation and correct rounding	• 1 $0{\cdot}96$ • 2 $0{\cdot}96^5 \times 40$ • 3 32·6 gigatonnes
(b)	**ans: 31 gigatonnes** **(3 marks)**	
	• 1 sets up recurrence relation • 2 knows to calculate 3 figures • 3 final answer	• 1 $U_{n+1} = 0{\cdot}96^5 U_n + 3{\cdot}8$ • 2 1st year: 36·4; 2nd year: 33·4795 • 3 3rd year: 31 gigatonnes
(c)	**ans: upper 20·6; lower 16·8** **(3 marks)**	
	• 1 knows limit exists • 2 finds upper limit • 3 finds lower limit	• 1 limit exists since $-1 < 0{\cdot}96^5 < 1$ • 2 $L = \dfrac{3{\cdot}8}{1-(0{\cdot}96)^5} = 20{\cdot}6$ • 3 $20{\cdot}6 - 3{\cdot}8 = 16{\cdot}8$
4(a)	**ans: $a = -2$** **(2 marks)**	
	• 1 finds expression for $f(g(-2))$ • 2 equates to -1 and solves for a	• 1 $f(g(-2)) = f(-1) = 1 + a$ • 2 $a = -2$
(b)	**ans: $x = -2, 0, 2$** **(5 marks)**	
	• 1 substitutes • 2 simplifies • 3 equates to 2 • 4 factorises • 5 solves for x	• 1 $f(f(x)) = (x^2-2)^2 - 2$ • 2 $x^4 - 4x^2 + 2$ • 3 $x^4 - 4x^2 + 2 = 2; x^4 - 4x^2 = 0$ • 4 $x^2(x^2-4) = 0$ • 5 $x = -2, 0, 2$
5(a)	**ans: $x = 1$** **(2 marks)**	
	• 1 realises y = 0; equates to 0 • 2 solves for x	• 1 $3x^2 - 6x + 3 = 0$ • 2 $3(x-1)^2 = 0; x = 1$
(b)	**ans: $b = 2$** **(5 marks)**	
	• 1 integrates expression • 2 substitutes values • 3 simplifies, equates to 1, rearranges • 4 uses synthetic division to solve • 5 realises one solution: discards $b^2 - b + 1$	• 1 $[x^3 - 3x^2 + 3x]_1^b$ • 2 $(b^3 - 3b^2 + 3b) - (1 - 3 + 3)$ • 3 $b^3 - 3b^2 + 3b - 2 = 0$ • 4 $\begin{array}{c\|cccc} 2 & 1 & -3 & 3 & -2 \\ & & 2 & -2 & 2 \\ \hline & 1 & -1 & 1 & 0 \end{array}$ • 5 $b = 2$

	Give 1 mark for each •	Illustration(s) for awarding each mark
5(c)	**ans:** $y = 6x - 9$ **(4 marks)**	
	•[1] finds 'c'	•[1] when $x = 2, y = 3$; Q(2,3)
	•[2] knows to differentiate	•[2] $\frac{dy}{dx} = 6x - 6$
	•[3] substitutes to find gradient	•[3] when $x = 2$; $\frac{dy}{dx} = 6$
	•[4] substitutes into general equation	•[4] $y - 3 = 6(x - 2)$
6(a)	**ans:** **(-2,1)** **(3 marks)**	
	•[1] substitutes eq.of line in eq. of circle	•[1] $x^2 + (2x+5)^2 - 4x + 2(2x+5) - 15 = 0$
	•[2] simplifies and solves for x	•[2] $5(x+2)^2 = 0; x = -2$
	•[3] substitutes to find y	•[3] $y = 2(-2) + 5$; y = 1
(b)	**ans:** $(x+6)^2 + (y-3)^2 = 20$ **(3 marks)**	
	•[1] establishes coordinates of B	•[1] B(-6,3)
	•[2] finds r^2	•[2] $r^2 = 20$
	•[3] substitutes into general circle equation	•[3] $(x+6)^2 + (y-3)^2 = 20$
7(a)	**ans:** AE = $\sqrt{5}$; BC = 4 **(2 marks)**	
	•[1] knows to use Pythagoras'	•[1] evidence
	•[2] finds two lengths	•[2] AE = $\sqrt{5}$; BC = $\sqrt{(25-9)} = 4$
(b)	**ans:** **proof** **(4 marks)**	
	•[1] knows to expand	•[1] $\cos(x+y) = \cos x \cos y - \sin x \sin y$
	•[2] finds expression for ratios	•[2] $\cos x = \frac{4}{5}; \cos y = \frac{2}{\sqrt{5}}; \sin x = \frac{3}{5}; \sin y = \frac{1}{\sqrt{5}}$
	•[3] subs and starts to simplify	•[3] $(\frac{4}{5} \times \frac{2}{\sqrt{5}}) - (\frac{3}{5} \times \frac{1}{\sqrt{5}}); \frac{5}{5\sqrt{5}}; \frac{1}{\sqrt{5}}$
	•[4] completes simplification to answer	•[4] $\frac{1}{\sqrt{5}} \times \frac{\sqrt{5}}{\sqrt{5}} = \frac{\sqrt{5}}{5}$
8(a)	**ans:** m = **2400ml** **(4 marks)**	
	•[1] knows to differentiate and equate to 0	•[1] $H'(m) = 0$
	•[2] differentiates	•[2] $4 - \frac{1}{600}m = 0$
	•[3] solves for x	•[3] $m = 2400$
	•[4] justifies maximum	•[4] table of values; second derivative
(b)	**ans:** **4800 feet** **(1 mark)**	
	•[1] knows to sub into function and evaluate	•[1] $4(2400) - \frac{(2400)^2}{1200} = 4800$feet

Total: 60 marks