ROOTS OF QUADRATICS

Question number	Scheme	Marks	
8.	(a) $x^2 + kx + (8-k)$ $\quad (=0)$ $\quad$ $8-k$ need not be bracketed	M1	
	$b^2 - 4ac = k^2 - 4(8-k)$	M1	
	$b^2 - 4ac < 0 \Rightarrow k^2 + 4k - 32 < 0$ $\quad$ (*)	A1cso	(3)
	(b) $(k+8)(k-4) = 0$ $\quad k = ...$	M1	
	$k = -8$ $\quad k = 4$	A1	
	Choosing 'inside' region (between the two k values)	M1	
	$-8 < k < 4$ or $4 > k > -8$	A1	(4)
			7
	(a) 1st M: Using the k from the right hand side to form 3-term quadratic in x ('= 0' can be implied), or… attempting to complete the square $\left(x+\frac{k}{2}\right)^2 - \frac{k^2}{4} + 8 - k \ (=0)$ or equiv., using the k from the right hand side. For either approach, <u>condone sign errors</u>. 1st M may be implied when candidate moves straight to the discriminant. 2nd M: Dependent on the 1st M. Forming expressions in k (with no x's) by using b^2 and $4ac$. (Usually seen as the discriminant $b^2 - 4ac$, but separate expressions are fine, and also allow the use of $b^2 + 4ac$. (For 'completing the square' approach, the expression must be clearly separated from the equation in x). If b^2 and $4ac$ are used in the <u>quadratic formula</u>, they must be clearly separated from the formula to score this mark. For any approach, <u>condone sign errors</u>. If the wrong statement $\sqrt{b^2 - 4ac} < 0$ is seen, maximum score is M1 M1 A0. (b) Condone the use of x (instead of k) in part (b). 1st M: Attempt to solve a 3-term quadratic equation in k. It <u>might</u> be different from the given quadratic in part (a). Ignore the use of < in solving the equation. The 1st M1 A1 can be scored if –8 and 4 are achieved, even if stated as $k < -8$, $k < 4$. <u>Allow</u> the first M1 A1 to be scored in part (a). N.B. '$k > -8$, $k < 4$' scores 2nd M1 A0 '$k > -8$ or $k < 4$' scores 2nd M1 A0 '$k > -8$ and $k < 4$' scores 2nd M1 A1 '$k = -7, -6, -5, -4, -3, -2, -1, 0, 1, 2, 3$' scores 2nd M0 A0 Use of ≤ (in the answer) loses the final mark.		

Question number	Scheme	Marks
8. (a)	[No real roots implies $b^2-4ac<0$.] $b^2-4ac=q^2-4\times 2q\times(-1)$	M1
	So $q^2-4\times 2q\times(-1)<0$ i.e. $q^2+8q<0$ **(*)**	A1cso (2)
(b)	$q(q+8)=0$ or $(q\pm 4)^2 \pm 16=0$	M1
	$(q)=0$ or -8 (2 cvs)	A1
	$-8<q<0$ <u>or</u> $q\in(-8, 0)$ <u>or</u> $q<0$ and $q>-8$	A1ft (3)
		5
(a)	M1 for attempting b^2-4ac with one of b or a correct. < 0 not needed for M1 This may be inside a square root. A1cso for simplifying to printed result with no incorrect working or statements seen. Need an intermediate step e.g. $q^2--8q<0$ or $q^2-4\times 2q\times -1<0$ or $q^2-4(2q)(-1)<0$ or $q^2-8q(-1)<0$ or $q^2-8q\times -1<0$ i.e. must have × or brackets on the $4ac$ term < 0 must be seen at least one line before the final answer.	
(b)	M1 for factorizing or completing the square or attempting to solve $q^2\pm 8q=0$. A method that would lead to 2 values for q. The "= 0" may be implied by values appearing later. 1st A1 for $q=0$ and $q=-8$ 2nd A1 for $-8<q<0$. Can follow through their cvs but must choose "inside" region. $q<0$, $q>-8$ is A0, $q<0$ or $q>-8$ is A0, (-8, 0) on its own is A0 BUT "$q<0$ and $q>-8$" is A1 Do not accept a number line for final mark	

Question Number	Scheme	Marks
7 (a)	$b^2-4ac>0 \Rightarrow \quad 16-4k(5-k)>0$ or equiv., e.g. $16>4k(5-k)$	M1A1
	So $k^2-5k+4>0$ (Allow any order of terms, e.g. $4-5k+k^2>0$) (*)	A1cso (3)
(b)	<u>Critical Values</u> $(k-4)(k-1)=0 \quad k=\ldots.$	M1
	$k = 1$ or 4	A1
	Choosing "outside" region	M1
	<u>$\boldsymbol{k<1}$ **or** $\boldsymbol{k>4}$</u>	A1 (4) **[7]**

For this question, ignore (a) and (b) labels and award marks wherever correct work is seen.

(a)

M1 for attempting to use the discriminant of the initial equation (> 0 not required, but substitution of *a*, *b* and *c* in the correct formula is required).
If the formula b^2-4ac is seen, at least 2 of *a*, *b* and *c* must be correct.
If the formula b^2-4ac is <u>not</u> seen, all 3 (*a*, *b* and *c*) must be correct.
This mark can still be scored if substitution in b^2-4ac is within the quadratic formula.
This mark can also be scored by comparing b^2 and $4ac$ (with substitution).
However, use of b^2+4ac is M0.

1st A1 for fully correct expression, possibly unsimplified, with > symbol. NB must appear before the last line, even if this is simply in a statement such as $b^2-4ac>0$ or 'discriminant positive'.
Condone a bracketing slip, e.g. $16-4\times k\times 5-k$ if subsequent work is correct and convincing.

2nd A1 for a fully correct derivation with no incorrect working seen.
Condone a bracketing slip if otherwise correct and convincing.

<u>Using</u> $\sqrt{b^2-4ac}>0$:
Only available mark is the first M1 (unless recovery is seen).

(b)

1st M1 for attempt to solve an appropriate 3TQ

1st A1 for both k = 1 and 4 (only the critical values are required, so accept, e.g. $k>1$ and $k>4$). **

2nd M1 for choosing the "outside" region. A diagram or table alone is not sufficient.
Follow through their values of k.
The set of values must be 'narrowed down' to score this M mark… listing everything $k<1$, $1<k<4$, $k>4$ is M0.

2nd A1 for correct answer only, condone "$k<1$, $k>4$" and even "$k<1$ and $k>4$", but "$1>k>4$" is A0.

** Often the statement $k>1$ and $k>4$ is followed by the correct final answer. Allow full marks.

<u>Seeing 1 and 4 used as critical values</u> gives the first M1 A1 by implication.

In part (b), condone working with *x*'s except for the final mark, where the set of values must be a set of values of *k* (i.e. 3 marks out of 4).

Use of ≤ (or ≥) in the final answer loses the final mark.

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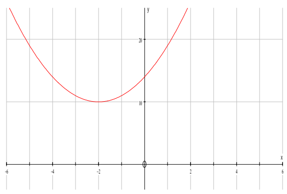
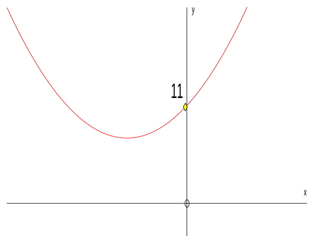
Question Number	Scheme	Marks
Q6	$b^2 - 4ac$ attempted, in terms of p. $(3p)^2 - 4p = 0$ o.e. Attempt to solve for p e.g. $p(9p-4)=0$ Must potentially lead to $p = k,\ k \neq 0$ $p = \frac{4}{9}$ (Ignore $p = 0$, if seen)	M1 A1 M1 A1cso **[4]**
	1st M1 for an attempt to substitute into $b^2 - 4ac$ or $b^2 = 4ac$ with b or c correct Condone x's in one term only. This can be inside a square root as part of the quadratic formula for example. **Use of inequalities can score the M marks only** 1st A1 for any correct equation: $(3p)^2 - 4\times1\times p = 0$ or better 2nd M1 for an attempt to factorize or solve their quadratic expression in p. Method must be sufficient to lead to their $p = \frac{4}{9}$. Accept factors or use of quadratic formula or $\left(p \pm \frac{2}{9}\right)^2 = k^2$ (o.e. eg) $\left(3p \pm \frac{2}{3}\right)^2 = k^2$ or equivalent work on <u>their</u> eqn. $9p^2 = 4p \Rightarrow \frac{9p^{\cancel{2}}}{\cancel{p}} = 4$ which would lead to $9p = 4$ is OK for this 2nd M1 ALT <u>Comparing coefficients</u> M1 for $(x+\alpha)^2 = x^2 + \alpha^2 + 2\alpha x$ and A1 for a correct equation eg $3p = 2\sqrt{p}$ M1 for forming solving leading to $\sqrt{p} = \frac{2}{3}$ or better <u>Use of quadratic/discriminant formula (or any formula) Rule for awarding M mark</u> If the formula is quoted accept some correct substitution leading to a partially correct expression. If the formula is not quoted only award for a fully correct expression using their values.	

Question number	Scheme	Marks
Q10	(a) $(x+2k)^2$ or $\left(x+\frac{4k}{2}\right)^2$	M1
	$(x\pm F)^2 \pm G \pm 3 \pm 11k$ (where F and G are <u>any</u> functions of k, not involving x)	M1
	$(x+2k)^2 - 4k^2 + (3+11k)$ Accept unsimplified equivalents such as $\left(x+\frac{4k}{2}\right)^2 - \left(\frac{4k}{2}\right)^2 + 3 + 11k$, <u>and i.s.w. if necessary</u>.	A1 (3)
	(b) Accept part (b) solutions seen in part (a).	
	$"4k^2 - 11k - 3" = 0$ $(4k+1)(k-3) = 0$ $k = \ldots,$ [Or, 'starting again', $b^2 - 4ac = (4k)^2 - 4(3+11k)$ and proceed to $k = \ldots$]	M1
	$-\frac{1}{4}$ and 3 (Ignore any inequalities for the first 2 marks in (b)).	A1
	Using $b^2 - 4ac < 0$ for no real roots, i.e. $"4k^2 - 11k - 3" < 0$, to establish inequalities involving their <u>two</u> critical values m and n (<u>even if the inequalities are wrong</u>, e.g. $k < m$, $k < n$).	M1
	$-\frac{1}{4} < k < 3$ (See conditions below) Follow through their critical values. The final A1ft is still scored if the answer $m < k < n$ follows $k < m$, $k < n$. <u>Using x instead of k in the final answer</u> loses only the 2nd A mark, (condone use of x in earlier working).	A1ft (4)
	(c)  Shape $\cup$ (seen in (c))	B1
	Minimum in correct quadrant, <u>not</u> touching the x-axis, <u>not</u> on the y-axis, and there must be no other minimum or maximum.	B1
	(0, 14) or 14 on y-axis. Allow (14, 0) marked on y-axis. n.b. Minimum is at $(-2, 10)$, (but there is no mark for this).	B1 (3) **[10]**
	(b) 1st M: Forming and solving a 3-term quadratic in k (usual rules.. see general principles at end of scheme). The quadratic must come from $"b^2 - 4ac"$, or from the $"q"$ in part (a). Using <u>wrong discriminant</u>, e.g. $"b^2 + 4ac"$ will score <u>no marks</u> in part (b). 2nd M: As defined in main scheme above. 2nd A1ft: $m < k < n$, where $m < n$, for their critical values m and n. Other possible forms of the answer (in each case $m < n$): (i) $n > k > m$ (ii) $k > m$ <u>and</u> $k < n$ In this case the word "and" must be seen (implying intersection). (iii) $k \in (m, n)$ (iv) $\{k : k > m\} \cap \{k : k < n\}$ <u>Not</u> just a number line. <u>Not</u> just $k > m$, $k < n$ (without the word "and"). (c) Final B1 is dependent upon a sketch having been attempted in part (c).	

Question Number	Scheme	Marks
4. **(a)**	$(x+3)^2+2$ or $p=3$ or $\frac{6}{2}$ $q=2$	B1 B1 (2)
(b)	 U shape with min in 2nd quad (Must be above x-axis and not on y=axis) U shape crossing y-axis at (0, 11) only (Condone (11,0) marked on y-axis)	B1 B1 (2)
(c)	$b^2-4ac=6^2-4\times11$ $=\underline{-8}$	M1 A1 (2) **6**
	Notes	
(a)	Ignore an "= 0" so $(x+3)^2+2=0$ can score both marks	
(b)	The U shape can be interpreted fairly generously. Penalise an obvious V on 1st B1 only. The U needn't have equal "arms" as long as there is a clear min that "holds water" 1st B1 for U shape with minimum in 2nd quad. Curve need not cross the y-axis but minimum should NOT touch x-axis and should be left of (not on) y-axis 2nd B1 for U shaped curve crossing at (0, 11). Just 11 marked on y-axis is fine. The point must be marked on the sketch (do not allow from a table of values) Condone stopping at (0, 11)	
(c)	M1 for some correct substitution into b^2-4ac. This may be as part of the quadratic formula but must be in part (c) and must be only numbers (no x terms present). Substitution into $b^2<4ac$ or $b^2=4ac$ or $b^2>4ac$ is M0 A1 for -8 only. If they write $-8<0$ treat the <0 as ISW and award A1 If they write $-8\geq0$ then score A0 A substitution in the quadratic formula leading to -8 inside the square root is A0. So substituting into $b^2-4ac<0$ leading to $-8<0$ can score M1A1. Only award marks for use of the discriminant in part (c)	