

# Complex Numbers

## Revision Problem Set

Sourced from all major JC Preliminary Examinations 2025

| Q  | School   | Topic                          | Marks | Difficulty |
|--|----------|--------------------------------|-------|------------|
| <b>Section A — Quadratic equations</b>                         |          |                                |       |            |
| 1  | RVHS P1  | Complex quadratic              | 6     | ●●●        |
| <b>Section B — Roots of polynomials (degree 3 &amp; 4)</b>     |          |                                |       |            |
| 2  | RVHS P1  | Real polynomial, complex root  | 4     | ●●○        |
| 3  | NYJC P2  | Polynomials (complex coeff.)   | 6     | ●●○        |
| 4  | SAJC P2  | Polynomials (complex coeff.)   | 9     | ●●○        |
| 5  | JPJC P2  | Real cubic + Argand            | 11    | ●●○        |
| 6  | VJC P1   | Complex equations & cube roots | 9     | ●●●        |
| 7  | EJC P1   | Roots of cubic equation        | 10    | ●●●        |
| 8  | TMJC P1  | Real cubic; find roots         | 11    | ●●●        |
| 9  | CJC P2   | Complex quartic reasoning      | 12    | ●●●        |
| 10   | HCI P1   | Complex polynomial             | 12    | ●●●        |
| 11   | ACJC P1  | Real quartic + Argand          | 13    | ●●●        |
| <b>Section C — Simultaneous equations</b>                      |          |                                |       |            |
| 12   | NJC P1   | Simultaneous equations         | 6     | ●●○        |
| 13   | SAJC P1  | Simultaneous equations         | 8     | ●●○        |
| 14   | TJC P1   | Simultaneous equations         | 10    | ●●○        |
| <b>Section D — Argand diagram, modulus-argument &amp; loci</b> |          |                                |       |            |
| 15   | RVHS P2  | Triangle geometry              | 5     | ●●○        |
| 16   | NJC P2   | Modulus-argument form          | 7     | ●●○        |
| 17   | VJC P2   | Modulus-argument form          | 9     | ●●○        |
| 18   | NYJC P1  | Argand geometry                | 8     | ●●●        |
| 19   | ASRJC P2 | Modulus-argument & Argand      | 10    | ●●●        |
| 20   | DHS P1   | Complex locus                  | 11    | ●●●        |
| 21   | RI P1    | Complex analysis               | 12    | ●●●        |

Difficulty: ●○● Foundational   ●●○ Standard   ●●● Challenging

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## Section A · Quadratic equations

**Q1** [2025/RVHS/P1/Q3]

[6 marks]

**Do not use a calculator in answering this question.**

Find the roots of the equation  $z^2 - (1 + 2i)z + 1 + 7i = 0$ , giving your answers in the cartesian form  $a + ib$ . [6]

$$z = 2 - i \quad \text{or} \quad z = -1 + 3i$$

## Section B · Roots of polynomials (degree 3 & 4)

**Q2** [2025/RVHS/P1/Q1]

[4 marks]

The function  $f$  is defined by  $f(x) = ax^3 + bx^2 + cx + d$  where  $a, b, c$  and  $d$  are real numbers. Given that  $4 + i$  and  $-1$  are roots of  $f(x) = 0$ , find  $b, c$  and  $d$  in terms of  $a$ . [4]

$$b = -7a, \quad c = 9a, \quad d = 17a$$

**Q3** [2025/NYJC/P2/Q2]

[6 marks]

(a) It is given that the roots of the equation  $-ix^3 + 5ix^2 + ax + b = 0$ , where  $a$  and  $b$  are purely imaginary, are  $2 + i, 2 - i$  and  $1$ . Explain why the complex roots occur in conjugate pairs. [2]

(b) By using (a) and an appropriate substitution, find the roots of the equation

$$ix^3 + 5ix^2 + a^*x + b = 0,$$

where the complex conjugate of  $a$  is denoted by  $a^*$ . [4]

$$x = -2 + i, -2 - i \text{ and } -1$$

**Q4** [2025/SAJC/P2/Q2]

[9 marks]

(a) It is given that  $f(x) = px^6 + qx^4 + r$ , where  $p, q$ , and  $r$  are real constants.

(i) Show that if  $x = \alpha$  is a root of  $f(x) = 0$ , then  $x = -\alpha$  is also a root. [1]

(ii) Given now that  $x = 5$  and  $x = \beta$  are roots of  $f(x) = 0$ , where  $\text{Re}(\beta) \neq 0$  and  $\text{Im}(\beta) \neq 0$ , write down all the remaining roots. [3]

(b) The complex number  $z$  satisfies the equation

$$z^3 + (3 - a)z^2 - (2 + 6i)z - 6 = 0,$$

where  $a$  is a complex number. It is given that one of the roots is  $1 + i$ .

Find  $a$  and the other roots of the equation. [5]

(a)(i)  $x = -\alpha$  is also a root. (a)(ii) The remaining roots are  $-5, -\beta, \beta^*$ , and  $-\beta^*$ .

(b) The other roots are  $z = -3$  and  $z = -1 + i$ .

Q5 [2025/JPJC/P2/Q4]

[11 marks]

Do not use a calculator in answering this question.

- (a) One of the roots of the equation  $5w^3 + pw^2 + 68w + q = 0$ , where  $p$  and  $q$  are real, is  $3 - i$ . Find the other roots of the equation and the values of  $p$  and  $q$ . [5]
- (b) Two complex numbers are given by  $z_1 = -1 + 2i$  and  $z_2 = 2 + i$ . Draw an Argand diagram showing  $z_1$  and  $z_2$ , labelling the origin as  $O$  and the points representing  $z_1$  and  $z_2$  as  $Z_1$  and  $Z_2$  respectively. Given that  $z_3 = z_1 + z_2$ , mark the corresponding point  $Z_3$  on your Argand diagram, showing clearly the geometrical relationship between  $Z_1$ ,  $Z_2$  and  $Z_3$ . [2]
- (i) Find  $\frac{z_1}{z_2}$  in the form  $ki$ . [2]
- (ii) Hence, or otherwise, show that  $OZ_2Z_3Z_1$  is a square. [2]

(a) Other roots:  $3 + i$  and  $\frac{3}{5}$ ;  $p = -33$ ,  
 $q = -30$ . (b)(i)  $\frac{z_1}{z_2} = i$ .

Q6 [2025/VJC/P1/Q7]

[9 marks]

Do not use a calculator in answering this question.

- (a) Find the complex number  $z$  which satisfies the equation

$$\frac{4|z|}{15 - z^*} = 5i.$$

[3]

- (b) The complex number  $w$  is such that  $(w - i)^3 = -i$ .

(i) Given that one possible value of  $w$  is  $2i$ , find the two other possible values of  $w$ . Give your answers in cartesian form  $a + bi$ . [4]

The points  $W_1$ ,  $W_2$  and  $W_3$  on the Argand diagram represent the three roots of the equation  $(w - i)^3 = -i$ , and the point  $A$  represents the complex number  $ki$ , where  $k$  is a positive real number.

(ii) Show that the points  $W_1$ ,  $W_2$  and  $W_3$  lie on a circle with centre  $A$  for some value of  $k$ , stating the value of  $k$ . [2]

(a)  $z = 15 - 20i$ ; (b)(i)  $w = \frac{\sqrt{3}}{2} + \frac{1}{2}i$  or  $-\frac{\sqrt{3}}{2} + \frac{1}{2}i$ ; (b)(ii)  $k = 1$

Q7 [2025/EJC/P1/Q8]

[10 marks]

Do not use a calculator in answering this question.

The complex number  $w$  is such that  $w^2 = 2i$  and  $0 \leq \arg(w) \leq \frac{\pi}{2}$ .

- (a) Find  $w$ . [3]
- (b) Given that one of the roots of the equation  $z^3 - z^2 + (1 - i)z + s = 0$  is  $w$ , find the other roots of the equation and the value of  $s$ . [5]
- (c) Hence, find the roots of the equation  $-iv^3 + v^2 + (1 + i)v + s = 0$ . [2]

(a):  $w = 1 + i$  (b):  $z = 0, z = -i, s = 0$   
(c):  $v = 1 - i, v = 0, v = -1$

Q8 [2025/TMJC/P1/Q9]

[11 marks]

It is given that  $-2 + 2i$  is a root of the equation

$$z^3 + az^2 + bz - 16\sqrt{2} = 0,$$

where  $a$  and  $b$  are real numbers.

- (a) Find the values of  $a$  and  $b$  and the other two roots. Leave your answers in the exact form. [5]
- (b) In an Argand diagram with origin  $O$ , the three roots are represented by points  $A$ ,  $B$  and  $C$  where  $A$  represents  $-2 + 2i$  and  $C$  represents the real root. Label these points on an Argand diagram, indicating clearly the modulus and argument of each root. State also a geometrical relationship between  $A$  and  $B$ . [3]
- (c) Hence, prove that  $\tan \frac{3\pi}{8} = 1 + \sqrt{2}$ . [3]

(a)  $a = 4 - 2\sqrt{2}$ ,  $b = 8 - 8\sqrt{2}$ ; other roots:  
 $-2 - 2i$  and  $2\sqrt{2}$

**Q9** [2025/CJC/P2/Q4]

[12 marks]

One of the roots of the equation

$$2z^4 - 14z^3 + 33z^2 - 26z + p = 0, \quad \text{where } p \text{ is a constant,}$$

is  $3 + i$ .

- (a) Based on the above information only, a student claims that the equation has a root  $3 - i$ . State, with a reason, why the student's claim may not be true. [1]
- (b) Show that  $p = 10$ . [2]

**For the rest of this question, do not use a calculator.**

- (a) Find the roots of the equation  $2z^4 - 14z^3 + 33z^2 - 26z + 10 = 0$  and mark them clearly on a single labelled Argand diagram. [7]
- (b) The points of the Argand diagram in part (c) form the vertices of a quadrilateral. Identify the type of quadrilateral and determine its area. [2]

(c) Roots:  $3 \pm i$ ,  $\frac{1}{2} \pm \frac{1}{2}i$ . (d) Trapezium;  
area = 3.75 units<sup>2</sup>.

**Q10** [2025/HCI/P1/Q12]

[12 marks]

**Do not use a graphing calculator for this question.**

It is given that  $f(z) = z^4 - 6z^2 + k$ , where  $k$  is a non-zero constant.

- (a) If  $k$  is a purely imaginary number, determine, with justification, whether  $f(z) = 0$  can have real roots. [1]
- (b) Show that  $f(-z) = f(z)$ . [1]
- (c) Given that  $2 + i$  is a root of the equation  $f(z) = 0$ , determine  $k$ . Hence, or otherwise, find the remaining roots, showing your workings clearly. [6]

Use the value of  $k$  found in part (c) for the rest of this question.

- (d) Given that the product of all the roots of  $f(z) = 0$  is  $D$ , find the value of  $D$ , showing your workings clearly. [2]
- (e) A complex number  $w_1$  satisfies the equation  $kw^4 - 6w^2 + 1 = 0$ . Given that  $w_1$  can be obtained from  $2 + i$ , find  $w_1$ . [2]

(c)  $k = 25$ ; roots  $2 - i$ ,  $-2 - i$ ,  $-2 + i$ . (d)  
 $D = 25$ . (e)  $w_1 = \frac{2}{5} - \frac{1}{5}i$

Q11 [2025/ACJC/P1/Q10]

[13 marks]

**Do not use a calculator in answering this question.**

- (a) One of the roots of the equation  $\omega^4 - 2\omega^3 + 10\omega^2 + p\omega + q = 0$ , where  $p$  and  $q$  are real, is  $2 + 3i$ . Find the values of  $p$  and  $q$  and the other roots of the equation. [6]
- (b) The complex numbers  $u$  and  $v$  are such that  $u = -\sqrt{2} + i\sqrt{2}$ , and  $|v| = 3$  and  $\arg v = \theta$ , where  $0 < \theta < \frac{\pi}{4}$ . The points  $A$ ,  $B$  and  $C$  represent  $u$ ,  $v$  and  $u + v$  respectively on an Argand diagram.
- (i) Find the modulus and argument of  $u$ . [2]
- (ii) Sketch the points  $A$ ,  $B$  and  $C$  on an Argand diagram. [2]
- (iii) By finding the angle  $OAC$  in terms of  $\theta$  or otherwise, show that  $|u + v|^2 = a + b \cos(\theta + K)$ , where  $a$ ,  $b$  and  $K$  are constants to be determined. [3]

$$\begin{aligned} \text{(a)} \quad p = 6, \quad q = 65; \quad \text{other roots: } 2 - 3i, \\ -1 + 2i, \quad -1 - 2i. \quad \text{(b)(i)} \quad |u| = 2, \\ \arg u = \frac{3\pi}{4}. \quad \text{(b)(iii)} \\ |u + v|^2 = 13 - 12 \cos\left(\theta + \frac{\pi}{4}\right); \quad a = 13, \\ b = -12, \quad K = \frac{\pi}{4}. \end{aligned}$$

## Section C · Simultaneous equations

Q12 [2025/NJC/P1/Q2]

[6 marks]

**Do not use a calculator in answering this question.**

- (i) Find the values of  $z$  and  $w$  that satisfy the equations  $(1 + i)z + 2w = -2 + 4i$  and  $3z - w = 4 + 2i$ , expressing your answers in the form  $c + di$ , where  $c, d \in \mathbf{R}$ . [4]
- (ii) Points  $W$  and  $Z$  represent  $w$  and  $z$  found in part (i). Find  $\frac{w}{z}$  in the form  $p + qi$ , where  $p, q \in \mathbf{R}$ . Hence, state the transformation that maps line segment  $O\overset{z}{Z}$  onto line segment  $OW$ . [2]

$$\begin{aligned} \text{(i)} \quad z = 1 + i, \quad w = -1 + i \quad \text{(ii)} \quad \frac{w}{z} = i, \quad \text{i.e.} \\ p = 0, \quad q = 1. \quad \text{Rotating line segment } OZ \text{ by} \\ \frac{\pi}{2} \text{ anti-clockwise about the origin gives } OW. \end{aligned}$$

Q13 [2025/SAJC/P1/Q10]

[8 marks]

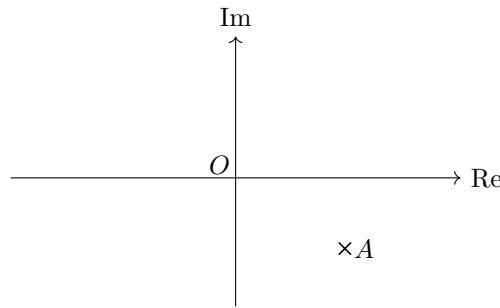
**Do not use a calculator in answering this question.**

- (a) Find the complex numbers  $z$  and  $w$  which satisfy the following simultaneous equations.

$$\begin{aligned} |z| + 5w &= 0 \\ iz - 4w &= -4 + 7i \end{aligned}$$

Give your answers in the form  $a + bi$ , where  $a$  and  $b$  are real constants. [5]

- (b) The point  $A$  on the Argand diagram represents the complex number  $u$ .



(i) On the copy of the Argand diagram in the Printed Answer booklet, plot the point  $B$  to represent the complex number  $-u$ . [1]

The points  $C$  and  $D$  represent the complex numbers  $v - u$  and  $(v - u)^*$  respectively, where  $v$  is an unknown complex number. It is also given that  $\angle CDA = 90^\circ$ .

(ii) By using the Argand diagram or otherwise, state the value of  $\text{Im}(v)$  and justify your answer. [2]

(a)  $z = 7 + 24i, w = -5;$  (b)(ii)  $\text{Im}(v) = 0$

**Q14** [2025/TJC/P1/Q8]

[10 marks]

(a) The complex numbers  $z$  and  $w$  satisfy the following equations.

$$2z + |w| = 2 - 4i$$

$$iz - w = 2i$$

Find  $z$  and  $w$ , giving your answers in the form  $a + ib$ , where  $a$  and  $b$  are real numbers. [5]

(b) It is given that  $z_1 = 2 - i$  and  $z_3 = -3 + 2i$ . On an Argand diagram, mark the points  $A$  and  $C$  representing  $z_1$  and  $z_3$  respectively. [1]

The points  $B$  and  $D$  on the Argand diagram represent complex numbers  $z_2$  and  $z_4$  respectively. Given that  $ABCD$  is a square, labelled in an anti-clockwise direction, find  $z_2$  and  $z_4$ . [4]

(a)  $z = -\frac{2}{3} - 2i, w = 2 - \frac{8}{3}i$  (b)  
 $z_2 = 1 + 3i, z_4 = -2 - 2i$

## Section D · Argand diagram, modulus-argument & loci

**Q15** [2025/RVHS/P2/Q2]

[5 marks]

The points  $A, B$  and  $C$  represent the complex numbers  $z_A = 5 + 6i, z_B = 9 + 3i$  and  $z_C$  respectively.  $ABC$  is an isosceles triangle labelled in a clockwise direction where  $\angle CAB = 90^\circ$ .

(a) Find  $z_C$ . [3]

(b) The point  $D$  representing the complex number  $z_D$ , is such that  $ABDC$  is a parallelogram. Find  $z_D$ . [2]

(a)  $z_C = 2 + 2i$  (b)  $z_D = 6 - i$

**Q16** [2025/NJC/P2/Q1]

[7 marks]

**Do not use a calculator in answering this question.**

The complex number  $w$  is such that  $w = i - \sqrt{3}$ .

- (i) Find  $|w|$  and  $\arg(w)$  in exact form. [2]
- (ii) Represent  $w$ ,  $-w$  and  $2 - w$  in the same Argand diagram, illustrating clearly the geometrical relationship between them. [3]
- (iii) Hence, find  $\arg(2 - w)$  exactly. [2]

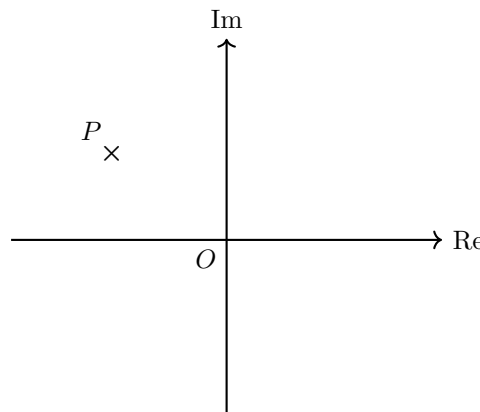
(i)  $|w| = 2$ ,  $\arg(w) = \frac{5\pi}{6}$  (ii)  $O, A, B$  lie on circle radius 2; triangle  $OAB$  isosceles with  $AB$  parallel to real axis. (iii)  $\arg(2 - w) = -\frac{\pi}{12}$

**Q17** [2025/VJC/P2/Q4]

[9 marks]

**Do not use a calculator in answering this question.**

The complex number  $z$  has modulus 1 and argument  $\theta$ , where  $\frac{\pi}{2} < \theta < \pi$ , and the complex number  $w$  is given by  $w = i\sqrt{3}z$ . The point  $P$  on the Argand diagram represents  $z$ .



- (a) On the copy of the Argand diagram with origin  $O$  in the Printed Answer Booklet, plot the points  $Q$  and  $R$  to represent  $w$  and  $z - w$  respectively. Show clearly the geometrical relationship between the points  $P, Q$  and  $R$ . [3]
- (b) Find the area of the quadrilateral  $ORPQ$ . [1]

It is given that  $\theta = \frac{3\pi}{4}$ .

- (c) Find  $z$  in the form  $x + yi$ , where  $x$  and  $y$  are real numbers. [2]
- (d) Show that  $z - w = k[(\sqrt{3} - 1) + (\sqrt{3} + 1)i]$ , where  $k$  is a constant to be determined. [2]
- (e) Hence show that  $\tan \frac{5\pi}{12} = \frac{\sqrt{3} + 1}{\sqrt{3} - 1}$ . [1]

(b)  $\sqrt{3}$  (c)  $z = -\frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}}i$  (d)  $k = \frac{1}{2}$

**Q18** [2025/NYJC/P1/Q6]

[8 marks]

The points  $P, Q$  and  $R$  representing the complex numbers  $p, q$  and  $r$  on an Argand diagram are such that  $\arg(p) = \alpha$  and  $\arg(q) = \beta$ , where  $0 < \alpha < \beta < \frac{\pi}{2}$ ,  $\beta > 2\alpha$  and  $r = p + q$ .

- (a) If  $|p| = |q|$ , describe the shape of the quadrilateral  $OPRQ$ . Hence find  $\arg(r)$  in terms of  $\alpha$  and  $\beta$ . [3]
- (b) The point  $Q'$ , representing the complex number  $q'$ , is the reflection of the point  $Q$  in  $OP$ . State

the angle  $POQ'$ . [1]

By leaving your answers in terms of  $\alpha$ ,  $\beta$  and  $|q|$  where applicable, hence, or otherwise,

(i) find the argument of the complex number  $q'$ , [1]

(ii) find the real and imaginary parts of  $q'$  and write down  $q'$  in  $a + ib$  form. [3]

$$\begin{aligned} \text{(a) rhombus; } \arg(r) &= \frac{1}{2}(\alpha + \beta) & \text{(b)} \\ \angle POQ' &= \beta - \alpha & \text{(b)(i)} \\ \arg(q') &= -(\beta - 2\alpha) = 2\alpha - \beta \end{aligned}$$

**Q19** [2025/ASRJ/P2/Q6]

[10 marks]

The points  $P$  and  $Q$  are represented by the complex numbers  $p$  and  $q$  respectively, where

$$p = \sqrt{2} + \sqrt{2}i, \quad \arg(q) = \frac{2\pi}{3}, \quad |q| = 2.$$

(a) Find  $|p|$  and  $\arg(p)$  in exact form. [2]

$$|p| = 2, \quad \arg(p) = \frac{\pi}{4}$$

(b) Sketch the points  $P$  and  $Q$  on an Argand diagram. [2]

(c) Use the Argand diagram to deduce  $\operatorname{Re}(q)$  and  $\operatorname{Im}(q)$ , giving your answers in exact form. [2]

$$\operatorname{Re}(q) = -1, \quad \operatorname{Im}(q) = \sqrt{3}$$

(d) The point  $R$  is represented by the complex number  $p + q$ . What can you deduce about the shape of quadrilateral  $OPRQ$ , where  $O$  is the origin? [1]

$OPRQ$  is a rhombus.

(e) By considering  $\arg(p + q)$  or otherwise, show that

$$\tan \frac{11\pi}{24} = \sqrt{6} + \sqrt{3} + \sqrt{2} + 2.$$

[3]

**Q20** [2025/DHS/P1/Q8]

[11 marks]

A complex number  $z$  varies with  $t$  such that

$$z = 2 \cos t + i(3 \sin t), \quad \text{where } 0 \leq t < 2\pi.$$

(a) By taking  $x = \operatorname{Re}(z)$  and  $y = \operatorname{Im}(z)$ , sketch on an Argand diagram the curve that shows the positions of the points representing the complex number  $z$ . Find the Cartesian equation of this curve. [3]

(b) Two complex numbers  $z_1$  and  $z_2$  for two distinct values of  $t$  are such that  $|z_1| = |z_2|$  and  $0 < \arg(z_1) < \frac{\pi}{2}$ . By referring to the Argand diagram in part (a), find the possible values of  $\arg(z_1 + z_2)$ . [2]

(c) It is given further that  $z_1$  and  $z_2$  are roots to the quadratic equation  $z^2 + \alpha z + \beta = 0$ . Explain whether it is necessary for  $\alpha$  to be real. [2]

(d) Given that  $\alpha$  is not real and  $|z_1| = |z_2| = \frac{\sqrt{26}}{2}$ , find the values of  $\alpha$  and  $\beta$ . [4]

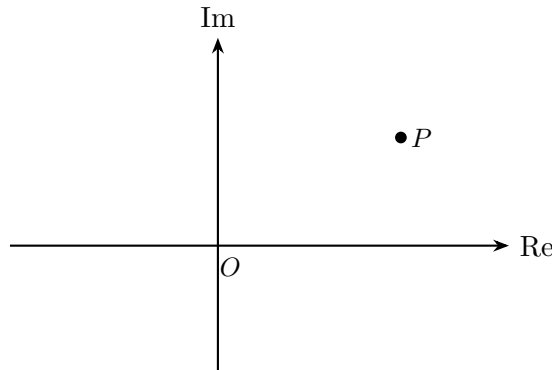
(a) Cartesian equation:  $\frac{x^2}{4} + \frac{y^2}{9} = 1$  (b)  $\arg(z_1 + z_2)$  is either undefined, 0, or  $\frac{\pi}{2}$ . (c) It is **not necessary** for  $\alpha$  to be real, since  $z_1$  and  $z_2$  need not be complex conjugates. (d)  $\alpha = -3\sqrt{2}i, \beta = -\frac{13}{2}$

**Q21** [2025/RI/P1/Q8]

[12 marks]

**Do not use a calculator in answering this question.**

(a) The diagram below shows an Argand diagram.



The point  $P$  on the Argand diagram represents the complex number  $w$  given by  $w = u + iv$ , where  $u$  and  $v$  are real and positive.

- (i) Explain algebraically why  $\arg(kw) = \arg(w)$  for any real constant  $k > 1$ . [1]
  - (ii) Points  $Q$  and  $R$  represent the complex numbers  $kw$  and  $ikw$  respectively, where  $k$  is a real constant and  $k > 1$ . On the same Argand diagram in the Printed Answer Booklet, plot the points  $Q$  and  $R$ . Show clearly the geometrical relationship between the points  $P, Q$  and  $R$ . [2]
- (b) In another Argand diagram, the points  $A, B$  and  $C$  represent the complex numbers  $z, f(z)$  and  $f(f(z))$  respectively, where  $f(z) = z^2 - 2z$ .
- It is given that  $ABC$  is a right-angled triangle, described in an anticlockwise sense, with a right angle at  $B$ , and  $BC = mBA$ , where  $m$  is a positive real constant.
- (i) Show that  $f(f(z)) - f(z) = z(z - 2)(z - 3)(z + 1)$ . [2]
  - (ii) By considering  $\frac{f(f(z)) - f(z)}{f(z) - z}$ , or otherwise, show that  $(z - 2)(z + 1) = mi$ . [2]
  - (iii) In the case where  $z = x + 2i$ , where  $x$  is a positive real number, find  $x$  and  $m$ . Hence obtain the complex number represented by the point  $B$ . [5]

$x = 3, m = 10. \quad B$  represents  $-1 + 8i$ .