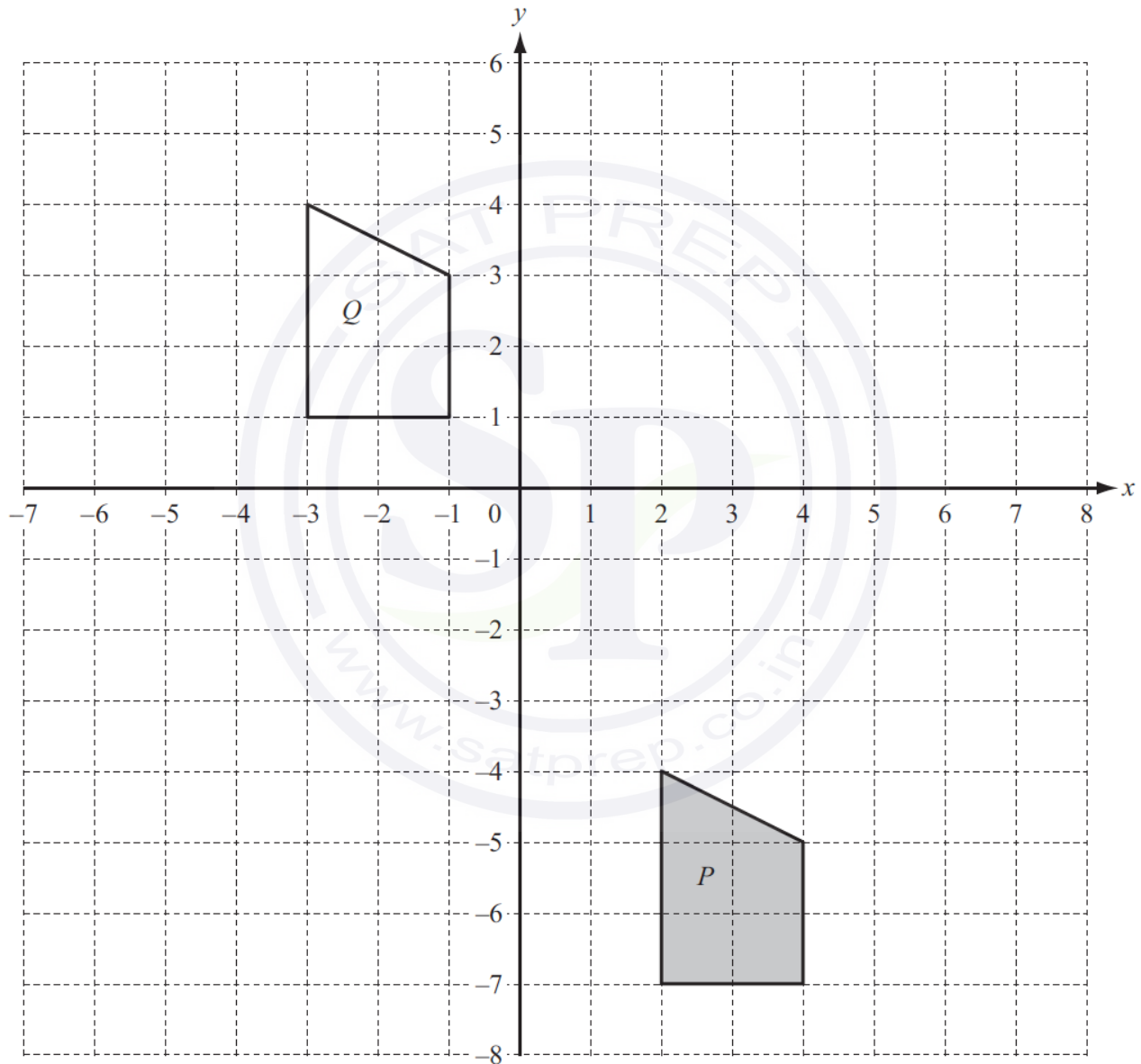


**Extended Mathematics**  
**Topic : Vector-Function-Transformation**  
**Year : May 2013 - May 2023**  
**Paper -4**  
**Questions Booklet**

Question 1



(i) Describe fully the **single** transformation which maps shape  $P$  onto shape  $Q$ .

*Answer(a)(i)* ..... [2]

(ii) On the grid above, draw the image of shape  $P$  after reflection in the line  $y = -1$ . [2]

Question 2

$$f(x) = x^2 + x - 3 \quad g(x) = 2x + 7 \quad h(x) = 2^x$$

(a) Solve the equation  $f(x) = 0$ .  
Show all your working and give your answers correct to 2 decimal places.

*Answer(a)*  $x =$  ..... or  $x =$  ..... [4]

(b)  $fg(x) = px^2 + qx + r$

Find the values of  $p$ ,  $q$  and  $r$ .

*Answer(b)*  $p =$  .....

$q =$  .....

$r =$  ..... [3]

(c) Find  $g^{-1}(x)$ .

*Answer(c)*  $g^{-1}(x) =$  ..... [2]

(d) Find  $x$  when  $h(x) = 0.25$ .

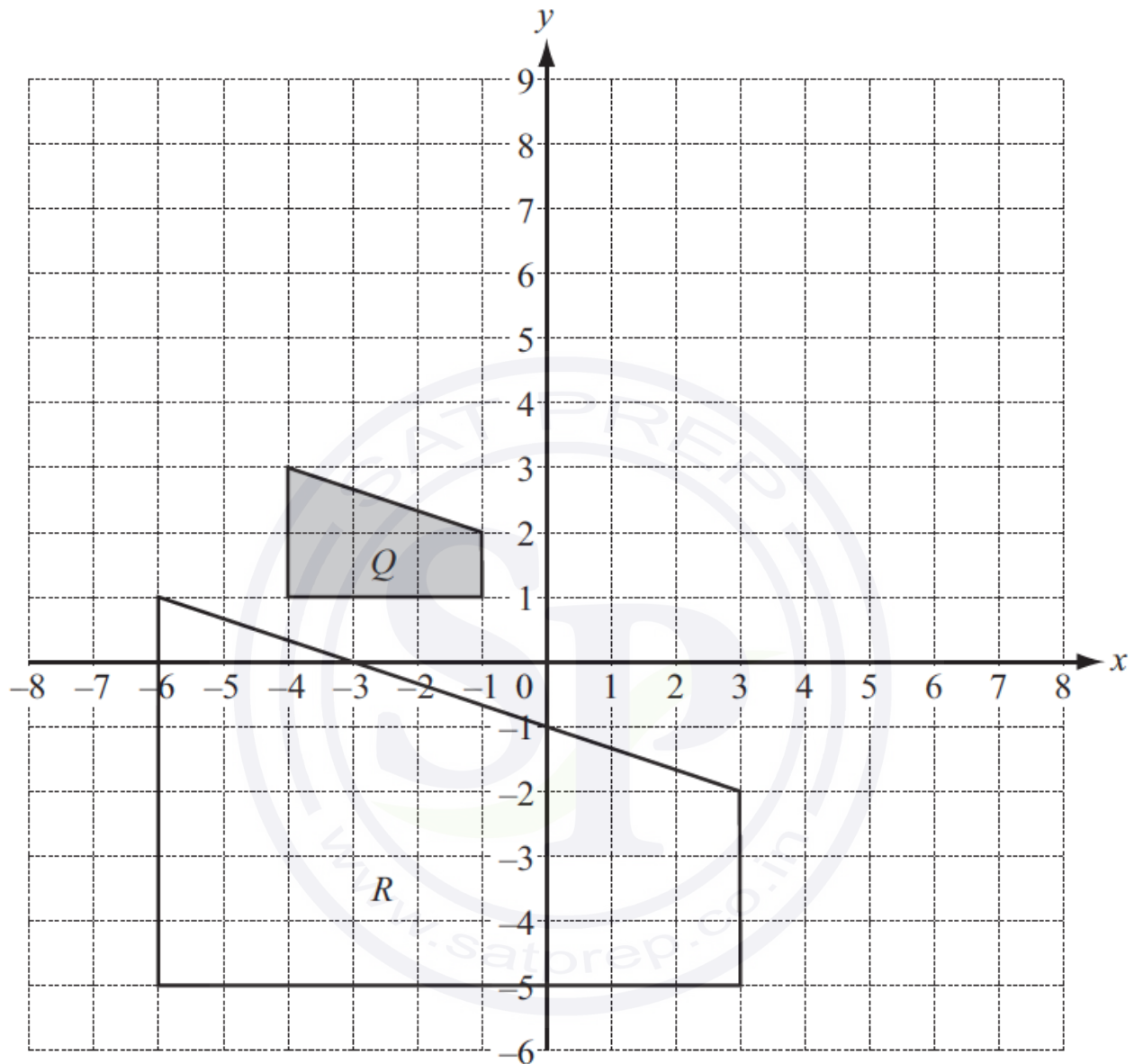
*Answer(d)*  $x =$  ..... [1]

(e) Find  $hhh(3)$ .

Give your answer in standard form, correct to 4 significant figures.

*Answer(e)* ..... [4]

Question 3



(a) Describe fully the **single** transformation that maps shape *Q* onto shape *R*.

Answer(a) ..... [3]

(b) (i) Draw the image when shape *Q* is translated by the vector  $\begin{pmatrix} 5 \\ 4 \end{pmatrix}$ . [2]

(ii) Draw the image when shape *Q* is reflected in the line  $x = 2$ . [2]

(iii) Draw the image when shape *Q* is stretched, factor 3, *x*-axis invariant. [2]

Questions 4

(a) The co-ordinates of  $P$  are  $(-4, -4)$  and the co-ordinates of  $Q$  are  $(8, 14)$ .

(i) Find the gradient of the line  $PQ$ .

*Answer(a)(i)* ..... [2]

(ii) Find the equation of the line  $PQ$ .

*Answer(a)(ii)* ..... [2]

(iii) Write  $\vec{PQ}$  as a column vector.

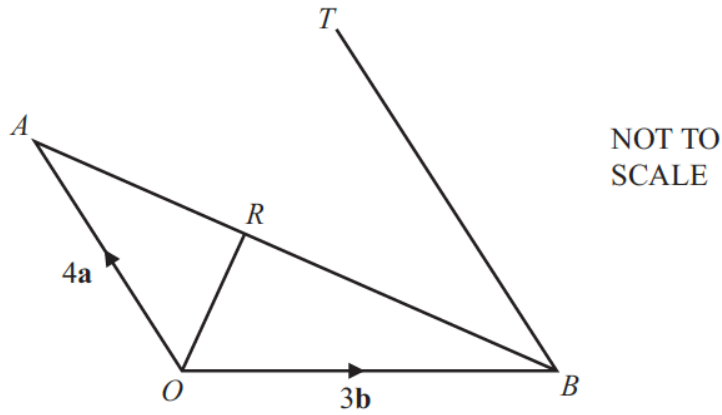
*Answer(a)(iii)*  $\vec{PQ} = \begin{pmatrix} \phantom{0} \\ \phantom{0} \end{pmatrix}$  [1]

(iv) Find the magnitude of  $\vec{PQ}$ .

*Answer(a)(iv)* ..... [2]

Continue on the next page...

(b)



In the diagram,  $\vec{OA} = 4\mathbf{a}$  and  $\vec{OB} = 3\mathbf{b}$ .

$R$  lies on  $AB$  such that  $\vec{OR} = \frac{1}{5}(12\mathbf{a} + 6\mathbf{b})$ .

$T$  is the point such that  $\vec{BT} = \frac{3}{2}\vec{OA}$ .

(i) Find the following in terms of  $\mathbf{a}$  and  $\mathbf{b}$ , giving each answer in its simplest form.

(a)  $\vec{AB}$

Answer(b)(i)(a)  $\vec{AB} = \dots\dots\dots$  [1]

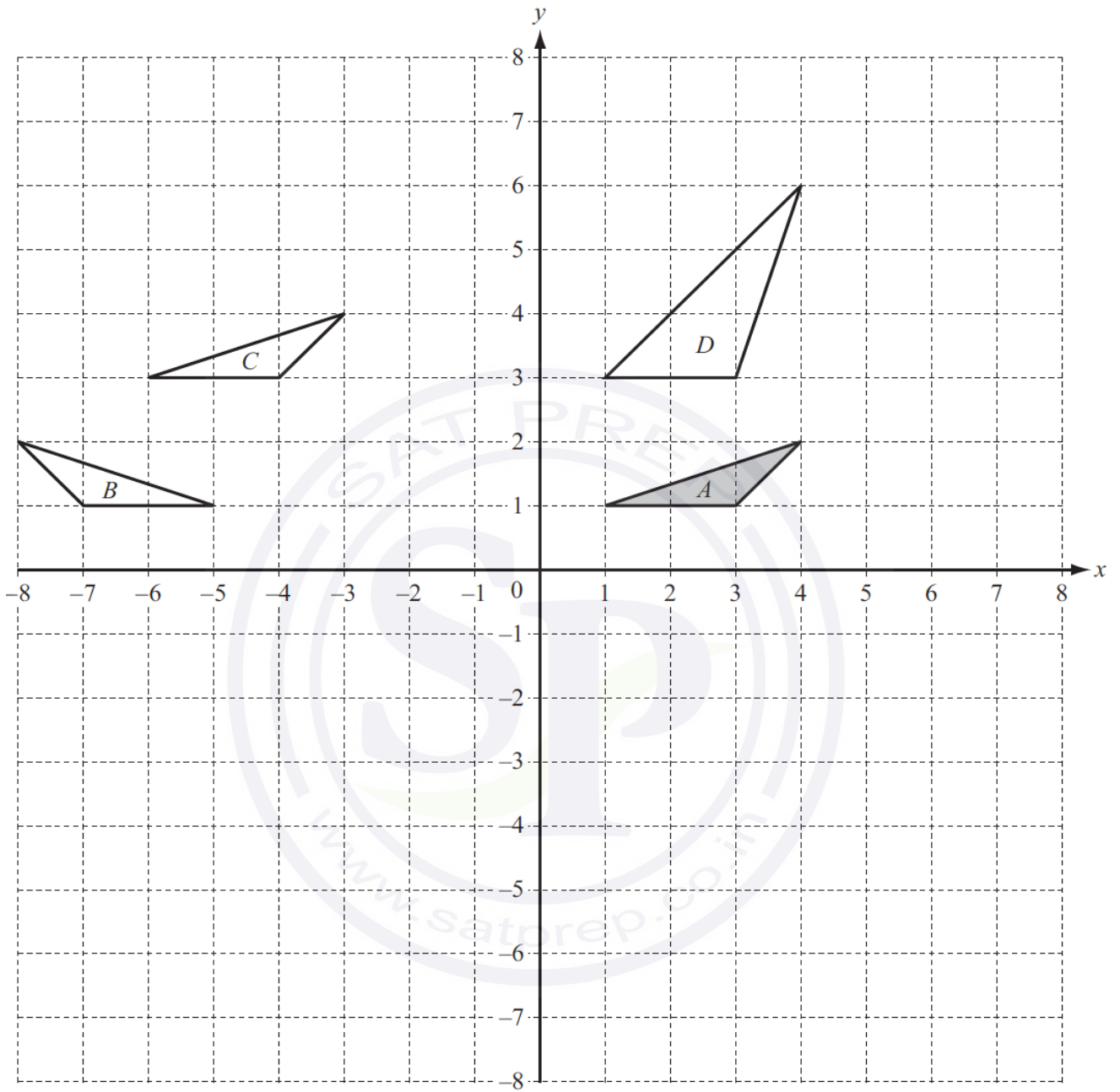
(b)  $\vec{AR}$

Answer(b)(i)(b)  $\vec{AR} = \dots\dots\dots$  [2]

(c)  $\vec{OT}$

Answer(b)(i)(c)  $\vec{OT} = \dots\dots\dots$  [1]

Question 5



Continue on the next page...

(a) Describe fully the **single** transformation that maps triangle  $A$  onto

(i) triangle  $B$ ,

Answer(a)(i) ..... [2]

(ii) triangle  $C$ ,

Answer(a)(ii) ..... [2]

(iii) triangle  $D$ .

Answer(a)(iii) ..... [3]

(b) On the grid, draw

(i) the rotation of triangle  $A$  about  $(6, 0)$  through  $90^\circ$  clockwise, [2]

(ii) the enlargement of triangle  $A$  by scale factor  $-2$  with centre  $(0, -1)$ , [2]

Question 6

$f(x) = 4x + 3$        $g(x) = \frac{7}{x+1} (x, -1)$        $h(x) = x^2 + 5x$

(a) Work out

(i)  $h(-3)$ ,

Answer(a)(i) ..... [1]

(ii)  $hg(13)$ .

Answer(a)(ii) ..... [2]

(b) Find  $f^{-1}(x)$ .

Answer(b)  $f^{-1}(x) =$  ..... [2]

(c) (i) Solve the equation  $f(x) = 23$ .

Answer(c)(i)  $x =$  ..... [2]

(ii) Solve the equation  $h(x) = 7$ .

Show all your working and give your answers correct to 2 decimal places.

Answer(c)(ii)  $x =$  ..... or  $x =$  ..... [5]

Question 7

$$g(x) = 1 - 2x \quad h(x) = x^2 - 1$$

(i) Find  $gh(3)$ .

Answer (i) .....[2]

(ii) Find  $g^{-1}(x)$ .

Answer (ii) .....[2]

(iii) Solve the equation  $h(x) = 3$ .

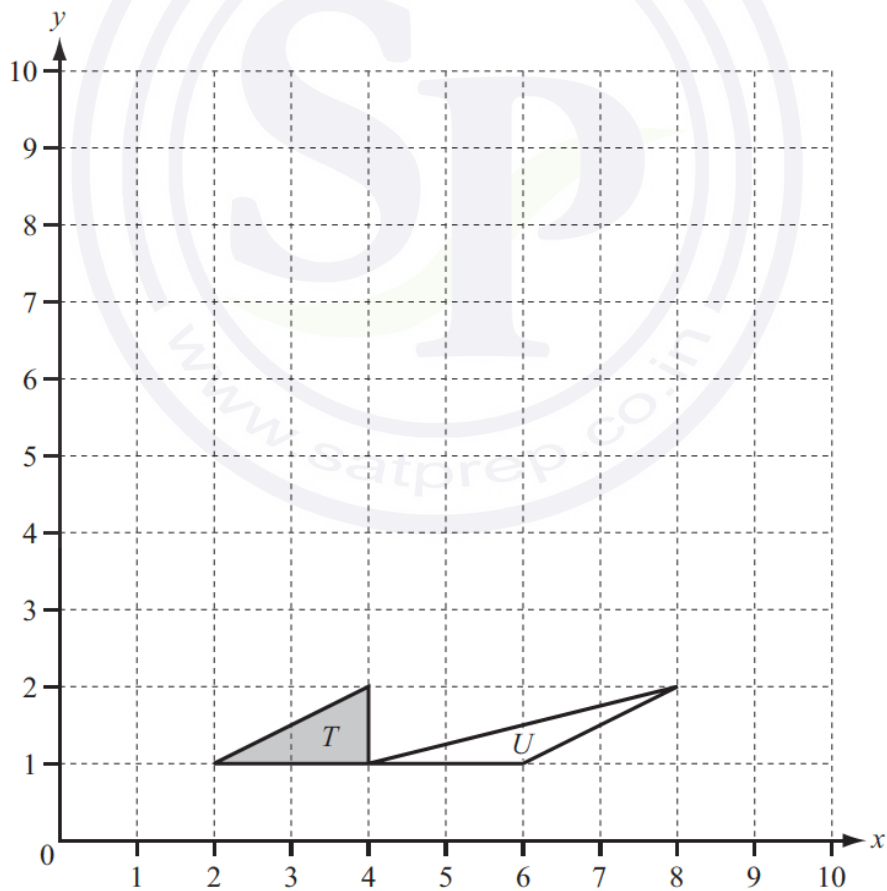
Answer (iii)  $x = \dots\dots\dots$  or  $x = \dots\dots\dots$ [2]

(iv) Solve the equation  $g(3x) = 2x$ .

Answer (iv)  $x = \dots\dots\dots$ [3]

Question 8

(a)



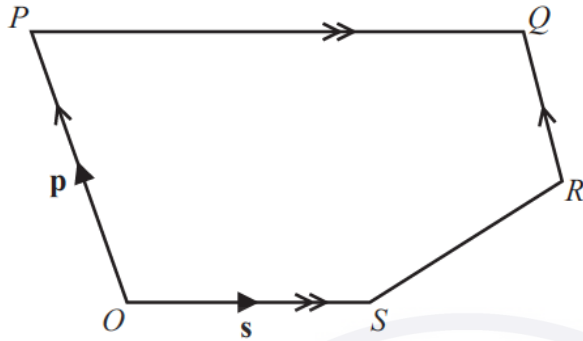
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(i) Draw the reflection of triangle  $T$  in the line  $y = 5$ . [2]

(ii) Draw the rotation of triangle  $T$  about the point  $(4, 2)$  through  $180^\circ$ . [2]

(b)



In the pentagon  $OPQRS$ ,  $OP$  is parallel to  $RQ$  and  $OS$  is parallel to  $PQ$ .  
 $PQ = 2OS$  and  $OP = 2RQ$ .  
 $O$  is the origin,  $\vec{OP} = \mathbf{p}$  and  $\vec{OS} = \mathbf{s}$ .

Find, in terms of  $\mathbf{p}$  and  $\mathbf{s}$ , in their simplest form,

(i) the position vector of  $Q$ ,

Answer(b)(i) ..... [2]

(ii)  $\vec{SR}$ .

Answer(b)(ii)  $\vec{SR} =$  ..... [2]

(c) Explain what your answers in **part (b)** tell you about the lines  $OQ$  and  $SR$ .

Answer(c) ..... [1]

Question 9

$f(x) = 4 - 3x$        $g(x) = 3^{-x}$

(a) Find  $f(2x)$  in terms of  $x$ .

Answer(a)  $f(2x) =$  ..... [1]

(b) Find  $ff(x)$  in its simplest form.

Answer(b)  $ff(x) =$  ..... [2]

(c) Work out  $gg(-1)$ .  
 Give your answer as a fraction.

Answer(c) ..... [3]

Continue on the next page...

(d) Find  $f^{-1}(x)$ , the inverse of  $f(x)$ .

Answer(d)  $f^{-1}(x) = \dots\dots\dots$  [2]

(e) Solve the equation  $gf(x) = 1$ .

Answer(e)  $x = \dots\dots\dots$  [3]

Question 10

$f(x) = 4 - 3x$                    $g(x) = 3^{-x}$

(a) Find  $f(2x)$  in terms of  $x$ .

Answer(a)  $f(2x) = \dots\dots\dots$  [1]

(b) Find  $ff(x)$  in its simplest form.

Answer(b)  $ff(x) = \dots\dots\dots$  [2]

(c) Work out  $gg(-1)$ .  
Give your answer as a fraction.

Answer(c)  $\dots\dots\dots$  [3]

(d) Find  $f^{-1}(x)$ , the inverse of  $f(x)$ .

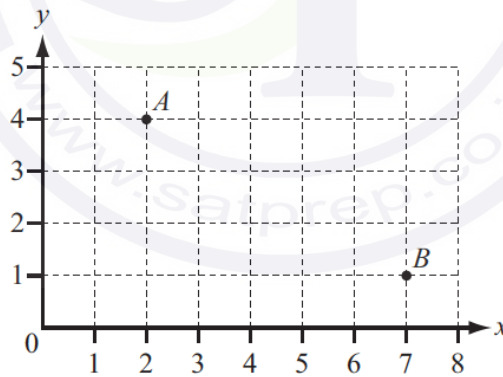
Answer(d)  $f^{-1}(x) = \dots\dots\dots$  [2]

(e) Solve the equation  $gf(x) = 1$ .

Answer(e)  $x = \dots\dots\dots$  [3]

Question 11

(a)



(i) Write down the position vector of  $A$ .

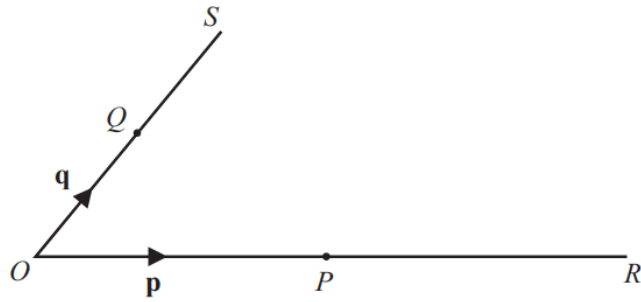
Answer(a)(i)  $\left( \begin{array}{c} \phantom{0} \\ \phantom{0} \end{array} \right)$  [1]

(ii) Find  $|\vec{AB}|$ , the magnitude of  $\vec{AB}$ .

Answer(a)(ii)  $\dots\dots\dots$  [2]

Continue on the next page...

(b)



NOT TO SCALE

$O$  is the origin,  $\vec{OP} = \mathbf{p}$  and  $\vec{OQ} = \mathbf{q}$ .  
 $OP$  is extended to  $R$  so that  $OP = PR$ .  
 $OQ$  is extended to  $S$  so that  $OQ = QS$ .

(i) Write down  $\vec{RQ}$  in terms of  $\mathbf{p}$  and  $\mathbf{q}$ .

Answer(b)(i)  $\vec{RQ} = \dots\dots\dots$  [1]

(ii)  $PS$  and  $RQ$  intersect at  $M$  and  $RM = 2MQ$ .

Use vectors to find the ratio  $PM : PS$ , showing all your working.

Answer(b)(ii)  $PM : PS = \dots\dots\dots : \dots\dots\dots$  [4]

Question 12

$f(x) = \frac{1}{x}, x \neq 0$

$g(x) = 1 - x$

$h(x) = x^2 + 1$

(a) Find  $fg(\frac{1}{2})$ .

Answer(a)  $\dots\dots\dots$  [2]

(b) Find  $g^{-1}(x)$ , the inverse of  $g(x)$ .

Answer(b)  $g^{-1}(x) = \dots\dots\dots$  [1]

(c) Find  $hg(x)$ , giving your answer in its simplest form.

Answer(c)  $hg(x) = \dots\dots\dots$  [3]

(d) Find the value of  $x$  when  $g(x) = 7$ .

Answer(d)  $x = \dots\dots\dots$  [1]

(e) Solve the equation  $h(x) = 3x$ .

Show your working and give your answers correct to 2 decimal places.

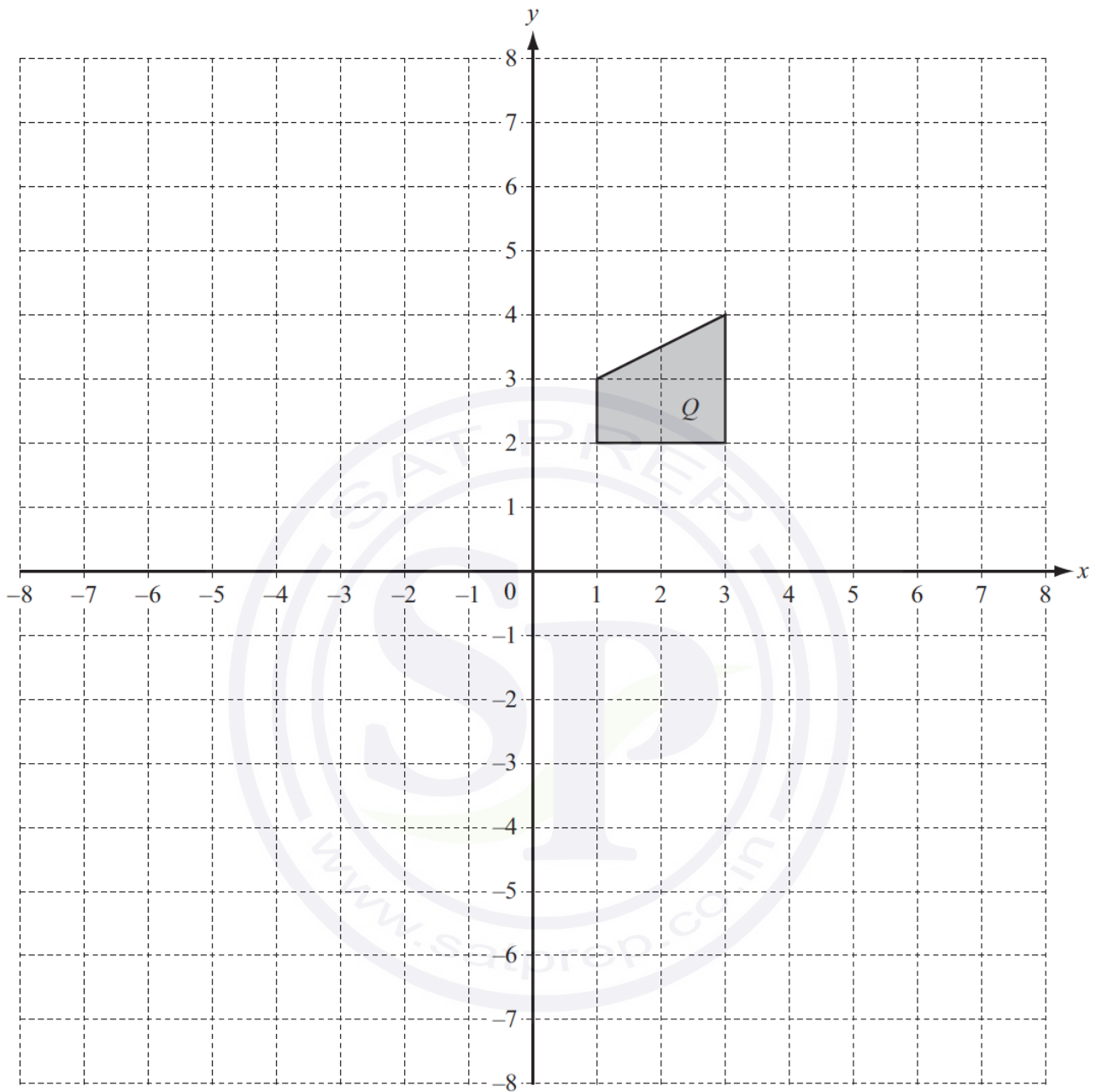
Answer(e)  $x = \dots\dots\dots$  or  $x = \dots\dots\dots$  [4]

(f) A function  $k(x)$  is its own inverse when  $k^{-1}(x) = k(x)$ .

For which of the functions  $f(x)$ ,  $g(x)$  and  $h(x)$  is this true?

Answer(f)  $\dots\dots\dots$  [1]

Question 13



Draw the reflection of shape  $Q$  in the line  $x = -1$ . [2]

Draw the enlargement of shape  $Q$ , centre  $(0, 0)$ , scale factor  $-2$ . [2]

Question 14

(a)  $\vec{PQ} = \begin{pmatrix} -3 \\ 4 \end{pmatrix}$

(i)  $P$  is the point  $(-2, 3)$ .

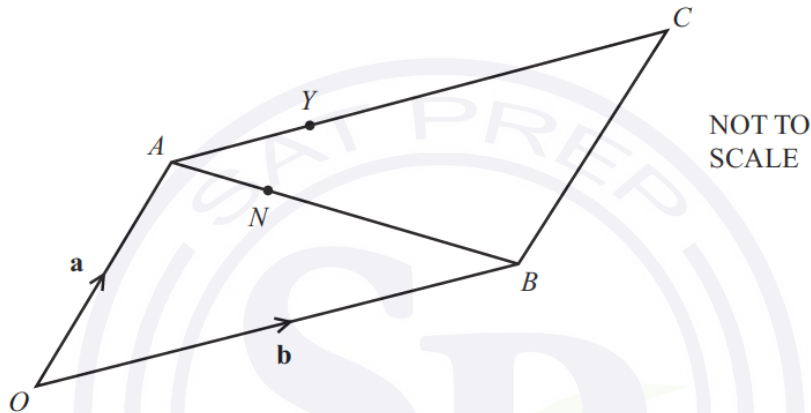
Work out the co-ordinates of  $Q$ .

Answer(a)(i) (....., .....) [1]

(ii) Work out  $|\vec{PQ}|$ , the magnitude of  $\vec{PQ}$ .

Answer(a)(ii) ..... [2]

(b)



$OACB$  is a parallelogram.

$\vec{OA} = \mathbf{a}$  and  $\vec{OB} = \mathbf{b}$ .

$AN:NB = 2:3$  and  $AY = \frac{2}{5}AC$ .

(i) Write each of the following in terms of  $\mathbf{a}$  and/or  $\mathbf{b}$ .  
Give your answers in their simplest form.

(a)  $\vec{ON}$

Answer(b)(i)(a)  $\vec{ON} = \dots\dots\dots$  [2]

(b)  $\vec{NY}$

Answer(b)(i)(b)  $\vec{NY} = \dots\dots\dots$  [2]

(ii) Write down two conclusions you can make about the line segments  $NY$  and  $BC$ .

Answer(b)(ii) .....

..... [2]

Question 15

$$f(x) = 2x - 3$$

$$g(x) = \frac{1}{x+1} + 2$$

$$h(x) = 3^x$$

(i) Work out  $f(4)$ .

*Answer (i)* ..... [1]

(ii) Work out  $fh(-1)$ .

*Answer (ii)* ..... [2]

(iii) Find  $f^{-1}(x)$ , the inverse of  $f(x)$ .

*Answer (iii)* ..... [2]

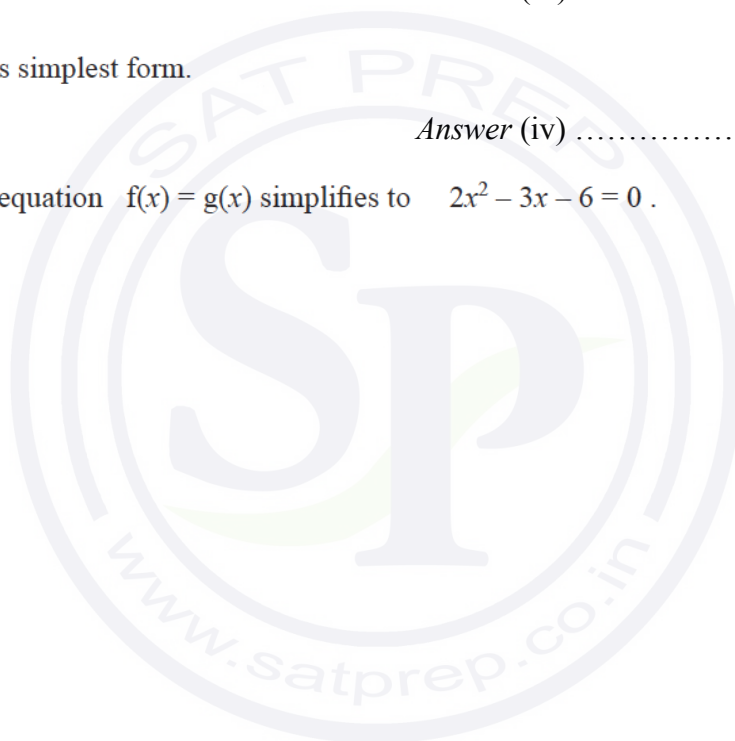
(iv) Find  $ff(x)$  in its simplest form.

*Answer (iv)* ..... [2]

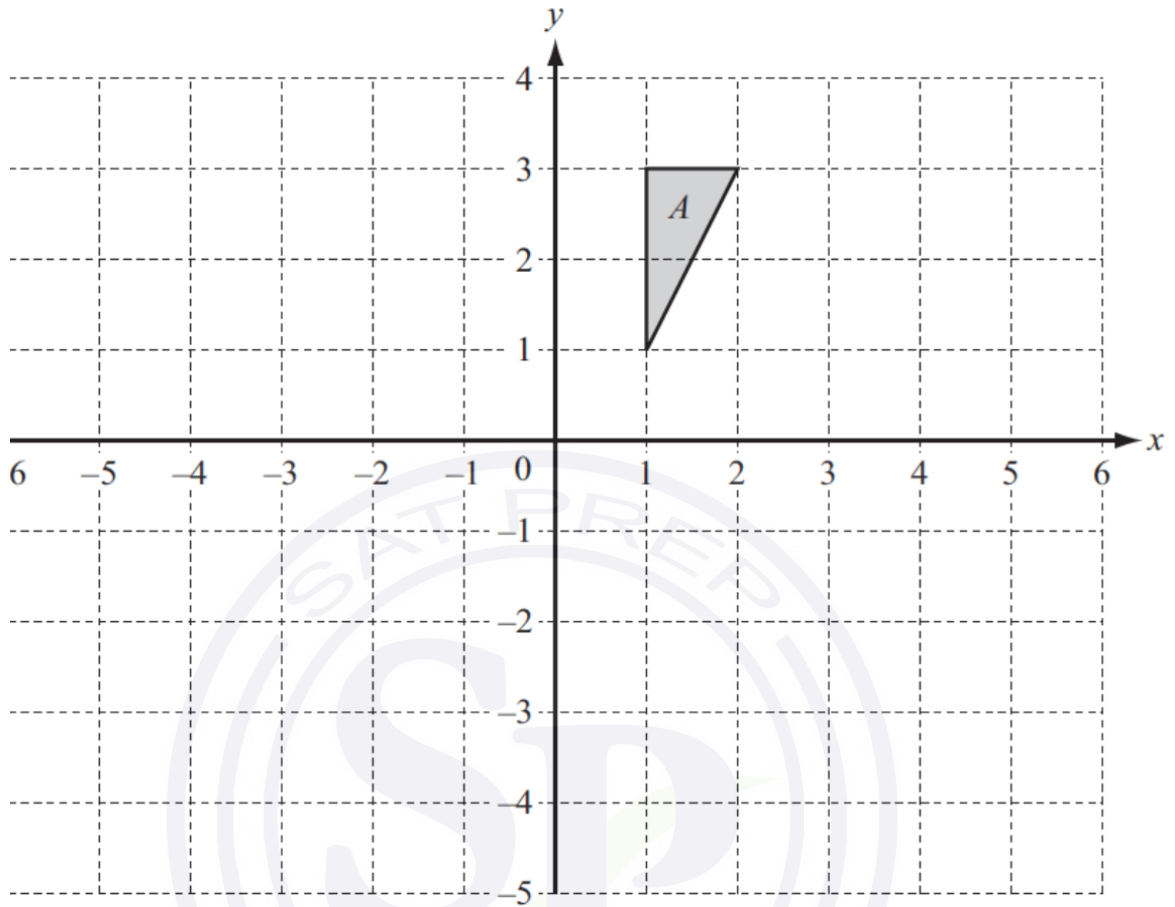
(v) Show that the equation  $f(x) = g(x)$  simplifies to  $2x^2 - 3x - 6 = 0$ .

*Answer(a)(v)*

[3]



Question 16



On the grid,

- (i) draw the image of shape  $A$  after a translation by the vector  $\begin{pmatrix} -5 \\ -4 \end{pmatrix}$ . [2]
- (ii) draw the image of shape  $A$  after a rotation through  $90^\circ$  clockwise about the origin. [2]

Question 17

$$f(x) = 5x - 2$$

$$g(x) = \frac{7}{x-3}, \quad x \neq 3$$

$$h(x) = 2x^2 + 7x$$

(a) Work out

(i)  $f(2)$ ,

*Answer(a)(i)* ..... [1]

(ii)  $hg(17)$ .

*Answer(a)(ii)* ..... [2]

(b) Solve  $g(x) = x + 3$ .

*Answer(b)*  $x =$  ..... or  $x =$  ..... [3]

(c) Solve  $h(x) = 11$ , showing all your working and giving your answers correct to 2 decimal places.

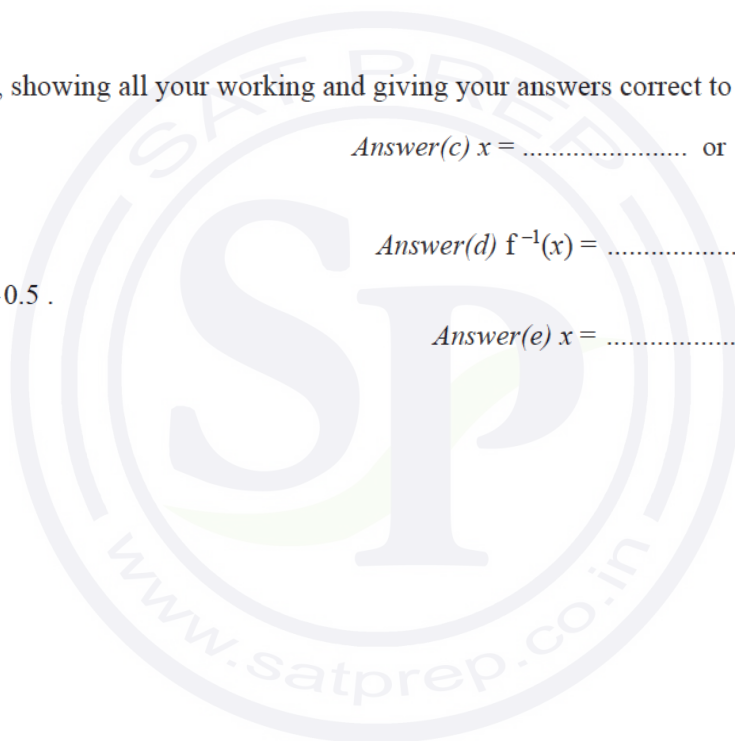
*Answer(c)*  $x =$  ..... or  $x =$  ..... [5]

(d) Find  $f^{-1}(x)$ .

*Answer(d)*  $f^{-1}(x) =$  ..... [2]

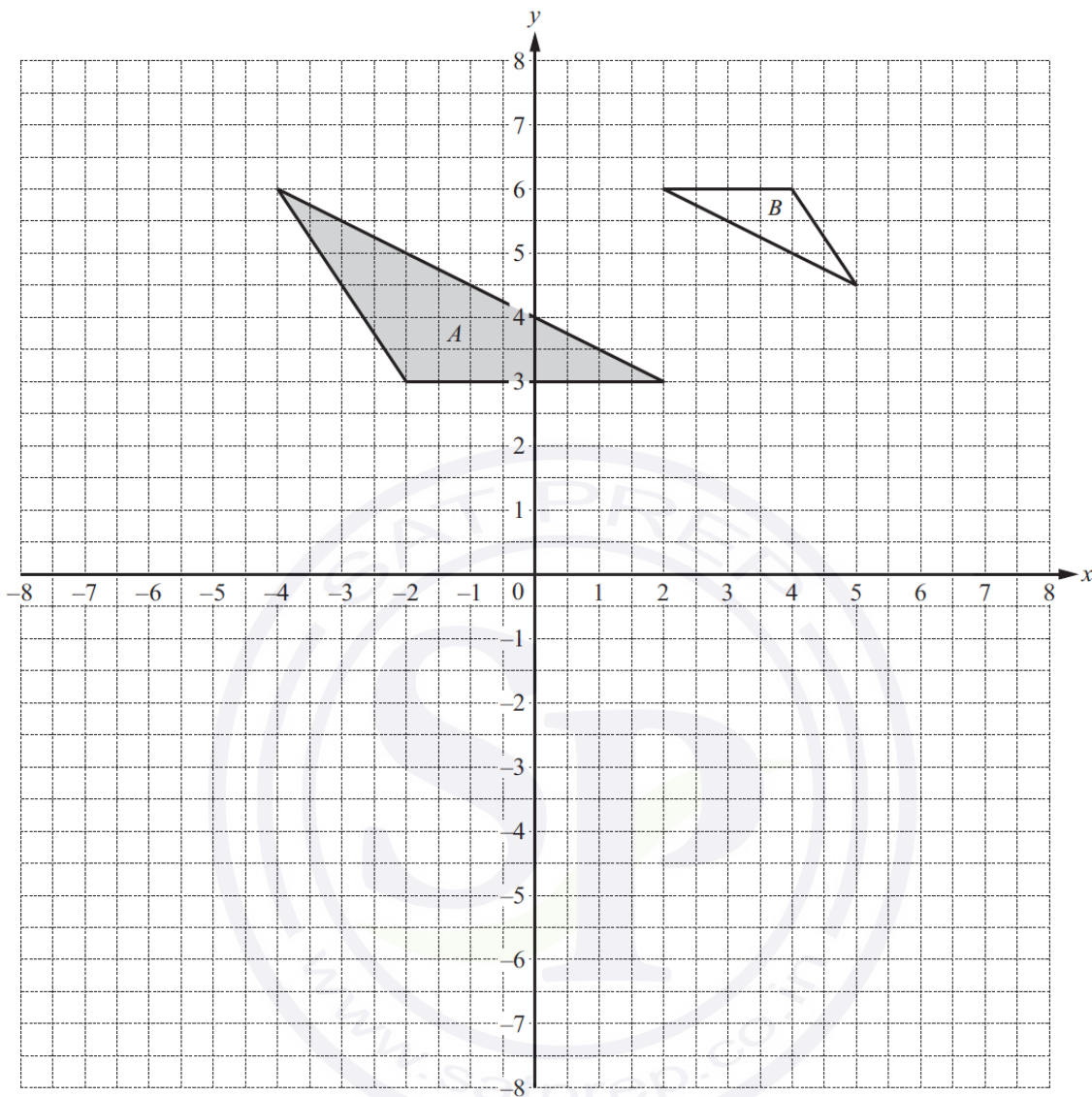
(e) Solve  $g^{-1}(x) = -0.5$ .

*Answer(e)*  $x =$  ..... [1]



Question 18





(a) Describe fully the **single** transformation that maps triangle *A* onto triangle *B*.

Answer(a) .....

..... [3]

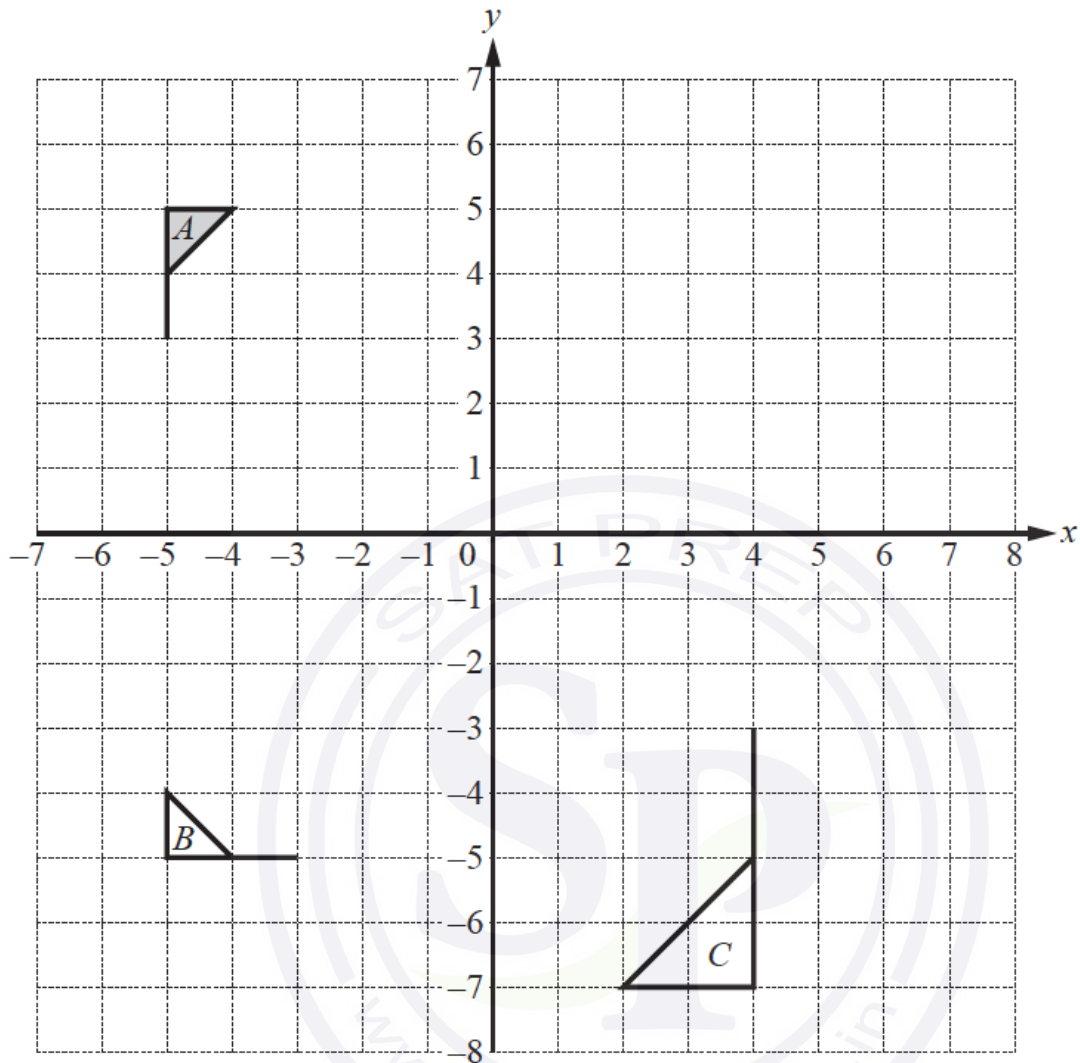
(b) On the grid, draw the image of

(i) triangle *A* after a reflection in the line  $x = -3$ , [2]

(ii) triangle *A* after a rotation about the origin through  $270^\circ$  anticlockwise, [2]

(iii) triangle *A* after a translation by the vector  $\begin{pmatrix} -1 \\ -5 \end{pmatrix}$ . [2]

Question 19



(a) Describe fully the **single** transformation that maps

(i) flag *A* onto flag *B*,

Answer(a)(i) ..... [3]

(ii) flag *A* onto flag *C*.

Answer(a)(ii) ..... [3]

(b) Draw the image of flag *A* after a translation by the vector  $\begin{pmatrix} 2 \\ 1 \end{pmatrix}$ . [2]

(c) Draw the image of flag *A* after a reflection in the line  $x = 1$ . [2]

Question 20

$$f(x) = 2x - 1$$

$$g(x) = x^2 + x$$

$$h(x) = \frac{2}{x}, x \neq 0$$

(a) Find  $ff(3)$ .

Answer(a) ..... [2]

(b) Find  $gf(x)$ , giving your answer in its simplest form.

Answer(b) ..... [3]

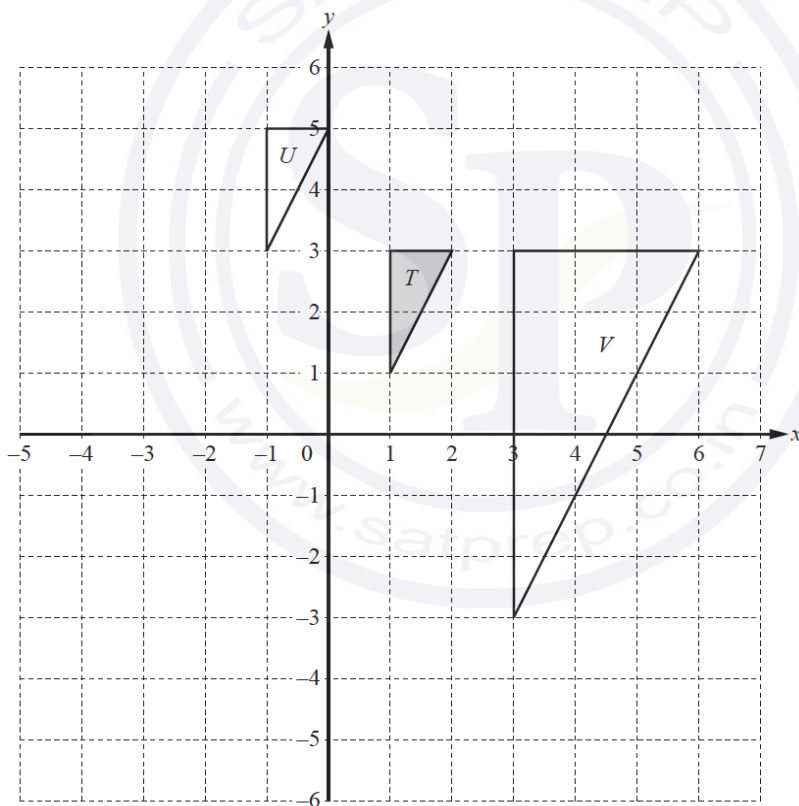
(c) Find  $f^{-1}(x)$ .

Answer(c)  $f^{-1}(x) =$  ..... [2]

(d) Find  $h(x) + h(x + 2)$ , giving your answer as a single fraction.

Answer(d) ..... [4]

Question 21



(a) On the grid, draw the image of

(i) triangle  $T$  after a reflection in the line  $x = -1$ , [2]

(ii) triangle  $T$  after a rotation through  $180^\circ$  about  $(0, 0)$ . [2]

Continue on the next page...

(b) Describe fully the **single** transformation that maps

(i) triangle  $T$  onto triangle  $U$ ,

Answer(b)(i) ..... [2]

(ii) triangle  $T$  onto triangle  $V$ .

Answer(b)(ii) ..... [3]

Question 22

(a)  $\vec{PQ} = \begin{pmatrix} 5 \\ -8 \end{pmatrix}$

(i) Find the value of  $|\vec{PQ}|$ .

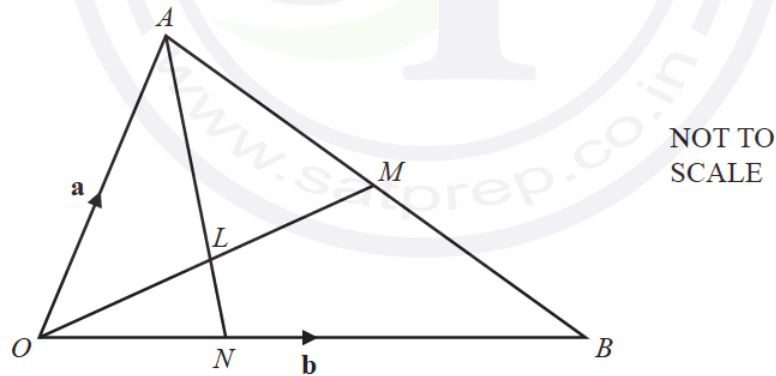
Answer(a)(i)  $|\vec{PQ}| = \dots\dots\dots$  [2]

(ii)  $Q$  is the point  $(2, -3)$ .

Find the co-ordinates of the point  $P$ .

Answer(a)(ii)  $(\dots\dots\dots, \dots\dots\dots)$  [1]

(b)



In the diagram,  $M$  is the midpoint of  $AB$  and  $L$  is the midpoint of  $OM$ .

The lines  $OM$  and  $AN$  intersect at  $L$  and  $ON = \frac{1}{3}OB$ .

$\vec{OA} = \mathbf{a}$  and  $\vec{OB} = \mathbf{b}$ .

(i) Find, in terms of  $\mathbf{a}$  and  $\mathbf{b}$ , in its simplest form,

(a)  $\vec{OM}$ ,

Continue on the next page...

Answer(b)(i)(a)  $\vec{OM} = \dots\dots\dots$  [2]

(b)  $\vec{OL}$ ,

Answer(b)(i)(b)  $\vec{OL} = \dots\dots\dots$  [1]

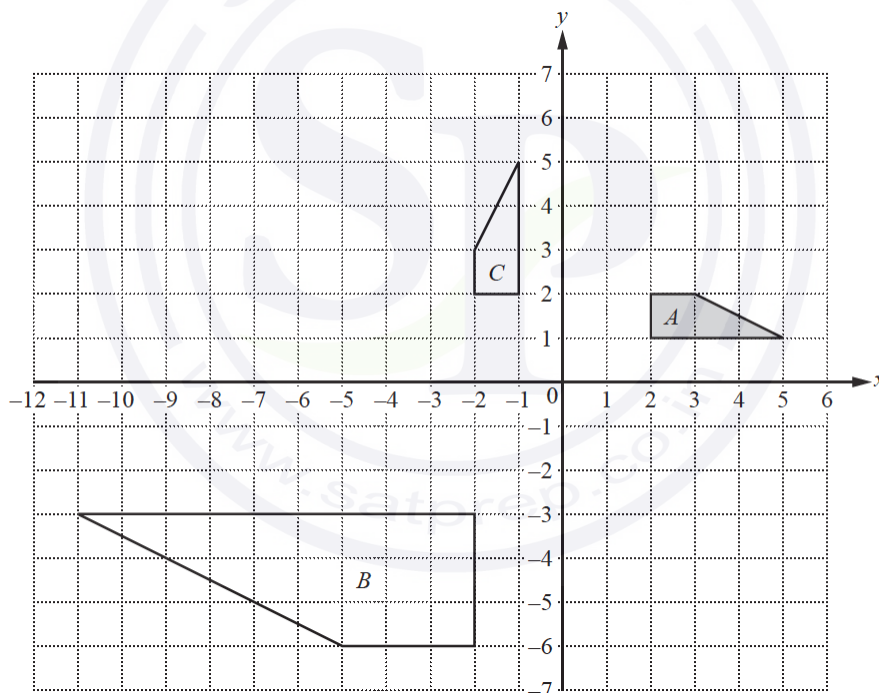
(c)  $\vec{AL}$ .

Answer(b)(i)(c)  $\vec{AL} = \dots\dots\dots$  [2]

(ii) Find the ratio  $AL : AN$  in its simplest form.

Answer(b)(ii)  $\dots\dots\dots : \dots\dots\dots$  [3]

Question 23



(a) Draw the image of

(i) shape  $A$  after a translation by  $\begin{pmatrix} -1 \\ 3 \end{pmatrix}$ , [2]

(ii) shape  $A$  after a rotation through  $180^\circ$  about the point  $(0, 0)$ , [2]

Continue on the next page...

(b) Describe fully the **single** transformation that maps shape  $A$  onto shape  $B$ .

Answer(b) .....  
..... [3]

Question 26

$$f(x) = 2x - 1 \qquad g(x) = \frac{1}{x}, \quad x \neq 0 \qquad h(x) = 2^x$$

(a) Find  $h(3)$ .

Answer(a) ..... [1]

(b) Find  $fg(0.5)$ .

Answer(b) ..... [2]

(c) Find  $f^{-1}(x)$ .

Answer(c)  $f^{-1}(x) =$  ..... [2]

(d) Find  $ff(x)$ , giving your answer in its simplest form.

Answer(d) ..... [2]

(e) Find  $(f(x))^2 + 6$ , giving your answer in its simplest form.

Answer(e) ..... [2]

(f) Simplify  $hh^{-1}(x)$ .

Answer(f) ..... [1]

(g) Which of the following statements is true?

$$f^{-1}(x) = f(x)$$

$$g^{-1}(x) = g(x)$$

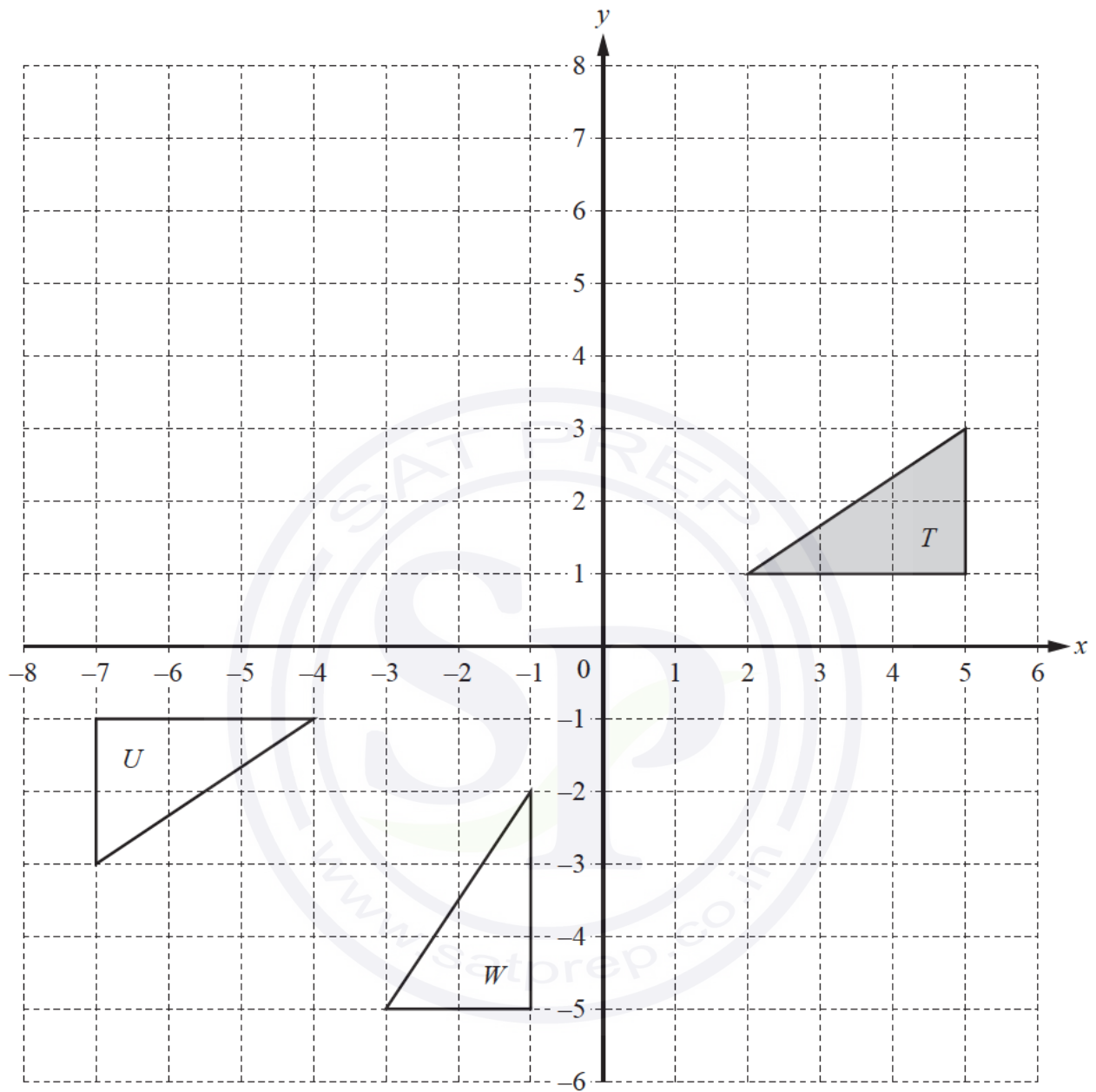
$$h^{-1}(x) = h(x)$$

Answer(g) ..... [1]

(h) Use two of the functions  $f(x)$ ,  $g(x)$  and  $h(x)$  to find the composite function which is equal to  $2^{x+1} - 1$ .

Answer(h) ..... [1]

Question 25



(a) On the grid, draw the image of

(i) triangle  $T$  after a translation by the vector  $\begin{pmatrix} -4 \\ 4 \end{pmatrix}$ , [2]

(ii) triangle  $T$  after a reflection in the line  $y = -1$ . [2]

Continue on the next page...

(b) Describe fully the **single** transformation that maps triangle  $T$  onto triangle  $U$ .

*Answer(b)* .....  
..... [3]

Describe fully the **single** transformation that maps triangle  $T$  onto triangle  $W$ .

..... [2]

Question 26

$$f(x) = 2x + 5$$

$$g(x) = 2^x$$

$$h(x) = 7 - 3x$$

(a) Find

(i)  $f(3)$ ,

*Answer(a)(i)* ..... [1]

(ii)  $gg(3)$ .

*Answer(a)(ii)* ..... [2]

(b) Find  $f^{-1}(x)$ .

*Answer(b)*  $f^{-1}(x) =$  ..... [2]

(c) Find  $fh(x)$ , giving your answer in its simplest form.

*Answer(c)* ..... [2]

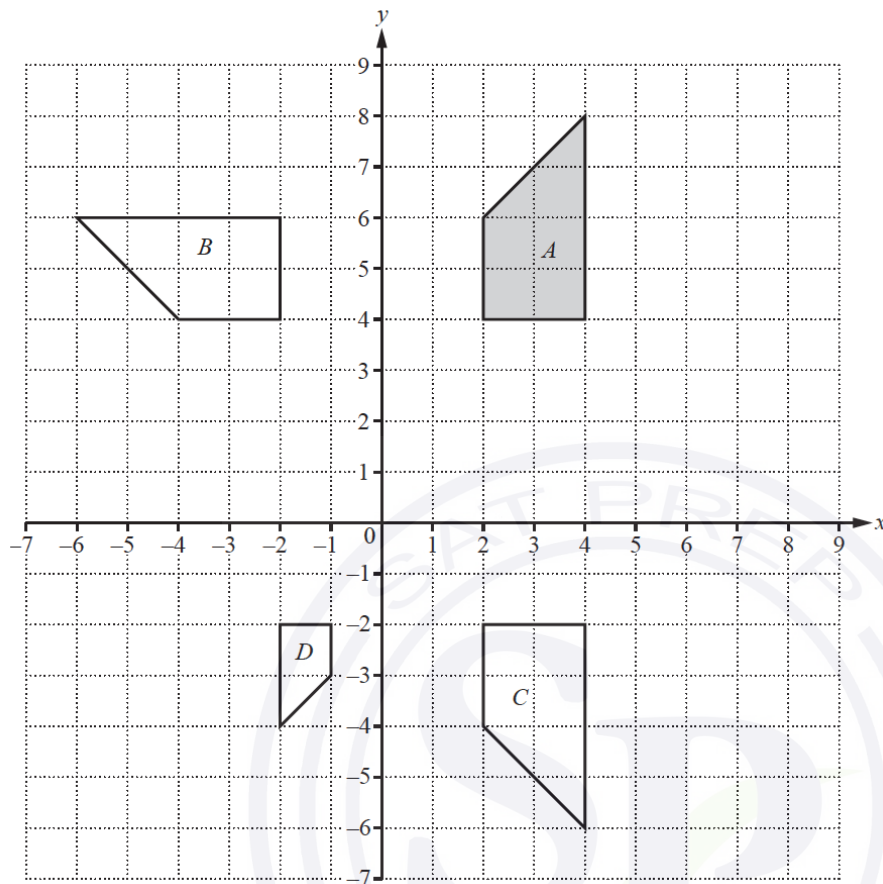
(d) Find the integer values of  $x$  which satisfy this inequality.

$$1 < f(x) \leq 9$$

*Answer(d)* ..... [3]



Question 27



(a) Describe fully the **single** transformation that maps

(i) shape *A* onto shape *B*,

*Answer(a)(i)* ..... [3]

(ii) shape *A* onto shape *C*,

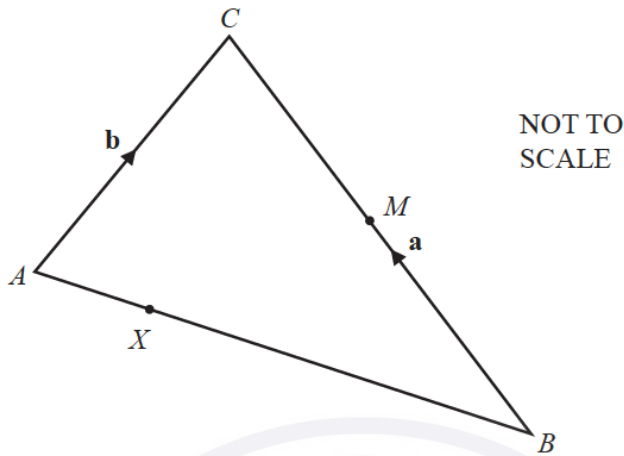
*Answer(a)(ii)* ..... [2]

(iii) shape *A* onto shape *D*.

*Answer(a)(iii)* ..... [3]

On the grid, draw the image of shape *A* after a translation by the vector  $\begin{pmatrix} 2 \\ -3 \end{pmatrix}$ . [2]

Question 28



$\vec{BC} = \mathbf{a}$  and  $\vec{AC} = \mathbf{b}$ .

(a) Find  $\vec{AB}$  in terms of  $\mathbf{a}$  and  $\mathbf{b}$ .

Answer(a)  $\vec{AB} = \dots\dots\dots$  [1]

(b)  $M$  is the midpoint of  $BC$ .  
 $X$  divides  $AB$  in the ratio  $1 : 4$ .

Find  $\vec{XM}$  in terms of  $\mathbf{a}$  and  $\mathbf{b}$ .

Show all your working and write your answer in its simplest form.

Answer(b)  $\vec{XM} = \dots\dots\dots$  [4]

Question 29

$f(x) = 2 - 3x$

$g(x) = 7x + 3$

(a) Find

(i)  $f(-3)$ ,

$\dots\dots\dots$  [1]

(ii)  $g(2x)$ .

$\dots\dots\dots$  [1]

(b) Find  $gf(x)$  in its simplest form.

$\dots\dots\dots$  [2]

(c) Find  $x$  when  $3f(x) = 7$ .

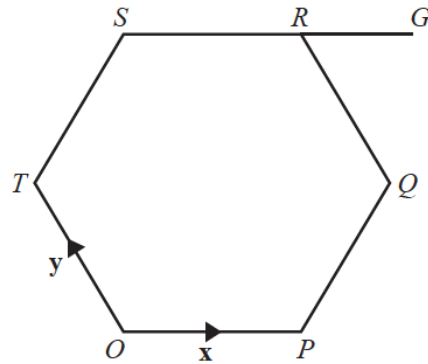
$x = \dots\dots\dots$  [3]

(d) Solve the equation.

$f(x + 4) - g(x) = 0$

$x = \dots\dots\dots$  [3]

Question 30



NOT TO SCALE

$O$  is the origin and  $OPQRST$  is a regular hexagon.

$\vec{OP} = \mathbf{x}$  and  $\vec{OT} = \mathbf{y}$ .

(a) Write down, in terms of  $\mathbf{x}$  and/or  $\mathbf{y}$ , in its simplest form,

(i)  $\vec{QR}$ ,

$\vec{QR} = \dots\dots\dots$  [1]

(ii)  $\vec{PQ}$ ,

$\vec{PQ} = \dots\dots\dots$  [1]

(iii) the position vector of  $S$ .

$\dots\dots\dots$  [2]

(b) The line  $SR$  is extended to  $G$  so that  $SR : RG = 2 : 1$ .

Find  $\vec{GQ}$ , in terms of  $\mathbf{x}$  and  $\mathbf{y}$ , in its simplest form.

$\vec{GQ} = \dots\dots\dots$  [2]

(c)  $M$  is the midpoint of  $OP$ .

(i) Find  $\vec{MG}$ , in terms of  $\mathbf{x}$  and  $\mathbf{y}$ , in its simplest form.

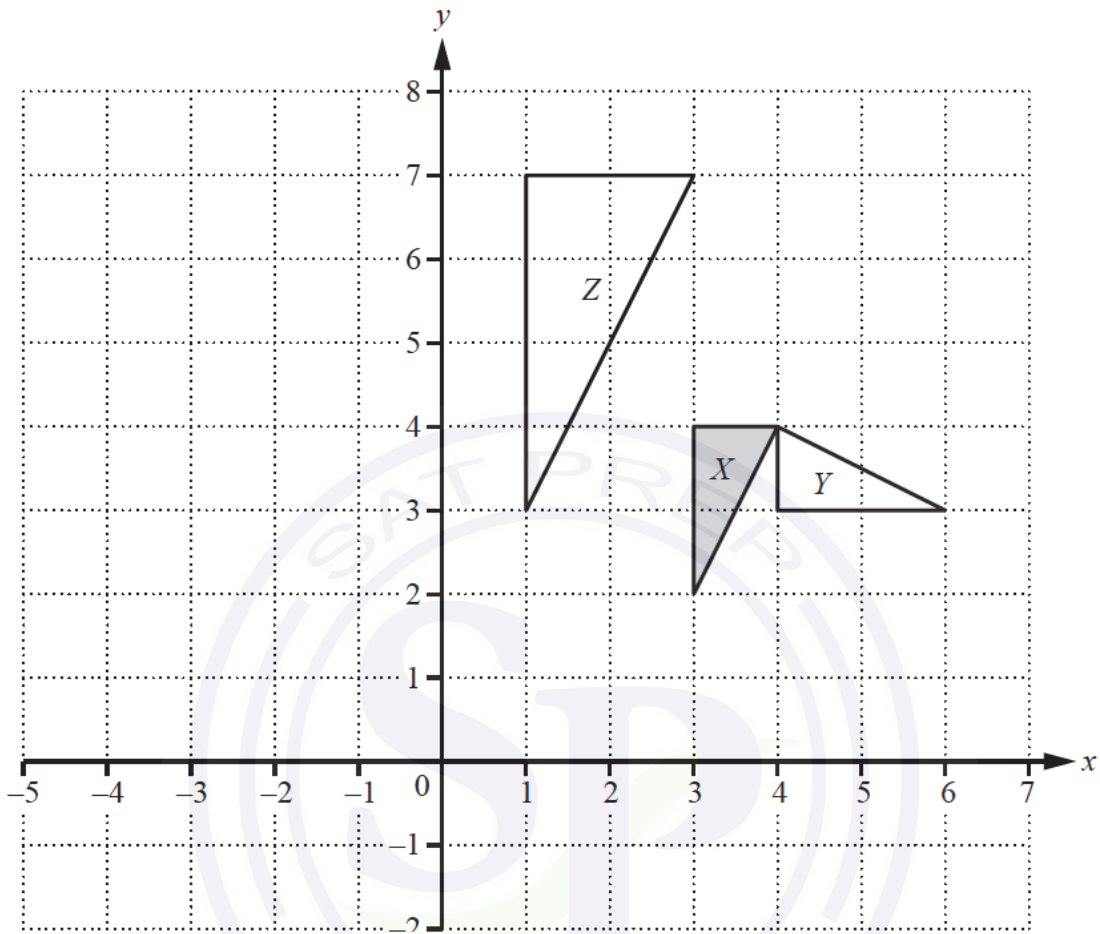
$\vec{MG} = \dots\dots\dots$  [2]

(ii)  $H$  is a point on  $TQ$  such that  $TH : HQ = 3 : 1$ .

Use vectors to show that  $H$  lies on  $MG$ .

[2]

Question 31



(a) Describe fully the **single** transformation that maps

(i) triangle  $X$  onto triangle  $Y$ ,

.....  
 ..... [3]

(ii) triangle  $X$  onto triangle  $Z$ .

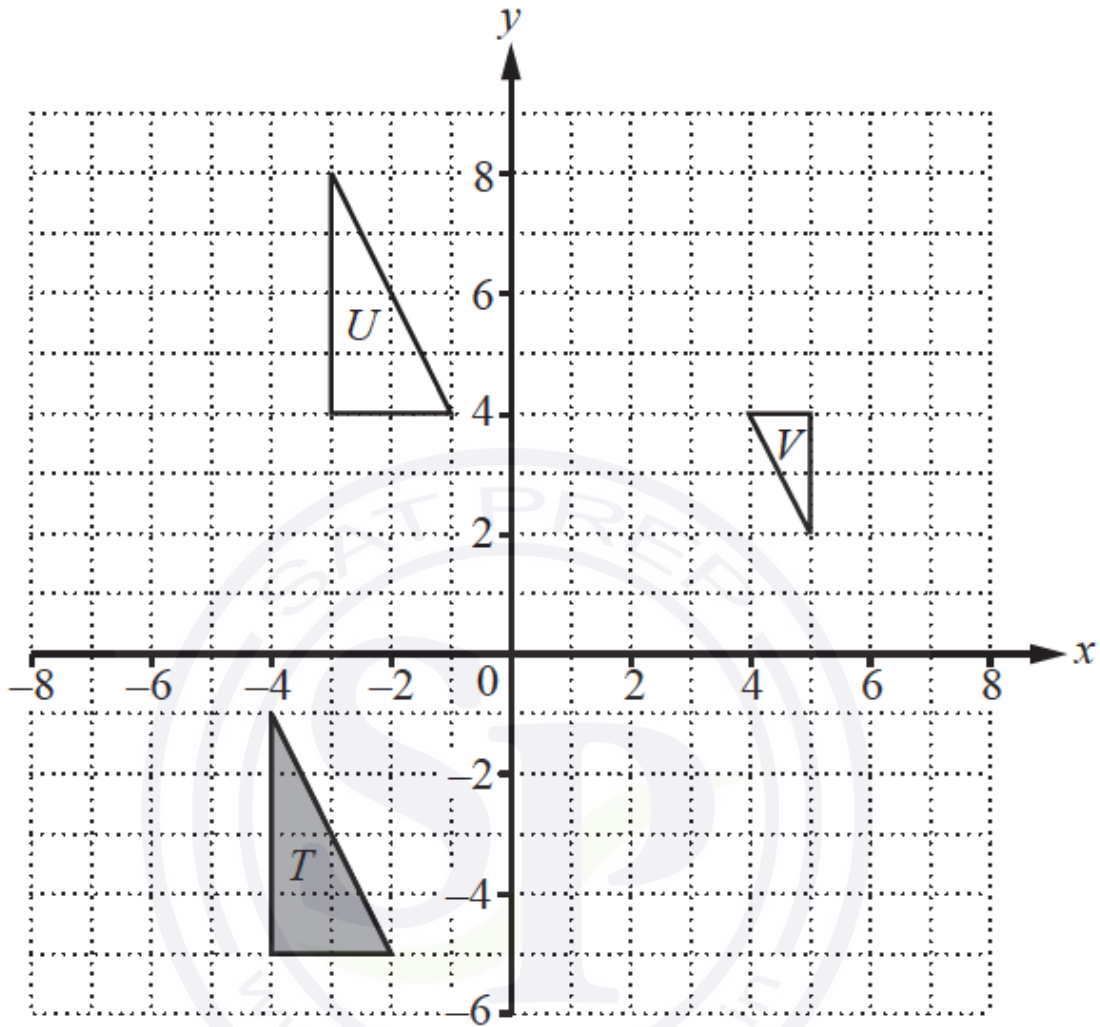
.....  
 ..... [3]

(b) (i) Draw the image of triangle  $X$  after a translation by the vector  $\begin{pmatrix} -5 \\ 3 \end{pmatrix}$ .

Label this triangle  $P$ . [2]

(ii) Draw the reflection of triangle  $P$  in the line  $y = 3$ . [2]

Question 32



- (i) Draw the image of triangle  $T$  after a reflection in the line  $x = 0$ . [2]
- (ii) Draw the image of triangle  $T$  after a rotation through  $90^\circ$  clockwise about  $(-2, -1)$ . [2]
- (iii) Describe fully the **single** transformation that maps triangle  $T$  onto triangle  $U$ .  
 .....  
 ..... [2]
- (iv) Describe fully the **single** transformation that maps triangle  $T$  onto triangle  $V$ .  
 .....  
 ..... [3]

Question 33

$$f(x) = 5x + 7 \qquad g(x) = \frac{4}{x-3}, \quad x \neq 3$$

(a) Find

(i)  $fg(1)$ ,

..... [2]

(ii)  $gf(x)$ ,

..... [2]

(iii)  $g^{-1}(x)$ ,

$g^{-1}(x) =$  ..... [3]

(iv)  $f^{-1}f(2)$ .

..... [1]

[3]

(ii) Solve  $5x^2 - 8x - 25 = 0$ .

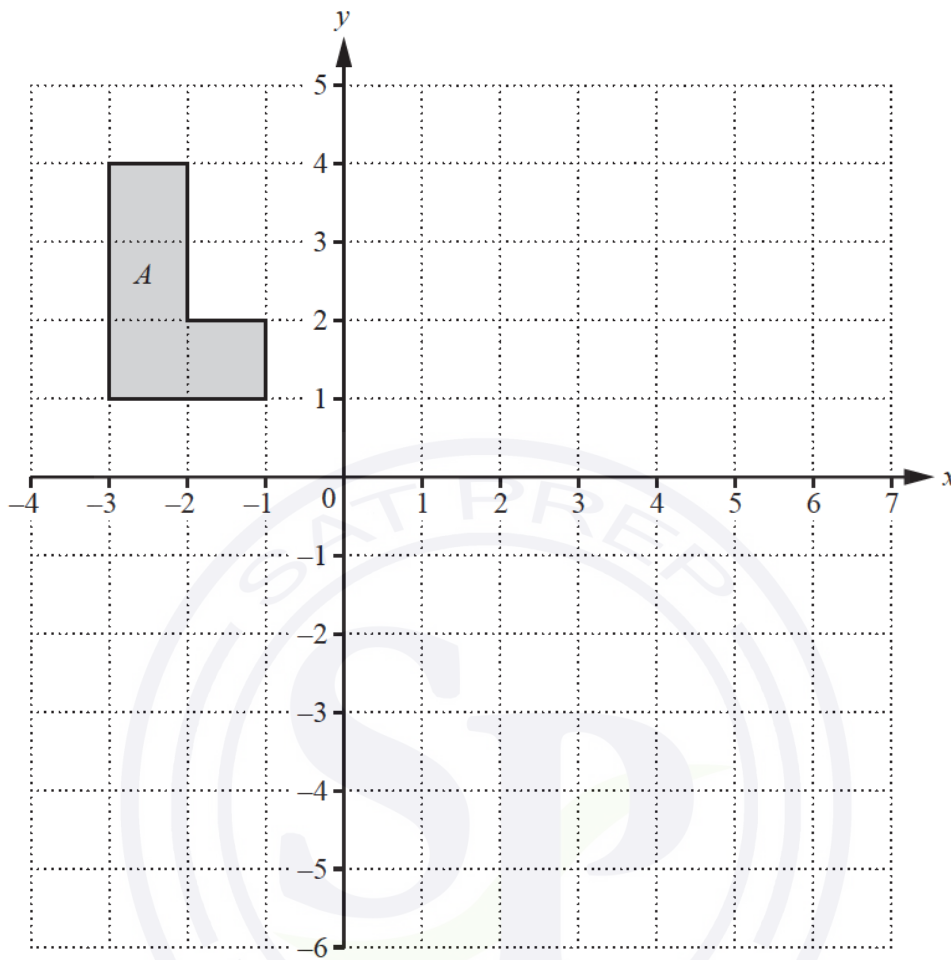
Show all your working and give your answers correct to 2 decimal places.

(b)  $f(x) = g(x)$

(i) Show that  $5x^2 - 8x - 25 = 0$ .

$x =$  ..... Or  $x =$  ..... [4]

Question 34



On the grid, draw the image of

- (i) shape  $A$  after a reflection in the line  $x = 1$ , [2]
- (ii) shape  $A$  after an enlargement with scale factor  $-2$ , centre  $(0, 1)$ , [2]

Question 35

$$f(x) = 2x + 1$$

$$g(x) = x^2 + 4$$

$$h(x) = 2^x$$

- (a) Solve the equation  $f(x) = g(1)$ .

$$x = \dots\dots\dots [2]$$

- (b) Find the value of  $fh(3)$ .

$$\dots\dots\dots [2]$$

- (c) Find  $f^{-1}(x)$ .

$$f^{-1}(x) = \dots\dots\dots [2]$$

- (d) Find  $gf(x)$  in its simplest form.

$$\dots\dots\dots [3]$$

- (e) Solve the equation  $h^{-1}(x) = 0.5$ .

$$x = \dots\dots\dots [1]$$

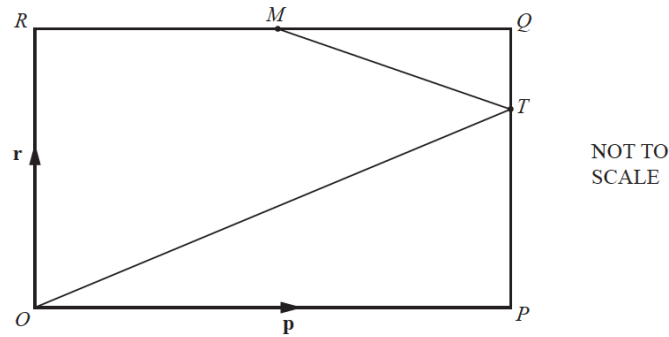
- (f)  $\frac{1}{h(x)} = 2^{kx}$

Write down the value of  $k$ .

$$k = \dots\dots\dots [1]$$



Question 36



(a) Find, in terms of  $\mathbf{p}$  and/or  $\mathbf{r}$ , in its simplest form

(i)  $\overrightarrow{MQ}$ ,

$\overrightarrow{MQ} = \dots\dots\dots [1]$

(ii)  $\overrightarrow{MT}$ ,

$\overrightarrow{MT} = \dots\dots\dots [1]$

(iii)  $\overrightarrow{OT}$ .

$\overrightarrow{OT} = \dots\dots\dots [1]$

(b)  $RQ$  and  $OT$  are extended to meet at  $U$ .

Find the position vector of  $U$  in terms of  $\mathbf{p}$  and  $\mathbf{r}$ .  
Give your answer in its simplest form.

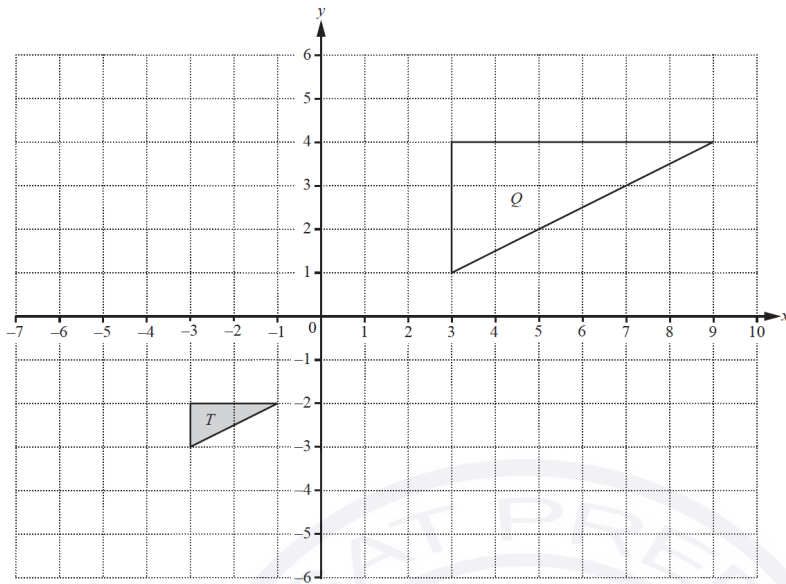
$\dots\dots\dots [2]$

(c)  $\overrightarrow{MT} = \begin{pmatrix} 2k \\ -k \end{pmatrix}$  and  $|\overrightarrow{MT}| = \sqrt{180}$ .

Find the positive value of  $k$ .

$k = \dots\dots\dots [3]$

Question 37



(a)  $\mathbf{m} = \begin{pmatrix} 3 \\ 2 \end{pmatrix}$       $\mathbf{n} = \begin{pmatrix} -2 \\ 3 \end{pmatrix}$

(i) Work out  $2\mathbf{m} - 3\mathbf{n}$ .

(i) Draw the image of triangle  $T$  after a translation by the vector  $\begin{pmatrix} 5 \\ -2 \end{pmatrix}$ . [2]

(ii) Draw the image of triangle  $T$  after a reflection in the line  $y = 1$ . [2]

(iii) Describe fully the **single** transformation that maps triangle  $T$  onto triangle  $Q$ .

.....  
 ..... [3]

Question 38

(a)  $\mathbf{m} = \begin{pmatrix} 3 \\ 2 \end{pmatrix}$       $\mathbf{n} = \begin{pmatrix} -2 \\ 3 \end{pmatrix}$

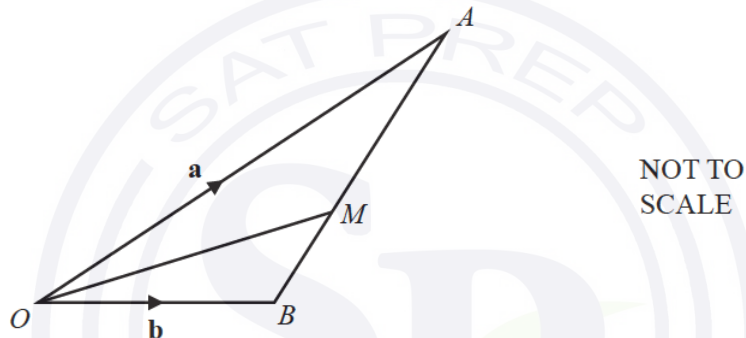
(i) Work out  $2\mathbf{m} - 3\mathbf{n}$ .

$\begin{pmatrix} \phantom{0} \\ \phantom{0} \end{pmatrix}$  [2]

(ii) Calculate  $|2\mathbf{m} - 3\mathbf{n}|$ .

..... [2]

(b) (i)



In the diagram,  $O$  is the origin,  $\vec{OA} = \mathbf{a}$  and  $\vec{OB} = \mathbf{b}$ .  
The point  $M$  lies on  $AB$  such that  $AM : MB = 3 : 2$ .

Find, in terms of  $\mathbf{a}$  and  $\mathbf{b}$ , in its simplest form

(a)  $\vec{AB}$ ,

$\vec{AB} = \dots\dots\dots$  [1]

(b)  $\vec{AM}$ ,

$\vec{AM} = \dots\dots\dots$  [1]

(c) the position vector of  $M$ .

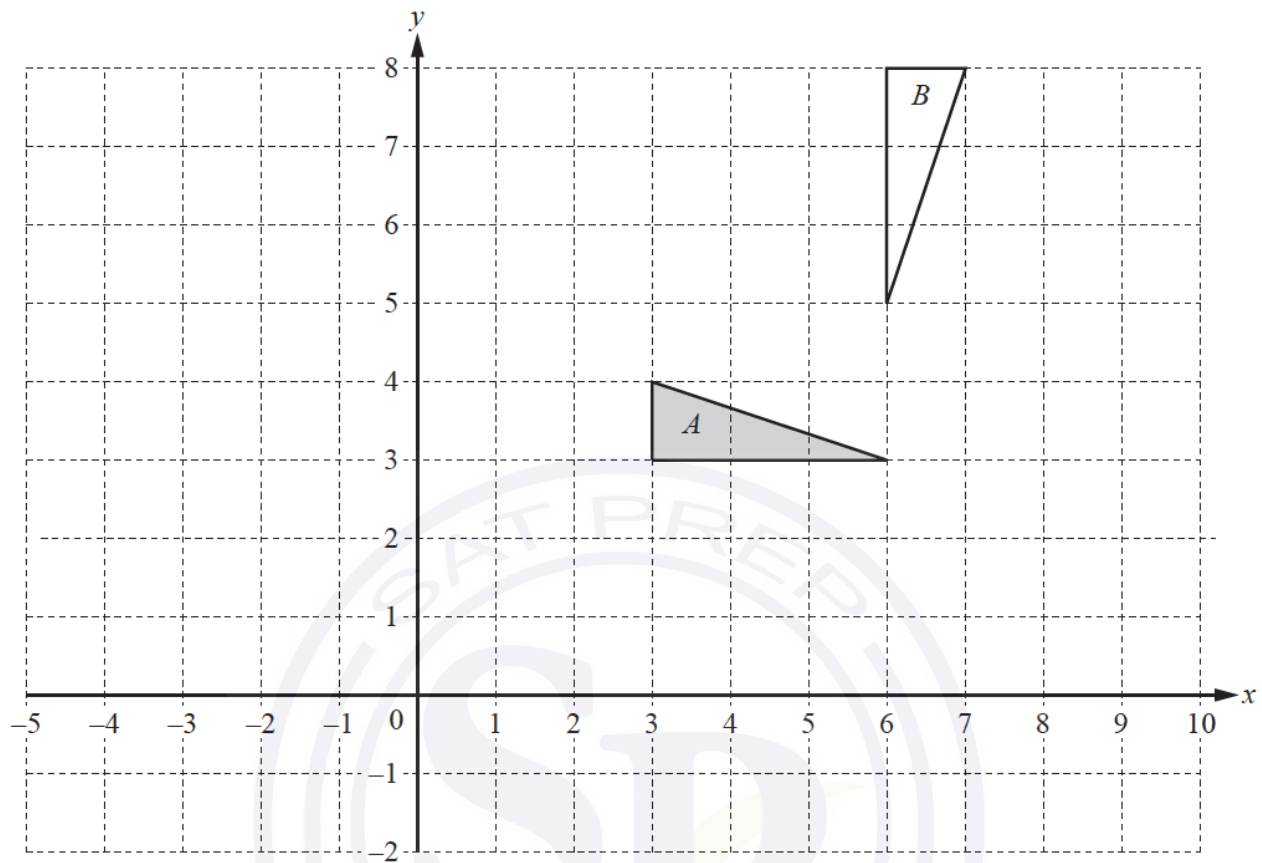
..... [2]

(ii)  $OM$  is extended to the point  $C$ .  
The position vector of  $C$  is  $\mathbf{a} + k\mathbf{b}$ .

Find the value of  $k$ .

$k = \dots\dots\dots$  [1]

Question 39



(a) Draw the image when triangle  $A$  is reflected in the line  $x = 1$ . [2]

(b) Draw the image when triangle  $A$  is translated by the vector  $\begin{pmatrix} -2 \\ 3 \end{pmatrix}$ . [2]

(c) Draw the image when triangle  $A$  is enlarged by scale factor 2 with centre  $(4, 5)$ . [2]

(d) Describe fully the **single** transformation that maps triangle  $A$  onto triangle  $B$ .  
 .....  
 ..... [3]

Question 40

(a)  $y = \frac{3}{x} + 2, \quad x \neq 0$

(i) Find the value of  $y$  when  $x = -6$ .

$y = \dots\dots\dots [1]$

(ii) Find  $x$  in terms of  $y$ .

$x = \dots\dots\dots [3]$

(b)  $g(x) = 2 - x \qquad h(x) = 2^x$

(i) Find  $g(5)$ .

$\dots\dots\dots [1]$

(ii) Find  $h(2)$ .

(iii) Find  $x$  when  $g(x) = h(3)$ .

$x = \dots\dots\dots [2]$

(iv) Find  $x$  when  $g^{-1}(x) = -1$ .

$x = \dots\dots\dots [1]$

Question 41

$f(x) = 2x + 1$

$g(x) = 3x - 2$

$h(x) = 3^x$

(a) Find  $hf(2) - fh(1)$ .

$\dots\dots\dots [3]$

(b) Find  $gf(x)$ , giving your answer in its simplest form.

$\dots\dots\dots [2]$

(c) Solve the inequality  $f(x) > g(x)$ .

$\dots\dots\dots [2]$

(d) Solve the equation  $h(x) = \frac{1}{9}$ .

$x = \dots\dots\dots [1]$

(e) Find  $g^{-1}(x)$ .

$g^{-1}(x) = \dots\dots\dots [2]$

(f) Find  $\frac{5}{f(x)} + g(x)$ .

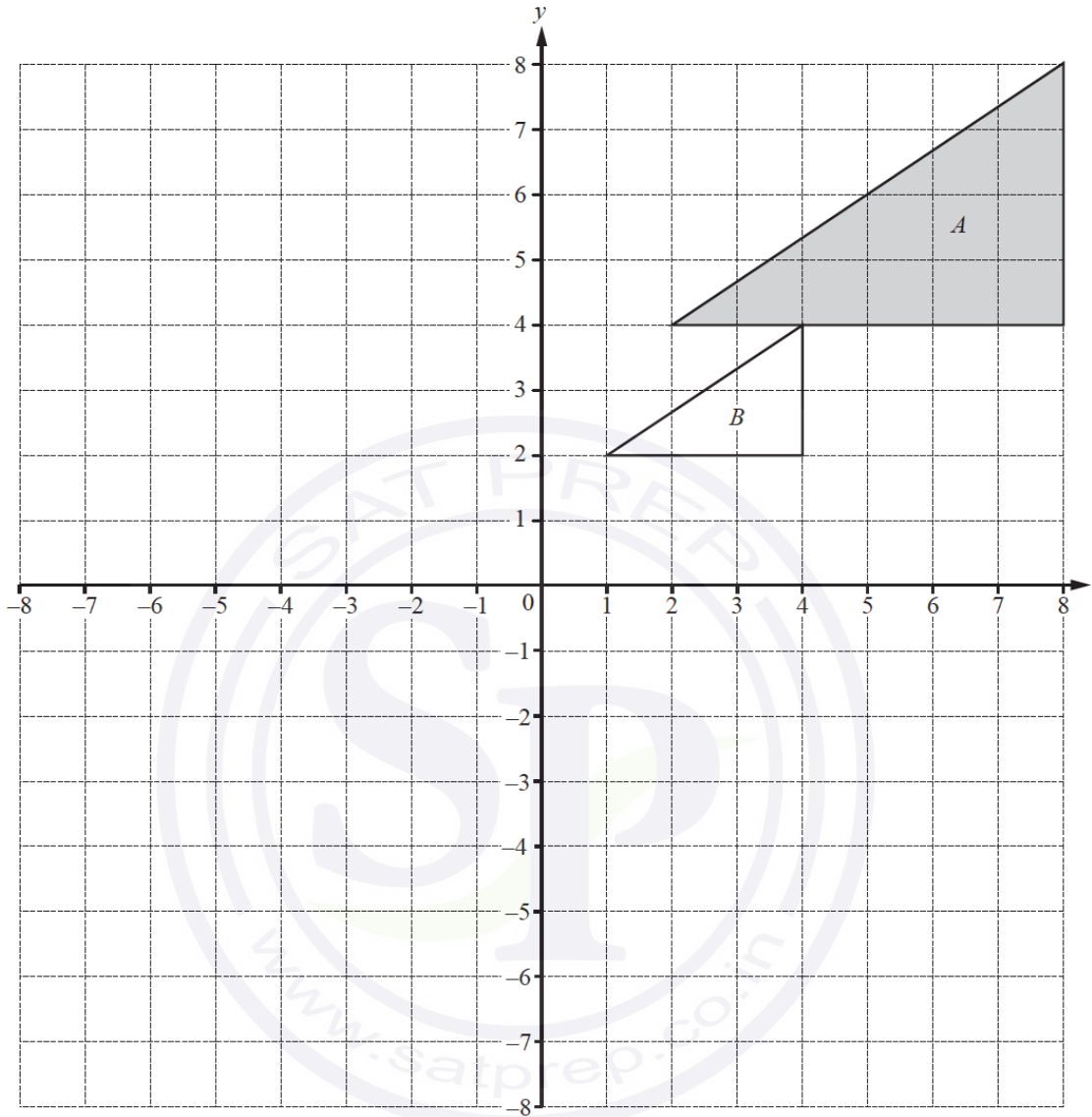
Give your answer as a single fraction.

$\dots\dots\dots [3]$

(g) Solve the equation  $f^{-1}(x) = 4$ .

$x = \dots\dots\dots [1]$

Question 41



(a)  $\mathbf{v} = \begin{pmatrix} -4 \\ -8 \end{pmatrix}$

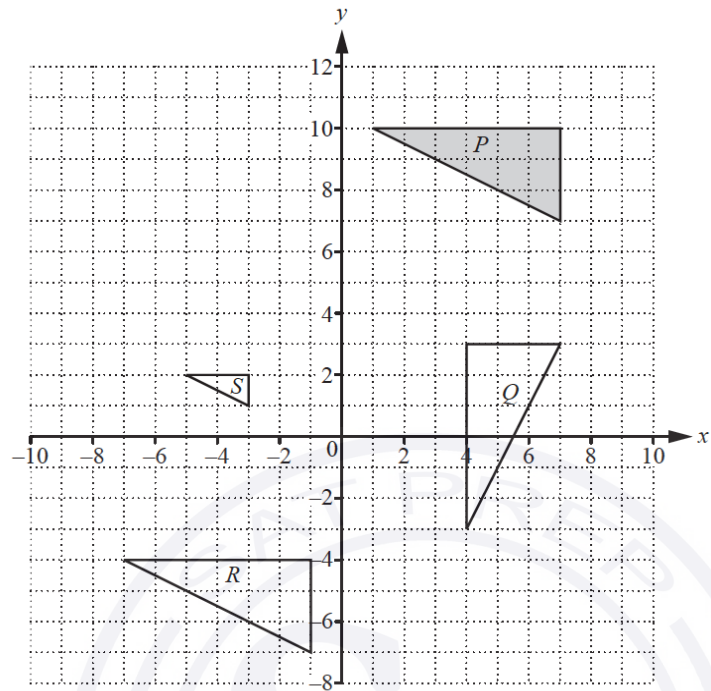
(i) Draw the image of triangle *A* after the translation by vector *v*. [2]

(ii) Calculate  $|\mathbf{v}|$ .  
 ..... [2]

(b) (i) Describe fully the **single** transformation that maps triangle *A* onto triangle *B*.

.....  
 ..... [3]

Question 43



(a) Describe fully the **single** transformation that maps

(i) shape *P* onto shape *Q*,

.....  
 ..... [3]

(ii) shape *P* onto shape *R*,

.....  
 ..... [2]

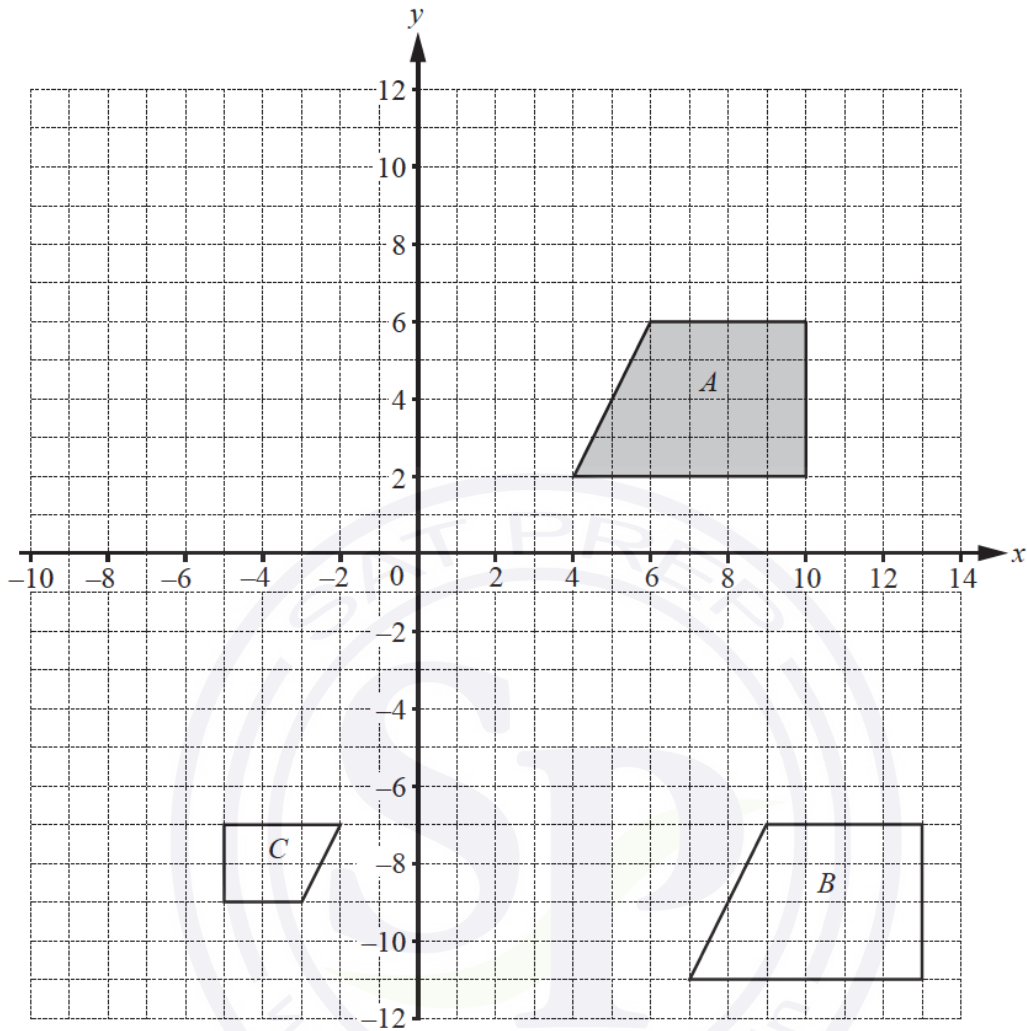
(iii) shape *P* onto shape *S*.

.....  
 ..... [3]

(b) (i) Draw the reflection of **shape S** in the line  $y = x$ .

[2]

Question 44



(a) Describe fully the **single** transformation that maps shape *A* onto

(i) shape *B*,

.....  
 ..... [2]

(ii) shape *C*.

.....  
 ..... [3]

(b) Draw the image of shape *A* after rotation through  $90^\circ$  anticlockwise about the point  $(3, -1)$ . [2]

(c) Draw the image of shape *A* after reflection in  $y = 1$ . [2]



Question 45

$$f(x) = 3x - 2$$

$$g(x) = x^2$$

$$h(x) = 3^x$$

(a) Find  $f(-3)$ .

..... [1]

(b) Find the value of  $x$  when  $f(x) = 19$ .

$x =$  ..... [2]

(c) Find  $fh(2)$ .

..... [2]

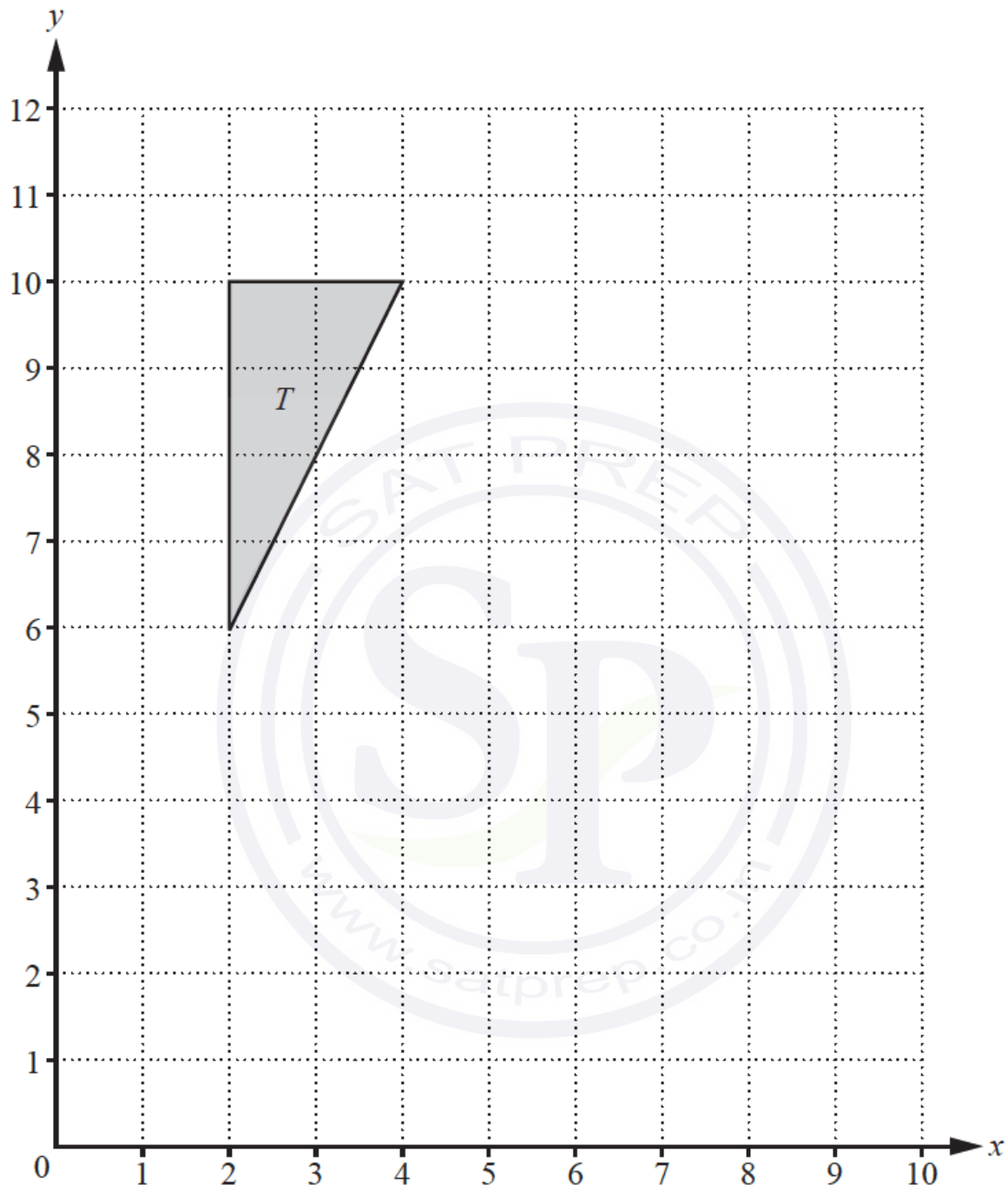
(d) Find  $gf(x) + f(x) + x$ .  
Give your answer in its simplest form.

..... [3]

(e) Find  $f^{-1}(x)$ .

$f^{-1}(x) =$  ..... [2]

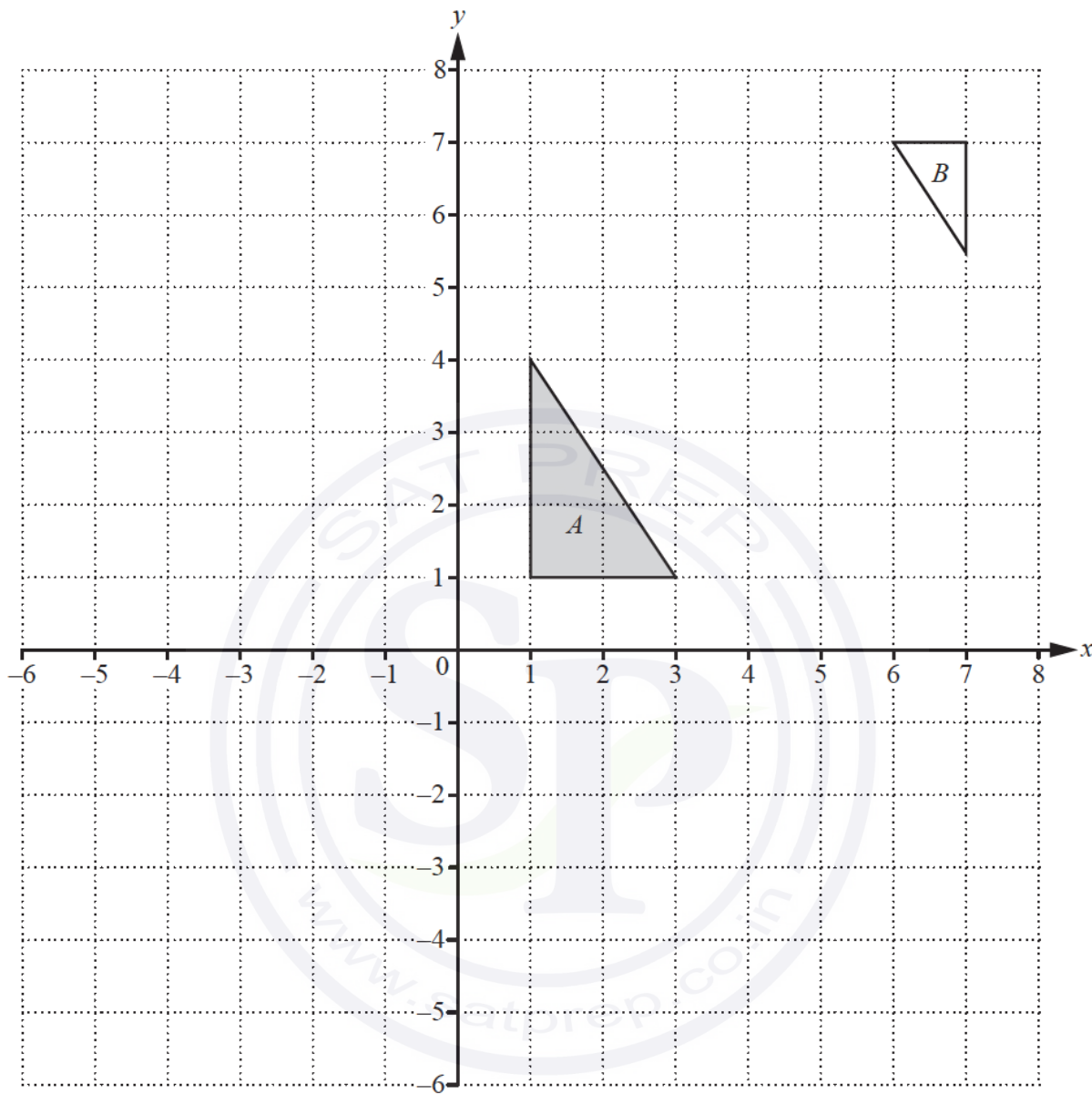
Question 46



On the grid, draw the image of

- (i) triangle  $T$  after translation by the vector  $\begin{pmatrix} 6 \\ -5 \end{pmatrix}$ , [2]
- (ii) triangle  $T$  after rotation through  $90^\circ$  anticlockwise with centre  $(4, 10)$ , [2]
- (iii) triangle  $T$  after enlargement with scale factor  $\frac{1}{2}$ , centre  $(10, 0)$ . [2]

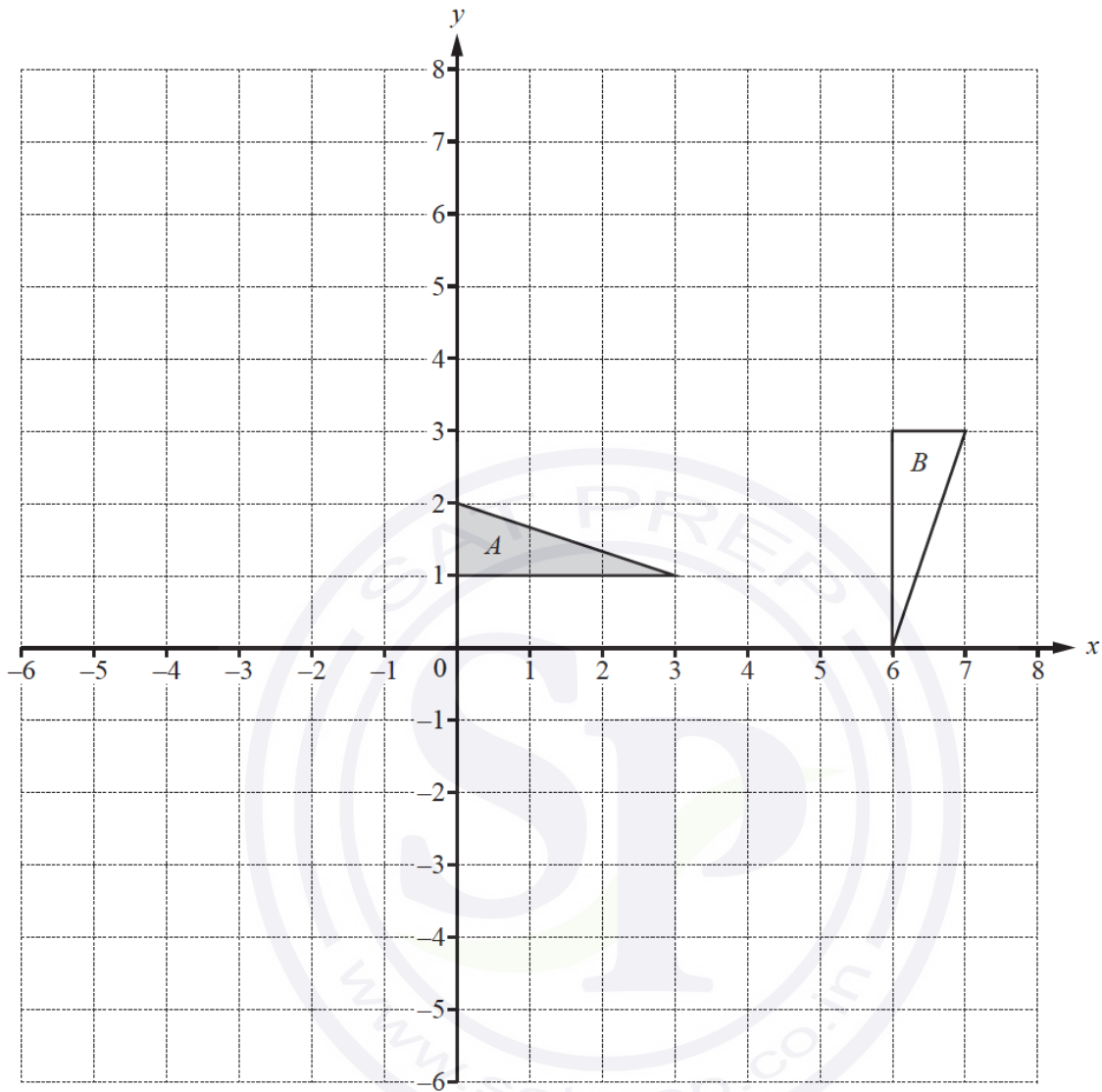
Question 47



- (a) (i) Draw the image of triangle  $A$  after reflection in the line  $x = 4$ . [2]
- (ii) Draw the image of triangle  $A$  after rotation of  $90^\circ$  anticlockwise about  $(0, 0)$ . [2]
- (iii) Draw the image of triangle  $A$  after translation by the vector  $\begin{pmatrix} 1 \\ -5 \end{pmatrix}$ . [2]
- (b) Describe fully the **single** transformation that maps triangle  $A$  onto triangle  $B$ .

.....  
 ..... [3]

Question 48



(a) Draw the image of

(i) triangle  $A$  after a reflection in the line  $x = 0$ , [2]

(ii) triangle  $A$  after an enlargement, scale factor 2, centre  $(0, 4)$ , [2]

(iii) triangle  $A$  after a translation by the vector  $\begin{pmatrix} -5 \\ 3 \end{pmatrix}$ . [2]

(b) Describe fully the **single** transformation that maps triangle  $A$  onto triangle  $B$ .

.....  
 ..... [3]

Question 49

$$f(x) = 1 - 2x \qquad g(x) = x + 4 \qquad h(x) = x^2 + 1$$

(a) Find  $f(-1)$ .

..... [1]

(b) Solve the equation.

$$2f(x) = g(x)$$

$x =$  ..... [2]

(c) Find  $fg(x)$ .

Give your answer in its simplest form.

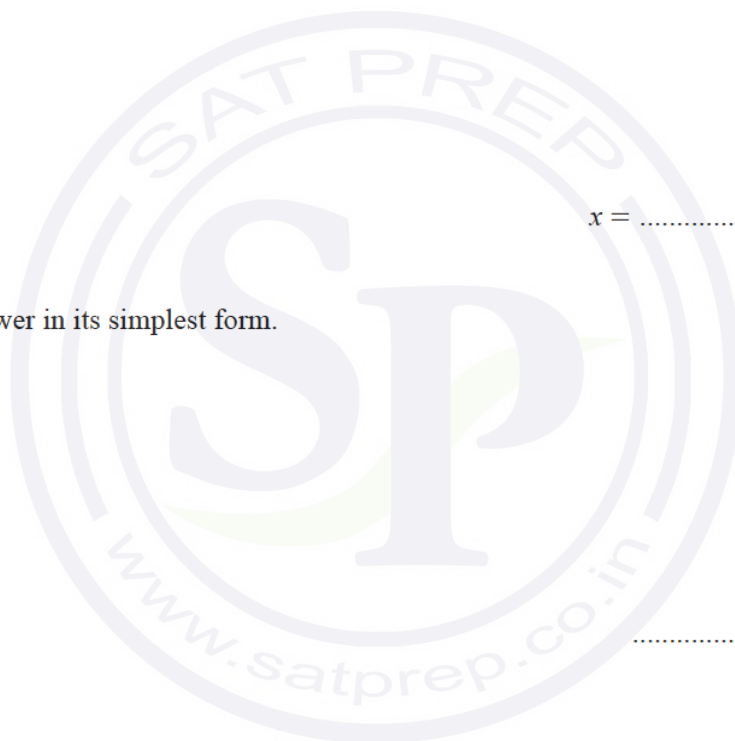
..... [2]

(d) Find  $hh(2)$ .

..... [2]

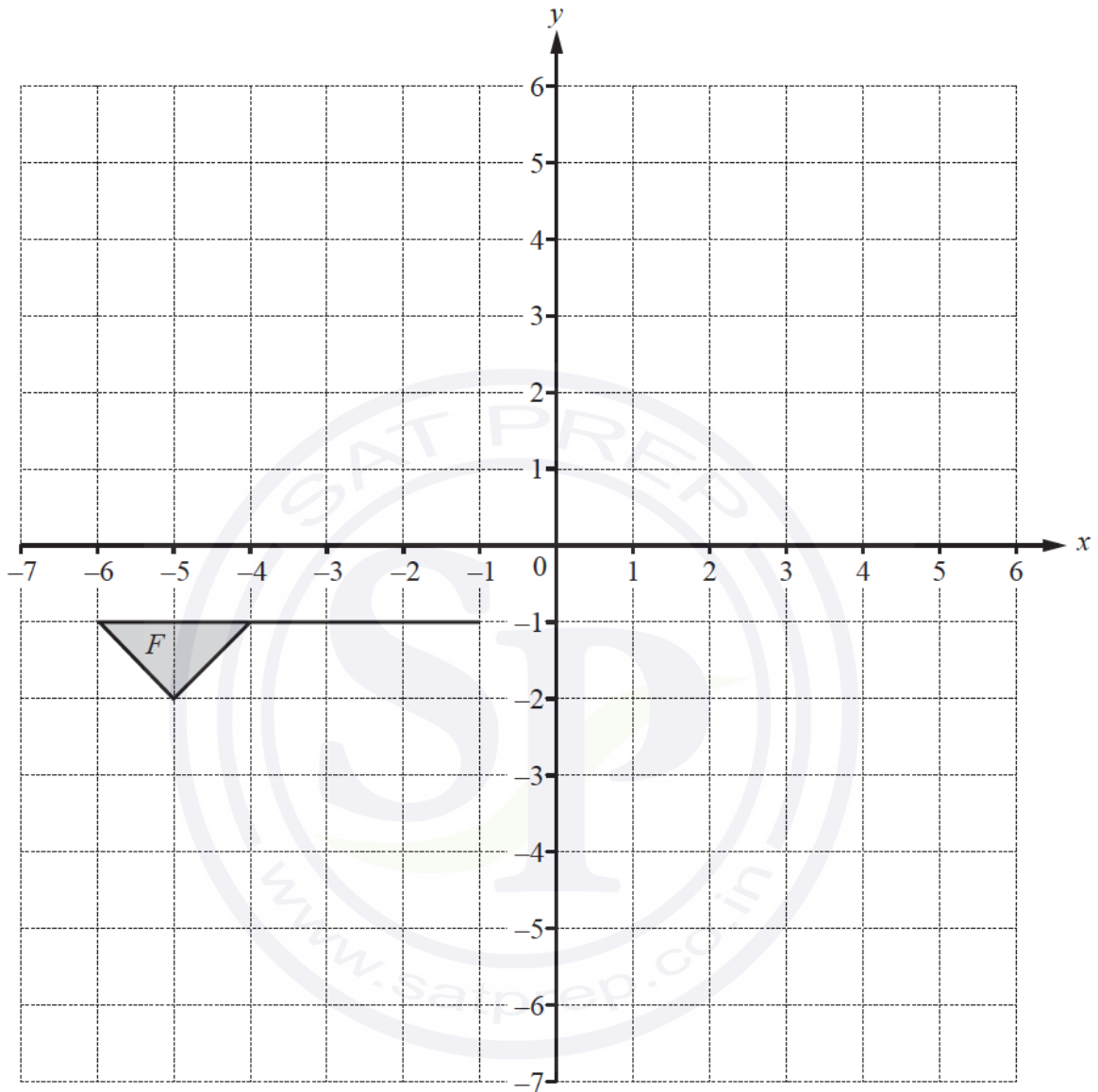
(e) Find  $f^{-1}(x)$ .

$$f^{-1}(x) = \dots\dots\dots [2]$$



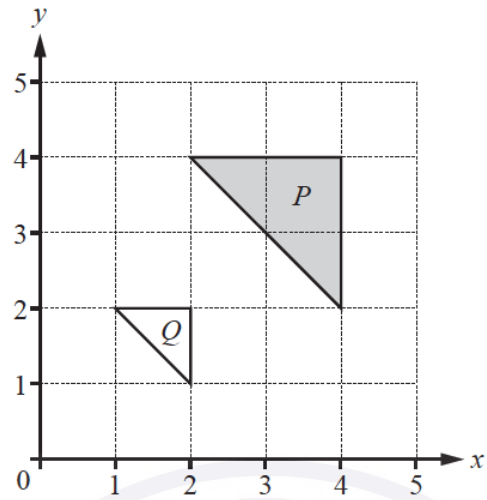
Question 50

(a)



Continue on the next page...

(b)



(i) Describe fully the **single** transformation that maps triangle  $P$  onto triangle  $Q$ .

.....  
..... [3]

(c) The point  $A$  is translated to the point  $B$  by the vector  $\begin{pmatrix} 4u \\ 3u \end{pmatrix}$ .

$$|\vec{AB}| = 12.5$$

Find  $u$ .

$u =$  ..... [3]

Question 51

(a)  $f(x) = 2x - 3$                        $g(x) = x^2 + 1$

(i) Find  $gg(2)$ .

..... [2]

(ii) Find  $g(x+2)$ , giving your answer in its simplest form.

..... [2]

(iii) Find  $x$  when  $f(x) = 7$ .

$x =$  ..... [2]

(iv) Find  $f^{-1}(x)$ .

$f^{-1}(x) =$  ..... [2]

(b)  $h(x) = x^x, x > 0$

(i) Calculate  $h(0.3)$ .  
Give your answer correct to 2 decimal places.

..... [2]

(ii) Find  $x$  when  $h(x) = 256$ .

$x =$  ..... [1]



Question 52

$$f(x) = 8 - 3x$$

$$g(x) = \frac{10}{x+1}, x \neq -1$$

$$h(x) = 2^x$$

(a) Find

(i)  $hf\left(\frac{8}{3}\right)$ ,

..... [2]

(ii)  $gh(-2)$ ,

..... [2]

(iii)  $g^{-1}(x)$ ,

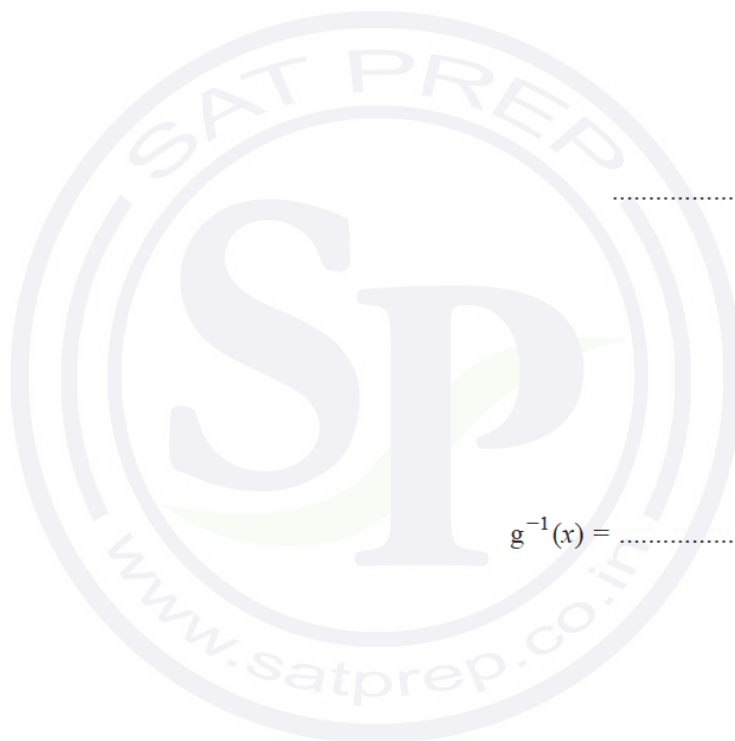
$g^{-1}(x) =$  ..... [3]

(iv)  $f^{-1}f(5)$ .

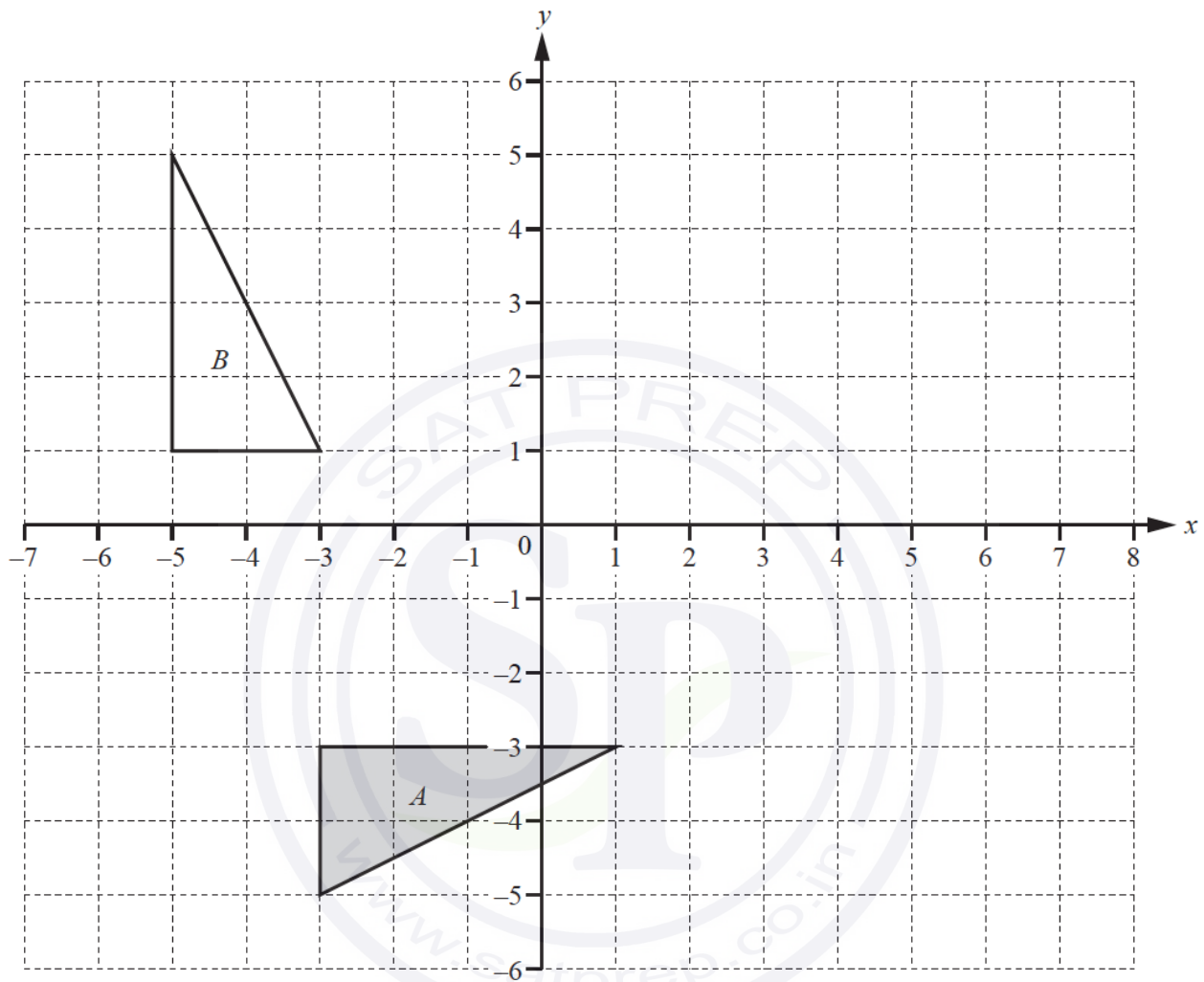
..... [1]

(b) Write  $f(x) + g(x)$  as a single fraction in its simplest form.

..... [3]



Question 53



(a) (i) Draw the image of triangle *A* after a reflection in the line  $x = 2$ . [2]

(ii) Draw the image of triangle *A* after a translation by the vector  $\begin{pmatrix} -2 \\ 4 \end{pmatrix}$ . [2]

(iii) Draw the image of triangle *A* after an enlargement by scale factor  $-\frac{1}{2}$ , centre (3, 1). [3]

(b) Describe fully the **single** transformation that maps triangle *A* onto triangle *B*.

.....  
 ..... [3]

Question 54

(a)  $\vec{OA} = \begin{pmatrix} 4 \\ 3 \end{pmatrix}$        $\vec{AB} = \begin{pmatrix} 8 \\ -7 \end{pmatrix}$        $\vec{AC} = \begin{pmatrix} -3 \\ 6 \end{pmatrix}$

Find

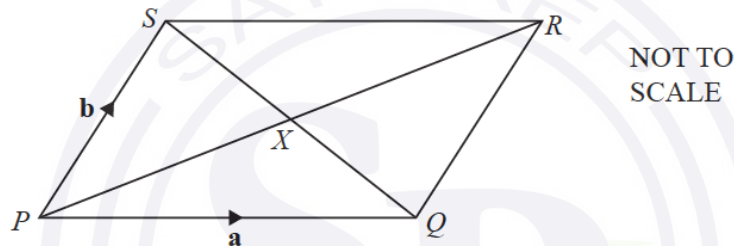
(i)  $|\vec{OB}|$ ,

$|\vec{OB}| = \dots\dots\dots$  [3]

(ii)  $\vec{BC}$ .

$\vec{BC} = \begin{pmatrix} \phantom{0} \\ \phantom{0} \end{pmatrix}$  [2]

(b)



$PQRS$  is a parallelogram with diagonals  $PR$  and  $SQ$  intersecting at  $X$ .

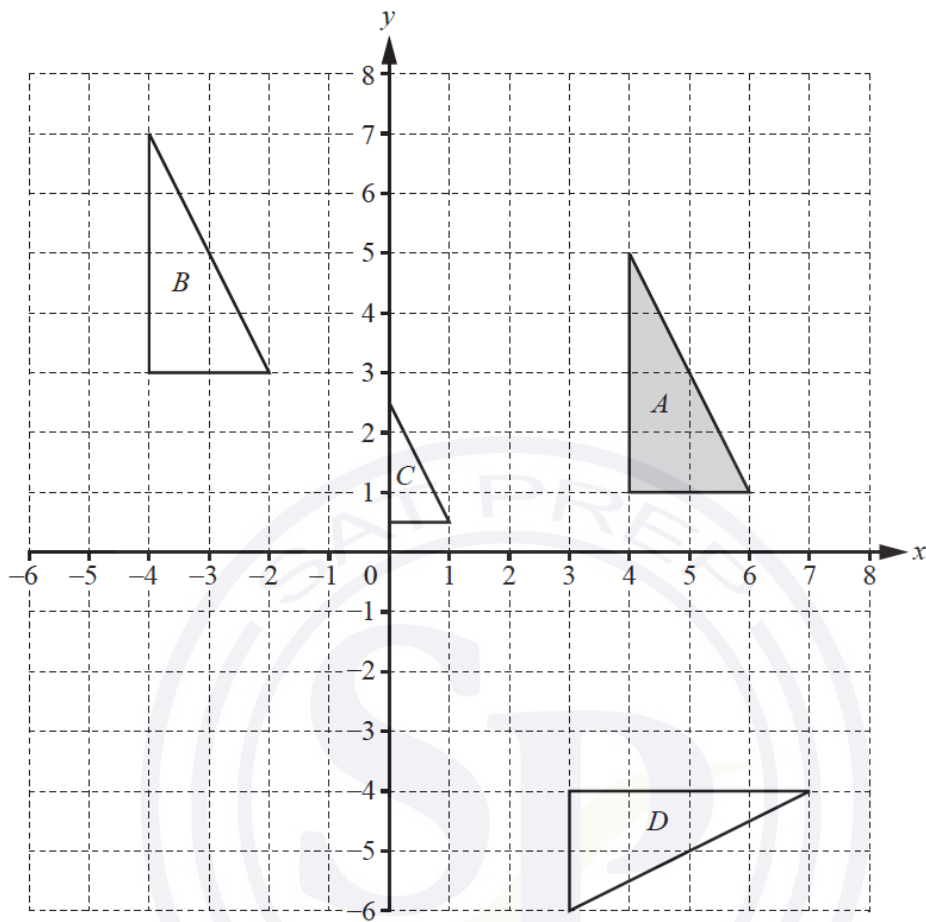
$\vec{PQ} = \mathbf{a}$  and  $\vec{PS} = \mathbf{b}$ .

Find  $\vec{QX}$  in terms of  $\mathbf{a}$  and  $\mathbf{b}$ .

Give your answer in its simplest form.

$\vec{QX} = \dots\dots\dots$  [2]

Question 55



(a) Describe fully the **single** transformation that maps

(i) triangle *A* onto triangle *B*,

.....  
 ..... [2]

(ii) triangle *A* onto triangle *C*,

.....  
 ..... [3]

(iii) triangle *A* onto triangle *D*.

.....  
 ..... [3]

Question 56

(a)  $\mathbf{a} = \begin{pmatrix} -3 \\ 2 \end{pmatrix}$      $\mathbf{b} = \begin{pmatrix} 5 \\ 4 \end{pmatrix}$      $\mathbf{c} = \begin{pmatrix} 14 \\ 9 \end{pmatrix}$

(i) Find  $3\mathbf{a} - 2\mathbf{b}$ .

$$\begin{pmatrix} \phantom{0} \\ \phantom{0} \end{pmatrix} \quad [2]$$

(ii) Find  $|\mathbf{a}|$ .

..... [2]

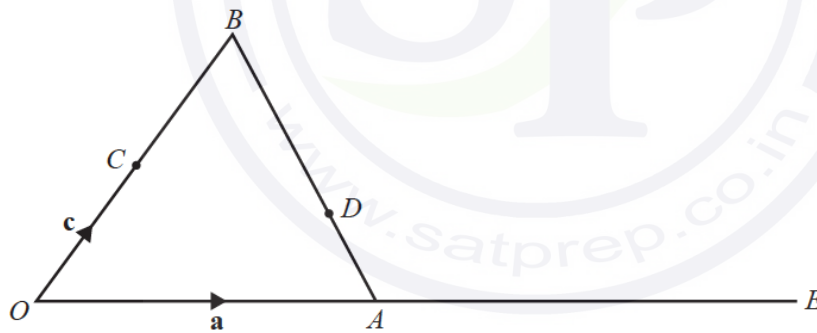
(iii)  $m\mathbf{a} + n\mathbf{b} = \mathbf{c}$

Write down two simultaneous equations and solve them to find the value of  $m$  and the value of  $n$ . Show all your working.

$m = \dots\dots\dots$

$n = \dots\dots\dots$  [5]

(b)



NOT TO SCALE

$OAB$  is a triangle and  $C$  is the mid-point of  $OB$ .  
 $D$  is on  $AB$  such that  $AD : DB = 3 : 5$ .  
 $OAE$  is a straight line such that  $OA : AE = 2 : 3$ .  
 $\vec{OA} = \mathbf{a}$  and  $\vec{OC} = \mathbf{c}$ .

Continue on the next page...

(i) Find, in terms of **a** and **c**, in its simplest form,

(a)  $\vec{AB}$ ,

$\vec{AB} = \dots\dots\dots [1]$

(b)  $\vec{AD}$ ,

$\vec{AD} = \dots\dots\dots [1]$

(c)  $\vec{CE}$ ,

$\vec{CE} = \dots\dots\dots [1]$

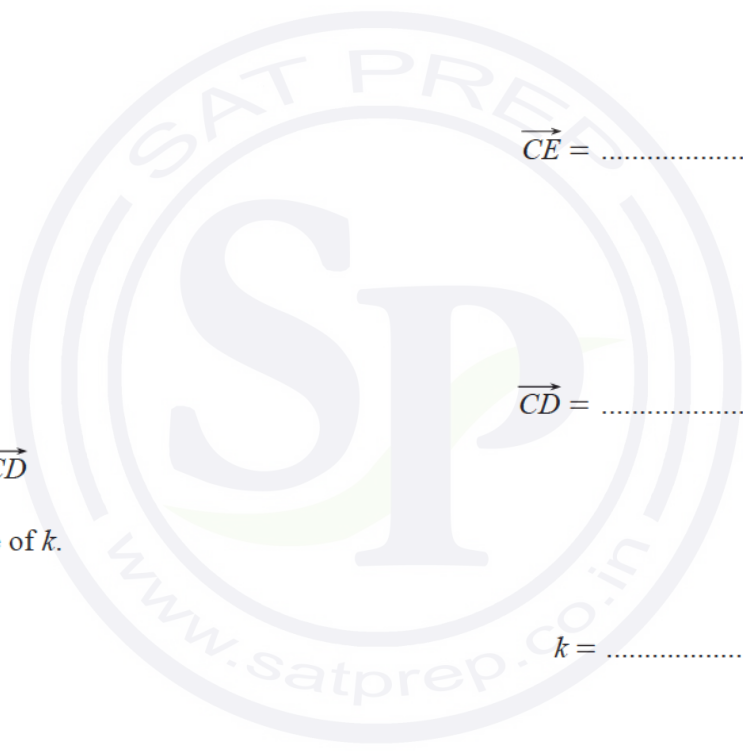
(d)  $\vec{CD}$ .

$\vec{CD} = \dots\dots\dots [2]$

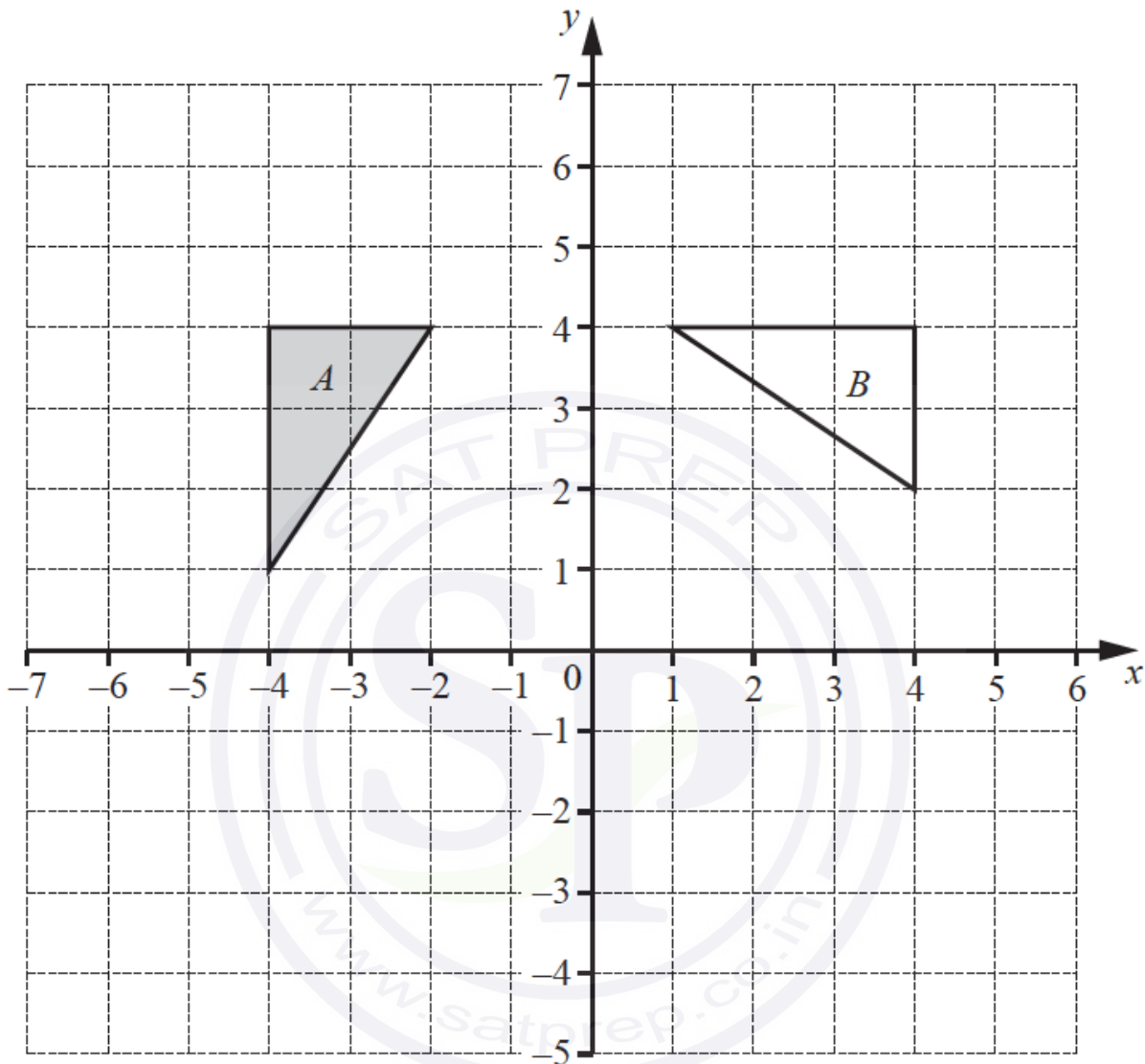
(ii)  $\vec{CE} = k\vec{CD}$

Find the value of  $k$ .

$k = \dots\dots\dots [1]$



Question 57



(a) Describe fully the **single** transformation that maps triangle *A* onto triangle *B*.

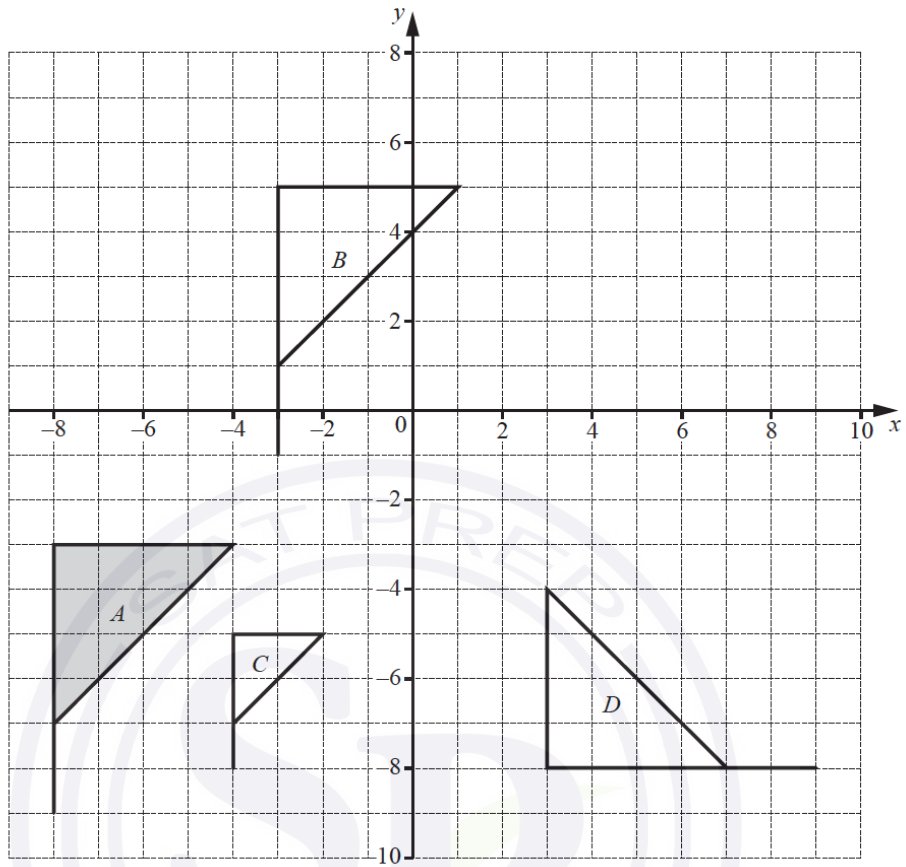
.....  
 ..... [3]

(b) On the grid, draw the image of

(i) triangle *A* after a reflection in the *x*-axis, [1]

(ii) triangle *A* after a translation by the vector  $\begin{pmatrix} 7 \\ -5 \end{pmatrix}$ , [2]

Question 58



(a) Describe fully the **single** transformation that maps

(i) flag *A* onto flag *B*,

.....  
 ..... [2]

(ii) flag *A* onto flag *C*,

.....  
 ..... [3]

(iii) flag *A* onto flag *D*.

.....  
 ..... [3]

(b) Draw the reflection of flag *A* in the line  $y = -1$ .

[2]



Question 59

$$f(x) = \frac{3}{x+2}, x \neq -2$$

$$g(x) = 8x - 5$$

$$h(x) = x^2 + 6$$

(a) Work out  $g\left(\frac{1}{4}\right)$ .

..... [1]

(b) Work out  $ff(2)$ .

..... [2]

(c) Find  $gg(x)$ , giving your answer in its simplest form.

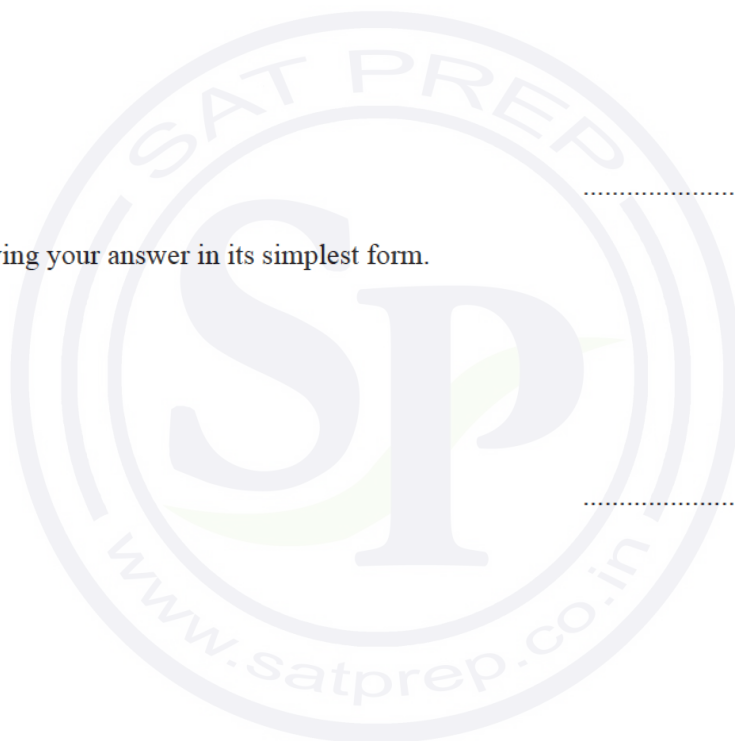
..... [2]

(d) Find  $g^{-1}(x)$ .

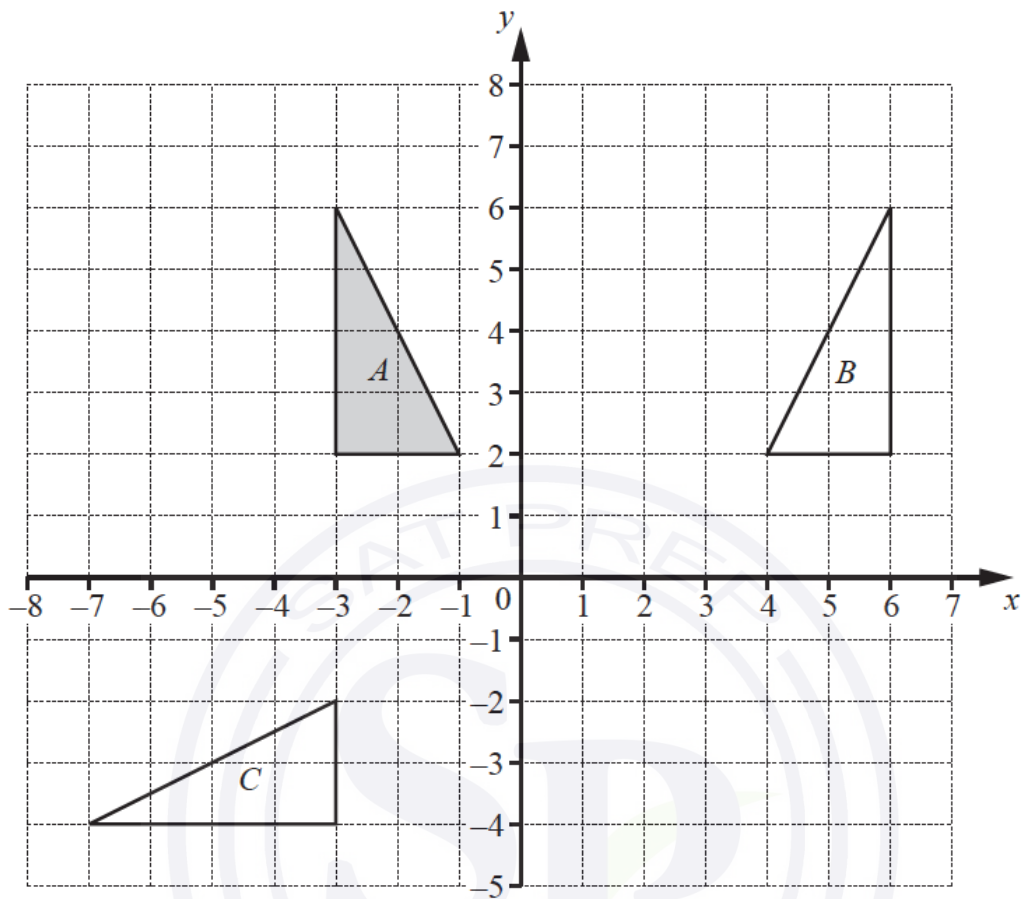
$g^{-1}(x) =$  ..... [2]

(e) Write  $g(x) - f(x)$  as a single fraction in its simplest form.

..... [3]



Question 60



(a) Describe fully the **single** transformation that maps

(i) triangle *A* onto triangle *B*,

.....  
 ..... [2]

(ii) triangle *A* onto triangle *C*.

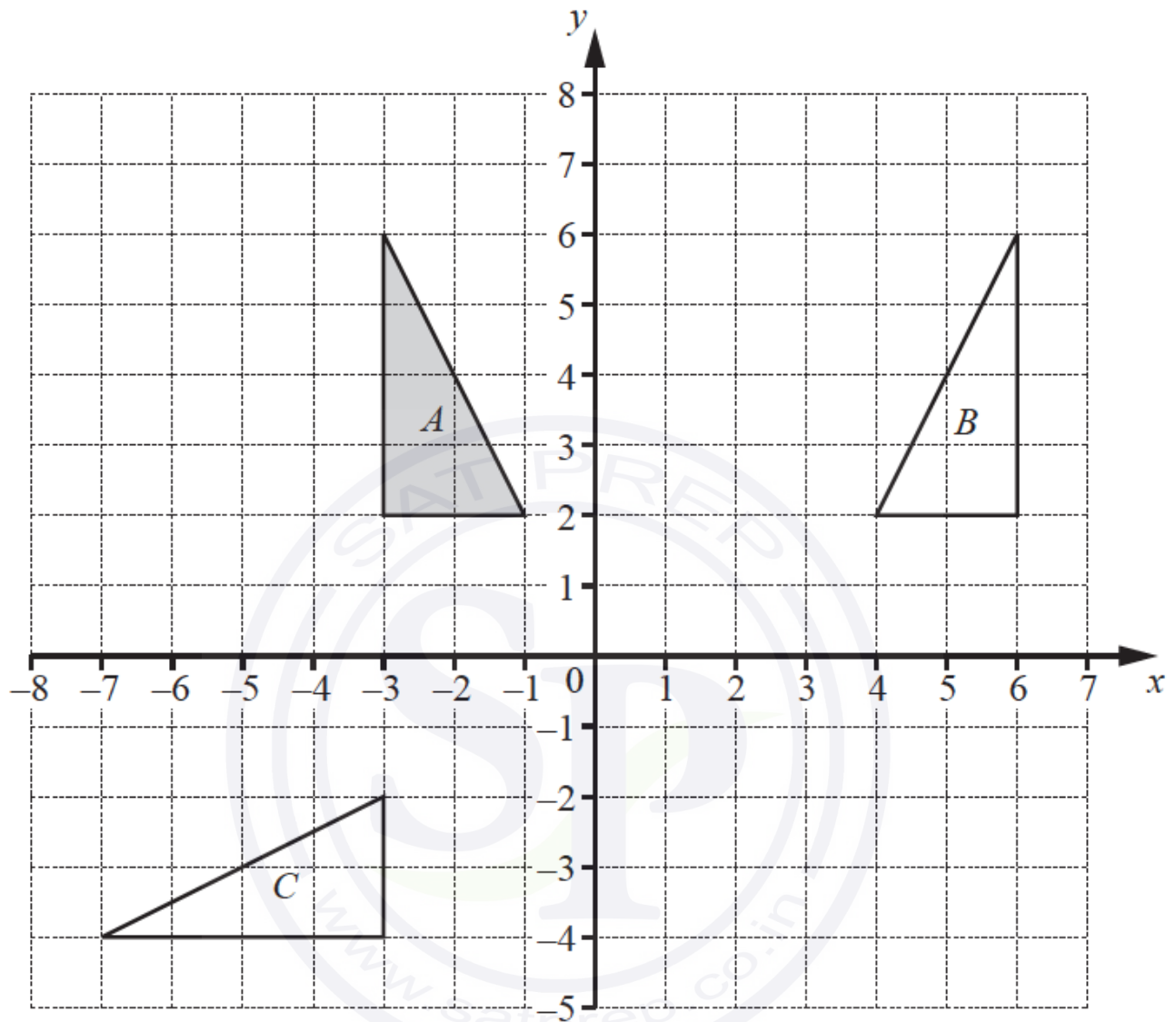
.....  
 ..... [3]

(b) On the grid, draw the image of

(i) triangle *A* after an enlargement, scale factor  $-\frac{1}{2}$ , centre  $(3, 0)$ , [2]

(ii) triangle *A* after a translation by the vector  $\begin{pmatrix} -3 \\ 1 \end{pmatrix}$ , [2]

Question 61



(a) Describe fully the **single** transformation that maps

(i) triangle *A* onto triangle *B*,

.....

..... [2]

Continue on the next page...

(ii) triangle  $A$  onto triangle  $C$ .

.....  
..... [3]

(b) On the grid, draw the image of

(i) triangle  $A$  after an enlargement, scale factor  $-\frac{1}{2}$ , centre  $(3, 0)$ , [2]

(ii) triangle  $A$  after a translation by the vector  $\begin{pmatrix} -3 \\ 1 \end{pmatrix}$ , [2]

Question 62

$f(x) = 7x - 2$        $g(x) = x^2 + 1$        $h(x) = 3^x$

(a) Find  $gh(2)$ .  
..... [2]

(b) Find  $f^{-1}(x)$ .  
 $f^{-1}(x) =$  ..... [2]

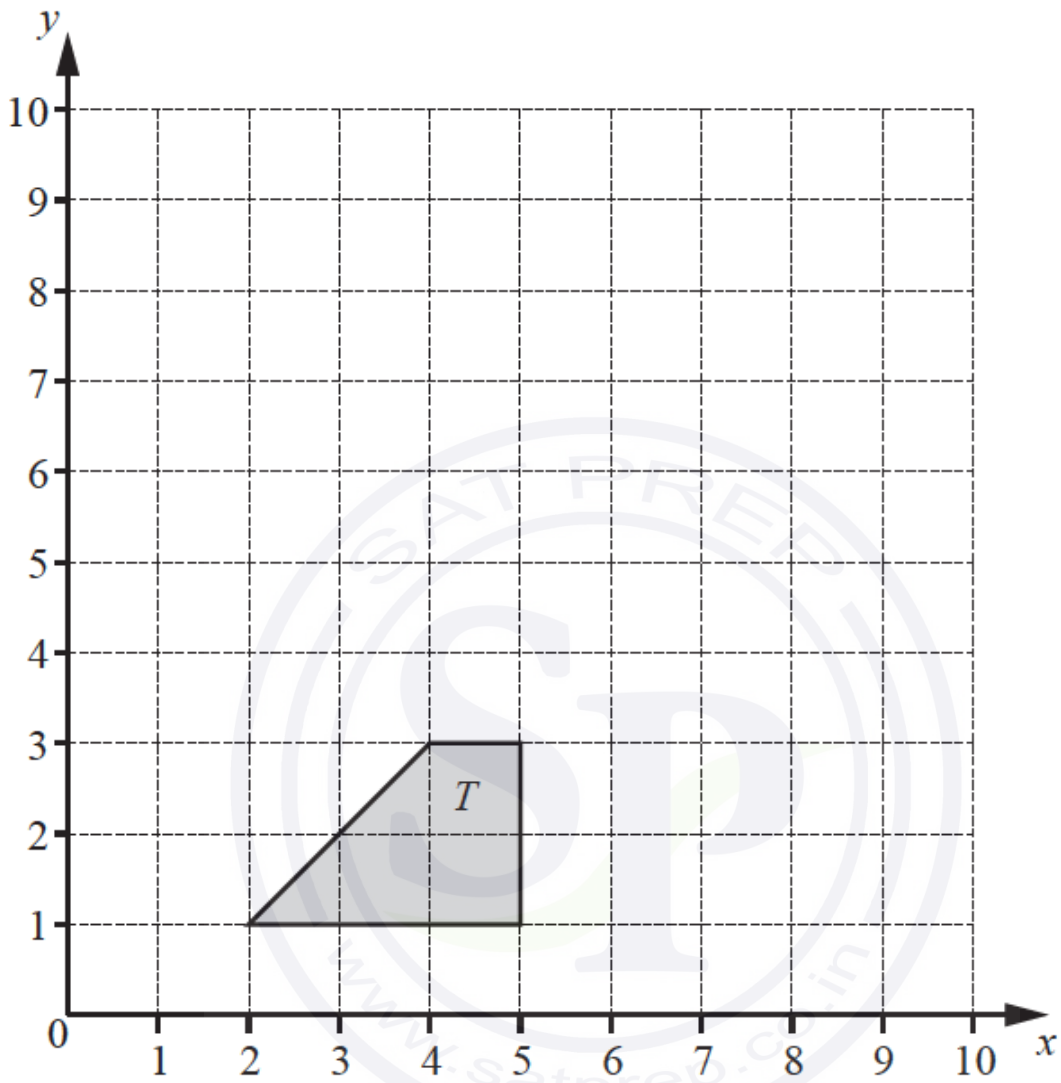
(c)  $gg(x) = ax^4 + bx^2 + c$   
Find the values of  $a$ ,  $b$  and  $c$ .

(c)  $gg(x) = ax^4 + bx^2 + c$   
Find the values of  $a$ ,  $b$  and  $c$ .

$a =$  .....  
 $b =$  .....  
 $c =$  ..... [3]

(d) Find  $x$  when  $hf(x) = 81$ .  
 $x =$  ..... [3]

Question 63



- (a) (i) Translate shape *T* by the vector  $\begin{pmatrix} -1 \\ 6 \end{pmatrix}$ .  
 Label the image *A*. [2]
- (ii) Rotate shape *T* about the point (5, 3) through 180°. Label the image *B*. [2]
- (iii) Describe fully the **single** transformation that maps shape *A* onto shape *B*.  
 ..... [3]  
 .....
- (b) (i) Reflect shape *T* in the line  $y = x$ . [2]

Question 64

$$f(x) = 2x - 3$$

$$g(x) = 9 - x^2$$

$$h(x) = 3^x$$

(a) Find

(i)  $f(4)$ ,

..... [1]

(ii)  $hg(3)$ ,

..... [2]

(iii)  $g(2x)$  in its simplest form,

..... [1]

(iv)  $fg(x)$  in its simplest form.

..... [2]

(b) Find  $f^{-1}(x)$ .

$f^{-1}(x) =$  ..... [2]

(c) Find  $x$  when  $5f(x) = 3$ .

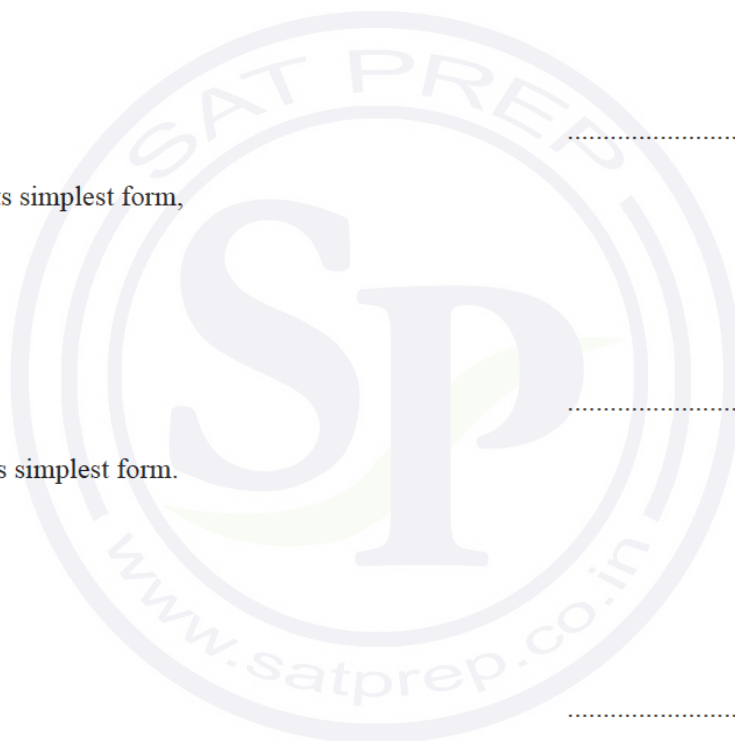
$x =$  ..... [2]

(d) Solve the equation  $gf(x) = -16$ .

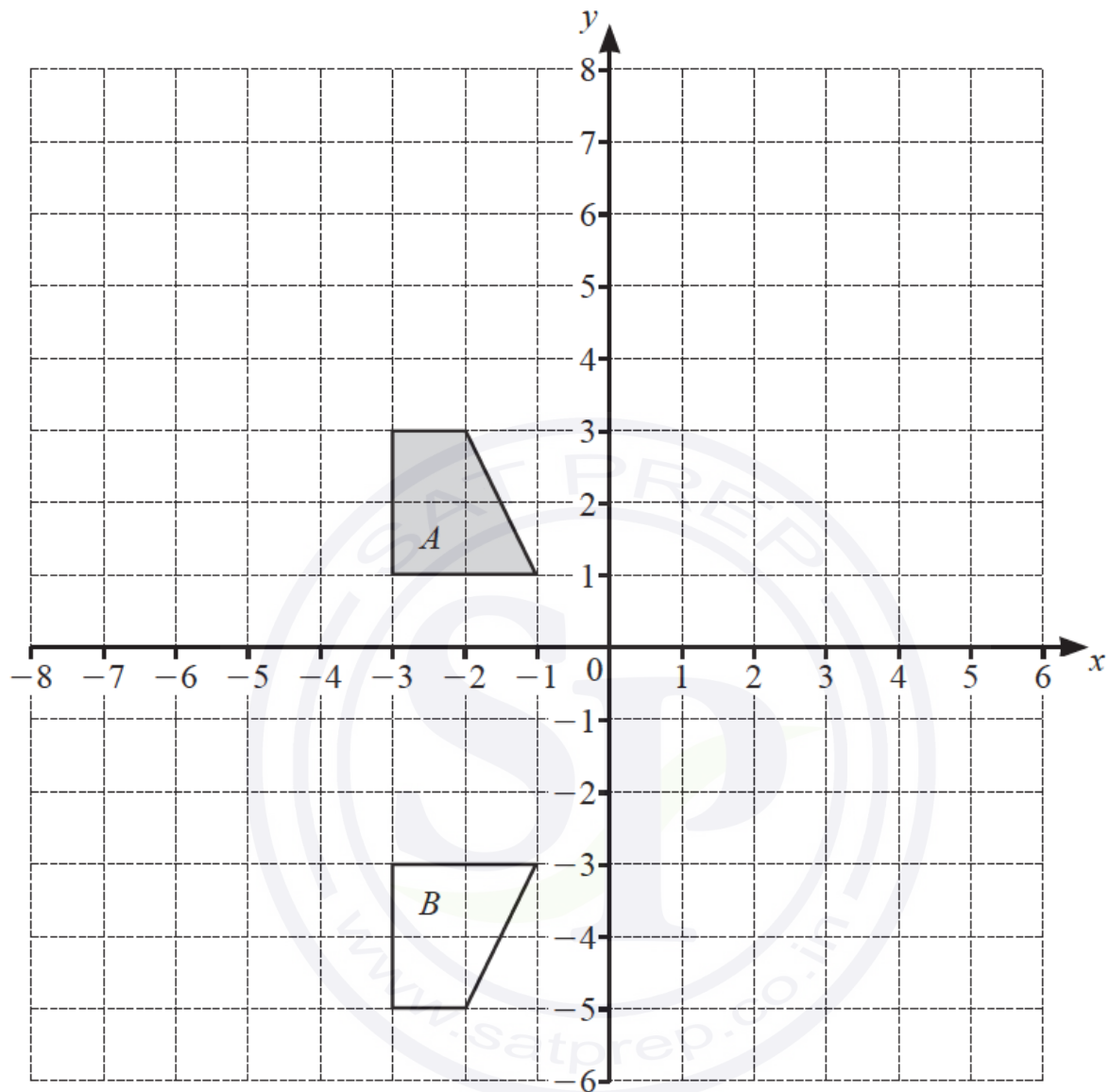
$x =$  ..... or  $x =$  ..... [4]

(e) Find  $x$  when  $h^{-1}(x) = -2$ .

$x =$  ..... [1]



Question 65



(a) Describe fully the **single** transformation that maps shape *A* onto shape *B*.

.....  
 ..... [2]

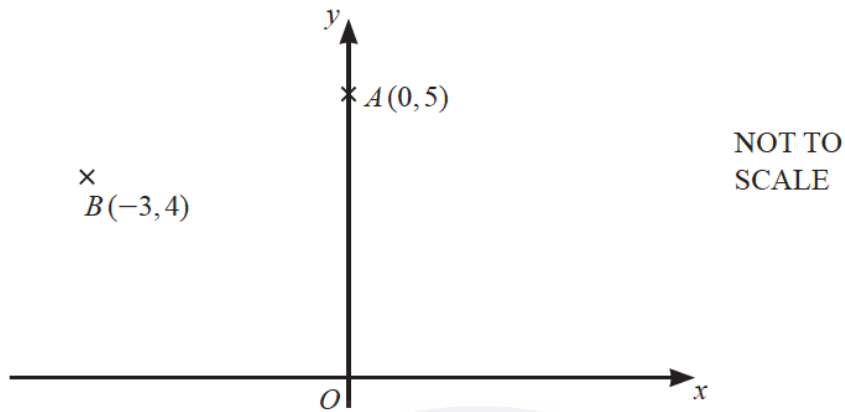
(b) On the grid, draw the image of

(i) shape *A* after a translation by the vector  $\begin{pmatrix} -3 \\ 4 \end{pmatrix}$ , [2]

(ii) shape *A* after a rotation through  $180^\circ$  about  $(0, 0)$ , [2]

(iii) shape *A* after an enlargement, scale factor 2, centre  $(-7, 0)$ . [2]

Question 66



(i) Write  $\vec{OA}$  as a column vector.

$$\vec{OA} = \begin{pmatrix} \phantom{0} \\ \phantom{0} \end{pmatrix} \quad [1]$$

(ii) Write  $\vec{AB}$  as a column vector.

$$\vec{AB} = \begin{pmatrix} \phantom{0} \\ \phantom{0} \end{pmatrix} \quad [1]$$

(iii)  $A$  and  $B$  lie on a circle, centre  $O$ .

Calculate the length of the arc  $AB$ .

..... [6]



Question 67

$$f(x) = 7 - 2x \qquad g(x) = \frac{10}{x}, x \neq 0 \qquad h(x) = 27^x$$

(a) Find

(i)  $f(-3)$ ,

..... [1]

(ii)  $hg(30)$ ,

..... [2]

(iii)  $f^{-1}(x)$ .

$f^{-1}(x) =$  ..... [2]

(b) Solve.

$$g(2x + 1) = 4$$

$x =$  ..... [3]

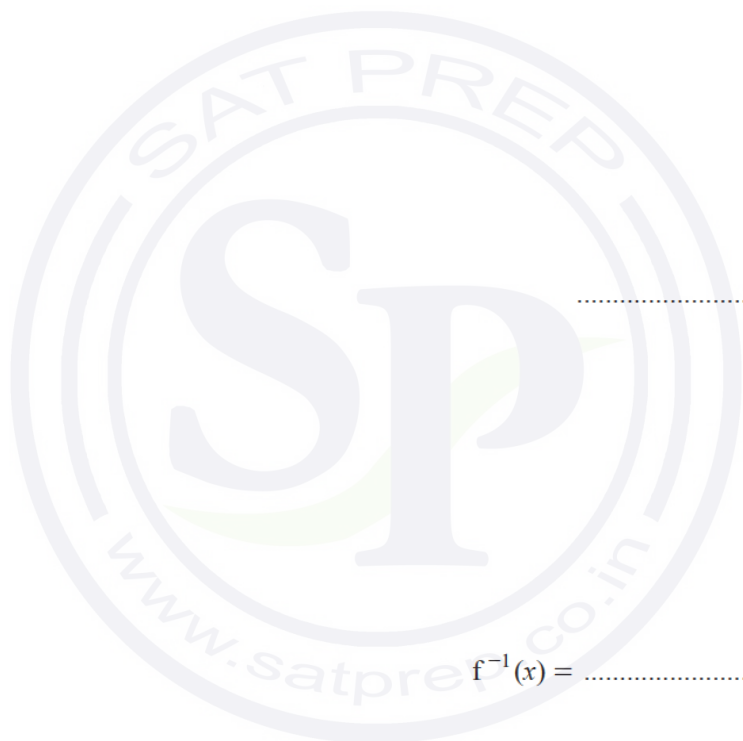
(c) Simplify, giving your answer as a single fraction.

$$\frac{1}{f(x)} + g(x)$$

..... [3]

(d) Find  $h^{-1}(19\,683)$ .

..... [1]



Question 68

A line joins  $A (1, 3)$  to  $B (5, 8)$ .

- (a) (i) Find the midpoint of  $AB$ .

(....., ..... ) [2]

- (ii) Find the equation of the line  $AB$ .  
Give your answer in the form  $y = mx + c$ .

$y =$  ..... [3]

- (b) The line  $AB$  is transformed to the line  $PQ$ .

Find the co-ordinates of  $P$  and the co-ordinates of  $Q$  after  $AB$  is transformed by

- (i) a translation by the vector  $\begin{pmatrix} 5 \\ -2 \end{pmatrix}$ ,

$P$  (....., .....)

$Q$  (....., .....) [2]

- (ii) a rotation through  $90^\circ$  anticlockwise about the origin,

$P$  (....., .....)

$Q$  (....., .....) [2]

- (iii) a reflection in the line  $x = 2$ ,

$P$  (....., .....)

$Q$  (....., .....) [2]

Continue on them next ...

Question 69

$$f(x) = 4x - 1$$

$$g(x) = x^2$$

$$h(x) = 3^{-x}$$

(a) Find in its simplest form

(i)  $f(x-3)$ ,

..... [1]

(ii)  $g(5x)$ .

..... [1]

(b) Find  $f^{-1}(x)$ .

$f^{-1}(x) =$  ..... [2]

(c) Find the value of  $hh(1)$ , correct to 4 significant figures.

..... [3]

(d) (i) Show that  $g(3x-2) - h(-3)$  can be written as  $9x^2 - 12x - 23$ .

[2]

(ii) Use the quadratic formula to solve  $9x^2 - 12x - 23 = 0$ .  
Give your answers correct to 2 decimal places.

$x =$  ..... or  $x =$  ..... [4]

(e) Find  $x$  when  $f(61) = h(x)$ .

$x =$  ..... [2]

Question 70

$$f(x) = 7x - 4$$

$$g(x) = \frac{2x}{x-3}, x \neq 3$$

$$h(x) = x^2$$

(a) Find  $g(6)$ .

..... [1]

(b) Find  $fg(4)$ .

..... [2]

(c) Find  $fh(x)$ .

..... [1]

(d) Find  $\frac{f(x)}{2} + g(x)$ .

Give your answer as a single fraction, in terms of  $x$ , in its simplest form.

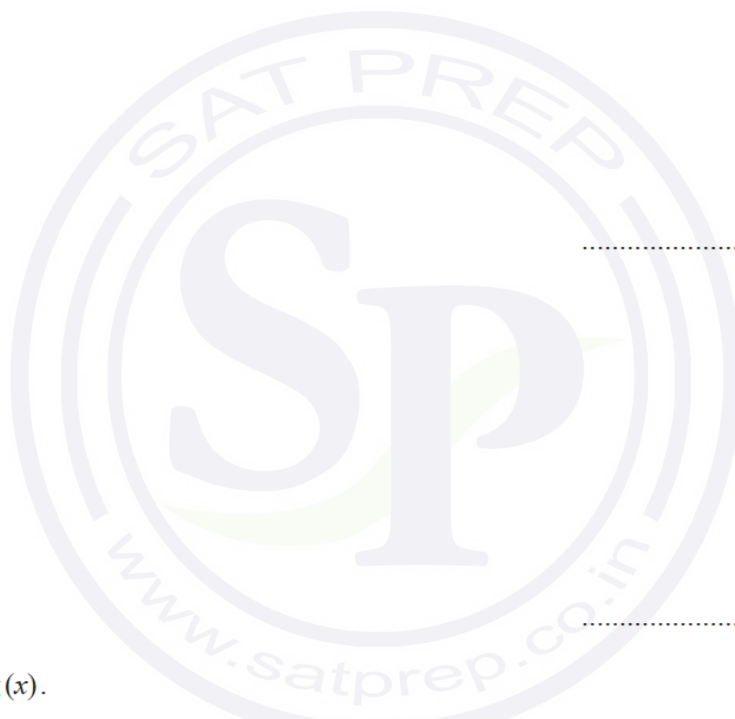
..... [3]

(e) Find the value of  $x$  when  $f(x+2) = -11$ .

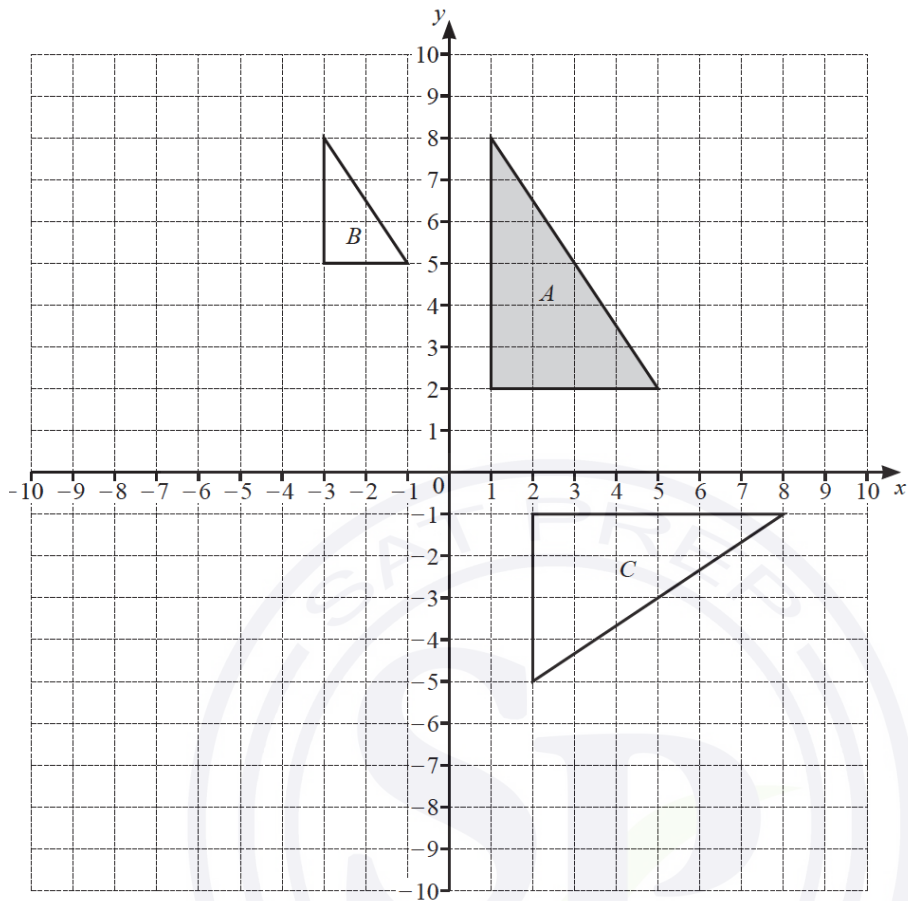
$x =$  ..... [2]

(f) Find the values of  $p$  that satisfy  $h(p) = p$ .

..... [2]



Question 71



(a) (i) Draw the image of triangle  $A$  after a reflection in the line  $y = -x$ . [2]

(ii) Draw the image of triangle  $A$  after a translation by the vector  $\begin{pmatrix} -2 \\ -9 \end{pmatrix}$ . [2]

(b) Describe fully the **single** transformation that maps

(i) triangle  $A$  onto triangle  $B$ ,

.....  
 ..... [3]

(ii) triangle  $A$  onto triangle  $C$ .

.....  
 ..... [3]

Question 72

$$f(x) = 3x + 2 \qquad g(x) = x^2 + 1 \qquad h(x) = 4^x$$

(a) Find  $h(4)$ .

..... [1]

(b) Find  $fg(1)$ .

..... [2]

(c) Find  $gf(x)$  in the form  $ax^2 + bx + c$ .

..... [3]

(d) Find  $x$  when  $f(x) = g(7)$ .

$x =$  ..... [2]

(e) Find  $f^{-1}(x)$ .

$f^{-1}(x) =$  ..... [2]

(f) Find  $\frac{g(x)}{f(x)} + x$ .

Give your answer as a single fraction, in terms of  $x$ , in its simplest form.

..... [3]

(g) Find  $x$  when  $h^{-1}(x) = 2$ .

$x =$  ..... [1]

Question 73

(a)  $\mathbf{p} = \begin{pmatrix} 4 \\ 5 \end{pmatrix}$      $\mathbf{q} = \begin{pmatrix} -2 \\ 7 \end{pmatrix}$

(i) Find  $2\mathbf{p} + \mathbf{q}$ .

$\left( \begin{array}{c} \phantom{0} \\ \phantom{0} \end{array} \right)$  [2]

(ii) Find  $|\mathbf{p}|$ .

..... [2]

(b)  $A$  is the point  $(4, 1)$  and  $\vec{AB} = \begin{pmatrix} -3 \\ 1 \end{pmatrix}$ .

Find the coordinates of  $B$ .

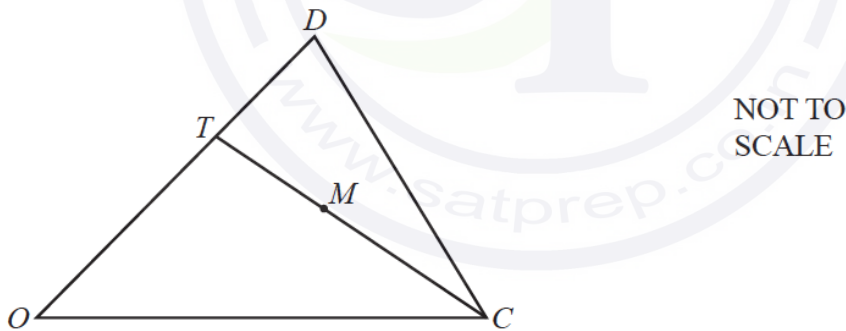
(....., .....) [1]

(c) The line  $y = 3x - 2$  crosses the  $y$ -axis at  $G$ .

Write down the coordinates of  $G$ .

(....., .....) [1]

(d)



In the diagram,  $O$  is the origin,  $OT = 2TD$  and  $M$  is the midpoint of  $TC$ .

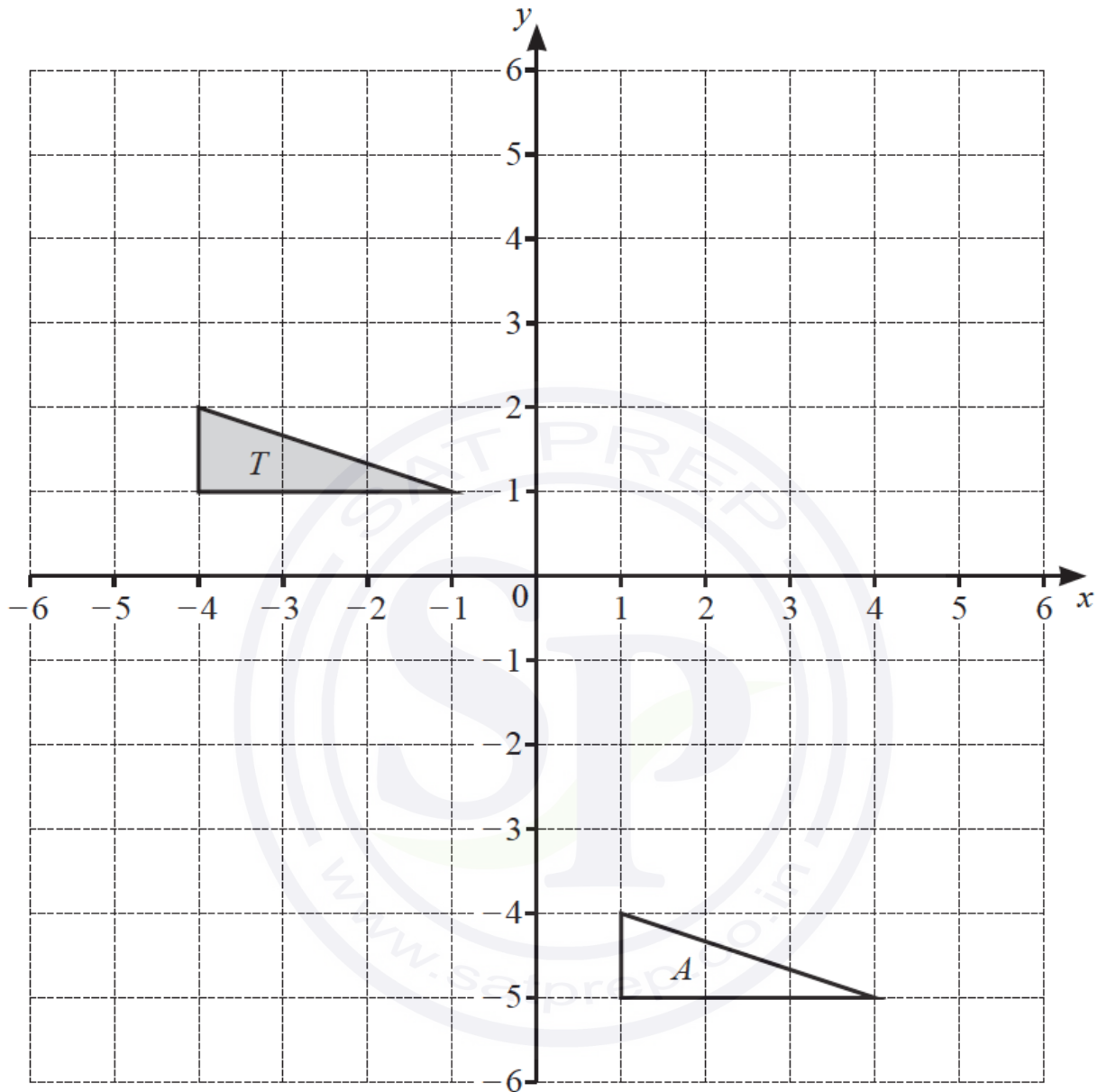
$\vec{OC} = \mathbf{c}$  and  $\vec{OD} = \mathbf{d}$ .

Find the position vector of  $M$ .

Give your answer in terms of  $\mathbf{c}$  and  $\mathbf{d}$  in its simplest form.

..... [3]

Question 74



- (a) Draw the image of triangle  $T$  after a reflection in the line  $y = -1$ . [2]
- (b) Draw the image of triangle  $T$  after a rotation through  $90^\circ$  clockwise about  $(0, 0)$ . [2]
- (c) Describe fully the **single** transformation that maps triangle  $T$  onto triangle  $A$ .

..... [2]

.....



Question 75

$f(x) = 4 - 3x$        $g(x) = x^2 + x$        $h(x) = 3^x$

(a) Find  $fh(2)$ .

..... [2]

(b) Find  $f^{-1}(x)$ .

$f^{-1}(x) =$  ..... [2]

(c) Simplify.

(i)  $f(1 - 2x)$

..... [2]

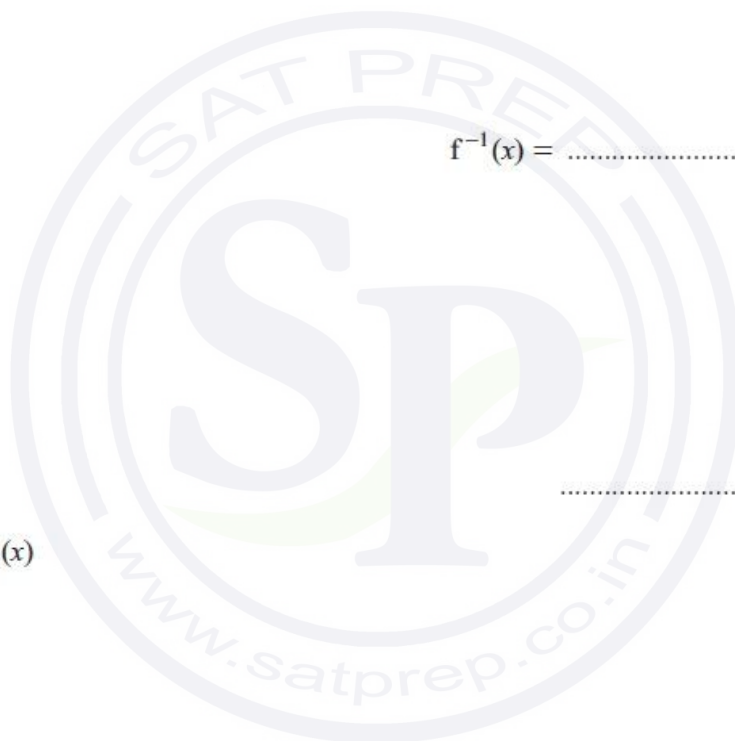
(ii)  $gf(x) - 9g(x)$

..... [4]

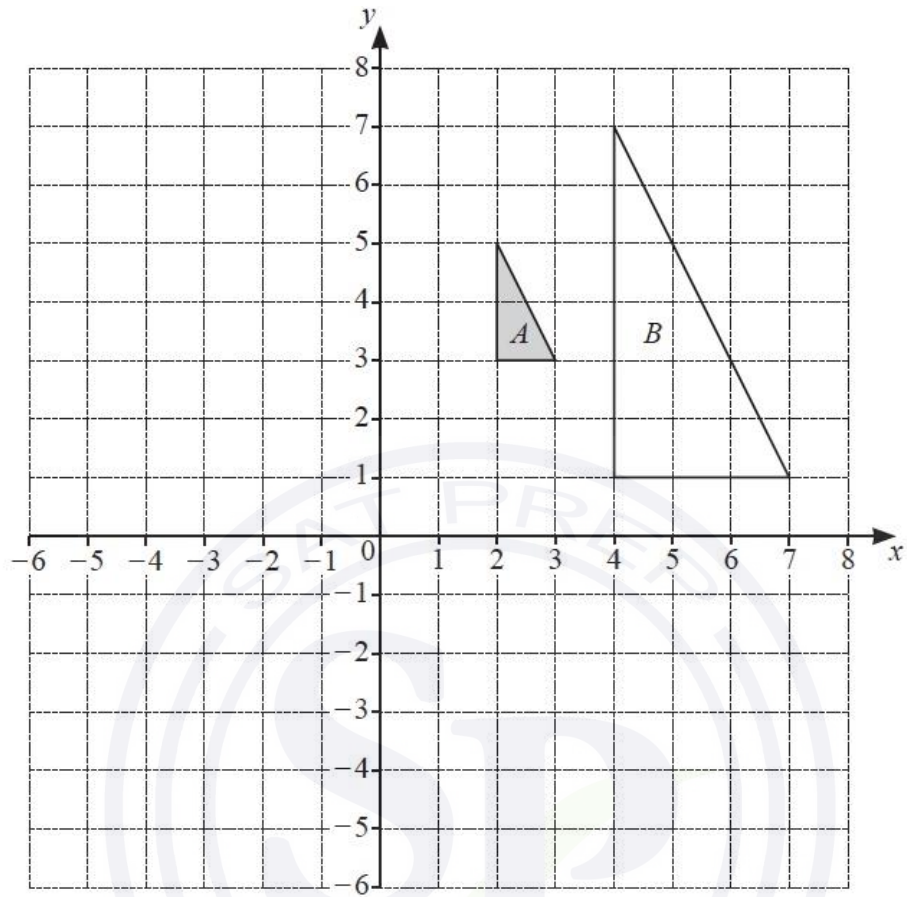
(d)  $\frac{1}{h(x)} = 9^{kx}$

Find the value of  $k$ .

$k =$  ..... [2]



Question 76



- (a) On the grid, draw the image of
- (i) triangle  $A$  after a rotation of  $90^\circ$  anticlockwise about  $(0, 0)$ . [2]
  - (ii) triangle  $A$  after a translation by the vector  $\begin{pmatrix} 3 \\ -5 \end{pmatrix}$ . [2]
- (b) Describe fully the **single** transformation that maps triangle  $A$  onto triangle  $B$ .
- .....
- ..... [3]

Question 77

$$f(x) = x^2 + 1 \quad g(x) = 1 - 2x \quad h(x) = \frac{1}{x}, \quad x \neq 0 \quad j(x) = 5^x$$

(a) Find the value of

(i)  $f(3)$ ,

..... [1]

(ii)  $gf(3)$ .

..... [1]

(b) Find  $g^{-1}(x)$ .

$g^{-1}(x) =$  ..... [2]

(c) Find  $x$  when  $h(x) = 2$ .

$x =$  ..... [1]

(d) Find  $g(x)g(x) - gg(x)$ , giving your answer in the form  $ax^2 + bx + c$ .

..... [4]

(e) Find  $hh(x)$ , giving your answer in its simplest form.

..... [1]

(f) Find  $j(5)$ .

..... [1]

(g) Find  $x$  when  $j^{-1}(x) = 2$ .

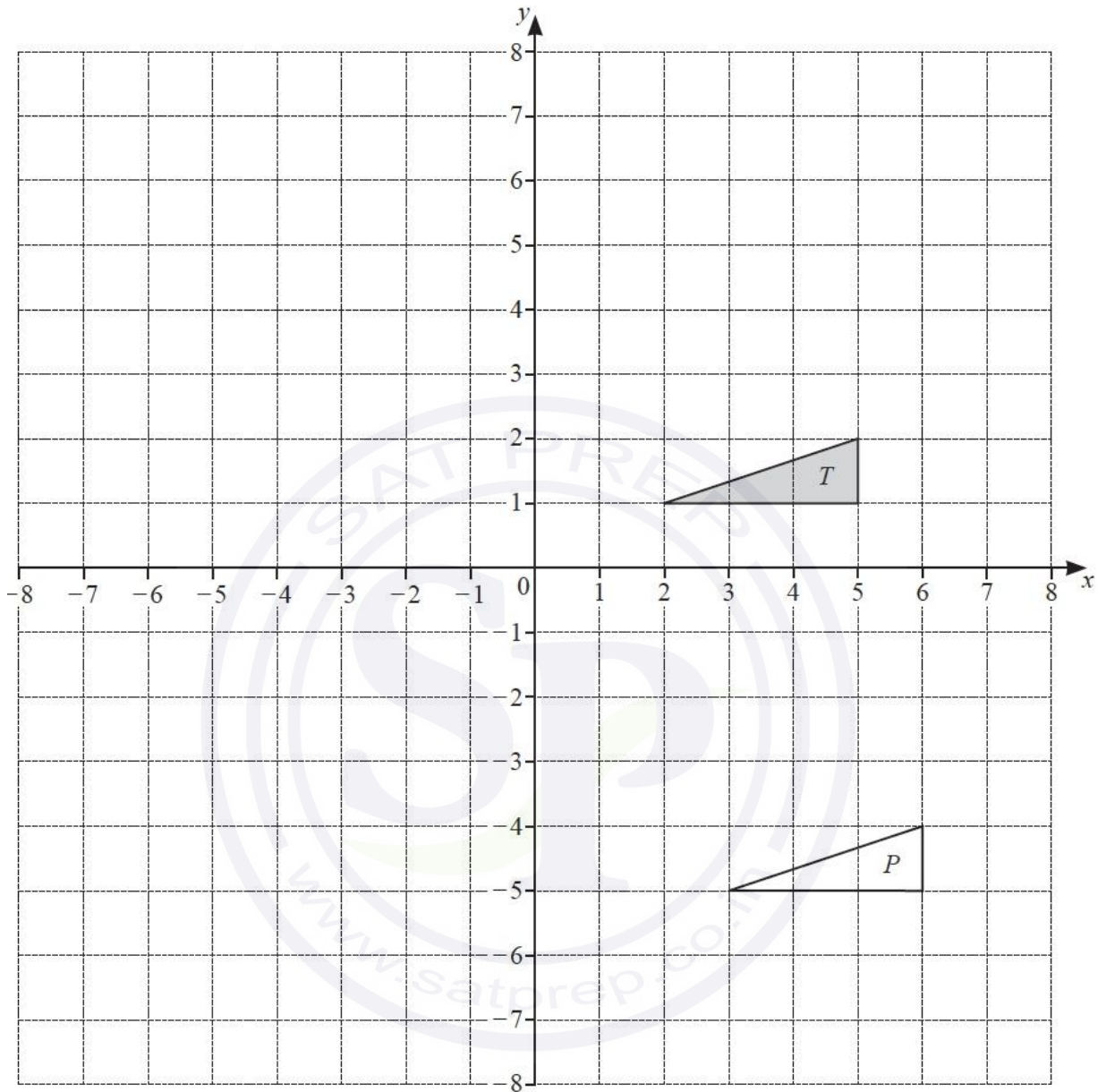
$x =$  ..... [1]

(h)  $j(x) = hg(-12)$

Find the value of  $x$ .

$x =$  ..... [2]

Question 78



(a) Describe fully the **single** transformation that maps triangle  $T$  onto triangle  $P$ .

.....  
 .....

[2]

(b) (i) Reflect triangle  $T$  in the line  $x = 1$ .

[2]

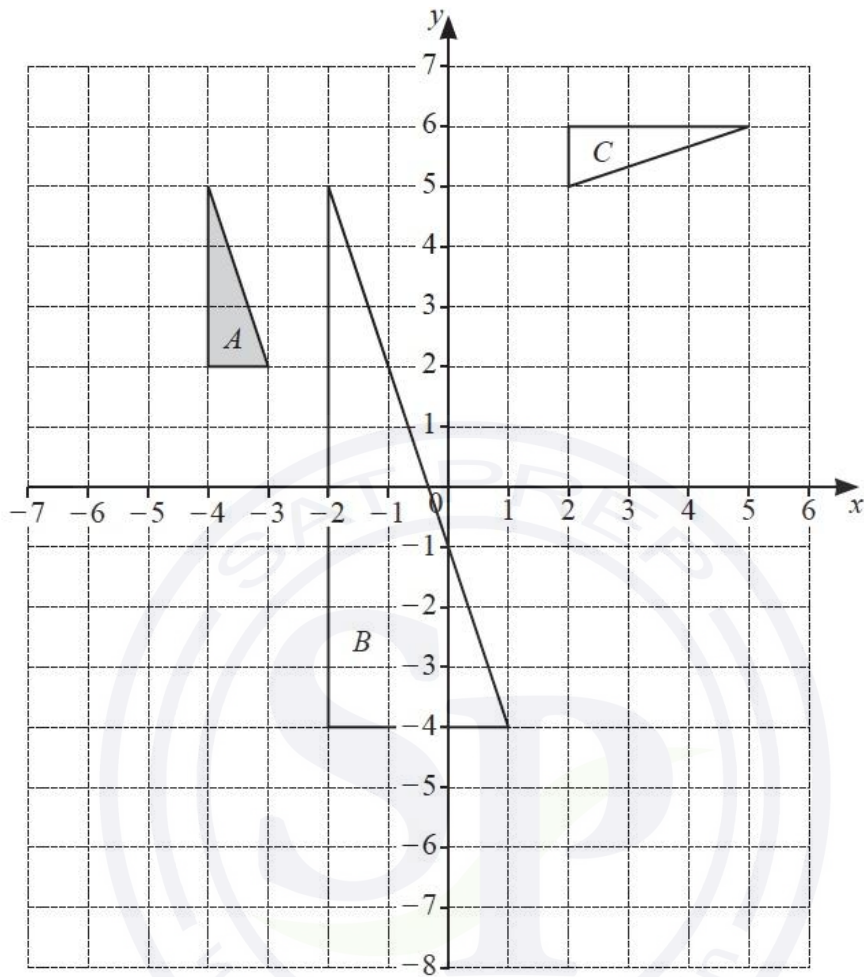
(ii) Rotate triangle  $T$  through  $90^\circ$  anticlockwise about  $(6, 0)$ .

[2]

(iii) Enlarge triangle  $T$  by a scale factor of  $-2$ , centre  $(1, 0)$ .

[2]

Question 79



(a) Draw the image of shape *A* after a translation by the vector  $\begin{pmatrix} 8 \\ -6 \end{pmatrix}$ . [2]

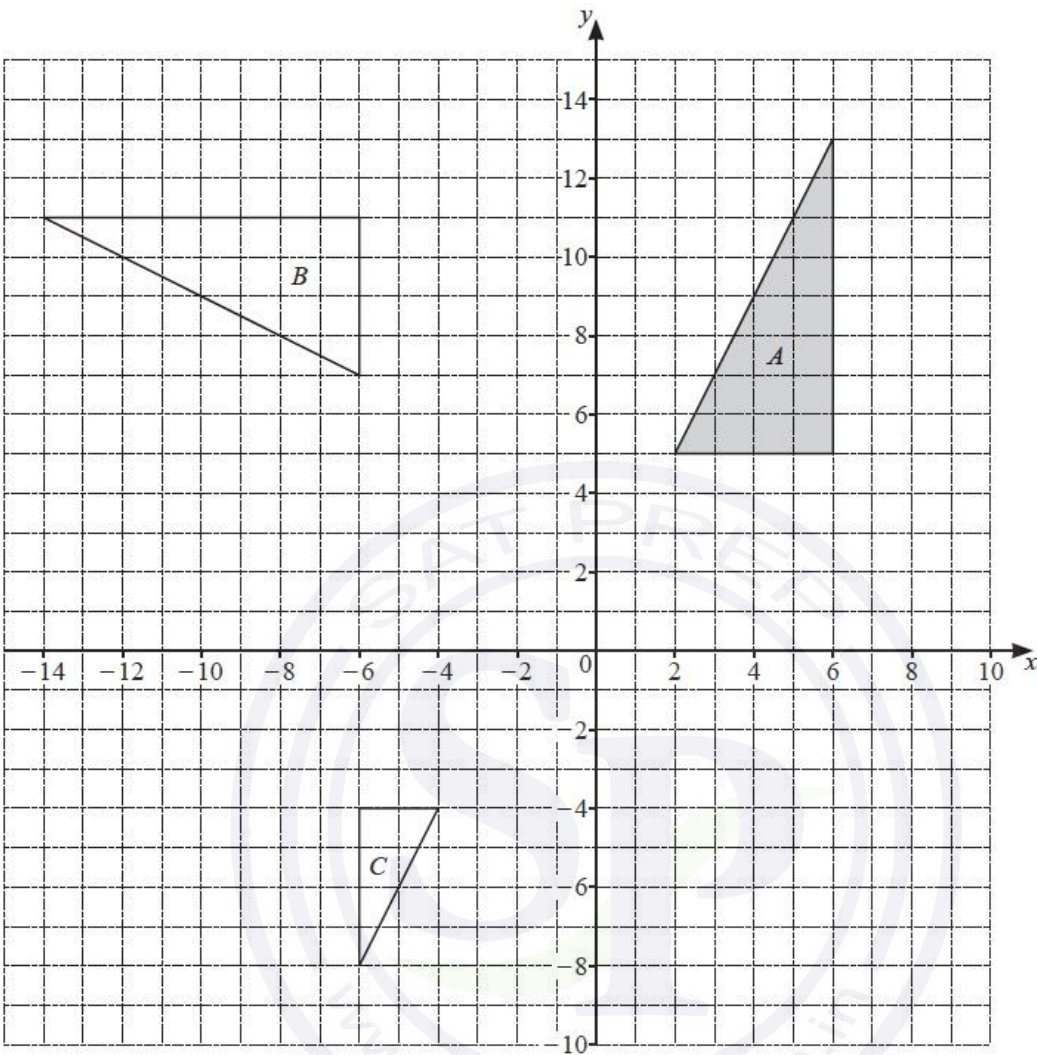
(b) Draw the image of shape *A* after a reflection in the line  $y = -1$ . [2]

(c) Describe fully the **single** transformation that maps shape *A* onto shape *B*.  
 ..... [3]

(d) Describe fully the **single** transformation that maps shape *A* onto shape *C*.  
 ..... [3]



Question 80



(a) Describe fully the **single** transformation that maps

(i) triangle *A* onto triangle *B*,

.....  
 ..... [3]

(ii) triangle *A* onto triangle *C*.

.....  
 ..... [3]

(b) Draw the image of triangle *A* after a translation by the vector  $\begin{pmatrix} -5 \\ -10 \end{pmatrix}$ . [2]

(c) Draw the image of triangle *A* after a reflection in the line  $y = 4$ . [2]

Question 81

$$f(x) = 3x - 2 \quad g(x) = 5x - 7 \quad h(x) = x^2 + x \quad j(x) = 3^x$$

(a) Find

(i)  $f(2)$ ,

..... [1]

(ii)  $g(2)$ ,

..... [1]

(iii)  $gf(2)$ .

..... [1]

(b) Find  $f^{-1}(x)$ .

$f^{-1}(x) =$  ..... [2]

(c) Find  $hf(x)$ , giving your answer in the form  $ax^2 + bx + c$ .

..... [3]

(d) Find the derivative of  $h(x)$ .

..... [1]

(e) (i) Find  $x$  when  $j^{-1}(x) = 4$ .

$x =$  ..... [1]

(ii) Simplify  $j^{-1}j(x)$ .

..... [1]

Question 82

The position vector of  $P$  is  $\begin{pmatrix} -2 \\ 3 \end{pmatrix}$  and the position vector of  $Q$  is  $\begin{pmatrix} -2 \\ 5 \end{pmatrix}$ .

(i) Find the vector  $\vec{PQ}$ .

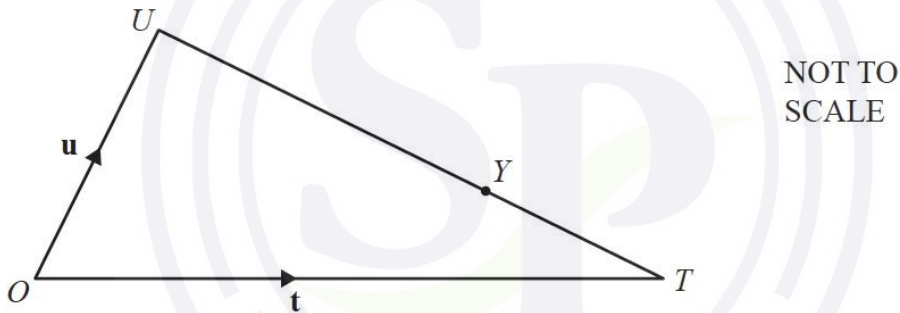
$$\begin{pmatrix} \phantom{0} \\ \phantom{0} \end{pmatrix} \quad [2]$$

(ii)  $R$  is the point such that  $\vec{PR} = 3\vec{PQ}$ .

Find the position vector of  $R$ .

$$\begin{pmatrix} \phantom{0} \\ \phantom{0} \end{pmatrix} \quad [2]$$

Question 83



$\vec{OT} = \mathbf{t}$ ,  $\vec{OU} = \mathbf{u}$  and  $UY = 2YT$ .

(i) Find  $\vec{OY}$  in terms of  $\mathbf{t}$  and  $\mathbf{u}$ .  
Give your answer in its simplest form.

$$\vec{OY} = \dots\dots\dots [2]$$

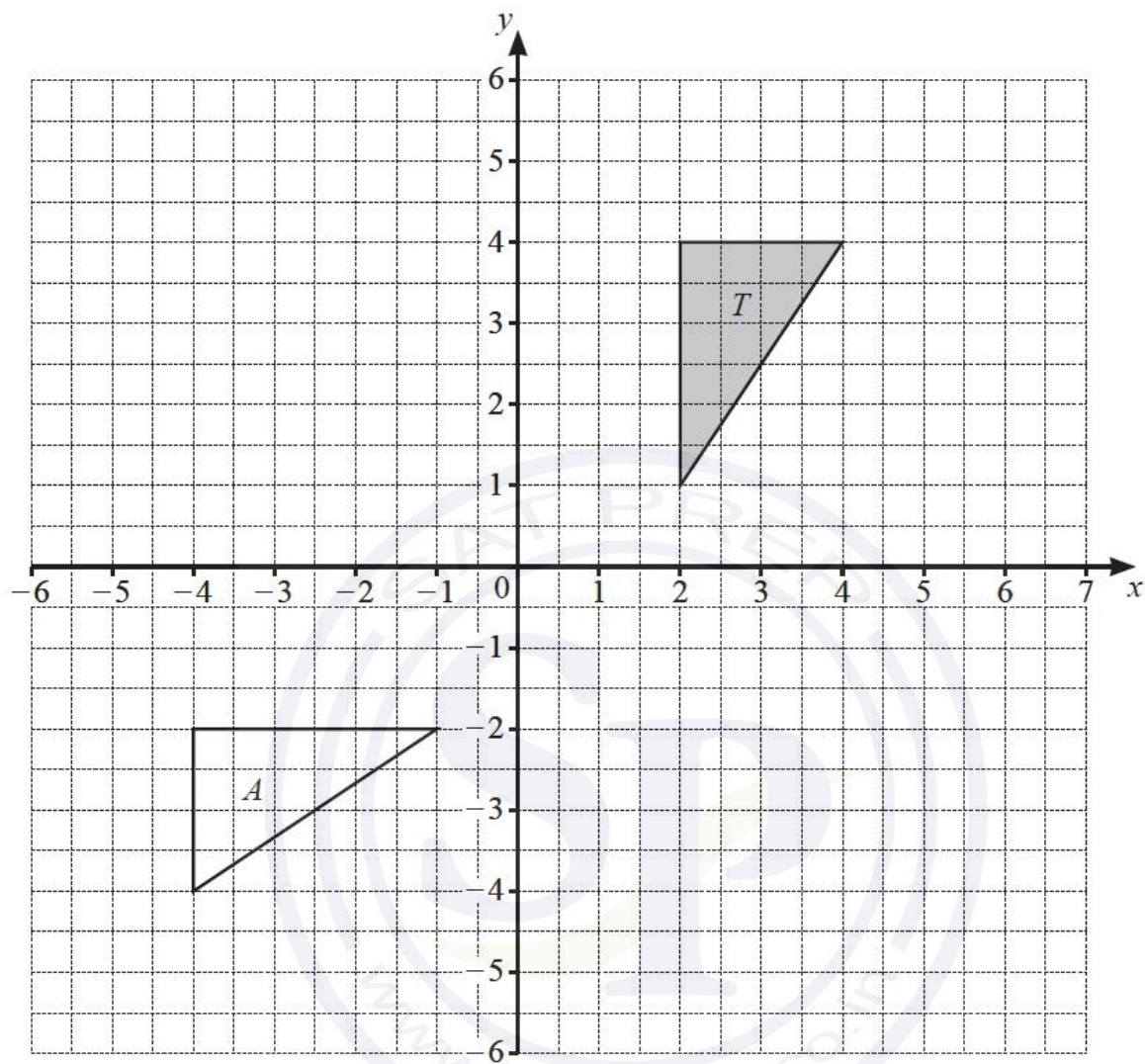
(ii)  $Z$  is on  $OT$  and  $YZ$  is parallel to  $UO$ .

Find  $\vec{OZ}$  in terms of  $\mathbf{t}$  and/or  $\mathbf{u}$ .  
Give your answer in its simplest form.

$$\vec{OZ} = \dots\dots\dots [1]$$



Question 84



- (a) On the grid, draw the image of
- (i) triangle  $T$  after a translation by the vector  $\begin{pmatrix} 2 \\ -1 \end{pmatrix}$ , [2]
  - (ii) triangle  $T$  after a rotation,  $90^\circ$  clockwise, about the origin, [2]
  - (iii) triangle  $T$  after an enlargement, scale factor  $-\frac{1}{2}$ , centre  $(-2, 3)$ . [2]
- (b) Describe fully the **single** transformation that maps triangle  $T$  onto triangle  $A$ .
- .....
- ..... [2]

Question 85

(a)  $\mathbf{a} = \begin{pmatrix} -3 \\ 8 \end{pmatrix}$     $\mathbf{b} = \begin{pmatrix} 2 \\ -5 \end{pmatrix}$

(i) Find

(a)  $\mathbf{b} - \mathbf{a}$ ,

$\begin{pmatrix} \phantom{0} \\ \phantom{0} \end{pmatrix}$  [1]

(b)  $2\mathbf{a} + \mathbf{b}$ ,

$\begin{pmatrix} \phantom{0} \\ \phantom{0} \end{pmatrix}$  [2]

(c)  $|\mathbf{b}|$ .

..... [2]

(ii)  $\mathbf{a} + k\mathbf{b} = \begin{pmatrix} 13 \\ m \end{pmatrix}$ , where  $k$  and  $m$  are integers.

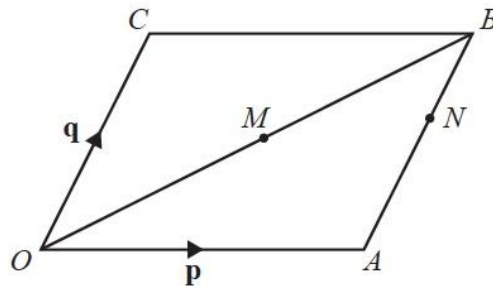
Find the value of  $k$  and the value of  $m$ .

$k =$  .....

$m =$  ..... [3]

Continue on the next page...

(b)



NOT TO SCALE

$OACB$  is a parallelogram and  $O$  is the origin.  
 $M$  is the midpoint of  $OB$ .  
 $N$  is the point on  $AB$  such that  $AN : NB = 3 : 2$ .  
 $\vec{OA} = \mathbf{p}$  and  $\vec{OC} = \mathbf{q}$ .

(i) Find, in terms of  $\mathbf{p}$  and  $\mathbf{q}$ , in its simplest form.

(a)  $\vec{OB}$

$\vec{OB} = \dots\dots\dots$  [1]

(b)  $\vec{CM}$

$\vec{CM} = \dots\dots\dots$  [2]

(c)  $\vec{MN}$

$\vec{MN} = \dots\dots\dots$  [2]

(ii)  $CB$  and  $ON$  are extended to meet at  $D$ .

Find the position vector of  $D$  in terms of  $\mathbf{p}$  and  $\mathbf{q}$ .  
Give your answer in its simplest form.

$\dots\dots\dots$  [3]

Question 86

$$f(x) = 3 - 2x \qquad g(x) = x^2 + 5 \qquad h(x) = x^3$$

(a) Find  $f(-5)$ .  
 ..... [1]

(b) Find  $ff(x)$ .  
 Give your answer in its simplest form.  
 ..... [2]

(c) Solve  $g(x) = f(x) + 37$ .  
 $x = \dots\dots\dots$  or  $x = \dots\dots\dots$  [4]

(d) Find  $f^{-1}(x)$ .  
 $f^{-1}(x) = \dots\dots\dots$  [2]

(e) Find  $hf(x) + g(x)$ .  
 Give your answer in its simplest form.  
 ..... [5]

Question 87

$$f(x) = 2x - 1 \qquad g(x) = x^2 + 2x \qquad h(x) = 4^x \qquad j(x) = 2^x$$

(a) Find the value of  
 (i)  $h(3)$ ,  
 ..... [1]

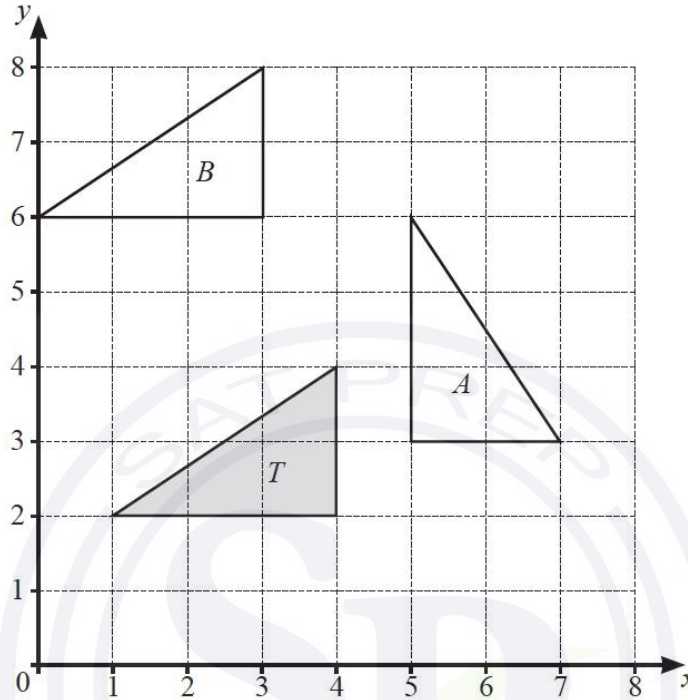
(ii)  $fh(3)$ .  
 ..... [1]

(b) Solve the equation  $gf(x) = 0$ .  
 $x = \dots\dots\dots$  or  $x = \dots\dots\dots$  [4]

(c)  $p^{-1}(x) = f(x)$   
 Find  $p(x)$ .  
 ..... [2]

Question 88

The diagram shows three triangles,  $T$ ,  $A$ , and  $B$ , drawn on a  $1 \text{ cm}^2$  grid.



- (a) Describe fully the **single** transformation that maps triangle  $T$  onto triangle  $A$ .

.....  
 ..... [3]

- (b) (i) Describe fully the **single** transformation that maps triangle  $T$  onto triangle  $B$ .

.....  
 ..... [2]

- (ii) Calculate the distance that each point of triangle  $T$  moves when it is mapped onto triangle  $B$ .

..... cm [2]

Question 89

(a)  $F$  is the point  $(5, -2)$  and  $\vec{FG} = \begin{pmatrix} -2 \\ 3 \end{pmatrix}$ .

Find

(i) the coordinates of point  $G$ ,

(....., .....) [1]

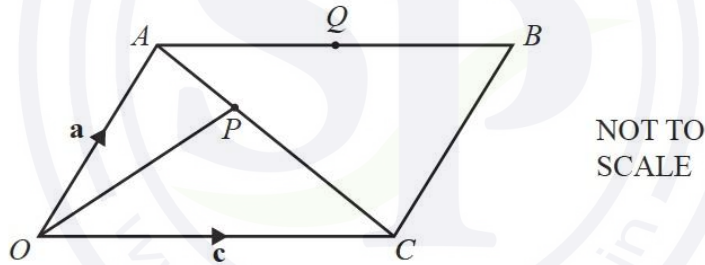
(ii)  $5\vec{FG}$ ,

$\begin{pmatrix} \phantom{0} \\ \phantom{0} \end{pmatrix}$  [1]

(iii)  $|\vec{FG}|$ .

..... [2]

(b)



$OACB$  is a parallelogram.

$P$  is a point on  $AC$  and  $Q$  is the midpoint of  $AB$ .

$\vec{OA} = \mathbf{a}$  and  $\vec{OC} = \mathbf{c}$ .

(i) Find, in terms of  $\mathbf{a}$  and/or  $\mathbf{c}$

(a)  $\vec{AQ}$ ,

$\vec{AQ} = \dots\dots\dots$  [1]

(b)  $\vec{OQ}$ .

Continue on the next page...

$$\overrightarrow{OQ} = \dots\dots\dots [1]$$

(ii)  $\overrightarrow{OP} = \frac{2}{3}\mathbf{a} + \frac{1}{3}\mathbf{c}$

(a) Show that  $O, P$  and  $Q$  lie on a straight line.

[2]

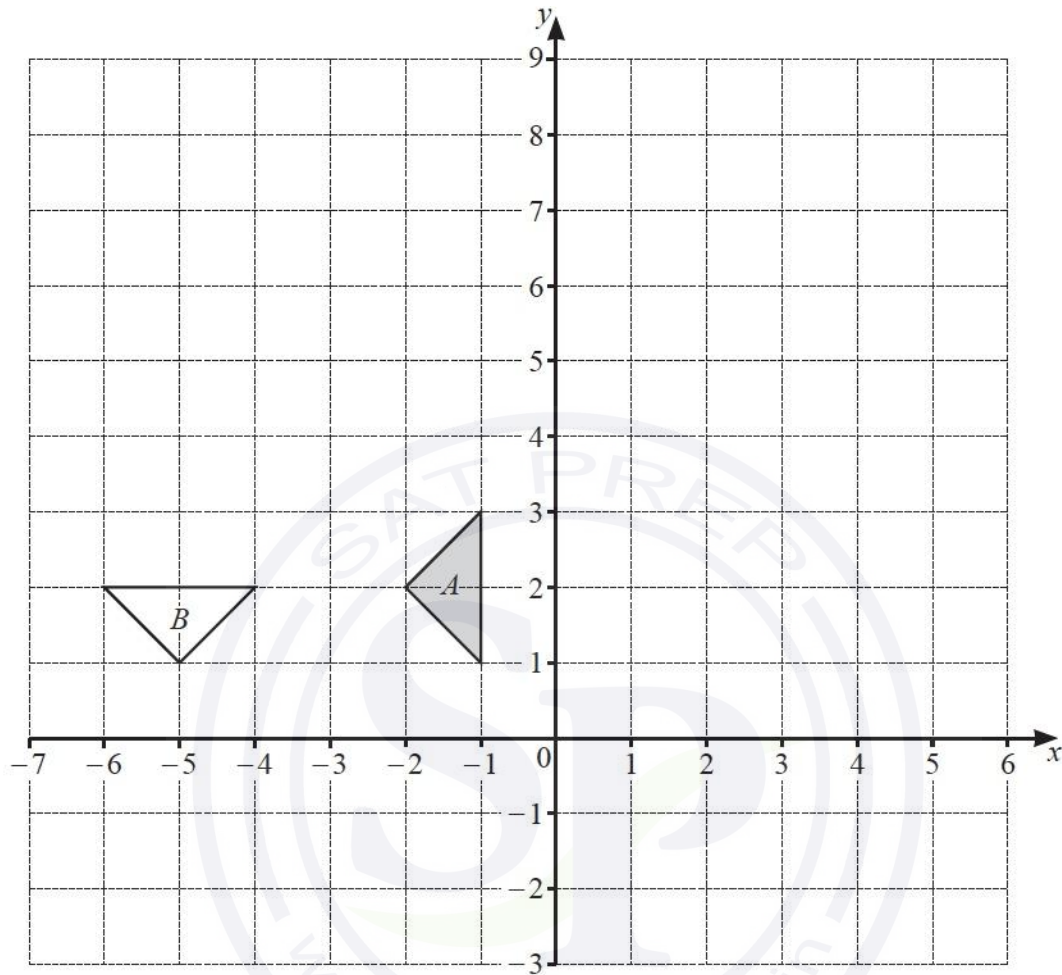
(b) Write down the ratio  $OP : OQ$ .  
Give your answer in the form  $1 : n$ .

1 :  $\dots\dots\dots$  [1]





Question 90



- (a) On the grid, draw the image of triangle  $A$  after
- (i) a translation by the vector  $\begin{pmatrix} -4 \\ 5 \end{pmatrix}$ , [2]
  - (ii) a reflection in the line  $x = 1$ , [2]
  - (iii) an enlargement, scale factor 2 and centre  $(-5, -2)$ . [2]

(b) Describe fully the **single** transformation that maps triangle  $A$  onto triangle  $B$ .

.....  
 ..... [3]



Question 91

$$f(x) = 3 - 5x$$

(i) Find  $x$  when  $f(x) = -5$ .

$$x = \dots\dots\dots [2]$$

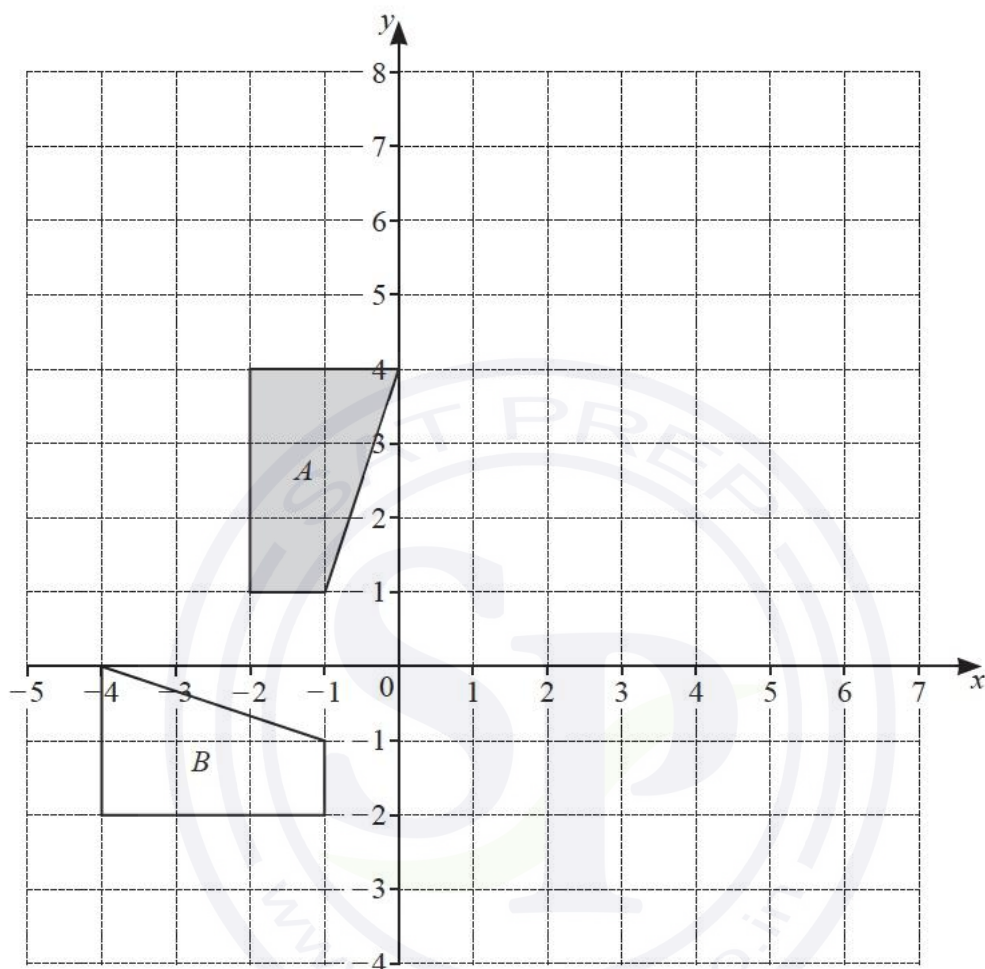
(ii) Find  $f^{-1}(x)$ .

$$f^{-1}(x) = \dots\dots\dots [2]$$



Question 92

(a)

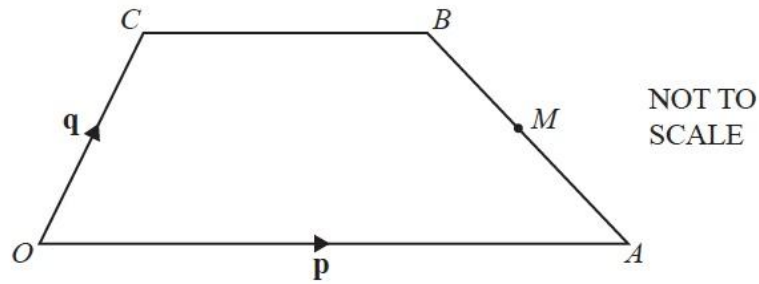


- (i) On the grid, draw the image of
  - (a) shape *A* after an enlargement, scale factor 2, centre (0, 1). [2]
  - (b) shape *A* after a reflection in the line  $y = x - 1$ . [3]

(ii) Describe fully the **single** transformation that maps shape *A* onto shape *B*.  
.....  
..... [3]

Continue on the next page...

(b)



$OABC$  is a trapezium and  $O$  is the origin.

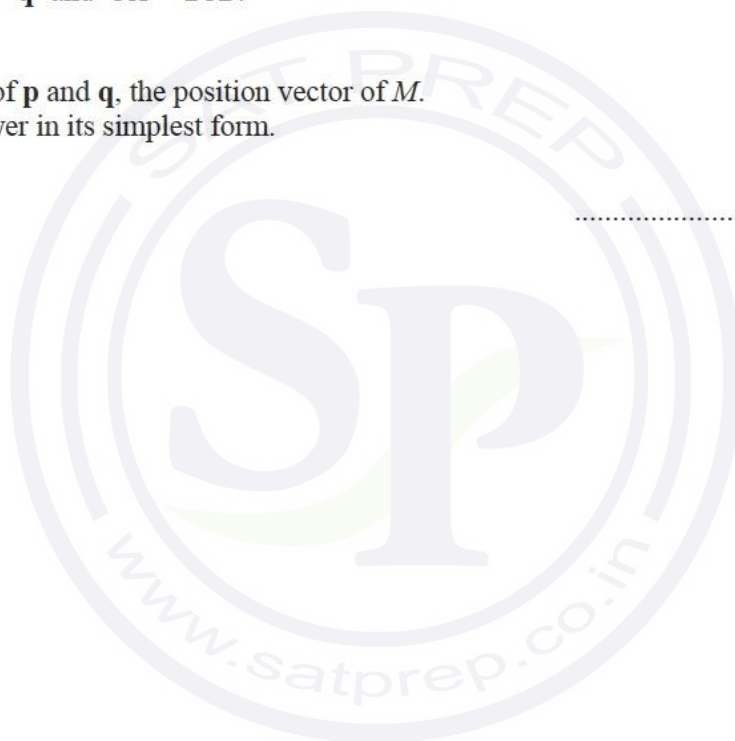
$M$  is the midpoint of  $AB$ .

$\vec{OA} = \mathbf{p}$ ,  $\vec{OC} = \mathbf{q}$  and  $OA = 2CB$ .

Find, in terms of  $\mathbf{p}$  and  $\mathbf{q}$ , the position vector of  $M$ .

Give your answer in its simplest form.

..... [3]



Question 93

$$f(x) = 1 + 4x$$

$$g(x) = x^2$$

(a) Find

(i)  $gf(3)$ ,

..... [2]

(ii)  $fg(x)$ ,

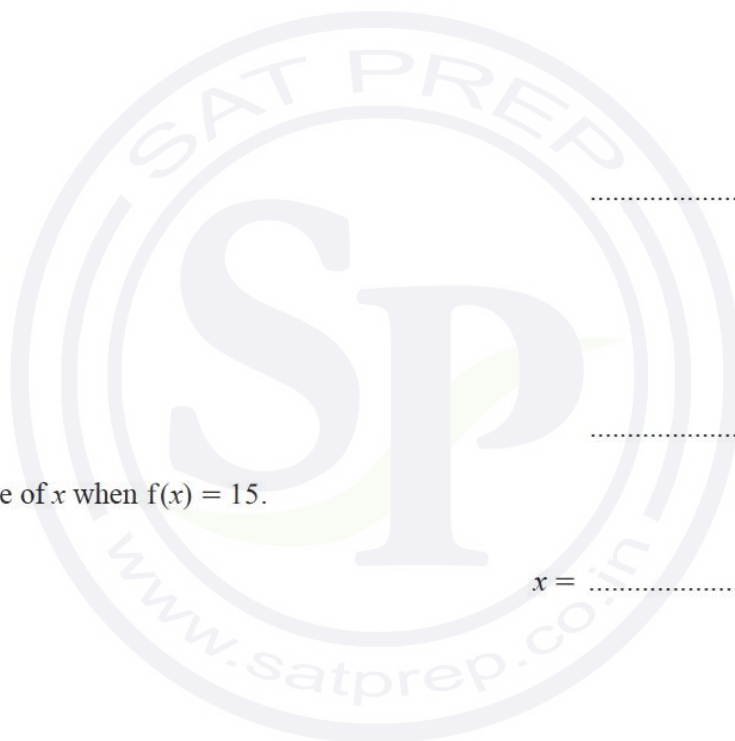
..... [1]

(iii)  $f^{-1}f(x)$ .

..... [1]

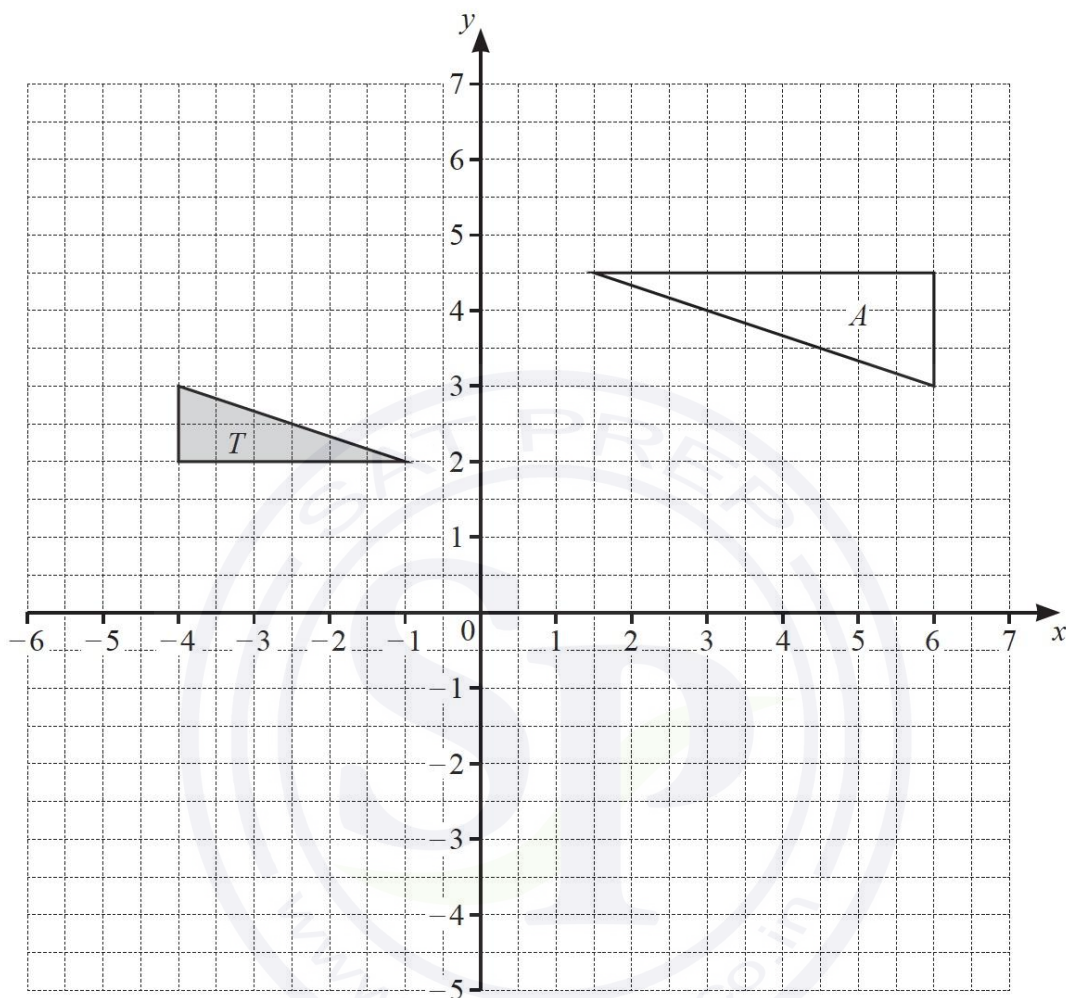
(b) Find the value of  $x$  when  $f(x) = 15$ .

$x =$  ..... [2]



Question94

(a)



(i) Draw the image of triangle  $T$  after a reflection in the line  $y = x$ . [2]

(ii) Draw the image of triangle  $T$  after a translation by the vector  $\begin{pmatrix} -1 \\ 3 \end{pmatrix}$ . [2]

(iii) Describe fully the **single** transformation that maps triangle  $T$  onto triangle  $A$ .

.....

..... [3]

Continue on the next page...

- (b) A quadrilateral  $P$  is enlarged by a scale factor of 1.2 to give quadrilateral  $Q$ .  
The area of quadrilateral  $P$  is  $20 \text{ cm}^2$ .

Calculate the area of quadrilateral  $Q$ .

.....  $\text{cm}^2$  [2]



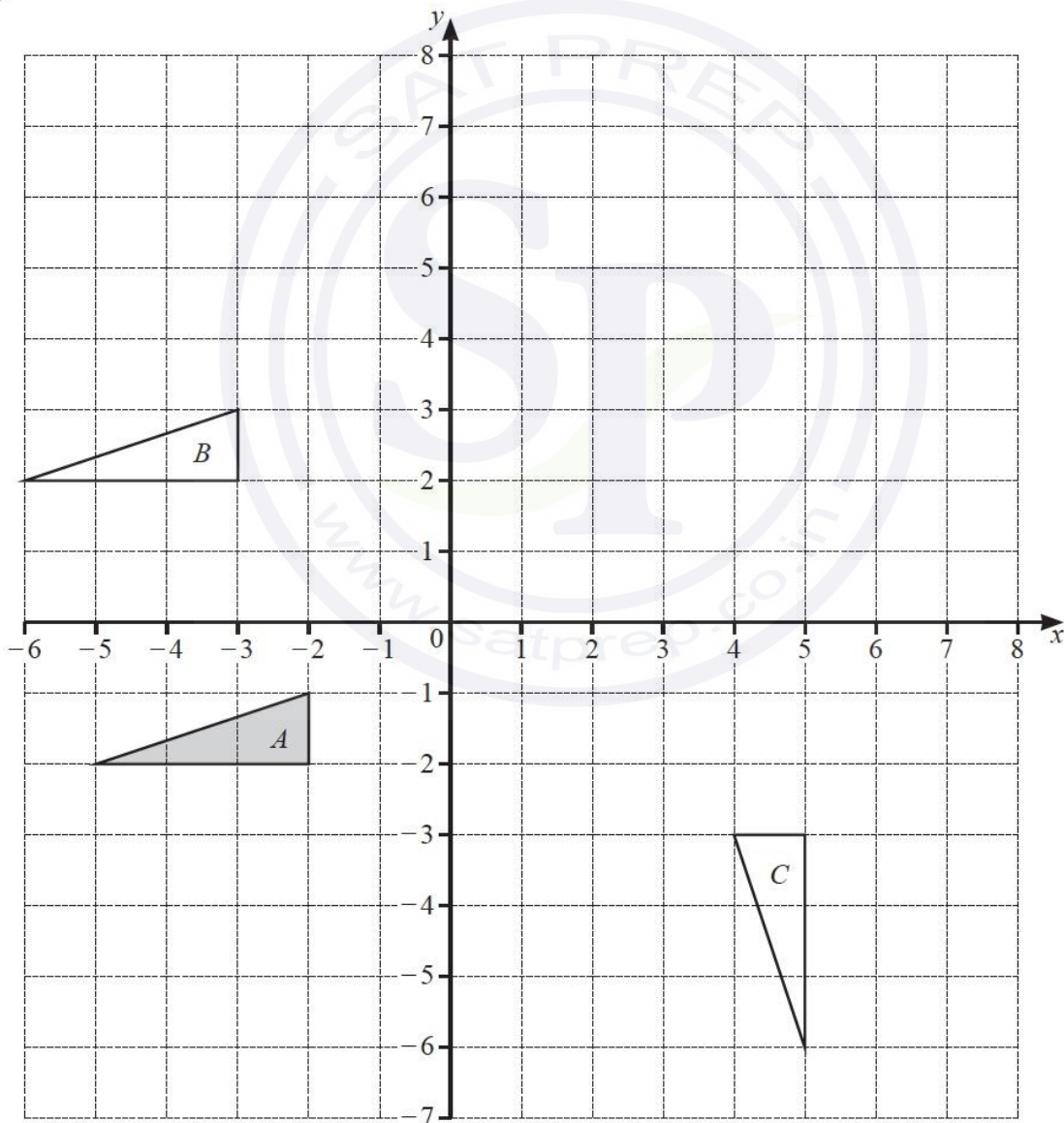
Question 95

(a) Draw the lines of symmetry of the rectangle.



[2]

(b)



(i) Describe fully the **single** transformation that maps

(a) triangle  $A$  onto triangle  $B$ ,

.....

..... [2]

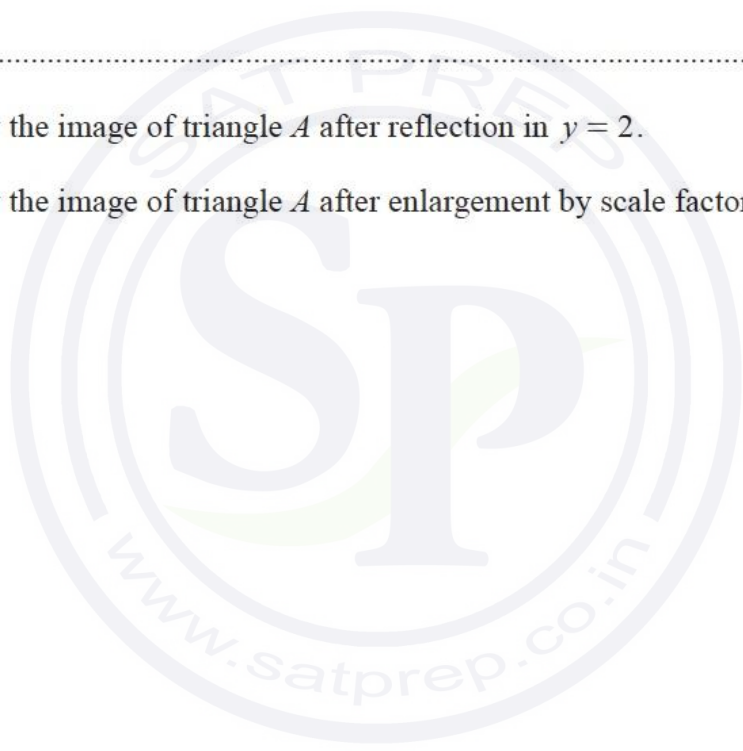
(b) triangle  $A$  onto triangle  $C$ .

.....

..... [3]

(ii) (a) Draw the image of triangle  $A$  after reflection in  $y = 2$ . [2]

(b) Draw the image of triangle  $A$  after enlargement by scale factor  $-2$ , centre  $(-1, 1)$ . [2]





Question 96

$f(x) = 2x - 1$

$g(x) = 3x - 2$

$h(x) = \frac{1}{x}, x \neq 0$

$j(x) = 5^x$

(a) Find

(i)  $f(2)$ ,

..... [1]

(ii)  $gf(2)$ .

..... [1]

(b) Find  $g^{-1}(x)$ .

$g^{-1}(x) =$  ..... [2]

(c) Find  $x$  when  $h(x) = j(-2)$ .

$x =$  ..... [2]

(d) Write  $f(x) - h(x)$  as a single fraction.

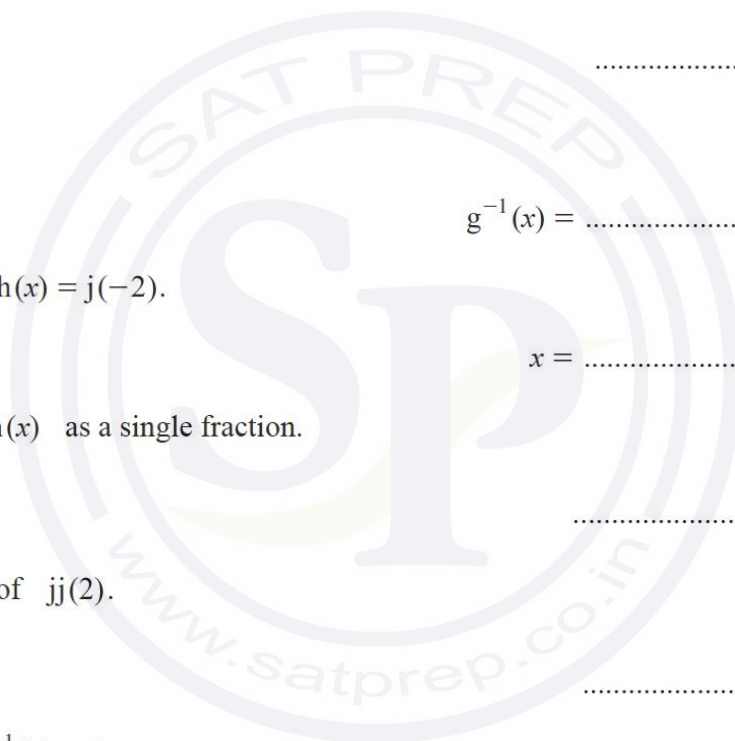
..... [2]

(e) Find the value of  $jj(2)$ .

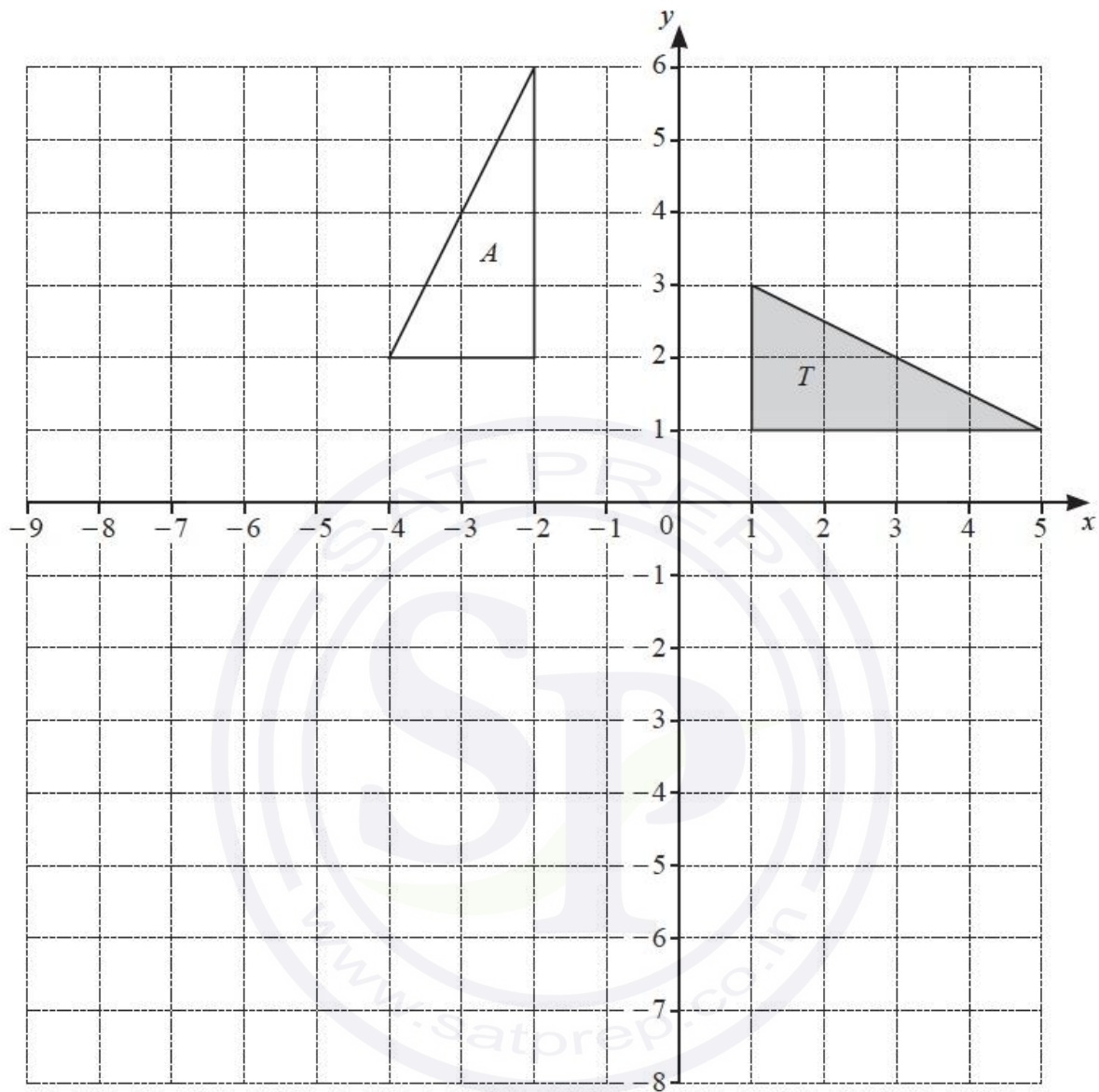
..... [1]

(f) Find  $x$  when  $j^{-1}(x) = 4$ .

$x =$  ..... [2]



Question 97



- (a) Draw the reflection of triangle  $T$  in the line  $y = -2$ . [2]
- (b) Draw the enlargement of triangle  $T$  with scale factor  $\frac{1}{2}$  and centre of enlargement  $(-5, -3)$ . [2]
- (c) Describe fully the **single** transformation that maps triangle  $T$  onto triangle  $A$ .

.....  
 ..... [3]

Question 98

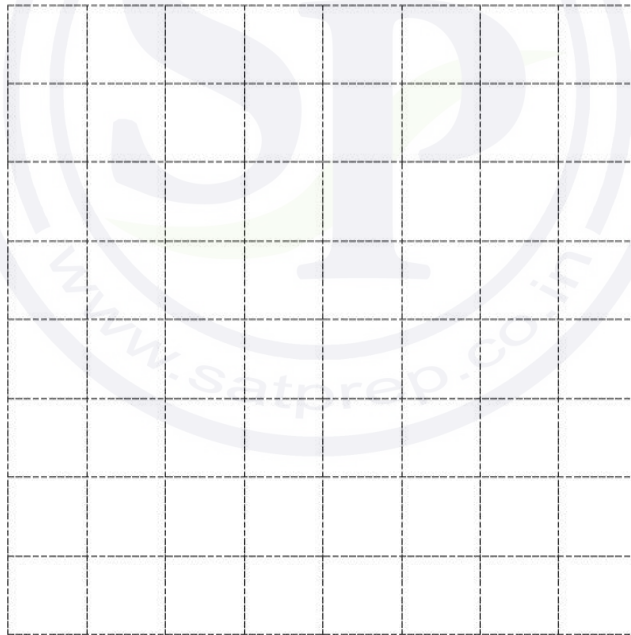
(a)  $\mathbf{a} = \begin{pmatrix} 1 \\ 2 \end{pmatrix}$        $\mathbf{b} = \begin{pmatrix} -3 \\ 5 \end{pmatrix}$

(i) On the grid, draw and label vector  $2\mathbf{a}$ .



[1]

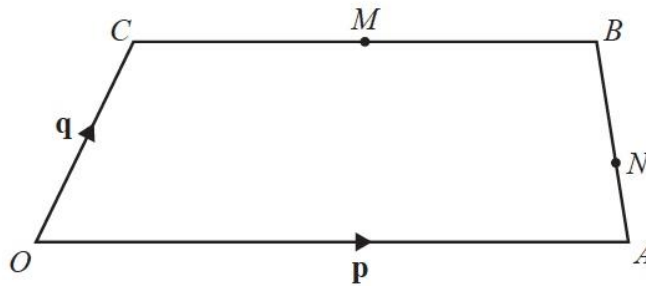
(ii) On the grid, draw and label vector  $(\mathbf{a} - \mathbf{b})$ .



[2]

Continue on the next page..

(b)



NOT TO  
SCALE

$OACB$  is a trapezium with  $OA$  parallel to  $CB$ .

$M$  is the midpoint of  $CB$  and  $N$  is the point on  $AB$  such that  $AN : NB = 1 : 2$ .

$O$  is the origin,  $\vec{OA} = \mathbf{p}$ ,  $\vec{OC} = \mathbf{q}$  and  $\vec{CB} = \frac{3}{4}\mathbf{p}$ .

(i) Find, in terms of  $\mathbf{p}$  and/or  $\mathbf{q}$ , in its simplest form

(a)  $\vec{OB}$

$\vec{OB} = \dots\dots\dots$  [1]

(b)  $\vec{AB}$

$\vec{AB} = \dots\dots\dots$  [2]

(c)  $\vec{MN}$ .

$\vec{MN} = \dots\dots\dots$  [3]

(ii)  $OA$  and  $MN$  are extended to meet at  $G$ .

Find the position vector of  $G$  in terms of  $\mathbf{p}$ .

$\dots\dots\dots$  [2]

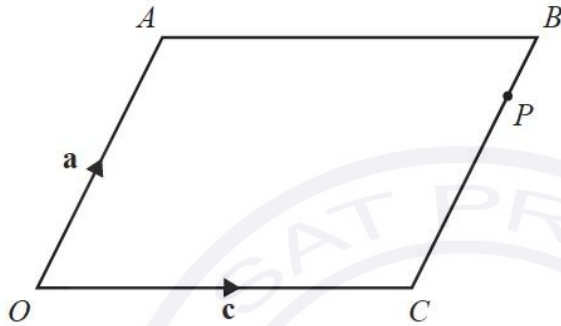
Question 99

(a)  $\left| \begin{pmatrix} 9m \\ 40m \end{pmatrix} \right| = \frac{205}{2}$

Find the two possible values of  $m$ .

$m = \dots\dots\dots$  or  $\dots\dots\dots$  [3]

(b)



NOT TO SCALE

$OACB$  is a parallelogram.

$\vec{OA} = \mathbf{a}$  and  $\vec{OC} = \mathbf{c}$ .

$P$  is the point on  $CB$  such that  $CP : PB = 3 : 1$ .

(i) Find, in terms of  $\mathbf{a}$  and/or  $\mathbf{c}$ , in their simplest form,

(a)  $\vec{AC}$ ,

$\vec{AC} = \dots\dots\dots$  [1]

(b)  $\vec{CP}$ ,

$\vec{CP} = \dots\dots\dots$  [1]

(c)  $\vec{OP}$ .

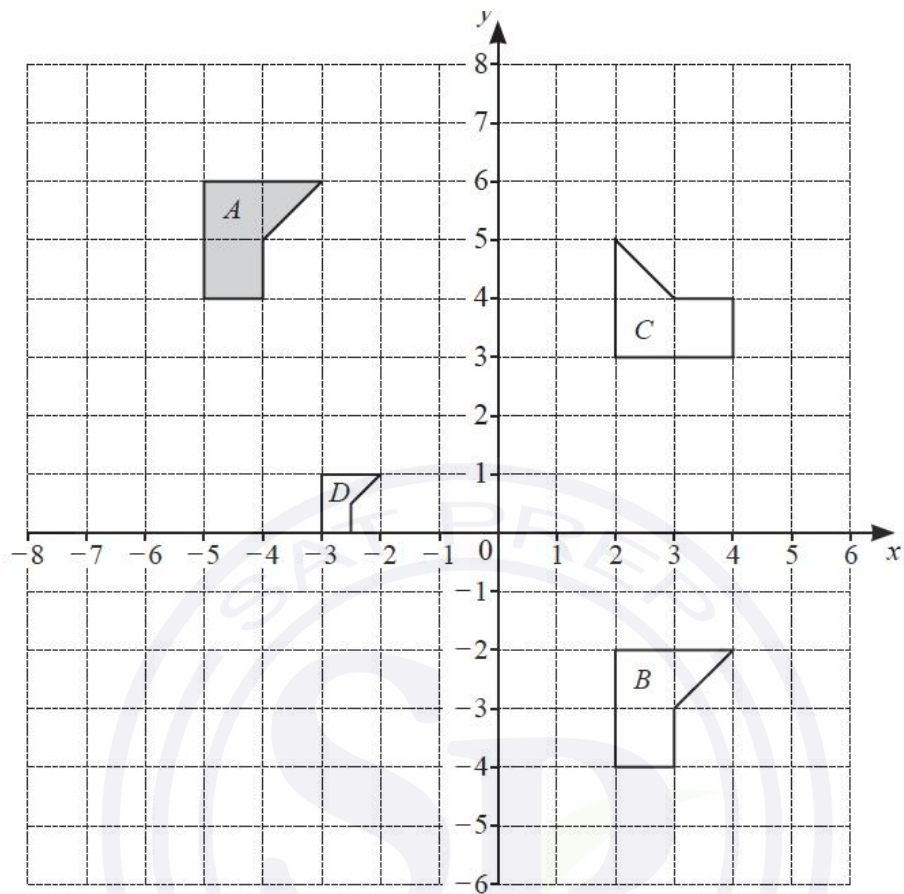
$\vec{OP} = \dots\dots\dots$  [1]

(ii)  $OP$  and  $AB$  are extended to meet at  $Q$ .

Find the position vector of  $Q$ .

$\dots\dots\dots$  [2]

Question 100



(a) Describe fully the **single** transformation that maps

(i) shape *A* onto shape *B*,

.....  
 ..... [2]

(ii) shape *A* onto shape *C*,

.....  
 ..... [3]

(iii) shape *A* onto shape *D*.

.....  
 ..... [3]

(b) On the grid, draw the image of shape *A* after a reflection in the line  $y = x + 8$ . [2]



Question 101

$$f(x) = 10 - x \qquad g(x) = \frac{2}{x}, \quad x \neq 0 \qquad h(x) = 2^x \qquad j(x) = 5 - 2x$$

(a) (i) Find  $g\left(\frac{1}{2}\right)$ .  
 ..... [1]

(ii) Find  $hg\left(\frac{1}{2}\right)$ .  
 ..... [1]

(b) Find  $x$  when  $f(x) = 7$ .  
 $x =$  ..... [1]

(c) Find  $x$  when  $g(x) = h(3)$ .  
 $x =$  ..... [2]

(d) Find  $j^{-1}(x)$ .  
 $j^{-1}(x) =$  ..... [2]

(e) Write  $f(x) + g(x) + 1$  as a single fraction in its simplest form.  
 ..... [3]

(f)  $(f(x))^2 - ff(x) = ax^2 + bx + c$   
 Find the values of  $a$ ,  $b$  and  $c$ .  
 $a =$  .....  
 $b =$  .....  
 $c =$  ..... [4]

(g) Find  $x$  when  $h^{-1}(x) = 10$ .  
 $x =$  ..... [2]

Question 102

(a)  $\mathbf{p} = \begin{pmatrix} 2 \\ 3 \end{pmatrix}$        $\mathbf{q} = \begin{pmatrix} -1 \\ 1 \end{pmatrix}$

Find

(i)  $3\mathbf{q}$ ,

$\begin{pmatrix} \phantom{0} \\ \phantom{0} \end{pmatrix}$  [1]

(ii)  $\mathbf{p} - \mathbf{q}$ ,

$\begin{pmatrix} \phantom{0} \\ \phantom{0} \end{pmatrix}$  [1]

(iii)  $|\mathbf{p}|$ .

..... [2]

(b)  $B$  is the point  $(2, 7)$  and  $\overrightarrow{AB} = \begin{pmatrix} -4 \\ 6 \end{pmatrix}$ .

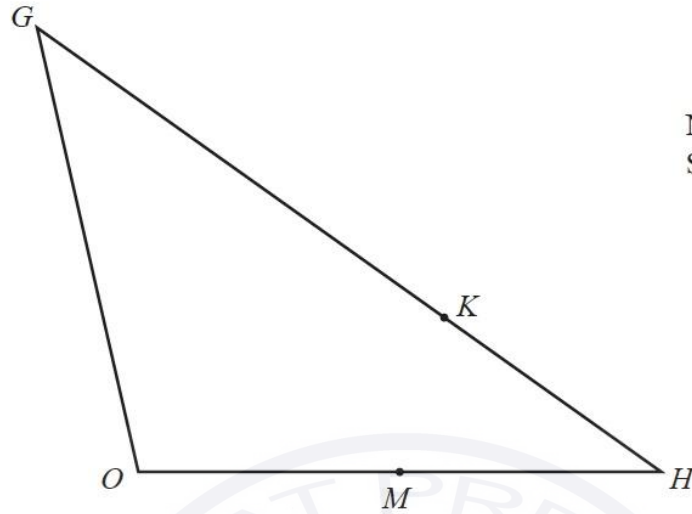
Find the coordinates of  $A$ .

(....., .....) [2]

Continue on the next page....



(c)



NOT TO SCALE

In triangle  $OGH$ ,  $M$  is the midpoint of  $OH$  and  $K$  divides  $GH$  in the ratio  $5 : 2$ .

$\vec{OG} = \mathbf{g}$  and  $\vec{OH} = \mathbf{h}$ .

Find  $\vec{MK}$  in terms of  $\mathbf{g}$  and  $\mathbf{h}$ .

Give your answer in its simplest form.

$\vec{MK} = \dots\dots\dots$  [4]

Question 103

$f(x) = 2x - 1$

$g(x) = 3x + 2$

$h(x) = \frac{1}{x}, x \neq 0$

$j(x) = x^2$

(a) Find  $j(-1)$ .

$\dots\dots\dots$  [1]

(b) Find  $x$  when  $f(x) + g(x) = 0$ .

$x = \dots\dots\dots$  [2]

(c) Find  $gg(x)$ , giving your answer in its simplest form.

$\dots\dots\dots$  [2]

(d) Find  $hf(x) + gh(x)$ , giving your answer as a single fraction in its simplest form.

$\dots\dots\dots$  [4]

Continue on the next page...

(e) When  $pp(x) = x$ ,  $p(x)$  is a function such that  $p^{-1}(x) = p(x)$ .

Draw a ring around the function that has this property.

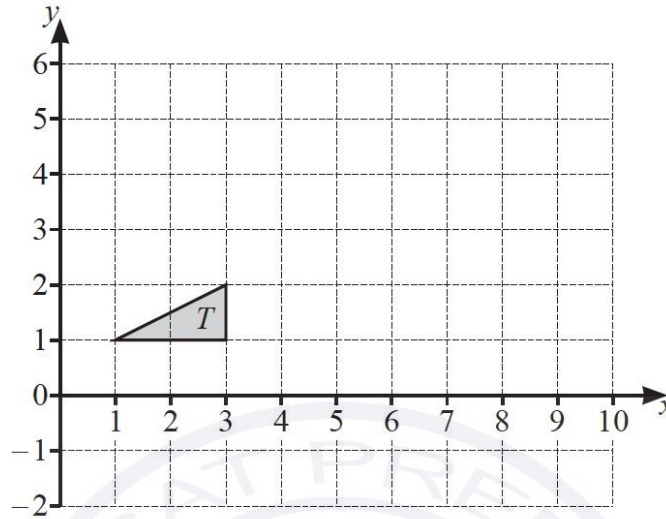
$$f(x) = 2x - 1 \quad g(x) = 3x + 2 \quad h(x) = \frac{1}{x}, x \neq 0 \quad j(x) = x^2$$

[1]



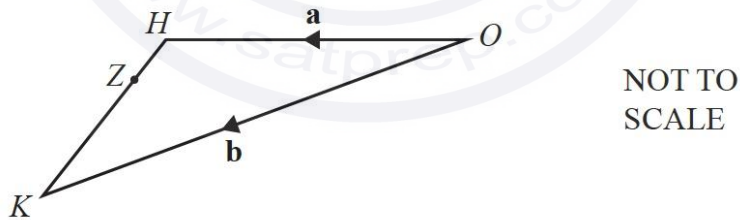
Question 104

(a)



- (i) Enlarge triangle  $T$  by scale factor 3, centre  $(0, 2)$ . [2]
- (ii) (a) Rotate triangle  $T$  about  $(4, 2)$  by  $90^\circ$  clockwise. Label the image  $P$ . [2]
- (b) Reflect triangle  $T$  in the line  $x + y = 6$ . Label the image  $Q$ . [3]
- (c) Describe fully the **single** transformation that maps triangle  $P$  onto triangle  $Q$ . [2]

(b)



The diagram shows triangle  $OHK$ , where  $O$  is the origin.  
 The position vector of  $H$  is  $\mathbf{a}$  and the position vector of  $K$  is  $\mathbf{b}$ .  
 $Z$  is the point on  $HK$  such that  $HZ : ZK = 2 : 5$ .

Find the position vector of  $Z$ , in terms of  $\mathbf{a}$  and  $\mathbf{b}$ .  
 Give your answer in its simplest form.

..... [3]

Question 105

$$f(x) = x - 4$$

$$g(x) = 2x + 5$$

$$h(x) = 3^x$$

(a) Find

(i)  $f(-3)$

..... [1]

(ii)  $g^{-1}(x)$

$g^{-1}(x) =$  ..... [2]

(iii)  $f(x) \times g(x) \times f(x)$ .

..... [4]

(b) Find  $x$  when  $h(x) = g(f(2))$ .

$x =$  ..... [2]

