M1.

(a) $\overrightarrow{BC} = 2\mathbf{a} - 3\mathbf{b}$ or

$\overrightarrow{CB} = -2\mathbf{a} + 3\mathbf{b}$ or

$\overrightarrow{AM} = \mathbf{a}$ or $\overrightarrow{MA} = -\mathbf{a}$ or

$\overrightarrow{BN} = \frac{2}{5}\overrightarrow{BC}$ or $\overrightarrow{CN} = -\frac{3}{5}\overrightarrow{BC}$

oe

M1

$$\mathbf{a} + \frac{3}{5}(-2\mathbf{a} + 3\mathbf{b})$$

$$-\mathbf{a} + 3\mathbf{b} + \frac{2}{5}(2\mathbf{a} - 3\mathbf{b})$$

oe

M1

$$-\frac{1}{5}\mathbf{a} + \frac{9}{5}\mathbf{b}$$

oe eg $-0.2\mathbf{a} + 1.8\mathbf{b}$ or $\frac{1}{5}(9\mathbf{b} - \mathbf{a})$

Must collect terms

A1

(b) $\overrightarrow{MN}$ is not a multiple of $\overrightarrow{AB}$

oe

B1ft

[4]

M2.

(a) $\mathbf{a} + \frac{1}{2}\mathbf{b}$

oe

B1

$\overrightarrow{QS} = -\mathbf{a} + \mathbf{b}$

or $\overrightarrow{SQ} = \mathbf{a} - \mathbf{b}$

oe

M1

$\overrightarrow{QN} = -\frac{1}{3}\mathbf{a} + \frac{1}{3}\mathbf{b}$

or $\overrightarrow{SN} = \frac{2}{3}\mathbf{a} - \frac{2}{3}\mathbf{b}$

oe

M1dep

(b) $\overrightarrow{PN} = \frac{2}{3}\mathbf{a} + \frac{1}{3}\mathbf{b}$

or $\overrightarrow{NM} = \frac{1}{3}\mathbf{a} + \frac{1}{6}\mathbf{b}$

oe

A1

Valid reason

Strand (ii)
e.g. PN is a multiple of PM
PN is a multiple of NM
$\overrightarrow{PN} = \frac{1}{3}(2\mathbf{a} + \mathbf{b})$ *and* $\overrightarrow{PM} = \frac{1}{2}(2\mathbf{a} + \mathbf{b})$
$\overrightarrow{PN} = \frac{2}{3}(\mathbf{a} + \frac{1}{2}\mathbf{b})$ *and* $\frac{2}{3}\overrightarrow{PM}$

Q1

[5]

M3.

(a) $\overrightarrow{AB} = -6\boldsymbol{a} + 4\boldsymbol{b}$

or $\overrightarrow{AM} = -3\boldsymbol{a} + 2\boldsymbol{b}$

or $\overrightarrow{MB} = -3\boldsymbol{a} + 2\boldsymbol{b}$

Need not be simplified

oe

M1

$\boldsymbol{a} + \frac{1}{2}(4\boldsymbol{b} - \boldsymbol{a} - 5\boldsymbol{a})$

$= \boldsymbol{a} + \frac{1}{2}(4\boldsymbol{b} - 6\boldsymbol{a})$

$= \boldsymbol{a} + 2\boldsymbol{b} - 3\mathbf{a}$

$= 2\boldsymbol{b} - 2\boldsymbol{a}$

or

$-5\boldsymbol{a} + 4\boldsymbol{b} + \frac{1}{2}(\boldsymbol{a} + 5\boldsymbol{a} - 4\boldsymbol{b})$

$= -5\boldsymbol{a} + 4\boldsymbol{b} + \frac{1}{2}(6\boldsymbol{a} - 4\boldsymbol{b})$

$= -5\boldsymbol{a} + 4\boldsymbol{b} + 3\boldsymbol{a} - 2\boldsymbol{b}$

$= 2\boldsymbol{b} - 2\boldsymbol{a}$

oe

A1

(b) $NC = 5(\mathbf{b} - \mathbf{a})$ or $5\mathbf{b} - 5\mathbf{a}$

M1

2 : 5

5 : 2 implies M1

A1

[4]

M4.(a) $MN = \frac{1}{2}\mathbf{x} + \frac{1}{2}\mathbf{y}$

oe

$MN = \frac{1}{2}BC + \frac{1}{2}CD$

$MN = MC + CN$

B1

$BD = \mathbf{x} + \mathbf{y}$

oe

$BD = BC + CD$

B1

BD is a multiple of *MN*

oe

Q1

(b) 2 : 1

B1

[4]

M5.(a) 5**a** + 3**b** + 6**a − 7**b

M1

11**a** − 4**b**

A1

(b) 22

ft their 11 × 8 ÷ their 4

*Accept 22**a** (− 8**b**)*

B1 ft

[3]

M6.

(a) Opposite sides parallel (same direction) and equal (same length)
or opposite sides are equal vectors

Strand (i). Must mention that opposite sides are parallel and equal ***or*** *equal vectors*

Q1

(b) $\mathbf{b} - \mathbf{c}$ **or** $-\mathbf{c} + \mathbf{b}$

B1

(c) $LP = \frac{1}{2}\mathbf{a} + \frac{1}{2}(\mathbf{c} - \mathbf{a})$

LP = must be stated or LP = LA + AP

B1 for $\frac{1}{2}\mathbf{a} + \frac{1}{2}(\mathbf{c} - \mathbf{a})$

B2

Alternative 1

$\frac{1}{2}\mathbf{a} + \frac{1}{2}(\mathbf{c} - \mathbf{a}) = \mathbf{a} + \frac{1}{2}\mathbf{c} - \frac{1}{2}\mathbf{a}$

B1 for $\frac{1}{2}\mathbf{a} + \frac{1}{2}(\mathbf{c} - \mathbf{a})$

B2

Alternative 2

$(LP) = -\frac{1}{2}\mathbf{a} + \mathbf{b} + (\mathbf{c} - \mathbf{b}) + \frac{1}{2}(\mathbf{a} - \mathbf{c})$

This is LP = LO + OB + BC + CP

M1

$-\frac{1}{2}\mathbf{a} + \mathbf{b} + \mathbf{c} - \mathbf{b} + \frac{1}{2}\mathbf{a} - \frac{1}{2}\mathbf{c}$

A1

Alternative 3

$(LP) = -\frac{1}{2}\mathbf{a} + \mathbf{c} + \frac{1}{2}(\mathbf{a} - \mathbf{c})$

This is LP = LO + OC + CP

M1

$-\frac{1}{2}\mathbf{a} + \mathbf{c} + \frac{1}{2}\mathbf{a} - \frac{1}{2}\mathbf{c}$

A1

Alternative 4
OC = **c** and *L* and *P* are midpoints

Using midpoint theorem. This may be expressed differently but if evidence that mid-point theorem used then award M1

M1

$LP = \frac{1}{2}OC$

This is for accurately describing the results using the mid-point theorem.

A1

Alternative 5
Written explanation such as
(Journey of) *L* to *A* to *P* is half (the journey of) *O* to *A* to *C* so *LP* is half *OC*.

B1 if intention seen but explanation not complete or slight error

B2

(d) $MN = \frac{1}{2}\mathbf{b} + \frac{1}{2}(\mathbf{c} - \mathbf{b})$

M1

$LP = MN = \frac{1}{2}\mathbf{c}$ …… *LMNP* is a

parallelogram (as opposite sides are the same vector)

By choosing MN it is opposite LP so no need to say opposite sides but a 'conclusion' must be stated or implied

A1

Alternative 1
$LM = -\frac{1}{2}\mathbf{a} + \frac{1}{2}\mathbf{b}$

M1

$LM = PN = -\frac{1}{2}\mathbf{a} + \frac{1}{2}\mathbf{b}$ …… *LMNP* is a parallelogram (as opposite sides are the same vector).

By choosing LM and PN no need to say opposite sides but a 'conclusion' must be stated or implied

A1

Alternative 2

LP parallel to *OC* and $\frac{1}{2}$*OC* (midpoint theorem)

M1

MN parallel to *OC* and $\frac{1}{2}$*OC* (midpoint theorem) so *LMNP* is a parallelogram as opposite sides parallel and the same length

A1

[6]