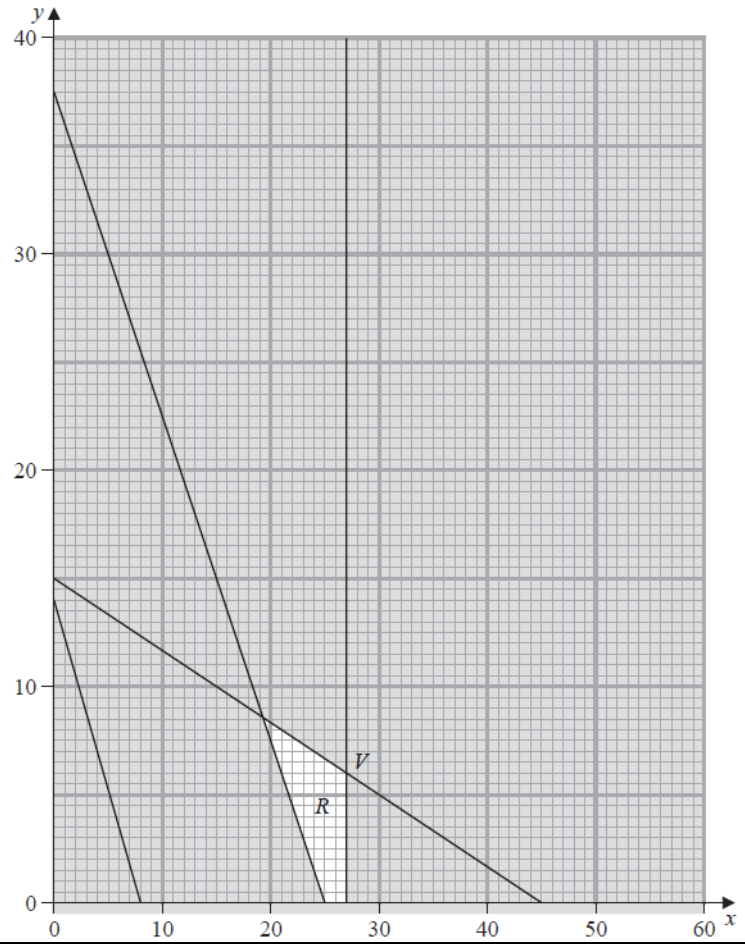
Question Number	Scheme	Marks
a1M1: Any larger working value replaced by any smaller working value at at **least two nodes** except A, B, C and D **a1A1:** All values at A, B, C and D correct and the working values in the correct order. Condone lack of a zero as a working value at A **a2A1:** All values at E and F correct and the working values in the correct order. Penalise order of labelling only once per question (so E and F must be labelled in that order and E must be labelled after D) **a3A1ft:** All values at G and H correct on the follow through and the working values in the correct order. Penalise order of labelling only once per question. To follow through G check that the working values at G follow from the candidate's final values for the nodes that are directly attached to G (which are E, F and H). For example, **if** correct then the order of labelling of nodes E, F and H are 5, 6 and 8 respectively so the working values at G should come from E and F in that order. The first working value at G should be 18 (the Final value at F) + 7 (the weight of the arc FG) and the second working value at G should be 11 (the Final value at E) + 16 (the weight of the arc EG). Repeat the process for H (which will have working values from D, E and G with the order of these nodes determined by the candidate's order of labelling at D, E and G) **a2M1:** Correct entries in the table following through their final values – dependent on the previous M mark (need only fill in either the A row or A column) **a4A1:** cao **b1B1:** Correct nearest neighbour route starting and finishing at A (A – B – D – E – F – G – H – C – A) **b2B1:** cao (57) on length of route **ci1M1:** First three arcs (CE, DE, BD) **or** all 7 nodes {C, E, D, B, F, G, H} correctly chosen in order. If any explicit rejections seen then M1only in (c)(i). Order of nodes may be seen at the top of the matrix/table {4, 1, 3, 2, 5, 6, 7}. Award M0 for a correct tree with no working. Award M1 only for the first three arcs (oe) selected correctly if starting at a different node than C. If correct values circled in the table but no indication of order of selection then M0 **ci1A1:** cso – all **arcs** correctly **stated** and chosen in the correct order (with no additional arcs). They must be considering arcs for this mark (do not accept a list of nodes or numbers across the top of the matrix unless the correct list of arcs (in the correct order) is also seen). If AB and AC added explicitly in (c)(i) then A0 but can score both marks in (c)(ii) **cii2M1:** Weight of RMST + 7 + 8 (two smallest arcs incident to A) with $19 \leqslant \text{RMST} \leqslant 39$ (if clearly not six arcs in RMST then M0). Give bod if 15 is added to the total of six values circled in the table provided those six values sum to a value between 19 and 39 inclusive **cii2A1:** cao (44) – if correct RMST stated in (c)(i) followed by 44 (with no additional working) then award M1A1 in (c)(ii). This mark is dependent on Prim's algorithm being used to find the RMST (allow this mark if rejections seen in (c)(i) when applying Prim). So in (c) M1A0M1A1 is possible e.g. if only stating the node (instead of the arc) selection in order when applying Prim. If the correct six values are circled in the table and added to 15 to give 44 but the order of arc/node selection is not stated (so no indication that Prim has been applied) then A0 (as the qu. says, 'Hence…') **d1B1: Any** indication of an interval from their answer to **(c)(ii)** to their answer to **(b)** with one value correct (e.g. $44 \sim 57$ scores B1 but $57 \sim 44$ or $57 \leqslant$ optimal distance $\leqslant 44$ scores B0). **If correct route seen in (b) but the upper bound not stated in (b) allow recovery in part (d) it stated here (but still withold the second mark in (b)).** **d2B1:** cao ($44 \leqslant$ optimal distance $\leqslant 57$) including correct inequalities (allow $44 <$ optimal distance $\leqslant 57$) – allow interval notation e.g., [44, 57] or (44, 57]	
7.(a)	Minimise $(P=)9x+12y+16z$	B1
	$x+y+z \geqslant 40$	B1
	$z \geqslant 2y$	B1
	$\frac{3}{5}(x+y+z) \geqslant x$ simplifies to $2x \leqslant 3y+3z$	M1 A1
	$x+1.5y+2.5z \leqslant 75$ simplifies to $2x+3y+5z \leqslant 150$	M1 A1
	$(x \geqslant 0, y \geqslant 0, z \geqslant 0)$	**(7)**
(b)	$9x+12y+16(45-x-y)$	M1

Question Number	Scheme	Marks
	which leads to $-7x-4y+720$	A1
	+720 is a constant so the total value is minimised when $-7x-4y$ is **and** $-7x-4y=-(7x+4y)$, as $-(7x+4y)$ is negative (for all positive values of x and y) and so minimising an expression which is negative is equivalent to maximising the corresponding positive expression $7x+4y$	A1 **(3)**
(c)		B1 B1 B1 B1 **(4)**
(d)	Correct objective line	B1
	V correctly labelled	B1 **(2)**
(e)	27 small containers, 6 medium containers and 12 large containers	B1
	Total cost is (£)507	B1 **(2)**
		18 marks

Notes for Question 7

a1B1: cao – expression correct and 'minimise' or 'min' but not 'minimum'
a2B1: cao ($x+y+z\geqslant 40$ oe but must be four terms only with integer coefficients e.g. $x+y+z-40\geqslant 0$)
a3B1: cao ($z\geqslant 2y$ oe $\left(\text{e.g. } 4y-2z\leqslant 0\right)$ but must be two terms only with integer coefficients)
a1M1: correct method - must see $\frac{3}{5}(x+y+z)\bullet x$ where $\bullet$ is any inequality or =. The bracket must be present or implied by later working. Allow 0.6 but not 60% (unless implied by later working)
a1A1: cao – simplified (one term only in x, y and z) – answer must have integer coefficients (e.g. $4x-6y-6z\leqslant 0$) - the correct simplified inequality with either no working **or** working with % sign implies M1A1
a2M1: correct method – must see $x+1.5y+2.5z\bullet 75$ (oe) where $\bullet$ is any inequality or =

Question Number	Scheme	Marks

a2A1: cao – simplified (one term only in x, y and z) – answer must have integer coefficients (e.g. $4x+6y \leqslant 300-10z$) – the correct simplified inequality with no working implies M1A1

b1M1: substituting $z = 45-x-y$ into $9x+12y+16z$

b1A1: cao of $-7x-4y+720$ **and** any attempt at explaining why the minimum total cost is achieved when $7x + 4y$ is maximised

b2A1: stating that 720 is a constant (and so doesn't impact on the optimal values of x, y and z) **and** a correct deduction that minimising a negative expression is equivalent to maximising the corresponding positive expression (so just stating that $-7x-4y$ is minimised when $7x+4y$ is maximised is A0)

The lines in **(c)** must define the correct FR **and if extended** pass within a small square of the points stated:

$x+3y=45$ with points (0, 15) and (45, 0)

$3x+2y=75$ with points (0, 37.5) and (25, 0)

$x=27$ with points (27, 0) and (27, 40) – a common wrong response is to draw either $y = 27$ or $x = 28$ – these are both B0

c1B1: Any one line drawn correctly

c2B1: Any two lines drawn correctly

c3B1: Any three lines drawn correctly

c4B1: Correct R labelled – not just implied by shading – dependent on scoring the first three marks in this part (condone if no shading below the x-axis)

d1B1: A correct objective line drawn on the graph with a gradient of –1.75 – line must be at least the length of (2, 0) to (0, 3.5) and within one small square - for reference common intersections points with each axes are given below

x	y
4	7
5	8.75
8	14
10	17.5
12	21
15	26.25
16	28
20	35

x	y
2.85...	5
5.71…	10
8.57…	15
11.4…	20
14.3…	25
17.1…	30
20	35
22.9…	40

d2B1: V labelled clearly on their graph. This mark is dependent on

- the first three marks in (c)
- not labelling or implying that any other region is the FR
- the first B mark in (d)

By clearly labelled the vertex should either be labelled 'V' or circled or clearly distinguishable from any other vertex (but B0 if not clear e.g. another vertex circled too) (note that $V(27, 6)$)

e1B1: cao (must be in context – so not in terms of x, y and z) – dependent on first three marks in (c) and the first mark in (d) (27 small, 6 medium and 12 large)

e2B1: cao (507) - dependent on first three marks in (c) and the first mark in (d) – units not required. Condone incorrect units e.g. $

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