AQA

AS
Mathematics

MD01 – Decision 1
Mark scheme

6360
June 2016

Version 1.0 Final Mark Scheme

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from aqa.org.uk

Key to mark scheme abbreviations

M	mark is for method
m or dM	mark is dependent on one or more M marks and is for method
A	mark is dependent on M or m marks and is for accuracy
B	mark is independent of M or m marks and is for method and accuracy
E	mark is for explanation
√or ft or F	follow through from previous incorrect result
CAO	correct answer only
CSO	correct solution only
AWFW	anything which falls within
AWRT	anything which rounds to
ACF	any correct form
AG	answer given
SC	special case
OE	or equivalent
A2,1	2 or 1 (or 0) accuracy marks
–*x* EE	deduct *x* marks for each error
NMS	no method shown
PI	possibly implied
SCA	substantially correct approach
c	candidate
sf	significant figure(s)
dp	decimal place(s)

No Method Shown

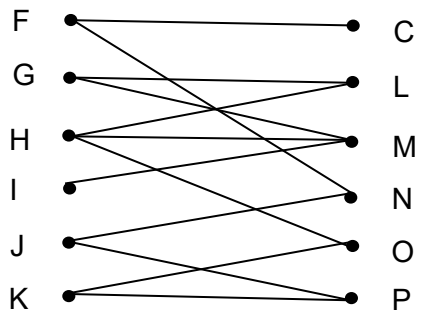
Where the question specifically requires a particular method to be used, we must usually see evidence of use of this method for any marks to be awarded.

Where the answer can be reasonably obtained without showing working and it is very unlikely that the correct answer can be obtained by using an incorrect method, we must award **full marks**. However, the obvious penalty to candidates showing no working is that incorrect answers, however close, earn **no marks**.

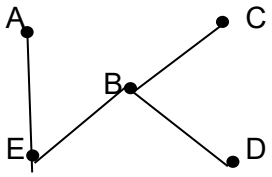
Where a question asks the candidate to state or write down a result, no method need be shown for full marks.

Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

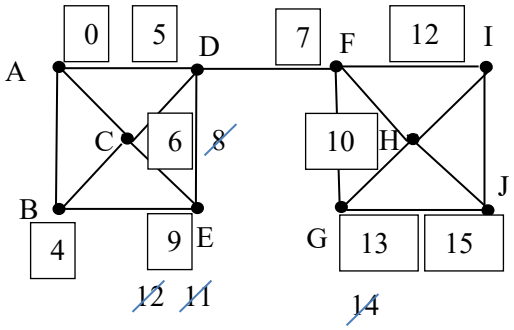
Otherwise we require evidence of a correct method for any marks to be awarded.

Q1	Solution	Mark	Total	Comments
(a)		**M1** **A1**	**2**	Bipartite graph; 2 sets of 6 labelled (condone errors) vertices; at least 10 edges All correct, including labelling
(b)	I − M + G Correct path e.g. I − M + G – L + H – O + K – P + J – N + F – C or I − M + G – L + H – O O + K – P + J – N + F – C or IMGLHOKPJNFC	**M1** **A1**		or C − F + N Allow different notations e.g. those below on the left or reverse Accept a clear diagram for both marks e.g. by numbering or clearly visible as a path
	Match FC, GL, HO, IM , JN, KP	**B1**	**3**	oe Must be a list
	Total		**5**	

Q2	Solution	Mark	Total	Comments
(a)	Initial List (R E M I X)			Allow working in rows or columns
	(End of 1st Pass) E R M I X	**M1**		SCA; i.e. swap E and R **only** on 1st pass but do not allow a continuation which is clearly bubble sort
	(End of 2nd Pass) E M R I X	**A1**		2nd pass
	(End of 3rd Pass) E I M R X			
	(End of 4th Pass) E I M R X	**A1**	**3**	All correct
(b)(i)	9 (passes)	**B1**		In part (b) watch out for candidates answering in the question area rather than the script.
(ii)	6 (comparisons)	**B1**		
(iii)	1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 (+ 10)	**M1**		or use of $\frac{n(n\pm1)}{2}$ with n = 9 or n = 10
	45	**A1**	**4**	45 scores 2/2 unless clearly from incorrect working (FIW)
	Total		**7**	

Q3	Solution	Mark	Total	Comments
(a)	Accept answers for part (a) in any order or all together.			
(i)	BD (5) AE (6) BE (7) BC (8)	**M1**		SCA; first 3 **edges** of 4 edges in correct order, accept vertices in reverse order e.g. DB instead of BD
		A1		All correct; (must be edges not lengths)
(ii)		**B1**		Spanning tree; all correct including labelling
(iii)	26	**B1**	**4**	
(b)	Accept answers for part (b) in any order or all together			
(i)	e.g. (BD, AE, BE,) BC would then be included, not CD or e.g. x is not less than 10 so x cannot equal 7	**E1**		oe Do not accept answers which suggest a cycle
(ii)	$x \geq 10$	**B2**	**3**	**SC1** $x > 10$ or $10 \leq x < n$ or $10 \leq x \leq n$ but $10 < x < n$ scores B0
	Total		**7**	

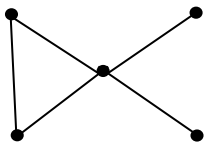
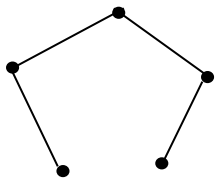
Q4	Solution	Mark	Total	Comments
(a)(i)	(Odd vertices: B, D, F, H)			
	BD + FH (10 + 12) = 22	**M1**		These 3 sets of lettered pairs added
	BF + DH (18 + 14) = 32	**A2,1,0**		3 correct, 2 correct
	BH + DF (16 + 18) = 34			
	Min 167 + 22	**m1**		PI 167 + their min of 3 totals
	= 189 (min)	**A1 CSO**		Must have scored the first 4 marks If **M0** scored, then 189 scores **SC2**
(ii)	3	**B1**	**6**	
(b)(i)	Repeat BD	**M1**		PI Eg 167 + BD or 189 – FH or 167 + 10 or 189 - 12
	177 (min)	**A1**		
(ii)	F, H	**B1**	**3**	Both correct with no extras and must be 2 vertices not an edge Do not accept 'Start F and Finish H'
(c)(i)	179 (min)	**B1**		
(ii)	B	**B1**	**2**	
	Total		**11**	

Q5	Solution	Mark	Total	Comments
(a)(i)		M1 A1 A1 A1		SCA, using Dijkstra, with 2 values at C and 2 or 3 values at E Correct values at C and at E Correct two values at G and no others All correct, including cancelling (in all forms of presentation) and boxing (condone omission of 0 at A)
(ii)	A D F H G	B1	5	Do NOT allow reverse order
(b)	$9 + x < 13$ or $x < 4$	M1		oe
	$9 + x + 3 \geq 15$ or $x \geq 3$	M1		oe
	$(x =)\ 3$	A1 CSO	3	If M0 M0 scored then SC1 for $(x =)$ 3
	Total		8	

Notes:

(b) Do not allow edges within the inequality unless recovered
e.g. 9 + EG < 13 scores M0
but 9 + EG < 13 followed by $x < 4$ scores M1

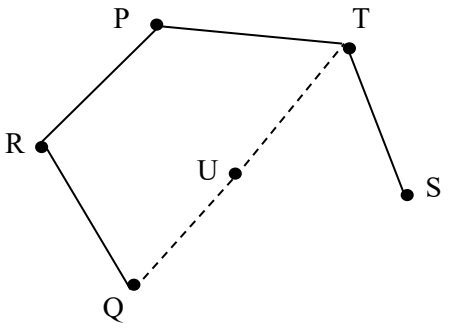
As x is an integer, allow equivalents e.g. $9 + x \leq 12$, $x \leq 3$, $9 + x + 3 > 14$, $x > 2$

Q6	Solution	Mark	Total	Comments
(a)	14	**B1**	**1**	
(b)	e.g. 	**M1**		Graph with 5 vertices and 5 edges and exactly one vertex of degree 4 (but may not be simple)
		A1	**2**	Simple & semi-Eulerian
(c)	e.g. 			Graph with 5 vertices that is:
		B1		semi-Eulerian
		B1	**2**	a tree
(d)	Graph is simple **<u>therefore</u>** each vertex of degree 5 must be connected to each of the other 5 vertices.	**E1**		Must include 'simple' (or a full definition) or 'no vertex can have degree greater than 5' as a reason within the explanation.
	The remaining four vertices must each be connected to the two vertices of degree 5. Therefore no vertex has degree 1.	**E1**	**2**	
	Total		**7**	

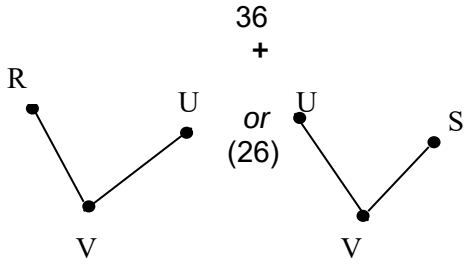
Notes:

(b) & (c) In many responses there may be several diagrams. If one is clearly intended as the answer accept it as such; otherwise treat as multiple solutions.

(d) The E marks are independent as these explanations could be seen in either order or combined in one statement but the phrase 'simple' (or a full definition) or 'no vertex can have degree greater than 5' must be included as a reason for 2 marks

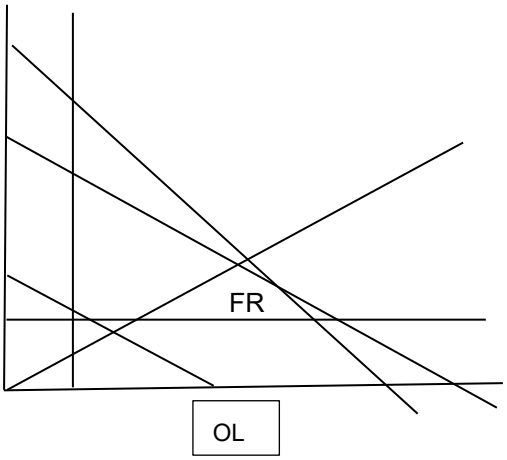
Q7	Solution	Mark	Total	Comments
(a)	(1) (5) (4) (3) (2) (6)			
		M1		SCA; Use of matrix form, 4+ numbers circled and 4+ parallel 'lines' deleted
		A1		PT (6) and TS (5) circled
		A1		PR (7) and RQ (8) circled
	Order of vertices: P, T, S, R, Q, U	B1		Order of adding vertices – either listed (condone PTSRQU) or indicated at the top/side of the matrix (numbers could be 1,…5 starting at T or 0, … , 5 starting at P) Do NOT allow a list of edges
		A1		All correct, including order, with correct values circled and all 'lines' crossed out, either as shown or as 'mirror image'. (Condone omission of 'line' at U) If QU (10) **and** TU (10) circled then the need for a choice must be indicated with the table
		B1	6	Correct MST with vertices labelled. Either QU or TU but not both (unless if QU **and** TU both drawn then the need for a choice must be indicated with the diagram)

	P	Q	R	S	T	U
P	–	14	7	11	6	12
Q	14	–	8	10	9	10
R	7	8	–	12	13	15
S	11	10	12	–	5	11
T	6	9	13	5	–	10
U	12	10	15	11	10	–

(b)(i)		**M1**		Spanning tree connecting P,Q,R,S,T,U or using *their* answer from (a) or 36 AND 2 labelled edges from V (edges, but not lengths, can be listed or shown in a diagram NOT simply circling values in the table)
		A1		Correct edges from V with a spanning tree (not necessarily a MST)
	= 62	**B1**	**3**	
7(b)(ii)	V U Q R P T S V (12 10 8 7 6 5 14) (= 62)	**M1**		Tour, from V, visiting all other vertices, once only
		A1		Correct tour, must be in this order
	V U T S Q R P V (12 10 5 10 8 7 15) (= 67)	**M1**		Second tour, from V, visiting all other vertices, once only
		A1		Correct tour, must be in this order
	62 **and** 67	**B1**		Both upper bound values correct
	62, because 62 < 67	**E1F**	**6**	oe If both UB values the same then E0
(iii)	V U Q R P T S V or reverse	**B1**		oe This tour starting from any vertex e.g. U Q R P T S V U S T P R Q U V S
	Tour/upper bound has the same length (62) as the lower bound (therefore optimal) or As lower bound gives a tour, therefore optimal	**E1**	**2**	Must come from correct 62 from bii and LB of 62 in bi Their (bi) must be correct
	Total		**17**	

Notes:
(b)(ii) If candidate works on the tables, please see next page for mark scheme

Q7	Solution	Mark	Total	Comments
(b)(ii)	Alternative mark scheme for tours on tables: (5) (3) (4) (7) (6) (2) (1/8) P: – **14** (**7**) **11** **6** **12** **15** Q: **14** – **8** **10** **9** (**10**) **18** R: **7** (**8**) – **12** **13** **15** **14** S: **11** **10** **12** – (**5**) **11** **14** T: (**6**) **9** **13** **5** – **10** **17** U: **12** **10** **15** **11** **10** – (**12**) V: **15** **18** **14** (**14**) **17** **12** – (7) (5) (6) (4) (3) (2) (1/8) P: – **14** (**7**) **11** **6** **12** **15** Q: **14** – **8** (**10**) **9** **10** **18** R: **7** (**8**) – **12** **13** **15** **14** S: **11** **10** **12** – (**5**) **11** **14** T: **6** **9** **13** **5** – (**10**) **17** U: **12** **10** **15** **11** **10** – (**12**) V: (**15**) **18** **14** **14** **17** **12** – 62 **and** 67 62, because 62 < 67	**M1** **A1** **M1** **A1** **B1** **E1F**	**6**	7 values circled, one per row and one per column, V clearly the starting vertex Correct numbers circled and correct order indicated (condone either missing 1 or 8 at V) (numbering could be 0, 1,…7) 7 values circled, one per row and one per column, V clearly the starting vertex Correct numbers circled and correct order indicated (condone either missing 1 or 8 at V) (numbering could be 0, 1,…7) Both upper bound values correct oe If both UB values the same then E0

Q8	Solution	Mark	Total	Comments
(a)	$10x + 15y \leq 360$ (simplifies to) $2x + 3y \leq 72$	**B1** **AG**	**1**	Accept $\frac{x}{6} + \frac{y}{4} \leq 6$ (or correct decimal/fractional equivalent)
(b)				
	$x + y \leq 32$ oe	**B1**		$x + y < 32$ AND $x > 2y$ oe scores **SC1**
	$x \geq 2y$ oe	**B1**	**2**	
(c)				Each line must be ruled to have the B mark available. For all lines, must be correct to ½ square horizontal and vertical at the indicated vertices.
		B1		$x = 5$ and $y = 5$ from axes to (5,30) and (30,5)
		B1		$y = ½ x$ (0, 0), (20, 10)
		B1		$x + y = 32$ (32, 0), (0, 32)
		B1		$2x + 3y = 72$ (0,24), (36,0)
		B1		FR, **all 5 lines above correct** and region labelled (ignore shading)
	Objective line: any line with gradient = - ¾	**M1**		Accept either - ¾ (allow -0.7 to -0.8) or its reciprocal (allow -1.3 to -1.4) for the **M1** only
		A1	**7**	A correct line (which may not intersect the axes)
(d)(i)	(24,8) or (27,5) or (21,10)	**M1**		Allow values in the range(23-25,7-9) or (26-28,4-6) or (20-22,9-11) PI by further working
	24 Luxury and 8 Special	**A1** **CAO**		
(ii)	(Profit =) £520	**B1**	**3**	Must include £
	Total		**13**	