AQA Computer Science A-Level 4.6.5 Boolean algebra Past Paper Mark Schemes

AL	GEBRA	IC SOI	LUTION			
	ethod 1			Method 2	-10	
	$\overline{\mathbf{A} \cdot \mathbf{B}}$	+A		$\overline{\mathbf{A} \cdot \mathbf{B}} + A$	A	
	$=\overline{A} +$	$\overline{B} + A$	4	$=\overline{\mathbf{A}\cdot\mathbf{B}\cdot}$	Ā	
		=		$= \overline{0 \cdot B}$		
	$= 1 + \bar{I}$	3		= 0		
	= 1			= 1		
wri at c		ethod, r iswer)	not just in		or $0.B = 0$ (must be has done this if arri	
TR	UTH TA	ABLE S	OLUTIC Y	N: Z		
A	В	A·B	Ā·B	$\overline{\mathbf{A} \cdot \mathbf{B}} + \mathbf{A}$		
0		0	1	1		
0	1	0	1	1		
	0	0	1	1		
	0	0	1	1		
1 1 1 n	1 ark for	l	0 Y correct	1		
1 1 n 1 n	1 ark for	l column column	0 Y correct Z correct	1		
1 1 n 1 n	1 ark for	l column column	0 Y correct Z correct	1		
1 1 n 1 n 1 n	1 ark for	l column column correct	0 Y correct Z correct answer	1		
1 1 n 1 n 1 n AN	1 ark for ark for ark for Y OTH	l column column correct a	0 Y correct Z correct answer THOD:		correct answer the	n
1 1 n 1 n 1 n 1 n I n I n Sawa	1 mark for on mark for on mark for of tark for of Y OTH tudent has and marks	l column column correct a ER ME is used a s as follo	0 Y correct Z correct answer THOD: any other ows:	method to arrive at	correct answer the	n
1 1 m 1 m 1 m 1 m AN If s awa 1 m	1 mark for of mark for of mark for of Y OTHI tudent has ard mark: mark for of	l column column correct a ER ME as used a s as foll correct a	0 Y correct Z correct answer THOD: any other ows: answer, n	method to arrive <u>at</u> o working out		n
l l n l n l n l n l n l n l n l n l n l	1 mark for on mark for on mark for on tudent have and mark mark for on mark for on marks for one marks for one	1 column correct a ER ME as used a s as foll correct a correct	0 Y correct Z correct answer THOD: any other ows: answer, no answer, no	method to arrive <u>at</u> o working out vith working out, no	ot all steps shown.	n
l l n l n l n l n l n l n l n l n l n l	1 mark for on mark for on mark for on tudent have and mark mark for on mark for on marks for one marks for one	1 column correct a ER ME as used a s as foll correct a correct	0 Y correct Z correct answer THOD: any other ows: answer, no answer, no	method to arrive <u>at</u> o working out	ot all steps shown.	n
1 1 n 1 n 1 n 1 n 1 n 1 n 1 n 1 n 1 n 1	1 mark for on mark for on mark for on tudent have and mark mark for on mark for on marks for one marks for one	l column correct a ER ME is used a s as foll correct a correct correct	0 Y correct Z correct answer THOD: any other ows: answer, n answer, n answer w	method to arrive <u>at</u> o working out vith working out, no	ot all steps shown.	n
1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 mark for of mark for of Y OTHI tudent has ard marks for marks for marks for	1 column correct a ER ME as used a s as follo correct a correct correct	0 Y correct Z correct answer THOD: any other ows: answer, no answer, no answer w for 0	method to arrive <u>at</u> o working out vith working out, no	ot all steps shown.	n
1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 mark for on mark for on mark for on ark for on mark for on mark for on marks for marks for marks for marks for marks for marks for marks for	1 column correct a ER ME is used a s as foll correct a correct correct correct	0 Y correct Z correct answer THOD: any other ows: answer, n answer, n answer w answer w for 0 ons :	method to arrive <u>at</u> o working out vith working out, no	ot all steps shown. king out shown.	n
1 1 1 1 1 1 1 1 1 1 1 1 1 1	I mark for a mark for a mark for a tudent ha mark for a marks for marks for marks for marks for for X · Y For X · Y	I column correct a s used a s as foll correct correct correct , False e notation Y allow	0 Y correct Z correct answer THOD: any other ows: answer, no answer, no answer, no answer w answer w for 0 ons : X AND Y	method to arrive <u>at</u> o working out vith working out, no vith all steps of wor Y, $X \land Y, X \cap Y$, $X \lor Y, X \cup Y$	ot all steps shown. king out shown.	n 3

January 2010 Comp 2

January 2011 Comp 2

3	$(\overline{\overline{A}.\overline{B}})$ becomes A + B ; A (A+B); A A OR B;	
	$B+B.\overline{C}$ becomes B; A.B+A. \overline{B} becomes A;	
	A.(B+1) becomes A ;	4
	1 mark for each	4

January	2012	Comp	2
-		-	

2	d	$(X + Y).(X + \overline{Y})$ [Fully expanding brackets - 1 mark] $X.X + X.\overline{Y} + Y.X + Y.\overline{Y}$ [Recognising $X.X = X$ OR $Y.\overline{Y} = 0 - 1$ mark] $X + X.\overline{Y} + Y.X + 0$ [Taking X outside brackets - 1 mark] $X(1 + \overline{Y} + Y)$ OR $X + X(\overline{Y} + Y)$ X [Final Answer, 1 mark] Alternative Answer : (Distributive) $(X + Y).(X + \overline{Y}) = X + (Y.\overline{Y})$ [Use of distributive law - 1 mark] $X + (Y.\overline{Y}) = X + 0$ [Recognising $Y.\overline{Y} = 0 - 1$ mark] X + 0 = X [1 mark] X [Final Answer, 1 mark] Alternative Answer : (De Morgan's) $\overline{X + Y} + \overline{X} + \overline{Y} = 0$	NOTE : Mark against one of the answers included. MAX 2 for working/meth od if mistakes occur. Any new solutions refer to team leader.
		$\overline{\overline{X+Y}} + \overline{\overline{X}} = Q$ [Use of De Morgan's – 1 mark]	

$\overline{X+Y} + \overline{X+\overline{Y}} = \overline{Q}$		
$ \overline{\overline{X}.\overline{Y}} + \overline{\overline{X}.\overline{\overline{Y}}} = \overline{Q} $ [Two further applications of De Morgan's] $ \overline{X}.\overline{Y} + \overline{X}.Y = \overline{Q} $		
$\bar{X}.(\bar{Y} + Y) = \bar{Q}$ [Taking X outside brackets - 1 mark] [Recognising ~Y + Y = 1 - 1 mark] $\bar{X}.1 = \bar{Q}$ [Recognising X.1=X - 1 mark]		
$\bar{X} = \bar{Q}$		
X = Q [Final answer, 1 mark]		
MAX 3 for working/method; 1 for final answer		
X on own with no working gains 1 mark.	MAX 4	

January 2013 Comp 2

4	С	De Morgan's (law);	1

4	d	Mark allocation:	3
		One mark for taking either A, NOT C or A AND NOT	
		C outside of brackets to produce a correct expression;	
		One mark for eliminating B in a valid way;	
		One mark for correct final answer;	
		Example One:	
		A. B. \overline{C} + A. \overline{C}	
		A (B, $\overline{C} + \overline{C}$) - taking A outside of brackets;	
		$A(\bar{C}(B+1))$ (B+1)=1	
		Simplifying to remove B using B + 1 = 1;	
		$B.\overline{C} + \overline{C} = \overline{C}$	
		Simplifying to remove B using B. $\overline{C} + \overline{C} = \overline{C}$;	
		A. $A(\overline{C}(B+1)) \rightarrow A.\overline{C};$	
		Final answer A. C	

Exar	nple T	NO:		
A. B.	Ē + A.	Ĉ		
A. Ē(B + 1) – takir	ng outside of	brackets;
(B +	1)=1;	- simpli	fying to remo	ve B
A. A	. C(B -	+1) →	A.C	
Final	answe	AC		
Filla	diiswe	A.C		
Trut	h Table	Method	i i	
			4.7	4.9.2.1.2
A 0	B 0	C 0	A. Č	A. B. Č + A. Č 0
0	0	1	0	0
0	1	0	0	0
0				0
0	_	1	0	
0	1	1	0	
0	1	0	1	1
0	1			

9	(c)	ALG	EBR/	AIC SO	OLUTION			
	1.0	B . ($A + \overline{B}$)				
		D	+B.	D				
						for expansion		
		$B \cdot A$	+0				that $\mathbf{B} \cdot \mathbf{B} = 0$]	
		$B \cdot A$	Li.		[1 mark	for correct ans	swer]	
		TRU	ты т/		SOLUTIO	N-		
		INO	111 17	X	Y	Z	1	
		A	B	B	$A + \overline{B}$	$B \cdot (A + \overline{B})$	1	
		0	0	1	1	0	1	
		0	1	0	0	0]	
		1	0	1	1	0]	
		1	1	0	1	1 and Y correct] [
					nn Z corre ct answer	Contraction of Provide State		
					ETHOD:			
					sed any ot		arrive at correct answer	
						no working o	ut	
							out, not all steps	
		show						
		3 ma	rks fo	or corr	ect answe	r with all step	s of working out shown.	
		A True for 1, False for 0						
		A alt	ernati	ve not	tations :		48-198 - 1999 N	
			or X.	Y allo	W X AND	Y, XAY, XC	Y, XY	
		• For $X \cdot Y$ allow X AND Y, $X \wedge Y$, $X \cap Y$, XY						
				Y allow	WXORY,	$X \lor Y, X \cup$	Y	3

June 2010 Comp 2

June 2011 Comp 2

3	c	$(\overline{A \cdot B}) + (\overline{A \cdot \overline{B}})$									
		$(\overline{A} + \overline{B}) + (\overline{A} + B)$; ; 2 marks – 1 each for De Morgans rule for each side of									
		the central OR (award the mark for right hand expression, even if double NOT over B is not cancelled) $\overline{A} + \overline{B} + B$; Recognising NOT A OR NOT A is NOT A, and producing a correct expression									
		A+1; Recognising B or NOT B is 1									
		Final answer 1 ;									
		Alternative answer									
		$\overline{(\overline{A \cdot B}) \cdot (\overline{A \cdot \overline{B}})}$; Application of De Morgan's to entire expression									
		$\overline{(A \cdot B) \cdot (A \cdot \overline{B})}$; Cancellation of NOTs; 1 mark – De Morgans on entire expression									
		A · B · B; Recognising A and A is A									
		$\overline{A \cdot 0}$; Recognising B ANDed with its complement is 0									
		0 ; Recognising 0 AND anything is 0									
		Final answer 1 ;									
		NOTE : Marks can be awarded for the skills above if seen but MAX 3 (out of 4) for whole question if working has errors in it									
		A T, True for 1 and F, False for 0									
		A alternative notations :									
		• For $X \cdot Y$ allow X AND Y, $X \wedge Y, X \cap Y, XY$									
		 For X+Y allow X OR Y, X ∨ Y, X ∪ Y For X allow NOT X, ¬X 	STUDD								
			MAX 3								
		Or by truth table M = marking point M M M M	for stages								
		A B AB AB B AB AB AB AB + AB 1	1 for								
		0 0 0 1 1 0 1 1 0 1 0 1 0 0 1 1 1 0 0 1 1 0 1	final								
		1 0 0 1 1 1 0 1	= 4								

8	c	Solution 1: $Q = \overline{A} \cdot (\overline{B} \cdot A)$ [Application of De Morgan's Law -1 mar $Q = A \cdot B \cdot A$ [allow simplification of double nots at same time] [Simplification of A.A to A - 1 mark] $Q = A \cdot B$ [Correct solution - 1 mark]Solution 2:		1 mark for De Morgan; 1 mark for simplifica tion; 1 mark for final answer;
		$Q = \overline{\overline{A} + (\overline{B} + \overline{A})} $ [Application of De Morgan's Law – 1 mark] $Q = \overline{\overline{A} + \overline{B} + \overline{A}} $ [allow simplification of double nots at same time] $Q = \overline{\overline{A} + \overline{B}} $ [Simplification of NOT A OR NOT A to NOT A – 1 mark] Q = A.B [De Morgan's again to correct solution – 1 mark]		Other notations as for question 8b
		No working marks for truth table solution (asked to use De Morgan's in question)	3	

June 2012 Comp 2

June 2013 Comp 2

6	(b)	(i)	В;	1	
---	-----	-----	----	---	--

6 (b) (ii) B;	1
---------------	---

6	(b)	(iii)	0;;	
			Award 1 mark if De Morgan's has been applied once correctly but candidate does not end up simplifying to 0	2
			Example: $\overline{B + (\overline{A} + \overline{B})}$	
			Example: \overline{B} . (A.B)	

June 2016 AS Paper 2

03	Marks are for AO2 (appl)	()	4
	 If, in any one step, expression simulta stage but don't aw simplified incorrect was changed to P. simplifying the first correctly simplifyin 	aminers orking out until an incorrect step has been made. a candidate is simplifying different parts of an neously award all relevant marks for this multiple ard any further marks for working in any parts dy. Example, if the expression $P.P.(P + Q) + P.P.1$ (P+Q) + P.0 the candidate would get one mark for part to $P.(P+Q)$ and could get further marks for g this part of the expression further but should not be simplifying the incorrectly changed part P.0 (ie to 0).	
	Mark as follows		
	1 mark for final answer: 7	LB	
	Max 3 for working; Max 3 significant steps of working	if answer is correct but any incorrect working or g is missing:	
	simpler expression. Max 1 mark for applying an ide simpler expression. Max 1 mark for expanding brack	oplication of De Morgan's Law that would lead to a 2 for applications of De Morgan's Law. Initity other than cancelling nots that produces a 2 for applying identities. Ckets or putting an expression into brackets that would on. Max 2 for expanding brackets or putting an	
	Note: a simpler expressio expression but uses fewer	n is one that is logically equivalent to the original logical operators.	
	Example working (1)		
	$= (\overline{A} + B). (\overline{A}. (B + A))$	[application of De Morgan's law]	
	$= (\overline{A} + B). (\overline{A}.B + \overline{A}.A)$	[expansion of brackets]	
	$= (\overline{A} + B). (\overline{A}. B)$	[use of identities $X, \overline{X} = 0$ and $X+0 = X$]	
	$=\overline{A}.\overline{A}.B+B.\overline{A}.B$	[expansion of brackets]	
	$= (\overline{A} + B). (\overline{A}. B + \overline{A}. A)$ $= (\overline{A} + B). (\overline{A}. B)$ $= \overline{A}. \overline{A}. B + B. \overline{A}. B$ $= \overline{A}. B + \overline{A}. B$ $= \overline{A}. B + \overline{A}. B$	[use of identity $X.X = X$ twice]	
	$=\overline{A}.B$	[use of identity $X + X = X$]	
1 1	I		1

$=(\overline{\overline{A}+B})+(A+(\overline{B}+\overline{A}))$	[application of De Morgan's Law]
$=\overline{A.\overline{B}+\overline{A}.(B+A)}$	[application of De Morgan's Law twice]
$=\overline{A.\overline{B}+(\overline{\overline{A}.B+\overline{A}.A})}$	[expansion of brackets]
$=\overline{A.B}+\overline{\overline{A.B}}$	[use of identities $\overline{A}.A = 0$ and $X + 0 = X$]
$=\overline{\overline{A}+B}+\overline{\overline{A}.B}$	[application of De Morgan's Law]
$=(\overline{A}+B).(\overline{A}.B)$	[application of De Morgan's Law]
$=\overline{A}.\overline{A}.B+B.\overline{A}.B$	[expansion of brackets]
$=\overline{A}.B+\overline{A}.B$	[use of identity $X.X = X$ twice]
$=\overline{A}.B$	[use of identity $X + X = X$]
Alternative example work	ing (3)
$=\overline{(\overline{\overline{A}+B})+(A+(\overline{B}+\overline{A}))}$	[application of De Morgan's Law]
$=\overline{A.\overline{B}+\overline{\overline{A}.(B+A)}}$	[De Morgan's Law twice]
$=\overline{A.\overline{B}+(\overline{\overline{A}.B+\overline{A}.A})}$	[Expansion]
$=\overline{A.\overline{B}+\overline{A.B}}$	[Identity $\overline{A}.A = 0$ and $A + 0 = A$]
$=\overline{\overline{A}+B}+\overline{\overline{A}}.B$	[application of De Morgan's Law]
$=(\overline{A}+B).(\overline{A}.B)$	[application of De Morgan's Law]
$=\overline{A}.\overline{A}.B+B.\overline{A}.B$	[Expansion]
$=\overline{A}.B+\overline{A}.B$	[Identity $\overline{A}.\overline{A} = \overline{A}$ and $B.B = B$]
$=\overline{A}B$	[Final answer via identity $A + A = A$]

June 2017 AS Paper 2

3	Marks are for AO2 (apply)		4
	 Award marks for working out If, in any one step, a candidat simultaneously award all relevant for working expression P.P.(P+Q) + P.P. would get one mark for simpli marks for correctly simplifying 	until an incorrect step has been made. te is simplifying different parts of an expression vant marks for this multiple stage but don't award in any parts simplified incorrectly. Example, if the 1 was changed to P.(P+Q)+P.0, the candidate ifying the first part to P.(P+Q) and could get further g this part of the expression further but should not	
	Mark as follows		
	1 mark for final answer X		
	Max 3 marks for working:		
	 produces a simpler express 1 mark for expanding brack 	sion. kets	
	Max 3 if answer is correct but any missing.	incorrect working or significant steps of working is	
	Example working (1)		
	$\begin{array}{l} X.X + X.\overline{Y} + Y.X + Y.\overline{Y} \\ X + X.\overline{Y} + Y.X + 0 \\ X(1 + \overline{Y} + Y) \text{ or } X + X(\overline{Y} + Y) \end{array}$	[expansion of brackets] [use of $X \cdot X = X$ and $Y, \overline{Y} = 0$] [taking X outside of brackets]	
	Alternative example working (2)		
	$ \begin{array}{c} X + (Y, \overline{Y}) \\ X + 0 \\ X \end{array} $	[Use of distributive law] [Y. $\overline{Y} = 0$] [Recognising X+0 = X]	
	3	 Marking guidance for examiners Award marks for working out If, in any one step, a candidat simultaneously award all relet any further marks for working expression P.P.(P+Q) + P.P. would get one mark for simplifying be awarded marks for s	 Marking guidance for examiners Award marks for working out until an incorrect step has been made. If, in any one step, a candidate is simplifying different parts of an expression simultaneously award all relevant marks for this multiple stage but don't award any further marks for working in any parts simplified incorrectly. Example, if the expression P.P.(P+Q) + P. P. 1 was changed to P.(P+Q)+P.0, the candidate would get one mark for simplifying the first part to P.(P+Q) and could get further marks for correctly simplifying the incorrectly changed part P.0 (ie to 0) Mark as follows mark for final answer X Max 3 marks for working: 1 mark for each application of an identity other than cancelling NOTs that produces a simpler expression. 1 mark for expanding brackets 1 mark for putting an expression into brackets that would lead to a simpler expression. Max 3 if answer is correct but any incorrect working or significant steps of working is missing. Example working (1) X × + X^T + Y.X + 0 X + (Y^T Y) or X + X(Y + Y) [Use of distributive law] X + (Y^T) [Use of distributive law] X + (Y^T) [Use of distributive law] X + (Y^T)

June 2017 Paper 2

04	3	All marks AO2 (apply)	
		 Marking guidance for examiners Award marks for working out until an incorrect step has been made. If, in any one step, a candidate is simplifying different parts of an expression simultaneously award all relevant marks for this multiple stage but don't award any further marks for working in any parts simplified incorrectly. For example, if the expression P.P.(P+Q) + P.P.1 was changed to P.(P+Q)+P.0, the candidate would get one mark for simplifying the first part to P.(P+Q) and could get further marks for correctly simplifying this part of the expression further but should not be awarded marks for simplifying the incorrectly changed part P.0 (ie to 0) 	4
		1 mark for final answer: B + C	
		MAX 3 for working. Award up to two marks for applying each one of the three techniques (one mark per application):	
		 a successful application of De Morgan's Law (and any associated cancellation of NOTs) that produces a simpler expression. 	
		 applying an identity other than cancelling NOTs that produces a simpler expression. successfully expanding brackets. 	
		Note: A simpler expression is one that is logically equivalent to the original expression but uses fewer logical operators.	
		Example Working (1)	
		$\overline{(\overline{A} + A \cdot (A + B))} + \overline{(B \cdot \overline{C})}$	
		$= (\overline{A} + A \cdot (A + B)) \cdot \overline{(\overline{B} \cdot \overline{C})}$ Application of DeMorgan $= (\overline{A} + A \cdot (A + B)) \cdot (B + C)$ Application of DeMorgan	
		$= (A + A \cdot (A + B)) \cdot (B + C)$ Application of Demorgan = $(\overline{A} + A) \cdot (B + C)$ By identity $A = A \cdot (A + B)$	
		$= (A + A)^{-}(B + C)$ $= 1 \cdot (B + C)$ By identity $\overline{A} + A = 1$	
		= B + C By identity 1 · X = X	
		Example Working (2)	

$\overline{(\overline{A} + A \cdot (A + B))} + ($	B·C)	
$= \overline{\left(\overline{A} + A \cdot A + A \cdot B\right)}$	+ $(\overline{B} \cdot \overline{C})$ Expansion of brackets	
$= (\overline{A} + A + A \cdot B) + ($	$(\overline{B} \cdot \overline{C})$ By identity $A \cdot A = A$	
$=\overline{(1+A\cdot B)}+(\overline{B}\cdot \overline{C})$	By identity $\overline{A} + A = 1$	
$=\overline{(1)}+(\overline{B}\cdot\overline{C})$	By identity $1 + X = 1$	
$= \overline{0 + (\overline{B} \cdot \overline{C})}$	By identity $\bar{0} = 1$	
$= \overline{(\overline{B} \cdot \overline{C})}$	By identity $0 + X = X$	
= B + C	Application of DeMorgan	

				<u>Ju</u>	ne 2	009 (<u> Comp 2</u>		
(c)	ALG	EBR	AIC S	OLU	TION:				
	$A \cdot I$ $B \cdot ($ B $A \text{ alte}$ $\bullet F c$ $\bullet F c$	B + B $A + \overline{A}$ ernative or X · or X+	A) // E ve nota Y allo Y allo	ations ow X w X ([Com [Com	the term of the term of term	of DeMorgan's 1 In B taken out 1 er 1 mark] $X \cap Y, XY$ $\cup Y$		
	TRU	ТН Т	ABLE	sol			7	7	
		D	_	-	X	Y	Z	-	
	A	B	A	B	$\overline{A} + \overline{B}$	B·A	$\overline{A} + \overline{B} + B \cdot \overline{A}$		
	0	0	1	1	0	0	0	1	
	0	1	1	0	0	1	1]	
	1	0	0	1	0	0	0		
	1	1	0	0	1	0	1		
	1 mark for both columns X and Y correct 1 mark for column Z correct 1 mark for correct answer (B)								
	A Rig	htmo	st colu	ımn l	abelled a	s L or Q			3

Specimen AS Paper 2

09	2	Marks are for AO2 (apply)	3
		A.B. $(A + B)$ A.B.A + A.B.B;B.A + A.B;[use of A.A = A]A.B;[use of A + A = A]	
		1 mark: Final answer: A.B;	
		Max 2 for working	

09	3	Marks are for AO2 (apply)	3
		(X + Y).(X + NOT Y) XX + X(NOT Y) + XY + Y(NOT Y); [expansion of brackets] X + X(NOT Y) + XY; [use of X.X = X or use of Y(NOT Y) = 0] X (1 + NOT Y + Y); [use of 1 + X = 1]	
		1 mark: Final answer - X;	
		Max 2 for working	

Specimen Paper 2

	Equation	Correct? (Shade three)]	
	$A \cdot \overline{A} = 1$			
	$A + B = \overline{\overline{A} \cdot \overline{B}}$	~		
	A + 1 = 1	~		
	$A \cdot (A + B) = A$	~]	
	$A + (A \cdot B) = B$]	
	$A \cdot 1 = 1$			
		s from the numb	ed then take the number of er of correct answers to	

11	2	All marks AO2 (apply)	3
		Example solution:	
		$\overline{\overline{A}} + \overline{\overline{B}} + \overline{B} \cdot \overline{A}$	
		$= A \cdot B + B \cdot \overline{A}$	
		$= B \cdot (A + \overline{A})$	
		= B · 1	
		= B	
		In any attempted solution award:	
		1 mark for an application of DeMorgan's law	
		1 mark for an application of a Boolean identity or expanding the brackets	
		1 mark for correct answer	