1	1	**Marks are for 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. 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) **Mark as follows** **MAX 3 marks for working** Award one mark each for applying the techniques below: • a successful application of De Morgan's Law (and any associated cancellation of NOTs) that produces a simpler expression. • successfully expanding brackets. Award one mark for each application of a Boolean identity **MAX 2**. **Note:** A simpler expression is one that is logically equivalent to the original expression but uses fewer logical operators. **Example working (1)** $\overline{\overline{A \cdot \overline{B}} \cdot \overline{\overline{A} \cdot (B + B)}}$ [use of $\overline{B} + 0 = \overline{B}$] $\overline{\overline{A \cdot \overline{B}} \cdot \overline{\overline{A} \cdot B}}$ [use of B + B = B] $A \cdot \overline{B} + \overline{A} \cdot B$ [application of De Morgan's Law] **Example working (2)** $A \cdot (\overline{B} + 0) + \overline{A} \cdot (B + B)$ [use of De Morgan's Law] $A \cdot \overline{B} + \overline{A} \cdot 0 + \overline{A} \cdot B + \overline{A} \cdot B$ [expansion of brackets]	4

		$A \cdot \overline{B} + \overline{A} \cdot B + \overline{A} \cdot B$ $A \cdot \overline{B} + \overline{A} \cdot B$ **Example working (3)** $A \cdot (\overline{B} + 0) + \overline{A} \cdot (B + B)$ $A \cdot \overline{B} + \overline{A} \cdot B$ **1 mark** for final answer A XOR B // A Exclusive OR B // A EOR B // A EXOR B // A $\oplus$ B	[use of $\overline{A} \cdot 0 = 0$ and removal] [application of $\overline{A} \cdot B + \overline{A} \cdot B = \overline{A} \cdot B$] [use of De Morgan's Law] [$\overline{B} + 0 = \overline{B}$ and $B+B=B$ means two marks for identities within brackets]	

2	1	**Mark is for AO1 (understanding)** OR; **A**. A+B // +	1

2	2	**Marks are for 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. 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) **Mark as follows** **1 mark** for final answer A **3 marks for working** **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. **Note:** Any application of De Morgan's Law or expanding brackets which result in an expression which should be bracketed must be shown with brackets to be awarded a mark. **Example working (1)** $A \cdot (A + C) \cdot \overline{A} \rightarrow A \cdot \overline{A}$ [Absorption] $A \cdot \overline{A} \rightarrow 0$ [Complement] $\overline{(\overline{A} \cdot \overline{A \cdot B})} \rightarrow A + A \cdot B$ [De Morgan's Law] $A + A \cdot B \rightarrow A$ [Absorption] $0 + A \rightarrow A$ [Identity] **Example working (2)** $A \cdot (A + C) \cdot \overline{A} \rightarrow A \cdot \overline{A}$ [Absorption] $A \cdot \overline{A} \rightarrow 0$ [Complement] $\overline{(\overline{A} \cdot \overline{A \cdot B})} \rightarrow (\overline{\overline{A} \cdot (\overline{A} + \overline{B})})$ [De Morgan's Law] $(\overline{\overline{A} \cdot (\overline{A} + \overline{B})}) \rightarrow \overline{\overline{A} + \overline{A} \cdot \overline{B}}$ [Associative] $\overline{\overline{A} + \overline{A} \cdot \overline{B}} \rightarrow \overline{\overline{A}}$ [Absorption] $\overline{\overline{A}} \rightarrow A$ [Double Not] $0 + A \rightarrow A$ [Identity]	4

3	1	**4 marks are for AO2 (apply)** **Marking guidance for examiners** • Award marks for working out until an incorrect step has been made. If a student misses out some steps but does not make an error then continue marking. • 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 this part of the expression further but should not be awarded marks for simplifying the incorrectly changed part P.0 (ie to 0) **Mark as follows** **1 mark** for final answer $\mathrm{A} \cdot \overline{\mathrm{C}}$ **Max 3 marks for working:** • **1 mark** for <u>each</u> application of an identity or theorem other than cancelling NOTs that produces a simpler expression. • **1 mark** for a <u>single</u> successful application of the distributive law that produces a simpler expression. **Note:** a simpler expression is one that is logically equivalent to the original expression but uses fewer logical operators. **Max 3** if answer is correct but any incorrect working or significant steps of working is missing. **Example working (1)** $\overline{\overline{\mathrm{A}+\mathrm{0}}+\mathrm{C}\cdot\mathrm{A}}$ [B. NOT B = 0] $(\mathrm{A}+\mathrm{0})\cdot\overline{\mathrm{C}\cdot\mathrm{A}}$ [Application of De Morgan's Law] $(\mathrm{A}+\mathrm{0})\cdot(\overline{\mathrm{C}}+\overline{\mathrm{A}})$ [Application of De Morgan's Law] $\mathrm{A}\cdot(\overline{\mathrm{C}}+\overline{\mathrm{A}})$ [A + 0 = A] $\mathrm{A}\cdot\overline{\mathrm{C}}+\mathrm{A}\cdot\overline{\mathrm{A}}$ [Expand brackets] $\mathrm{A}\cdot\overline{\mathrm{C}}+\mathrm{0}$ $[\mathrm{A}\cdot\overline{\mathrm{A}}=\mathrm{0}]$ $\mathrm{A}\cdot\overline{\mathrm{C}}$ $[\mathrm{A}+\mathrm{0}=\mathrm{A}]$ **Example working (2)** $(\mathrm{A}+\mathrm{B}\cdot\overline{\mathrm{B}})\cdot\overline{\mathrm{C}\cdot\mathrm{A}}$ [Application of De Morgan's Law] $(\mathrm{A}+\mathrm{0})\cdot\overline{\mathrm{C}\cdot\mathrm{A}}$ [B. NOT B = 0] $\mathrm{A}\cdot\overline{\mathrm{C}\cdot\mathrm{A}}$ [A + 0 = A] $\mathrm{A}\cdot(\overline{\mathrm{C}}+\overline{\mathrm{A}})$ [Application of De Morgan's Law] $\mathrm{A}\cdot\overline{\mathrm{C}}+\mathrm{A}\cdot\overline{\mathrm{A}}$ [Expand brackets] $\mathrm{A}\cdot\overline{\mathrm{C}}+\mathrm{0}$ $[\mathrm{A}\cdot\overline{\mathrm{A}}=\mathrm{0}]$ $\mathrm{A}\cdot\overline{\mathrm{C}}$ $[\mathrm{A}+\mathrm{0}=\mathrm{A}]$	4

<table>
<tr><th>Qu</th><th>Pt</th><th>Marking Guidance</th><th>Marks</th></tr>
<tr><td>4</td><td>1</td><td>
Marks are for AO2 (analyse)

1 mark for showing the correct truth table column for $\left(\mathrm{A}+\overline{\mathrm{B}}\right)\cdot\mathrm{B}$;

1 mark for showing the correct truth table column for $\left(\mathrm{A}+\overline{\mathrm{B}}\right)$;

<table>
<tr><th>$\mathbf{A}$</th><th>$\mathbf{B}$</th><th>$\overline{\mathbf{B}}$</th><th>$\left(\mathbf{A}+\overline{\mathbf{B}}\right)$</th><th>$\left(\mathbf{A}+\overline{\mathbf{B}}\right)\cdot\mathbf{B}$</th></tr>
<tr><td>0</td><td>0</td><td>1</td><td>1</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>1</td><td>1</td></tr>
</table>
1 mark for showing the correct answer as $\mathrm{A}\cdot\mathrm{B}$;
</td><td>3</td></tr>
</table>

<table>
<tr><th>Qu</th><th>Pt</th><th>Marking Guidance</th><th>Marks</th></tr>
<tr><td>4</td><td>2</td><td>

Marks are for AO2 (application)

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).

1 mark for final answer of $A \cdot \overline{B}$;

3 marks for working

MAX 3 for working. Award up to two marks for applying each of the three techniques (one mark per application) to produce a simpler expression.

- Applying De Morgan's Theorem.
- Multiply and/or factorise brackets.
- Using a law or identity.

Note: A simpler expression is one that is logically equivalent to the original expression but uses fewer logical operators.

Example 1:

$\left(A+\overline{B}\right)\cdot\left(\overline{\overline{A}+B}\right)$	DMT
$\left(A+\overline{B}\right)\cdot\left(A\cdot\overline{B}\right)$	Multiply brackets
$A\cdot A\cdot\overline{B} + \overline{B}\cdot A\cdot\overline{B}$	X.X = X
$A\cdot\overline{B}+\overline{B}\cdot A$	X + X = X
$A\cdot\overline{B}$	

Example 2:

$\left(A+\overline{B}\right)\cdot\left(\overline{\overline{A}+B}\right)$	DMT
$\overline{\overline{\left(A+\overline{B}\right)}+\left(\overline{A}+B\right)}$	DMT
$\overline{\overline{A}\cdot B+\left(\overline{A}+B\right)}$	A + (A.X) = A
$\overline{\overline{A}+B}$	DMT
$A\cdot\overline{B}$	

</td><td>4</td></tr>
</table>

Qu	Pt	Marking Guidance	Marks
5	1	**Marks are for AO2 (application)** **1 mark** for each highlighted column L, N and Y completed correctly. **A**. Follow through for Y if column N is completed incorrectly.	3

A	B	C	L	M	N	X	Y
0	0	0	0	0	0	0	0
0	0	1	0	0	0	1	0
0	1	0	1	0	0	1	0
0	1	1	1	1	0	0	1
1	0	0	1	0	0	1	0
1	0	1	1	1	0	0	1
1	1	0	0	0	1	0	1
1	1	1	0	0	1	1	1

Qu	Pt	Marking Guidance	Marks
5	2	**Marks are for AO2 (application)** **2 marks:** $(A \oplus B) \cdot C + A \cdot B$ // $((A \cdot \bar{B}) + (\bar{A} \cdot B)) \cdot C + A \cdot B$ // $(\bar{A} \cdot B \cdot C) + (A \cdot (B + C))$ // **1 mark** for one of the following somewhere in the expression: • $(A \oplus B) \cdot C$ **I.** presence / absence of brackets around $A \oplus B$ • $((A \cdot \bar{B}) + (\bar{A} \cdot B)) \cdot C$ • $A \cdot B$ **Note:** If using a different algebraic notation refer to team leader.	2

Qu	Pt	Marking Guidance	Marks
5	3	**Marks are for AO2 (application)** **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	4

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).

Mark as follows:

MAX 3 marks for working

Award one mark each for applying the techniques below:

- A successful application of De Morgan's Law (and any associated cancellation of NOTs) that produces a simpler expression.
- Successfully expanding brackets.
- Extracting common factors from terms.

Award one mark for each application of a Boolean identity **MAX 2**.

Note: A simpler expression is one that is logically equivalent to the original expression but uses fewer logical operators.

1 mark for final answer: B

$\overline{\overline{\overline{A} + \overline{B}}} + B \cdot \overline{A} \cdot 1$	[use of $\overline{C} + C = 1$]
$\overline{\overline{\overline{A} + \overline{B}}} + B \cdot \overline{A}$	[use of $\overline{A} \cdot 1 = \overline{A}$]
$A \cdot B + B \cdot \overline{A}$	[use of de Morgan's Law]
$B \cdot (A + \overline{A})$	[factoring B]
$B \cdot 1$	[use of common factor - $B \cdot (A + \overline{A}) = B \cdot 1$]
B	[use of $B \cdot 1 = B$]

Alternative answer 1

$\overline{\overline{\overline{A} + \overline{B}}} + B \cdot \overline{A} \cdot 1$	[use of $\overline{C} + C = 1$]
$\overline{\overline{\overline{A} + \overline{B}}} + B \cdot \overline{A}$	[use of $\overline{A} \cdot 1 = \overline{A}$]
$\overline{(\overline{A} + \overline{B}) \cdot \overline{B \cdot \overline{A}}}$	[use of de Morgan's Law]
$\overline{(\overline{A} + \overline{B}) \cdot (\overline{B} + A)}$	[use of de Morgan's Law]
$\overline{\overline{A} \cdot \overline{B} + \overline{A} \cdot A + \overline{B} \cdot \overline{B} + \overline{B} \cdot A}$	[expansion of brackets]
$\overline{\overline{A} \cdot \overline{B} + \overline{B} \cdot \overline{B} + \overline{B} \cdot A}$	[use of $\overline{A} \cdot A = 0$, $A + 0 = A$]
$\overline{\overline{A} \cdot \overline{B} + \overline{B} + \overline{B} \cdot A}$	[use of $\overline{B} \cdot \overline{B} = \overline{B}$]
$\overline{\overline{B} + \overline{B} \cdot A}$	[use of $\overline{A} \cdot \overline{B} + \overline{B} = \overline{B}$]
$\overline{\overline{B}}$	[use of $\overline{B} + \overline{B} \cdot A = \overline{B}$]
B	[Negation of double NOTs]

Qu	Pt	Marking Guidance	Marks
06	1	**Marks are for AO2 (application)** 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 this part of the expression further but should not be awarded marks for simplifying the incorrectly changed part P.0 (ie to 0). Award up to **3 marks** for working. **1 mark per application** of a technique that produces a simplified expression. Of the 3 working marks **award at most 1 mark for correctly applying the Distributive Law** to expand or introduce brackets. **Note:** A simpler expression is one that is logically equivalent to the original expression but uses fewer logical operators. **1 mark** for final answer: $X \cdot Z + X \cdot Y + W \cdot Z$ or $X \cdot (Z + Y) + W \cdot Z$ **Example working 1:** $\overline{W} \cdot X \cdot Z + W \cdot Z + X \cdot Y \cdot \overline{Z} + \overline{W} \cdot X \cdot Y \cdot 1$ $\overline{W} \cdot X \cdot Z + W \cdot Z + X \cdot Y \cdot \overline{Z} + \overline{W} \cdot X \cdot Y$ Identity $A.1 = A$ $Z \cdot (\overline{W} \cdot X + W) + X \cdot Y \cdot \overline{Z} + \overline{W} \cdot X \cdot Y$ Distributive, put into brackets $Z \cdot (X + W) + X \cdot Y \cdot \overline{Z} + \overline{W} \cdot X \cdot Y$ $\overline{A}.B + A = B + A$ $X \cdot Z + W \cdot Z + X \cdot Y \cdot \overline{Z} + \overline{W} \cdot X \cdot Y$ Distributive, expand brackets $X \cdot \left(Z + Y \cdot \overline{Z}\right) + W \cdot Z + \overline{W} \cdot X \cdot Y$ Distributive, put into brackets $X \cdot (Z + Y) + W \cdot Z + \overline{W} \cdot X \cdot Y$ $\overline{A}.B + A = B + A$ $X \cdot Z + X \cdot Y + W \cdot Z + \overline{W} \cdot X \cdot Y$ Distributive, expand brackets $X \cdot Z + X \cdot Y \cdot \left(1 + \overline{W}\right) + W \cdot Z$ Distributive $X \cdot Z + X \cdot Y + W \cdot Z$ Identity $1 + A = A$ $X \cdot (Z + Y) + W \cdot Z$ (optional step)	4

Example working 2 :

$\bar{W}.X.Z+W.Z+X.Y.\bar{Z}+\bar{W}.X.Y.1$	
$\bar{W}.X.Z+W.Z+X.Y.\bar{Z}+\bar{W}.X.Y$	Identity A.1 = A
$Z.(\bar{W}.X+W) + X.Y.\bar{Z}+\bar{W}.X.Y$	Distributive, put into brackets
$Z.(X+W) + X.Y.\bar{Z}+\bar{W}.X.Y$	Identity $\bar{A}.B + A = B + A$
$Z.X + Z.W + X.Y.\bar{Z}+\bar{W}.X.Y$	Distribution, expand brackets
$Z.W + Z.X + X.Y.\bar{Z}+\bar{W}.X.Y$	Re-arrange terms
$Z.W+ X(Z+\bar{Z}.Y) + \bar{W}.X.Y$	Distribution, put into brackets
$Z.W+ X(Y + Z) + \bar{W}.X.Y$	Identity $\bar{A}.B + A = B + A$
$Z.W + X.Y + X.Z + \bar{W}.X.Y$	Distribution, expand brackets
$X.Z + Z.W + X.Y + \bar{W}.X.Y$	Re-arrange terms
$X.Z + Z.W + X.Y$	Identity A + A.B = A