Consider the following logic statements.

\( p: \text{Carlos is playing the guitar} \)
\( q: \text{Carlos is studying for his IB exams} \)

1a. Write in words the compound statement \( \neg p \land q \).

**Markscheme**
Carlos is not playing the guitar and he is studying for his IB exams. \( (A1)(A1) \) \( (C2) \)

**Note:** Award \( (A1) \) for “and”, \( (A1) \) for correct statements.

[2 marks]

**Examiners report**
In part (a) occasionally ‘if…then…’ was not seen but generally this was well done.

1b. Write the following statement in symbolic form.

“Either Carlos is playing the guitar or he is studying for his IB exams but not both.”

**Markscheme**
\( p \lor q \) \( (A1) \) \( (C1) \)

[1 mark]

**Examiners report**
Part (b) was also well done despite the dearth of previous testing of the exclusive or statement.

1c. Write the converse of the following statement in symbolic form.

“If Carlos is playing the guitar then he is not studying for his IB exams.”

**Markscheme**
\( \neg q \Rightarrow p \) \( (A1)(A1)(A1) \) \( (C3) \)

**Notes:** Award \( (A1) \) for implication, \( (A1) \) for \( \neg q \), \( (A1) \) for both \( \neg q \) and \( p \) in the correct order. If correct converse seen in words only award \( (A1)(A1)(A0) \). Accept \( p \Leftrightarrow \neg q \). Accept \( \neg q \) for \( \neg q \).

[3 marks]

**Examiners report**
Finding the converse of a statement in part (c) proved to be difficult for a significant number of candidates and incorrect answers of the form \( q \Rightarrow \neg p \) were more frequently seen than the correct answer. Such incorrect answers lost two marks.
Consider the statements
\[ p: \text{The numbers } x \text{ and } y \text{ are both even.} \]
\[ q: \text{The sum of } x \text{ and } y \text{ is an even number.} \]

2a. Write down, in words, the statement \( p \Rightarrow q \). \([2 \text{ marks}]\)

**Markscheme**

If (both) the numbers \( x \) and \( y \) are even (then) the sum of \( x \) and \( y \) is an even number. \((A1)(A1) \quad (C2)\)

**Note:** Award \((A1)\) for If…(then), \((A1)\) for the correct statements in the correct order. \([2 \text{ marks}]\)

**Examiners report**

Although a few candidates did not seem to understand the meaning of the \( \Rightarrow \) symbol, many scored a minimum of two marks on the first two parts of the question. Indeed, many correct statements were seen in part (a). Many candidates however confused converse with inverse in part (b) resulting in the incorrect statement “if the sum of \( x \) and \( y \) are both even then the numbers \( x \) and \( y \) are both even” appearing on many scripts earning \((M1)(A0)\). Despite this incorrect compound statement, many candidates recovered with correct reasoning in part (c) from their correct (or incorrect) statement in part (b). Candidate's responses to part (c) of the question should have been given in the context of the question set and those that simply inferred their answer from truth tables only, earned no marks.

2b. Write down, in words, the inverse of the statement \( p \Rightarrow q \). \([2 \text{ marks}]\)

**Markscheme**

If (both) the numbers \( x \) and \( y \) are not even (then) the sum of \( x \) and \( y \) is not an even number. \((A1)(A1) \quad (C2)\)

**Notes:** Award \((A1)\) for If…(then), \((A1)\) for the correct not \( p \), and not \( q \) in the correct order. Accept the word odd for the phrase “not even”. \([2 \text{ marks}]\)

**Examiners report**

Although a few candidates did not seem to understand the meaning of the \( \Rightarrow \) symbol, many scored a minimum of two marks on the first two parts of the question. Indeed, many correct statements were seen in part (a). Many candidates however confused converse with inverse in part (b) resulting in the incorrect statement “if the sum of \( x \) and \( y \) are both even then the numbers \( x \) and \( y \) are both even” appearing on many scripts earning \((M1)(A0)\). Despite this incorrect compound statement, many candidates recovered with correct reasoning in part (c) from their correct (or incorrect) statement in part (b). Candidate's responses to part (c) of the question should have been given in the context of the question set and those that simply inferred their answer from truth tables only, earned no marks.

2c. State whether the inverse of the statement \( p \Rightarrow q \) is always true. Justify your answer. \([2 \text{ marks}]\)

**Markscheme**

The inverse of a statement is not (necessarily) true, because two odd (not even) numbers, always have an even sum. \((A1)(R1) \quad (C2)\)

**Notes:** Award \((A1)(R1)\) if a specific counter example given instead of a reason stated in general terms, e.g. the inverse is not true because, 5 and 7 have an even sum. Do not award \((A1)(R0)\). Follow through from their statement in part (b). \([2 \text{ marks}]\)
Examiners report

Although a few candidates did not seem to understand the meaning of the \( \Rightarrow \) symbol, many scored a minimum of two marks on the first two parts of the question. Indeed, many correct statements were seen in part (a). Many candidates however confused converse with inverse in part (b) resulting in the incorrect statement “if the sum of \( x \) and \( y \) are both even then the numbers \( x \) and \( y \) are both even” appearing on many scripts earning \((M1)(A0)\). Despite this incorrect compound statement, many candidates recovered with correct reasoning in part (c) from their correct (or incorrect) statement in part (b). Candidate’s responses to part (c) of the question should have been given in the context of the question set and those that simply inferred their answer from truth tables only, earned no marks.

Consider the propositions \( p \) and \( q \).

\[ p: \text{I take swimming lessons} \]
\[ q: \text{I can swim 50 metres} \]

3a. Complete the truth table below.

\[
\begin{array}{c|c|c|c|c}
 p & q & \neg q & p \lor \neg q \\
 T & T &  &  \\
 T & F &  &  \\
 F & T &  &  \\
 F & F &  &  \\
\end{array}
\]

Examiners report

This question was well answered by most of the candidates who could complete the truth table, write the proposition in symbolic form and write the given proposition in words, although the ‘If’ was sometimes omitted. Where marks were lost on Question 2, it was generally in the second column of the truth table.

3b. Write the following compound proposition in symbolic form.

“I cannot swim 50 metres and I take swimming lessons.”

\[ \neg q \land p \]

Examiners report

\[ (A1)(A1) \quad (C2) \]

Note: Award \((A1)\) for \( \neg q \) and \( p \) in any order, \((A1)\) for \( \land \).
Examiners report
This question was well answered by most of the candidates who could complete the truth table, write the proposition in symbolic form and write the given proposition in words, although the ‘If’ was sometimes omitted. Where marks were lost on Question 2, it was generally in the second column of the truth table.

3c. Write the following compound proposition in words.
\[ q \implies \neg q \]

Markscheme
If I can swim 50 metres (then) I do not take swimming lessons.  \((A1)(A1)\)  \((C2)\)

Note: Award \((A1)\) for If… (then), \((A1)\) for correct propositions in the correct order.

2 marks

Examiners report
This question was well answered by most of the candidates who could complete the truth table, write the proposition in symbolic form and write the given proposition in words, although the ‘If’ was sometimes omitted. Where marks were lost on Question 2, it was generally in the second column of the truth table.

Consider two propositions \(p\) and \(q\).

4a. Complete the truth table below.

<table>
<thead>
<tr>
<th>(p)</th>
<th>(q)</th>
<th>(\neg q)</th>
<th>(p \implies \neg q)</th>
<th>(\neg p)</th>
<th>(\neg p \implies q)</th>
</tr>
</thead>
<tbody>
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<td>T</td>
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</table>

Markscheme
\[
\begin{array}{c|c|c|c|c|c}
\hline
p & q & \neg q & p \implies \neg q & \neg p & \neg p \implies q \\
\hline
T & T & F & F & T & T \\
T & F & T & T & F & T \\
F & T & F & T & T & T \\
F & F & F & F & F & T \\
\hline
\end{array}
\]


Note: Award \((A1)\) for each correct column (second column (ft) from first, fourth (ft) from third). Follow through from second column to fourth column for a consistent mistake in implication.

4 marks

Examiners report
The truth table was well done by the majority of candidates but significantly fewer could give the correct reason for whether the compound proposition was a tautology, so many lost 2 marks in this part of the question.
4b. Decide whether the compound proposition

\[( p \Rightarrow \neg q ) \Leftrightarrow ( \neg p \Rightarrow q ) \]

is a tautology. State the reason for your decision.

**Markscheme**

Since second and fourth columns are not identical \((R1)(ft)\)

\[\Rightarrow \text{Not a tautology} \quad (A1)(ft) \quad (C2)\]

**Note:** \((R0)(A1)\) may not be awarded.

[2 marks]

**Examiners report**

The truth table was well done by the majority of candidates but significantly fewer could give the correct reason for whether the compound proposition was a tautology, so many lost 2 marks in this part of the question.

5a. Complete the truth table shown below. \[3 \text{ marks}\]

<p>| | | | | |</p>
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</tbody>
</table>

**Markscheme**

\[
\begin{array}{|c|c|c|c|c|}
\hline
p & q & p \land q & p \lor (p \land q) & (p \lor (p \land q)) \Rightarrow p \\
\hline
T & T & T & T & T \\
T & F & F & T & T \\
F & T & T & F & T \\
F & F & F & F & T \\
\hline
\end{array}
\]

\[(A1)(A1)(ft)(A1)(ft) \quad (C3)\]

**Note:** Award \((A1)\) for each correct column.

[3 marks]

**Examiners report**

The truth table was very well answered and where the table was incorrect a follow through mark could be given for part (b) for a correct answer resulting from their final column. Some candidates appeared unsure of the concept of a tautology.

5b. State whether the compound proposition \((p \lor (p \land q)) \Rightarrow p\) is a contradiction, a tautology or neither. \[1 \text{ mark}\]
5c. Consider the following propositions.

\( p: \) Feng finishes his homework
\( q: \) Feng goes to the football match

Write in symbolic form the following proposition.

If Feng does not go to the football match then Feng finishes his homework.

\[ \neg q \implies p \]

**Markscheme**

\( \neg q \implies p \) (A1)(A1) (C2)

**Note:** Award (A1) for \( \neg q \) and \( p \) in correct order, (A1) for \( \implies \) sign.

**Examiners report**

Nearly all candidates could write the proposition in part (c) in symbolic form.
6b. State whether the statement \((p \land q) \Rightarrow (\neg p \lor q)\) is a logical contradiction, a tautology or neither. [1 mark]

**Markscheme**

Tautology \((A1)(ft)\) \((C1)\)

**Note:** Answer must be consistent with last column in table.

[1 mark]

**Examiners report**

Weaker candidates had some difficulty here with the majority scoring less than 2 marks on this question. The more confident candidates were able to score well with most marks being lost only on completing the truth table for \((\neg p \lor q)\). As a consequence, the final column entries of the table were often incorrect but earned the \((A1)(ft)\) mark. Many candidates went on to correctly identify the correct \((ft)\) response to (b)(i) and were able to support their answer with a correct reason.

6c. Give a reason for your answer to part (b)(i). [1 mark]

**Markscheme**

All entries (in the final column) are true. \((R1)(ft)\) \((C1)\)

**Note:** Answer must be consistent with their answer to part (b)(i).

**Note:** Special case \((A1)(R0)\) may be awarded.

[1 mark]

**Examiners report**

Weaker candidates had some difficulty here with the majority scoring less than 2 marks on this question. The more confident candidates were able to score well with most marks being lost only on completing the truth table for \((\neg p \lor q)\). As a consequence, the final column entries of the table were often incorrect but earned the \((A1)(ft)\) mark. Many candidates went on to correctly identify the correct \((ft)\) response to (b)(i) and were able to support their answer with a correct reason.
7a. Complete the following truth table. [2 marks]

```
<table>
<thead>
<tr>
<th>p</th>
<th>q</th>
<th>...¬q...</th>
<th>p ⇒ ¬q</th>
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<tbody>
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</tbody>
</table>
```

**Markscheme**

```
<table>
<thead>
<tr>
<th>p</th>
<th>q</th>
<th>...¬q...</th>
<th>p ⇒ ¬q</th>
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</table>
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**(A1)(A1)     (C2)

Note: Award (A1) for ¬q, (A1) for last column.

[2 marks]

**Examiners report**

This question was well answered with most candidates able to complete the truth table correctly in part a) and write the correct compound proposition in symbolic form in part b). A significant number of candidates could not write the correct contrapositive, although most were awarded one mark for writing an implication.

7b. Consider the propositions [2 marks]

\[ p: \text{Cristina understands logic} \]
\[ q: \text{Cristina will do well on the logic test} \]

Write down the following compound proposition in symbolic form.

“*If Cristina understands logic then she will do well on the logic test*”

**Markscheme**

\[ p ⇒ q \quad (A1)(A1) \quad (C2) \]

**Note:** Award (A1) for ⇒, (A1) for p and q in the correct order.

[2 marks]

**Examiners report**

This question was well answered with most candidates able to complete the truth table correctly in part a) and write the correct compound proposition in symbolic form in part b). A significant number of candidates could not write the correct contrapositive, although most were awarded one mark for writing an implication.
7c. Write down in words the contrapositive of the proposition given in part (b).

**Markscheme**
If Cristina does not do well on the logic test then she does not understand logic. \((A1)(A1) \quad (C2)\)

**Note:** Award \((A1)\) for If…(then), must be an implication, \((A1)\) for the correct propositions in the correct order.

**Examiners report**
This question was well answered with most candidates able to complete the truth table correctly in part a) and write the correct compound proposition in symbolic form in part b). A significant number of candidates could not write the correct contrapositive, although most were awarded one mark for writing an implication.

---

8a. Consider the statement \(p\):

“If a quadrilateral is a square then the four sides of the quadrilateral are equal”.

Write down the inverse of statement \(p\) in words.

**Markscheme**
If a quadrilateral is not a square (then) the four sides of the quadrilateral are not equal. \((A1)(A1) \quad (C2)\)

**Note:** Award \((A1)\) for “if…(then)”, \((A1)\) for the correct phrases in the correct order.

**Examiners report**
There was confusion among some students about which was the inverse and converse of the given statement.

---

8b. Write down the converse of statement \(p\) in words.

**Markscheme**
If the four sides of the quadrilateral are equal (then) the quadrilateral is a square. \((A1)(A1)\) \((C2)\)

**Note:** Award \((A1)\) for “if…(then)”, \((A1)\) for the correct phrases in the correct order.

**Note:** Follow through in (b) if the inverse and converse in (a) and (b) are correct and reversed.

**Examiners report**
There was confusion among some students about which was the inverse and converse of the given statement.

---

8c. Determine whether the converse of statement \(p\) is always true. Give an example to justify your answer.
Markscheme

The converse is not always true, for example a rhombus (diamond) is a quadrilateral with four equal sides, but it is not a square.

\((A1)(R1)\)  \((C2)\)

Note: Do not award \((A1)(R0)\).

[2 marks]

Examiners report

There was confusion among some students about which was the inverse and converse of the given statement. Part (c) was poorly done with very few students able to provide an example that shows that the converse is not always true.

The Venn diagram below represents the students studying Mathematics \((A)\), Further Mathematics \((B)\) and Physics \((C)\) in a school.

- 50 students study Mathematics
- 38 study Physics
- 20 study Mathematics and Physics but not Further Mathematics
- 10 study Further Mathematics but not Physics
- 12 study Further Mathematics and Physics
- 6 study Physics but not Mathematics
- 3 study none of these three subjects.

Copy and complete the Venn diagram on your answer paper.

[3 marks]

9a. Copy and complete the Venn diagram on your answer paper.

\[3 \text{ marks}\]

Markscheme

\[U\]

\[A \cap B \cap C\]

\[8 10 12\]


Note: Award \((A1)\) for each correct number in the correct position.

\[3 \text{ marks}\]
Examiners report
This part was successfully attempted by the great majority. The less familiar form of the Venn diagram seemed not to cause too many problems, although a common mistake was the failure to add the 20 in set A in part (b). A surprising number seemed unfamiliar with set notation in (d) and thus were not able to attempt this part.

9b. Write down the number of students who study Mathematics but not Further Mathematics. [1 mark]

Markscheme
28 (AI)(ft)

Note: 20 + their 8.

[1 mark]

Examiners report
This part was successfully attempted by the great majority. The less familiar form of the Venn diagram seemed not to cause too many problems, although a common mistake was the failure to add the 20 in set A in part (b). A surprising number seemed unfamiliar with set notation in (d) and thus were not able to attempt this part.

9c. Write down the total number of students in the school. [1 mark]

Markscheme
59 (AI)(ft)

[1 mark]

Examiners report
This part was successfully attempted by the great majority. The less familiar form of the Venn diagram seemed not to cause too many problems, although a common mistake was the failure to add the 20 in set A in part (b). A surprising number seemed unfamiliar with set notation in (d) and thus were not able to attempt this part.

9d. Write down \( n(B \cup C) \). [2 marks]

Markscheme
10 + 12 + 20 + 6 (M1)

Note: Award (M1) for use of the correct regions.

= 48 (AI)(R)(G2)

OR

59 – 8 – 3 (M1)

= 48 (AI)(R)

[2 marks]
Examiners report

This part was successfully attempted by the great majority. The less familiar form of the Venn diagram seemed not to cause too many problems, although a common mistake was the failure to add the 20 in set A in part (b). A surprising number seemed unfamiliar with set notation in (d) and thus were not able to attempt this part.

Three propositions are given as

\[ p: \text{It is snowing} \quad q: \text{The roads are open} \quad r: \text{We will go skiing} \]

9e. Write the following compound statement in symbolic form. \[2\text{ marks}\]

“It is snowing and the roads are not open.”

Markscheme

\[ p \land \neg q \quad (AI)(AI) \]

Note: Award \((AI)\) for \(\land\), \((AI)\) for both statements in the correct order.

[2 marks]

Examiners report

The work on logic also proved accessible to the great majority with a large number of candidates attaining full marks. The most common errors were the omission of the “If” in the conditional statement in (b) and the inability to follow the implication in the truth table in (c).

9f. Write the following compound statement in words. \[3\text{ marks}\]

\[ (\neg p \land q) \Rightarrow r \]

Markscheme

If it is not snowing and the roads are open (then) we will go skiing. \((AI)(AI)(AI)\)

Note: Award \((AI)\) for “if…(then)”, \((AI)\) for “not snowing and the roads are open”, \((AI)\) for “we will go skiing”.

[3 marks]

Examiners report

The work on logic also proved accessible to the great majority with a large number of candidates attaining full marks. The most common errors were the omission of the “If” in the conditional statement in (b) and the inability to follow the implication in the truth table in (c).
An incomplete truth table for the compound proposition \((\neg p \land q) \Rightarrow r\) is given below.

Copy and complete the truth table on your answer paper.

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<table>
<thead>
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**Markscheme**

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Note: Award \((A1)\) for each correct column.

[3 marks]

**Examiners report**

The work on logic also proved accessible to the great majority with a large number of candidates attaining full marks. The most common errors were the omission of the “If” in the conditional statement in (b) and the inability to follow the implication in the truth table in (c).

Police in a town are investigating the theft of mobile phones one evening from three cafés, “Alan’s Diner”, “Sarah’s Snackbar” and “Pete’s Eats”.

They interviewed two suspects, Matthew and Anna, about that evening.

Matthew said:

“I visited Pete’s Eats and visited Alan’s Diner and I did not visit Sarah’s Snackbar.”

Let \(p\), \(q\) and \(r\) be the statements:

- \(p\): I visited Alan’s Diner
- \(q\): I visited Sarah’s Snackbar
- \(r\): I visited Pete’s Eats

Write down Matthew’s statement in symbolic logic form.

[3 marks]
Examiners report
The logic question was clearly difficult for many students. Part a was very poorly done with the majority of students not recognising that two conjunctions were required. Although candidates performed better on part b, many omitted the ‘if, (then)’. One of the most common errors in part b was to translate the disjunction as ‘and’ rather than ‘or’.

What Anna said was lost by the police, but in symbolic form it was
\[(q \lor r) \Rightarrow \neg p\]
Write down, in words, what Anna said.

Examiners report
The logic question was clearly difficult for many students. Part a was very poorly done with the majority of students not recognising that two conjunctions were required. Although candidates performed better on part b, many omitted the ‘if, (then)’. One of the most common errors in part b was to translate the disjunction as ‘and’ rather than ‘or’.

Consider the two propositions p and q.
\[p: \text{The sun is shining} \quad q: \text{I will go swimming}\]
Write in words the compound proposition
\[p \Rightarrow q\]

Examiners report
The most common error was poor use of the “If...then” connective.

Write in words the compound proposition
\[\neg p \lor q\]
Note: Award (A1) for both correct statements and (A1) for “either” “…or”.

2 marks

Examiners report
Confusion between “and” and “or” was rare, however, the use of implication in this part was a little too common.

11c. The truth table for these compound propositions is given below.

<table>
<thead>
<tr>
<th>$p$</th>
<th>$q$</th>
<th>$p \Rightarrow q$</th>
<th>$\neg p$</th>
<th>$\neg p \lor q$</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
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<td>T</td>
</tr>
</tbody>
</table>

Complete the column for $\neg p$.

11d. The truth table for these compound propositions is given below.

<table>
<thead>
<tr>
<th>$p$</th>
<th>$q$</th>
<th>$p \Rightarrow q$</th>
<th>$\neg p$</th>
<th>$\neg p \lor q$</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
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</table>

State the relationship between the compound propositions $p \Rightarrow q$ and $\neg p \lor q$.
A geometric sequence has second term $12$ and fifth term $324$.

12a. Calculate the value of the common ratio.

**Markscheme**

\[ u_1 r^4 = 324 \quad (A1) \]  
\[ u_1 r = 12 \quad (A1) \]  
\[ r^3 = 27 \quad (M1) \]  
\[ r = 3 \quad (A1)(G3) \]

**Note:** Award at most $(G3)$ for trial and error.

**Examiners report**

An easy ratio to find and the majority of candidates found $r = 3$, though many had trouble showing the appropriate method, thus losing marks.

12b. Calculate the $10^{th}$ term of this sequence.

**Markscheme**

\[ 4 \times 3^9 = 78732 \quad (A1)(M1)(A1)(ft)(G3) \]  
\[ 12 \times 3^8 = 78732 \]

**Note:** Award $(A1)$ for $u_1 = 4$ if $n = 9$, or $u_1 = 12$ if $n = 8$, $(M1)$ for correctly substituted formula.

(ft) from their (a).

**Examiners report**

A fairly straightforward part for most candidates.

12c. The $k^{th}$ term is the first term which is greater than $2000$. Find the value of $k$.

**Markscheme**

The $k^{th}$ term is the first term which is greater than $2000$. Find the value of $k$.

**Examiners report**

A fairly straightforward part for most candidates.
**Markscheme**

\[ 4 \times 3^{k-1} > 2000 \quad (M1) \]

**Note:** Award (M1) for correct substitution in correct formula. Accept an equation.

\[ k > 6 \quad (A1) \]

\[ k = 7 \quad (A1)(R)(G2) \]

**Notes:** If second line not seen award (A2) for correct answer. (R) from their (a).

Accept a list, must see at least 3 terms including the 6th and 7th.

**Note:** If arithmetic sequence formula is used consistently in parts (a), (b) and (c), award (A0)(A0)(M0)(A0) for (a) and (R) for parts (b) and (c).

[3 marks]

**Examiners report**

The majority found \( k - 7 \); many without supporting work which lost them a mark. Where candidates had difficulty in this part, it was generally a case of poor algebraic skills.

Consider the following propositions

\[ p: \text{The number is a multiple of five.} \]
\[ q: \text{The number is even.} \]
\[ r: \text{The number ends in zero.} \]

Write in words \((q \land \neg r) \Rightarrow \neg p\).  

[3 marks]

**Markscheme**

If the number is even and the number does not end in zero, (then) the number is not a multiple of five.  

\( (A1)(A1)(A1) \)

**Note:** Award (A1) for “if…(then)”, (A1) for “the number is even and the number does not end in zero”, (A1) for the number is not a multiple of 5.

[3 marks]

**Examiners report**

This question on logic was straightforward for most candidates who scored full marks for parts (a) and (b) (i). A few omitted the brackets in part (b).

Consider the statement “If the number is a multiple of five, and is not even then it will not end in zero”.

Write this statement in symbolic form.  

[4 marks]
Consider the statement “If the number is a multiple of five, and is not even then it will not end in zero”.

Write the contrapositive of this statement in symbolic form.

Markscheme

\[ r \Rightarrow (\neg p \lor q) \quad \text{OR} \quad r \Rightarrow \neg(p \land \neg q) \]

Note: Award \((A1)\)(ft) for reversing the order, \((A1)\) for negating the statements on both sides.

If parentheses not present award at most \((A1)(ft)(A0)\).

Do not penalise twice for missing parentheses in (i) and (ii).

[2 marks]

Examiners report

Very poorly answered with many candidates scoring just one mark. The main error was to open the bracket and not use the “or”.

In a particular school, students must choose at least one of three optional subjects: art, psychology or history.

Consider the following propositions

\[ a: \text{I choose art}, \]
\[ p: \text{I choose psychology}, \]
\[ h: \text{I choose history}. \]

Write, in words, the compound proposition

\[-h \Rightarrow (p \lor a)\]

[3 marks]
**Markscheme**

If I do not choose history then I choose either psychology or I choose art \((A1)(A1)(A1)\) \((C3)\)

Notes: Award \((A1)\) for ‘if… (then)…’
Award \((A1)\) for ‘not choose history.’
Award \((A1)\) for ‘choose (either) psychology or art (or both).’
If the order of the statements is wrong award at most \((A1)(A1)(A0)\).

[3 marks]

**Examiners report**

Many correct answers were seen in part (a) with only a minority of candidates misinterpreting the symbol \(\lor\) as ‘and’. Some candidates left out the word ‘if’ and consequently lost the first mark.

---

13b. Complete the truth table for \(\neg a \Rightarrow p\).

\[
\begin{array}{cccc}
  a & p & \neg a & \neg a \Rightarrow p \\
  T & T & F &  \\
  T & F & F &  \\
  F & T & T &  \\
  F & F & T & \\
\end{array}
\]

[1 mark]

**Markscheme**

\[
\begin{array}{cccc}
  a & p & \neg a & \neg a \Rightarrow p \\
  T & T & F & T \\
  T & F & F & T \\
  F & T & T & T \\
  F & F & T & F \\
\end{array}
\]

\((A1)\) \((C1)\)

[1 mark]

**Examiners report**

Part (b) was not done as well as expected indicating that some work needs to be done by centres on the truth table for the logic symbol \(\Rightarrow\).

---

13c. State whether \(\neg a \Rightarrow p\) is a tautology, a contradiction or neither. Justify your answer.

**Markscheme**

Neither, because not all the entries in the last column are the same. \((A1)(R0)(R1)\) \((C2)\)

Notes: Do not award \((R0)(A1)\). Follow through from their answer to part (b). Reasoning must be consistent with their answer to part (b).

[2 marks]
Examiners report

Many correct answers of ‘neither’ were seen in part (c) but the justification was sometimes lacking definitive reasoning. Without sufficient reasoning, the answer mark was not awarded.

Let \( p \) and \( q \) represent the propositions
\[ p: \text{food may be taken into the cinema} \]
\[ q: \text{drinks may be taken into the cinema} \]

14a. Complete the truth table below for the symbolic statement \( \neg(p \lor q) \).

<table>
<thead>
<tr>
<th>( p )</th>
<th>( q )</th>
<th>( p \lor q )</th>
<th>( \neg(p \lor q) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>T</td>
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</tbody>
</table>

[2 marks]

Markscheme

\[
\begin{array}{c|c|c|c}
\hline
p & q & p \lor q & \neg(p \lor q) \\
\hline
T & T & T & F \\
T & F & T & F \\
F & T & T & F \\
F & F & F & T \\
\hline
\end{array}
\]

\( (A1)(A1)(R) \quad (C2) \)

Note: \( (A1) \) for each correct column.

[2 marks]

Examiners report

(a) was generally answered well.

14b. Write down in words the meaning of the symbolic statement \( \neg(p \lor q) \).

[2 marks]
Markscheme
It is not true that food or drinks may be taken into the cinema.
Note: (A1) for “it is not true”, (A1) for “food or drinks”.
OR
Neither food nor drinks may be taken into the cinema.
Note: (A1) for “neither”, (A1) for “nor”.
OR
No food and no drinks may be taken into the cinema.
Note: (A1) for “no food”, “no drinks”. (A1) for “and”.
OR
No food or drink may be brought into the cinema. (A2) (C2)
Note: (A1) for “no”, (A1) for “food or drink”. Do not penalize for use of plural/singular.

Note: the following answers are incorrect:
No food and drink may be brought into the cinema. Award (A1) (A0)
Food and drink may not be brought into the cinema. Award (A1) (A0)
No food or no drink may be brought into the cinema. Award (A1) (A0)

[2 marks]

Examiners report
(b) lack of precision in language led to many errors.

14c. Write in symbolic form the compound statement:
“no food and no drinks may be taken into the cinema”. [2 marks]

Markscheme
\(\neg p \land \neg q\)
Note: (A1) for both negations, (A1) for conjunction.
OR
\(\neg (p \lor q)\) (A1) (C2)
Note: (A1) for negation, (A1) for \(p \lor q\) in parentheses.

[2 marks]

Examiners report
(a) was generally answered well.
(b) lack of precision in language led to many errors.
15a. Write the sentence above using logic symbols.

**Markscheme**

\[ m \land (s \lor d) \quad (A2) \]

(A1) for \( m \land \)

(A1) for \( s \lor d \)

(A1)(A0) if brackets are missing.

OR

\[ (m \land s) \lor (m \land d) \quad (A2) \]

(A1) for both brackets correct, (A1) for disjunctive “or” (A1)(A0) if brackets are missing. (C2)

[2 marks]

**Examiners report**

(a) This caused problems for many candidates. They seem to expect to include the implication symbol somewhere.

15b. Write in words \( s \implies \neg d \).

**Markscheme**

If you choose a salad then you do not choose a dessert. (A2)

(A1) for “if … then…” (A1) for salad and no dessert in the correct order.

OR

If you choose a salad you do not choose a dessert. (A2) (C2)

[2 marks]

**Examiners report**

(b) Most candidates managed to write this correctly.

15c. Complete the following truth table.

<p>| | | | |</p>
<table>
<thead>
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</tr>
</tbody>
</table>

**Markscheme**

\[
\begin{array}{c|c|c|c|}
s & d & \neg s & \neg s \implies d \\
T & T & F & T \\
T & F & F & T \\
F & T & T & T \\
F & F & T & F \\
\end{array}
\]

(A1) for each correct column (A1)(A1)(ft) (C2)

[2 marks]
Examiners report

(c) Not all candidates could complete the truth table correctly. Many managed the first column but then made mistakes in the last column.

The truth table below shows the truth-values for the proposition

\[ p \lor q \Rightarrow \neg p \lor \neg q \]

<table>
<thead>
<tr>
<th>( p )</th>
<th>( q )</th>
<th>( \neg p )</th>
<th>( \neg q )</th>
<th>( p \lor q )</th>
<th>( \neg p \lor \neg q )</th>
<th>( p \lor q \Rightarrow \neg p \lor \neg q )</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
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</tr>
</tbody>
</table>

16a. Explain the distinction between the compound propositions, \( p \lor q \) and \( p \lor q \).

Markscheme

Both are 'p or q', the first is 'but not both' (A1)

Note: Award mark for clear understanding if wording is poor. (C1)

[1 mark]

Examiners report

a) The majority of candidates were able to explain the difference between inclusive and exclusive correctly but many used “and” and “or” to distinguish between the two.

16b. Fill in the four missing truth-values on the table.

Markscheme

\[ p \lor q \Rightarrow \neg p \lor \neg q \]

<table>
<thead>
<tr>
<th>( \neg q )</th>
<th>( p \lor q \lor \neg q )</th>
<th>( \neg p \lor \neg q )</th>
<th>( p \lor q \Rightarrow \neg p \lor \neg q )</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
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</tbody>
</table>

Note: Follow through is for final column. (C4)

[4 marks]

Examiners report

b) Less than half were able to find the truth value of the two disjunctions in the table correctly. Most candidates did gain some marks but a number of them left at least one cell blank even though it was a 50% chance of getting the correct value.

16c. State whether the proposition \( p \lor q \Rightarrow \neg p \lor \neg q \) is a tautology, a contradiction or neither.

[1 mark]
**Markscheme**

Tautology. \((A1)(\text{ft})\) \((C1)\)

[1 mark]

**Examiners report**

c) Most candidates answered this part correctly with many receiving follow through for “neither” from an incorrect table.

---

17a. List the members of sets

(i) \(B\)

(ii) \(C \cap B\)

(iii) \(B \cup C'\)

**Markscheme**

(i) \(B = 2, 3, 5, 7\) \((A1)\)

Brackets not required

(ii) \(C \cap B = 2, 3, 5\) \((A1)(\text{ft})\)

Follow through only from incorrect \(B\)

(iii) \(C' = 0, 1, 7, 8, 9\) \((A1)(\text{ft})\)

\(B \cup C' = 0, 1, 2, 3, 5, 7, 8, 9\) \((A1)(\text{ft})\)

Note: Award \((A1)\) for correct \(C'\) seen. The first \((A1)(\text{ft})\) in (iii) can be awarded only if \(C\) was listed incorrectly and a mark was lost as a result in (a)(ii). If \(C\) was not listed and \(C'\) is wrong, the first mark is lost. The second mark can (\text{ft}) within part (iii) as well as from (i). \((C4)\)

[4 marks]

**Examiners report**

a) Many candidates included \(1\) as a prime number for set \(B\). Most candidates were able to list the intersection of \(B\) and \(C\) correctly with many receiving a follow through for their incorrect \(B\). Very few candidates were able to list \(B \cup C'\) correctly with many listing the intersection. It was disappointing that only a few candidates listed \(C'\) separately – those that did often received a mark for this working.

---

17b. Consider the propositions:

\[ p : x \text{ is a prime number less than } 10. \]

\[ q : x \text{ is a positive integer between } 1 \text{ and } 7. \]

Write down, in words, the contrapositive of the statement, “If \(x\) is a prime number less than 10, then \(x\) is a positive integer between 1 and 7.”

[2 marks]
**Markscheme**

“If \(x\) is not a positive integer between 1 and 7, then \(x\) is not a prime number less than 10.” \((A1)(A1)\)

Award \((A1)\) for both \((not)\) statements, \((A1)\) for correct order. \((C2)\)

[2 marks]

**Examiners report**

b) The majority of candidates were able to write down the contrapositive correctly but many gave the inverse or the converse instead.

Consider each of the following statements

\[ p : \text{Alex is from Uruguay} \]
\[ q : \text{Alex is a scientist} \]
\[ r : \text{Alex plays the flute} \]

18a. Write the following argument in words [3 marks]

\[ \neg r \Rightarrow (q \lor p) \]

**Markscheme**

If Alex does not play the flute then he is either a scientist or from Uruguay. \((A1)(A1)(A1)\) \((C3)\)

Note: Award \((A1)\) if… then, correct \((A1)\) antecedent, \((A1)\) correct consequent.

**Examiners report**

[N/A]

18b. Complete the truth table for the argument in part (a) using the values below for \(p\), \(q\), \(r\) and \(\neg r\). [2 marks]

<table>
<thead>
<tr>
<th>(p)</th>
<th>(q)</th>
<th>(r)</th>
<th>(\neg r)</th>
<th>(q \lor p)</th>
<th>(\neg r \Rightarrow (q \lor p))</th>
</tr>
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<tbody>
<tr>
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</table>
18c. The argument $\neg r \Rightarrow (q \lor p)$ is invalid. State the reason for this. [1 mark]

Markscheme
Not all entries in the final column are T. (R1) (C1)

Examiners report
[N/A]

19a. Consider the following statements about the quadrilateral ABCD

$q : \text{ABCD has four equal sides} \quad s : \text{ABCD is a square}$

Express in words the statement, $s \Rightarrow q$. [2 marks]

Markscheme
If ABCD is a square, then ABCD has four equal sides. (AI)(AI) (C2)

Note: Award (AI) for if... then, (AI) for propositions in the correct order.

Examiners report
[N/A]

19b. Write down in words, the inverse of the statement, $s \Rightarrow q$. [2 marks]

Markscheme
If ABCD is not a square, then ABCD does not have four equal sides. (AI)(AI) (C2)

Note: Award (AI) for if... then, (AI) for propositions in the correct order.
Determine the validity of the argument in (b). Give a reason for your decision.

**Markscheme**

Not a valid argument. ABCD may have 4 equal sides but will not necessarily be a square. (It may be a rhombus) \( (A1)(R1) \) \( (C2) \)

**Note:** Award \( (R1) \) for correct reasoning, award \( (A1) \) for a consistent conclusion with their answer in part (b).

It is therefore possible that \( (R1)(A0) \) may be awarded, but \( (R0)(A1) \) can never be awarded.

**Note:** Simple examples of determining the validity of an argument without the use of a truth table may be tested.

Consider the following logic propositions:

- \( p \) : Sean is at school
- \( q \) : Sean is playing a game on his computer.

**20a.** Write in words, \( p \lor q \).

**Markscheme**

Either Sean is at school or Sean is playing a game on his computer but not both. \( (A1)(A1) \) \( (C2) \)

**Note:** \( (A1) \) for ‘either ... or but not both’ \( (A1) \) for correct statements. ‘Either’ can be omitted.

**Examiners report**

The common error in part (a) was not to include “but not both” and for (b), to give the inverse rather than the converse. The first column in the table (not \( q \)) was well done but a number of candidates answered the implication incorrectly.

**20b.** Write in words, the converse of \( p \Rightarrow \neg q \).

**Markscheme**

If Sean is not playing a game on his computer then Sean is at school. \( (A1)(A1) \) \( (C2) \)

**Note:** \( (A1) \) for ‘If ... then’ \( (A1) \) for correct propositions in the correct order.

**Examiners report**

The common error in part (a) was not to include “but not both” and for (b), to give the inverse rather than the converse. The first column in the table (not \( q \)) was well done but a number of candidates answered the implication incorrectly.
Complete the following truth table for \( p \Rightarrow \neg q \).  

<table>
<thead>
<tr>
<th>( p )</th>
<th>( q )</th>
<th>( \neg q )</th>
<th>( p \Rightarrow \neg q )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( T )</td>
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<td>( T )</td>
<td>( T )</td>
</tr>
</tbody>
</table>

**Markscheme**

\[
\begin{array}{|c|c|}
\hline
\neg q & p \Rightarrow \neg q \\
\hline
T & T \\
F & T \\
F & T \\
F & F \\
\hline
\end{array}
\]

(\( A1 \))(\( A1 \)) (\( ft \)) (\( C2 \))

*Note: (\( A1 \)) for each correct column.*

Examiners report

The common error in part (a) was not to include “but not both” and for (b), to give the inverse rather than the converse. The first column in the table (not \( q \)) was well done but a number of candidates answered the implication incorrectly.

21a. (i) Complete the truth table below.

<table>
<thead>
<tr>
<th>( p )</th>
<th>( q )</th>
<th>( p \land q )</th>
<th>( \neg(p \land q) )</th>
<th>( \neg p )</th>
<th>( \neg q )</th>
<th>( \neg p \lor \neg q )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( T )</td>
<td>( T )</td>
<td>( T )</td>
<td>( F )</td>
<td>( F )</td>
<td>( F )</td>
<td>( F )</td>
</tr>
<tr>
<td>( T )</td>
<td>( F )</td>
<td>( F )</td>
<td>( F )</td>
<td>( F )</td>
<td>( T )</td>
<td>( T )</td>
</tr>
<tr>
<td>( F )</td>
<td>( T )</td>
<td>( T )</td>
<td>( T )</td>
<td>( F )</td>
<td>( T )</td>
<td>( F )</td>
</tr>
<tr>
<td>( F )</td>
<td>( F )</td>
<td>( T )</td>
<td>( T )</td>
<td>( T )</td>
<td>( T )</td>
<td>( T )</td>
</tr>
</tbody>
</table>

(ii) State whether the compound propositions \( \neg(p \land q) \) and \( \neg p \lor \neg q \) are equivalent.

**Markscheme**

(i)

\[
\begin{array}{|c|c|}
\hline
p & q \\
\hline
T & T \\
T & F \\
F & T \\
F & F \\
\hline
p \land q & \neg(p \land q) \\
\hline
T & F \\
F & T \\
T & F \\
F & T \\
\hline
\neg p & \neg q & \neg p \lor \neg q \\
\hline
F & F & F \\
F & T & T \\
T & F & T \\
T & T & T \\
\hline
\end{array}
\]

(\( A3 \))

*Note: Award (\( A1 \)) for \( p \land q \) column correct, (\( A1 \))(\( ft \)) for \( \neg(p \land q) \) column correct, (\( A1 \)) for last column correct.*

(ii) Yes. (\( R1 \))(\( ft \)) (\( C4 \))

*Note: (\( ft \)) from their second and the last columns. Must be correct from their table.*

Examiners report

This question was well answered by many of the candidates. It is an area of the syllabus that is well taught and many managed to get a follow through mark even though one of the columns in the table might have been incorrect.
Consider the following propositions.

\[ p : \text{Amy eats sweets} \]
\[ q : \text{Amy goes swimming.} \]

Write, in symbolic form, the following proposition.

*Amy either eats sweets or goes swimming, but not both.*

---

**Markscheme**

\[ p \lor q. \quad (A1)(A1) \quad (C2) \]

**Note:** Award (A1) for \( p \ldots q, (A1) \) for \( \lor \). Accept \((p \lor q) \land \neg(p \land q) \) or \((p \lor q) \land \neg(p \lor \neg q)\).

[2 marks]

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**Examiners report**

This question was well answered by many of the candidates. It is an area of the syllabus that is well taught and many managed to get a follow through mark even though one of the columns in the table might have been incorrect.