Australian Government
Department of Industry, Science and Resources

National Measurement Institute

Proficiency Test Final Report AQA 24-16 Clandestine Laboratory

June 2025

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ACKNOWLEDGMENTS

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I would like to thank the management and staff of the participating laboratories for supporting the study. It is only through widespread participation that we can provide an effective service to laboratories.

The assistance of the following NMIA staff members in the planning, conduct and reporting of the study is acknowledged.

Jenny Xu

Melissa Bird

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Aaron Mamo

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Raluca Iavetz

Manager, Chemical Reference Values

105 Delhi Rd, North Ryde NSW 2113

Phone: +61 2 9449 0111

Email: proficiency@measurement.gov.au

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SUMMARY

AQA 24-16 Clandestine Laboratory commenced in August 2024. Eleven laboratories registered to participate, and all participants submitted results by the due date.

This was a qualitative program which involved the analysis of two samples. Sample S1, representing material seized from a hypothetical clandestine laboratory, required identification and determination of the synthetic pathway used to manufacture the substance. Sample S2, also from the hypothetical clandestine laboratory site, required identification and its potential use for illegitimate purposes.

Sample S1 was synthesised by the National Measurement Institute Australia (NMIA), and Sample S2 was supplied by Forensic & Analytical Science Service, NSW Health Pathology. Both samples were analysed by NMIA.

Sample S1 was phenyl-2-propanone (P2P). The scenario provided was indicative of this sample being synthesised from methyl α-acetylphenylacetate (MAPA) via hydrolysis under acidic conditions.

Sample S2 was MAPA. This substance could be used to synthesise P2P, and the scenario provided was also indicative of the production of methamphetamine from P2P.

The aims of this study were to assess the ability of the participant laboratories:

- *to correctly identify the clandestine laboratory product and the synthetic pathway used to produce the substance based on a scenario provided and the results of the analysis of the sample.*

All participants correctly identified the unknown substance as P2P, and correctly reported that the sample was synthesised from MAPA via hydrolysis under acidic conditions.

Some participants also reported potential alternative precursors, including α-phenylacetoacetonitrile (APAAN), and P2P glycidates.

Most participants used the items found at the site as part of their reasoning.

- *to correctly identify an unknown substance and its potential use for illegitimate purposes.*

All participants correctly identified the unknown substance as MAPA, and correctly identified its potential illegitimate use in synthesising methamphetamine.

Some participants also reported alternative potential end products, including other amphetamine-type stimulants.

Most participants used the items found at the site as part of their reasoning.

1 INTRODUCTION

1.1 NMIA Proficiency Testing Program

The National Measurement Institute Australia (NMIA) is responsible for Australia's national measurement infrastructure, providing a range of services including a chemical proficiency testing program.

Proficiency testing (PT) is the 'evaluation of participant performance against pre-established criteria by means of interlaboratory comparisons'.[1] NMIA PT studies target chemical testing in areas of high public significance such as trade, environment, law enforcement and food safety. NMIA offers studies in:

- pesticide residues in soil, water, fruit, vegetables and herbs;
- hydrocarbons, phenols and other organic compounds in soil and water;
- per- and polyfluoroalkyl substances in soil, biosolid, water, biota and food;
- inorganic analytes in soil, water, filters, food and pharmaceuticals;
- chlorophyll a in water; and
- controlled drug assay, drugs in wipes and clandestine laboratory.

1.2 Study Aims

The aims of the study were to assess the ability of the participant laboratories:

- to correctly identify the clandestine laboratory product and the synthetic pathway used to produce the substance based on a scenario provided and the results of the analysis of the sample; and
- to correctly identify an unknown substance and its potential use for illegitimate purposes.

The choice of the test method was left to the participating laboratories.

1.3 Study Conduct

NMIA is accredited by the National Association of Testing Authorities, Australia (NATA) to ISO/IEC 17043 as a provider of proficiency testing schemes.[1] However, this clandestine laboratory PT study is not within the scope of NMIA's accreditation.

2 STUDY INFORMATION

2.1 Study Timetable

The timetable of the study was:

Invitations sent	19/08/2024
Samples sent	5/11/2024
Results due	13/12/2024
Interim Report	17/12/2024

2.2 Participation and Laboratory Code

Eleven laboratories registered to participate in this study. All participants were assigned a confidential laboratory code number for this study. All participants submitted results by the due date.

2.3 Test Material Specification

The study sample set consisted of two samples:

- Sample S1 was 250 mg of methyl α-acetylphenylacetate (MAPA) supplied by Forensic & Analytical Science Service, NSW Health Pathology; and
- Sample S2 was 250 mg of phenyl-2-propanone (P2P) synthesised by NMIA Australian Forensic Drug Laboratory from MAPA.

2.4 Test Material Storage and Dispatch

After preparation, the test materials were securely stored at ambient temperatures.

A set of two test samples, Sample S1 liquid and Sample S2 powder (both approximately 250 mg each), was dispatched to each participant on 5 November 2024.

The following items were packaged with the samples:

- a covering letter which included sample details, the clandestine laboratory scenario, and instructions for participants; and
- a form for participants to confirm the receipt and condition of the samples.

An Excel spreadsheet for the electronic reporting of results was emailed to all participants.

2.5 Instructions to Participants

Participants were provided with the following scenario:

“Two samples labelled AQA 24-16 S1 and S2 have been provided: Sample S1 is 250 mg of liquid and Sample S2 is 250 mg of powder.

Sample S1

Officers attended a suspected clandestine laboratory and observed the following:

A 250 mL round bottom flask equipped with a condenser, located on top of a heating mantle. The flask was approximately half full and contained a two-phase mixture. The lower of the two layers was aqueous and was found to have an acidic pH.

The upper of the two layers was separated and has been submitted for analysis, labelled **AQA 24-16 S1**.

Sample S2

The following items were also observed at the suspected clandestine laboratory:

- A container labelled “sulfuric acid” containing a clear liquid
- A container labelled “hydrochloric acid” containing a clear liquid
- A container labelled “caustic soda” containing white prills
- A container labelled “N-methylformamide” containing a clear liquid
- A container labelled “formic acid”

Officer X also located an open unlabelled plastic bag which held a powder. The powder has been labelled as **AQA 24-16 S2** and has been submitted for analysis.”

Participants were instructed as follows:

“You will be asked to answer to the following questions:

For Sample S1

1. What is the major component of the liquid?
2. Based on the items retrieved from the clandestine laboratory and your results of analysis, provide an explanation of how the substance was synthesised.

For Sample S2

1. What is the powder?
2. Could this substance be used for illegitimate purposes? If so, how?

Please complete the results sheet by answering the scenario questions and giving brief details of your methodology. Please return the completed results sheet by email to jenny.xu@measurement.gov.au by 2 December 2024. Late results may not be included in the report. The samples should be stored at room temperature in a dry place.”

The due date for the results was extended to 13 December 2024 due to sample delivery delays experienced by some international participants.

2.6 Interim Report and Preliminary Report

An Interim Report was emailed to all participants on 17 December 2024.

No Preliminary Report was issued for this study.

3 SAMPLE ANALYSIS AND EXAMPLE RESPONSES

3.1 Sample S1

Preparation

To a round bottom flask was added MAPA, water and concentrated sulfuric acid. The flask was equipped with a condenser and heated at reflux for 6 hours, after which the solution was left to cool to room temperature. The upper of the two layers was then collected and prepared for distribution as Sample S1.

Analysis

An aliquot of Sample S1 was dissolved in dichloromethane and washed with an alkaline aqueous solution. The organic phase was then collected, dried over sodium sulfate and filtered. Analysis of the organic layer by gas chromatography – mass spectrometry (GC-MS) revealed the presence of P2P as the major component. The mass spectrum of this substance is shown in Figure 1.

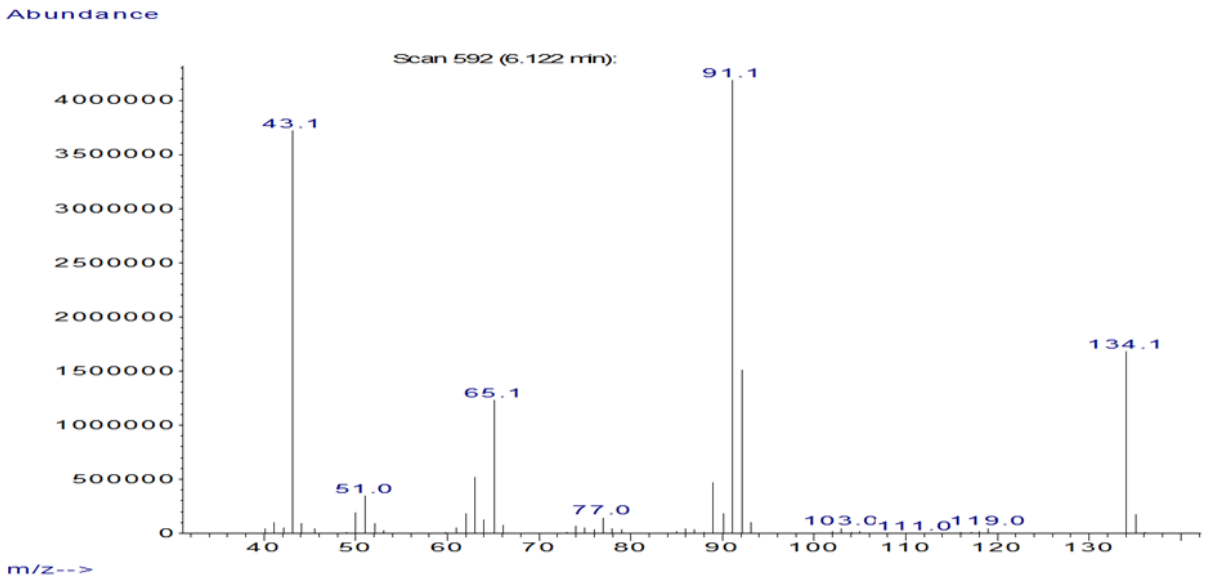


Figure 1 Mass Spectrum of P2P

The total ion chromatogram (TIC) of Sample S1 is presented in Figure 2. The presence of P2P was confirmed by retention time and mass spectral comparison to a P2P reference material. The GC-MS analysis indicated the presence of 3,4-diphenyl-3-buten-2-one, identified by comparison to a mass spectral library. The mass spectrum for this substance is shown in Figure 3.

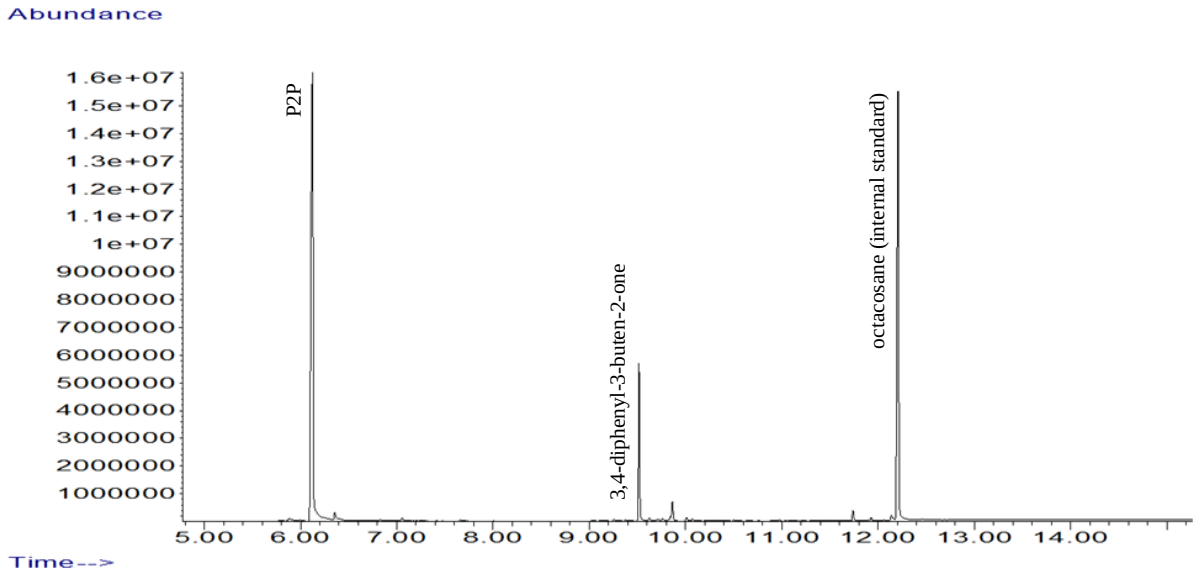


Figure 2 TIC of Sample S1

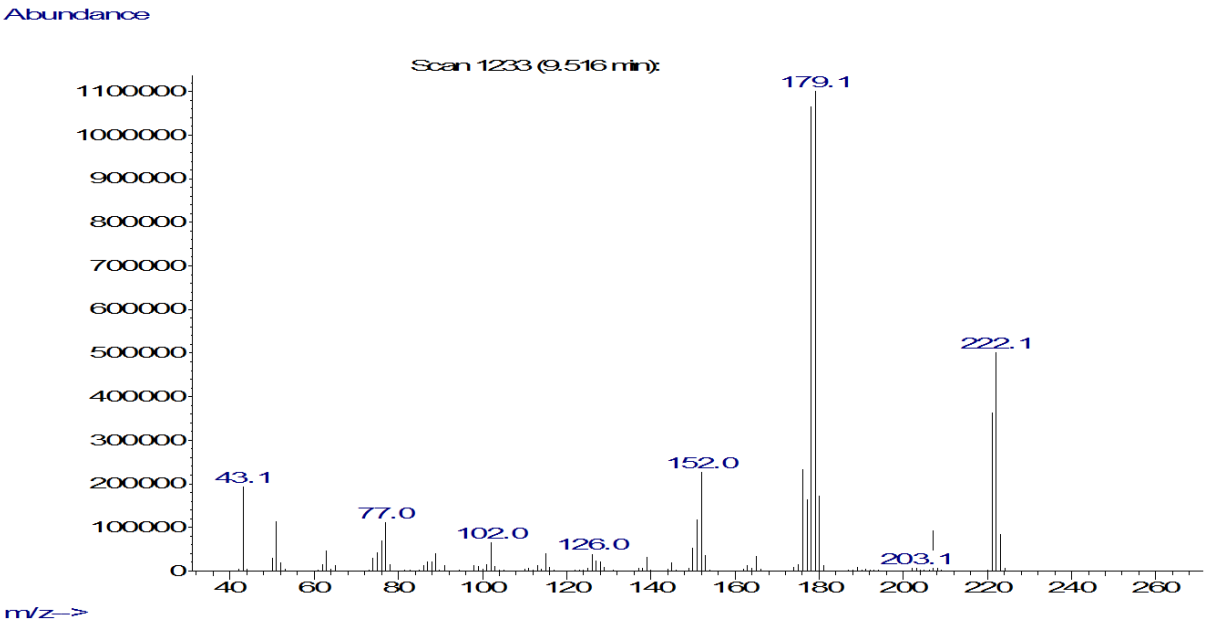
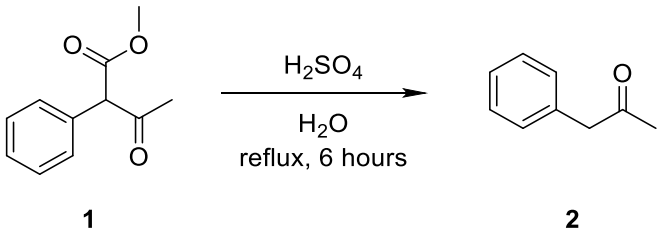


Figure 3 Mass Spectrum of 3,4-diphenyl-3-buten-2-one

Conclusions

The P2P (**2**) was synthesised from MAPA (**1**) via hydrolysis under acidic conditions and heat (Figure 4).



1 **2**

Figure 4 P2P (**2**) from MAPA (**1**)

This reaction is supported by the reaction set-up outlined in the scenario, with a two-phase mixture containing a lower, aqueous layer with an acidic pH and the round bottom flask equipped with a condenser, located on top of a heating mantle. This is further supported by

the presence of containers labelled “sulfuric acid” and “hydrochloric acid” at the laboratory, and the identification of Sample S2.

3.2 Sample S2

Analysis

Dilution of Sample S2 with chloroform/methanol followed by GC-MS analysis revealed the presence of MAPA as the major component. The mass spectrum of this substance is shown in Figure 5.

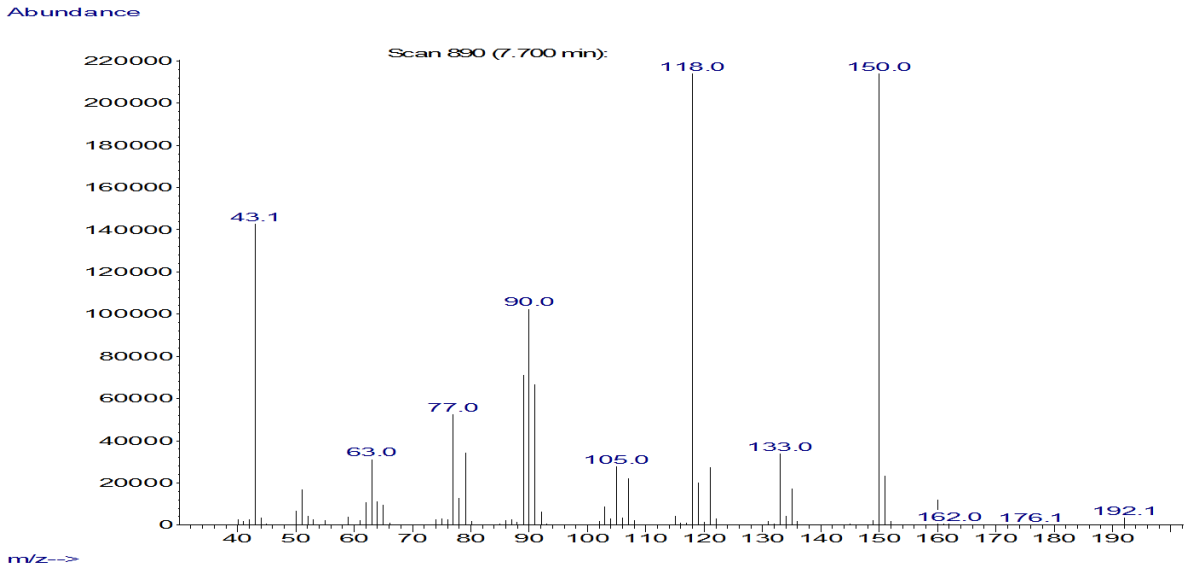


Figure 5 Mass Spectrum of MAPA

The TIC of Sample S2 is presented in Figure 6. The presence of MAPA was confirmed by retention time and mass spectral comparison to a MAPA reference material.

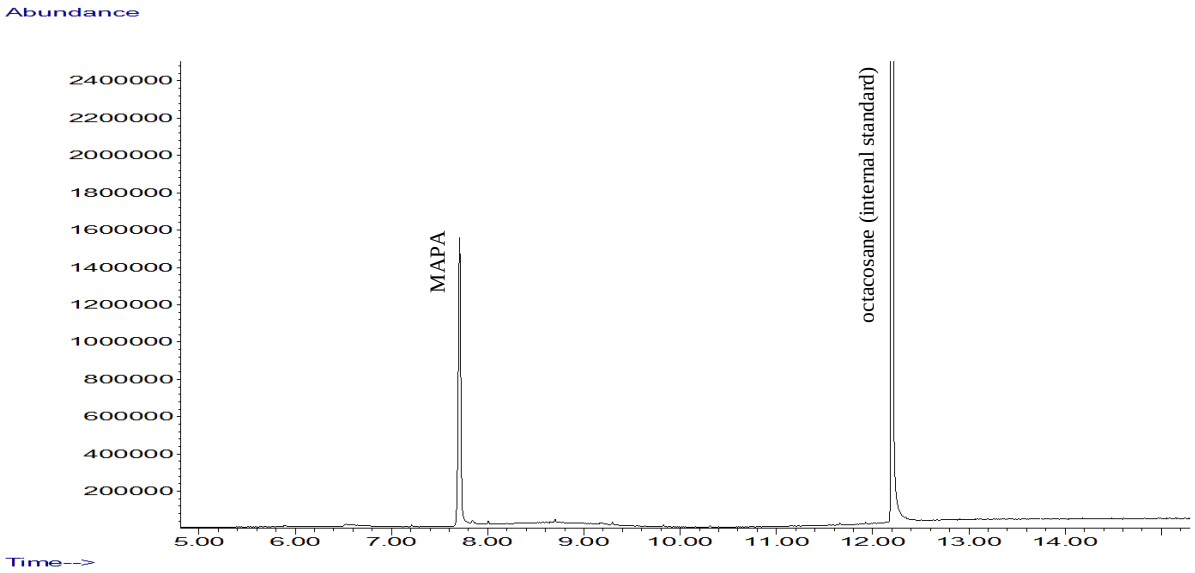


Figure 6 TIC of Sample S2

Analysis of Sample S2 by Fourier transform infrared spectroscopy – attenuated total reflectance (FTIR-ATR) produced a spectrum consistent with literature for MAPA.[2] The FTIR spectrum of Sample S2 is shown in Figure 7.

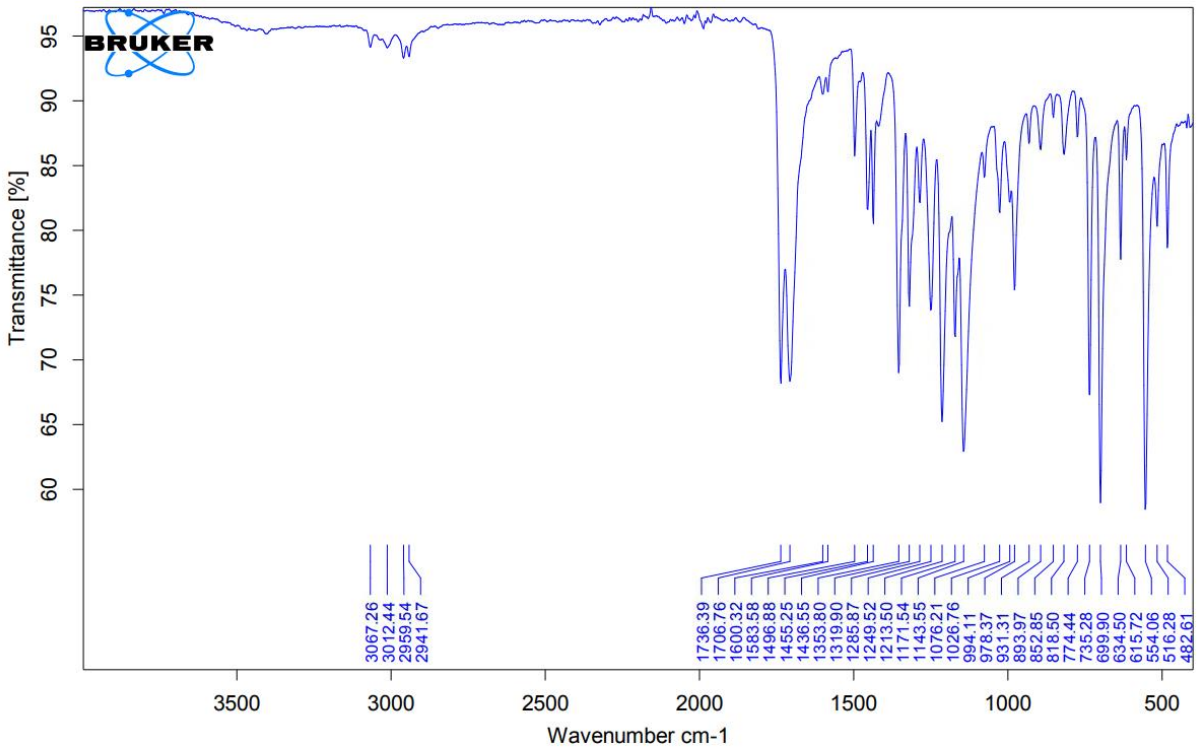


Figure 7 FTIR Spectrum of Sample S2

Conclusions

The unknown Sample S2 was identified as MAPA, which can be used for illegitimate purposes. MAPA can be converted to P2P via hydrolysis under acidic conditions.[3] This is supported by the presence of items labelled "sulfuric acid" and "hydrochloric acid" at the clandestine laboratory, and the reaction set-up as outlined in the scenario for Sample S1. The resultant P2P can then be converted to amphetamine-type stimulants (ATS) such as amphetamine (**3**) or methamphetamine (**4**) (Figure 8).

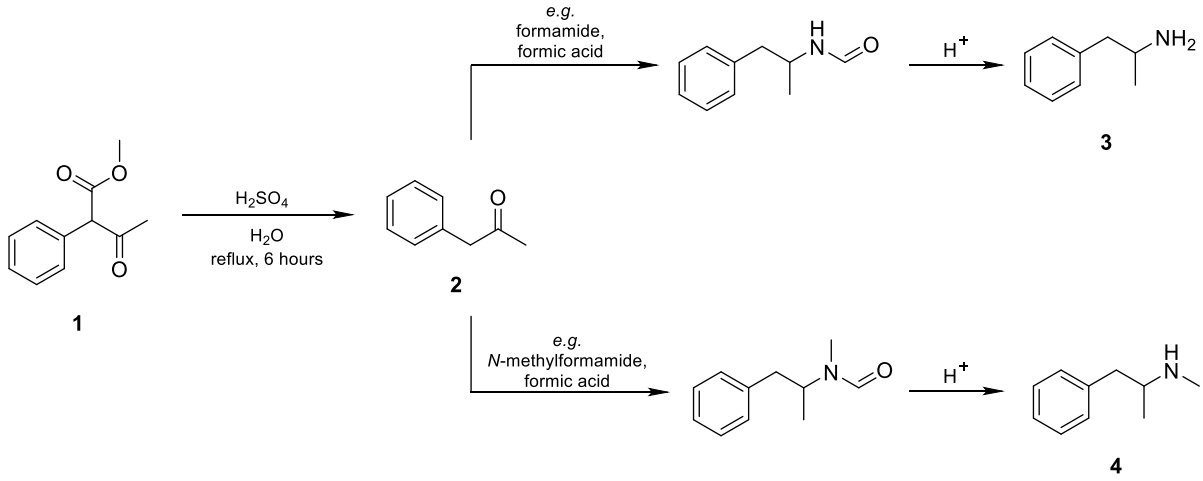


Figure 8 Conversion of MAPA (**1**) to Amphetamine (**3**) and Methamphetamine (**4**) via P2P (**2**).

The presence of the items labelled "N-methylformamide" and "formic acid" suggest the laboratory was equipped to synthesise methamphetamine from P2P via the Leuckart method. The P2P is mixed with *N*-methylformamide and formic acid, and heated to produce a *N*-formylmethylamphetamine intermediate, which is then hydrolysed to methamphetamine (**4**).[3]

3.3 Example Responses

The Interim Report included example responses for the questions asked to participants. These example responses have been presented below.

Sample S1

- Question 1: What is the major component of the liquid?

Answer: Phenyl-2-propanone (P2P)

- Question 2: Based on the items retrieved from the clandestine laboratory and your results of analysis, provide an explanation of how the substance was synthesised.

Answer: The phenyl-2-propanone (P2P) was synthesised from methyl α-acetylphenylacetate (MAPA) via hydrolysis under acidic conditions. This is supported by the reaction set-up outlined in the scenario above, with a two-phase mixture containing a lower, aqueous layer with an acidic pH. This is further supported by the presence of containers labelled "sulfuric acid" and "hydrochloric acid" at the laboratory, and the identification of Sample S2.

Sample S2

- Question 1: What is the powder?

Answer: Methyl α-acetylphenylacetate (MAPA)

- Question 2: Could this substance be used for illegitimate purposes? If so, how?

Answer: Methyl α-acetylphenylacetate (MAPA) can be used in the manufacture of amphetamine-type stimulants (ATS) such as amphetamine and methamphetamine. MAPA can be converted to phenyl-2-propanone (P2P) via hydrolysis under acidic conditions. This is supported by the presence of items labelled "sulfuric acid" and "hydrochloric acid" at the laboratory, and the reaction set-up as outlined in the scenario for Sample S1. The presence of the items labelled "N-methylformamide" and "formic acid" suggest the laboratory was equipped to synthesise methamphetamine from phenyl-2-propanone via the Leuckart method.

4 PRESENTATION AND ASSESSMENT OF RESULTS

In this section, some participants' responses may have been modified so that the participant cannot be identified.

4.1 Sample S1

Question 1

What is the major component of the liquid?

Table 1 Sample S1 Question 1 Participant Responses and Assessment

Lab. Code	Participant Response	Assessment
1	1-phenyl-2-propanone (P-2-P)	Acceptable
3	1-Phenyl-2-propanone (P2P)	Acceptable
4	Phenyacetone (BMK, P-2-P, 1-Phenyl-2-propanone)	Acceptable*
5	Phenyl-2-propanone	Acceptable
6	Phenylacetone (also known as Phenyl-2-propanone, Benzyl methyl ketone)	Acceptable
7	Phenyl-2-propanone (P2P)	Acceptable
8	Phenyl-2-propanone (P2P) was identified as the major component of the liquid.	Acceptable
9	1-Phenyl-2-propanone (P2P)	Acceptable
10	1-Phenyl-2-propanone (BMK)	Acceptable
11	1-Phenyl-2-propanone (P2P)	Acceptable
12	Phenyl-2-propanone (P2P)	Acceptable

* Compound name reported ('phenyacetone') is incorrect, however correct alternative names have been reported.

Question 2

Based on the items retrieved from the clandestine laboratory and your results of analysis, provide an explanation of how the substance was synthesised.

Table 2 Sample S1 Question 2 Participant Responses and Assessment

Lab. Code	Participant Response	Assessment	Comment
1*	P-2-P was probably synthesised from methyl alpha-phenylacetate (3-oxo-2-phenylbutanoate) (MAPA) or from alpha-phenylacetoacetonitrile (APAAN). Conversion of APAAN or MAPA to the P-2-P can be done by heating with acid e.g. hydrochloride or sulphuric acid for several hours. There are several other pre-cursors for P-2-P which can be converted to the P-2-P in the similar way. After heating, the upper layer is neutralised with alkaline solution e.g. caustic soda. Finally the P-2-P is separated with separation funnel and purified via distillation (this is optional).	Acceptable	The correct precursor and synthetic route have been reported. The participant has also suggested an alternative precursor that was not mentioned in the scenario or provided as a sample. The participant has included how chemicals present at the site support their conclusions. The participant reported that the upper layer was neutralised with an alkaline solution. While this is not reflective of the actual procedure used to synthesise the P2P for this study, this step may occur in a clandestine laboratory and as noted by the participant, could be consistent with the chemicals present at the site.
3	Conversion of MAPA to P2P using hydrochloric acid (or similar acid). MAPA and water placed in a reaction flask with a condenser fitted, and heated on a heating mantle. Hydrochloric acid added dropwise.	Acceptable	The correct precursor and synthetic route have been reported. The participant has included how the setup and chemicals present at the site support their conclusions.
4	Phenylacetone was prepared from MAPA by de-esterification and decarboxylation under acidic conditions.	Acceptable	The correct precursor and synthetic route have been reported. The participant has not included how items present at the site support their conclusions.
5	Methyl alpha-phenylacetoacetate (MAPA) undergoes deesterification and decarboxylation by heating under aqueous acidic conditions (i.e. with the hydrochloric acid found at the scene) to form phenyl-2-propanone (P2P). As P2P is immiscible with water it separates to give the top layer of the reaction mixture.	Acceptable	The correct precursor and synthetic route have been reported. The participant has included how the chemicals present at the site support their conclusions.

Lab. Code	Participant Response	Assessment	Comment
6	The presence of Methyl-2-phenylacetoacetate (MAPA) in the bag found at the scene suggests it was used to synthesise the precursor Phenylacetone. This can be done under acidic conditions, so either the sulfuric or hydrochloric acids found could have been used to achieved this. This is consistent with the round bottomed flask containing the lower acidic phase and the upper organic (mainly phenylacetone phase) being found.	Acceptable	The correct precursor and synthetic route have been reported. The participant has included how the setup and chemicals present at the site support their conclusions.
7	1-phenyl-2-propanone (P2P) was identified as the major component in the upper layer. P2P is a common precursor for synthesising amphetamine type substances. The lower layer was an acidic pH indicating the presence of an acid. Based on the items found from the scene and the results of analysis, the detection of P2P (Sample 1), MAPA (Sample 2) and sulfuric acid/hydrochloric acid, along with heating mantle and two-phase mixture suggests P2P was synthesis from MAPA. When heating under acidic conditions, the phenylacetoacetate decarboxylates to produce P2P. Analysis of Sample 1 found an impurity, 1-benzyl-3-methylnaphthalene, further indicating the hydrolysis reaction to P2P under acidic conditions. The impurities dibenzylketone and 3,4-diphenyl-3-buten-2-one were also found, which are commonly found in the MAPA to amphetamine/methamphetamine synthesis via the Leuckart method.	Acceptable	The correct precursor and synthetic route have been reported. The participant has included how the setup and chemicals present at the site support their conclusions. The participant reported that they found impurities in the sample.
8*	Phenyl-2-propanone (P2P) was identified as the major component of the liquid (Sample S1). This liquid was the top layer of a biphasic liquid, with the bottom layer of liquid reported in scene notes to be an aqueous, acidic liquid. This, together with the presence of methyl alpha-acetylphenylacetate (MAPA), hydrochloric and sulfuric acid and laboratory glassware and equipment necessary for a reflux setup at this location, suggests that P2P has been manufactured from MAPA using an acid such as hydrochloric or sulfuric acid under the application of heat. However, traces of MAPA or other impurities specific to this synthesis route were not detected in the liquid.	Acceptable	The correct precursor and synthetic route have been reported. The participant has included how the setup and chemicals present at the site support their conclusions.
9*	The P2P was likely synthesised by the hydrolysis of methyl alpha-acetolphenylacetate (MAPA) by the addition of sulphuric acid with heating.	Acceptable	The correct precursor and synthetic route have been reported. The participant has included how chemicals present at the site support their conclusions.
10*	Based on the presence of impurities referenced in the literature article [1] below, it appears the 1-phenyl-2-propanone (also known as BMK and P2P) has been synthesised from the acid hydrolysis of a precursor, such as MAPA (see sample 2) or APAAN. Hydrochloric, sulphuric or phosphoric acid have been reported for this hydrolysis.	Acceptable	The correct precursor and synthetic route have been reported. The participant has also suggested an alternative precursor that was not mentioned in the scenario or

Lab. Code	Participant Response	Assessment	Comment
	However, no precursor was detected in the sample, therefore confirmation of the starting material was not possible. Impurities that were detected in the analysis were 3,4-diphenyl-3-buten-2-one, diphenylacetone (dibenzylketone), stilbene, 1,5-diphenyl-4-methyl-penten-2-one, 3,5-diphenyl-4-methyl-3-penten-2-one, 1,3-dimethyl-1,2-phenylnapthalene, and 1-benzyl-3-methylnaphthalene. No reference standards were run to confirm their identification.		provided as a sample, noting that they had not detected any precursor in the sample and therefore could not confirm the starting material. The participant reported that they found impurities in the sample. The participant has included how chemicals present at the site support their conclusions.
11*	P2P can be synthesised by refluxing various suitable precursor chemicals with a mineral acid solution (e.g. hydrochloric, sulfuric or phosphoric acid). These precursor chemicals include methyl alpha-phenylacetoacetate (MAPA), alpha-phenylacetoacetonitrile (APAAN), and P2P glycidates. The process is typically performed in a heated reaction vessel fitted with a condenser configured for refluxing. As P2P is not miscible in water it will be present as a separate liquid layer, either on the top or bottom depending on the relative densities of the layers. Sample S1 may be the product of acid hydrolysis of a precursor chemical such as MAPA.	Acceptable	The correct precursor and synthetic route have been reported. The participant has also suggested alternative precursors that was not mentioned in the scenario or provided as a sample, noting in their additional information that nothing was detected to confirm production from MAPA specifically. The participant has included how the setup and chemicals present at the site support their conclusions. The participant reported that the P2P could either be on the top or bottom layer, however in the scenario provided it was noted that the top layer was collected and submitted as this sample.
12*	Analysis: The top layer (S1) of the bi-layered liquid contained P2P. The powder (S2) contained methyl alpha acetyl phenylacetate (MAPA). Observations: The bottom layer of the liquid located in the round bottom flask was an acidic aqueous solution. The round bottom flask was connected to a condenser and was located on top of a heating mantle (i.e. reflux configuration). Containers labelled "hydrochloric acid" and "sulfuric acid" were also observed. P2P can be manufactured from a number of substances, in acidic solutions under reflux conditions, including MAPA.	Acceptable	The correct precursor and synthetic route have been reported. The participant has included how the setup and chemicals present at the site support their conclusions.

* Additional information in Table 3.

Table 3 Sample S1 Additional Comments from Participants

Lab. Code	Additional Comments
1	This accreditation does not cover Raman or pH measurement.
8	The phenyl-2-propanone (P2P) identified in Sample S1, together with the N-methylformamide, formic acid, hydrochloric acid, sulfuric acid, sodium hydroxide and the laboratory glassware and equipment located at this site could be used to manufacture methylamphetamine via a Leuckart-type reaction. However, methylamphetamine was not detected in either of the samples analysed.
9	Sulphate ions, 1,3-dimethyl-2-phenylnaphthalene and 1-benzyl-3-methylnaphthalene were detected in the sample.
10	[1] *Reference provided by participant.* Note: In a follow up paper (*reference provided by participant)*, it is noted if MAPA is hydrolysed under similar conditions to APAAN, similar impurities are noted, particularly the napthalenes.
11	The notes do not indicate whether the condenser was configured for reflux or distillation. There was nothing detected in sample S1 to confirm production from MAPA.
12	Phenyl-2-propanone (S1) in combination with formic acid and N-methylformamide produces N-formylmethylamphetamine. Containers labelled formic acid and N-methylformamide were observed at the scene. N-formylmethylamphetamine can be hydrolysed to produce methylamphetamine using any of hydrochloric acid, sulfuric acid or caustic soda. Containers labelled hydrochloric acid, sulfuric acid and caustic soda were observed at the scene.

Table 4 Sample S1 Methods Used

Lab. Code	FTIR	GC-MS	LC-MS	Raman	pH Test	Colour Test	IC
1	✓	✓		✓	✓		
3	✓	✓			✓		
4	✓	✓			✓		
5	✓	✓				✓	
6	✓	✓					
7	✓	✓			✓		
8	✓	✓	✓		✓		
9	✓	✓			✓		✓
10	✓	✓		✓	✓		
11	✓	✓					
12	✓	✓					

4.2 Sample S2

Question 1

What is the powder?

Table 5 Sample S2 Question 1 Responses and Assessment

Lab. Code	Response	Assessment
1	methyl alpha-phenylacetate (3-oxo-2-phenylbutanoate) (MAPA)	Acceptable*
3	Methyl 2-phenylacetoacetate (MAPA)	Acceptable
4	MAPA (Methyl-2-phenylacetoacetate; α-acetylbenzeneaceticacid-methyl ester)	Acceptable
5	Methyl alpha-phenylacetoacetate (MAPA)	Acceptable
6	Methyl 3-oxo-2-phenylbutanoate (MAPA)	Acceptable
7	Methyl-2-phenylacetoacetate (MAPA)	Acceptable
8	Methyl alpha-acetylphenylacetate (MAPA) was identified as the major component of the powder.	Acceptable
9	Methy alpha-acetolphenylacetate (MAPA)	Acceptable**
10	Methyl-3-oxo-2-phenylbutanoate (MAPA)	Acceptable
11	Methyl alpha-phenylacetoacetate (MAPA)	Acceptable
12	methyl alpha acetyl phenylacetate (MAPA)	Acceptable

* Systematic name reported (‘3-oxo-2-phenylbutanoate’) is incorrect, however correct common name and abbreviation have been reported.

** Compound name reported (‘methy alpha-acetolphenylacetate’) is incorrect, however correct abbreviation has been reported.

Question 2

Could this substance be used for illegitimate purposes? If so, how?

Table 6 Sample S2 Question 2 Responses and Assessment

Lab. Code	Participant Response	Assessment	Comment
1*	Yes, this substance can be used for illegitimate purposes. MAPA can be converted to the P-2-P, which is the main precursor for production of amphetamine or methamphetamine by Leuckart method. MAPA conversion to P-2-P is described in the sample 1 answer. The Leuckart method is the main method for amphetamine production and it is also widely used for large scale methamphetamine production.	Acceptable	The correct illegitimate use has been reported, including synthetic route from MAPA to methamphetamine. The participant has suggested both amphetamine and methamphetamine as end products. The participant has not included how items present at the site support their conclusions.
3*	Yes - MAPA can be converted to P2P using a method such as that described above. P2P can subsequently be used to manufacture amphetamine type substances such as methamphetamine.	Acceptable	The correct illegitimate use has been reported. The participant has suggested ATS generally, including methamphetamine, as end products. The participant has not included how items present at the site support their conclusions.
4	MAPA can be de-esterified and decarboxylated to phenylacetone. Phenylacetone can be used to produce among others amphetamine and methamphetamine. A container labelled N-methylformamide was observed at the suspected clandestine laboratory. So one would suspect production of methamphetamine.	Acceptable	The correct illegitimate use has been reported. The participant has suggested methamphetamine as the end product, using the chemicals present at the site to support their conclusions.
5	Methyl alpha-phenylacetoacetate (MAPA) is a controlled precursor as defined by legislation. It does not have legitimate use beyond small amounts for research, development and laboratory analytical purposes. MAPA is converted into phenyl-2-propanone (P2P) by reflux under acidic conditions, which is also a controlled precursor due to its use in the production of methylamphetamine. In the given context, this could be effected by the "Leuckart" synthesis: P2P reacts with N-methylformamide and formic acid to form N-formylmethylamphetamine, which can be subsequently hydrolysed (under acidic or basic conditions) to furnish methylamphetamine.	Acceptable	The correct illegitimate use has been reported, including synthetic route from MAPA to methamphetamine. The participant has suggested methamphetamine as the end product, using the chemicals present at the site to support their conclusions.

Lab. Code	Participant Response	Assessment	Comment
6	This substance can be used to make the precursor Phenylacetone under acidic conditions, as described above. Phenylacetone could then be used to make Amphetamine or Methamphetamine. However, based on the reagents found, the likely route would have been to convert Phenylacetone to Methamphetamine using the N-Methylformamide and formic acid, in a procedure known as the Leuckart reaction. Methylamphetamine base could then be separated from the reaction mixture by the addition of the caustic soda found. This could then have been converted to Methamphetamine hydrochloride using the Hydrochloric acid present.	Acceptable	The correct illegitimate use has been reported, including synthetic route from MAPA to methamphetamine. The participant has suggested methamphetamine as the end product, using the chemicals present at the site to support their conclusions.
7	Yes. MAPA could be used for illegitimate purposes. MAPA is a pre-precursor to amphetamine type substances. MAPA can be used to synthesise amphetamine type substances either directly in a one-pot production or two steps via P2P as an intermediate. Based on the items found at scene and the presence of N-methylformamide, this substance can be used to produce methamphetamine via Leuckart synthesis methodology. Leuckart method is typically a two steps synthesis, starting with the formation of N-formylmethamphetamine which is subsequently hydrolysed to methamphetamine.	Acceptable	The correct illegitimate use has been reported, including synthetic route from MAPA to methamphetamine. The participant has suggested methamphetamine as the end product, using the chemicals present at the site to support their conclusions.
8	Methyl alpha-acetylphenylacetate (MAPA) can be used to produce phenyl-2-propanone (P2P), which is a precursor for the manufacture of amphetamine and methylamphetamine. P2P is produced by heating MAPA in the presence of an acid such as sulfuric or hydrochloric acid.	Acceptable	The correct illegitimate use has been reported. The participant has suggested both amphetamine and methamphetamine as end products. The participant has included how items present at the site could be used for the synthesis of P2P from MAPA. In their additional comments for Sample S1, the participant also reported how the setup and chemicals present at the site could be used for the synthesis of methamphetamine as the end product, including the correct synthetic route.
9*	MAPA may be used in the production of 1-phenyl-2-propanone (P2P). The hydrolysis of MAPA with an acid such as sulphuric acid or hydrochloric acid will produce P2P.	Acceptable	The participant has included additional comments regarding further synthesis. The correct illegitimate use has been reported, including synthetic route from MAPA to methamphetamine. The participant has suggested methamphetamine as the end product, using the chemicals present at the site to support their conclusions.

Lab. Code	Participant Response	Assessment	Comment
10*	MAPA can be converted to P2P through an acid hydrolysis. Hydrochloric acid, sulphuric acid or phosphoric acid can be used for this process. P2P is a common controlled precursor used in the manufacture of methylamphetamine. Based on the other chemicals located at the scene, methylamphetamine could be prepared from MAPA directly via the Leuckart reaction (used for the manufacture of methylamphetamine from P2P), which utilises N-methylformamide and formic acid to produce the N-formylmethylamphetamine intermediate, which can then be converted to methylamphetamine via either acid or base hydrolysis.	Acceptable	The correct illegitimate use has been reported, including synthetic route from MAPA to methamphetamine. The participant has suggested methamphetamine as the end product, using the chemicals present at the site to support their conclusions.
11*	MAPA can be converted into P2P by heating under reflux conditions with a mineral acid. The recovered P2P can then be converted into amphetamine or methylamphetamine using various processes, including a Leuckart reaction. The production of methylamphetamine through the Leuckart reaction also requires N-methylformamide, which was located at the scene.	Acceptable	The correct illegitimate use has been reported, including synthetic route from MAPA to methamphetamine. The participant has suggested methamphetamine as the end product, using the chemicals present at the site to support their conclusions.
12	MAPA is a precursor chemical that can be illegitimately used in the manufacture of phenyl-2-propanone (P2P). P2P is a controlled substance according to relevant legislation. P2P can be manufactured from MAPA by acid hydrolysis and decarboxylation under reflux conditions using acids such as hydrochloric acid and sulfuric acid.	Acceptable	The participant has correctly identified that the MAPA can be used to make P2P, an illicit substance as per their relevant legislation, using items present at the site to support their conclusions. In their additional comments for Sample S1, the participant also reported how the chemicals present at the site could be used for the synthesis of methamphetamine as the end product, including the correct synthetic route.

* Additional information in Table 7.

Table 7 Sample S2 Additional Comments from Participants

Lab. Code	Additional Comments
1	GC-MS analysis with alkaline tris-buffer extraction results MAPA and P-2-P. This is probably because the MAPA breaks down to P-2-P in alkaline solution. GC-MS analysis was done also with methanol extraction and the result was MAPA, the P-2-P was found only with a small trace amount.
3	No primary standard of MAPA, therefore the result is an indicated (not confirmed) result.
9	Using the other chemicals (if true to label), located at the scene in this scenario, any P2P produced could be converted to methylamphetamine by the addition of formic acid and N-methylformamide followed by acid hydrolysis using hydrochloric acid.
10	MAPA was confirmed through reference to mass spectral library data and online FTIR data. Online reference: https://www.policija.si/apps/nfl_response_web/0_Analytical_Reports_final/MAPA-ID-2087-19_report.pdf
11	The notes do not indicate whether the condenser was configured for reflux or distillation.

Table 8 Sample S2 Methods Used

Lab. Code	FTIR	GC-MS	LC-MS	Raman	pH Test	Colour Test
1	✓	✓		✓		
3	✓	✓				
4	✓	✓				
5	✓	✓				✓
6	✓	✓				
7	✓	✓				
8	✓	✓	✓		✓	
9	✓	✓				
10	✓	✓		✓		
11	✓	✓				
12	✓	✓				✓

5 DISCUSSION OF RESULTS

Participants were given a scenario of a hypothetical clandestine laboratory and were required to:

- identify Sample S1 liquid and to explain how the substance was synthesised.
- identify Sample S2 powder and to discuss if and how it could be used for illegitimate purposes.

5.1 Discussion of Results for Sample S1

Sample S1 was P2P. The provided scenario noted that this sample had been collected as the upper layer of a two-phase mixture which also contained a lower, aqueous layer with an acidic pH. The scenario also noted the presence of containers labelled "sulfuric acid" and "hydrochloric acid", as well as a bag of MAPA (as Sample S2) at the laboratory. This scenario was consistent with the synthesis of P2P from MAPA via hydrolysis under acidic conditions.

For Sample S1, a summary of participants' results is presented in Table 9.

Table 9 Summary of Results for Sample S1

Sample S1	Sample Identification	Precursor and Synthetic Pathway
Acceptable / Total Responses	11/11	11/11

All participants correctly identified Sample S1 as P2P, and correctly reported that the sample was synthesised from MAPA via hydrolysis under acidic conditions.

Laboratories **1**, **10** and **11** reported alternative precursors, including α-phenylacetoacetonitrile (APAAN), and P2P glycidates. While these precursors were not included in the scenario as being found in the clandestine laboratory, nor were they samples provided in this PT study, based on the analysis of the sample itself, these compounds are valid as potential precursors.

All participants except for Laboratory **4** used the items at the scenario provided to support their conclusions. Laboratories **3**, **6**, **7**, **8**, **11** and **12** used the equipment at the scene to support the synthesis of P2P.

5.2 Discussion of Results for Sample S2

Sample S2 was MAPA. This can be used to synthesis ATS such as amphetamine and methamphetamine by conversion to P2P. The presence of items listed in the scenario given indicate that the laboratory was specifically equipped to synthesise methamphetamine from P2P via the Leuckart method.

For Sample S2, a summary of participants' results is presented in Table 10.

Table 10 Summary of Results for Sample S2

Sample S2	Sample Identification	Illegitimate Purpose
Acceptable / Total Responses	11/11	11/11

All participants correctly identified Sample S2 as MAPA, and correctly identified its potential illegitimate use in synthesising methamphetamine (through P2P).

Laboratories **1** and **3** did not use the chemicals found at the scene to support their conclusions that the substance was used to manufacture methamphetamine. All other participants noted the presence of N-methylformamide and/or formic acid in the scenario, and used these

compounds to support their conclusion that the clandestine laboratory was likely set-up to synthesise methamphetamine as the end product.

Laboratories **1**, **5**, **6**, **7**, **8**, **10** and **11** correctly named the Leuckart reaction for the synthesis of methamphetamine from P2P. Laboratory **9** and **12** correctly explained the synthesis of methamphetamine from P2P, but did not name the reaction.

6 REFERENCES

Please note that for all undated references, the latest edition of the referenced document (including any amendments) applies.

[1] ISO/IEC 17043, *Conformity assessment – General requirements for the competence of proficiency testing providers*.

[2] Nacionalni Forenzični Laboratorij, 2019, Analytical Report MAPA (C11H12O3) methyl 3-oxo-2-phenylbutanoate, viewed May 2025, <https://www.policija.si/apps/nfl_response_web/0_Analytical_Reports_final/MAPA-ID-2087-19_report.pdf>.

[3] Langone, D., Painter, B., Nash, C., Hulshof, J., Oldenhof, S., Johnston, M.R. and Kirkbride, K.P., 2022, 'Impurity profiling of methamphetamine synthesized from methyl α-acetylphenylacetate', *Drug Test. Anal.*, vol. 14, no. 7, pp. 1310-1324.

APPENDIX 1 - ACRONYMS AND ABBREVIATIONS

APAAN	α-phenylacetoacetonitrile
ATR	Attenuated Total Reflectance
ATS	Amphetamine-Type Stimulants
BMK	Benzyl methyl ketone (alternative name for P2P)
FTIR	Fourier Transform Infrared Spectroscopy
GC	Gas Chromatography
IC	Ion Chromatography
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
LC	Liquid Chromatography
MAPA	Methyl α-acetylphenylacetate
MS	Mass Spectrometry
NATA	National Association of Testing Authorities, Australia
NMIA	National Measurement Institute Australia
P2P	Phenyl-2-propanone
PT	Proficiency Testing
TIC	Total Ion Chromatogram

END OF REPORT