Study Guide for the Trace Evidence Examination-Paint and Polymer

Introduction

Your study guide consists of a Job Description, a list of Knowledge, Skills, and Abilities (KSAs), References, and a 10 Question primer for the exam.

- The **Job Description** describes the education, background, training, and specific duties of an analyst in each discipline.
- The **KSAs** have ten major sections. Sections I-IX cover the core knowledge and skills expected of every forensic scientist and comprise 40% of the examination. Section X, consisting of the specific, discipline related, in –depth, upper level knowledge, skills, and abilities will make up 60% of the examination. Please note that the sub-categories listed under the capital letters in the KSAs are examples and are not meant to be all-inclusive, or to indicate that there will necessarily be a question on the exam from every sub-category.
- The **References** are broken into core references and discipline-related references. The core references are identical for all the ABC examinations. The discipline-related references are specific to each discipline.
- There are ten S**ample Questions** to give you an idea of the range of content and difficulty that will appear on the exam. For further information, please see "Introduction to ABC Certification Examinations."

Study Guide for the Trace Evidence Examination-Paint and Polymer

Job Description

A Qualified Trace (Paint and Polymer Specialty) analyst must be able to:

- Perform analyses on (most often minute quantities) of paint and polymer samples, using light microscopy, chemical and/or instrumental methods of analysis.
- Characterize paint and polymer samples based upon physical properties, chemical, and elemental composition.
- Perform comparisons of paint/polymer evidentiary samples.
- Perform vehicle color, year, make and model determinations for investigative aid purposes.
- Recognize, collect, secure, and preserve physical evidence.
- Recognize the potential for other forensic examinations in areas outside an area of specialization, prioritize the sequence of examinations, and handle evidence accordingly.
- Observe safe practices to ensure the safety of the analyst and co-workers.
- Engage in impartial and ethical work practices.
- Be proficient in the use and maintenance of laboratory instrumentation.
- Evaluate and interpret results of physical and instrumental analyses.
- Thoroughly and accurately produce documentation (notes and data) to support results and conclusions.
- Summarize results and conclusions in written reports.
- Testify under oath as to analytical processes, results, and conclusions.
- Recognize and employ quality assurance measures to ensure the integrity of the analyses.

Study Guide for the Trace Evidence Examination-Paint and Polymer

Knowledge, Skills, and Abilities

I. History
    A. Evolution of practice
    B. Significant historical figures (e.g., Locard, Gross, Orfila, Kirk)
II. Crime Scene Preservation
    A. Securing
    B. Isolating
    C. Recording
    D. Searching
    E. Recognition of evidentiary value
    F. Safety
III. Crime Laboratory Operations – Overview
    A. Laboratory Disciplines
        1. Forensic biology
        2. Controlled substances
        3. Trace analysis
        4. Toxicology
        5. Latent fingerprints
        6. Questioned documents
        7. Fire debris
        8. Firearms/Toolmarks
        9. Digital evidence
    B. Evidence associated with each discipline
IV. QA/QC
    A. Accreditation, Certification, Standardization
        1. Laboratory accreditation
            a) Audit Trails
            b) Accrediting bodies
            c) ISO 17025
            d) DNA Quality Assurance Standards (QAS)
            e) ASCLD/LAB
        2. Personnel certification
            a) ABC
            b) IAAI
            c) IAI
            d) ABFT
            e) FTCB
            f) AFTE
            g) ABFDE
            h) BFDE
            i) IACIS

3. Standardization
    a) ASTM
    b) UN
    c) TWG/SWG

B. QA/QC Application
1. Non compliant data
2. Documentation evaluation
3. Validation and verification
4. Linearity
5. Limits of detection
6. Limits of quantitation
7. Limits of reporting
8. Negative and positive controls
9. Calibrators/Standard Reference Material
10. Measurement of Uncertainty
11. Traceability
12. Corrective and preventative actions
13. Proficiency testing
14. Confidence interval/Confidence limit
15. Sampling plans/Sample selection

C. Document/Data Management
1. Databases
2. LIMS
3. Case document preservation/integrity

V. Safety
A. Chemical Hygiene
1. Safety labeling (SDS)
2. Globally Harmonized System of Classification and Labeling of Chemicals (GHSCLC)
3. Communication Plans

B. Universal Precautions
1. Blood-borne pathogens
2. Personal protective equipment

C. Hazardous Waste/Biohazardous Waste Handling
1. Spill control

VI. Legal
A. Decisions/laws
1. Frye
2. Daubert/Kumho
3. Brady
4. Melendez-Diaz

B. Legal terms
    1. Chain of custody
    2. Discovery
    3. Voir Dire
    4. Duces Tecum
C. Court Testimony
    1. Monitoring
    2. Courtroom etiquette
D. Procedural Law
    1. Hearings, trials, appeals
    2. Advocacy, burden of proof
    3. Subpoenas and affidavits
    4. Rules of Evidence

VII. Ethics
A. ABC Code of Professional Ethics
    1. Conflict of interest
    2. Professional integrity
    3. Objectivity
    4. Professional obligations

VIII. Evidence Handling
A. Evidence Recognition and Collection
    1. Prioritization based on circumstance
    2. Sampling
    3. Preservation
B. Evidence Classes (Class/Individual)
    1. Exclusionary evidence
    2. Identification
    3. Direct vs. indirect evidence
    4. Tangible vs. latent evidence
C. Evidence Preservation
    1. Chain of custody
    2. Alteration/degradation
    3. Storage (long term/short term)
D. Evidence Packaging
    1. Proper sealing
    2. Types of packaging

IX. General Science Terms and Principles
A. Definitions and applications
    1. Scientific method
B. General Chemistry Concepts
    1. Nomenclature (IUPAC)
    2. Type of molecules (e.g., aromatics, isoalkanes)
    3. Atomic, molecular weights
    4. Acids/bases

5. Periodic Table
6. Elemental composition
7. Bonding
    a) Ionic
    b) Covalent
    c) Hydrogen
    d) Van der Waals
8. Stereoisomer
9. Enantiomer

C. General Biology Concepts
1. Cell structure
2. Genetics
3. Botany
4. Characteristics of body fluids

D. General Physics Concepts
1. Energy
2. Electromagnetic spectrum
3. Force

E. General Physiology and Anatomy Concepts

F. General Statistics (S)
1. Mean
2. Median
3. Mode
4. Standard deviation
5. Variability
6. Population characteristics
7. Confidence Interval
8. Bayesian Theory

G. Stoichiometry

H. Logic
1. Critical thinking
2. Inductive and deductive reasoning
3. Contextual bias

I. Metric System
1. Metric to metric conversion
2. Metric to English conversion

X. Forensic Science Applications for Trace (Paint and Polymer) Analysts

A. Principles and concepts
1. Methods of production/manufacture of paints and polymers
2. Processes commonly used in the application of paints and coatings
3. Fracture match examinations

4. Properties of paints and polymers that allow their characterization, comparison, and identification
5. Current Information
    a) Scientific literature applicable to the examination of paints and polymers
    b) Attendance at workshops, classes, technical or professional meetings for current manufacturing processes, application techniques, uses, and methods of analysis of paints and polymers
    c) Critical comparison of old and new techniques in paint and polymer analysis
    d) Outside sources of information and expertise such as academic institutions or industry

B. Types of Evidence
    1. Composition of paints and polymers with recognition of associated terminology commonly used in the industry.
    2. Visual and stereoscopic analyses
        a) Layer structure
        b) Layer colors
        c) Layer textures
        d) Types of paint (automotive, architectural, primer, finish coat, etc.), Types of tape (duct, electrical, packaging, etc.)
        e) Surface defects, inclusions, contaminants
        f) Decorative flake

C. Evolution of the discipline
    1. History of the development of paints, coatings, polymers and their use as forensic evidence.

D. Accepted standards and practices
    1. Methods, procedures and tests commonly used in the analysis of paints and polymers
    2. Methods for determining vehicle year, make or model information from paint, including the capabilities and limitations of the Paint Data Query (PDQ) database
    3. Paint and polymer solvent tests and other chemical spot tests
    4. ASTM, SWGMAT, NIST

E. Results and Conclusions
    1. Process analysis
        a) Interpret the microscopic, chemical, and instrumental data obtained from the analysis of paints/polymers while being cognizant of conditions or circumstances that may affect the results
        b) Understand the limitations of an analysis in order to formulate a conclusion concerning paint or polymer evidence
        c) Apply the knowledge of class versus individual characteristics to paint and polymer evidence

d) Evaluate requests for analysis to determine what collections (questioned and known), examinations, and comparisons should be conducted to develop the most forensically useful information based on sample origin, type, quantity, condition, specific case scenarios, etc.
e) Collection of appropriate control and reference samples for comparison in paint and/or polymer analysis
f) Relate test data to paint and polymer information available from manufacturers concerning the production data and end use of the product
g) Use of appropriate photographic, and photomicrographic (or digital imaging) equipment and techniques

2. QA/QC
3. Reporting
    a) Construct a report which may include: chain of custody information, description of paint/polymer, nature of analyses, results of tests, conclusions (possibly including a common origin statement), summary, and information regarding the disposition of the evidence
4. Case Management
    a) Maintenance of documents and data for discovery

F. Light Microscopy
1. Theory and Application
    a) Principles of light microscopy
    b) Nomenclature
    c) Types of light microscopes
    d) Optical properties of trace evidence materials, such as refractive indices, birefringence, density, color, etc.
2. Procedures and Methods
    a) Illumination techniques such as polarized light, phase contrast, differential interference contrast, incident and reflected light, fluorescence, darkfield, brightfield
    b) Characterization and comparison of paints/polymers
    c) Making microscopical measurements
    d) Mounting media
3. Results and Interpretation
4. QA/QC
    a) Optimization of illumination and alignment
    b) Maintenance of the microscope

G. Electron microscopy (scanning and transmission)
1. Theory and Application
2. Procedures and Methods
3. Results and Interpretation
4. QA/QC

H. Elemental analysis by spectrometry techniques such as energy dispersive X-ray spectrometry, wavelength dispersive spectrometry, Inductive coupled plasma mass spectrometry

1. Theory and Application
2. Procedures and Methods
3. Results and Interpretation
4. QA/QC

I. Infrared, Raman, Visible, Ultraviolet, Fluorescence, Near Infrared spectrometry

1. Theory and Application
2. Procedures and Methods
3. Results and Interpretation
4. QA/QC

J. Gas Chromatography with various detectors and sample introduction techniques (mass spectrometers, pyrolysis)

1. Theory and Application
2. Procedures and Methods
3. Results and Interpretation
4. QA/QC

K. X-Ray Diffraction

1. Theory and Application
2. Procedures and Method
3. Results and Interpretation
4. QA/QC

L. High Pressure Liquid Chromatography with various detectors

1. Theory and Application
2. Procedures and Methods
3. Results and Interpretation
4. QA/QC

M. Thin Layer Chromatography

1. Theory and Application
2. Procedures and Methods
3. Results and Interpretation
4. QA/QC

References

Core

Techniques of Crime Scene Investigation, 7th Edition, by Fisher, B.J. (Boca Raton: CRC Press, 2004) ISBN 0-8493-1691-X.

Criminalistics, An Introduction to Forensic Science, 7th Edition (or higher), by Saferstein, R. (Upper Saddle River, NJ: Prentice Hall, 1998) ISBN 0-13-592940-7.

Forensic Science Handbook, Volume I, 2nd Edition, edited by Saferstein, R. (Englewood Cliffs, NJ: Prentice Hall, 2002) ISBN 0-13-091058-9.

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Fundamentals of Forensic Science, by Houck, M., Siegel, J. (Burlington, MA: Elsevier Academic Press, 2006) 0-12-356762-9.

Forensic Chemistry, by Bell, S., (Upper Saddle River, NJ: Pearson Prentice Hall, 2006) ISBN 0-13-147835-4.

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ISO/IEC 17025: General requirements for the competence of testing and calibration laboratories. International Organization of Standards, (ISO copyright office, Switzerland, 2005)

Discipline-related

Ryland, S. G., "Infrared Micospectroscopy of Forensic Paint Evidence," *Practical Guide to Infrared Microspectroscopy,* Humecki, H. (ed.), Marcel Dekker, New York, 1995, pp. 163-243

Scientific Working Group for Materials Analysis documents at http://swgmat.org/ Focusing on paint and tape documents

ASTM E 1610-02 Standard Guide for Forensic Paint Analysis and Comparison

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Various authors, Chapters 7-12, *Forensic Examination of Glass and Paint; Analysis and Interpretation*, Brian Caddy, ed., New York, NY, Taylor & Francis Inc., 2001, pp.123-287.

Applied Pyrolysis Handbook, edited by Wampler, T. P. (New York, NY: Marcel Dekker, Inc, 1995).

Polarized Light Microscopy by McCrone, W., McCrone, L., Delly, J. (Chicago, Illinois: Microscope, 2005) ISBN 0250402629.

Current Trends in Forensic Paint Examination by S.G. Ryland, T.A. Jergovich, K.P. Kirkbride, Forensic Science Review, 18: 97; 2006.

Encyclopedia of Forensic Sciences Volume 3, Jay Siegel (Editor); Geoffrey Knupfer (Editor); Pekka Suakko (Editor) ISBN 0122272153 Academic Press, New York, N.Y. pp. 1148 and 1188.

Polymer Chemistry: An Introduction, 3rd edition. By Malcolm P. Stevens. Oxford University Press: New York, Oxford. ISBN 0-19-512444-8, Chapters 1, 2, 3, 4, 5.

Pressure Sensitive Adhesive Tapes - A Guide to their Function, Design, Manufacture and Use by Johnston, J., Pressure Sensitive Tape Council, Northbrook, IL. 2003.

Jenny Smith, Chapter 12, *Forensic Analysis on the Cutting Edge*: *New Methods for Trace Evidence Analysis*, 1st edition, R.D. Blackledge (ed.), pp. 291-332.

"Identification of Pressure-Sensitive Adhesive Polypropylene Tape", *JFS*, Vol. 48, No. 1, 2003, pp. 68-76.

"A Validation Study for Duct Tape End Matches." Bradley, MJ, Keagy, RL, Lowe, PC, Rickenbach, MP, Wright, DM and LeBeau, MA. *JFS*, Vol. 51, No. 3, May 2006.

"A New Approach for the Analysis of Duct Tape Backings." Hobbs, AL, Gauntt, J, Keagy R, Lowe, PC, Ward, D. *Forensic Science Communications*, Vol. 9, No. 1, January 2007.

"A Validation Study for Vinyl Electrical Tape End Matches," Bradley, M.J., Gauntt, J.M., Mehltretter, A.H., Lowe, P.C., and Wright, D.M., *JFS,* Vol. 56, No. 3, 2011, pp. 606 - 611.

"Identification and Comparison of Electrical Tapes Using Instrumental and Statistical Techniques: I. Microscopic Surface Texture and Elemental Composition," Goodpaster, J.V., Sturdevant, A., Andrews, K., and Brun-Conti, L., *JFS,* Vol. 52, No. 3, 2007, pp. 610-629.

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"Analysis and Discrimination of Electrical Tapes: Part I. Adhesives," Mehltretter, A.H., Bradley, M.J., and Wright, D.M., *JFS,* Vol. 56, No. 1, 2011, pp. 82-94.

"Analysis and Discrimination of Electrical Tapes: Part II. Backings," Mehltretter, A.H., Bradley, M.J., and Wright, D.M., *JFS*, Vol. 56, No. 6, 2011, pp. 1493-1504.

"Forensic Analysis and Discrimination of Duct Tapes" Mehltretter, A.H. and Bradley, M.J., *JASTEE*, 2012, 3(1): 2-20.

"The Statistical Evaluation of Torn and Cut Duct Tape Physical End Matching." Tulleners, F.A., Braun, J.V. Award No. 2009-DN-BX-K235. Available: https://www.ncjrs.gov/pdffiles1/nij/grants/235287.pdf

"Forensic duct tape sourcing examinations: Developing investigative leads using multiple resources" Wright, D.M. and Mehltretter, A.H, *JASTEE*, 2013, 4(1): 13-28.

Also, from the Core readings listed above, especially close attention should be paid to:

Forensic Science Handbook, Volume I, 2nd Edition, edited by Saferstein, R. (Englewood Cliffs, NJ: Prentice Hall, 2002) ISBN 0-13-091058-9:

- Chapter 3 *Forensic Applications of Mass Spectrometry*
- Chapter 5 *Foundations of Forensic Microscopy*
- Chapter 6 *Visible Microscopical Spectrophotometry in the Forensic Sciences*
- Chapter 8- *Forensic Paint Examination*

Forensic Science Handbook, *Volume II*, 2nd Edition, edited by Saferstein, R. (Englewood Cliffs, NJ: Prentice Hall, 2005) ISBN 0-13-112434-X.

- Chapter 3- *Forensic Capillary Gas Chromatograpy*
- Chapter 5- *Microscopy and Microchemistry of Physical Evidence*
- Chapter 6- *An Introduction to the Forensic Aspects of Textile Fiber Examination*

Forensic Science Handbook, Volume III, edited by Saferstein, R. (Englewood Cliffs, NJ: Prentice Hall, 1993) ISBN 0-13-325390-2.

- Chapter 2- *A Guide to The Analysis of Forensic Dust Specimens*
- Chapter 3- *Forensic Applications of Infrared Spectroscopy*
- Chapter 4- *Infrared Microscopy and its Forensic Applications*

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Sample Questions

1. The primary reason for proving "chain of custody" on a particular item in court is to:

   A. Authenticate the item.
   B. Show how many people handled the item.
   C. Show how long it was in each person's possession.
   D. Deter or prevent unauthorized individuals from handling the evidence.

2. Which of the following actions is not forbidden by the ABC Code of Professional Conduct?

   A. Embellishing one's qualifications when testifying.
   B. Utilizing a secret method.
   C. Refusing to honor a subpoena duces tecum.
   D. Interpreting equivocal results based only on an employer's wishes.

3. The automotive paint binder classes of dispersion and solution lacquers can be recognized and differentiated by their:

   A. Infrared spectra.
   B. Solubilities in acetone, chloroform, and xylene.
   C. Pyrolysis gas chromatograms (pyrograms).
   D. b and c .

4. Which of the following is the most common trype of external plasticizer found in the paint industry?

   A. phosphates
   B. butyl acrylate
   C. phthalates
   D. adipates

5. Which one of the following polymers is MOST commonly used for the backing in black electrical tapes?

   A. polyvinychloride
   B. polyester
   C. polypropylene
   D. polyethylene

6. When examining a paint chip, which one of the following observations would support the conclusion that the chip is from an automobile that has been refinished?

   A. The presence of a clearcoat in the internal layer structure.
   B. A nitrocellulose topcoat.
   C. The presence of sanding stiae on the bottom of the base.
   D. Five or more layers in the finish system.

7. Duct tape is BEST differentiated by which one of the following features?

   A. Composition of the reinforcing cloth.
   B. Elemental composition of the adhesive surfaces.
   C. Physical characteristics.
   D. Type of polymer used for the tape backing.

8. Why are alkyd-based binders used extensively in the automotive refinish business?

   A. They are relatively inexpensive.
   B. They air dry.
   C. They do not require two package systems.
   D. All of the above.

9. Proficiency test specimens from an outside agency which are submitted to an analyst as if they were routine case specimens are part of _____ proficiency testing.

   A. blind, closed
   B. blind, open
   C. deficiency
   D. open

10. Which of the following elements would NOT normally be detected using conventional x-ray fluorescence or energy dispersive x-ray spectroscopic methods employing a beryllium window detector?

    I. Lithium.
    II. Chlorine.
    III. Boron.
    IV. Chromium

    A. I only
    B. I and III
    C. II and III
    D. II and IV