

## Study Guide for the Trace Evidence-Paints and Polymers Certification Examination

### Introduction

Your study guide consists of a Job Description, a list of Knowledge, Skills, and Abilities (KSAs), References, and a 20 Question primer for the examination.

- 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 examination 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 twenty **Sample Questions** to give you an idea of the range of content and difficulty that will appear on the examination. For further information, please see "Introduction to ABC Certification Examinations."



## **Study Guide for the Trace Evidence-Paints and Polymers Certification Examination**

### **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 insure 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-Paints and Polymers Certification Examination

### 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) DAB standards
      - e) ASCLD/LAB
    - 2. Personnel certification
      - a) ABC
      - b) IAAI
      - c) IAI
      - d) ABFT
      - e) AFTE

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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
    10. Estimate of uncertainty
    11. Traceability
    12. Corrective and preventative actions
    13. Proficiency testing
    14. Confidence interval/Confidence limit
  - C. Document/Data Management
    1. Databases
    2. LIMS
    3. Case document preservation/integrity
- V. Safety
- A. Chemical Hygiene
    1. Safety labeling (MSDS)
    2. 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
  - B. Legal terms
    1. Chain of custody
    2. Discovery
    3. Voir Dire

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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



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6. Elemental composition
7. Bonding
  - a) Ionic
  - b) Covalent
  - c) Hydrogen
  - d) Van der Waals
  - e) Stereoisomer
  - f) 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
  1. Mean
  2. Median
  3. Mode
  4. Standard deviation
  5. Variability
  6. Population characteristics
- G. Stoichiometry
- H. Logic
  1. Critical thinking
  2. Inductive and deductive reasoning
- 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

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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.)
    - 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

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- 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



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- 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

## Study Guide for the Trace Evidence-Paints and Polymers Certification Examination

### References

Listed below are the references for the Trace Evidence-Paint and Polymers Certification Examination. Small numbers of examination questions may have been drawn from a variety of other sources including general instrumental or chemistry text. Similar information may be obtained by studying earlier or later editions of the listed works, as well as other works covering the same topics.

#### *Core*

(40% of examination content)

The following texts were used for the generation of test questions for the CORE knowledge. Applicants are encouraged to familiarize themselves with information provided by these texts as that information relates to the KSA (knowledge, skills, and abilities) outlined in this study guide

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

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

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

*Forensic Science Handbook, Volume II*, 2<sup>nd</sup> Edition, edited by Saferstein, R. (Englewood Cliffs, NJ: Prentice Hall, 2004) ISBN 0-13-112434-X.

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

*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.

“The Rules of Professional Conduct” supplied by the American Board of Criminalistics.  
[www.criminalistics.com](http://www.criminalistics.com)

## Study Guide for the Trace Evidence-Paints and Polymers Certification Examination

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

### ***Discipline-related*** (60% of examination content)

In addition to the core information provided in the text above, the following texts are specific to the discipline (paints and polymers) portion of the examination.

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

Scientific Working Group-Materials, "Standard Guide for Using Scanning Electron Microscopy/X-Ray Spectrometry in Forensic Paint Examinations," *Forensic Science Communications*, vol. 4, no. 4, October 2001.

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

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.

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*Polymer Chemistry: An Introduction*, 3<sup>rd</sup> edition, by Malcolm P. Stevens, Oxford University Press: New York, Oxford, ISBN 0-19-512444-8, Chapters 1, 2, 3, 4, And 5.

"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, M.J., Keagy, R.L., Lowe, P.C., Rickenbach, M.P., Wright, D.M. and LeBeau, M.A., *JFS*, Vol. 51, No. 3, May 2006.

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

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

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

- Chapter 3 - *Forensic Capillary Gas Chromatography*
- 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 spectral regions has the highest energy?
  - a. Ultraviolet.
  - b. Infrared.
  - c. Radio.
  - d. Visible.
3. When handling biological materials, which of the following is the most reasonable approach to take?
  - a. Precautions are not normally necessary for sample handling since transmission of disease has not been shown to occur from such contact.
  - b. Precautions need only be taken when samples are in the liquid state since disease vectors are no longer viable upon drying.
  - c. Precautions should be taken regardless of the condition or the origin of the samples being handled.
  - d. Precautions need only be taken with unknown stains and liquids since preservatives and chelating agents present in reference samples will kill any communicable disease.
4. 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.



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5. Upon reviewing your notes for a court appearance in one week, you realize that there is a clerical error and two results have been reversed. Which of the following is the best course of action?
  - a. Issue a corrected report including the date of the correction and testify to the error if asked.
  - b. Immediately notify the attorney and issue a report which makes the correction clear.
  - c. Immediately make an entry in your notes as to your discovery and correct it in testimony if asked.
  - d. Correct the error in testimony if asked, but make no additions or alterations to your notes.
  
6. 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.
  
7. Which of the following is the most common type of external plasticizer found in the paint industry?
  - a. phosphates
  - b. butyl acrylate
  - c. phthalates
  - d. adipates
  
8. Which one of the following polymers is MOST commonly used for the backing in black electrical tapes?
  - a. polyvinylchloride
  - b. polyester
  - c. polypropylene
  - d. polyethylene

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9. 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 striae on the bottom of the base.
- d. Five or more layers in the finish system.

10. At the scene of a breaking and entering, an impression with a visible red smear is observed on the door frame. Which of the following would be appropriate samples to obtain?

- I. Paint from the impression
- II. Paint from the adjacent area of the door frame
- III. Paint from the other side of the door frame

- a. II and III
- b. I only
- c. I and II
- d. II only

11. 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.

12. Which one of the following materials would be unsuitable as a sample support medium, (slide) for small peels of paint when analyzing them by transmitted Fourier Transform Infrared (FTIR) microspectrophotometry?

- a. potassium bromide
- b. silver chloride
- c. silicon dioxide
- d. cesium iodide

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13. 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.

14. Refractive index can be defined as:

- a. The ration of velocity of light in a vacuum to that in any medium.
- b. The process of separating light into component colors.
- c. The bending of a light wave because of a change in velocity.
- d. The light halo that disappears when the medium and the specimen have similar light dispersion

15. Which one of the following statements is FALSE with respect to organic paint pigments?

- a. They often provide more vivid colors than inorganic pigments.
- b. They are typically more expensive than inorganic pigments.
- c. Unlike inorganic pigments, they are soluble in the paint vehicle.
- d. They are generally more prone to weathering than inorganic pigments.

16. Gas chromatography (GC) has the capability of separating mixtures on the basis of their distribution between:

- a. two moving gas phases
- b. a stationary gas phase and a moving liquid phase
- c. a stationary liquid phase and a moving gas phase
- d. two moving liquid phases

17. Which of the following terms is the **BROADEST** category describing chemical compounds that have the same chemical formula and the same atomic bond arrangement, and differ only in the orientation of the molecules in three-dimensional space?

- a. stereoisomers
- b. diastereoisomers
- c. enantiomers
- d. isomers



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18. 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

19. Paint flakes can be removed from the parent surface:

- a. by tape lifting the surface
- b. by lifting or prying loosely attached flakes, cutting samples of the entire paint layer structure using a clean knife or blade, or dislodging by gently impacting the opposite side of the painted surface
- c. but should never be done in the field, the item should always be submitted to the laboratory for collection
- d. by cutting just the surface flakes and avoiding contaminating the sample with any of the parent surface

20. 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

**Answers can be found in the references.**