AQA Additional Applied Science - 11.3 Forensic Science

Forensic science uses scientific techniques to identify and match substances and objects. Most of the work of the Forensic Science service is done to help police investigate crimes but forensic methods can also be used for other purposes, e.g. to study archaeological specimens, to investigate the cause of an industrial accident or to show whether or not people are related. Many types of materials and objects need to be investigated, so a wide variety of methods is used. The results often have to be used as evidence in a court of law, so accuracy and reliability are very important.

Collecting evidence from the crime scene

As a scientific investigation, forensic work begins with the careful observation and recording of materials found at the crime scene.
Before any laboratory tests can be carried out, samples need to be collected and labelled without introducing any contamination.

You need to be able to:

- describe how to avoid the contamination of evidence at a crime scene by:
    - restricting access
    - wearing protective clothing
    - using appropriate methods of sampling, storage and recording
- *describe how to take appropriate samples from large quantities of materials*
- *describe how to collect and record the following types of forensic samples:*
    - *broken glass*
    - *fibres*
    - *soil*
    - *fingerprints*
    - *blood.*

You should be able to use data, theories and explanations to:

- suggest why an inappropriate collection or sampling technique may lead to uncertainty about the validity and reliability of evidence.

Marks and impressions left at the scene of a crime may be recorded using plaster of Paris, plasticine or by taking a photograph. A comparison can be made with tools, tyres and the soles of shoes owned by a suspect. Fingerprints can be revealed and lifted from various types of surfaces and compared with known prints.

You need to be able to:
describe a suitable technique to make a permanent record of a mark or impression found at the scene of a crime
describe a suitable technique to reveal, lift and store a fingerprint left by a suspect at the scene of a crime
recognise the three distinctive types of fingerprint pattern (loop, arch, whorl)
make measurements to enable a comparison of crime scene marks and impressions with real objects.

You should be able to use data, theories and explanations to:
suggest which measurements or distinctive features could be used to make a comparison
state whether there is a possible match between two different samples using distinctive marks or impressions.

Analysing evidence from the crime scene

The melting point and boiling point of a substance and its behaviour when it is dissolved in water depend on its structure and bonding. The characteristic behaviour of a substance enables it to be identified. Qualitative analysis is an important aspect of the work of the forensic scientist. Chemical tests can be used to determine which substances are present in a sample.

You need to be able to:

- describe the structure of ionic compounds as consisting of a giant lattice held together by strong forces of attraction between positively charged and negatively charged ions (e.g. sodium chloride)
- explain why ionic compounds have high melting points.

You should be able to use data, theories and explanations to:

- state whether an ionic compound is soluble in water
- write the formula for an ionic compound.

You need to be able to:

- recall that many substances that are obtained from living materials are organic compounds with covalent bonding
- name some simple covalent compounds, given their formulae, and state the formula, given the name of the compound (carbon dioxide, CO_2; water, H_2O; ethanol, C_2H_5OH; glucose, $C_6H_{12}O_6$)
- understand that, although the covalent bonds between the atoms in a molecule are strong, the forces between the molecules are weak
- explain why covalent compounds have low melting points and boiling points
- *describe how to detect the presence of Na^+, K^+, Ca^{2+} and Cu^{2+} ions using flame tests*
- *describe how to test the solubility of a compound in water*
- *describe how to obtain a clear solution for use in further tests*
- *describe the use of universal indicator paper to measure the pH of a solution*
- *describe the use of precipitation reactions to detect the presence of Ca^{2+}, Cu^{2+},Fe^{2+}, Fe^{3+}, Pb^{2+}, Cl^-, and SO_4^{2-} ions*
- *describe the reaction of CO_3^{2-} ions with dilute acid*
- *describe the test for carbon dioxide using limewater*
- *describe the test for ethanol using acidified potassium dichromate solution and outline the use of this reaction in the original breathalyser*
- *describe the test for glucose using Benedict.s solution.*

You should be able to use data, theories and explanations to:

- name the product of a precipitation reaction
- draw conclusions about the identity of substances when given the results of a series of chemical tests

You should be able to assess the applications of science when:

- suggesting ways to improve the accuracy and reliability of the evidence being collected.

Chromatography is a technique that can be used to separate and compare samples of ink.

You need to be able to:

- *describe the separation of coloured mixtures using thin layer and paper chromatography with both water and non-aqueous solvents*
- explain why different colours in a mixture are carried different distances by the solvent and how this observation can be used to match the mixture with known samples or identify the substances present in the mixture.

Forensic scientists use more expensive and powerful equipment than is available for use in the school laboratory. This equipment gives more accurate results, often using very small quantities of material. The comparison microscope, the polarising microscope and the electron microscope are important tools used in the forensic science laboratory to compare samples.

You need to be able to:

- *describe the distinctive features of fibres, bullets, seeds and soil that enable samples to be matched.*

You should be able to use data, theories and explanations to:

- describe the distinctive features of pollen grains and layers of paint
- suggest why instrumental techniques provide more precise and reliable evidence than that obtained from simple laboratory experiments
- state whether observable features indicate a link between a suspect and the scene of a crime
- interpret data and state whether there is a high probability that a suspect is linked to the scene of a crime.

Blood typing can determine whether a blood stain is human and the blood group to which it belongs. Samples of DNA can be extracted from blood, semen and saliva. DNA can be cut up into fragments and separated by electrophoresis, and the DNA profile of the material from a crime scene can be matched with great certainty to the DNA provided by a suspect. This technique of DNA profiling can also be used to show whether or not people are related.

You need to know and understand:

- the composition of blood (red blood cells, white blood cells, platelets, plasma)
- the four main blood groups: A, B, AB and O
- that DNA is located in the nucleus of the cell
- that DNA is unique to the individual (except identical twins)
- that children inherit their DNA from their parents
- how charged particles move in an electric field and how this movement can be used to separate them (e.g. in order to produce a DNA profile).

You should be able to use data, theories and explanations to:

- draw conclusions from the results of blood tests and DNA profiling.

Fragments of glass and plastic found at a crime scene can be matched with fragments attached to a suspect's clothing or fitted to a vehicle involved in a road traffic offence. The refractive index of a glass fragment is found by noting its disappearance when it is immersed in oil with the same refractive index. The refractive index of blocks of glass or plastic can be obtained by measuring the angle of incidence and the angle of refraction and calculating $\sin i / \sin r$.

You need to be able to:

- describe how light is refracted at a glass surface
- *describe the procedure to measure the refractive index of a glass block*
- describe how the refractive index of a glass fragment is determined.

Using databases

Dental and medical records, vehicle records held on the DVLC database, insurance company records of valuable items, fingerprint and DNA databases and police records of descriptions of missing persons are examples of databases that are useful in forensic investigations. If a match can be found in

a database this increases the probability of a positive identification and a mismatch may be equally important to eliminate a suspect from the police inquiry.

You need to be able to:

- give a method to record a witness description (artist impression, identikit)
- describe the type of information stored in the databases used in forensic investigations
- explain how databases can be searched to find possible matches or to exclude a suspect from an investigation.

Interpreting and presenting evidence

Having carried out investigations in the laboratory, a forensic scientist must prepare a report and may have to stand up in court to present their evidence. The facts must be stated clearly in a logical order. The conclusions drawn from the facts must be explained and justified.

You should be able to use data, theories and explanations to:

- draw conclusions based on the facts and state whether, on the basis of the evidence, a suspect may have been present at a crime scene or may have committed a crime.