Marks

Question 32 — Forensic Chemistry (25 marks)

(a) (i) Identify the functional group in glycerol. **1**

(ii) Compare the reactions of both glycerol and 1-propanol when they react with cold dilute $KMnO_4$. **3**

(b) Discuss the value of electron spectroscopy and scanning tunnelling microscopy in the analysis of small samples in forensic chemistry. **4**

(c) (i) What class of compounds is used to break proteins into fragments of different lengths? **1**

(ii) Describe the processes of electrophoresis and chromatography in separating organic compounds. **4**

(d) During your practical work you performed a first-hand investigation to describe the emission spectrum of sodium.

(i) Name the piece of equipment you used to analyse the emission spectrum of sodium in the laboratory. **1**

(ii) Outline the procedure that you used in this investigation. **2**

(iii) Explain how the emission spectrum was produced. **3**

(e) Discuss the uses of DNA analysis in forensic chemistry. **6**

End of paper

a) i) -OH = alcohol group. / Hydroxy group

ii) cold dilute
$KMnO_4$ reacts with 1-propanol to produce propanoic acid. cold dilute $KMnO_4$ reacts with glycerol to produce $3CO_2$. Due to the fact that glycerol is a diol (has 3 OH) it requires more $KMnO_4$ for a reaction to occur than 1-propanol to oxidise all the OH's. does. Both reactions decolourise the purple $KMnO_4$. But 1-propanol does it ~~quicker~~, requiring a less amount of $KMnO_4$ than glycerol. due to the fact 1-propanol has only 1 OH glycerol has 3.

b) Electron Spectroscopy for chemical analysis (ESCA) is a surface analysis technique used to find the elemental composition of the surface layer of a solid. An x-ray beam is focused onto the sample causing electrons to be emitted. An electrostatic analyser measures the kinetic energies of the electrons & converts them to binding energies enabling

elemental identification. As it is a surface analysis technique it allows forensic chemists to identify the nature of a stain or deposit (or a skirt, tabletop etc) & match it to a suspect. However, this inhibits it from detecting things below the surface which could be invaluable if stains overlap. It can help forensic chemists understand the nature of weathering or corrosion a peice of evidence has experienced (ie. automobile paint) & allow them to trace a suspect or place found at a specific location. It only requires small samples which is beneficial as often forensic chemists are only given a small amount of evidence. Although, as it causes electrons to leave the sample it can destroy the sample prohibiting its use for further testing to validate results. ~~As sample must be~~ Limitations also include it must be clean & free of high pressure contaminants. & it is very sensitive & expensive.

- Produces an

Scanning tunnelling Microscopy ~~is a~~ accurate 3D image of the surface of solids allowing forensic chemists to obtain information about the irregularities in the surface. Its like AFM in that it uses a fine tip to scan the surface however a voltage is applied. This voltage causes electrons to leave surface & jump to tip of needle, thus is a destructive technique & wouldn't allow further testing if it was required. It only need a small sample which, like GCA, is good to forensic chemist who only get a small sample. The substance must be conducting or semi-conducting which is invaluable as only some substances can be analysed. It must a clean ~~sa~~ sample. As it provides forensic chemists with topographical images it aids them in controlling/improving environment & policies environmental legislation. Thus both techniques are of high value to the forensic chemist helping them to analyse evidence & solve cases.

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e)

i) Enzymes

ii) Paper electrophoresis:

A pape soaked in a buffer of pre-determine pH serves as a bridge between 2 electrode vessels. Next, an amino acid (organic material = whatever it may be) is applied as a spot. When current is applied, the amino acids (or whatever organic material it is) move to the electrode with a charge opposite to their own. Molecules having ~~large~~ high ~~effective~~ charge density move faster than those with a low charge density. Those already at their iso electric point stay at origin. When electrophoresis seperation is complete, the paper is dried & dyed (Ninhydrin) which makes the seperated amino acids visible.

Electrophoresis seperates on the differences in size & charge. It can be used not only on ~~amino~~ amino acids ~~and~~ but on organic material also.

Chromatography is the process of seperating organic compounds on the basis of their differential distribution in 2 phases - 1 stationary & one mobile. It seperates them according to their different solubilities in different solvents.

E.g seperating pigments in eucalptus leaves.

- leaves are crushed in a mortar with a pinch of sand & Methylated spirits
- Then they are filtred into a beaker.

- A drop of the filtred solution is applied to chromatography paper & placed in a test tube containing 1cm of methylated spirits
- The paper is left & the pigments move up the paper according to their different solubilities.

d/ i) Platinum wire, Bunsen burner, Spectroscope.

ii) Clean the platinum wire by placing in the bunsen.
- Place a small amount of Na on the wire & place in bunsen flame.
- View through a spectroscope.

iii) Each element has its own electron configuration, which sets out the positions of its electrons around the nucleus in shells of fixed positions to a stable atom. When an element is excited (by placing in an electrical discharge or as in our case by heating) it jumps into a higher energy level; that is a shell further away from the nucleus ~~emitting electromagnetic radiation that can be observed as lines~~

emits a wavelength of light. Each line in the emission spectrum

The electron is unstable in its new position & so it "falls back" to its ground state position emitting the absorbed photon of energy as it does so. Each line in the emission spectrum indicates a transition from one energy level to another.

Na produce an intense yellow colour.

e) DNA analysis is widely used in forensic chemistry to identify relationships between people, to identify individuals, to convict criminals as well as to alter the outcomes of investigations.

DNA analysis can be used to identify relationships between people. Each individuals DNA is unique. There is no relationship between the conventional fingerprint of a child & a parent. However

there is a relationship between a persons genetic fingerprint with that of their parents as a child receives half their genetic make up from each parent. Thus, ~~a match up of~~ correlating DNA can be used to ~~de~~determine paternity. Brothers & sisters have 50% of their introns (non-coding sequences in DNA which makes DNA unique to each individual) in common & cousins 25% ~~identical regions that identification~~ have identical ~~gene~~ DNA fingerprints. Thus, ~~DNA~~ analysis can be effective in identifying relationships between people, as those unrelated have no DNA the same.

Each individual has unique DNA due to non-coding sequences (introns) that are different in each individual. Human chromosomes contain many repeats of short sequences of bases. The length of these ~~re~~sequences & no. of repeats vary in each individual. They can be ~~repeated by thermocycler~~ replicated by polymerase chain reaction

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& then cut by restriction enzymes, seperated by electrophoresis & ~~then~~ used to identify individuals (possibly criminals) by collecting DNA samples. The fact that only small samples are needed benefits forensic chemists who are only provided with small peices of evidence.

~~DNA analysis can also be used to~~

~~With~~ Noting the fact that DNA analysis can ~~identify~~ individuals, it can therefore be used to convict criminals, if their DNA is found at a crime scene. However, this would rely on all suspects being willing to take a DNA test seen as DNA Databanks have not yet been established for such use due to ~~debate~~ controversial issues such as the right of an individual to privacy. ~~**~~ (please turn over here) →

DNA analysis can also be used today to alter the outcomes of forensic investigations of the past. This is evident in the article from the SMH on 29/8/02 "After 17yrs, DNA frees man wrongfully convicted of murder." The article tells the story of a man who in 1984

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Confessed to the rape & murder of a young girl. In recent times, the evidence; a bottle & underwear used to strangle the victim, were analysed using DNA fingerprinting. When originally there was no method to identify an individual through DNA. The DNA analysis showed that the convicted Mans DNA did not match that on the evidence & he was released pto.

However, due to the fact that identical twins have identical DNA fingerprints, in an extreme case, a twin may be convicted of a crime that their sibling has comitted. For this reason DNA evidence must not cannot be solely & used in forensic chemistry & DNA analysis/evidence must be used in conjunction with othe chemical tests to ensure accuracy of results & forensive investigation outcomes.

Therefore, it is evident that DNA analysis plays a major role in Forensic chemistry & is of great significance to the forensic chemist in analysing evidence & reaching conclusions. However as stated above, it should never be used on its own in order to ensure accuracy & reliability of results in criminal cases.