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**

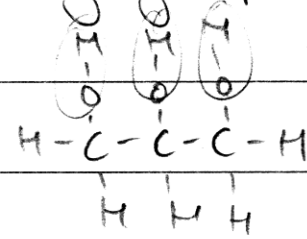
(ii) Outline the procedure that you used in this investigation. **2**

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

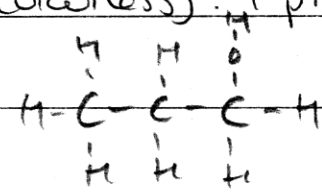
(e) Discuss the uses of DNA analysis in forensic chemistry. **6**

End of paper

a) i). ~~ester linkage~~ Hydroxyl group (-OH). There are 3 in glycerol -



ii) Glycerol is able to reduce a larger amount of $KMnO_4$, as $KMnO_4$ oxidises OH groups, and is thus itself reduced. As glycerol contains 3OH groups, there are more opportunities for oxidation, therefore more $KMnO_4$ can be reduced (it changes from purple → colourless). 1-propanol contains only one O-H group:



Therefore, it is going to reduce less $KMnO_4$ than glycerol (1,2,3 propanetriol) as there is less opportunity for oxidation.

b) Electron spectroscopy is able to identify the elements in the surface layer of a substance, measuring the kinetic energy of electrons of the inner shells of atoms. It irridiates the atoms with x-rays, forcing the ejection of these electrons. The ~~K~~ ionisation energy of the atom can be determined in the following eqn: ionisation energy = energy of x-rays - kinetic energy.

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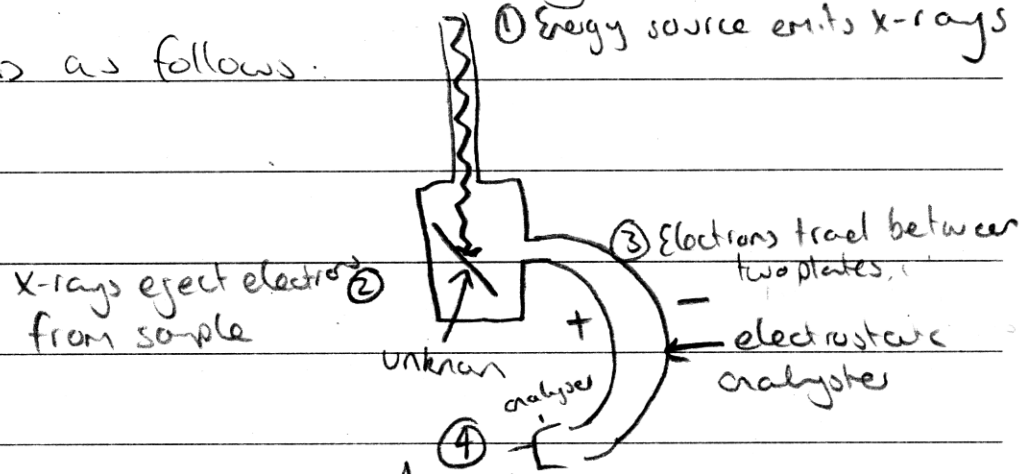
As each elemet ~~ea~~ has a different ionisation energy, ~~the~~ the discovery of the ionisation energy reveals the elemental composition of a sample. The Machinery used to evaluate kinetic energy is as follows.



Thus, electron spectroscopy is valuable in measuring composition of substance such as paint, and can be carried out on very small samples which is important as it is a destructive test. It is not as useful for obtaining concentration.

Scaning tunnelling Microscopy can identify the appearance of electrical conducting
the surface layer of a item such as a bullet. A very small platinum/rhodinium needle is swept ½ a nanometre above an object. A voltage is placed across the needle, and voltage varies depending on the distance the needle is from the object.

Piezoelectric crystals adjust the needle so voltage remains constant (thus distance remains constant) The result is a relief map of the substance, identifying scratch marks, etc. It is not very useful on very small samples, as it determines appearance, not composition. It is however, a non destructive test, thus very small samples can be analysed by this, then a destructive test such as AES.

c) i. enzymes

ii. Chromatography seperates substances based on their different solubilities in two stages - mobile (solvent) and stationary (water in cellulose fibres). More polar substances are more readily dissolved in polar water, thus they travel slowly up the chromatography paper. Less polar substances are more readily dissolved in the solvent, therefore travel faster. Thus, seperation occurs. The steps for chromatography (in the seperation of amino acids - a organic compound) is as follows:

Step 1: Seperate Amino acids by hydrolysis (warm with dilute acid).

Step 2: Place the amino acids on the start line, ~~or~~ near the bottom of the chromatography paper

Step 3: Dip the bottom of the paper (below the start line) in the solvent.

Step 4: Allow the solvent to travel up the paper.

Step 5: Dry the paper and spray with ninhydrin to expose parts of the amino acids.

Electrophoresis seperates a mixture on the basis of the size and charge of the substances which make it up. In the case of amino acids, each one has a different charge in the same pH, and is of different size, thus when subjected to electrophoresis, seperate easily. Steps for the seperation of Amen Acids by electrophoresis are as follows:

Step 1: Place Amino acids on the start line, in the middle of the electrophoresis paper which has been soaked in a buffer solution

Step 2: Apply a voltage across the paper: Turn Electricity on

Step 3: The positively charged amino acids will move toward the -ve electrode and vice versa. They will move for the if the are smaller, or if they are more charged (ie +3 charged amino acid will move closer to -ve electrode than a +2 charged one).

Step 4: After a short time, turn voltage off

Step 5: Spray paper with ninhydrin, exposing the position of the amino acids.

d) i. Spectroscope

ii. A solution of sodium ions was sprayed into a flame, exciting the electrons, and producing colored bands on the spectroscope when looked through, aimed towards the flame. The spectroscope was able to seperate the wavelengths produced by sodium, this we could see it with our eyes through the spectroscope.

iii) When ~~atoms~~ atoms are heated or placed in an electrical field, their ~~atoms~~ electrons become excited, jumping into higher energy levels. When they fall back to their normal energy level (or "grand state") they emit light of peculiar wavelengths. Large releases of energy produce short, U.V wavelengths, medium energy releases produce medium length, visible light wavelengths, and smaller energy jumps produce long, infra red rays. Emission spectra cases all 3 of these, however, when viewed with a spectroscope, only the visible wavelengths

(called the 'balmer' series of lines, generated when electrons fall back from a level greater than $n=2$, the second lowest energy state) are seperated, and viewed as colours. ~~As each element has a dif~~ Every element can be excited, producing light, but each one can jump back from different ~~or~~ levels, thus each element has a unique emission spectra. A monochromator in side the spectoscope seperated by wavelengths, thus we were able to see Sodiums unique emission spectrum.

c) DNA analysis seperates graps of amino acids, (called RFLP's) of which patten is unique to every person. ~~Relatives can have up to 50% of the~~ DNA is composed of 'exons' - of which are basically the same in every person, and 'introns' of which differs in each person. As relatives can have up to 50% of the same patten of RFLP's in the intron regions (parents and Children share 50% of same intron RFLP's, causing 25%), DNA analysis can be used to determine relations between people - such as in paternity cases, or ~~to~~ identify individuals - for criminal

investigation. The method for DNA analysis is as follows:

1. Seperate DNA from sample
2. Cut up DNA into RFLP's (segments) using restriction enzymes.
3. Make copies of Intron region RFLP's (10 regions used in Australia)
4. Determine length of RFLP's by electrophoresis.

Electrophoresis:

5. Spread RFLP's along edge of Agar Gel.
6. Place electrodes on gel. Turn on Voltage.
7. RFLP's move towards the electrode at a rate dependant on size. In a given time, smaller RFLP's will move closer to the +ve electrode than large ones.
8. Switch off voltage
9. Place nylon over gel. RFLP's stick to nylon.
10. Attach DNA probes to Nylon. These are radioactive that cause specific RFLP bands to darken.

What is left is a DNA 'fingerprint'. These lines can be matched to DNA found at a crime scene, [redacted] indicating a match or not. If a person [redacted] is really another father, 50% of the bands will match.

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DNA analysis is a ~~relatively easy way of delivering the~~ valuable crime fighting tool, as only the tiniest sample of ~~B~~ saliva, semen or even dandruff is needed ~~to~~ for analysis. By copying the RFLP's from the intron regions, the test can be done multiple times to prove validity, useful in convicting a person.