Problem 10: Patient prognosis

Curriculum links;
transition metal complexes, colorimetry, alcohols, carboxylic acids, esters, analytical techniques

Practical skills;
dilution, colorimetry, observation skills, GC analysis

A nineteen year old male has recently collapsed. His doctor would like the students to test;

i) the patient's urine for glucose
ii) the concentration of salicyclic acid (the break down product from aspirin) in the patient's urine [by colorimetry of the iron (III) salicylate complex]
iii) the patient's blood alcohol level (by interpretation of GC's provided)

Using this information the students are asked to make a recommendation as to the reason why the patient fainted.

Extension discussion points:
- Why are solutions of iron(III) ions more acidic than ethanoic acid? How does this help to explain the formation of the $[Fe(H_2O)_4(salicylate)]^+$ complex?
- What should be used for the blank in the colorimetry experiment?

Pre-Lab questions
(Remember to give full references for any information beyond A-level that you find out)

1. Glucose is a reducing sugar
   a) Draw the structure of glucose
   b) Use your knowledge of chemical tests in biology or chemistry to indicate a test you could use to show the presence of glucose in an unknown sample
   c) Why is the presence of glucose in a patient's urine a cause for concern?

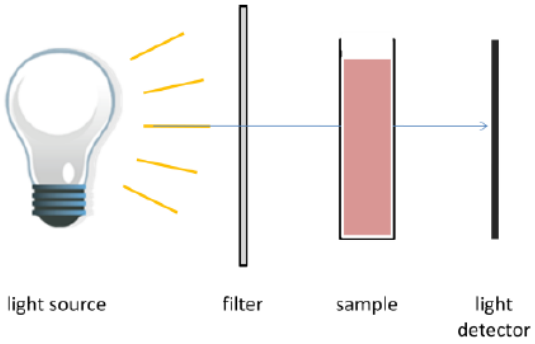
2. Aspirin is one of the most widely used painkillers in the world today. It works by inhibiting the formation of prostaglandins which are the chemicals responsible for the sensitisation of nerve endings.
   a) Draw the structure of aspirin and highlight the functional groups that you recognise.
   b) In the digestive tract, the aspirin is hydrolysed under basic conditions to form salicyclic acid and ethanoic acid, before being absorbed into the blood stream. Write an equation for the hydrolysis reaction.
   c) The reaction in fact occurs under mildly alkaline conditions in the digestive tract. Draw the structure of salicylic acid under these conditions.

3. Gas chromatography or GC is an analytical technique that can be used to identify unknown substances in a sample. Explain how GC is used to test athlete's blood or urine for drug taking. How is the process quantitative?

4. Colorimetry is an analytical technique that can be used to determine the concentration of a coloured compound in a solution by measuring the absorbance of

light by the sample relative to a sample of the same substance of known concentration. A simple diagram of a colorimeter is shown below;

a) Explain the purpose of the filter. How is the appropriate filter for a solution chosen?
b) Salicyclic acid can be detected in a urine sample by complexation of the salicylate anion with Fe3+ ions. A six co-ordinate complex, [Fe(salicylate)(H2O)4]+ is formed. This complex absorbs light at 520 nm and therefore appears to be pink/purple in colour.
    I. Draw the structure of the complex formed.
    II. What colour of filter should be fitted when using a colorimeter to record the absorbance of a solution of this complex?



Martin's medical practice
Larchester

Dear chemist,

I need your help with diagnosing a patient who recently reported to me after fainting during an evening out with friends. The patient is a nineteen year old male, with a BMI of 27.5 and blood pressure of 110 / 72. The patient reports suffering from a severe headache prior to his night out for which he took aspirin.

The patient is a keen rugby player with hopes of performing at international level. It is therefore important that we find the underlying cause of the fainting as soon as possible. In the first instance, I would like to rule out excess alcohol intake, diabetes or accidental aspirin overdose as the cause. Signs and symptoms of aspirin toxicity begin to appear at salicylate levels of higher than 300 mg/L in the patient's urine.

Accompanying this letter, you will find a urine sample and a GC analysis of the patient's blood. These were obtained immediately after the patient regained consciousness. Please use these to provide;

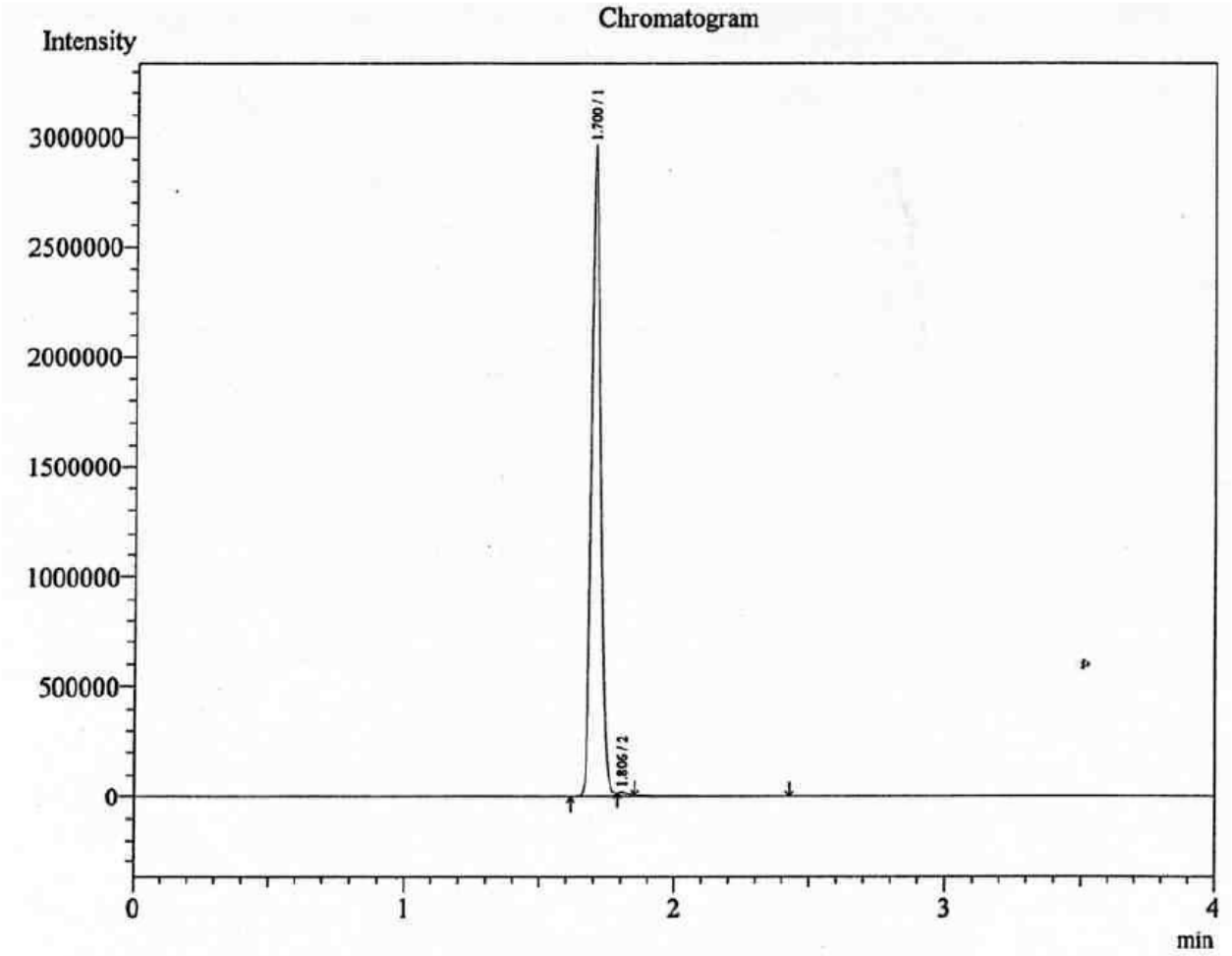
1. A qualitative test for the presence of glucose in the patient's urine
2. A quantitative assessment of the patient's blood alcohol content (BAC)
3. A quantitative assessment of the level of salicylate (the waste product from aspirin hydrolysis) in the patient's urine

The level of salicylate in the urine can be quantified by colorimetry. Complexing 1 cm^3 of the solution containing salicylate with 4 cm^3 of a 5% iron (III) chloride solution will give a coloured solution, the absorbance of which can be calibrated against a known concentration of salicylate. A solution of salicylate of concentration 500 mg dm^{-3} has been provided. This can be diluted to known concentrations for calibration.

Please provide a full report detailing the results of your group's analyses. For each analysis indicate whether the result is as would be expected. Make a recommendation, with reasoning, as to the cause of my patient's fainting.

Kind regards,

GC Analysis of Patient's Blood Sample

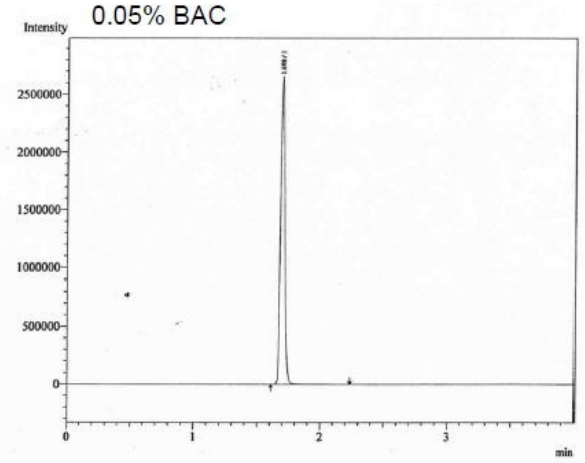


Peak Table - Channel 1

Peak#	Ret.Time	Height	Area	Area%
1	1.700	2931722	7169868	99.7271
2	1.806	10563	19623	0.2729
Total		2942285	7189491	

Chromatograms of blood samples of known alcohol content

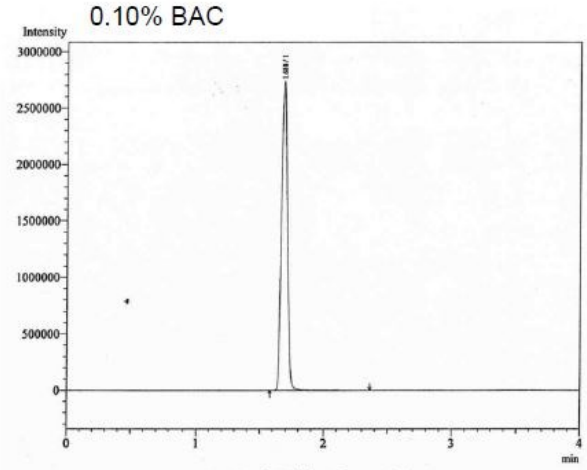
0.05% BAC



Peak Table - Channel 1

Peak#	Ret.Time	Height	Area	Area%
1	1.698	2642834	6242476	100.0000
Total		2642834	6242476	

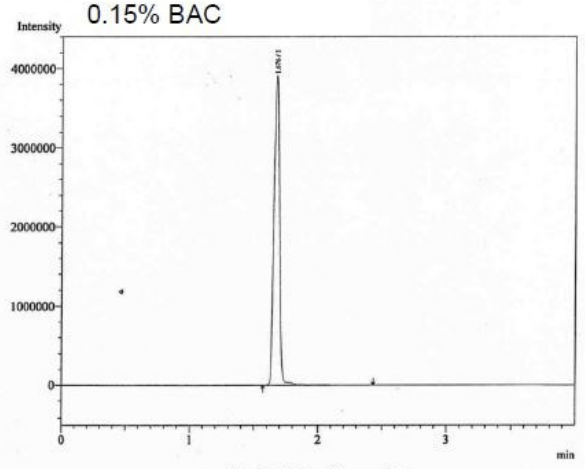
0.10% BAC



Peak Table - Channel 1

Peak#	Ret.Time	Height	Area	Area%
1	1.688	2737045	8768689	100.0000
Total		2737045	8768689	

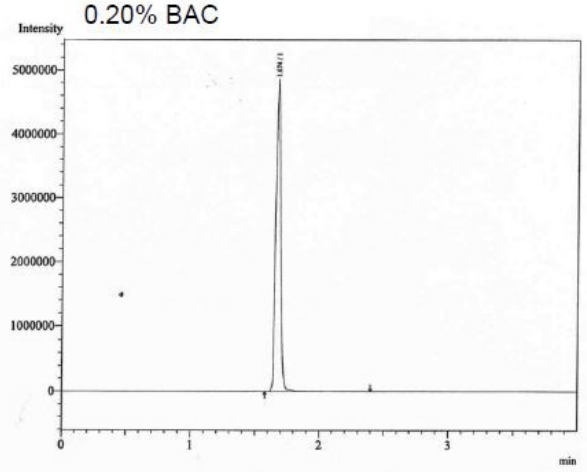
0.15% BAC



Peak Table - Channel 1

Peak#	Ret.Time	Height	Area	Area%
1	1.676	3890110	11738282	100.0000
Total		3890110	11738282	

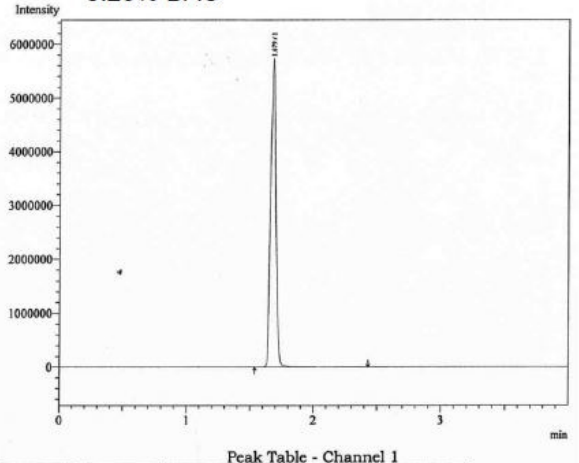
0.20% BAC



Peak Table - Channel 1

Peak#	Ret.Time	Height	Area	Area%
1	1.674	4852348	14155977	100.0000
Total		4852348	14155977	

0.25% BAC



Peak Table - Channel 1

Peak#	Ret.Time	Height	Area	Area%
1	1.679	5718831	16714044	100.0000
Total		5718831	16714044	