2005 - Question 1

Why was it necessary to analyse the sample of river water *immediately*?

The sample was analysed immediately so that oxygen content doesn't change (increase/decrease) due to activity of organisms in the water.

In making the additions to the sample, why should the solutions used be *concentrated*?

The solutions used should be concentrated in order toto minimise the amount of the water sample that is displaced / minimise the change in the oxygen dissolved in the sample.

Describe how the additions of the concentrated solution of manganese(II) sulfate (MnSO4) and alkaline potassium iodide (KOH/KI) to the bottle of river water should be carried out. What essential precaution should be taken when replacing the stopper of the bottle after these additions are made?

- remove a few cm^3 of river water from the bottle; addition made so that water overflows from the bottle.
- make additions under the level of the water using a dropper (pipette, syringe); do not bubble air (oxygen) into the water in the process.

The precaution should be taken in order to not trap air (oxygen) bubbles.

Describe clearly the procedure for using a pipette to measure exactly 50 cm^3 portions of the iodine (I_2) solution into the titration flask.

- rinse with water followed by iodine.
- fill pipette using a pipette filler to above the mark (graduation line)
- adjust to have bottom of meniscus on mark and ensure reading is at eye level (vertically)
- remove droplets sticking to the outside
- drain under gravity into titration flask
- touch tip of pipette against side of flask to add droplet sticking to outside tip
- do not blow out drop inside pipette

What indicator is used in this titration? State when the indicator should be added to the titration flask and describe the colour change observed at the end point.

Starch
WHEN: when the solution is straw-yellow (light yellow, straw-coloured).
COLOURS: blue-black (black, blue, indigo, navy) to colourless.

The titration reaction is described by the following equation.
$2S_2O_3 + I2 \rightarrow 2I^- + S_4O_6$
Calculate the concentration of the iodine solution in moles per litre given that 6.0 cm^3 of the 0.01 M sodium thiosulfate ($Na_2S_2O_3$) solution were required in the titration for complete reaction with 50 cm3 portions of the iodine solution.

$$\frac{50 \times X}{1} = \frac{6.0 \times 0.01}{2}$$

$$X = 0.0006 / 6 \times 10^{-4}$$

For every 1 mole of oxygen gas (O_2) in the water sample 2 moles of iodine (I_2) are liberated in this experiment. Hence calculate the concentration of dissolved oxygen in the water sample in p.p.m.

$0.0006 \div 2 = 0.0003$

$0.0003 \times 32 \times 1000 = 9.6$

Question 2

Why was the receiving vessel cooled in ice-water?

There is a volatile product produced; ethanal has low b.p. / ethanal boils at about 21 °C

State two features of the preparation that are necessary to maximise the yield of ethanal and, for each feature stated, explain why it is necessary.

- Adding excess ethanol – the product stops at ethanal/doesn't go to ethanoic acid / prevents further oxidation.
- Immediate distillation – ethanal removed before oxidation / prevents further oxidation.

Describe and account for the colour change which is observed during the addition of the ethanol and sodium dichromate(VI) solution to the hot acid.

DESCRIBE: Orange solution added to colourless liquid and becomes green.

ACCOUNT: Cr(VI) / $Cr_2O_7^{2-}$ is reduced to Cr(III) / Cr^{3+}

Describe how you would carry out Fehling's test on a sample of ethanal. What observation would you expect to make in this test?

- Mix equal amounts of Fehling's A and Fehling's B solutions.
- Add ethanal and warm / heat / put test tube in hot (boiling) water
- A brick-red precipitate produced

Assuming that all of the features needed to maximize the yield of ethanal were present, what mass of ethanal would be produced in the preparation if the students used 8.94 g of sodium dichromate(VI) (Na2Cr2O7.2H2O), and a 75% yield was obtained?

8.94 g sodium dichromate $\xrightarrow{\div 298^*}$ 0.03 mol

0.03 mol dichromate $\equiv$ 0.09 mol ethanal

0.09 mol ethanal $\xrightarrow{\times 44^*}$ 3.96 g ethanal

75 % yield $= \frac{3.96 \times 75}{100} = 2.97$ g

Question 3

Write a balanced equation for the decomposition of hydrogen peroxide.

$H_2O_2 \rightarrow ½O_2 + H_2O$

Draw a labelled diagram of an apparatus a student could assemble to measure the rate of decomposition of hydrogen peroxide in the presence of a manganese(IV) oxide (MnO2) catalyst. Indicate clearly how the reaction could be started at a time known exactly, and how the gas produced is collected and its volume measured.

A student has a choice of using the same mass of finely powdered manganese(IV) oxide or coarsely powdered (granulated) manganese(IV) oxide. Which of these would you expect to have a greater average rate of reaction over the first minute of the reaction? Give a reason for your answer.

The finely powdered option would be the one which would give the greater initial reaction rate; this is because there is a greater surface area and the reaction would occur more quickly.

A set of results obtained in an experiment to measure the rate of decomposition of hydrogen peroxide, in a solution of known volume and concentration, is given in the table.

Time/minutes	0	1	2	3	4	5	6	7	8
Volume of O_2/cm^3	0.0	13.5	23.4	30.5	35.4	38.3	39.6	40.0	40.0

Plot a graph to illustrate the volume of oxygen produced *versus* time.

Use the graph to determine
(*i*) the volume of oxygen produced during the first 2.5 minutes and
(*ii*) the instantaneous rate of the reaction at 2.5 minutes.

What changes would you expect in the graph if the experiment were repeated using a solution of the same volume but exactly half the concentration of the original hydrogen peroxide solution?

There would be a less steep rise to a maximum volume 20 cm^3