1 A painting on display in an art gallery is in poor condition and is taken down for restoration. Before the restoration work can start, samples of paint are analysed to find out which pigments they contain.

The blue paint is found to contain an iron pigment called Prussian Blue, which has the formula $KFe[Fe(CN)_6]$.

a Below are the reflectance spectra (A and B) of two paint samples from the picture.



- i Explain why the paint sample that gave spectrum **A** *could* contain Prussian Blue, whereas the paint sample that gave spectrum **B** cannot. (2 marks)
- ii What feature of the structure of Prussian Blue is responsible for its colour? (1 mark)
- **b** Another paint found in the picture contains the pigment Chrome Yellow, lead(II) chromate(VI), PbCrO₄.
 - i Write an ionic equation (with state symbols) that shows the reaction between lead(II) ions and chromate(VI) ions in solution to produce a precipitate of lead(II) chromate(VI). (3 marks)
 - ii The shade of yellow produced by lead chromate paints depends on a number of factors. Suggest one of these factors. (1 mark)
 - iii Explain how the results of atomic emission spectroscopy could be used to show the presence of lead in the paint. (3 marks)
- **c** The oil from the paint samples contains ester links, which can be hydrolysed by reaction with potassium hydroxide solution. This produces potassium salts of carboxylic acids and another substance, compound **Y**.
 - i Give the structural formula of compound Y. (2 marks)
 - ii The carboxylic acids are then converted into their methyl esters and identified using gas–liquid chromatography.

Draw a labelled diagram of a gas–liquid chromatograph, and outline how it is used to identify the components of a mixture of liquids. (4 marks)

iii The oils used to make paints are called *drying oils*; they slowly dry and harden in the air. State which structural feature of the oil molecule is responsible for this, and explain, in general terms, how the hardening process occurs. (*3 marks*)

[TOTAL: 19 MARKS]

(Adapted from OCR Chemistry (Salters), Paper 1, question 2, 1992)

2 The azo dye, Orange II (C.I. Acid Orange 7), was one of the first acidic azo dyes to be marketed. It is still used to colour wool.

One way of preparing Orange II from benzene and 2-naphthol is shown below.



- **a i** What general name is given to compounds such as those shown above that contain benzene rings? (1 mark)
 - **ii** Carefully explain the significance of the 'circle' drawn inside the benzene rings in the above formulae. (3 *marks*)
- **b i** In terms of transitions between energy levels in the molecule, explain what happens when a molecule of a coloured substance, such as Orange II, absorbs light. (2 marks)
 - ii Benzene absorbs electromagnetic radiation in the same way. Explain why benzene is colourless, whereas Orange II is coloured. (3 marks)
- **c i** What reagents and conditions are needed to convert benzene to nitrobenzene in step **1**?

(3 marks)

(3 marks)

- **ii** Choose from the following list **two** terms that describe the reaction in step 1. (2 marks)electrophilicnucleophilicradicalsubstitutionadditionelimination
- d Suggest the reagents and conditions needed for step 3. (2 marks)
- e i Give the structural formula of compound **X** which is formed by diazotisation in step **4**.
 - ii Name the type of reaction in which a dye is formed from a diazonium compound (eg compound X reacting with 2-naphthol). (1 mark)
- f State which functional group in Orange II is responsible for its solubility in water, and explain why. (3 marks)
- g Wool is a protein fibre and contains free ionisable –COOH and –NH₂ groups. Under acidic conditions, ionic attractions bind Orange II molecules to the wool fibres.
 Write the formulae of two functional groups, one on wool and one on the dye, that are responsible for this attraction. (2 marks)

[TOTAL: 25 MARKS]

(Adapted from OCR Chemistry (Salters), Paper 1, question 7, 1992)



3 The diagrams below show two dyes attached to cotton fibre by different methods.



- **a** State the type of bond which holds the dye to the cotton for:
 - i dye A; (1 mark)
 - ii dye B. (1 mark)
- **b** Which of dyes (dye **A** or dye **B**) would be less 'fast' (more likely to be washed out) in water? Give a reason for your answer. (3 marks)
- c Dye A and dye B both have the same chromophore.
 - i Explain what the term chromophore means. (1 mark)
 - ii Draw the structure of a chromophore that is common to dye A and dye B. (1 mark)
 - iii What general structural features are common to the chromophores in all azo dyes? (2 marks)
- **d** One way of changing the colour of dye **B** would be to substitute a $-COCH_3$ group for one of the hydrogen atoms on the benzene ring.
 - i Give the name and formula of a reagent, and the name of a catalyst, which would do this.
 - (3 marks)
 - ii Such acylation reactions are named after two scientists. What name is given to such reactions? (1 mark)
 - iii As well as acyl groups, another type of group can be substituted into a benzene ring using this named reaction. Name the *type* of group and give an example of a reagent that might be used. (2 marks)
 - iv Why is the substitution of an acyl group, such as $-COCH_3$, in dye **B** likely to change its colour? (1 mark)

[TOTAL: 16 MARKS]

(Adapted from OCR Chemistry (Salters), Paper 1, question 4, 1994)