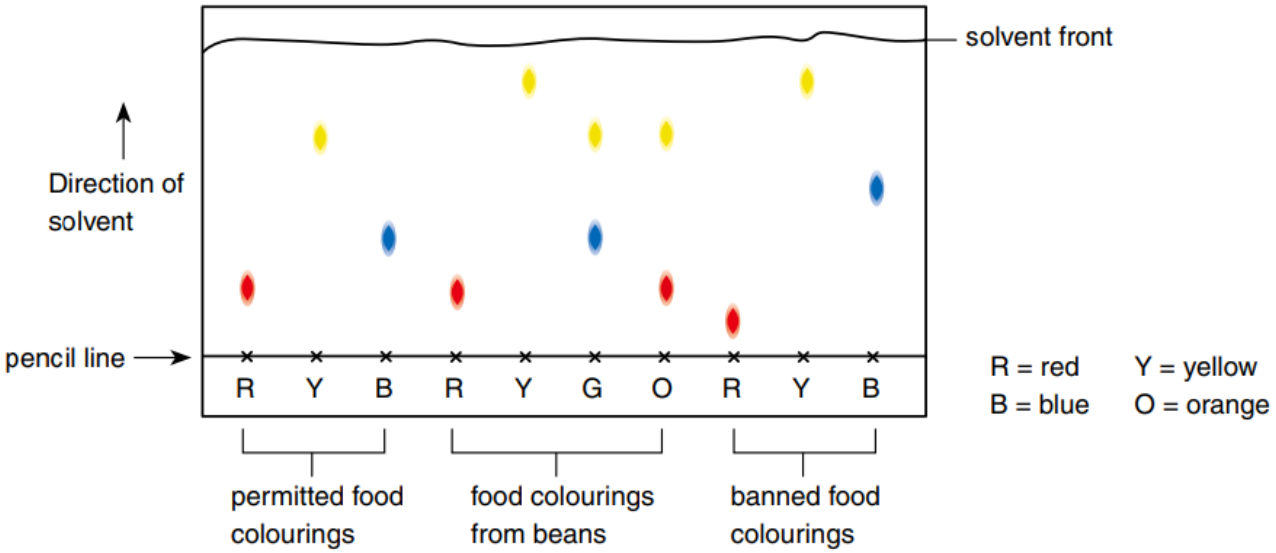
Quiz (Analysis of Food and Drugs)

1. Identifying banned food colourings in chocolate beans using thin-layer chromatography A chemist performed thin-layer chromatography to check whether a brand of chocolate beans contained banned food colourings. A mixture of water and ethanol was used as the developing solvent and the chromatogram obtained is shown below.



   (a) Describe how the colourings can be extracted from the chocolate beans for use in the experiment.

   (b) Which chocolate beans contain only a single food colour?

   (c) Do the green chocolate beans contain permitted or banned food colourings? What are they?

   (d) If you were the chemist, what conclusions could you draw from the chromatography test?

2. Carmoisine is a red food colouring. It is commonly added to soft drinks to make them look more attractive. However, carmoisine has been linked with hyperactivity in children. You were provided with a brand of soft drink. A set of standard carmoisine solutions was used to construct a calibration curve. The absorbance values of different concentrations of carmoisine solutions were recorded as shown below:

Concentration of carmoisine solution (mg dm^{-3})	Absorbance
0.0	0.000
1.0	0.026
5.0	0.131
10.0	0.267
15.0	0.405

(a) Plot a calibration curve for carmoisine solution.

(b) If a test sample from a soft drink has an absorbance of 0.070, what is the concentration of carmoisine in the sample?

(c) In the United Kingdom, the maximum permitted amount of carmoisine in soft drinks is 50 mg dm^{-3}. Does the amount of carmoisine in the soft drink exceed the safety limit?

3. Sulphur dioxide exists in white wine as sulphite ion with some free sulphur dioxide. The limit of its amount stated in the Hong Kong Preservatives in Food Regulations is 450 mg dm^{-3}. The amount of sulphur dioxide in a sample of white wine can be determined by the following procedure:

The free sulphur dioxide in wine is first converted to sulphite ion by alkali.

$$SO_2(aq) + 2OH^-(aq) \longrightarrow SO_3^{2-}(aq) + H_2O(l)$$

All of the sulphur dioxide is then liberated by adding excess acid.

$$SO_3^{2-}(aq) + 2H^+(aq) \longrightarrow SO_2(aq) + H_2O(l)$$

The mixture is then titrated with iodine solution, using starch solution as indicator.

$$SO_2(aq) + I_2(aq) + 2H_2O(l) \longrightarrow 2HI(aq) + H_2SO_4(aq)$$

25.0 cm^3 of a wine sample was titrated with 0.00170 M iodine solution. The titration results are recorded in the table.

Titration / **Volume (in cm^3)**	**1 (Trial)**	**2**	**3**	**4**
Final burette reading	46.80	35.55	25.05	14.75
Initial burette reading	35.55	25.05	14.75	4.30
Volume of iodine solution used	11.25	10.50	10.30	10.45

(a) State the colour change at the end point of the above titration.

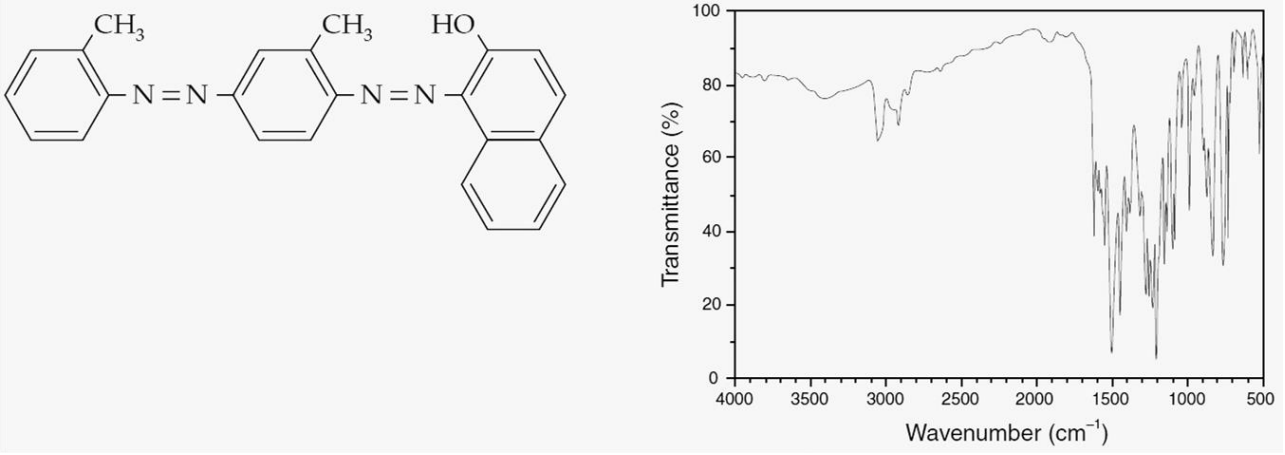
(b) Calculate a reasonable average for the volume of 0.00170 M iodine solution required to completely react with sulphur dioxide in 25.0 cm^3 of the wine sample.

(c) Calculate the concentration of sulphur dioxide in the wine.

(d) Does the amount of sulphur dioxide in the wine sample exceed the limit stated in the regulations?

(Relative atomic masses: O = 16.0; S = 32.1)

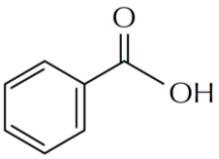
4. (a) The structure of Sudan IV and its infrared spectrum are shown below:



Interpret the absorption peaks at around 3000 cm^{-1} and 3400 cm^{-1} respectively.

(b) State ONE analytical method that can be applied to identify Sudan IV and ONE analytical method to determine its amount in a rice dumpling sample.

5. Benzoic acid is used as preservative in beverages. The structure of benzoic acid is shown below:



The amount of benzoic acid in a beverage sample can be determined by using the following procedure:

Step 1: Add 10.0 cm^3 of NaOH solution to 25.0 cm^3 of the sample and saturate it with NaCl solution.
Step 2: Acidify the sample with dilute HCl and then extract benzoic acid with trichloromethane.
Step 3: Evaporate trichloromethane from the organic layer and dissolve the residue in ethanol.
Step 4: Titrate the resultant solution with standard NaOH solution.

The titration results are tabulated below.

Titration / **Volume (cm^3)**	**1**	**2**	**3**	**4**
Final burette reading	48.00	31.50	46.60	30.30
Initial burette reading	31.50	15.30	30.30	13.95
Volume of NaOH used	16.50	16.20	16.30	16.35

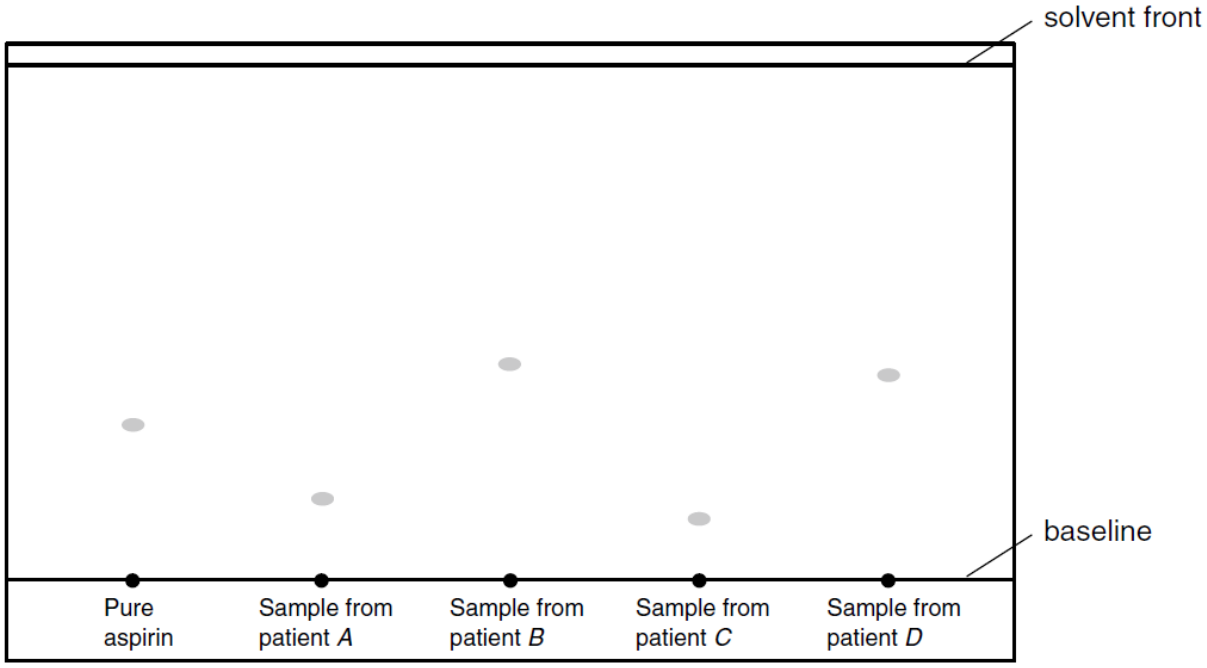
(a) Trichloromethane is used to extract benzoic acid for analysis.
(i) Write the structural formula of trichloromethane.
(ii) Suggest TWO reasons why trichloromethane is suitable for use in extracting benzoic acid.

(b) Calculate a reasonable average for the volume of 0.01 M NaOH required to neutralize the benzoic acid in the beverage sample.

(c) Calculate the concentration (in mg dm^{-3}) of benzoic acid in the beverage sample.

(Relative atomic masses: H = 1.0, C = 12.0, O = 16.0)

6. Imagine you are an analytical chemist working in the Government Laboratory. Recently, you have received several reports of drug poisoning from different districts. People were poisoned after taking a brand of aspirin. Different samples of the drugs were collected from these patients and sent to the laboratory for analysis. The following diagram shows the results of the preliminary test.



(a) Name the preliminary test used.

(b) Explain whether the samples collected from different patients contain the same kind of substance.

(c) Do you think the samples collected from the patients are fake drugs? Explain your answer.

(d) The samples were then further analysed by modern analytical instruments. The conclusion was in agreement with that in the preliminary test. What advice would you give to the public?

Suggested Answer

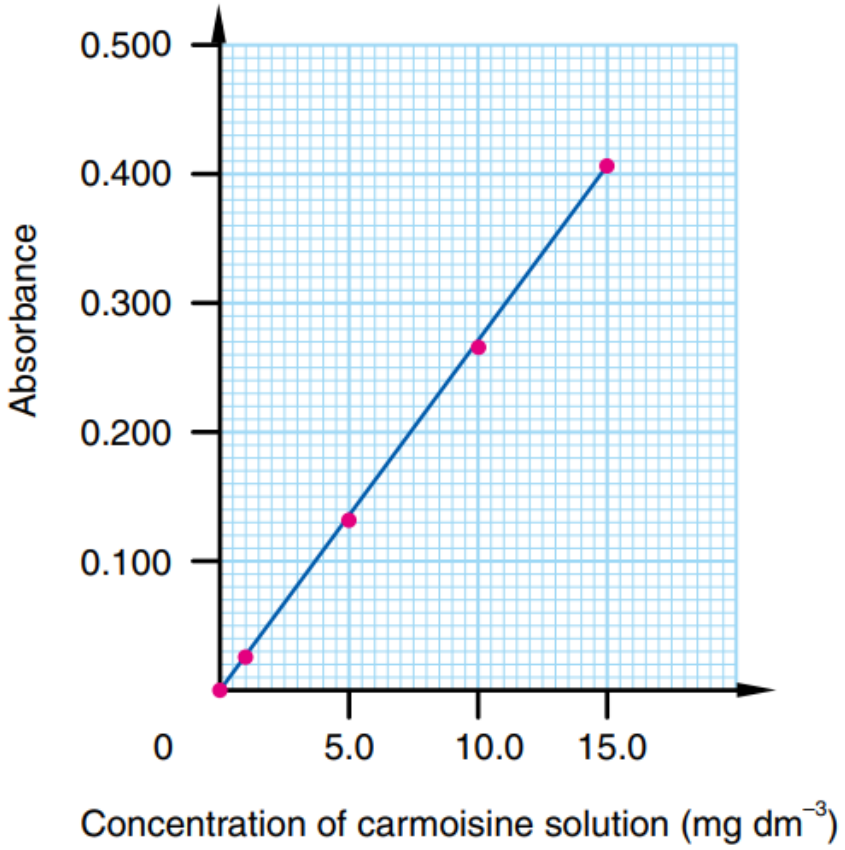
1. (a) By adding a small amount of water to the chocolate beans, the colourings can be extracted.

   (b) Red and yellow chocolate beans.

   (c) The green chocolate beans contain permitted blue colouring and permitted yellow colouring.

   (d) Only the yellow chocolate beans contain banned food colouring.

2. (a)



   (b) From the calibration curve, the concentration of carmoisine is 2.7 mg dm^{-3}.

   (c) As the concentration of carmoisine in the soft drink is far below 50 mg dm^{-3}, it is within the safety limit.

3. (a) The solution changes from colourless to dark blue.

   (b) The data from the first trial should not be taken into calculations.
   Average volume of I_2 solution used
   = (10.50 + 10.30 + 10.45) / 3
   = 10.42 cm^3

(c) $I_2(aq) + SO_2(aq) + 2H_2O(l) \longrightarrow 2HI(aq) + H_2SO_4(aq)$

Number of moles of I_2 in 10.42 cm^3 of 0.00170 M iodine solution
= 0.00170 × 0.01042
= 1.77×10^{-5}

From the equation, mole ratio of $I_2 : SO_2 = 1 : 1$.

∴ Number of moles of SO_2 in 25.0 cm^3 of wine
= 1.77×10^{-5}

Concentration of SO_2 in the wine sample
= $1.77 \times 10^{-5} \times 1000 / 25.0$
= 7.08×10^{-4} M

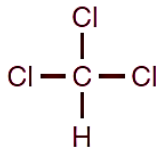
(d) The amount of SO_2 in the wine sample in mg dm^{-3}
= $7.08 \times 10^{-4} \times 64.1$
= 0.0454 g dm^{-3}
= 45.4 mg dm^{-3}

∴ The amount of sulphur dioxide in the wine sample does not exceed the limit (450 mg dm^{-3}).

4. (a) The absorption peak at around 3000 cm^{-1} is due to the C—H bond and that at around 3400 cm^{-1} is due to the O—H bond of Sudan IV.

(b) Thin-layer chromatography can be applied to identify Sudan IV and colorimetry can be applied to determine its amount in a rice dumpling sample.

5. (a) (i)



(ii) Trichloromethane has a low boiling point. It can be easily removed by evaporation

(b) Reasonable average for the volume of NaOH(aq) required
= (16.20 + 16.30 + 16.35) / 2
= 16.28 cm^3

(c) $NaOH + C_6H_5COOH \longrightarrow C_6H_5COO^-Na^+ + H_2O$

Number of moles of NaOH required
= 0.01 x 0.01628
= 1.63×10^{-4}

∴ Number of moles of C_6H_5COOH in the beverage sample = 1.63×10^{-4}

Molar mass of benzoic acid
= 122.0 g mol^{-1}

Concentration of benzoic acid in the beverage sample
= 1.63 x 10^{-4} x 122.0 / 0.025
= 0.795 g dm^{-3}
= 795 mg dm^{-3}

6. (a) Thin-layer chromatography

(b) They do not. This is because the Rf values obtained from each sample are different.

(c) Yes, this is because all samples from patients do not give a R_f value very close to that of the pure aspirin.

(d) Advise the public to consult doctors or pharmacists before taking any aspirin.

7. (a) Hydroxyl group, carbon-carbon double bond and carbonyl group.

(b) R_f value of compound A
= 1.6 / 3.8
= 0.42

(c) Yes, this is because a spot corresponding to compound A is found in the chromatogram of the suspected fake drug.