The chemistry of food

Contents

Acknowledgements

This resource was originally developed by Liverpool John Moores University to support outreach work delivered as part of the Chemistry for All project.

To find out more about the project, and get more resources to help widen participation, visit our Outreach resources hub: rsc.li/3CJX7M3.

Learning objectives

By the end of this session, you will be able to:

- Carry out at least two analytical procedures successfully to obtain reliable results.
- Use a minimum of one set of results to calculate an unknown quantity.
- Summarise at least two careers linked to food that use chemistry.

Career link

Food technology

Food technologists research and develop new foods and drinks. Sometimes they improve the quality of existing products. They may also develop the processing, packaging, storage and safety of food in line with government and industry standards.

Flavourist and innovation director

Watch the video on **slide 3** of the PowerPoint (also available from rsc.li/40V9mkh) of flavourist and innovation director, Claire. She uses her chemistry knowledge to develop flavours and technologies to make new food and beverage products.

Activity 1: identifying food colourings in soft drinks

To do

1. Follow the method sheet to find the R_f values of the food colouring using thin layer chromatography (TLC). Complete the table with your results.

To calculate the R_f value for each food colouring you need to divide the distance travelled by the sample (spot) by the distance travelled by the solvent.

Food colouring	E number	Distance travelled by sample (*D*)	Distance travelled by solvent (*S*)	R_f value ($D \div S$)
Tartrazine	E102			
Brilliant blue	E133			
Carmoisine	E122			
Sunset yellow	E110			
Patent blue V	E131			
Green S	E142			
Erythrosine	E127			

Now you know the R_f values of the commonly used food colourings, you can test a range of soft drinks to see if these colourings are being used.

2. Run a second TLC plate with extracts from the three soft drinks. Complete the results table to show which E numbers are present in each drink.

Soft drink name	Colours of spots present	Distance travelled by spot (*D*)	Distance travelled by solvent (*S*)	R_f value ($D \div S$)	E number(s) present

3. Write an email to the manufacturer of one of the soft drinks. Describe and explain the tests you carried out as a food analyst and what you found out about the food colourings present in their drink.

EMAIL

TO: ____

FROM: ____

SUBJECT: Artificial food colourings in a variety of drinks

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Career link

Research and development

Learn about research and development careers by meeting Giorgia. Her job profile on **slide 8**, also available from rsc.li/3yaWIRc, explains how she uses her chemistry skills and knowledge to improve food safety and reduce food waste.

Activity 2: finding the vitamin C content of fruit juice

A juice manufacturer claims that their juice contains at least 25 mg (0.25 g) of vitamin C in every 100 cm^3 juice. You are going to test this claim.

To do: titration

1. Follow the method sheet to find the vitamin C content of the juice. Record your results in the table.

   Type of juice tested ________________________________

   Volume of juice in conical flask (cm^3) ________________________________

   Concentration of iodine solution ________________________________ $mol\ dm^{-3}$

Volume readings from burette	Trial run	Titre 1	Titre 2	Titre 3	Titre 4	Titre 5	Titre 6
Start volume (cm^3)							
Final volume (cm^3)							
Total volume used (final – start) (cm^3)							

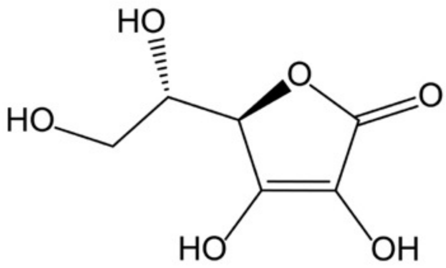
4. Select three titres within $\pm 0.1\ cm^3$ of each other and calculate the average titre value.

Titre (cm^3)	Titre (cm^3)	Titre (cm^3)

Average titre value (cm^3)	Average titre value (dm^3)

To answer: calculating the molecular mass of vitamin C

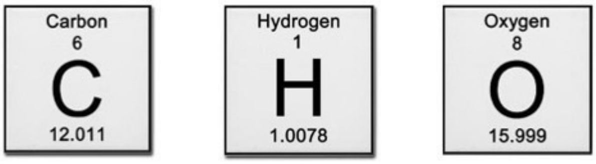
5. To find the relative formula mass (M_r) of a substance, you add together the relative atomic mass (A_r) for all the atoms shown in its chemical formula.



Vitamin C

The molecular formula of vitamin C is $C_6H_8O_6$

(a) Use the table to calculate the molecular mass of vitamin C.



(Note: all symbols are © Shutterstock)

Use these images from the periodic table to find the relative atomic masses (A_r) for each element and total mass of each element in vitamin C. Calculate the relative formula mass (M_r) of vitamin C by adding the total masses of each element together.

Name of atom	Number of atoms present	Relative atomic mass (A_r)	Total mass (number of atoms × A_r)
Carbon			
Hydrogen			
Oxygen			
Relative formula mass (M_r) of vitamin C			

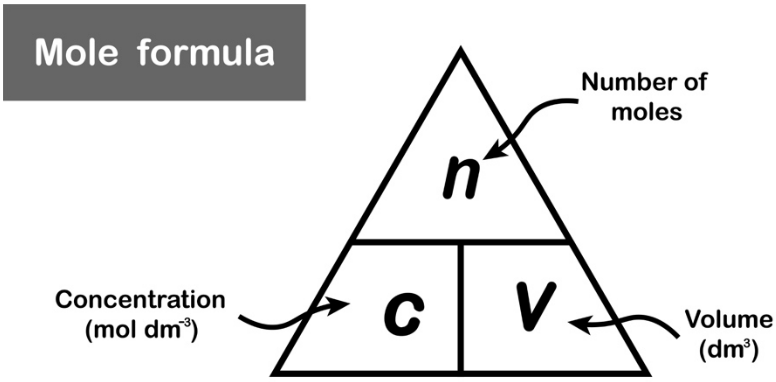
(b) Complete these values:

M_r of vitamin C = ________________________________

Concentration of I_2 = ________________________________ mol dm^{-3}

Volume of I_2= ________________________________ dm^{-3}

(c) Use the equation triangle to calculate the number of moles of iodine used in your titration:



i. First rearrange the equation:

number of moles of iodine (n) = ________________ × ________________

ii. Now insert the values from your titration into the equation:

number of moles of iodine (n) = ________________ × ________________

iii. Use the equation to find the reacting ratio of iodine to vitamin C molecules:

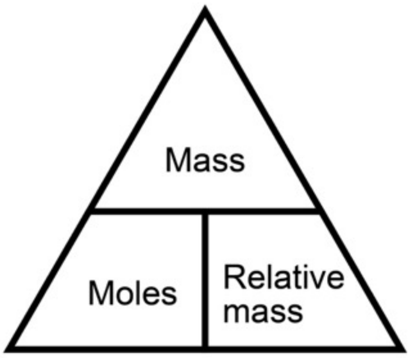
$$C_6H_8O_6(aq) + I_2(aq) \rightarrow C_6H_6O_6(aq) + 2H^+(aq) + 2I^-(aq)$$

Ratio = ________________ : ________________

iv. Use the ratio to calculate the number of moles of vitamin C present in the 100 cm^3 sample of juice used in your titration:

________________ moles

(d) Use the equation triangle to calculate the mass of vitamin C in 100 cm^3:



i. First rearrange the equation:

mass of vitamin C = ________________ × ________________

ii. Now insert the known values into the equation:

mass of vitamin C = ________________ × ________________

= ________________ mg vitamin C in 100 cm^3

6. Is the concentration of vitamin C in the juice in line with the manufacturer's claim that it contains 'at least 25 mg (0.25 g) of vitamin C in every 100 cm^3 juice'?

Write the manufacturer an email to describe what you did and explain what you found in your investigation.

EMAIL

TO: ____

FROM: ____

SUBJECT: Finding the vitamin C content of fruit juice

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Career link

Associate principal scientist

Watch the video job profile of associate principal scientist, Robert, on **slide 13** of the PowerPoint or at rsc.li/3YmUIFS. He builds computer models to predict the effect of different chemicals on the taste and texture of sweet foods.

Activity 3: finding the iron content of food

You will find out how much iron is present in a range of foods by completing an analysis by visible absorption spectroscopy.

To do

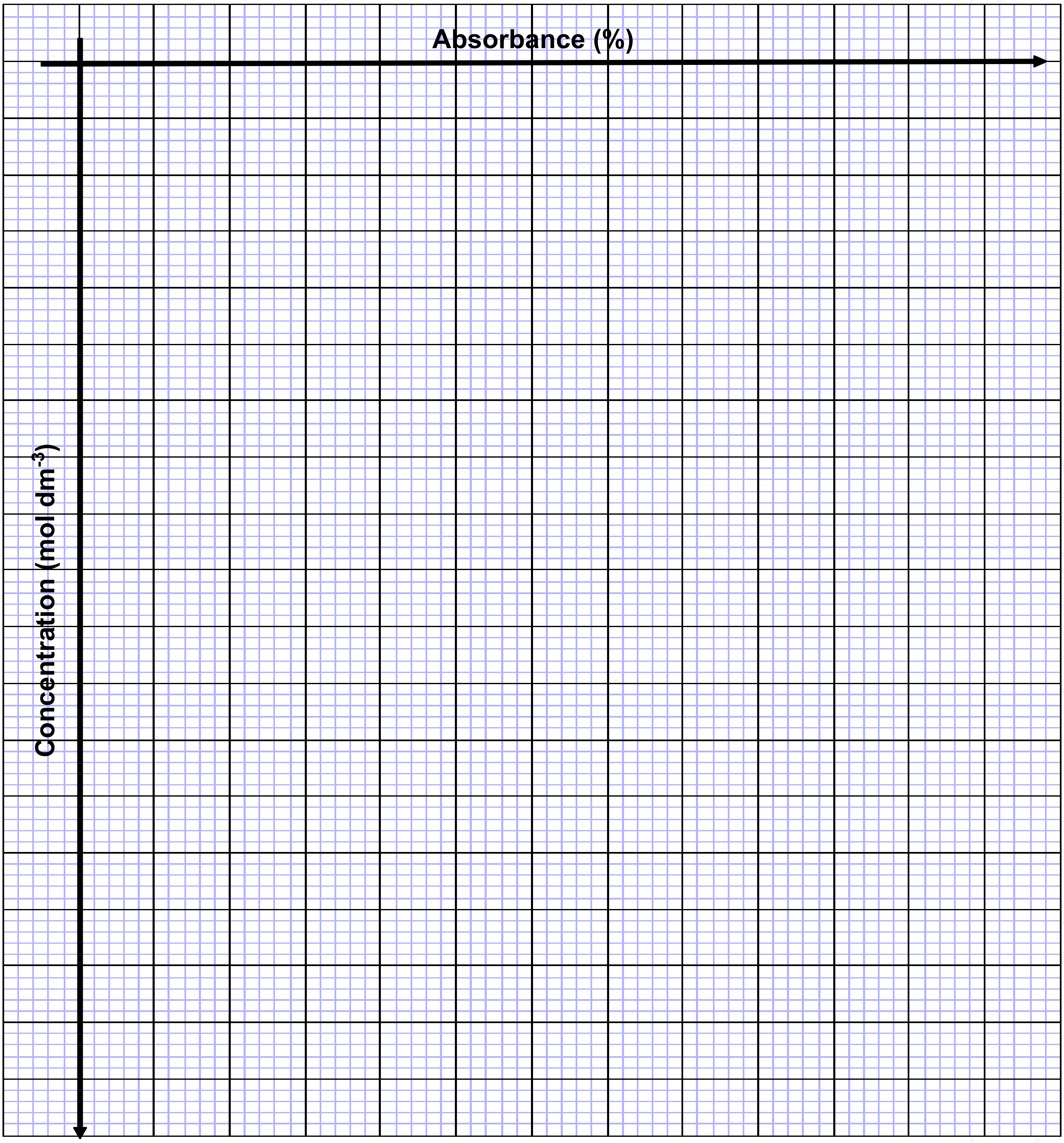
1. Follow the method sheet to measure the absorption of light (absorbance) in standard iron(III) chloride ($FeCl_3$) solutions.

Record your results in the table.

Dial position	Concentration of standard solution of $FeCl_3 \times 10^{-4}$ (mol dm^{-3})	Absorbance (%)
B	0	
1	0.5	
2	1.0	
3	1.5	
4	2.0	
5	2.5	

2. Use your results to produce a calibration curve.

Calibration curve for standard $FeCl_3$ solutions



3. Use the table to work out how much iron was in the food samples provided.

Food sample	Absorbance	Concentration of iron (× 10^{-4} mol dm^{-3})	Conversion factor to use to find concentration of iron in mg per 100 g of food	Concentration of iron (mg per 100 g of food)
Broccoli				
Spinach			× 200 × 55.85	
Peas				

To answer

(a) What do you think should be in the 'blank' cuvette, which is recorded as 0 mol dm^{-3} $FeCl_3$ solution?

(e) The recommended average daily iron intake in children and teens aged 12–19 is 13.7–15.1 mg per day. Do you think you are reaching this level? Give a reason for your answer.

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(f) The table below shows the food eaten by a 14 year-old girl during a typical day.

	Food	Iron content (mg)
Breakfast	30 g Coco pops	2.4
Lunch	Two slices of white bread with butter and jam One banana	1.8 0.31
Dinner	100 g chicken 100 g French fries 50 g green peas	1.3 0.8 0.75
Snacks	Chocolate bar 100 g potato crisps	0.0 1.6

The recommended daily intake of iron for a 14 year-old girl is 15 mg.

i. Calculate the current daily intake of iron for the 14 year-old girl. Is she eating the recommended daily amount?

ii. Use your experimental results, along with the table showing the iron content in foods, to design a diet plan for the girl to help her increase her daily intake of iron and reduce the risk of anaemia.

Think about the types of food she could add or swap for breakfast, lunch and dinner and the amount of iron these foods would provide.

Food	Serving / mass (g)	Iron content (mg)
Breakfast		
Lunch		
Dinner		
Snacks		

Iron content in food

Foods	Serving / mass (g)	Iron content (mg)
Cornflakes	1 cup / 30 g	3.6
Boiled egg	1 / 50 g	0.6
Wholemeal bread	1 slice / 30 g	1.0
White bread	1 slice / 30 g	0.9
Wholemeal pasta	1 cup / 91 g	3.3
Sweet potato	1 potato / 130 g	0.8
Brown rice	1 bowl / 200 g	1.0
White rice	1 cup / 100 g	1.6
Chicken	230 g	1.3
Lean beef	One palm-sized piece / 90 g	2.8
Lentils	1 cup / 180 g	6.6
Nuts	½ cup / 65 g	5.0
Raisins	½ cup / 70 g	1.35
Spinach	1 cup / 30 g	1.5
Dried fig	10 pieces / 85 g	3.6
Pumpkin seeds	28 g	2.5
Dried longan (Chinese fruit)	½ cup / 65 g	3.5

Career link

Market development

Learn about Vikki's role as a market development manager on **slide 20** or at rsc.li/3moUx9I. She uses her chemistry skills and knowledge to develop food packaging materials that make food last longer, are more sustainable and help to reduce waste.

Challenge questions

1. Titration question

A student carried out a titration to find the concentration of a solution of hydrochloric acid. A volume of 25.0 cm^3 of hydrochloric acid solution was neutralised exactly by 34.0 cm^3 of a potassium hydroxide solution with a concentration of 2.0 $mol\ dm^{-3}$.

The equation for the reaction is:

$$KOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$$

(a) Describe the experimental procedure for the titration carried out by the student.

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(4 marks)

(b) Calculate the number of moles of potassium hydroxide used.

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Number of moles = ______________________________

(2 marks)

(c) Calculate the concentration of the hydrochloric acid in $mol\ dm^{-3}$.

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Concentration = ______________________________ $mol\ dm^{-3}$

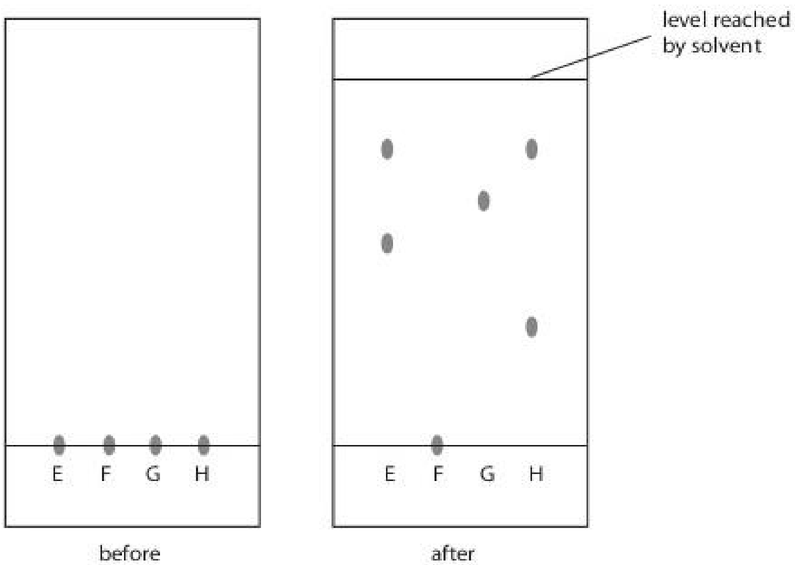
(3 marks)

(Total = 9 marks)

2. Chromatography question

Food colourings contain one or more food dyes. A student used paper chromatography to separate the dyes contained in food colourings. They placed three spots of three known food colourings (E, F and G) and one unknown food colouring (H) on the chromatography paper.

The diagram shows the appearance of the paper before and after the experiment.



(a) Describe how the student should complete the experiment after placing four spots on the plate.

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(3 marks)

(b) Suggest why food colouring **F** did not move during the experiment.

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(1 mark)

(c) How many food dyes are there in food colouring **E**?

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(1 mark)

(d) How many known food dyes are there in food colouring **H**?

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(1 mark)

Dyes are often identified by their R_f values:

R_f value = distance moved by dye ÷ distance moved by solvent

(e) Record the results for dye G and calculate its R_f value.

Distance moved by dye (mm)	
Distance moved by solvent (mm)	
R_f value of dye **G**	

(3 marks)

(Total = 9 marks)