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.

Guidance notes

The activity should take approximately five hours to complete in full, but you could extend this if you include molecular modelling.

The resource was initially created for 14–16 year-old learners but can be adapted for other age groups.

Download the PowerPoint presentation, technician notes, method sheets and student workbook that accompany this resource at rsc.li/3RGH1cT.

Carry out the food analysis practicals as a circus of three stations with small groups or pairs of learners circulating after approximately one hour at each station.

Use the PowerPoint to introduce and provide the background science to each of the three practical activities.

Read our health & safety guidance, available from rsc.li/3IAmFA0, and carry out a risk assessment before running any live practicals.

The safety equipment suggested is in line with CLEAPSS requirements. For non-hazardous substances, wearing lab coats can help to protect clothes. The safety rules might be different where you live so it is worth checking local and school guidance.

Remind learners they should never eat or drink in a science laboratory.

Learning objectives

- 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 links

Use the videos embedded in the PowerPoint to introduce learners to four scientists who use their chemistry skills, knowledge and qualifications in their careers.

Flavourist and innovation director

Slide 3 introduces Claire, a flavourist and innovation director, who uses her chemistry knowledge to develop flavours and technologies to make new food and beverage products. The video is also available from rsc.li/40V9mkh.

Research and development team leader

Use **slide 8** to highlight Giorgia's career as a research and development team leader. She uses her chemistry skills and knowledge to improve food safety and reduce food waste. The video is also available from rsc.li/3yaWIRc.

Associate principal scientist

Meet Robert, an associate principal scientist, on **slide 13.** He builds computer models to predict the effect of different chemicals on the taste and texture of sweet foods. The video is also available from rsc.li/3YmUIFS.

Market development manager

Slide 21 introduces Vikki, a market development manager, who uses her chemistry skills and knowledge to develop food packaging materials that make food last longer, are more sustainable and help to reduce waste. The video is also available from rsc.li/3moUx9I.

Activity 1: identifying food colourings in soft drinks

Learners find the R_f values of a range of food colourings through thin-layer chromatography (TLC). They then analyse concentrated extracts from soft drinks to find which food colourings are present by comparing the R_f values.

Slide 6 provides some background to TLC. **Slide 7** introduces the task.

Once learners have completed the practical work, they summarise their findings in a memo to a drinks manufacturer. This consolidates their learning and focuses on the career of a food analyst.

Answers (also on **slide 14**)

Learners should find that:

- Relentless® apple and kiwi extract contains E142, E110 and E133
- Powerade® extract contains E133 and E131
- Irn Bru® extract contains E110 and E127.

The answers to the questions in the student workbook will vary depending on the learners' results from the practical activity.

Activity 2: finding the vitamin C content of fruit juice

Learners use the reaction between iodine and vitamin C to find the vitamin C content of fruit juice. They carry out a titration, then use their results in structured calculations to determine the vitamin C concentration in the juice.

In their role of food analyst, they write to the juice manufacturer to explain their results with reference to claims on the juice's nutritional labelling.

Slide 10 provides some background about vitamin C. **Slides 11** and **12** show the equation for the reaction between vitamin C and iodine and provide background for the practical method.

Answers (also on **slide 14**)

The answers to questions 1 and 2 depend on the learners' titration results.

3. (a)

Name of atom	Number of atoms present	Relative atomic mass (A_r)	Total mass (number of atoms × A_r)
Carbon	6	12	72
Hydrogen	8	1	8
Oxygen	6	16	96
Relative formula mass (M_r) of vitamin C			176

The answers to (b) and (c) are dependent on the learners' titration results.

Activity 3: finding the iron content of food

Visible absorption spectroscopy is used to find the iron content of some food samples. Learners produce a calibration curve using standard iron solutions, then use this to find the iron content of the unknown samples.

Note: if you do not have the kit available you could skip this activity or use an alternative, such as Project 2 at rsc.li/3XrjIX8. This allows learners to use an alternative to a spectrophotometer and you could adapt it for testing iron solutions instead of different blackcurrant concentrations.

Note: if you do not have access to automatic pipettes, use normal pipettes instead.

The method uses $FeCl_3$ solutions prepared to model the known Fe concentrations in broccoli, spinach and peas: 'broccoli' (0.9×10^{-3} mol dm^{-3} $FeCl_3$); 'spinach' (3.6×10^{-3} mol dm^{-3} $FeCl_3$); and 'peas' (1.8×10^{-3} mol dm^{-3} $FeCl_3$). These solutions are already made up with the KSCN added in the correct concentration.

Answers

From absorbance measurements and the calibration curve, learners determine a value for the concentration of Fe in the solution in g dm^{-3}.

Value ***C*** = concentration of Fe in solution (g dm^{-3})

C × 55.85 = mass of Fe (g) in 1 dm^3 of solution

C × 55.85 × 1000 = mass of Fe (mg) in 1 dm^3 of solution

If solution prepared by the extraction procedure used 500 g of food to produce 1 dm^{-3} of solution:

C × 55.85 × 1000 = mass of Fe (mg) in 500 g of food

Then:

C × 55.85 × $\frac{1000}{5}$ = mass of Fe (mg) in 100 g of food

C × 55.85 × 200 = mass of Fe (mg) in 100 g of food

(Instructions in the student workbook give this conversion factor of 200 to calculate the mass of Fe (mg) in 100 g of food – but learners do not necessarily need to be involved in the detail of this calculation.)

The instructions in the student workbook and method sheet are for a spectroscope with six cuvette slots. Edit the instructions for different types of spectroscopes.

Ask learners how nutritionists might suggest changes to their diet to increase their daily intake of iron.

Slides 16–17 provide some background to iron in the diet.

Slide 18 introduces visible absorption spectroscopy.

Slide 19 shows the reaction between iron(III) ions in solution and thiocyanate ions.

Slide 20 explains what an automatic pipette is.

Answers (also on **slide 22**)

(a) The blank cuvette should contain everything that is in the solutions being measured apart from the $FeCl_3$ solution (that is, $KSCN$ at the same dilution with distilled water).

(b) Learners should answer using a rough calculation based on their typical diet.

(c)

i. The girl is only eating 8.96 mg in her daily diet so she is not taking in the recommended daily amount.

ii. Answers may vary but the girl should be taking in a good combinations of different food types including high iron content food such as lentils, nuts, wholemeal pasta and lean beef.

Challenge activities

Use current news items or reports for learners to read about teenage diets (eg too much sugar or caffeine; not enough iron/vitamins and so on). Learners could write their own summary articles and make suggestions for policymakers.

There are two questions, one on titration and one on chromatography, in the student workbook that learners could complete as an extension activity.

Answers

1. Titration question

(a) Any four points (for 1 mark each) from:

- acid measured by pipette or diagram
- potassium hydroxide in burette or diagram
- if solutions reversed, award
- note initial reading
- use of indicator
- note final reading or amount used.

(4 marks)

(b)

$\frac{34}{1000} \times 2.0$ 1

= 0.068 mol dm^{-3} 1

(2 marks)

(c)

1 mole HCl reacts with 1 mole KOH 1

Moles HCl in 25.0 cm^3 = 0.068 1

Moles HCl in 1 $\text{dm}^3 = \frac{0.068 \times 1000}{25}$ = 2.72 mol dm^{-3} 1

(3 marks)

(Total = 9 marks)

2. Chromatography question

(a) Place the paper in the beaker **1**

Add solvent to below the level of the spots **1**

Leave until the solvent reaches the top of the paper

OR

Leave until the dyes have separated out **1**

(3 marks)

(b) It could be insoluble in the solvent used.

(1 mark)

(c) 2

(1 mark)

(d) 2

(1 mark)

(e) Allow for a range of error (eg 1 mm either side of the values) – check the measurements once printed out and amend the answers if necessary.

Distance moved by dye (mm)	44.5
Distance moved by solvent (mm)	69.0
R_f value of dye **G**	0.63

(3 marks)

(Total = 9 marks)