

Energy content of food

investigate the energy content in a food sample

For Pearson Edexcel International GCSE Biology 4BI1 and Science (Double Award) 4SD0. **Biology only** This practical is not in the Double Award and is only examined on Paper 2. Teacher answers start on a new page.

Name

Date

Aim

To compare the energy released when different foods are burned, by measuring the temperature rise of a fixed mass of water.

Background

Food stores **chemical energy**. Burning (combustion) releases this stored energy as heat. If the heat is used to warm a known mass of water, the energy transferred can be calculated from the temperature rise.

Water needs 4.2 J of energy to raise the temperature of 1 g by 1 °C. 1 cm³ of water has a mass of 1 g, so 20 cm³ of water has a mass of 20 g.

Foods rich in lipid, such as nuts, usually release more energy per gram than foods rich in carbohydrate, such as bread. The result from this method is always lower than the real energy in the food, because **heat is lost to the surroundings** and the food may not burn completely.

Hypothesis

A food rich in lipid (a peanut) will release more energy per gram than a food rich in carbohydrate (bread), because lipid stores more chemical energy per gram.

Variables

Independent	The type of food
Dependent	The temperature rise of the water (°C), used to calculate the energy released per gram of food (J/g)
Control	• Volume (and so mass) of water, 20 cm³ • Mass of food burned • Starting temperature of the water • Distance between the burning food and the bottom of the boiling tube • Same apparatus, with a draught shield in the same position

Equipment

- Boiling tube
- Clamp, stand and boss
- Measuring cylinder, 25 cm³
- Thermometer, -10 to 110 °C
- Mounted needle (in a cork or handle)
- Top-pan balance reading to 0.01 g
- Bunsen burner and heatproof mat
- Tongs or forceps
- Draught shield (a metal screen, not card or paper)
- Food samples of similar size, such as a piece of peanut, a piece of crisp and a piece of bread

- Eye protection
- Beaker of cold water, for putting out burning food

Risk assessment

Hazard	Risk	Precaution
Nuts (allergen)	A student with a nut allergy could have a severe allergic reaction by touching or breathing in fumes from burning nuts.	Check for allergies before the lesson. Use a nut-free food such as a crisp or a cracker in place of nuts if anyone is allergic, and do not eat any food used in the practical.
Bunsen burner flame and burning food	Burns, and burning food that falls off the needle or sets other things alight.	Tie back long hair, keep the area clear of paper, work on a heatproof mat and keep a beaker of water nearby. Do not move the burning food over your hands. Put out any burning food in water.
Hot water, hot boiling tube and hot needle	Scalds or burns.	Allow the equipment to cool before touching it. Use tongs for the needle and do not let the water boil.
Glass thermometer and boiling tube	Cuts if the glass breaks.	Clamp the tube firmly low on the stand. Do not use the thermometer to stir hard; report any breakages and do not pick up broken glass.
Spitting or flaring food	Hot fragments or oil from burning food could enter the eyes.	Wear eye protection throughout.

Method

1. Put on eye protection. Use a measuring cylinder to measure 20 cm³ of cold water into a boiling tube. Clamp the tube at an angle (or upright) on the stand.
2. Place the draught shield around the stand, leaving room to hold the food under the tube.
3. Record the starting temperature of the water to the nearest 0.5 °C.
4. Weigh a small piece of the first food on the balance and record its mass.
5. Push the food on to the end of the mounted needle.
6. Light the Bunsen burner and, holding the needle with the food in the flame, light the food. Move the burner away.
7. As soon as the food is burning, hold it about 2 cm below the bottom of the boiling tube. Keep the distance the same each time.
8. Gently stir the water with the thermometer while the food burns.
9. When the food stops burning, keep stirring and record the highest temperature the water reaches.
10. Put out the needle in the beaker of cold water if it is still burning.
11. Calculate the temperature change (final temperature – starting temperature).
12. Empty the boiling tube, rinse it, and refill it with 20 cm³ of cold water. Repeat steps 3-11 for each other food, using the same mass of food each time if possible.
13. Calculate the energy released using: energy (J) = mass of water (g) × 4.2 × temperature change (°C).

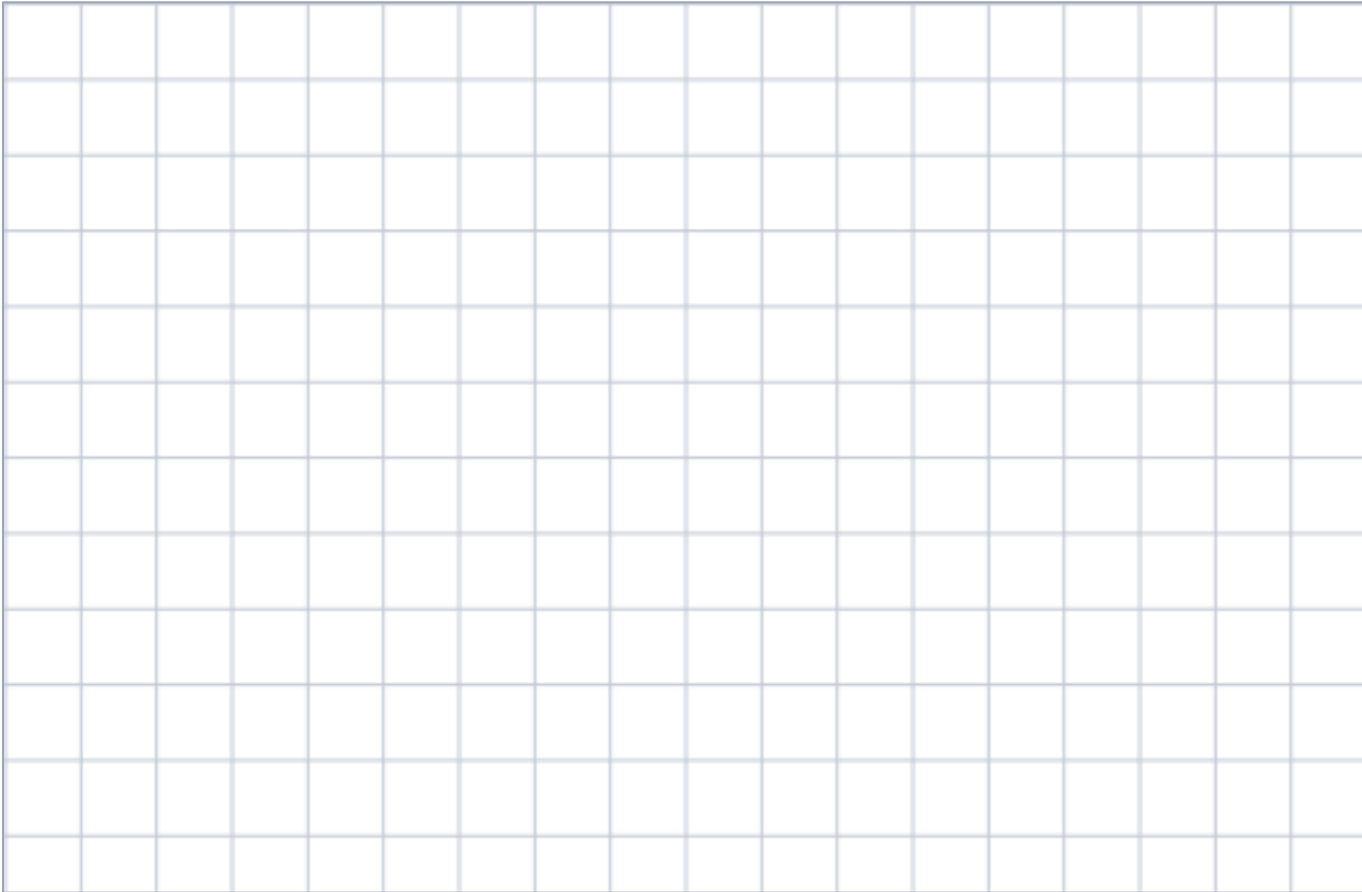
L4 . Calculate the energy per gram of food using: energy per gram (J/g) = energy released (J) ÷ mass of food (g).

Results

Results table						
Food	Mass of food (g)	Starting temperature of water (°C)	Final temperature of water (°C)	Temperature change (°C)	Energy released (J)	Energy per gram of food (J/g)
Peanut						
Crisp						
Bread						

Graph

Bar chart of the type of food (x-axis) against the energy released per gram of food in J/g (y-axis). Leave gaps between the bars because the food types are categories. No line of best fit.



Exam questions 10 questions · 29 marks

1 A student investigates the energy content of three foods. State the independent variable [2 marks] and the dependent variable in this investigation.

2 Give two variables the student should control so that the investigation is a fair test. **[2 marks]**

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3 In one test, burning a piece of food raised the temperature of 20 g of water from 20 °C to 38 °C. Calculate the energy released. Use: energy (J) = mass of water (g) × 4.2 × temperature change (°C). **[3 marks]**

Answer =

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4 The food in question 3 had a mass of 0.60 g. Calculate the energy released per gram of food. **[2 marks]**

Answer =

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5 The energy per gram found in this investigation is lower than the value printed on the food packet. Explain why. **[3 marks]**

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6 Suggest one change to the apparatus that would make the results more accurate, and explain why it would help. **[2 marks]**

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- 7

Student results	
Food	Energy per gram of food (J/g)
Peanut	4032
Crisp	2940
Bread	840

Answer =

- 8

- 9

10 A student says: 'The food with the largest temperature rise must contain the most energy per gram.' Evaluate this statement. **[4 marks]**

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Teacher answers

Practical 6: Energy content of food. The example results are practice data, not real measurements.

Example results

Example results (practice data), 20 cm ³ (20 g) of water in each test						
Food	Mass of food (g)	Starting temperature of water (°C)	Final temperature of water (°C)	Temperature change (°C)	Energy released (J)	Energy per gram of food (J/g)
Peanut	0.50	20	44	24	2016	4032
Crisp	0.40	20	34	14	1176	2940
Bread	0.80	20	28	8	672	840

Conclusion

The peanut released the most energy per gram (4032 J/g), the crisp released 2940 J/g and the bread released the least (840 J/g). This supports the hypothesis: foods rich in lipid store more chemical energy per gram than foods rich in carbohydrate. The values are lower than the real energy content of these foods because heat is lost to the surrounding air and the tube, and because some food does not burn completely. The results are a fair comparison only because the mass of water, starting temperature and distance from the flame were controlled.

Errors and improvements

Error	Effect on the results	Improvement
Heat is lost to the surroundings (the air, the tube and the stand) instead of warming the water.	The energy released is calculated as too low, so every food is underestimated (a systematic error).	Use a draught shield, hold the food closer to the tube, use a copper calorimeter or insulate the tube, and stir the water.
The food does not burn completely, or goes out before it has all burned.	Less energy is released than the food really contains, so the calculated value is too low.	Relight the food until it will not burn any more, and weigh the unburned food afterwards so that the mass burned is used in the calculation.
The water is not stirred, so the thermometer reads a temperature that is not the mean of the water.	The temperature rise is measured too high or too low, causing random variation in the results.	Stir the water gently throughout and read the highest temperature.
The mass of food and its distance from the tube vary between tests.	Foods are not compared fairly.	Use the same mass of each food and measure the distance with a ruler. Repeat each food and calculate a mean.
Only one reading is taken for each food.	An anomalous result cannot be spotted.	Repeat each food at least three times and calculate a mean energy per gram.

Mark scheme

One mark for each point unless a maximum is given. Words in brackets are not needed for the mark.

1. [2]

- independent variable: the type of food (1)
- dependent variable: the temperature change (rise) of the water (1) allow energy released

2. [2]

- volume / mass of water (1)
- mass of food (1)
- starting temperature of water (1)
- distance of food from the tube (1)
- type / size of tube (1)
- Max 2

3. [3]

- temperature change = 18 °C (1)
- $20 \times 4.2 \times 18$ (1)
- 1512 J (1) allow 1.5 kJ; unit required

4. [2]

- $1512 \div 0.60$ (1)
- 2520 J/g (1) allow ecf from q3

5. [3]

- heat is lost to the surroundings / air / apparatus (1)
- so not all the energy released heats the water (1)
- the food may not burn completely (1)
- so not all the energy stored in the food is released (1)
- Max 3

6. [2]

- use a draught shield / insulate the tube / hold the food closer / use a lid on the tube (1) allow use a (copper) calorimeter
- so that less heat is lost to the surroundings (1)
- ignore: use a bigger flame

7. [3]

- peanut / the food with most lipid released the most energy per gram (1)
- bread released the least (1)
- difference between peanut and bread: $4032 - 840 = 3192$ J/g (1)

8. [2]

- stirring spreads the heat evenly so the thermometer shows the temperature of all the water (1)
- burning nuts / nut particles could cause an allergic reaction (1) allow fumes

9. [6]

Level 3 5-6	A full, ordered method with the measurements, how the energy is calculated, and at least two control variables or a precaution. Steps are in a logical sequence.
Level 2 3-4	A mostly complete method with some measurements and some mention of the calculation or control; may lack ordering or detail.
Level 1 1-2	A few relevant points about burning the food and heating water, with little detail.

Indicative content

- measure a known volume / mass of water into a boiling tube (for example $20\text{ cm}^3 = 20\text{ g}$)
- record the starting temperature of the water
- weigh a piece of each food, hold it on a mounted needle and light it in a Bunsen flame
- hold the burning food under the tube until it stops burning, stirring the water
- record the highest temperature and calculate the temperature change
- energy released = mass of water $\times 4.2 \times$ temperature change; divide by the mass of food to give J/g
- control the volume of water, the mass of food, the starting temperature and the distance from the flame; use a draught shield
- repeat and calculate a mean; wear eye protection and have a beaker of water to put out burning food

10. [4]

- only true if the mass of food and mass of water were the same (1)
- a larger mass of food would release more energy and give a bigger rise (1)
- so the energy should be divided by the mass of food to compare per gram (1)
- heat loss may differ between tests, so results should be repeated (1)

Exam tips

- Learn the calculation in two steps: energy released (J) = mass of water $\times 4.2 \times$ temperature change, then divide by the mass of food for J/g. Show both lines of working and give the unit.
- When asked why the result is lower than the true value, always say heat is lost to the surroundings. Say the food may not burn completely if there is a second mark.
- Use 1 cm^3 of water = 1 g in the calculation. Using the volume as the mass is acceptable only because of this equivalence.
- In safety answers, name the specific hazard (burning food, nut allergy, hot water) and the precaution that matches it.
- In a 'fair test' question, name the variable (for example 'same mass of food'), not just 'keep everything the same'.