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Ages 12–16

Christmas Science Pack

Advent challenges · real science investigations
calculations · puzzles · certificate · answers



This pack belongs to: _____

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How to use this pack

- Do one Advent challenge each day from 1 December.
- Each investigation takes about 20–40 minutes.
- Name the variables, record data, calculate and conclude.
- Builds secondary / middle & high school science skills.

Safety first

- Activities marked **ADULT HELP** need a grown-up.
- Never taste experiments unless the sheet says it is safe.
- Use warm water, never hot water from the kettle.
- Wash hands and tidy up after every experiment.

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1 Science Advent Calendar

❄ 24 daily science challenges

Do one activity each day from **1 to 24 December** and tick **Done** when you finish. Most activities use things you already have at home.

1 Snow maths
A snowflake falls at about 1 m/s. How long does it take to fall from a cloud 1.5 km high? Give your answer in minutes.

Done ☐

2 Gritting roads
Salt water freezes below 0 °C. Explain why trucks spread salt on roads **before** a frosty night.

Done ☐

3 Winter leaves
Evergreen trees can still photosynthesise on mild, sunny winter days. Write the word equation for photosynthesis.

Done ☐

4 Flat fizz
Fizzy drinks contain dissolved carbon dioxide. Why does a warm drink go flat faster than a cold one?

Done ☐

5 Static balloon
Rub a balloon on a sweater and stick it to a wall. Explain what happens using the word **electrons**.

Done ☐

6 UV reindeer
Reindeer can see ultraviolet light. Snow reflects UV but lichen (their food) absorbs it. Why is this useful?

Done ☐

7 Red cabbage
Make red cabbage water. Add vinegar to one cup and baking soda to another. Record the colours: acid or alkali?

ADULT HELP

Done ☐

8 Light energy
A 5 W string of LED lights is on for 6 hours. How much energy does it transfer in kWh?

Done ☐

9 Diffusion
Drop food colouring into cold water and warm water. Which spreads faster? Explain using particles.

Done ☐

10 Frosty morning
Frost forms when water vapour turns straight into ice. What is this change of state called?

Done ☐

11 Orange density
An orange has a mass of 150 g and a volume of 160 cm³. Calculate its density. Will it float in water?

Done ☐

12 Magnet metals
Test decorations with a magnet. Name the three magnetic elements.

Done ☐

13 Baking soda
Sodium hydrogencarbonate breaks down when heated in a cake. Name the gas made and the type of reaction.

Done ☐

14 Cold metal
A metal tray feels colder than a wooden table in the same room. Explain why.

Done ☐

15 Trapped air
Robins fluff up their feathers to trap air. Why is trapped air such a good insulator?

Done ☐

16 Planet spotting
Find the brightest object in the evening sky. Why do planets not twinkle like stars?

Done ☐

17 Lava lamp
Oil, water, food colouring and a fizzy tablet in a bottle. Explain the moving blobs using density.

ADULT HELP

Done ☐

18 Hexagon ice
Snowflakes have six arms because of how water molecules line up in ice. What angle is between two arms?

Done ☐

19 Holly cuticle
Holly leaves have a thick, waxy cuticle. Which process does it reduce, and why is that useful in winter?

Done ☐

20 Balloon rocket
Tape a balloon to a straw on a string and let go. Explain the motion using Newton's third law.

Done ☐

21 Syrup globe
Glitter falls more slowly in syrup than in water. Which property of the syrup causes this?

Done ☐

22 Sugar variables
Does sugar dissolve faster in warm milk? Name the independent, dependent and one control variable.

ADULT HELP

Done ☐

23 Santa's speed
If Santa travels 510 million km in 32 hours, what is his average speed in km/s?

Done ☐

24 Your question
Write a question you could investigate in January. Name its independent and dependent variables.

Done ☐

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2 Investigation 1: Fizzy Tablet Race

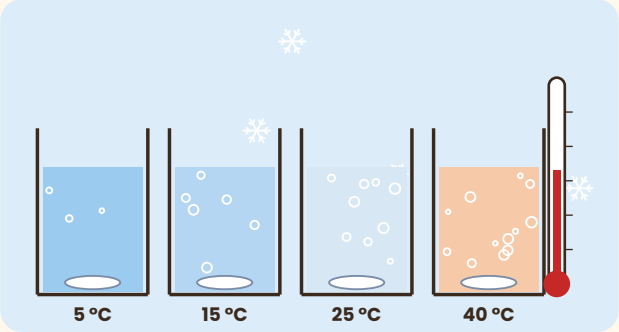
Rates of reaction

Science question: How does the temperature of water affect how fast an effervescent tablet reacts?

You will need

- 4 effervescent vitamin tablets (same brand)
- 4 identical cups and a measuring jug
- Water at 4 temperatures (fridge, tap, room, warm tap)
- A thermometer
- A stopwatch

ADULT HELP needed for this investigation.



Method

1. Pour **100 cm³** of water into each cup. Measure and record each temperature.
2. Drop one tablet into the first cup and start the stopwatch. Do not stir.
3. Stop timing when the fizzing stops. Record the time.
4. Repeat for the other temperatures. Ask an adult to supply the warm water.
5. Calculate the rate for each: **rate = 1 ÷ time**.

Independent variable (what I change)	Dependent variable (what I measure)	Control variables (what I keep the same)

Prediction (with a reason)

Results

Temperature (°C)	Time (s)	Rate = 1 ÷ time (/s)

Conclusion

Describe the pattern in your results, then explain it using particles and collisions.

Science Star fact: Collision theory: in warmer water particles move faster, so they collide more often and with more energy. More successful collisions per second = a faster rate.

2 Investigation 2: Endothermic Snow

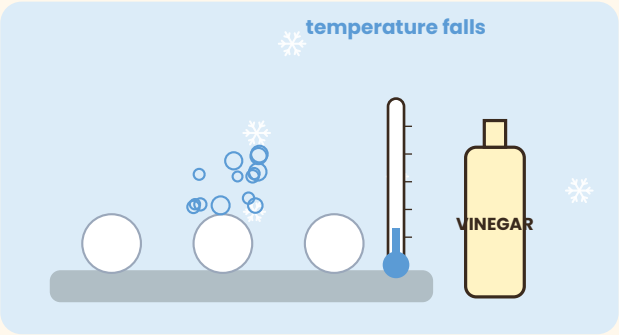
Energy changes

Science question: How does the amount of baking soda affect the temperature change when it reacts with vinegar?

You will need

- Bicarbonate of soda (sodium hydrogencarbonate)
- 200 cm³ vinegar (ethanoic acid)
- A polystyrene or paper cup
- A thermometer and a teaspoon
- Safety glasses if you have them

ADULT HELP needed for this investigation.



Method

1. Pour **50 cm³** of vinegar into the cup. Record the starting temperature.
2. Add **1 level teaspoon** of baking soda and stir gently with the thermometer.
3. Record the **lowest** temperature reached.
4. Repeat with fresh vinegar and 2, 3 and 4 teaspoons of baking soda.
5. Calculate the temperature change each time. Keep vinegar away from your eyes.

Independent variable (what I change)	Dependent variable (what I measure)	Control variables (what I keep the same)

Prediction (with a reason)

Results

Teaspoons	Start temp (°C)	Lowest temp (°C)	Change (°C)
1			
2			
3			
4			

Conclusion

Is this reaction exothermic or endothermic? Use your results to explain.

Science Star fact: Word equation: sodium hydrogencarbonate + ethanoic acid → sodium ethanoate + water + carbon dioxide. The reaction takes in energy from the surroundings, so the temperature falls.

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2 Investigation 3: Hot Chocolate Insulation

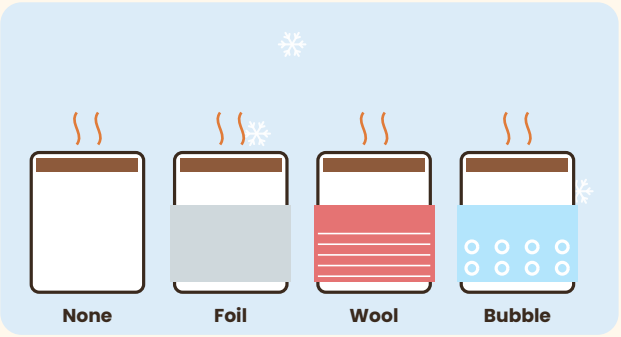
Energy transfer

Science question: Which material keeps a hot drink warm for longest?

You will need

- 4 identical mugs or jars
- Warm water (about 50 °C) from an adult
- Foil, a wool sock and bubble wrap
- A thermometer and a stopwatch
- Tape and a measuring jug

ADULT HELP needed for this investigation.



Method

1. Wrap three mugs: foil, wool and bubble wrap. Leave one unwrapped as a control.
2. Ask an adult to pour **200 cm³** of warm water into each mug.
3. Record the starting temperature in each mug (0 minutes).
4. Record the temperature every 2 minutes for 10 minutes.
5. Calculate the total temperature drop for each mug.

Independent variable (what I change)

.....

Dependent variable (what I measure)

.....

Control variables (what I keep the same)

.....

Prediction (with a reason)

.....

Results

Material	0 min	2 min	4 min	6 min	8 min	10 min	Drop (°C)
None							
Foil							
Wool							
Bubble							

Conclusion

Which material was the best insulator? Explain why, using conduction and convection.

.....

.....

Science Star fact: Wool and bubble wrap trap air. Air is a poor conductor, and because it is trapped it cannot form convection currents. Shiny foil reduces energy lost by infrared radiation.

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2 Investigation 4: Cupcake Case Parachutes

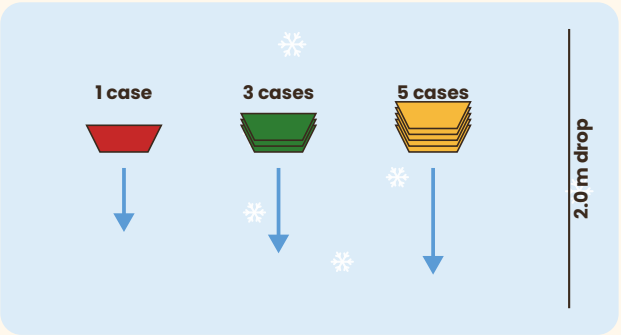
Forces & terminal velocity

Science question: How does the number of stacked cupcake cases affect their falling speed?

You will need

- 5 paper cupcake cases
- A tape measure
- A stopwatch
- A safe place to drop from 2.0 m
- A partner or adult helper

ADULT HELP needed for this investigation.



Method

1. Measure a drop height of **2.0 m**. An adult should do any dropping from a height.
2. Hold 1 case upside down at 2.0 m and drop it. Time how long it takes to land.
3. Repeat 3 times and calculate the mean time.
4. Repeat with 2, 3, 4 and 5 cases stacked together.
5. Calculate the speed: **speed = distance ÷ time**.

Independent variable (what I change)	Dependent variable (what I measure)	Control variables (what I keep the same)

Prediction (with a reason)

Results

Cases	Time 1 (s)	Time 2 (s)	Time 3 (s)	Mean (s)	Speed (m/s)
1					
2					
3					
4					
5					

Conclusion

Describe how speed changes with the number of cases. Explain using weight and air resistance.

Science Star fact: The cases quickly reach terminal velocity, when air resistance equals weight. More cases means more weight but the same area, so they must fall faster before the forces balance.

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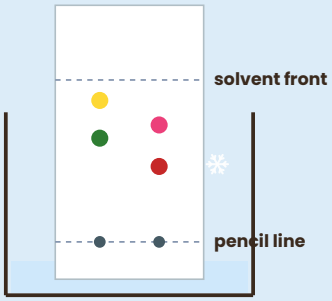
2 Investigation 5: Christmas Chromatography

Separating mixtures

Science question: Are the inks in red and green felt-tip pens pure substances or mixtures?

You will need

- Filter paper or a coffee filter cut into strips
- Red, green and brown felt-tip pens (washable)
- A pencil and a ruler
- A glass with 1 cm of water
- A clothes peg or tape



Method

1. Draw a **pencil** line 2 cm from the bottom of the strip.
2. Put a small dot of each pen colour on the line, spaced apart.
3. Hang the strip so the bottom is in the water but the dots are **above** it.
4. Remove the strip when the water is 1 cm from the top. Mark the solvent front.
5. Measure the distances and calculate **Rf = spot distance ÷ solvent distance**.

Independent variable (what I change)	Dependent variable (what I measure)	Control variables (what I keep the same)

Prediction (with a reason)

Results

Pen colour	Number of spots	Spot distance (cm)	Solvent distance (cm)	Rf value
Red				
Green				
Brown				

Conclusion

Which inks were mixtures? How do you know? Why must the start line be drawn in pencil?

Science Star fact: Each dye has its own Rf value in a given solvent, always between 0 and 1. A pure substance gives one spot. Scientists use chromatography to test inks, foods and medicines.

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3 The Science of Christmas

❄ Facts + exam-style questions

Read each fact, then answer the exam-style question. Marks are shown in [brackets].

1. Can reindeer see ultraviolet?

Reindeer are one of the few mammals that can see UV light. Snow reflects UV, but lichen (their winter food) and wolf fur absorb it, so they show up as dark shapes against the snow.

Exam-style question: Explain how this adaptation helps reindeer to survive in the Arctic. [2]

2. Why is fresh snow so quiet?

Fresh snow is full of tiny air pockets. Sound waves enter these pockets and their energy is absorbed instead of being reflected, so a snowy street sounds muffled.

Exam-style question: Suggest why recording studios line their walls with soft, porous foam. [2]

3. How efficient are fairy lights?

Efficiency = useful energy output ÷ total energy input × 100. An old filament bulb gives about 5 J of light for every 100 J of electrical energy. An LED gives about 40 J.

Exam-style question: Calculate the efficiency of each bulb. Where does the wasted energy go? [3]

4. Why does mince pie filling burn your mouth?

The fruity filling contains lots of water. Water has a high specific heat capacity, so the filling stores much more thermal energy than the pastry at the same temperature.

Exam-style question: Use $E = m \times c \times \Delta T$ to find the energy to warm 0.02 kg of water by 50 °C ($c = 4200$ J/kg °C). [2]

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3 The Science of Christmas (continued)

Biology · Chemistry · Physics

5. What makes firework colours?

When metal ions are heated, their electrons gain energy and then release it as light of a particular colour. Lithium gives crimson, sodium yellow, potassium lilac and copper green-blue.

Exam-style question: A firework burns with a lilac flame. Which metal ion does it contain? [1]

6. Why do some people hate sprouts?

Brussels sprouts contain bitter chemicals. A gene called TAS2R38 codes for a bitter taste receptor, and people who inherit certain versions of it taste the bitterness much more strongly.

Exam-style question: Is this an example of genetic or environmental variation? Explain. [2]

7. How does frost form?

On clear nights, the ground and cars lose energy by infrared radiation. If a surface cools below 0 °C, water vapour turns straight into ice crystals – a change called deposition.

Exam-style question: Suggest why frost is less likely on a cloudy night. [2]

8. Why do Christmas trees drop needles?

A cut tree has no roots to take up water. In a warm, dry room, water evaporates from the needles faster (transpiration), so they dry out and fall off.

Exam-style question: Give two ways to keep a cut Christmas tree fresh for longer. [2]

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4 Science Word Search

Puzzle 1 of 3

Find the 12 science words. They can go in **any direction** – forwards, backwards, up, down or diagonally.

O	G	P	Y	H	X	N	C	R	Z	P	Y	P	V
B	A	L	H	C	E	O	O	P	K	H	O	L	M
S	U	O	P	I	T	I	N	I	Y	O	W	Y	W
C	I	Y	A	M	E	T	D	N	C	T	D	T	L
Y	U	I	R	R	L	I	U	S	N	O	X	I	Y
T	Z	N	G	E	E	S	C	U	E	S	O	S	G
I	Z	O	O	H	C	O	T	L	I	Y	D	O	R
S	G	I	T	T	T	P	I	A	C	N	T	C	E
N	K	S	A	O	R	E	O	T	I	T	C	S	N
E	X	U	M	D	O	D	N	O	F	H	J	I	E
D	H	F	O	N	N	U	E	R	F	E	E	V	Y
I	D	F	R	E	V	T	J	U	E	S	G	Q	G
E	P	I	H	Y	W	P	G	B	V	I	K	U	Q
L	A	D	C	G	E	J	B	I	W	S	N	B	D

CHROMATOGRAPHY
CONDUCTION
DENSITY
DEPOSITION
DIFFUSION
EFFICIENCY
ELECTRON
ENDOTHERMIC
ENERGY
INSULATOR
PHOTOSYNTHESIS
VISCOSITY

Challenge: Choose 3 of the words and write a definition for each.

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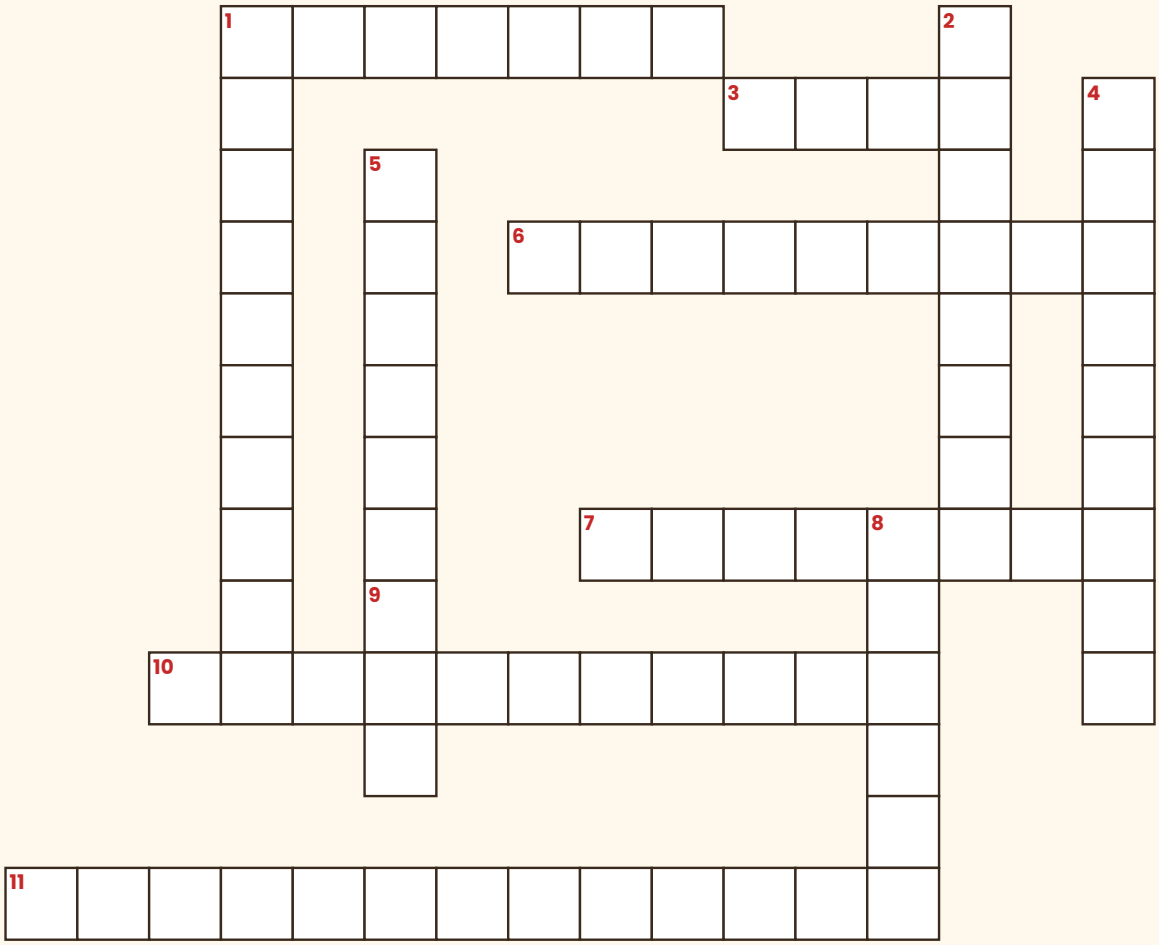
4 Science Crossword

Puzzle 2 of 3

Use the clues to complete the crossword. Every answer is a key science word.



Across

1. Mass divided by volume (7)
3. A section of DNA, e.g. TAS2R38 (4)
6. Negative particles transferred when you rub a balloon (9)
7. Speeds up a reaction without being used up (8)
10. A reaction that takes in energy from the surroundings (11)
11. Loss of water vapour from leaves (13)

Down

1. Gas turning straight into a solid, like frost (10)
2. Speed in a given direction (8)
4. A material that reduces energy transfer by heating (9)
5. Spreading of particles from high to low concentration (9)
8. Reindeer food that absorbs UV light (6)
9. A charged particle; copper ones colour fireworks (3)

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4 Element Code & Christmas Calculations

Puzzle 3 of 3

Each number is an **atomic number**. Write the element symbol in each box to reveal the message. Use the key or a periodic table.

Key: atomic number = element symbol

1	6	7	8	9	11	12	14	15	16	17
H	C	N	O	F	Na	Mg	Si	P	S	Cl
19	**20**	**26**	**39**	**47**	**52**	**53**	**57**	**92**	**99**	
K	Ca	Fe	Y	Ag	Te	I	La	U	Es	

Message 1

15	1	39	14	6	16	53	16	9	92	7

Message 2

6	1	8	6	8	57	52	6	8	8	19	53	99

Christmas Calculations – show your working

1. Rudolph runs 900 m in 60 s. Calculate his average speed. (speed = distance ÷ time)

2. A gold-coloured bauble has a mass of 38.6 g and a volume of 2.0 cm³. Gold has a density of 19.3 g/cm³. Is it solid gold? (density = mass ÷ volume)

3. A string of lights transfers 100 J of electrical energy and gives out 20 J of light. Calculate its efficiency. (efficiency = useful ÷ total × 100)

4. A 2 kW oven cooks the dinner for 1.5 hours. How many kWh of energy does it transfer? If 1 kWh costs 0.25 (in your currency), what does it cost? (energy = power × time)

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5 Achievement Badges

Colour & cut out

Earn a badge for each challenge you complete. Colour it in, cut along the dotted line and stick it in your science book.













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Certificate of Christmas Science Star

This certificate is proudly awarded to

_____

for brilliant predicting, testing and explaining
in the Christmas Science Pack.

Advent activities done: ____ / 24
Experiments done: ____ / 5
Puzzles solved: ____ / 3

Signed _____ Date _____

SCIENCE STAR

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6 Answers (for teachers & parents)

❄ Advent · Investigations · Facts

Science Advent Calendar

1. 1500 s = 25 minutes.
2. Salt lowers the freezing point, so water on the road does not freeze into ice.
3. carbon dioxide + water → glucose + oxygen (using light energy).
4. Gases are less soluble in warm liquids, so CO_2 escapes faster.
5. Rubbing transfers electrons to the balloon, giving it a negative charge that attracts the wall.
6. Food and predators show up as dark shapes against bright snow.
7. Acid (vinegar): red/pink. Alkali (baking soda): blue/green.
8. 5 W × 6 h = 30 Wh = 0.03 kWh.
9. Warm water – particles move faster, so diffusion is faster.
10. Deposition.
11. 150 ÷ 160 = 0.94 g/cm³; less than water (1.0), so it floats.
12. Iron, nickel and cobalt.
13. Carbon dioxide; thermal decomposition.
14. Metal is a better conductor, so it transfers energy away from your hand faster.
15. Air is a poor conductor and trapped air cannot form convection currents.
16. Planets are close enough to appear as tiny discs, not points of light.
17. Coloured water is denser and sinks; gas bubbles lift it up, then pop so it sinks again.
18. 60°.
19. Transpiration (water loss) – useful because roots cannot take up frozen water.
20. Air is pushed backwards out of the balloon, so the balloon is pushed forwards.
21. Viscosity – syrup is more viscous.
22. IV: temperature of milk; DV: time to dissolve; control: e.g. mass of sugar, volume of milk.
23. 510 000 000 ÷ 115 200 s ≈ 4400 km/s.
24. Answers vary.

Investigations – expected results

- **Fizzy Tablet Race:** higher temperature → shorter time → faster rate; particles collide more often and with more energy.
- **Endothermic Snow:** temperature falls; more baking soda gives a bigger drop (until the vinegar is used up). It is endothermic.
- **Hot Chocolate:** the unwrapped mug cools fastest; wool or bubble wrap usually best – trapped air reduces conduction and convection.
- **Cupcake Cases:** more cases → shorter time → higher speed, as more weight is needed to balance a bigger air resistance.
- **Chromatography:** inks with more than one spot are mixtures. Pencil does not dissolve in the solvent, so it will not run.

The Science of Christmas – mark scheme

1. Lichen shows up dark against snow, so they can find food; they can also spot wolves (predators) more easily.
2. Soft, porous materials absorb sound energy instead of reflecting it, so there are fewer echoes.
3. Filament: 5 ÷ 100 × 100 = 5%. LED: 40%. Wasted energy is transferred to the surroundings as heat (thermal energy).
4. E = 0.02 × 4200 × 50 = 4200 J.
5. Potassium (K^+).
6. Genetic variation – it is caused by inheriting different versions (alleles) of a gene.
7. Clouds absorb and re-emit infrared radiation back to the ground, so surfaces do not cool as much.
8. e.g. stand it in water and top it up; keep it away from radiators/heat; recut the base before standing it.

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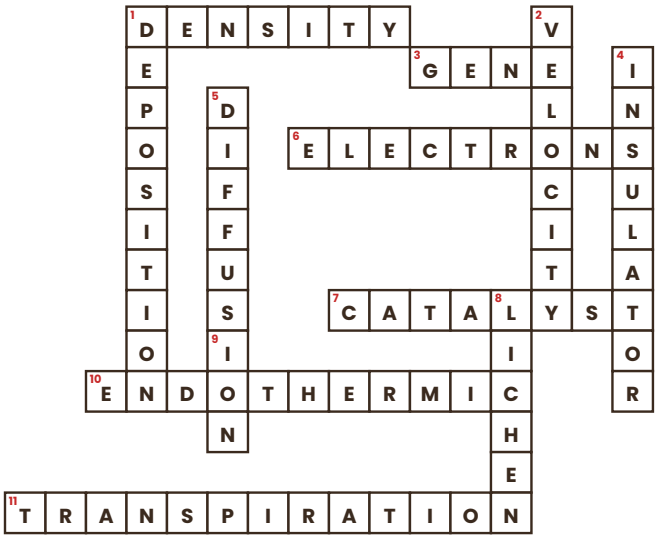
6 Answers: Puzzles & Calculations

❄ Word search · Crossword · Code

Word search

O	G	P	Y	H	X	N	C	R	Z	P	Y	P	V
B	A	L	H	C	E	O	O	P	K	H	O	L	M
S	U	O	P	I	T	I	N	I	Y	O	W	Y	W
C	I	Y	A	M	E	T	D	N	C	T	D	T	L
Y	U	I	R	R	L	I	U	S	N	O	X	I	Y
T	Z	N	G	E	E	S	C	U	E	S	O	S	G
I	Z	O	O	H	C	O	T	L	I	Y	D	O	R
S	G	I	T	T	T	P	I	A	C	N	T	C	E
N	K	S	A	O	R	E	O	T	I	T	C	S	N
E	X	U	M	D	O	D	N	O	F	H	J	I	E
D	H	F	O	N	N	U	E	R	F	E	E	V	Y
I	D	F	R	E	V	T	J	U	E	S	G	Q	G
E	P	I	H	Y	W	P	G	B	V	I	K	U	Q
L	A	D	C	G	E	J	B	I	W	S	N	B	D

Crossword



Across: 1 DENSITY, 3 GENE, 6 ELECTRONS, 7 CATALYST, 10 ENDOTHERMIC, 11 TRANSPIRATION
Down: 1 DEPOSITION, 2 VELOCITY, 4 INSULATOR, 5 DIFFUSION, 8 LICHEN, 9 ION

Element code & calculations

Message 1: P H Y Si C S I S F U N = **Physics is fun**. **Message 2:** C H O C O La Te C O O K I Es = **Chocolate cookies**.

1. 900 ÷ 60 = 15 m/s.
2. 38.6 ÷ 2.0 = 19.3 g/cm³ – matches gold, so it could be solid gold.
3. 20 ÷ 100 × 100 = 20%.
4. 2 × 1.5 = 3 kWh; 3 × 0.25 = 0.75 (in your currency).

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