Vertex Academy

# NCEA Level 1 Science workbook

26 worksheets · answers at the back

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# Year 11 Science: Science 1.1: kauri dieback, the science and the perspectives

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. Which of these is a science idea? (a) Kauri can live for over 2000 years. (b) PA in moved soil infects kauri roots, so trees near busy tracks are more likely to be infected.

2. Name a group with a perspective on kauri dieback in the Waitākere Ranges and outline their view in one sentence.

3. Explain why a raised boardwalk slows the spread of kauri dieback.

4. Give one example of tiakitanga in the response to kauri dieback, and say who showed it.

5. The share of Waitākere kauri infected rose from 7.9% in 2011 to 19.0% in 2016. By how many percentage points did it rise?

## Fix the mistake

6. Correct this statement: "My science idea is that 19% of kauri in the Waitākere Ranges are infected."

7. Correct this statement: "Another perspective is my uncle's, who thinks the tracks should stay open."

8. Correct this statement: "Kauri dieback is a fungus that spreads through the air."

9. Correct this statement: "I mentioned tiakitanga in my conclusion, so that is covered."

# Year 11 Science: Writing up a local issue: from Achieved to Excellence

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. Turn this fact into a science idea: "Some central Auckland beaches get black pins after heavy rain."

2. Explain why Safeswim scientists count enterococci instead of testing for every germ.

3. Explain how the Central Interceptor reduces overflows onto beaches.

4. Write one sentence that discusses why Ngāti Whātua Ōrākei's perspective matters to the response.

5. At a green pin the risk is under 2%; at a long-term red pin it is above 10%. Out of 100 swimmers, how many might get sick at each?

## Fix the mistake

6. Correct this statement: "My report is long and has lots of facts, so it should get Excellence."

7. Correct this statement: "The iwi think the beach is dirty and the scientists think it is dirty too."

8. Correct this statement: "E. coli and enterococci are the germs that make swimmers sick."

9. Correct this statement: "The Central Interceptor cleans the sewage in the tunnel."

# Year 11 Science: Five investigative approaches and the question each one answers

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. Which approach best answers: which of the beetles caught in pitfall traps in the school bush are native?

2. Which approach best answers: do kererū visit gardens more often in the months when more trees are fruiting?

3. A student tests whether the slope of a tray of soil changes how much soil washes off when 500 mL of water is poured over it. Name the independent variable, the dependent variable and one controlled variable.

4. Explain why modelling, not a fair test, is the right approach for predicting how a 1 m rise in sea level would affect a coastal town.

5. A student wrote: 'Exploring and observing was appropriate because we explored and observed the stream.' Say why this is not yet Merit, and what it needs.

## Fix the mistake

6. Correct this statement: "Every investigation is a fair test, so each one needs an independent and a dependent variable."

7. Correct this statement: "The graph shows pH falling as $CO_2$ rises, so this proves $CO_2$ causes it."

8. Correct this statement: "Pattern seeking was appropriate because we were looking for patterns."

9. Correct this statement: "Surveys and things said at a wānanga are not real science, so I left them out."

# Year 11 Science: Combining approaches: one stream investigated three ways

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. Three repeats of a fair test give 12 mg, 14 mg and 13 mg of algae. Find the mean.

2. A stream has an MCI of 104. Which class is it in?

3. A class identifies 12 kinds of invertebrate, and 3 of them are EPT kinds. Work out the percentage of EPT kinds.

4. In the fertiliser test, which jars are the control, and what are they for?

5. Give one thing the council data could not tell the class, which their own classifying and identifying could.

6. Write one sentence that links the pattern seeking and the classifying and identifying, with evidence, as an Excellence answer would.

## Fix the mistake

7. Correct this statement: "My controlled variable is the amount of fertiliser."

8. Correct this statement: "I included the odd jar in the mean so all my data counts."

9. Correct this statement: "The fair test proves fertiliser is what is wrong with the stream."

10. Correct this statement: "For Excellence I wrote a summary of each investigation again."

# Year 11 Science: The features of science and how to write about them

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Your turn: name the feature

**Name the main feature of science shown by each sentence.**

1. Scientists at Baring Head near Wellington have measured carbon dioxide in the air the same way for over fifty years, so other stations can compare with them.

2. Tuna counts in a river fall in the years after a dam is built upstream.

3. NIWA researchers worked with iwi who use hīnaki and know when tuna migrate.

4. A study's results were checked by other experts before the journal published them.

5. Early results suggested the chemical alone was enough, but later work found the whole seaweed worked better.

## Your turn: an exam-style question

**Resource: Longfin tuna are taonga to many iwi, and they are sensitive to pollution, so their health shows the health of a river. Iwi have caught tuna in hīnaki for generations and know their seasons. NIWA now samples eels with fyke nets, which catch eels above a set size, and with electric fishing, which stuns eels briefly so they can be measured and returned. Results from many rivers are compared to see which factors, such as farming or dams, change eel numbers. Focus on two features: varied perspectives (including mātauranga Māori) and the development and use of technology.**

6. How does varied perspectives contribute to the idea? (Achieved)

7. How does technology contribute to the idea? (Achieved)

8. Why is each of these features significant to the idea? (Merit)

9. How do the two features work together to develop the idea? (Excellence)

## Fix the mistake

10. Correct this statement: "Cattle farming is important, so the science helps farmers keep their jobs."

11. Correct this statement: "The study proved that the seaweed reduces methane."

12. Correct this statement: "Interactions: the scientists interacted with farmers and other scientists."

13. Correct this statement: "Technology made the data more accurate."

# Year 11 Science: A science idea in Aotearoa: carbon dioxide and a more acidic ocean

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Your turn: an exam-style question

**Use this lesson as your resource. Focus on two features: responding to needs and opportunities, and repeatable, checkable data.**

1. Give one example of a need or an opportunity that helped start the Baring Head record. (Achieved)

2. Give one way the Baring Head team made their data repeatable and checkable. (Achieved)

3. Why was repeatable, checkable data significant for this idea? (Merit)

4. How did needs and opportunities and repeatable data work together to develop the idea? (Excellence)

## Fix the mistake

5. Correct this statement: "The pH only fell from 8.09 to 8.06, so the ocean has hardly changed."

6. Correct this statement: "The ocean is becoming acidic, so its pH is now below 7."

7. Correct this statement: "Baring Head proves that the ocean is acidifying."

8. Correct this statement: "Existing models: Dr Currie used her earlier pH readings."

# Year 11 Science: Science claims: who is saying it and why

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. A Facebook post from a fitness influencer says a protein powder "burns fat while you sleep" and gives a discount code. What is the main purpose?

2. A university research team publishes a study on kauri dieback in a peer-reviewed journal. Who is the source?

3. A news site runs a story that, at the bottom, says it was supplied by the company that makes the product. Who is the source?

4. A company paid for a study showing its toothpaste whitens teeth. Name the convention this raises, and its effect on the claim.

## Exam-style question: a sunscreen advert

**Resource: SunShield Ltd's website says "Our new SPF 50 lotion is scientifically proven to block 98% of UVB rays. Dermatologist tested. Trusted by 10,000 Kiwi families." A footnote says the lab test was done on 20 volunteers by a lab SunShield hired, and was not published in a journal. There is a "Buy now" button.**

5. (a) Who published this information?

6. (b) Why was it published?

7. (c) State one science-related claim the resource makes.

8. (d) Identify the science language or conventions used to support the claim.

9. (e) How well do they support the claim? Use evidence from the resource.

## Fix the mistake

10. Correct this statement: "The source is Google, because that is where I found it."

11. Correct this statement: "The company sells the product, so the claim is false."

12. Correct this statement: "It was peer reviewed, so it is proven."

13. Correct this statement: "I know from experience that honey does not work, so the claim is wrong."

# Year 11 Science: Science language, graphs and judging a claim

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. A graph's axis starts at 20. Brand X scored 30 and brand Y scored 25. How many times taller does X's bar look, and what is the real percentage difference compared with Y?

2. Towns with more libraries have more crime. Give the most likely reason.

3. 50 people took a cold remedy and most felt better within 5 days. What convention is missing?

4. Which is more honest about a single study: "proves" or "suggests"? Why?

## Exam-style question: phones and sleep

**Resource: SleepRight NZ, which sells blue-light-blocking glasses, posts "Late-night phone use wrecks teen sleep and grades! Blue light suppresses melatonin, disrupting the circadian rhythm." A bar graph shows phone users after 10 pm sleep 7.0 and others 8.0, with the axis starting at 6.5 and no units. A footnote says 40 students at one Auckland school filled in an online survey; it was not peer reviewed.**

5. (a) Who published this information, and why?

6. (b) State one science-related claim in the post.

7. (c) Identify the science language used.

8. (d) Identify the science conventions used, or missing.

9. (e) How well do the language and conventions support the claim? Use evidence from the resource.

## Fix the mistake

10. Correct this statement: "The resource uses words like germinate and polymer, so the claim is supported."

11. Correct this statement: "The graph matches the claim, so the claim is true."

12. Correct this statement: "Ice cream sales and drownings rise together, so ice cream causes drowning."

13. Correct this statement: "There is no peer review, so the claim is wrong."

# Year 11 Science: Bacteria, fungi and viruses: how microorganisms live

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. Give two differences in structure between a bacterium and a yeast cell.

2. A bacterium divides every 30 minutes. Starting from one cell, how many cells are there after 4 hours?

3. Write the word equation for anaerobic respiration in yeast, and say which product makes bread rise.

4. Explain why a virus is described as not fully living.

5. Explain why dried apricots keep for months but fresh apricots go mouldy within a week or two.

## Fix the mistake

6. Correct this statement: "Viruses are just very small bacteria."

7. Correct this statement: "Fungi take in their food and digest it inside, like animals do."

8. Correct this statement: "At high temperatures the enzymes die."

9. Correct this statement: "Yeast only makes carbon dioxide when it ferments."

# Year 11 Science: Microbes and their environment: gut, food and soil

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. Name the four phases of a growth curve in order, and give one reason for the stationary phase.

2. Room 9 measured the pH of a kombucha brew: day 0, pH 5.0; day 4, pH 3.8; day 8, pH 3.2; day 12, pH 2.9. Describe the change and explain it with a life process.

3. Bread dough was left for an hour at 5 °C, 30 °C and 70 °C, and rose 2 mm, 25 mm and 0 mm. Explain how changing the temperature changed the rate of respiration in the yeast.

4. For kauri dieback, sort these factors into abiotic or biotic, in order: soil moisture, the kauri tree, feral pigs, temperature.

5. A student writes: 'Phytophthora makes kauri leaves turn yellow, so it changes the forest.' Explain why this does not reach Excellence.

## Fix the mistake

6. Correct this statement: "The bacteria respired faster at 43 °C because it was warmer."

7. Correct this statement: "In the stationary phase the yeast has stopped reproducing."

8. Correct this statement: "For Excellence I explained how E. coli gives people diarrhoea."

9. Correct this statement: "My graph shows the yeast grew best at 35 °C, so I don't need numbers in my writing."

# Year 11 Science: Chemical equations, ion formulae and conservation of mass

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. Write the formulae of potassium carbonate, iron(III) hydroxide and zinc nitrate.

2. Count the atoms of each element in $3Ca(NO_3)_2$.

3. Balance $Fe + O_2 \rightarrow Fe_2O_3$, the equation for iron rusting.

4. Hydrogen peroxide breaks down into water and oxygen. Balance $H_2O_2 \rightarrow H_2O + O_2$.

5. 5.0 g of baking soda is added to 50.0 g of vinegar in an open cup. When the fizzing stops the cup's contents weigh 52.4 g. What mass of carbon dioxide escaped?

6. Steel wool is heated in air and its mass goes up. Explain why, using conservation of mass.

## Fix the mistake

7. Correct this statement: "To balance $H_2 + O_2 \rightarrow H_2O$, change the water to $H_2O_2$."

8. Correct this statement: "Magnesium hydroxide is $MgOH_2$."

9. Correct this statement: "The mass went down in the open flask, so mass was not conserved."

10. Correct this statement: "Aluminium oxide is AlO because aluminium and oxygen combine."

# Year 11 Science: Five reaction types in everyday contexts

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. Name the reaction type: limestone heated in a kiln gives off a gas; two clear solutions are mixed and go cloudy; an iron gate turns orange-brown; lime is spread on an acidic paddock.

2. Write balanced equations for methane ($CH_4$) burning completely, and burning incompletely to make carbon monoxide.

3. Barium nitrate and sodium sulfate solutions are mixed. Name the precipitate, write the balanced equation, and name the spectator ions.

4. 50 g of calcium carbonate is heated until it has all decomposed. What mass of calcium oxide is left, and what mass of carbon dioxide escapes?

5. A gas heater with no flue is used in a closed bedroom. Discuss why this is dangerous, using combustion equations and conservation of mass.

6. Explain why an open bottle of fizzy drink gets lighter over an hour, but an unopened one does not.

## Fix the mistake

7. Correct this statement: "Incomplete combustion makes less carbon dioxide because some of the carbon is destroyed."

8. Correct this statement: "A rusty nail weighs less because the rust has eaten some of the iron away."

9. Correct this statement: "When silver nitrate and sodium chloride are mixed, every ion forms the precipitate."

10. Correct this statement: "Fizzing always means neutralisation."

# Year 11 Science: Where genetic variation comes from

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. A woman who is a carrier for albinism (Aa) has children with a man who is homozygous dominant (AA). What is the chance that a child has albinism?

2. In question 1, what fraction of the children are expected to be carriers?

3. Two parents with normal pigment have a child with albinism, then a second child with normal pigment. What is the chance that the second child is a carrier?

4. A man's skin cell mutates after years of sunburn. Can the mutation be passed to his children? Explain.

5. Name the two events in meiosis that make each gamete different, and say which one swaps parts between chromosomes.

## Exam-style question: drinking milk as an adult

**Context: Lactase is the enzyme that breaks down lactose, the sugar in milk. Most mammals stop making it after weaning, and so do many people. In some human populations, a mutation in a stretch of DNA that switches the lactase gene on lets people keep making lactase as adults. This allele for lactase persistence (L) is dominant over the allele for lactase non-persistence (l).**

6. Describe the difference between genotype and phenotype, using lactase persistence as your example.

7. Two adults who both digest milk easily have a son who, as an adult, gets sick after drinking milk. Explain how this happened, using a Punnett square, and give the chance for each of their children.

8. Discuss how the L allele first appeared and why it became common in populations with a long history of keeping dairy animals but stayed rare in others. In your answer, explain why the first mutation must have happened in a gamete-making cell, and link the nature of the allele to survival.

## Fix the mistake

9. Correct this statement: "A gene and an allele are the same thing."

10. Correct this statement: "Their first child had albinism, so the next three will not."

11. Correct this statement: "Getting skin cancer from the sun is a mutation, so the person's children can inherit it."

12. Correct this statement: "Meiosis makes new alleles."

# Year 11 Science: Variation in populations and gene tracking

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. A flock of 40 birds has 20 copies of allele b. What is the frequency of b?

2. Two unaffected parents have a child with a genetic condition. Is the allele for the condition dominant or recessive?

3. A flood kills most of a beetle population at random. Which population source is this, and what can happen to the allele frequencies?

4. Why were Richard Henry's chicks so valuable to Kākāpō Recovery, and which population source does this show?

5. In the PKU pedigree, what is the chance that individual 8 is a carrier, and how could it be confirmed?

## Exam-style question: albino chicks in a sanctuary

**Context: A predator-free island sanctuary breeds a rare flightless bird, all descended from a few founders. Albinism in this bird is caused by a recessive allele (a); the normal allele (A) is dominant. Male 5 was moved in from another island where no albino chick has ever been recorded.**

6. Give the genotypes of birds 1, 2 and 3, and the possible genotypes of bird 4.

7. Explain why the genotype of bird 4 cannot be confirmed from the pedigree, and calculate the chance that she is a carrier.

8. The rangers plan to pair female 6 with her uncle, bird 3. Discuss this plan. Include the chance that a chick from the pair is albino (assume bird 5 is AA), why this is non-random mating, and how a DNA test for the a allele would change the decision. Evaluate how reliable your answer is.

## Fix the mistake

9. Correct this statement: "Allele frequency of b = number of bb individuals ÷ population size."

10. Correct this statement: "An unaffected child of two carriers has a ¾ chance of being a carrier."

11. Correct this statement: "Non-random mating and inbreeding mean the same thing."

12. Correct this statement: "If a recessive allele becomes more common, more individuals will show the trait."

# Year 11 Science: Particles and forces in the five types of material

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. Iodine crystals are used to make an antiseptic. A student warms iodine and salt crystals side by side in a warm water bath. The iodine slowly gives off a purple vapour, but the salt crystals do not change. (a) Name the type of material iodine is and the type salt is. (b) Describe the particles and the forces between them in each substance. (c) Explain why the iodine turns to vapour at this temperature but the salt does not change.

2. Name the particles in copper wire and the force that holds them together.

3. A white solid does not conduct electricity, but it conducts once dissolved in water. What type of material is it, and why does dissolving change things?

4. Diamond and graphite are both pure carbon. Why does graphite conduct electricity when diamond does not?

5. Why is low-density polyethylene less dense than high-density polyethylene?

6. Carbon dioxide is a gas at room temperature. Which forces are weak in carbon dioxide, and which are strong?

## Fix the mistake

7. Correct this statement: "When water boils, the covalent bonds in the water molecules break."

8. Correct this statement: "Salt is made of sodium and chlorine molecules."

9. Correct this statement: "Graphite conducts because its layers slide."

10. Correct this statement: "Polymers are held together by weak forces, so they are weak."

# Year 11 Science: Physical properties and the uses of materials

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. A frying pan has an aluminium body, a PTFE non-stick coating on the inside, and a plastic handle. (a) Name the type of material for the aluminium body and for the PTFE coating. (b) Explain why aluminium is suitable for the body of the pan. (c) Discuss why the handle is made from a polymer rather than from aluminium.

2. Using the melting point and density table, which metal there has the lowest melting point, and what is its melting point?

3. Why does solid salt not conduct electricity, while salt water does?

4. A crystal of salt is hit with a hammer and shatters. Why?

5. Why is graphite used in pencils but diamond in drill tips?

6. Why is a magnesium alloy used for a wheel instead of pure magnesium?

## Fix the mistake

7. Correct this statement: "Solid salt conducts electricity because it is made of ions."

8. Correct this statement: "Alloys are harder because the bonds in them are stronger."

9. Correct this statement: "Salt dissolves because water breaks the covalent bonds in the NaCl molecules."

10. Correct this statement: "Magnesium wheels are better because magnesium is lighter."

# Year 11 Science: The Earth system, the carbon cycle and rising $CO_2$

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. Name the sphere each of these belongs to: a glacier, a kauri tree, a coal seam.

2. Write the balanced equation for burning methane. How many $CO_2$ molecules does one methane molecule make?

3. $CO_2$ at Mauna Loa rises and falls a little every year, peaking around May. Explain why.

4. Explain how burning fossil fuels can harm pāua.

5. Discuss one way warming can feed back to make itself worse.

## Try it: $CO_2$ at Baring Head

**Baring Head, on the coast just east of the entrance to Wellington Harbour, has measured $CO_2$ in clean Southern Ocean air for more than 50 years. Its readings are below.**

| Baring Head reading | $CO_2$ (ppm) |
|---|---|
| Latest (published July 2026) | 424.7 |
| One year earlier | 423.3 |
| Ten years earlier | 401.1 |
| Pre-industrial level | 280 |

6. By how much did $CO_2$ at Baring Head rise over the ten years, and what is that per year?

7. By what percentage is the latest reading above the pre-industrial level?

8. Mauna Loa's yearly mean for 2025 was 427.35 ppm. Give one reason Baring Head reads a little lower.

## Fix the mistake

9. Correct this statement: "Global warming is caused by the hole in the ozone layer letting in more heat."

10. Correct this statement: "Ocean acidification means the sea has turned into an acid."

11. Correct this statement: "The greenhouse effect is harmful and should be stopped."

12. Correct this statement: "Burning fossil fuels creates new carbon."

# Year 11 Science: Human-induced change in Aotearoa: soil, water and plastic

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. A new subdivision of houses and roads is built. Name the change it causes and two spheres it affects.

2. Explain why nitrate leaches through soil much more easily than phosphate.

3. A catchment was changed from pine forest to dairy farming. Nitrate in its spring water has kept rising for 15 years, although the farm has not changed since. Explain why.

4. Explain how clearing forest from steep hill country can harm an estuary downstream.

5. Discuss one implication of microplastics reaching the sea.

## Try it: litter on our beaches

**Litter Intelligence volunteers count every item of litter in marked areas of beach. The table gives average items per 1000 m² by region.**

| Region | Average litter items per 1000 m² |
|---|---|
| Wellington | 558 |
| Auckland | 416 |
| Hawke's Bay | 317 |
| Canterbury | 275 |
| Bay of Plenty | 104 |
| Gisborne | 74 |
| West Coast | 27 |

6. How many times more litter per 1000 m² did Wellington's surveyed beaches have than the West Coast's?

7. Suggest one reason for the difference.

8. Paper and wood are only 4.5% of items, while plastic and foamed plastic are 74.9%. Explain why plastic builds up on beaches more than paper and wood.

## Fix the mistake

9. Correct this statement: "The West Coast has the most erosion, so it has the worst human-induced erosion."

10. Correct this statement: "Nitrate gets into rivers mainly by fertiliser washing off the paddock surface in rain."

11. Correct this statement: "Listing more effects is how you get Excellence."

12. Correct this statement: "Plastic in the sea breaks down and disappears after a few years."

# Year 11 Science: A physics investigation: planning and processing evidence

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. A class drops a tennis ball from different heights and measures how high it bounces. Name the independent variable, the dependent variable and two controlled variables.

2. A group timed 10 swings of a pendulum as 14.2 s, 14.4 s and 12.9 s, and they think they miscounted once. Find the mean period and its uncertainty.

3. A spring's total length was measured with masses from 0 g to 300 g hung on it. The best-fit line passes through (0 g, 12.0 cm) and (300 g, 18.0 cm). Find the gradient, and say whether length is proportional to mass.

4. A class measured the current through different resistors from the same battery pack: 10 Ω gave 0.59 A, 20 Ω gave 0.30 A, 30 Ω gave 0.20 A and 40 Ω gave 0.15 A. Name the relationship and give the evidence.

5. Explain why timing 10 swings and dividing by 10 gives a better period than timing one swing.

## Fix the mistake

6. Correct this statement: "Joining each point to the next with a ruler to make a zigzag graph."

7. Correct this statement: "The graph goes up in a straight line, so the quantities are proportional."

8. Correct this statement: "Averaging all three repeats, including the reading that was clearly a mistake."

9. Correct this statement: "Gradient = 4.0, with no unit."

# Year 11 Science: A worked physics investigation: wire length and resistance

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. At 60 cm one group read 1.66 V across the wire and 0.20 A through it. Find the resistance.

2. The class added a 70 cm length and got 9.8 Ω, 9.6 Ω and 9.7 Ω. Find the mean and its uncertainty, and say whether it agrees with R = 13.5 Ω/m × L + 0.3 Ω.

3. Use the line to predict the reading for a 50 cm length.

4. A student concluded: "When the wire got longer the resistance got bigger because there is more wire." Which grade is this closest to, and what two things would lift it to Merit?

5. Explain why the class's line meets the resistance axis at 0.3 Ω instead of passing through the origin.

## Fix the mistake

6. Correct this statement: "The graph is a straight line, so resistance is proportional to length."

7. Correct this statement: "A longer wire has more resistance because the electrons get used up on the way."

8. Correct this statement: "Writing the physics in one paragraph and the results in another."

9. Correct this statement: "Predicting 1.50 m with the gradient 0.135 and getting 0.5 Ω."

# Year 11 Science: Day and night, and the seasons in New Zealand

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. Which season does New Zealand have when the Southern Hemisphere is tilted towards the Sun?

2. Christchurch is at about 43.5°S. Calculate the height of the midday Sun there on 22 December.

3. Use the sunrise and sunset table: how much longer is Christchurch's day on 22 December than on 21 June?

4. Earth is closest to the Sun on 4 January. Explain why this is not the reason New Zealand has summer then.

5. In which direction does the Sun rise in Auckland on 21 June?

## Exam-style question: summer evenings in Invercargill

**A student moves from Auckland (37°S) to Invercargill (46°S). In December she notices it is still light at 9:30 pm, but in June it is dark by 5:15 pm. Use the sunrise and sunset table above.**

6. Describe why Invercargill has day and night, and why the Sun rises in the east.

7. Explain why Invercargill's days are longer and warmer in December than in June. Refer to Earth's tilt and orbit.

8. Discuss why Invercargill has longer days than Auckland in December, shorter days in June, and almost the same day length in September.

## Fix the mistake

9. Correct this statement: "Summer happens because Earth is closer to the Sun."

10. Correct this statement: "Earth's axis tips towards the Sun in summer and away in winter."

11. Correct this statement: "It is hotter in summer because there is more sunlight."

12. Correct this statement: "In summer the Sun is directly overhead in New Zealand at midday."

# Year 11 Science: Moon phases and eclipses, seen from New Zealand

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. In the orbit diagram, which phase is seen from Earth at position 7?

2. Why does it take 29.5 days, not 27.3, to go from one new moon to the next?

3. On 3 March 2026 (Universal Time) there was a total lunar eclipse. What phase was the Moon in?

4. A full moon happens about every 29.5 days. Explain why there is not a lunar eclipse every month.

5. In New Zealand, a crescent Moon is seen in the western sky just after sunset. Which side of it is lit, and is it waxing or waning?

## Exam-style question: the Christmas Eve super full moon

**On 24 December 2026 a full moon happens 7 hours before the Moon reaches perigee, its closest point to Earth, 356 650 km away. Two weeks earlier, at apogee, it was 406 421 km away. Use the orbit diagram and the tables in this lesson.**

6. Describe where the Sun, Earth and Moon are at full moon, and how often a full moon comes round.

7. Explain why viewers in New Zealand see the Moon go through phases over a month, and how a waxing Moon looks different here from in the Northern Hemisphere.

8. Discuss why a super full moon is seen only one to three times a year, rather than every month.

## Fix the mistake

9. Correct this statement: "The phases happen because Earth's shadow covers part of the Moon."

10. Correct this statement: "A solar eclipse happens at full moon."

11. Correct this statement: "There should be an eclipse every month because there is a new moon every month."

12. Correct this statement: "The waxing crescent in New Zealand is lit on the right, like the pictures in most books."

# Year 11 Science: Tides: the Moon, the Sun and real New Zealand tide data

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. Auckland had a high tide at 08:55 on 10 November 2026. Using the average of 12 h 25 min, predict the time of the next high tide.

2. At which two Moon phases do spring tides happen?

3. On 18 November 2026 Auckland's highest high tide was 2.8 m and its lowest low tide 1.1 m. Calculate the tidal range.

4. Explain why there is also a high tide on the far side of Earth, opposite the Moon.

5. On 27 November 2026 Nelson's tidal range was 3.8 m and Wellington's was 1.4 m. Explain why the ranges differ when both feel the same Moon and Sun.

## Exam-style question: November tides in Auckland

**Use the LINZ data in this lesson for Auckland in November 2026: high tides about 12 h 25 min apart, a range of 1.7 m on 18 November (first quarter) and 3.2 m on 26 to 28 November (full moon on 25 November, perigee on 26 November).**

6. Describe what causes high and low tides.

7. Explain why Auckland has two high tides most days, and why they come about 50 minutes later each day.

8. Discuss why the tidal range changes over the month, and why the spring tides of 26 to 28 November were bigger than those of 9 to 11 November (range 2.6 m, new moon on 9 November, apogee on 14 November).

## Fix the mistake

9. Correct this statement: "There is one high tide a day, when the Moon is overhead."

10. Correct this statement: "Spring tides happen in spring."

11. Correct this statement: "Neap tides happen when the Moon is furthest away."

12. Correct this statement: "The Sun is much bigger, so it causes bigger tides than the Moon."

# Year 11 Science: Kinetic energy, potential energy and work

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. Calculate the kinetic energy of a 1200 kg car travelling at 15 m/s.

2. A 0.5 kg book is lifted from the floor onto a shelf 1.8 m high. How much Ep does it gain?

3. A shopper pushes a trolley 25 m along an aisle with a force of 80 N. How much work is done?

4. A diver steps off a 5.0 m platform. Ignoring air resistance, how fast is she going when she reaches the water?

5. A 55 kg student runs up stairs with a total height of 12 m in 20 s. Find the Ep gained and her power.

## Exam-style question: the playground slide

**Aroha has a mass of 40 kg. She climbs to the top of a playground slide 2.5 m above the ground and slides down from rest. Use g = 10 N/kg.**

6. Describe the energy changes as Aroha goes down the slide.

7. Calculate the greatest speed Aroha could have at the bottom, and state the assumption you made.

8. Her real speed at the bottom is 6.0 m/s. Discuss what happened to the rest of her energy, using calculations, and explain why the slide feels slightly warm afterwards.

## Fix the mistake

9. Correct this statement: "$v^2 = 64$, so the apple lands at 64 m/s."

10. Correct this statement: "Energy is lost when the object hits air resistance, so the total energy goes down."

11. Correct this statement: "A 500 g ball dropped 2 m has Ep = 500 × 10 × 2 = 10 000 J."

12. Correct this statement: "Doubling the speed doubles the kinetic energy."

# Year 11 Science: Thermal energy, heating and insulation

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. How much energy is needed to heat 2.0 kg of water from 20 °C to 45 °C?

2. 9000 J of energy raises the temperature of a 0.5 kg metal block by 20 °C. Find its specific heat capacity and use the table to name the metal.

3. How much energy is needed to boil away 0.2 kg of water that is already at 100 °C?

4. 21 000 J is given to 0.25 kg of water. By how much does its temperature rise?

5. Explain why a puffer jacket keeps you warm, in terms of heat transfer.

## Exam-style question: the hot water bottle

**Sione fills a hot water bottle with 1.5 kg of water at 60 °C and puts it in his bed. Eight hours later the water is at 20 °C. The specific heat capacity of water is 4200 J kg$^{-1}$ °C$^{-1}$.**

6. Calculate the thermal energy the water gives out over the eight hours.

7. Calculate the average rate at which the bottle gives out energy, with a unit.

8. Sione's grandmother knits a thick woollen cover for the bottle. Discuss how the cover affects conduction, convection and radiation, and what this means for how long his bed stays warm.

## Fix the mistake

9. Correct this statement: "Water heated from 20 °C to 70 °C: E = 0.5 × 4200 × 70."

10. Correct this statement: "Cold gets into the flask through the walls."

11. Correct this statement: "Hot air rises because heat rises."

12. Correct this statement: "While ice melts its temperature rises because energy is going in."

# Year 11 Science: Electrical energy, power and circuits

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. What current flows through a 12 Ω resistor with 6.0 V across it?

2. A toaster draws 4.0 A from the 230 V supply. What is its power?

3. How much energy, in joules, does that toaster use in 3.0 minutes?

4. What does it cost to run a 2.0 kW heater for 3 hours at 42.1 c/kWh?

5. A 9 W LED gives the same light as a 60 W incandescent bulb. By what percentage is its power lower?

## Exam-style question: the hair dryer

**Ari's hair dryer is rated at 1800 W on the 230 V mains supply. She uses it on high for 10 minutes every day. Electricity costs 42.1 cents per kWh.**

6. Describe the energy changes in the hair dryer.

7. Calculate the current in the hair dryer on high, with a unit.

8. Calculate how much it costs Ari to use the hair dryer for a year.

9. On the low setting, the heating element has a higher resistance. Discuss how this changes the current, the power and how long Ari takes to dry her hair.

## Fix the mistake

10. Correct this statement: "A 2 kW heater for 3 hours: E = 2 × 3 = 6 J."

11. Correct this statement: "Current gets used up by the heater, so less comes out than goes in."

12. Correct this statement: "A bigger resistance means a bigger current, because the resistor works harder."

13. Correct this statement: "Power and energy are the same thing, both in watts."

## Answer key (for parents and tutors)

1. Which of these is a science idea? (a) Kauri can live for over 2000 years. (b) PA in moved soil infects kauri roots, so trees near busy tracks are more likely to be infected.
   **(b), because it links a cause (PA moving in soil) to an effect (more infection near tracks); (a) is a fact.**
2. Name a group with a perspective on kauri dieback in the Waitākere Ranges and outline their view in one sentence.
   **For example, Te Kawerau ā Maki: as mana whenua they placed a rāhui in December 2017 so the forest could recover, because the loss of kauri threatens a taonga and their people.**
3. Explain why a raised boardwalk slows the spread of kauri dieback.
   **PA travels in soil, and the boardwalk keeps boots off the soil above the roots, so walkers cannot pick up or drop infected soil there.**
4. Give one example of tiakitanga in the response to kauri dieback, and say who showed it.
   **For example, the iwi took responsibility by placing the rāhui to protect the forest for future generations; or walkers taking care by cleaning their shoes at every station.**
5. The share of Waitākere kauri infected rose from 7.9% in 2011 to 19.0% in 2016. By how many percentage points did it rise?
   **19.0 − 7.9 = 11.1 percentage points.**
6. Correct this statement: "My science idea is that 19% of kauri in the Waitākere Ranges are infected."
   **That is a fact; the science idea is the cause and effect behind it, for example that PA moves in soil and infects roots.**
7. Correct this statement: "Another perspective is my uncle's, who thinks the tracks should stay open."
   **A perspective must belong to a particular group, like Te Kawerau ā Maki, Auckland Council or a tramping club, with their reasons.**
8. Correct this statement: "Kauri dieback is a fungus that spreads through the air."
   **PA is a water mould (oomycete), not a fungus, and it spreads in moved soil, which is why cleaning boots works.**
9. Correct this statement: "I mentioned tiakitanga in my conclusion, so that is covered."
   **Show it in the evidence: say who takes care or responsibility, what they actually do, and how that links to the science.**

## Answer key (for parents and tutors)

1. Turn this fact into a science idea: "Some central Auckland beaches get black pins after heavy rain."
   **In older suburbs wastewater and stormwater share pipes, so heavy rain fills them past capacity and untreated wastewater overflows onto the beach.**
2. Explain why Safeswim scientists count enterococci instead of testing for every germ.
   **Enterococci live in the gut, so a high count shows faecal material is present, and with it the germs that cause illness; they are quicker and cheaper to count than every possible germ.**
3. Explain how the Central Interceptor reduces overflows onto beaches.
   **It gives the network much more room: about 226 000 m³ of storage, so stormy flows are held and sent to the Māngere plant at a rate it can treat instead of spilling out.**
4. Write one sentence that discusses why Ngāti Whātua Ōrākei's perspective matters to the response.
   **For example: The iwi's focus on the mauri of the harbour and its kaimoana means the response is judged by the long-term health of the Waitematā, not just whether a beach is green on one day.**
5. At a green pin the risk is under 2%; at a long-term red pin it is above 10%. Out of 100 swimmers, how many might get sick at each?
   **Green: fewer than 2 in 100; long-term red: more than 10 in 100.**
6. Correct this statement: "My report is long and has lots of facts, so it should get Excellence."
   **Grades come from depth: Excellence needs a discussion of why both perspectives matter to the response, not more facts.**
7. Correct this statement: "The iwi think the beach is dirty and the scientists think it is dirty too."
   **Give each group's reasons: the science view uses bacteria counts, while Ngāti Whātua Ōrākei judge the mauri of the harbour and its kaimoana.**
8. Correct this statement: "E. coli and enterococci are the germs that make swimmers sick."
   **They are indicator bacteria: they show that faecal material is present, and with it the viruses and bacteria that cause illness.**
9. Correct this statement: "The Central Interceptor cleans the sewage in the tunnel."
   **The tunnel stores and carries wastewater; treatment happens at the Māngere plant, at a rate the plant can cope with.**

## Answer key (for parents and tutors)

1. Which approach best answers: which of the beetles caught in pitfall traps in the school bush are native?
   **Classifying and identifying: each beetle is named with a key or guide and sorted into native or introduced.**
2. Which approach best answers: do kererū visit gardens more often in the months when more trees are fruiting?
   **Pattern seeking: the number of visits and the amount of fruit both vary on their own and cannot be controlled, so you look for a link across many months.**
3. A student tests whether the slope of a tray of soil changes how much soil washes off when 500 mL of water is poured over it. Name the independent variable, the dependent variable and one controlled variable.
   **Independent: the slope (angle) of the tray. Dependent: the amount (mass) of soil washed off. Controlled, for example: the 500 mL of water, how fast it is poured, the type and amount of soil.**
4. Explain why modelling, not a fair test, is the right approach for predicting how a 1 m rise in sea level would affect a coastal town.
   **The sea cannot be raised to test it, and the change is too big and too far in the future, so a model (a map or computer model of the town and its land heights) is used to predict it.**
5. A student wrote: 'Exploring and observing was appropriate because we explored and observed the stream.' Say why this is not yet Merit, and what it needs.
   **It only repeats the approach's name; it needs a reason the approach suited the question, backed by evidence from the investigation, such as what was found and measured on the visit.**
6. Correct this statement: "Every investigation is a fair test, so each one needs an independent and a dependent variable."
   **Only fair testing changes one variable on purpose; the other four approaches answer different kinds of question.**
7. Correct this statement: "The graph shows pH falling as $CO_2$ rises, so this proves $CO_2$ causes it."
   **A pattern shows a link, not a cause; you need a fair test, a model or known chemistry as well to argue the cause.**
8. Correct this statement: "Pattern seeking was appropriate because we were looking for patterns."
   **That only repeats the name; give the reason with evidence, such as the ocean cannot be controlled, so 23 years of measured data was the only way to see the trend.**
9. Correct this statement: "Surveys and things said at a wānanga are not real science, so I left them out."
   **Surveys, statistics and wider knowledge, including mātauranga shared at a wānanga, all count as evidence when used with care and acknowledged.**

## Answer key (for parents and tutors)

1. Three repeats of a fair test give 12 mg, 14 mg and 13 mg of algae. Find the mean.
   **(12 + 14 + 13) ÷ 3 = 13 mg.**
2. A stream has an MCI of 104. Which class is it in?
   **Good (100 to 119).**
3. A class identifies 12 kinds of invertebrate, and 3 of them are EPT kinds. Work out the percentage of EPT kinds.
   **3 ÷ 12 × 100 = 25%.**
4. In the fertiliser test, which jars are the control, and what are they for?
   **The 0-drop jars; they show how much algae grows from the stream water alone, so the extra growth in the other jars can be put down to the fertiliser.**
5. Give one thing the council data could not tell the class, which their own classifying and identifying could.
   **How healthy their own stream is: which animals actually live in it, and its own MCI.**
6. Write one sentence that links the pattern seeking and the classifying and identifying, with evidence, as an Excellence answer would.
   **For example: the council data showed urban streams score as low as 37, which led us to check our own urban stream, and its MCI of 86 with only 22% EPT kinds confirmed it follows the same pattern.**
7. Correct this statement: "My controlled variable is the amount of fertiliser."
   **That is the independent variable, the one you change; controlled variables are kept the same, such as water volume, light and temperature.**
8. Correct this statement: "I included the odd jar in the mean so all my data counts."
   **If a result is far from its repeats and you can find why (the jar was moved into the sun), leave it out of the mean and say so.**
9. Correct this statement: "The fair test proves fertiliser is what is wrong with the stream."
   **It shows nutrients increase algae in jars; to claim it for the stream you need nutrient readings from the stream itself.**
10. Correct this statement: "For Excellence I wrote a summary of each investigation again."
    **Excellence analyses the links: how one finding led to, supported or limited another, with evidence from each.**

## Answer key (for parents and tutors)

1. Scientists at Baring Head near Wellington have measured carbon dioxide in the air the same way for over fifty years, so other stations can compare with them.
   **Repeatable, checkable data (a long record taken the same way).**
2. Tuna counts in a river fall in the years after a dam is built upstream.
   **Patterns and interactions (tuna numbers linked to a dam).**
3. NIWA researchers worked with iwi who use hīnaki and know when tuna migrate.
   **Varied perspectives, including mātauranga Māori.**
4. A study's results were checked by other experts before the journal published them.
   **Checking claims (peer review).**
5. Early results suggested the chemical alone was enough, but later work found the whole seaweed worked better.
   **Tentativeness: the idea changed when new evidence came in.**
6. How does varied perspectives contribute to the idea? (Achieved)
   **Achieved: Iwi have long-term knowledge of where and when tuna run and use them to judge river health; this tells scientists where and when to sample.**
7. How does technology contribute to the idea? (Achieved)
   **Achieved: Fyke nets and electric fishing let scientists catch, measure and return eels, so they can count them without killing them.**
8. Why is each of these features significant to the idea? (Merit)
   **Merit: Mātauranga is significant because it holds observations over many generations, far longer than any science record, so it shows changes a short study would miss; without it, sampling could be at the wrong place or season. Technology is significant because standard nets and electric fishing give counts taken the same way everywhere, so rivers can be compared; without that, a pattern linking farming or dams to eel numbers could not be seen.**
9. How do the two features work together to develop the idea? (Excellence)
   **Excellence: Mātauranga points to where and when eels gather, so the nets and electric fishing are used where they give the most useful data; the standard counts then test and add numbers to what iwi have noticed, such as fewer tuna below a dam. Each makes the other stronger, and together they give evidence that can guide kaitiakitanga of the river.**
10. Correct this statement: "Cattle farming is important, so the science helps farmers keep their jobs."
    **That is science helping society. For a social factor, show society shaping the science: farming matters, so researchers looked for ways to cut methane without cutting herds.**
11. Correct this statement: "The study proved that the seaweed reduces methane."
    **Evidence supports an idea but never proves it; say the trials gave strong evidence, and that more research is still testing it.**
12. Correct this statement: "Interactions: the scientists interacted with farmers and other scientists."
    **In science an interaction is a link between variables, such as more seaweed in the feed and less methane; people working together is collaboration.**
13. Correct this statement: "Technology made the data more accurate."
    **Data must always be reliable; say what the technology let them measure or do that they could not before, using the resource.**

## Answer key (for parents and tutors)

1. Give one example of a need or an opportunity that helped start the Baring Head record. (Achieved)
   **Opportunity: Keeling wanted a Southern Hemisphere record to match Mauna Loa, and New Zealand scientists took up that chance (the need was to find out whether rising $CO_2$ was global).**
2. Give one way the Baring Head team made their data repeatable and checkable. (Achieved)
   **They kept only readings from steady southerly winds, and checked the analyser against reference gases so readings from different years can be compared.**
3. Why was repeatable, checkable data significant for this idea? (Merit)
   **$CO_2$ rises by only about 1.3 to 2.4 ppm a year, so without identical, checked methods over fifty years the trend could not be told apart from measurement error, and other stations could not compare their numbers with it.**
4. How did needs and opportunities and repeatable data work together to develop the idea? (Excellence)
   **The need for a southern record gave the reason to build a station and keep it running; that commitment made it possible to collect consistent data for decades; the long, repeatable record then showed a speeding-up rise, which created a new need, to find out where the $CO_2$ goes, and so led to measuring the ocean at Munida. Each feature fed the other.**
5. Correct this statement: "The pH only fell from 8.09 to 8.06, so the ocean has hardly changed."
   **pH is a log scale, so that small drop is an 8.6% rise in hydrogen ions over 23 years, which is a real change for shell-building animals.**
6. Correct this statement: "The ocean is becoming acidic, so its pH is now below 7."
   **Seawater is still basic, around pH 8.06; acidification means the pH is falling towards 7, not that it has passed it.**
7. Correct this statement: "Baring Head proves that the ocean is acidifying."
   **Baring Head measures $CO_2$ in the air; the ocean evidence comes from sampling the sea, such as the Munida Transect, and evidence supports an idea rather than proving it.**
8. Correct this statement: "Existing models: Dr Currie used her earlier pH readings."
   **An existing model is an accepted idea, here that dissolved $CO_2$ forms carbonic acid; earlier readings from the same study are part of the data, not a model.**

## Answer key (for parents and tutors)

1. A Facebook post from a fitness influencer says a protein powder "burns fat while you sleep" and gives a discount code. What is the main purpose?
   **To sell the protein powder (and earn from the discount code); persuading, not informing.**
2. A university research team publishes a study on kauri dieback in a peer-reviewed journal. Who is the source?
   **The university research team that did the study.**
3. A news site runs a story that, at the bottom, says it was supplied by the company that makes the product. Who is the source?
   **The company, because it created the article; the news site only published it.**
4. A company paid for a study showing its toothpaste whitens teeth. Name the convention this raises, and its effect on the claim.
   **A conflict of interest: the company gains if you believe it, so it might leave out unhelpful results, making the claim less believable.**
5. (a) Who published this information?
   **SunShield Ltd, the company that makes and sells the sunscreen (Achieved).**
6. (b) Why was it published?
   **To persuade people to buy the lotion, while informing them about UV protection (Achieved).**
7. (c) State one science-related claim the resource makes.
   **The lotion blocks 98% of UVB rays (Achieved).**
8. (d) Identify the science language or conventions used to support the claim.
   **Language: SPF 50, UVB, dermatologist tested, scientifically proven. Conventions: a percentage result, a lab test, a sample of 20 people, no peer review, a conflict of interest (Achieved for naming these).**
9. (e) How well do they support the claim? Use evidence from the resource.
   **Merit: SunShield sells the lotion, so it gains if people believe it and may only report good results, which weakens the claim; words like "dermatologist tested" make it sound expert, but we are not told what the test found. Excellence: the 98% figure and the hired lab make the claim look scientific, but 20 people is a small sample, so the result could be a fluke, and because the test was not peer reviewed nobody independent has checked the method. "Trusted by 10,000 families" is a testimonial, which is popularity, not evidence. Overall the claim is only weakly supported; it would be stronger with a larger test by an independent lab, published and peer reviewed.**
10. Correct this statement: "The source is Google, because that is where I found it."
    **The source is whoever created or paid for the information, such as the company or researchers, not the search engine or app.**
11. Correct this statement: "The company sells the product, so the claim is false."
    **A conflict of interest makes a claim less trustworthy, not automatically false; say what evidence might be missing.**
12. Correct this statement: "It was peer reviewed, so it is proven."
    **Peer review makes a claim more reliable, but science is never proven for good; new evidence can still change it.**
13. Correct this statement: "I know from experience that honey does not work, so the claim is wrong."
    **Judge the claim on the evidence in the resource, not your own opinion or extra research; markers do not credit that.**

## Answer key (for parents and tutors)

1. A graph's axis starts at 20. Brand X scored 30 and brand Y scored 25. How many times taller does X's bar look, and what is the real percentage difference compared with Y?
   **Bar heights are 30 − 20 = 10 and 25 − 20 = 5, so X looks 2 times as tall; the real difference is 5 ÷ 25 × 100 = 20% more.**
2. Towns with more libraries have more crime. Give the most likely reason.
   **A third factor: bigger towns have more people, so more libraries and more crime; libraries do not cause crime.**
3. 50 people took a cold remedy and most felt better within 5 days. What convention is missing?
   **A control group taking a placebo, since most colds get better in about that time anyway.**
4. Which is more honest about a single study: "proves" or "suggests"? Why?
   **"Suggests", because one study can support a conclusion but cannot prove it; new evidence could change it.**
5. (a) Who published this information, and why?
   **SleepRight NZ, a company selling blue-light glasses; to persuade teenagers or parents to buy them, while seeming to inform (Achieved).**
6. (b) State one science-related claim in the post.
   **Using a phone late at night makes teenagers sleep less (or lowers their grades) (Achieved).**
7. (c) Identify the science language used.
   **Melatonin, circadian rhythm, blue light, suppresses (Achieved).**
8. (d) Identify the science conventions used, or missing.
   **A bar graph with a cut-off axis and no units, a sample of 40 from one school, a survey with no control group, no peer review, and a conflict of interest (Achieved).**
9. (e) How well do the language and conventions support the claim? Use evidence from the resource.
   **Merit: the words melatonin and circadian rhythm make the post sound expert, but they are not explained or linked to any measurement in the study, so they add authority without evidence. The axis starting at 6.5 makes a 1 hour difference look like a threefold gap, and with no units we cannot even be sure it is hours. Excellence: these weaknesses add up. 40 students from one school is a small, narrow sample, and because it is a survey it only shows a correlation; teens who stay up on phones may differ in other ways, such as stress or homework. SleepRight profits from the claim and the work was not peer reviewed, so nobody independent checked it. Nothing in the resource measures grades at all. The claim is weakly supported; a peer-reviewed study of many schools, with a group randomly asked to stop phone use at 10 pm and a graph from 0 with units, would make it far stronger.**
10. Correct this statement: "The resource uses words like germinate and polymer, so the claim is supported."
    **Name the words, then say whether they are used correctly and explained, and how that changes how believable the claim is.**
11. Correct this statement: "The graph matches the claim, so the claim is true."
    **Judge how the graph is drawn (axis start, units, labels, sample) and why it was included, not just whether it agrees with the claim.**
12. Correct this statement: "Ice cream sales and drownings rise together, so ice cream causes drowning."
    **A correlation shows a link, not a cause; a third factor such as hot weather can drive both.**
13. Correct this statement: "There is no peer review, so the claim is wrong."
    **Missing peer review means nobody independent has checked it, which makes the claim less certain, not false.**

## Answer key (for parents and tutors)

1. Give two differences in structure between a bacterium and a yeast cell.
   **A yeast cell has a nucleus, but a bacterium has its DNA as a loop free in the cytoplasm; the yeast cell wall is made of chitin; a yeast cell is also bigger (3 to 10 µm against 1 to 5 µm).**
2. A bacterium divides every 30 minutes. Starting from one cell, how many cells are there after 4 hours?
   **4 hours = 240 minutes, 240 ÷ 30 = 8 divisions, $2^8$ = 256 cells.**
3. Write the word equation for anaerobic respiration in yeast, and say which product makes bread rise.
   **glucose → ethanol + carbon dioxide; the carbon dioxide makes bread rise.**
4. Explain why a virus is described as not fully living.
   **A virus is not a cell and carries out no life processes on its own: it can only replicate, and only inside a host cell using the host's machinery.**
5. Explain why dried apricots keep for months but fresh apricots go mouldy within a week or two.
   **Mould needs water: without moisture, the enzymes released by the hyphae cannot digest the fruit and the hyphae cannot absorb nutrients, and spores cannot germinate, so the dried fruit keeps.**
6. Correct this statement: "Viruses are just very small bacteria."
   **Viruses are not cells at all: they are genetic material in a protein coat, many times smaller than a bacterium.**
7. Correct this statement: "Fungi take in their food and digest it inside, like animals do."
   **Fungi release enzymes onto the food and absorb the digested small molecules through their hyphae, which is extracellular digestion.**
8. Correct this statement: "At high temperatures the enzymes die."
   **Enzymes are proteins, not living things; heat denatures them, changing their shape so they stop working.**
9. Correct this statement: "Yeast only makes carbon dioxide when it ferments."
   **Yeast makes carbon dioxide in both aerobic and anaerobic respiration; only the anaerobic route also makes ethanol.**

## Answer key (for parents and tutors)

1. Name the four phases of a growth curve in order, and give one reason for the stationary phase.
   **Lag, log (exponential), stationary, death. In the stationary phase food is running low and wastes are building up, so cells are made only as fast as they die.**
2. Room 9 measured the pH of a kombucha brew: day 0, pH 5.0; day 4, pH 3.8; day 8, pH 3.2; day 12, pH 2.9. Describe the change and explain it with a life process.
   **The pH fell by 2.1 over 12 days (5.0 to 2.9), quickly at first and then more slowly. Yeast respires the sugar into ethanol, and acetic acid bacteria use the ethanol and excrete acetic acid, which lowers the pH of the brew.**
3. Bread dough was left for an hour at 5 °C, 30 °C and 70 °C, and rose 2 mm, 25 mm and 0 mm. Explain how changing the temperature changed the rate of respiration in the yeast.
   **From 5 °C to 30 °C the dough rose more (2 mm to 25 mm) because the yeast's enzymes worked faster as particles moved faster and collided more often, so respiration made more carbon dioxide. At 70 °C it rose 0 mm because the heat denatured the enzymes, so respiration stopped.**
4. For kauri dieback, sort these factors into abiotic or biotic, in order: soil moisture, the kauri tree, feral pigs, temperature.
   **Abiotic, biotic, biotic, abiotic.**
5. A student writes: 'Phytophthora makes kauri leaves turn yellow, so it changes the forest.' Explain why this does not reach Excellence.
   **It describes a symptom of the disease, the microbe acting as a whole, not how one of its life processes changes a factor. Better: its threads feeding in the roots (nutrition) destroy root tissue, so less water reaches the canopy, which thins and lets more light and heat reach the forest floor.**
6. Correct this statement: "The bacteria respired faster at 43 °C because it was warmer."
   **Give the reason in the cells: near 43 °C their enzymes work close to their best, so lactic acid builds faster, as the pH falling to 4.5 shows.**
7. Correct this statement: "In the stationary phase the yeast has stopped reproducing."
   **Cells are still dividing, but about as many die as are made, because food is running low and wastes are building up.**
8. Correct this statement: "For Excellence I explained how E. coli gives people diarrhoea."
   **Symptoms are about the microbe as a whole; Excellence needs how a life process, such as the acid or gas it excretes, changes a factor of the environment.**
9. Correct this statement: "My graph shows the yeast grew best at 35 °C, so I don't need numbers in my writing."
   **Quote the observations in your sentences, with units, because the grade depends on linking the evidence, not just pointing to it.**

## Answer key (for parents and tutors)

1. Write the formulae of potassium carbonate, iron(III) hydroxide and zinc nitrate.
   **$K^+$ and $CO_3^{2-}$ give $K_2CO_3$; $Fe^{3+}$ and $OH^-$ give $Fe(OH)_3$; $Zn^{2+}$ and $NO_3^-$ give $Zn(NO_3)_2$.**

2. Count the atoms of each element in $3Ca(NO_3)_2$.
   **Ca 3, N 6, O 18 (3 × 2 × 3 = 18).**

3. Balance $Fe + O_2 \rightarrow Fe_2O_3$, the equation for iron rusting.
   **$4Fe + 3O_2 \rightarrow 2Fe_2O_3$ (Fe 4 and O 6 on each side).**

4. Hydrogen peroxide breaks down into water and oxygen. Balance $H_2O_2 \rightarrow H_2O + O_2$.
   **$2H_2O_2 \rightarrow 2H_2O + O_2$ (H 4 and O 4 on each side).**

5. 5.0 g of baking soda is added to 50.0 g of vinegar in an open cup. When the fizzing stops the cup's contents weigh 52.4 g. What mass of carbon dioxide escaped?
   **5.0 + 50.0 = 55.0 g at the start, so 55.0 − 52.4 = 2.6 g of $CO_2$ escaped.**

6. Steel wool is heated in air and its mass goes up. Explain why, using conservation of mass.
   **Iron atoms combine with oxygen atoms from the air to make iron oxide; no atoms are created, but the oxygen atoms were not weighed at the start, so the solid gains their mass.**

7. Correct this statement: "To balance $H_2 + O_2 \rightarrow H_2O$, change the water to $H_2O_2$."
   **$H_2O_2$ is hydrogen peroxide, a different substance; change coefficients only: $2H_2 + O_2 \rightarrow 2H_2O$.**

8. Correct this statement: "Magnesium hydroxide is $MgOH_2$."
   **Two hydroxide ions need brackets, $Mg(OH)_2$, because the 2 applies to both the O and the H.**

9. Correct this statement: "The mass went down in the open flask, so mass was not conserved."
   **Mass was conserved, but a gas product escaped into the air, so the balance no longer weighed all the products.**

10. Correct this statement: "Aluminium oxide is AlO because aluminium and oxygen combine."
    **$Al^{3+}$ and $O^{2-}$ only cancel as $Al_2O_3$: 2 × (+3) = +6 and 3 × (−2) = −6.**

## Answer key (for parents and tutors)

1. Name the reaction type: limestone heated in a kiln gives off a gas; two clear solutions are mixed and go cloudy; an iron gate turns orange-brown; lime is spread on an acidic paddock.
   **Decomposition, precipitation, combination, neutralisation.**

2. Write balanced equations for methane ($CH_4$) burning completely, and burning incompletely to make carbon monoxide.
   **Complete: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$. Incomplete: $2CH_4 + 3O_2 \rightarrow 2CO + 4H_2O$ (C 2, H 8, O 6 on each side).**

3. Barium nitrate and sodium sulfate solutions are mixed. Name the precipitate, write the balanced equation, and name the spectator ions.
   **Barium sulfate: $Ba(NO_3)_2 + Na_2SO_4 \rightarrow BaSO_4 + 2NaNO_3$; $Na^+$ and $NO_3^-$ are spectators.**

4. 50 g of calcium carbonate is heated until it has all decomposed. What mass of calcium oxide is left, and what mass of carbon dioxide escapes?
   **$CaCO_3 \rightarrow CaO + CO_2$, and 100 g gives 56 g CaO and 44 g $CO_2$, so 50 g gives 28 g of calcium oxide and 22 g of carbon dioxide (28 + 22 = 50).**

5. A gas heater with no flue is used in a closed bedroom. Discuss why this is dangerous, using combustion equations and conservation of mass.
   **Achieved: methane burns in oxygen; with plenty of air, $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$. Merit: in a closed room the oxygen is used up, and with too little oxygen there are not enough O atoms to turn every C atom into $CO_2$, so $2CH_4 + 3O_2 \rightarrow 2CO + 4H_2O$ happens instead. Excellence: the carbon atoms cannot disappear, so as oxygen runs short more of them leave as carbon monoxide, which is colourless, odourless and poisonous, and water vapour builds up as well; opening a window or using a flued heater supplies oxygen for complete combustion.**

6. Explain why an open bottle of fizzy drink gets lighter over an hour, but an unopened one does not.
   **Carbonic acid decomposes, $H_2CO_3 \rightarrow H_2O + CO_2$, and in the open bottle the $CO_2$ gas escapes, taking its mass with it; in the sealed bottle every atom stays inside, so the mass is conserved.**

7. Correct this statement: "Incomplete combustion makes less carbon dioxide because some of the carbon is destroyed."
   **No carbon is destroyed; with too little oxygen some carbon atoms leave as carbon monoxide or soot instead of $CO_2$.**

8. Correct this statement: "A rusty nail weighs less because the rust has eaten some of the iron away."
   **Rust contains oxygen taken from the air, so the nail plus its rust weighs more than the clean nail did.**

9. Correct this statement: "When silver nitrate and sodium chloride are mixed, every ion forms the precipitate."
   **Only $Ag^+$ and $Cl^-$ form solid AgCl; $Na^+$ and $NO_3^-$ are spectator ions that stay dissolved.**

10. Correct this statement: "Fizzing always means neutralisation."
    **Fizzing just means a gas is made; a soft drink going flat is decomposition of carbonic acid, not a neutralisation.**

## Answer key (for parents and tutors)

1. A woman who is a carrier for albinism (Aa) has children with a man who is homozygous dominant (AA). What is the chance that a child has albinism?
   **0: every child gets an A from the father, so children are AA or Aa and none is aa.**
2. In question 1, what fraction of the children are expected to be carriers?
   **½ (50%): the Punnett square gives AA, AA, Aa, Aa.**
3. Two parents with normal pigment have a child with albinism, then a second child with normal pigment. What is the chance that the second child is a carrier?
   **⅔: both parents are Aa; a pigmented child is AA, Aa or Aa (the aa box is ruled out), and 2 of those 3 are carriers.**
4. A man's skin cell mutates after years of sunburn. Can the mutation be passed to his children? Explain.
   **No: it is a somatic mutation in a skin cell, and only mutations in cells that make eggs or sperm are inherited.**
5. Name the two events in meiosis that make each gamete different, and say which one swaps parts between chromosomes.
   **Crossing over and independent assortment; crossing over is the one where the two chromosomes of a pair swap sections.**
6. Describe the difference between genotype and phenotype, using lactase persistence as your example.
   **(Achieved) Genotype is the pair of alleles a person has for the gene: LL, Ll or ll. Phenotype is what shows: being able to digest milk as an adult (LL or Ll) or not (ll). Merit adds that Ll and LL give the same phenotype because L is dominant, so you cannot tell a carrier by looking.**
7. Two adults who both digest milk easily have a son who, as an adult, gets sick after drinking milk. Explain how this happened, using a Punnett square, and give the chance for each of their children.
   **(Merit) The son is ll, so he received an l from each parent; the parents can digest milk, so each has an L; both parents are Ll. Punnett square: L and l eggs against L and l sperm gives LL, Ll, Ll, ll: 3 persistent to 1 non-persistent, so each child has a ¼ (25%) chance of being ll. Meiosis separates each parent's L and l into different gametes, and random fertilisation joined two l gametes.**
8. Discuss how the L allele first appeared and why it became common in populations with a long history of keeping dairy animals but stayed rare in others. In your answer, explain why the first mutation must have happened in a gamete-making cell, and link the nature of the allele to survival.
   **(Excellence) The L allele arose as a change in the base sequence of the DNA that controls the lactase gene. It must have occurred in a cell that makes eggs or sperm, because only then can it be inherited and spread through later generations; a somatic mutation would have died with that person. In dairying populations the allele was beneficial: adults who could digest milk had an extra food and drink source, so they were more likely to survive famines and raise children, who inherited L. Over many generations differing survival raised the frequency of L. Where people did not keep dairy animals, L gave no advantage, so it stayed rare. Because L is dominant, Ll carriers of l are persistent too, so the l allele is not removed and still turns up when two carriers have children, as in part 2.**
9. Correct this statement: "A gene and an allele are the same thing."
   **A gene is the section of DNA for a trait; alleles are the different versions of that gene, such as A and a.**
10. Correct this statement: "Their first child had albinism, so the next three will not."
    **Each fertilisation is independent, so every child of two carriers has the same ¼ chance, whatever the earlier children were.**
11. Correct this statement: "Getting skin cancer from the sun is a mutation, so the person's children can inherit it."
    **That is a somatic mutation in skin cells; only mutations in cells that make eggs or sperm are heritable.**
12. Correct this statement: "Meiosis makes new alleles."
    **Only mutation makes new alleles; crossing over and independent assortment make new combinations of alleles that already exist.**

## Answer key (for parents and tutors)

1. A flock of 40 birds has 20 copies of allele b. What is the frequency of b?
   **40 birds have 80 alleles, so b = 20 ÷ 80 = 0.25.**
2. Two unaffected parents have a child with a genetic condition. Is the allele for the condition dominant or recessive?
   **Recessive: each parent must carry it without showing it.**
3. A flood kills most of a beetle population at random. Which population source is this, and what can happen to the allele frequencies?
   **Small population size (a bottleneck): allele frequencies change by chance (genetic drift), and rare alleles can be lost.**
4. Why were Richard Henry's chicks so valuable to Kākāpō Recovery, and which population source does this show?
   **He came from the mainland population, so his chicks carried alleles the Rakiura birds lacked, adding variation; this is like migration (gene flow).**
5. In the PKU pedigree, what is the chance that individual 8 is a carrier, and how could it be confirmed?
   **⅔ (her parents 5 and 6 are both Pp and she is unaffected); a DNA test for the p allele would confirm it.**
6. Give the genotypes of birds 1, 2 and 3, and the possible genotypes of bird 4.
   **(Achieved) 3 is albino, so aa. 1 and 2 are unaffected but each passed an a to bird 3, so both are Aa. Bird 4 is unaffected, so AA or Aa.**
7. Explain why the genotype of bird 4 cannot be confirmed from the pedigree, and calculate the chance that she is a carrier.
   **(Merit) Aa × Aa gives 1 AA : 2 Aa : 1 aa. Bird 4 is not aa, so she is one of the three other boxes, and 2 of those 3 are Aa: a ⅔ chance she is a carrier. Her chicks 6 and 7 do not help: with an AA mate every chick is unaffected whether she is AA or Aa, so the pedigree cannot separate the two.**
8. The rangers plan to pair female 6 with her uncle, bird 3. Discuss this plan. Include the chance that a chick from the pair is albino (assume bird 5 is AA), why this is non-random mating, and how a DNA test for the a allele would change the decision. Evaluate how reliable your answer is.
   **(Excellence) Bird 6 is a carrier only if 4 is Aa (⅔) and passed on a (½): ⅔ × ½ = ⅓. Bird 3 is aa and always passes on a, so a chick is albino only if 6 is Aa and passes on a (½): ⅓ × ½ = ⅙, about 17%. Every chick from bird 3 also gets an a, so all the unaffected chicks are carriers, raising the frequency of a. Pairing relatives on purpose is non-random mating; in a small population it makes aa chicks, which are less likely to survive in the wild, more likely. A DNA test on bird 6 settles it: if she is AA, no chick will be albino (all will be Aa carriers); if she is Aa, each chick has a ½ chance. Pairing 6 with an unrelated AA male instead gives no albino chicks at all. The ⅙ depends on the assumption that bird 5 is AA; no recorded albino chicks on his island is not proof, and if 5 were Aa the risk would be higher. So the purpose of tracking, to keep the a allele from rising and avoid albino chicks, is best met by DNA testing 4, 5 and 6 before choosing pairs.**
9. Correct this statement: "Allele frequency of b = number of bb individuals ÷ population size."
   **Count copies of b: each Bb has one and each bb has two, then divide by twice the number of individuals.**
10. Correct this statement: "An unaffected child of two carriers has a ¾ chance of being a carrier."
    **Once we know the child is unaffected the aa box is ruled out, so it is 2 out of the remaining 3: ⅔.**
11. Correct this statement: "Non-random mating and inbreeding mean the same thing."
    **Inbreeding is one kind of non-random mating; choosing mates by a trait such as colour or size is non-random mating too.**
12. Correct this statement: "If a recessive allele becomes more common, more individuals will show the trait."
    **Not always: the extra copies can sit in carriers, where the dominant allele masks them, so the phenotype stays rare.**

## Answer key (for parents and tutors)

1. Iodine crystals are used to make an antiseptic. A student warms iodine and salt crystals side by side in a warm water bath. The iodine slowly gives off a purple vapour, but the salt crystals do not change. (a) Name the type of material iodine is and the type salt is. (b) Describe the particles and the forces between them in each substance. (c) Explain why the iodine turns to vapour at this temperature but the salt does not change.
   **(a) Iodine is a molecular substance; salt is an ionic material. (b) Iodine is made of $I_2$ molecules, each two atoms held by a strong covalent bond, with weak intermolecular forces between molecules. Salt is a 3D lattice of alternating $Na^+$ and $Cl^-$ ions held by strong ionic bonds in every direction. Getting (a) right and describing one structure earns Achieved. (c) To become a vapour, the iodine molecules only need to separate from each other, which means overcoming the weak forces between molecules; the covalent bonds inside each $I_2$ do not break. Little heat energy does this, so a warm water bath is enough. To melt salt, the strong ionic bonds between ions all through the lattice must be overcome, which needs far more energy, so the salt stays solid. Explaining one substance this way is Merit; comparing both, naming which forces break in each and linking the difference in force strength to what the student saw, is Excellence.**

2. Name the particles in copper wire and the force that holds them together.
   **Positive copper ions (cations) and delocalised electrons, held by metallic bonding: the strong attraction between the cations and the sea of electrons.**

3. A white solid does not conduct electricity, but it conducts once dissolved in water. What type of material is it, and why does dissolving change things?
   **Ionic; in the solid the ions are fixed in the lattice, but in solution they are free to move and carry charge.**

4. Diamond and graphite are both pure carbon. Why does graphite conduct electricity when diamond does not?
   **In graphite each carbon bonds to only three others, leaving one delocalised electron free to move; in diamond all four outer electrons are used in covalent bonds, so none are free.**

5. Why is low-density polyethylene less dense than high-density polyethylene?
   **LDPE chains have side branches that stop them packing closely, so there is less mass in each cubic centimetre; HDPE's straight chains pack tightly.**

6. Carbon dioxide is a gas at room temperature. Which forces are weak in carbon dioxide, and which are strong?
   **The forces between $CO_2$ molecules are weak; the covalent bonds between the carbon and oxygen atoms inside each molecule are strong.**

7. Correct this statement: "When water boils, the covalent bonds in the water molecules break."
   **Boiling only overcomes the weak forces between molecules; each $H_2O$ molecule stays whole in the steam.**

8. Correct this statement: "Salt is made of sodium and chlorine molecules."
   **Salt is an ionic lattice of $Na^+$ and $Cl^-$ ions; there are no molecules in an ionic material.**

9. Correct this statement: "Graphite conducts because its layers slide."
   **Graphite conducts because each carbon has one delocalised electron free to move; sliding layers explain softness, not conduction.**

10. Correct this statement: "Polymers are held together by weak forces, so they are weak."
    **Bonds along each chain are strong covalent bonds; only the forces between chains are weak, and long chains have many of them.**

## Answer key (for parents and tutors)

1. A frying pan has an aluminium body, a PTFE non-stick coating on the inside, and a plastic handle. (a) Name the type of material for the aluminium body and for the PTFE coating. (b) Explain why aluminium is suitable for the body of the pan. (c) Discuss why the handle is made from a polymer rather than from aluminium.
   **(a) Aluminium is a metallic solid; PTFE is a polymer. (b) Aluminium is a lattice of cations surrounded by delocalised electrons, held by strong metallic bonding. The delocalised electrons carry heat energy quickly from the element to the food, so the pan heats evenly. The strong metallic bonding means a lot of energy is needed to melt it, so it stays solid on the stove. The non-directional bonding lets layers slide, so aluminium can be pressed into a pan shape. Its low density for a metal (2.70 g/cm³) keeps the pan light to lift. Describing one property with its use is Achieved; explaining it from the particles and forces is Merit. (c) The handle must stay cool enough to hold. A polymer is long chain molecules held by covalent bonds along the chain and weak forces between chains; it has no delocalised electrons, so it conducts heat poorly. Aluminium would carry heat straight to the hand. The trade-off is that most polymers soften at far lower temperatures than aluminium, so the handle is kept away from the heat. Comparing both materials, linking each one's particles and forces to how well it conducts heat, and making a judgement is Excellence.**
2. Using the melting point and density table, which metal there has the lowest melting point, and what is its melting point?
   **Sodium, 98 °C.**
3. Why does solid salt not conduct electricity, while salt water does?
   **In the solid the ions are held in fixed positions in the lattice; in salt water they are free to move and carry charge.**
4. A crystal of salt is hit with a hammer and shatters. Why?
   **The blow shifts a layer of ions so like charges line up; they repel and the lattice splits.**
5. Why is graphite used in pencils but diamond in drill tips?
   **Graphite's layers have only weak forces between them, so they slide off onto paper; in diamond every atom is held by four strong covalent bonds in 3D, making it extremely hard.**
6. Why is a magnesium alloy used for a wheel instead of pure magnesium?
   **The different-sized atoms in the alloy disrupt the layers so they cannot slide as easily, making it harder and less likely to dent or bend.**
7. Correct this statement: "Solid salt conducts electricity because it is made of ions."
   **Ions in solid salt are fixed in the lattice; it conducts only when melted or dissolved, when the ions are free to move.**
8. Correct this statement: "Alloys are harder because the bonds in them are stronger."
   **Alloys are harder because different-sized atoms disrupt the layers, so the layers cannot slide as easily.**
9. Correct this statement: "Salt dissolves because water breaks the covalent bonds in the NaCl molecules."
   **Salt has no molecules or covalent bonds; water molecules attract the $Na^+$ and $Cl^-$ ions and pull them out of the lattice.**
10. Correct this statement: "Magnesium wheels are better because magnesium is lighter."
    **Say why: magnesium has a lower density (1.74 g/cm³) because its atoms are lighter, so a wheel of the same size has less mass.**

## Answer key (for parents and tutors)

1. Name the sphere each of these belongs to: a glacier, a kauri tree, a coal seam.
   **Glacier: hydrosphere (water as ice); kauri: biosphere; coal seam: geosphere.**
2. Write the balanced equation for burning methane. How many $CO_2$ molecules does one methane molecule make?
   **$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$; one $CO_2$ molecule for each methane molecule, because there is one carbon atom in each.**
3. $CO_2$ at Mauna Loa rises and falls a little every year, peaking around May. Explain why.
   **Most land plants are in the Northern Hemisphere: in its spring and summer photosynthesis takes in more $CO_2$ than respiration and decay release, so $CO_2$ falls; in autumn and winter decay and respiration win, so it builds up again until May.**
4. Explain how burning fossil fuels can harm pāua.
   **Burning adds $CO_2$ to the air; some dissolves in seawater to form carbonic acid, releasing $H^+$ ions that lower the pH and react with carbonate ions, so pāua have less carbonate to build their calcium carbonate shells.**
5. Discuss one way warming can feed back to make itself worse.
   **For example: warmer seawater dissolves less $CO_2$, so more stays in the air and adds to warming; or melting snow and ice exposes darker ground and sea that absorb more sunlight and warm further. Either keeps going after it starts, so it makes cutting emissions early more important.**
6. By how much did $CO_2$ at Baring Head rise over the ten years, and what is that per year?
   **424.7 − 401.1 = 23.6 ppm in ten years, about 2.4 ppm a year.**
7. By what percentage is the latest reading above the pre-industrial level?
   **(424.7 − 280) ÷ 280 × 100 = 144.7 ÷ 280 × 100 ≈ 52% higher.**
8. Mauna Loa's yearly mean for 2025 was 427.35 ppm. Give one reason Baring Head reads a little lower.
   **Most fossil fuel is burned in the Northern Hemisphere, and air takes about a year to mix across the equator, so the Southern Hemisphere lags slightly behind.**
9. Correct this statement: "Global warming is caused by the hole in the ozone layer letting in more heat."
   **The ozone hole lets through more ultraviolet; warming comes from greenhouse gases absorbing and re-emitting infrared given off by the surface.**
10. Correct this statement: "Ocean acidification means the sea has turned into an acid."
    **Seawater is still alkaline at about pH 8; acidification means its pH is falling as dissolved $CO_2$ adds hydrogen ions.**
11. Correct this statement: "The greenhouse effect is harmful and should be stopped."
    **The natural greenhouse effect keeps the Earth warm enough for life; the problem is the enhanced effect from the extra gases people add.**
12. Correct this statement: "Burning fossil fuels creates new carbon."
    **Burning moves carbon that was locked in the geosphere for millions of years into the atmosphere; carbon atoms are never created or destroyed.**

## Answer key (for parents and tutors)

1. A new subdivision of houses and roads is built. Name the change it causes and two spheres it affects.
   **Sealed (impervious) ground means more, faster stormwater carrying metals and litter; it affects the hydrosphere (streams, harbour) and the biosphere (stream life), and the geosphere (soil covered, metals in harbour mud).**
2. Explain why nitrate leaches through soil much more easily than phosphate.
   **Nitrate is very soluble and negatively charged, so soil particles do not hold it and it drains down with rainwater; phosphate binds tightly to soil particles and moves mainly when the soil itself erodes.**
3. A catchment was changed from pine forest to dairy farming. Nitrate in its spring water has kept rising for 15 years, although the farm has not changed since. Explain why.
   **Nitrate leaches into groundwater, which moves slowly, so water reaching the spring now may have soaked in years to decades ago; the full effect of the change to dairy has not arrived yet.**
4. Explain how clearing forest from steep hill country can harm an estuary downstream.
   **Without deep roots, slopes slip in heavy rain and the soil washes into rivers as sediment; in the estuary it settles, smothering seagrass and shellfish beds such as tuangi, cutting light and removing nursery habitat for fish.**
5. Discuss one implication of microplastics reaching the sea.
   **For example: filter feeders such as mussels take in microplastics, which pass up food webs to fish, birds and people who eat kaimoana; because plastic does not biodegrade the amount keeps building for decades, so the most effective response is stopping plastic at the source rather than cleaning it up later.**
6. How many times more litter per 1000 m² did Wellington's surveyed beaches have than the West Coast's?
   **558 ÷ 27 ≈ 20.7, so about 21 times as much.**
7. Suggest one reason for the difference.
   **Wellington has far more people, roads and stormwater drains that wash litter straight into the harbour, and the harbour traps it along the shore; the West Coast has few people.**
8. Paper and wood are only 4.5% of items, while plastic and foamed plastic are 74.9%. Explain why plastic builds up on beaches more than paper and wood.
   **Paper and wood biodegrade, as microbes break them down, but plastic does not; plastic also floats and lasts for decades, so currents keep carrying it ashore and it accumulates.**
9. Correct this statement: "The West Coast has the most erosion, so it has the worst human-induced erosion."
   **Most West Coast erosion is natural (steep, wet, rising mountains); erosion is human-induced where land use speeds it up, such as pasture on cleared hills.**
10. Correct this statement: "Nitrate gets into rivers mainly by fertiliser washing off the paddock surface in rain."
    **Most nitrate leaches down through the soil from urine patches and fertiliser, then reaches rivers through groundwater, often years later.**
11. Correct this statement: "Listing more effects is how you get Excellence."
    **Excellence needs discussion of implications: links between spheres, timescales, who is affected and which responses would work.**
12. Correct this statement: "Plastic in the sea breaks down and disappears after a few years."
    **Plastic breaks into microplastics but does not biodegrade, so it stays in water, sediment and animals for decades or longer.**

## Answer key (for parents and tutors)

1. A class drops a tennis ball from different heights and measures how high it bounces. Name the independent variable, the dependent variable and two controlled variables.
   **Independent: drop height. Dependent: bounce height. Controlled, for example: the same ball, the same floor surface, measuring both heights to the bottom of the ball.**

2. A group timed 10 swings of a pendulum as 14.2 s, 14.4 s and 12.9 s, and they think they miscounted once. Find the mean period and its uncertainty.
   **12.9 s is the outlier (about one swing short), so the mean is (14.2 + 14.4) ÷ 2 = 14.3 s and the period is 1.43 s. Half the range is (14.4 − 14.2) ÷ 2 = 0.1 s for 10 swings, so T = 1.43 ± 0.01 s.**

3. A spring's total length was measured with masses from 0 g to 300 g hung on it. The best-fit line passes through (0 g, 12.0 cm) and (300 g, 18.0 cm). Find the gradient, and say whether length is proportional to mass.
   **Gradient = (18.0 − 12.0) ÷ (300 − 0) = 0.020 cm/g, or 2.0 cm per 100 g. The relationship is linear but not proportional, because the line crosses the length axis at 12.0 cm, not at 0.**

4. A class measured the current through different resistors from the same battery pack: 10 Ω gave 0.59 A, 20 Ω gave 0.30 A, 30 Ω gave 0.20 A and 40 Ω gave 0.15 A. Name the relationship and give the evidence.
   **Inverse: resistance × current stays about the same (10 × 0.59 = 5.9, 20 × 0.30 = 6.0, 30 × 0.20 = 6.0, 40 × 0.15 = 6.0), so doubling the resistance halves the current.**

5. Explain why timing 10 swings and dividing by 10 gives a better period than timing one swing.
   **Reaction time adds about the same error when starting and stopping however long you time for, so spread over 10 swings it is ten times smaller per swing, and the percentage uncertainty in the period drops.**

6. Correct this statement: "Joining each point to the next with a ruler to make a zigzag graph."
   **Draw one smooth line or curve of best fit through the trend; data points scatter a little around the true pattern.**

7. Correct this statement: "The graph goes up in a straight line, so the quantities are proportional."
   **Proportional needs a straight line through the origin; a straight line that cuts the axis elsewhere is only linear.**

8. Correct this statement: "Averaging all three repeats, including the reading that was clearly a mistake."
   **Leave an outlier with a known cause out of the mean, and record in your write-up which reading you dropped and why.**

9. Correct this statement: "Gradient = 4.0, with no unit."
   **A gradient has the y unit over the x unit, here $s^2/m$, and it means something physical, so always write and explain the unit.**

## Answer key (for parents and tutors)

1. At 60 cm one group read 1.66 V across the wire and 0.20 A through it. Find the resistance.
   **R = V ÷ I = 1.66 ÷ 0.20 = 8.3 Ω.**
2. The class added a 70 cm length and got 9.8 Ω, 9.6 Ω and 9.7 Ω. Find the mean and its uncertainty, and say whether it agrees with R = 13.5 Ω/m × L + 0.3 Ω.
   **Mean = (9.8 + 9.6 + 9.7) ÷ 3 = 29.1 ÷ 3 = 9.7 Ω; uncertainty = (9.8 − 9.6) ÷ 2 = ± 0.1 Ω. The line predicts 13.5 × 0.70 + 0.3 = 9.75 Ω, which is inside 9.7 ± 0.1 Ω, so it agrees.**
3. Use the line to predict the reading for a 50 cm length.
   **R = 13.5 × 0.50 + 0.3 = 6.75 + 0.3 = 7.05 Ω, about 7.1 Ω.**
4. A student concluded: "When the wire got longer the resistance got bigger because there is more wire." Which grade is this closest to, and what two things would lift it to Merit?
   **Achieved at best: it describes the trend but gives no numbers and no physics. For Merit, add processed evidence (the straight-line graph with gradient 13.5 Ω/m) and explain the cause (a longer wire has more metal ions for the free electrons to collide with).**
5. Explain why the class's line meets the resistance axis at 0.3 Ω instead of passing through the origin.
   **The clips' contacts with the wire add about 0.3 Ω of resistance in series at every length, even a length of zero, so the whole line is lifted by that amount.**
6. Correct this statement: "The graph is a straight line, so resistance is proportional to length."
   **The measured line meets the axis at 0.3 Ω, so it is linear; only the wire's own resistance, with the contacts taken away, is proportional.**
7. Correct this statement: "A longer wire has more resistance because the electrons get used up on the way."
   **Electrons are not used up, and the current is the same all the way round; they lose energy in more collisions with ions.**
8. Correct this statement: "Writing the physics in one paragraph and the results in another."
   **Excellence needs them together: every physics idea should point at a number, and every number should be explained.**
9. Correct this statement: "Predicting 1.50 m with the gradient 0.135 and getting 0.5 Ω."
   **0.135 is in Ω per cm, so use 150 cm, or use 13.5 Ω/m with 1.50 m; both give about 20.6 Ω.**

## Answer key (for parents and tutors)

1. Which season does New Zealand have when the Southern Hemisphere is tilted towards the Sun?
   **Summer (December to February).**
2. Christchurch is at about 43.5°S. Calculate the height of the midday Sun there on 22 December.
   **90 − 43.5 + 23.4 = 69.9, so about 70°.**
3. Use the sunrise and sunset table: how much longer is Christchurch's day on 22 December than on 21 June?
   **15 h 26 min − 8 h 56 min = 6 h 30 min longer.**
4. Earth is closest to the Sun on 4 January. Explain why this is not the reason New Zealand has summer then.
   **At the same time of year the Northern Hemisphere, at almost the same distance, has winter, and the distance changes by only about 3%; New Zealand has summer because the Southern Hemisphere is tilted towards the Sun.**
5. In which direction does the Sun rise in Auckland on 21 June?
   **North of east (north-east), because in winter the Southern Hemisphere is tilted away from the Sun.**
6. Describe why Invercargill has day and night, and why the Sun rises in the east.
   **Earth spins on its axis once every 24 hours. Invercargill has day when it is turned to face the Sun and night when it is turned away. Earth spins from west to east, so the Sun appears to rise in the east (Achieved).**
7. Explain why Invercargill's days are longer and warmer in December than in June. Refer to Earth's tilt and orbit.
   **Earth's axis is tilted 23.4° and keeps pointing the same way as Earth orbits the Sun each year. In December the Southern Hemisphere is tilted towards the Sun, so more of Invercargill's daily circle is in sunlight (15 h 49 min of daylight) and the Sun climbs high (about 67°), so its radiation is concentrated. In June the hemisphere is tilted away: only 8 h 35 min of daylight and a midday Sun near 20°, so the radiation is spread over more ground for fewer hours and it is colder (Merit).**
8. Discuss why Invercargill has longer days than Auckland in December, shorter days in June, and almost the same day length in September.
   **Excellence links latitude to tilt: in December the Southern Hemisphere leans towards the Sun, and the further south a place is, the larger the part of its daily circle that stays in the lit half, so Invercargill (15 h 49 min) beats Auckland (14 h 42 min). In June the same tilt puts more of the far-south circle in darkness, so Invercargill (8 h 35 min) has less daylight than Auckland (9 h 38 min). At the September equinox neither hemisphere leans towards the Sun, so the boundary between day and night passes through both poles, cuts every circle of latitude in half, and both cities get about 12 hours.**
9. Correct this statement: "Summer happens because Earth is closer to the Sun."
   **Earth is closest in early January, when the Northern Hemisphere has winter; seasons come from the tilt, not the distance.**
10. Correct this statement: "Earth's axis tips towards the Sun in summer and away in winter."
    **The axis always points the same way in space; it is Earth's position in its orbit that decides which hemisphere leans towards the Sun.**
11. Correct this statement: "It is hotter in summer because there is more sunlight."
    **Say there is more solar radiation per square metre, because the Sun is higher, and that it shines for more hours each day.**
12. Correct this statement: "In summer the Sun is directly overhead in New Zealand at midday."
    **The Sun is only ever overhead between 23.4°N and 23.4°S; in Auckland it peaks at about 77°, always to the north.**

## Answer key (for parents and tutors)

1. In the orbit diagram, which phase is seen from Earth at position 7?
   **Last quarter: the half of the disc on the right is lit, as seen from New Zealand.**
2. Why does it take 29.5 days, not 27.3, to go from one new moon to the next?
   **While the Moon orbits Earth, Earth also moves along its orbit round the Sun, so the Moon must go about 2 extra days of orbit to line up with the Sun again.**
3. On 3 March 2026 (Universal Time) there was a total lunar eclipse. What phase was the Moon in?
   **Full moon: Earth was between the Sun and the Moon.**
4. A full moon happens about every 29.5 days. Explain why there is not a lunar eclipse every month.
   **The Moon's orbit is tilted about 5° to Earth's orbit, so at most full moons the Moon passes above or below Earth's shadow; an eclipse needs a full moon near where the two orbits cross.**
5. In New Zealand, a crescent Moon is seen in the western sky just after sunset. Which side of it is lit, and is it waxing or waning?
   **Lit on the left (the side towards the set Sun), and it is waxing.**
6. Describe where the Sun, Earth and Moon are at full moon, and how often a full moon comes round.
   **A full moon happens when Earth is between the Sun and the Moon, so the whole sunlit half of the Moon faces Earth. It happens about every 29.5 days (Achieved).**
7. Explain why viewers in New Zealand see the Moon go through phases over a month, and how a waxing Moon looks different here from in the Northern Hemisphere.
   **The Moon reflects sunlight and the Sun always lights half of it. As the Moon orbits Earth, its position compared with the Sun changes, so we see a different fraction of the lit half: none at new moon, half the disc at the quarters, all of it at full moon. From New Zealand we look north at the Moon, so a waxing Moon is lit on the left; northern viewers face south and see it lit on the right, the image flipped (Merit).**
8. Discuss why a super full moon is seen only one to three times a year, rather than every month.
   **Excellence links the two cycles: the Moon's orbit is an ellipse, so its distance varies, and at perigee it looks about 14% wider than at apogee (33.51 against 29.40 arc minutes). Perigee comes round every 27.5 days but full moon every 29.5 days, because Earth's orbit round the Sun means the Moon must travel further to line up opposite the Sun. Each month the full moon slips about 2 days later in the perigee cycle, so the two coincide only for a run of one to three months about every 14 months, as on 24 December 2026, when the full moon and perigee were just 7 hours apart.**
9. Correct this statement: "The phases happen because Earth's shadow covers part of the Moon."
   **Earth's shadow only reaches the Moon during a lunar eclipse; phases come from how much of the Moon's sunlit half faces us.**
10. Correct this statement: "A solar eclipse happens at full moon."
    **The Moon must be between the Sun and Earth for a solar eclipse, which is new moon; a lunar eclipse is at full moon.**
11. Correct this statement: "There should be an eclipse every month because there is a new moon every month."
    **The Moon's orbit is tilted about 5°, so most new and full moons pass above or below the Sun–Earth line.**
12. Correct this statement: "The waxing crescent in New Zealand is lit on the right, like the pictures in most books."
    **Most books show the northern view; from New Zealand a waxing Moon is lit on the left.**

## Answer key (for parents and tutors)

1. Auckland had a high tide at 08:55 on 10 November 2026. Using the average of 12 h 25 min, predict the time of the next high tide.
   **08:55 + 12 h 25 min = 21:20 (the LINZ prediction is 21:06, as single days vary).**
2. At which two Moon phases do spring tides happen?
   **New moon and full moon, when the Sun, Earth and Moon are in a line.**
3. On 18 November 2026 Auckland's highest high tide was 2.8 m and its lowest low tide 1.1 m. Calculate the tidal range.
   **2.8 – 1.1 = 1.7 m.**
4. Explain why there is also a high tide on the far side of Earth, opposite the Moon.
   **The Moon pulls Earth more strongly than the water on the far side, so that water is left behind as a second bulge.**
5. On 27 November 2026 Nelson's tidal range was 3.8 m and Wellington's was 1.4 m. Explain why the ranges differ when both feel the same Moon and Sun.
   **The size of the tide depends on the local shape of the coast, harbour and seabed, which channels and amplifies the tide more in Tasman Bay than in Wellington.**
6. Describe what causes high and low tides.
   **The Moon's gravity, and to a lesser extent the Sun's, pulls on Earth's oceans, making bulges of water. Places in a bulge have high tide; places between the bulges have low tide (Achieved).**
7. Explain why Auckland has two high tides most days, and why they come about 50 minutes later each day.
   **The Moon pulls the near-side ocean more than Earth's centre, and Earth's centre more than the far-side ocean, so there are two bulges on opposite sides of Earth. Earth spins through both, giving two highs and two lows. The Moon moves about 13° along its orbit each day in the direction Earth spins, so Earth needs about 50 extra minutes to bring Auckland back under the Moon: the cycle is 24 h 50 min, highs are 12 h 25 min apart, and each day's tides are about 50 minutes later (Merit).**
8. Discuss why the tidal range changes over the month, and why the spring tides of 26 to 28 November were bigger than those of 9 to 11 November (range 2.6 m, new moon on 9 November, apogee on 14 November).
   **Excellence links positions, timing and data: at new and full moon the Sun, Earth and Moon line up, the Sun's smaller bulges add to the Moon's, and the range is largest (spring tides, 3.2 m after the 25 November full moon). At first quarter the Moon is at 90° to the Sun, the Sun's bulges fall where the Moon's lows are, and the range is smallest (neap tide, 1.7 m on 18 November). This repeats about every 14 to 15 days. The late-November springs were bigger because the full moon came within a day of perigee, when the Moon is closest and its tidal effect strongest, a perigean spring or king tide; the 9 November new moon came near apogee, when the Moon is furthest away, so that spring range was only 2.6 m. Because perigee repeats every 27.5 days but full and new moons every 29.5 days, king tides happen only at irregular intervals.**
9. Correct this statement: "There is one high tide a day, when the Moon is overhead."
   **There are two bulges, one facing the Moon and one on the far side, so most places get two high tides a day.**
10. Correct this statement: "Spring tides happen in spring."
    **Spring tides come at every new and full moon, about every two weeks all year; the name is not about the season.**
11. Correct this statement: "Neap tides happen when the Moon is furthest away."
    **Neap tides come at first and last quarter, when the Moon is at right angles to the Sun; distance changes the size of king tides.**
12. Correct this statement: "The Sun is much bigger, so it causes bigger tides than the Moon."
    **The Sun is about 390 times further away, so its tide-raising effect is only about half the Moon's.**

## Answer key (for parents and tutors)

1. Calculate the kinetic energy of a 1200 kg car travelling at 15 m/s.
   **$E_k = \frac{1}{2}mv^2 = \frac{1}{2} \times 1200 \times 15^2 = 135\,000$ J.**

2. A 0.5 kg book is lifted from the floor onto a shelf 1.8 m high. How much Ep does it gain?
   **$E_p = mgh = 0.5 \times 10 \times 1.8 = 9$ J.**

3. A shopper pushes a trolley 25 m along an aisle with a force of 80 N. How much work is done?
   **$W = Fd = 80 \times 25 = 2000$ J.**

4. A diver steps off a 5.0 m platform. Ignoring air resistance, how fast is she going when she reaches the water?
   **All Ep becomes Ek, so $v = \sqrt{(2gh)} = \sqrt{(2 \times 10 \times 5.0)} = \sqrt{100} = 10$ m/s.**

5. A 55 kg student runs up stairs with a total height of 12 m in 20 s. Find the Ep gained and her power.
   **$E_p = 55 \times 10 \times 12 = 6600$ J; $P = E \div t = 6600 \div 20 = 330$ W (assuming all her work goes into Ep).**

6. Describe the energy changes as Aroha goes down the slide.
   **Gravitational potential energy is transformed into kinetic energy as she loses height and gains speed, and some becomes thermal energy and sound because of friction (Achieved).**

7. Calculate the greatest speed Aroha could have at the bottom, and state the assumption you made.
   **$E_p = mgh = 40 \times 10 \times 2.5 = 1000$ J. Assume all the Ep becomes Ek (no friction or air resistance): $1000 = \frac{1}{2} \times 40 \times v^2$, so $v^2 = 50$ and $v = 7.1$ m/s. Full working earns Merit; the correct unit and the stated assumption are needed for Excellence.**

8. Her real speed at the bottom is 6.0 m/s. Discuss what happened to the rest of her energy, using calculations, and explain why the slide feels slightly warm afterwards.
   **Real $E_k = \frac{1}{2} \times 40 \times 6.0^2 = 720$ J, so $1000 - 720 = 280$ J did not become Ek (Merit for the calculation and naming friction). Excellence links it all: friction between her clothes and the slide makes the particles at both surfaces vibrate faster, raising their temperature, and she also pushes air particles aside; that 280 J is transferred to the slide, her clothes and the air as thermal energy and sound. Energy is conserved ($720 + 280 = 1000$ J), but only 72% of the Ep became Ek, so she reaches 6.0 m/s instead of 7.1 m/s.**

9. Correct this statement: "$v^2 = 64$, so the apple lands at 64 m/s."
   **That is $v^2$, not $v$; take the square root to get $v = 8$ m/s, a step markers often see missed.**

10. Correct this statement: "Energy is lost when the object hits air resistance, so the total energy goes down."
    **Energy is never lost; it is transferred to the air as thermal energy and sound, so the total stays the same.**

11. Correct this statement: "A 500 g ball dropped 2 m has $E_p = 500 \times 10 \times 2 = 10\,000$ J."
    **Mass must be in kilograms: 500 g = 0.5 kg, so $E_p = 0.5 \times 10 \times 2 = 10$ J.**

12. Correct this statement: "Doubling the speed doubles the kinetic energy."
    **Speed is squared in $E_k = \frac{1}{2}mv^2$, so doubling the speed makes the kinetic energy four times as big.**

## Answer key (for parents and tutors)

1. How much energy is needed to heat 2.0 kg of water from 20 °C to 45 °C?
   **$\Delta T = 45 - 20 = 25$ °C; $E = mc\Delta T = 2.0 \times 4200 \times 25 = 210\,000$ J.**
2. 9000 J of energy raises the temperature of a 0.5 kg metal block by 20 °C. Find its specific heat capacity and use the table to name the metal.
   **$c = E \div (m\Delta T) = 9000 \div (0.5 \times 20) = 900$ J kg$^{-1}$ °C$^{-1}$, so it is aluminium.**
3. How much energy is needed to boil away 0.2 kg of water that is already at 100 °C?
   **$E = mL = 0.2 \times 2\,260\,000 = 452\,000$ J.**
4. 21 000 J is given to 0.25 kg of water. By how much does its temperature rise?
   **$\Delta T = E \div (mc) = 21\,000 \div (0.25 \times 4200) = 20$ °C.**
5. Explain why a puffer jacket keeps you warm, in terms of heat transfer.
   **The filling traps lots of still air; air is a poor conductor because its particles are far apart, and trapped air cannot move to form convection currents, so heat leaves your body only slowly.**
6. Calculate the thermal energy the water gives out over the eight hours.
   **$\Delta T = 60 - 20 = 40$ °C; $E = mc\Delta T = 1.5 \times 4200 \times 40 = 252\,000$ J (Achieved for the right formula with numbers; Merit for the correct answer).**
7. Calculate the average rate at which the bottle gives out energy, with a unit.
   **8 hours = $8 \times 3600 = 28\,800$ s; $P = E \div t = 252\,000 \div 28\,800 = 8.75$ W, about 8.8 W (Excellence needs both calculations with units).**
8. Sione's grandmother knits a thick woollen cover for the bottle. Discuss how the cover affects conduction, convection and radiation, and what this means for how long his bed stays warm.
   **Achieved: the wool is an insulator so it keeps the heat in. Merit: wool traps air, which is a poor conductor, and the trapped air cannot move, so conduction and convection are reduced. Excellence: air particles are far apart, so they pass on kinetic energy slowly by collisions, and air held still in the fibres cannot rise and carry heat away; the cover's outer surface also stays cooler, so less infrared is radiated. The water still gives out about 252 000 J as it cools to 20 °C, but over a longer time, so the power is lower and the bed stays warm for longer.**
9. Correct this statement: "Water heated from 20 °C to 70 °C: $E = 0.5 \times 4200 \times 70$."
   **Use the change in temperature, $\Delta T = 70 - 20 = 50$ °C, not the final temperature.**
10. Correct this statement: "Cold gets into the flask through the walls."
    **There is no such thing as cold flowing; heat (thermal energy) always moves from the hotter object to the colder one.**
11. Correct this statement: "Hot air rises because heat rises."
    **Heated air particles move faster and spread apart, so the air becomes less dense than the air around it and rises.**
12. Correct this statement: "While ice melts its temperature rises because energy is going in."
    **The temperature stays at 0 °C while it melts; the energy goes into breaking the fixed arrangement of particles, not speeding them up.**

## Answer key (for parents and tutors)

1. What current flows through a 12 Ω resistor with 6.0 V across it?
   **I = V ÷ R = 6.0 ÷ 12 = 0.5 A.**
2. A toaster draws 4.0 A from the 230 V supply. What is its power?
   **P = VI = 230 × 4.0 = 920 W.**
3. How much energy, in joules, does that toaster use in 3.0 minutes?
   **E = Pt = 920 × 180 = 165 600 J (3.0 minutes = 180 s).**
4. What does it cost to run a 2.0 kW heater for 3 hours at 42.1 c/kWh?
   **E = 2.0 kW × 3 h = 6 kWh; cost = 6 × 42.1 = 252.6 c, about $2.53.**
5. A 9 W LED gives the same light as a 60 W incandescent bulb. By what percentage is its power lower?
   **(60 − 9) ÷ 60 × 100% = 85% lower.**
6. Describe the energy changes in the hair dryer.
   **Electrical energy becomes thermal energy in the heating element, kinetic energy of the fan and the moving air, and some sound (Achieved).**
7. Calculate the current in the hair dryer on high, with a unit.
   **I = P ÷ V = 1800 ÷ 230 = 7.8 A (Merit needs the working and the unit).**
8. Calculate how much it costs Ari to use the hair dryer for a year.
   **E = 1.8 kW × (10 ÷ 60) h = 0.3 kWh a day; 0.3 × 365 = 109.5 kWh a year; cost = 109.5 × 42.1 = 4610 c, about $46.10 (Excellence for the full chain with units).**
9. On the low setting, the heating element has a higher resistance. Discuss how this changes the current, the power and how long Ari takes to dry her hair.
   **Achieved: the current is lower, so it is less hot. Merit: the voltage stays at 230 V, so a higher resistance gives a smaller current (I = V ÷ R), and P = VI is smaller. Excellence: with V constant and I smaller, P = VI is lower, so fewer joules of electrical energy become thermal energy each second; by E = Pt she needs roughly the same total energy to evaporate the water, so she must use it for longer to dry her hair.**
10. Correct this statement: "A 2 kW heater for 3 hours: E = 2 × 3 = 6 J."
    **kW × hours gives kWh, so it is 6 kWh; for joules use watts and seconds: 2000 × 10 800 = 21 600 000 J.**
11. Correct this statement: "Current gets used up by the heater, so less comes out than goes in."
    **Current is the same all round a series circuit; it is energy that the heater transfers to the room.**
12. Correct this statement: "A bigger resistance means a bigger current, because the resistor works harder."
    **At the same voltage, I = V ÷ R, so a bigger resistance gives a smaller current.**
13. Correct this statement: "Power and energy are the same thing, both in watts."
    **Power is the rate of energy transfer in watts (J/s); energy is the total amount, in joules or kWh, and E = Pt links them.**