Vertex Academy

Year 9 Science workbook

16 worksheets · answers at the back

Contents

1. The periodic table: groups, periods, metals and non-metals
2. Atomic theory: Rutherford, Bohr and the parts of an atom
3. Mass number, electron shells and valence electrons
4. Acids and bases: pH scale, alkalis and indicators
5. Tests for hydrogen, oxygen, carbon dioxide and water
6. Electric circuits: charge, current, voltage and resistance
7. Electric circuits: insulators, resistors, energy and efficiency
8. Net force, balanced and unbalanced forces, and pressure
9. Position-time graphs, free-body diagrams and pressure
10. Stars, planets and moons: our place in the universe
11. Asteroids, comets, meteors and scale models of the Solar System
12. The planets in order, dwarf planets and how we explore space
13. Cell structure: organelles, plant and animal cells, bacteria
14. Disease and immunity: pathogens, white blood cells and vaccines
15. Diffusion, photosynthesis and respiration
16. Ecosystems: biotic and abiotic factors, quadrats and transects

Year 9 Science: The periodic table: groups, periods, metals and non-metals

Name: _____ Date: _____

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

Practice

1. Element 17 is in period 3. Name it, give its group, and say whether it is a metal or non-metal.

2. Calcium is in group 2. Would a calcium wire conduct electricity? Give a reason.

3. Why is argon, not air, pumped around the metal while welding?

4. Melting points in group 17 rise down the group: chlorine −101 °C, bromine −7 °C, iodine 114 °C. Predict the state of astatine, the next halogen, at room temperature.

5. A grey element is shiny, conducts, and fizzes violently in water. Which group is it most likely in?

Fix the mistake

6. Correct this statement: "Groups are the rows and periods are the columns."

7. Correct this statement: "The modern periodic table is in order of atomic mass."

8. Correct this statement: "Hydrogen sits at the top of group 1, so it is a metal."

9. Correct this statement: "CO is the symbol for cobalt."

Year 9 Science: Atomic theory: Rutherford, Bohr and the parts of an atom

Name: _____ Date: _____

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

Practice

1. How many protons and electrons are in a neutral atom of magnesium, atomic number 12?

2. An atom has 7 protons. Name the element.

3. In the gold foil experiment, why did most alpha particles pass straight through the foil?

4. Which particle did Thomson's plum pudding model include, and which part did Rutherford add?

5. A particle has 17 protons and 18 electrons. What is its overall charge?

Fix the mistake

6. Correct this statement: "Some alpha particles bounced back, so the gold foil experiment showed atoms are solid."

7. Correct this statement: "Electrons sit in the nucleus with the protons."

8. Correct this statement: "Neutrons are the negative particles."

9. Correct this statement: "Atomic number means protons plus neutrons added together."

Year 9 Science: Mass number, electron shells and valence electrons

Name: _____ Date: _____

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

Practice

1. Aluminium-27 has atomic number 13. How many protons, neutrons and electrons does a neutral atom have?

2. Write the electron arrangement for sulfur, atomic number 16.

3. Potassium has atomic number 19. How many valence electrons does it have, and in which shell?

4. Fluorine is 2,7. Will it tend to lose or gain electrons, and how many?

5. Why is it harder to recycle helium than to recycle copper?

Fix the mistake

6. Correct this statement: "The mass number of chlorine-35 means it has 35 neutrons."

7. Correct this statement: "Potassium is 2,8,9, because the third shell can take more electrons."

8. Correct this statement: "Chlorine is in group 17, so it has 7 electrons."

9. Correct this statement: "Sodium loses an electron, so it becomes a negative ion."

Year 9 Science: Acids and bases: pH scale, alkalis and indicators

Name: _____ Date: _____

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

Practice

1. A solution has pH 4. Is it acidic, neutral or alkaline, and what colour would universal indicator turn?

2. Magnesium oxide hardly dissolves in water. Is it a base, an alkali, or both?

3. You need to check whether a farmer's paddock soil is pH 5.8 or 6.2. Which method should you use, and why?

4. Why is it a bad idea to identify a liquid in the lab by tasting it, even though acids taste sour?

5. Oven cleaner has pH 13 and lemon juice has pH 2. Which is further from neutral, and what does that tell you about handling it?

Fix the mistake

6. Correct this statement: "pH 2 is only a little more acidic than pH 3, because the numbers are just 1 apart."

7. Correct this statement: "The higher the pH number, the stronger the acid."

8. Correct this statement: "Alkali and base mean the same thing."

9. Correct this statement: "Litmus paper tells you the pH of a solution."

Year 9 Science: Tests for hydrogen, oxygen, carbon dioxide and water

Name: _____ Date: _____

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

Practice

1. A gas relights a glowing splint. What is it?

2. Marble chips are added to hydrochloric acid. Which test would you use on the gas, and what result do you expect?

3. A clear liquid turns blue cobalt chloride paper pink. Does this prove the liquid is pure water? Explain.

4. Red cabbage indicator turns blue-green in a cleaning spray. Is the spray acidic, neutral or alkaline?

5. A student spills dilute sodium hydroxide on their hand. What should they do first?

Fix the mistake

6. Correct this statement: "A lit splint went out in the gas, so it must be carbon dioxide."

7. Correct this statement: "Hydrogen relights a glowing splint, and oxygen pops with a lit one."

8. Correct this statement: "The liquid turned cobalt chloride paper pink, so it is pure water."

9. Correct this statement: "To dilute an acid, pour the water into the acid."

Year 9 Science: Electric circuits: charge, current, voltage and resistance

Name: _____ Date: _____

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

Practice

1. A 9 V battery is connected to a 3 Ω resistor. What current flows?

2. In a series circuit an ammeter before the first lamp reads 0.4 A. What does an ammeter after the second lamp read?

3. A parallel circuit has two branches carrying 0.3 A and 0.5 A. What current comes out of the battery?

4. One lamp in a string of three blows. What happens to the other two if the string is in series, and if it is in parallel?

5. A balloon rubbed on hair sticks to the ceiling. Explain why, using the word electrons.

Fix the mistake

6. Correct this statement: "Current gets used up by the first bulb, so less comes out the other side."

7. Correct this statement: "Adding a lamp in parallel makes all the lamps dimmer, just like in series."

8. Correct this statement: "With 6 V across 3 Ω, the current is 6 × 3 = 18 A."

9. Correct this statement: "A rubbed balloon becomes positive because it picks up protons from the jumper."

Year 9 Science: Electric circuits: insulators, resistors, energy and efficiency

Name: _____ Date: _____

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

Practice

1. Why is the inside of a cable copper and the outside plastic?

2. A student puts a voltmeter in the loop of a series circuit and the lamp goes out. Explain what went wrong.

3. A kettle element on 230 V draws 8 A for 120 s. How much energy is transferred?

4. A motor receives 500 J of electrical energy and gives 350 J of movement energy. How much is wasted, and what is its efficiency?

5. Give one advantage and one disadvantage of relying on hydro for most of New Zealand's electricity.

Fix the mistake

6. Correct this statement: "A voltmeter goes in the loop, the same as an ammeter."

7. Correct this statement: "The lamp uses up the energy, so it no longer exists."

8. Correct this statement: "A lamp on 6 V drawing 0.5 A for one minute uses 6 × 0.5 × 1 = 3 J."

9. Correct this statement: "A lamp with 100 J in and 40 J of light out is 250% efficient, from 100 ÷ 40."

Year 9 Science: Net force, balanced and unbalanced forces, and pressure

Name: _____ Date: _____

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

Practice

1. A boat's engine pushes forward with 800 N. Water drag is 650 N backward. Find the net force and say what the boat does.

2. A cyclist moves at a steady 20 km/h in a straight line. What is the net force on her, and how do you know?

3. In a test of how the mass of a trolley affects its speed down a ramp, name the independent, dependent and two controlled variables.

4. Trial times: 3.10 s, 3.06 s, 3.62 s, 3.08 s. Which is the outlier, and what is the mean of the others?

5. A 50 N box sits on a base of 0.25 m². What pressure does it exert?

Fix the mistake

6. Correct this statement: "A moving object needs a forward net force to keep going at a steady speed."

7. Correct this statement: "450 N to the left and 400 N to the right give a net force of 850 N."

8. Correct this statement: "600 N on 400 cm² gives a pressure of 600 ÷ 400 = 1.5 Pa."

9. Correct this statement: "One careful run is enough, and an odd result can just be deleted."

Year 9 Science: Position-time graphs, free-body diagrams and pressure

Name: _____ Date: _____

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

Practice

1. On a position-time graph, a line goes from 0 m at 0 s to 120 m at 20 s in a straight line. What is the speed, and is it steady?

2. Describe the motion shown by a position-time graph that is flat from 5 s to 12 s.

3. A kayak has 150 N of paddle thrust forward and 90 N of drag backward; its weight and the water's upward push are both 800 N. Find the net force.

4. A 60 N force pushes a drawing pin with a point of 0.000 001 m². What pressure does the point make, and why does it go into a cork board?

5. Explain why one wide snowboard and two skis both work on soft snow, but walking in boots does not.

Fix the mistake

6. Correct this statement: "A flat line on a position-time graph means the object is moving at a steady speed."

7. Correct this statement: "A straight line sloping upwards means the object is speeding up."

8. Correct this statement: "The free-body diagram of a box should show the box pushing down on the floor."

9. Correct this statement: "An axe cuts wood because it pushes harder than a hammer."

Year 9 Science: Stars, planets and moons: our place in the universe

Name: _____ Date: _____

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

Practice

1. Venus is often the brightest point in the evening sky after sunset. Is it a star or a planet, and how do you know it does not make its own light?

2. Titan orbits Saturn and is bigger than the planet Mercury. Which group does Titan belong to, and why does its size not matter?

3. A friend says the Moon only comes out at night. Give two pieces of evidence that this is wrong.

4. Mars is on average about 228 million km from the Sun. How long does sunlight take to reach Mars, in minutes?

5. Matariki rises together and keeps the same shape every year. Explain why it cannot be a group of planets.

Fix the mistake

6. Correct this statement: "The Moon glows at night because it makes its own light."

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

8. Correct this statement: "The Sun cannot be a star because it is far bigger and brighter than the stars at night."

9. Correct this statement: "Titan is bigger than Mercury, so Titan must be a planet."

Year 9 Science: Asteroids, comets, meteors and scale models of the Solar System

Name: _____ Date: _____

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

Practice

1. Saturn is 9.5 AU from the Sun. How far is that in kilometres?

2. Which unit would you use for each: the width of Mars, the distance from the Sun to Uranus, the distance to the Southern Cross stars? Give a reason for one of them.

3. A rock lands in a paddock in Canterbury after streaking across the sky. Name the streak and name the rock.

4. In the beach-ball model, where 1 AU is 32 m, how far from the ball does Mars (1.52 AU) go?

5. A comet's tail points to the left of the comet in a photo. Which way is the Sun, and why?

Fix the mistake

6. Correct this statement: "A meteor and a meteorite are the same thing."

7. Correct this statement: "A comet's tail trails behind it, showing where it has come from."

8. Correct this statement: "Jupiter is 5.2 AU away, so it is 5.2 × 150 = 780 km from the Sun."

9. Correct this statement: "The asteroid belt is so packed with rocks that spacecraft have to steer around them."

Year 9 Science: The planets in order, dwarf planets and how we explore space

Name: _____ Date: _____

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

Practice

1. List the planets in order from the Sun and mark which are rocky, gas giants and ice giants.

2. Eris is round, orbits the Sun and lies among many other icy bodies beyond Neptune. Why is it not a planet?

3. Saturn is about 9.5 AU from the Sun. Roughly what fraction of Earth's sunlight does it receive?

4. A telescope cannot touch Mars, yet scientists know its air is mostly carbon dioxide. How?

5. Give one thing an orrery shows well and one thing it gets wrong.

Fix the mistake

6. Correct this statement: "Pluto stopped being a planet because it is too small."

7. Correct this statement: "At twice the distance from the Sun, a planet gets half the sunlight."

8. Correct this statement: "Mercury is closest to the Sun, so it must be the hottest planet."

9. Correct this statement: "Scientists switched to a Sun-centred model as soon as Copernicus published it in 1543."

Year 9 Science: Cell structure: organelles, plant and animal cells, bacteria

Name: _____ Date: _____

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

Practice

1. A student says plant cells have chloroplasts instead of mitochondria. Explain what is wrong.

2. A cell has DNA, a membrane, cytoplasm and a cell wall, but no nucleus. Is it prokaryotic or eukaryotic, and what kind of organism is it likely to be?

3. An onion cell is 300 µm long. How long will it look in an image at ×100, in mm?

4. Why does a lettuce left without water go floppy? Use the words vacuole and cell wall.

5. Why did scientists need the electron microscope to understand how mitochondria work?

Fix the mistake

6. Correct this statement: "Animal cells have a cell wall too, just a thinner one."

7. Correct this statement: "Bacteria have no nucleus, so they have no DNA."

8. Correct this statement: "Actual size = image size × magnification."

9. Correct this statement: "24 mm ÷ 400 = 0.06, so the cell is 0.06 µm across."

Year 9 Science: Disease and immunity: pathogens, white blood cells and vaccines

Name: _____ Date: _____

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

Practice

1. Sort into infectious or non-infectious, and name the pathogen type for the infectious ones: measles, asthma, athlete's foot, Giardia infection, type 2 diabetes.

2. Why will a doctor not give antibiotics for a cold?

3. Explain why someone who had chickenpox as a child usually does not get sick from it again.

4. School absences from flu over four days were 4, 8, 15 and 31. Describe the pattern, predict day 5, and suggest one measure to slow it.

5. Boot-cleaning stations stand at track entrances in the Waitākere Ranges. Which prevention strategy is this, and which spread route does it block?

Fix the mistake

6. Correct this statement: "Antibiotics will cure a cold or the flu."

7. Correct this statement: "A vaccine gives you a mild case of the disease."

8. Correct this statement: "You do not catch chickenpox twice because the antibodies stay in your blood forever."

9. Correct this statement: "You can catch asthma or type 2 diabetes from someone who has it."

Year 9 Science: Diffusion, photosynthesis and respiration

Name: _____ Date: _____

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

Practice

1. Explain, using the word concentration, why oxygen moves from the blood into a muscle cell.

2. Write the word equation for photosynthesis and name where in the cell it happens.

3. Jelly babies left in water swell up. Write a testable question about temperature and say what you would measure and keep the same.

4. Germinating peas in a sealed flask warm up, and limewater connected to the flask turns milky. Which process is happening and what two pieces of evidence show it?

5. Is a plant respiring at night, photosynthesising, or both? Explain.

Fix the mistake

6. Correct this statement: "Plants photosynthesise and animals respire."

7. Correct this statement: "Respiration is the same thing as breathing."

8. Correct this statement: "Particles diffuse because they want to spread out into empty space."

9. Correct this statement: "Photosynthesis makes energy for the plant."

Year 9 Science: Ecosystems: biotic and abiotic factors, quadrats and transects

Name: _____ Date: _____

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

Practice

1. Sort into biotic or abiotic: a dead kauri leaf, soil pH, a weta, rainfall, a fungus on a log.

2. Mosses grow thickly on the south side of a building but hardly at all on the north side. Suggest two abiotic factors that explain this, remembering New Zealand is in the Southern Hemisphere.

3. Six random 1 m² quadrats on a 300 m² lawn hold 2, 4, 1, 3, 0 and 2 clover plants. Estimate the clover on the lawn.

4. You want to know how plants change from a sunny paddock into the shade of bush. Would you use random quadrats or a transect? Say what you would measure.

5. Give one way a tohu and a scientific survey are alike, and one way they differ.

Fix the mistake

6. Correct this statement: "A fallen log or dead leaves are abiotic, because they are not alive any more."

7. Correct this statement: "Put the quadrats where there are lots of plants, so you get good data."

8. Correct this statement: "With 0.25 m² quadrats, multiply the mean per quadrat straight by the area of the field."

9. Correct this statement: "To see how plants change from the beach up a dune, scatter quadrats at random."

Answer key (for parents and tutors)

1. Element 17 is in period 3. Name it, give its group, and say whether it is a metal or non-metal.
   Chlorine, group 17 (a halogen), a non-metal, because it is right of the staircase.
2. Calcium is in group 2. Would a calcium wire conduct electricity? Give a reason.
   Yes. Group 2 is on the left of the table, so calcium is a metal, and metals conduct.
3. Why is argon, not air, pumped around the metal while welding?
   Argon is a noble gas in group 18, so it does not react with the hot metal, while oxygen in air would.
4. Melting points in group 17 rise down the group: chlorine −101 °C, bromine −7 °C, iodine 114 °C. Predict the state of astatine, the next halogen, at room temperature.
   A solid. The melting points keep rising down the group and iodine is already solid, so astatine's melting point will be higher still.
5. A grey element is shiny, conducts, and fizzes violently in water. Which group is it most likely in?
   Group 1, the alkali metals: reactive metals that react strongly with water.
6. Correct this statement: "Groups are the rows and periods are the columns."
   Groups are the columns (1 to 18) and periods are the rows (1 to 7); elements in one group behave alike, which is why the columns matter most.
7. Correct this statement: "The modern periodic table is in order of atomic mass."
   It is in order of atomic number, the number of protons, which is why tellurium comes before iodine even though it is heavier.
8. Correct this statement: "Hydrogen sits at the top of group 1, so it is a metal."
   Hydrogen is a non-metal gas; it is placed at the top left, but it does not conduct or behave like the alkali metals.
9. Correct this statement: "CO is the symbol for cobalt."
   Cobalt is Co, with a lower case second letter; CO has two capitals, so it is two elements, carbon and oxygen, joined as a compound.

Answer key (for parents and tutors)

1. How many protons and electrons are in a neutral atom of magnesium, atomic number 12?
   12 protons and 12 electrons, because the atomic number gives the protons and a neutral atom has equal numbers.
2. An atom has 7 protons. Name the element.
   Nitrogen, element 7.
3. In the gold foil experiment, why did most alpha particles pass straight through the foil?
   Atoms are mostly empty space, so most particles never came near a nucleus.
4. Which particle did Thomson's plum pudding model include, and which part did Rutherford add?
   Thomson's model included the electron; Rutherford added a small, dense, positive nucleus.
5. A particle has 17 protons and 18 electrons. What is its overall charge?
   −1, because 17 positive charges and 18 negative charges leave one extra negative (it is a chloride ion).
6. Correct this statement: "Some alpha particles bounced back, so the gold foil experiment showed atoms are solid."
   Most particles went straight through, so atoms are mostly empty space; the rare bounce-backs showed a tiny, dense, positive nucleus.
7. Correct this statement: "Electrons sit in the nucleus with the protons."
   Only protons and neutrons are in the nucleus; electrons are in shells around it, held by the attraction of opposite charges.
8. Correct this statement: "Neutrons are the negative particles."
   Neutrons have no charge; electrons are negative and protons are positive.
9. Correct this statement: "Atomic number means protons plus neutrons added together."
   The atomic number counts only the protons; protons plus neutrons is the mass number, which Part 2 covers.

Answer key (for parents and tutors)

1. Aluminium-27 has atomic number 13. How many protons, neutrons and electrons does a neutral atom have?
   13 protons, 14 neutrons (27 − 13), 13 electrons.
2. Write the electron arrangement for sulfur, atomic number 16.
   2,8,6.
3. Potassium has atomic number 19. How many valence electrons does it have, and in which shell?
   One valence electron in the fourth shell, because the arrangement is 2,8,8,1.
4. Fluorine is 2,7. Will it tend to lose or gain electrons, and how many?
   Gain 1, since one more electron fills its outer shell, while losing 7 would take far more energy.
5. Why is it harder to recycle helium than to recycle copper?
   Copper stays in the wire or pipe and can be collected and melted down, but released helium escapes into the air and then into space.
6. Correct this statement: "The mass number of chlorine-35 means it has 35 neutrons."
   The mass number counts protons and neutrons together, so neutrons = 35 − 17 = 18.
7. Correct this statement: "Potassium is 2,8,9, because the third shell can take more electrons."
   For the first 20 elements the third shell holds 8 before the fourth starts, so potassium is 2,8,8,1.
8. Correct this statement: "Chlorine is in group 17, so it has 7 electrons."
   Chlorine has 17 electrons, arranged 2,8,7; the 7 is only the number in its outer, valence shell.
9. Correct this statement: "Sodium loses an electron, so it becomes a negative ion."
   Losing a negative electron leaves 11 protons and 10 electrons, so sodium becomes a positive ion, Na^+.

Answer key (for parents and tutors)

1. A solution has pH 4. Is it acidic, neutral or alkaline, and what colour would universal indicator turn?
   Acidic, because it is below 7; universal indicator turns orange.
2. Magnesium oxide hardly dissolves in water. Is it a base, an alkali, or both?
   A base only. It neutralises acids, but an alkali must dissolve in water.
3. You need to check whether a farmer's paddock soil is pH 5.8 or 6.2. Which method should you use, and why?
   A pH meter, because universal indicator cannot tell apart values only 0.4 apart.
4. Why is it a bad idea to identify a liquid in the lab by tasting it, even though acids taste sour?
   The liquid could be corrosive or poisonous, and tasting is never a safe lab test.
5. Oven cleaner has pH 13 and lemon juice has pH 2. Which is further from neutral, and what does that tell you about handling it?
   Oven cleaner: it is 6 units above 7, while lemon juice is 5 units below. It is a strong alkali and corrosive, so wear gloves and eye protection and rinse any splash with plenty of water.
6. Correct this statement: "pH 2 is only a little more acidic than pH 3, because the numbers are just 1 apart."
   Each step on the pH scale is a tenfold change, so pH 2 is ten times more acidic than pH 3.
7. Correct this statement: "The higher the pH number, the stronger the acid."
   Acids are below 7 and get stronger as the number goes down; a high pH means a strong alkali.
8. Correct this statement: "Alkali and base mean the same thing."
   An alkali is a base that dissolves in water, so every alkali is a base, but insoluble bases such as copper oxide are not alkalis.
9. Correct this statement: "Litmus paper tells you the pH of a solution."
   Litmus only shows acid or alkali; you need universal indicator for a rough pH number or a pH meter for an exact one.

Answer key (for parents and tutors)

1. A gas relights a glowing splint. What is it?
   Oxygen; only nearly pure oxygen relights a glowing splint.
2. Marble chips are added to hydrochloric acid. Which test would you use on the gas, and what result do you expect?
   Bubble it through limewater; the limewater turns milky because the gas is carbon dioxide from the acid and carbonate.
3. A clear liquid turns blue cobalt chloride paper pink. Does this prove the liquid is pure water? Explain.
   No. It shows water is present, but the liquid could have other things dissolved in it; you would also check its boiling point is 100 °C.
4. Red cabbage indicator turns blue-green in a cleaning spray. Is the spray acidic, neutral or alkaline?
   Alkaline, since red cabbage turns blue to green above pH 7.
5. A student spills dilute sodium hydroxide on their hand. What should they do first?
   Rinse the hand under running water for at least 15 minutes and tell the teacher; sodium hydroxide is corrosive even when dilute.
6. Correct this statement: "A lit splint went out in the gas, so it must be carbon dioxide."
   A splint also goes out in nitrogen and other gases, so only limewater turning milky confirms carbon dioxide.
7. Correct this statement: "Hydrogen relights a glowing splint, and oxygen pops with a lit one."
   It is the other way round: hydrogen gives a squeaky pop with a lit splint, and oxygen relights a glowing one.
8. Correct this statement: "The liquid turned cobalt chloride paper pink, so it is pure water."
   Pink only shows water is present; a pure sample also has a boiling point of exactly 100 °C at sea level.
9. Correct this statement: "To dilute an acid, pour the water into the acid."
   Add the acid slowly to the water, because water poured into concentrated acid heats up fast and can spit acid out.

Answer key (for parents and tutors)

1. A 9 V battery is connected to a 3 Ω resistor. What current flows?
   3 A, because I = V ÷ R = 9 ÷ 3.

2. In a series circuit an ammeter before the first lamp reads 0.4 A. What does an ammeter after the second lamp read?
   0.4 A, because the current is the same everywhere in a series loop.

3. A parallel circuit has two branches carrying 0.3 A and 0.5 A. What current comes out of the battery?
   0.8 A, because branch currents add: 0.3 + 0.5.

4. One lamp in a string of three blows. What happens to the other two if the string is in series, and if it is in parallel?
   In series both go out, because the only path is broken. In parallel both stay lit, because each has its own path.

5. A balloon rubbed on hair sticks to the ceiling. Explain why, using the word electrons.
   Rubbing moves electrons from the hair onto the balloon, so the balloon becomes negatively charged. Its charge pulls on the opposite charges in the ceiling surface, and the attraction holds it up.

6. Correct this statement: "Current gets used up by the first bulb, so less comes out the other side."
   Current is the same all the way round a series loop; the bulbs take energy from the charge, not the charge itself.

7. Correct this statement: "Adding a lamp in parallel makes all the lamps dimmer, just like in series."
   Each parallel branch still gets the full battery voltage, so every lamp stays as bright; the battery just supplies more current and goes flat sooner.

8. Correct this statement: "With 6 V across 3 Ω, the current is 6 × 3 = 18 A."
   Rearrange V = IR to I = V ÷ R, so the current is 6 ÷ 3 = 2 A; more resistance means less current, not more.

9. Correct this statement: "A rubbed balloon becomes positive because it picks up protons from the jumper."
   Only electrons move when you rub; the balloon gains electrons and becomes negative, leaving the jumper positive.

Answer key (for parents and tutors)

1. Why is the inside of a cable copper and the outside plastic?
   Copper is a conductor, so it carries the current; plastic is an insulator, so the charge cannot reach whoever holds the cable.

2. A student puts a voltmeter in the loop of a series circuit and the lamp goes out. Explain what went wrong.
   A voltmeter has a very high resistance, so in the loop it almost stops the current. It should be connected across the lamp.

3. A kettle element on 230 V draws 8 A for 120 s. How much energy is transferred?
   220 800 J (about 221 kJ), from $E = V \times I \times t = 230 \times 8 \times 120$.

4. A motor receives 500 J of electrical energy and gives 350 J of movement energy. How much is wasted, and what is its efficiency?
   150 J is wasted, mostly as heat, and the efficiency is $350 \div 500 \times 100\% = 70\%$.

5. Give one advantage and one disadvantage of relying on hydro for most of New Zealand's electricity.
   Advantage: renewable, with no carbon dioxide while running, and it can be turned up quickly when demand rises. Disadvantage: dry years leave the lakes low, so fossil fuel stations like Huntly have to make up the shortfall.

6. Correct this statement: "A voltmeter goes in the loop, the same as an ammeter."
   A voltmeter goes across the component; in the loop its very high resistance almost stops the current.

7. Correct this statement: "The lamp uses up the energy, so it no longer exists."
   Energy is conserved: the lamp changes electrical energy into light and heat, and the heat spreads into the room rather than disappearing.

8. Correct this statement: "A lamp on 6 V drawing 0.5 A for one minute uses $6 \times 0.5 \times 1 = 3$ J."
   Time must be in seconds for joules, so $E = 6 \times 0.5 \times 60 = 180$ J.

9. Correct this statement: "A lamp with 100 J in and 40 J of light out is 250% efficient, from $100 \div 40$."
   Efficiency is useful out ÷ total in × 100%, so $40 \div 100 \times 100\% = 40\%$; it can never pass 100%, because no device makes energy.

Answer key (for parents and tutors)

1. A boat's engine pushes forward with 800 N. Water drag is 650 N backward. Find the net force and say what the boat does.
   150 N forward, from 800 − 650, so the boat speeds up.

2. A cyclist moves at a steady 20 km/h in a straight line. What is the net force on her, and how do you know?
   Zero, because her speed and direction are not changing; her pedalling force exactly matches friction and air resistance.

3. In a test of how the mass of a trolley affects its speed down a ramp, name the independent, dependent and two controlled variables.
   Independent: the trolley's mass. Dependent: the time (or speed) down the ramp. Controlled: any two of ramp height, ramp length, surface, release method and the timer.

4. Trial times: 3.10 s, 3.06 s, 3.62 s, 3.08 s. Which is the outlier, and what is the mean of the others?
   3.62 s is the outlier. Mean = (3.10 + 3.06 + 3.08) ÷ 3 = 9.24 ÷ 3 = 3.08 s.

5. A 50 N box sits on a base of 0.25 m². What pressure does it exert?
   200 Pa, from 50 ÷ 0.25.

6. Correct this statement: "A moving object needs a forward net force to keep going at a steady speed."
   At a steady speed in a straight line the net force is zero; the forward push only cancels friction and air resistance.

7. Correct this statement: "450 N to the left and 400 N to the right give a net force of 850 N."
   Opposite forces subtract, so the net force is 450 − 400 = 50 N to the left, the way of the bigger force.

8. Correct this statement: "600 N on 400 cm² gives a pressure of 600 ÷ 400 = 1.5 Pa."
   Pascals need square metres, so convert 400 cm² to 0.04 m² first: 600 ÷ 0.04 = 15 000 Pa.

9. Correct this statement: "One careful run is enough, and an odd result can just be deleted."
   Repeat each test at least three times so an outlier stands out, and record any result you leave out along with the reason.

Answer key (for parents and tutors)

1. On a position-time graph, a line goes from 0 m at 0 s to 120 m at 20 s in a straight line. What is the speed, and is it steady?
   6 m/s, from 120 ÷ 20, and it is steady because the line is straight.

2. Describe the motion shown by a position-time graph that is flat from 5 s to 12 s.
   The object is stopped (stationary) for 7 s, because its position does not change.

3. A kayak has 150 N of paddle thrust forward and 90 N of drag backward; its weight and the water's upward push are both 800 N. Find the net force.
   Vertical forces cancel, so the net force is 150 − 90 = 60 N forward, and the kayak speeds up.

4. A 60 N force pushes a drawing pin with a point of 0.000 001 m². What pressure does the point make, and why does it go into a cork board?
   60 ÷ 0.000 001 = 60 000 000 Pa. The tiny point concentrates the force into a huge pressure that pushes the cork apart.

5. Explain why one wide snowboard and two skis both work on soft snow, but walking in boots does not.
   A snowboard and two skis both spread the weight over a large area, giving a low pressure the snow can hold up. Boots put the same weight on a small area, so the pressure is high and they sink.

6. Correct this statement: "A flat line on a position-time graph means the object is moving at a steady speed."
   A flat line means the position is not changing, so the object is stopped; a straight sloping line is a steady speed.

7. Correct this statement: "A straight line sloping upwards means the object is speeding up."
   A straight line has the same slope all the way, so the speed is steady; only a curve that gets steeper shows speeding up.

8. Correct this statement: "The free-body diagram of a box should show the box pushing down on the floor."
   A free-body diagram shows only the forces acting on the box, such as its weight and the floor's support, not forces it puts on other things.

9. Correct this statement: "An axe cuts wood because it pushes harder than a hammer."
   With the same force, the axe's thin edge has a much smaller area, so the pressure F ÷ A is far bigger.

Answer key (for parents and tutors)

1. Venus is often the brightest point in the evening sky after sunset. Is it a star or a planet, and how do you know it does not make its own light?
   A planet. It shines steadily, it drifts against the stars over weeks, and it only shines because sunlight reflects off its clouds.
2. Titan orbits Saturn and is bigger than the planet Mercury. Which group does Titan belong to, and why does its size not matter?
   A moon. The group depends on what it orbits, and Titan orbits a planet, not the Sun directly.
3. A friend says the Moon only comes out at night. Give two pieces of evidence that this is wrong.
   The Moon is often seen in a blue afternoon sky near first quarter and in the morning sky near last quarter, and it can be up at night or in the day depending on its phase.
4. Mars is on average about 228 million km from the Sun. How long does sunlight take to reach Mars, in minutes?
   228,000,000 ÷ 300,000 = 760 s, and 760 ÷ 60 = about 12.7 minutes.
5. Matariki rises together and keeps the same shape every year. Explain why it cannot be a group of planets.
   Matariki is a cluster of stars. Planets each wander across the sky at their own pace, so a group of them would not keep a fixed shape year after year.
6. Correct this statement: "The Moon glows at night because it makes its own light."
   The Moon is grey rock that only reflects sunlight, which is why we see just the part of it facing the Sun.
7. Correct this statement: "The phases happen because Earth's shadow covers part of the Moon."
   Phases come from how much of the Moon's sunlit half faces us as it orbits; Earth's shadow only falls on the Moon in a lunar eclipse.
8. Correct this statement: "The Sun cannot be a star because it is far bigger and brighter than the stars at night."
   The Sun is a star that looks bigger and brighter only because it is about 8 light-minutes away, while the next star is over 4 light-years away.
9. Correct this statement: "Titan is bigger than Mercury, so Titan must be a planet."
   The group depends on what an object orbits, not its size, and Titan orbits Saturn, so it is a moon.

Answer key (for parents and tutors)

1. Saturn is 9.5 AU from the Sun. How far is that in kilometres?
   9.5 × 150 million km = 1,425 million km, about 1.4 billion km.
2. Which unit would you use for each: the width of Mars, the distance from the Sun to Uranus, the distance to the Southern Cross stars? Give a reason for one of them.
   Kilometres for the width of Mars, AU for the Sun to Uranus, light-years for the Southern Cross. Each keeps the numbers small: 19.2 AU is easier to use than 2.9 billion km.
3. A rock lands in a paddock in Canterbury after streaking across the sky. Name the streak and name the rock.
   The streak is a meteor; the rock on the ground is a meteorite.
4. In the beach-ball model, where 1 AU is 32 m, how far from the ball does Mars (1.52 AU) go?
   1.52 × 32 m = about 49 m.
5. A comet's tail points to the left of the comet in a photo. Which way is the Sun, and why?
   To the right. The tail is pushed away from the Sun by sunlight and the solar wind, so it always points away from it.
6. Correct this statement: "A meteor and a meteorite are the same thing."
   A meteor is the glowing streak in the air, and a meteorite is the piece of rock that survives and lands on the ground.
7. Correct this statement: "A comet's tail trails behind it, showing where it has come from."
   The tail always points away from the Sun, pushed by sunlight and the solar wind, so a comet heading away from the Sun travels tail first.
8. Correct this statement: "Jupiter is 5.2 AU away, so it is 5.2 × 150 = 780 km from the Sun."
   1 AU is 150 million km, so the answer is 780 million km; dropping the million makes the distance a million times too small.
9. Correct this statement: "The asteroid belt is so packed with rocks that spacecraft have to steer around them."
   The belt is mostly empty space, with asteroids typically hundreds of thousands of kilometres apart, so probes fly straight through.

Answer key (for parents and tutors)

1. List the planets in order from the Sun and mark which are rocky, gas giants and ice giants.
   Mercury, Venus, Earth, Mars (rocky); Jupiter, Saturn (gas giants); Uranus, Neptune (ice giants).
2. Eris is round, orbits the Sun and lies among many other icy bodies beyond Neptune. Why is it not a planet?
   It has not cleared its orbit of other objects, so it is a dwarf planet.
3. Saturn is about 9.5 AU from the Sun. Roughly what fraction of Earth's sunlight does it receive?
   $9.5^2 = 90$, so about 1/90, roughly 1%.
4. A telescope cannot touch Mars, yet scientists know its air is mostly carbon dioxide. How?
   By analysing the light that passes through or reflects off its atmosphere: carbon dioxide absorbs particular colours, and those gaps show up in the spectrum. Landers have since confirmed it.
5. Give one thing an orrery shows well and one thing it gets wrong.
   It shows planets moving at different speeds, with the outer ones slower. It gets the distances and sizes badly wrong and makes orbits perfect circles.
6. Correct this statement: "Pluto stopped being a planet because it is too small."
   Pluto is round and orbits the Sun, but it has not cleared its orbit of other icy bodies, which is the test it fails.
7. Correct this statement: "At twice the distance from the Sun, a planet gets half the sunlight."
   It gets a quarter, because the same light spreads over four times the area; always square the distance before dividing.
8. Correct this statement: "Mercury is closest to the Sun, so it must be the hottest planet."
   Venus is hotter, about 465 °C, because its thick carbon dioxide atmosphere traps heat, so distance is not the only factor.
9. Correct this statement: "Scientists switched to a Sun-centred model as soon as Copernicus published it in 1543."
   Agreement took decades, building up as telescope evidence such as the phases of Venus and Kepler's accurate predictions piled up.

Answer key (for parents and tutors)

1. A student says plant cells have chloroplasts instead of mitochondria. Explain what is wrong.
   Plant cells have both. Mitochondria release energy from glucose in every plant cell, and chloroplasts make that glucose in the green parts.
2. A cell has DNA, a membrane, cytoplasm and a cell wall, but no nucleus. Is it prokaryotic or eukaryotic, and what kind of organism is it likely to be?
   Prokaryotic, because the DNA is not inside a nucleus; it is most likely a bacterium.
3. An onion cell is 300 µm long. How long will it look in an image at ×100, in mm?
   300 µm × 100 = 30,000 µm = 30 mm.
4. Why does a lettuce left without water go floppy? Use the words vacuole and cell wall.
   Without water the large vacuoles shrink and stop pushing out against the cell walls, so the cells go soft and the leaves droop.
5. Why did scientists need the electron microscope to understand how mitochondria work?
   Mitochondria are only about 1 µm across and their inner folds are far smaller than the 0.2 µm limit of a light microscope; only an electron microscope magnifies and resolves enough to show them.
6. Correct this statement: "Animal cells have a cell wall too, just a thinner one."
   Animal cells have only a cell membrane; the stiff cellulose wall is found in plant cells, which is why animal cells can change shape.
7. Correct this statement: "Bacteria have no nucleus, so they have no DNA."
   Bacteria do have DNA, usually one loop loose in the cytoplasm; having no nucleus only means it has no membrane around it.
8. Correct this statement: "Actual size = image size × magnification."
   Divide instead: actual size = image size ÷ magnification, because the real cell is smaller than its image.
9. Correct this statement: "24 mm ÷ 400 = 0.06, so the cell is 0.06 µm across."
   The answer is in the unit you divided, so it is 0.06 mm, which is 60 µm; convert to µm before dividing to avoid this.

Answer key (for parents and tutors)

1. Sort into infectious or non-infectious, and name the pathogen type for the infectious ones: measles, asthma, athlete's foot, Giardia infection, type 2 diabetes.
   Measles: infectious, virus. Asthma: non-infectious. Athlete's foot: infectious, fungus. Giardia infection: infectious, protist. Type 2 diabetes: non-infectious.
2. Why will a doctor not give antibiotics for a cold?
   Colds are caused by viruses, and antibiotics only work on bacteria.
3. Explain why someone who had chickenpox as a child usually does not get sick from it again.
   Memory cells made during the first infection stay in the body and respond so fast to a second exposure that the virus is destroyed before symptoms appear.
4. School absences from flu over four days were 4, 8, 15 and 31. Describe the pattern, predict day 5, and suggest one measure to slow it.
   The number roughly doubles each day, so about 60 on day
5. Boot-cleaning stations stand at track entrances in the Waitākere Ranges. Which prevention strategy is this, and which spread route does it block?
   Measures include staying home when sick, covering coughs, hand washing, better ventilation or flu vaccination. 5. Hygiene; it blocks spread in contaminated soil carried on footwear.
6. Correct this statement: "Antibiotics will cure a cold or the flu."
   Antibiotics only kill bacteria, and colds and flu are caused by viruses, so antibiotics do nothing against them.
7. Correct this statement: "A vaccine gives you a mild case of the disease."
   A vaccine shows your immune system the pathogen's antigens without causing the disease, so it makes antibodies and memory cells in advance.
8. Correct this statement: "You do not catch chickenpox twice because the antibodies stay in your blood forever."
   Antibody levels fall after an illness; memory cells stay behind and make new antibodies quickly if the pathogen comes back.
9. Correct this statement: "You can catch asthma or type 2 diabetes from someone who has it."
   They are non-infectious diseases with no pathogen behind them, so they cannot pass from person to person.

Answer key (for parents and tutors)

1. Explain, using the word concentration, why oxygen moves from the blood into a muscle cell.
   The muscle cell uses oxygen in respiration, so its oxygen concentration is lower than in the blood, and oxygen diffuses from high to low concentration.
2. Write the word equation for photosynthesis and name where in the cell it happens.
   carbon dioxide + water → glucose + oxygen, using light and chlorophyll, in the chloroplasts.
3. Jelly babies left in water swell up. Write a testable question about temperature and say what you would measure and keep the same.
   For example: does water temperature change how much a jelly baby's mass increases in an hour? Measure the mass before and after; keep the jelly baby type, the volume of water and the time the same.
4. Germinating peas in a sealed flask warm up, and limewater connected to the flask turns milky. Which process is happening and what two pieces of evidence show it?
   Respiration: the heat shows energy being released, and the milky limewater shows carbon dioxide being produced.
5. Is a plant respiring at night, photosynthesising, or both? Explain.
   Only respiring. With no light it cannot photosynthesise, but respiration goes on all the time.
6. Correct this statement: "Plants photosynthesise and animals respire."
   Plants respire all the time in their mitochondria, just like animals; in light they also photosynthesise.
7. Correct this statement: "Respiration is the same thing as breathing."
   Respiration is the reaction in every cell that releases energy from glucose; breathing only moves air in and out of the lungs.
8. Correct this statement: "Particles diffuse because they want to spread out into empty space."
   Particles move randomly, and more leave a crowded area than enter it, so the overall movement is from higher to lower concentration.
9. Correct this statement: "Photosynthesis makes energy for the plant."
   Energy cannot be made; photosynthesis stores light energy in glucose, and respiration later releases it.

Answer key (for parents and tutors)

1. Sort into biotic or abiotic: a dead kauri leaf, soil pH, a weta, rainfall, a fungus on a log.
   Biotic: dead kauri leaf (recently living), weta, fungus. Abiotic: soil pH, rainfall.
2. Mosses grow thickly on the south side of a building but hardly at all on the north side. Suggest two abiotic factors that explain this, remembering New Zealand is in the Southern Hemisphere.
   In New Zealand the north side faces the Sun, so the south side gets less light and stays cooler and damper, which suits mosses that dry out easily.
3. Six random 1 m² quadrats on a 300 m² lawn hold 2, 4, 1, 3, 0 and 2 clover plants. Estimate the clover on the lawn.
   Total 12, mean 2 per m², and 2 × 300 = about 600 plants.
4. You want to know how plants change from a sunny paddock into the shade of bush. Would you use random quadrats or a transect? Say what you would measure.
   A transect, because you are looking at change across a boundary. Measure light, temperature and soil moisture at each quadrat, and record the plants and their cover.
5. Give one way a tohu and a scientific survey are alike, and one way they differ.
   Alike: both rely on repeated observation of patterns and use them to make predictions. Different: tohu are passed on over generations and tied to place, while a survey uses measured numbers taken with instruments at set times.
6. Correct this statement: "A fallen log or dead leaves are abiotic, because they are not alive any more."
   Recently living things count as biotic, because they still feed and shelter other organisms such as fungi, slaters and worms.
7. Correct this statement: "Put the quadrats where there are lots of plants, so you get good data."
   Place quadrats at random, because choosing spots on purpose biases the sample and overestimates the numbers.
8. Correct this statement: "With 0.25 m² quadrats, multiply the mean per quadrat straight by the area of the field."
   First divide the mean by 0.25 to get the number per m², otherwise the estimate comes out four times too small.
9. Correct this statement: "To see how plants change from the beach up a dune, scatter quadrats at random."
   Use a transect, with quadrats at regular distances along a tape, because random quadrats cannot show change along a line.