- There are three types of sub-atomic particle – protons, neutrons, and electrons

10.1 Student Book answers

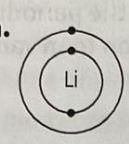
1. Proton number – the number of protons in an atom of an element.
2. A diagram with 5 purple circles and 6 green circles in a cluster.
3. **a.** 8 **b.** 17 **c.** 47
4. **a.** Vanadium, V
   b. Argon, Ar
   c. Iron, Fe

10.2 Student Book answers

1. Electron configuration – the arrangement of electrons in shells in an atom.

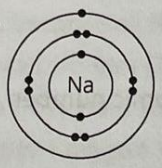
2. a. 7 **b.** 9 **c.** 13

3. a.



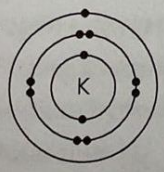
lithium

b.



sodium

c.



potassium

4. Similar – there is one electron in the outer shell, furthest from the nucleus; different – each has a different number of electron shells.

a maximum number of electrons.

10.3 Student Book answers

1. Ion – an atom that has gained one or more electrons to be negatively charged, or lost one or more electrons to be positively charged.
2. The outer electron shell is full, and the ion stable.
3. **a.** K^+

   b. Mg^{2+}

   c. Br^-
4. Charge on ion is −1, because gaining one electron gives a full outer shell, which is a stable arrangement.

10.4 Student Book answers

1. Ionic bonding – the electrostatic attraction between positive and negative ions that holds an ionic compound together; ionic compound – a compound made up of positive and negative ions; giant ionic structure – the three-dimensional pattern of oppositely charged ions in an ionic compound.
2. Electrostatic
3. **a.** The electrostatic attraction between oppositely charged ions is strong.
   b. If you drop a crystal of an ionic compound, it breaks between one row of ions and another.
4. Strengths – shows positions of ions, shows that the ions are held together strongly; limitations – does not show that ions vibrate on the spot, does not explain why ionic compounds are brittle.

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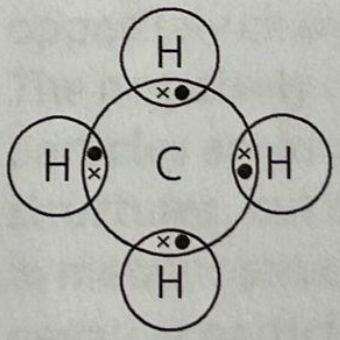
- An atom with a full outer shell is stable.
- The chemical formula of a substance gives the relative number of atoms of each element in it.

10.5 Student Book answers

1. Covalent bond – a shared pair of electrons that joins two atoms together.

2.



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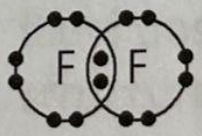

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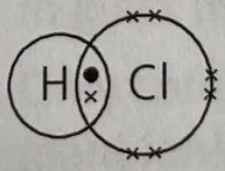

- Interactive test

Prior learning

- A covalent bond is a shared pair of electrons that joins two atoms together.

10.6 Student Book answers

1. Giant covalent structure – a three-dimensional network of atoms that are joined together by covalent bonds.
2. **a.** Covalent
   b. To achieve a share in a fuller outer shell of electrons, so achieving a stable electronic configuration.
3. Simple molecules are attracted to each other only weakly, but in a giant covalent structure, the atoms are joined together in a three-dimensional network by strong covalent bonds.

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network of atoms that are joined together by covalent bonds.

10.7 Student Book answers

1. Positive ions and electrons; electrostatic
2. The electrostatic attraction between the positive ions in fixed positions and negative ions moving between the ions is strong.
3. Both have giant structures, both include positively charged ions, both have high melting points. Both are held together by electrostatic attraction between oppositely charged particles. The negatively charged particles are ions in ionic structures, but electrons in metallic structures. The negative particles are in fixed positions in giant ionic structures, but move around in giant metallic structures.
4. Only compounds can have giant ionic structures, and the periodic table shows only elements.

Prior learning

- An ionic substance is made of positive and negative ions.
- A covalent bond is a shared pair of electrons.

10.8 Student Book answers

1. Systematic review – a study that uses repeatable methods to collect and analyse secondary data from many scientists.
2. Sodium chloride, potassium chloride, and trisodium citrate.
3. Replaces lost water and ions; glucose helps the body to absorb sodium ions and water. Glucose also provides energy.

10.9 Review answers

Student Book answers

1. a. Neutron [1]

b. Electron configuration [1]

c. Proton number [1]

d. Positive[1]

e. Negative [1]

2. a. 9 [1]

b. Diagram showing 9 protons and 10 neutrons, arranged in a cluster [1]

c. [3]

d. Fluorine and chlorine [1]
They both have the same number of electrons (7) in their outer shells [1]

3. Top row – B, 3 [1]
Second row – C, 6, 4 [1]
Third row – Li, 3 [1]
Fourth row – Mg, 12 [1]
Fifth row – Na, 1 [1]

4. a. 13 [1]

b. 2 electrons in shell nearest nucleus, 8 in next shell, 3 in outer shell [2]

c. One from: boron, gallium, indium, thallium

5. a. Li^+ [1]

b. Ca^{2+} [1]

c. Fe^{3+} [1]

d. Cl^- [1]

e. N^{3-} [1]

6. −2 [1] because it needs two more electrons to gain a full outer electron shell / gain a stable electron configuration [1]

7. a. Electrostatic [1]

b. The electrostatic attractions between the positive and negative ions are strong [1]

c. Mg^{2+}[1]

d. I^- [1]

e. MgI_2 [1]

f. If dropped or hit, it breaks between one row of ions and another [1]

8. a. F_2 [1]

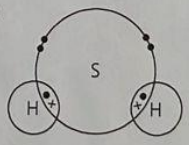
b. Covalent [1]

c. Fluorine molecules are attracted to each other only weakly [1]

9. a. H_2S [1]

b. Gas [1]

c.



10. a. Giant covalent structure [1]

b. Each carbon atom makes strong covalent bonds with four other carbon atoms [1]

matter in an object. It is measured in grams or kilograms.

- Volume is the amount of space an object takes up. It is measured in cm^3, m^3, or litres.

11.1 Student Book answers

1. The density of a material is its mass in a certain volume.
2. $density = \frac{mass}{volume}$

$density = \frac{20\,g}{2\,cm^2}$

$density = 10\,g/cm^3$

3. $density = \frac{18\,g}{20\,cm^2}$

$density = 0.9\,g/cm^3$

4. $volume = 2\,cm \times 3\,cm \times 4\,cm$
$= 24\,cm^3$

$density = \frac{mass}{volume}$

$density = \frac{192\,g}{24\,cm^2}$

$density = 8\,g/cm^3$

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11.2 Student Book answers

1. Mass of particles; how closely packed the particles are.
2. Aluminium – 2.7 g/cm^3 and gold – 19 g/cm^3. The mass of gold particles is greater, so gold has the higher density.
3. The particles are more closely packed in the liquid state than in the gas state.
4. Tungsten, because its atoms have the greater mass.
5. She could arrange the chocolates in the bottom of a jar very carefully, so that they make a pattern. This represents the solid state. Then she could shake a jar, so the particles spread out. This represents the gas state. There are fewer chocolates per unit volume in the model of the gas, so the gas has the lower density.

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an object made from the material. Then divide the mass by the volume.

11.3 Student Book answers

1. Ruby
2. **a.** $density = \frac{mass}{volume}$

$$density = \frac{2.00\ g}{0.77\ cm^2}$$

$$density = 2.59\ g/cm^3$$

b. Quartz

3. They build on earlier scientists' work / they write about their work.
4. Modern scientists normally specialise in one area, but al-Biruni worked in many areas of science.

again (see lesson 2.1).

- Tell students that this lesson is about the elements in Group 1, the column on the left of the periodic table. Point out that lithium, at the top of the group, is in great demand owing to its use in electric car batteries.
- Tell students that there are patterns in the physical and chemical properties of the Group 1 elements. This lesson is about their physical properties.
- Students use the data on **worksheet 11.4.1** to plot a bar chart of the Group 1 element melting points. Elicit that the data are from a secondary source – students have not measured the values themselves. Ask students to explain why they should plot a bar chart, not a line graph (the independent variable – the element – is categoric). Students then describe the pattern in melting points.
- If there is time, students answer questions 1 and 4 on Student Book page 195.
- Finish the lesson by eliciting properties of typical metals (shiny, conduct electricity, high melting points, high densities). Tell students that the Group 1 elements have some properties that are typical of all metals (shiny when freshly cut, conduct electricity), but that some of their properties are not typical of metals (relatively low melting points and densities).

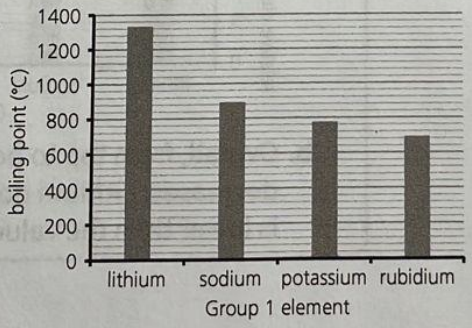
11.4 Student Book answers

1. Lithium – Li; sodium – Na; potassium – K; rubidium – Rb; caesium – Cs

2. From top to bottom, melting point decreases.

3. Group 1 elements have a giant metallic structure, with positively charged ions in fixed positions and negatively charged electrons moving around between the ions. From top to bottom of the group, the ions get bigger: electrostatic attractions between positive ions and negative electrons gets weaker and ions leave their fixed positions more easily, so melting points decrease.

4. a.



b. From top to bottom, boiling points decrease.

density and electrical conductivity – and answer questions about

Activities

- Demonstrate the reaction of lithium with water, or show a video clip. For demonstration instructions, search for *RSC Group 1 reactivity*. It is vital to follow the safety instructions carefully. Remind students that they have seen this reaction before, when studying metal reactivity in lesson 9.7.
- Elicit that the vigorous reaction of lithium with water is one of the chemical properties of lithium. Remind students that there are patterns in the physical properties of the Group 1 elements, for example, melting point. Today they will find out about the pattern in one of their chemical properties.
- Demonstrate the reactions of sodium and potassium with water, following the same procedure as for lithium. Again, follow the safety instructions carefully. Students record their observations and describe the pattern in the reactions of the Group 1 elements with water. They also write word equations for the reactions. **Worksheet 11.5.1** support this activity.
- If there is time, students answer questions 1 and 4 on Student Book page 197, which are about two physical properties – density and electrical conductivity.
- Finish the lesson by pointing out that there are patterns in the physical and chemical properties of the elements in all groups of the periodic table.

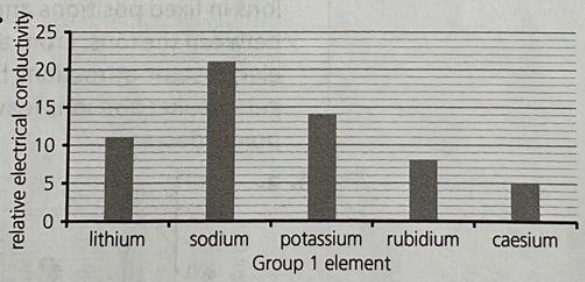
11.5 Student Book answers

1. Increases from top to bottom of Group 1.

2. Rubidium hydroxide and hydrogen

3. When a Group 1 element reacts with water, each atom gives its outer electron to an atom of another element. From top to bottom of Group 1, the outer electron gets further from the nucleus, and easier to give away. This makes the reactions more and more vigorous.

4. a.



b. Overall, from top to bottom of the group, electrical conductivity decreases. Lithium does not fit the pattern – its electrical conductivity is lower than the values for sodium and potassium.

Prior learning

- There are patterns in the physical and chemical properties of the elements in a periodic table group.

11.6 Student Book answers

1. Decreases from top to bottom of the group, with magnesium not fitting the pattern.
2. Barium chloride solution and hydrogen gas
3. calcium + hydrochloric acid → calcium chloride + hydrogen
4. From top to bottom of the group, the outer electrons get further from the nucleus, and so easier to give away. This means that the reactions will get more vigorous from top to bottom of the group.

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11.7 Review answers

Student Book answers

1. a. 62 cm^3 [1]

b. 69 – 62 = 7 cm^3 [2]

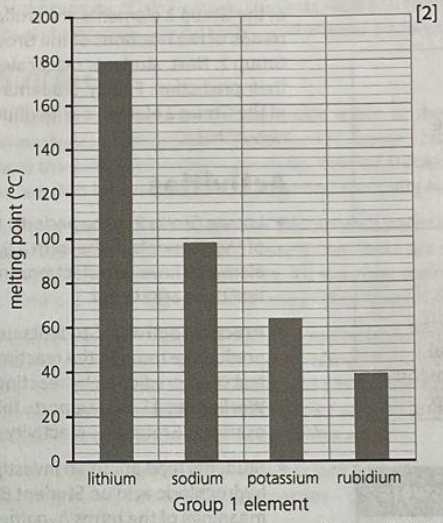
c. Density = 24 / 7 = 3.4 g/cm^3 [2]

2. a. Sodium – 2,8,1 [1]
potassium 2,8,8,1 [1]

b. They both have one electron in the outer shell [1]

c. All the elements in a periodic table group have the same number of electrons in their outer shell [1]

3. a. [2]



b. From top to bottom of the group, melting point decreases [1]

4. a. Hydrogen [1]

b. An alkaline solution was formed in the reaction [1]

c. sodium + water → sodium hydroxide + water [1]

d. i. Both reactions form hydrogen gas / both reactions form an alkaline solution [1]

ii. The reaction with potassium is more vigorous / there is a purple flame when potassium reacts with water, but no flame/an orange flame when sodium reacts with water. [1]

e. From top to bottom of the group, the reactions get more vigorous [1]

5. a. From top to bottom of the group, the atoms get bigger [1]

b. The atoms of each element have one more filled electron shell than atoms of the element above it [1]

6. a. From top to bottom of the group, boiling point decreases [1]

b. Any value below 777 °C. The melting point of barium is 727 °C [1]

7. a. Independent variable – the element [1];
dependent variable – how vigorous the reaction is [1]

b. One from volume/amount of water, temperature of water [1]

c. The reaction is likely to be very vigorous and therefore hazardous [1]

8. a. Do not conduct electricity [1]
poor conductors of heat/thermal energy [1]

b. i. Bromine

ii. Increases from top to bottom of group [1]

iii. Value between – 220 and – 7 °C. Actual value is – 34 °C

rearrange and join together differently to make new substances.

- A word equation is a simple way of representing a chemical reaction.
- The chemical formula of a substance gives the relative number of atoms of each element in the substance.

12.1 Student Book answers

1. Mass is conserved – the total mass of products equals the total mass of reactants; energy is conserved – the total amount of energy does not change.
2. Reacts to make
3. **a.** Carbon and hydrogen
   b. Carbon dioxide, CO_2 and water, H_2O
   c. Two million

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way of representing a chemical reaction.

- The chemical formula of a substance gives the relative number of atoms of each element in the substance.
- Symbol equations show chemical reactions with chemical formulae.

12.2 Student Book answers

1. $4Li(s) + O_2(g) \rightarrow 2Li_2O(s)$
2. $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$
3. $N_2(g) + O_2(g) \rightarrow 2NO(g)$

12.3 Student Book answers

1. Metal displacement reaction – a reaction in which a more reactive metal displaces – or pushes out – a less reactive metal from its compound.
2. Reactions that occur – **a**, **c**, and **d**
   Equations: magnesium + iron oxide →
   magnesium oxide + iron
   zinc + copper sulfate →
   zinc sulfate + copper
   copper + silver nitrate →
   copper nitrate + silver

Prior learning

- In a metal displacement reaction, a more reactive metal replaces a less reactive metal from its compound.

12.4 Student Book answers

1. Ore – a rock that a metal can be extracted from.
2. Heating with carbon – two from: zinc, lead, iron, copper. Using electricity – two from: sodium, calcium, magnesium, aluminium
3. Metals have many uses. For example – we use iron to make steel for bridges; we use aluminium for cans; we use lead for roofing and to protect from X-rays.
4. Electricity, because magnesium is above carbon in the reactivity series.

reactive metal from its compound.

12.5 Student Book answers

1. Three from: makes large amounts of waste rock, land cannot be used for other purposes, few animals and plants can live in copper mine areas, lorries and machinery pollute the air, requires large amounts of energy, makes large amounts of greenhouse gases/carbon dioxide.
2. Wind turbines and solar cells are connected by copper wires. As more electricity is generated by solar cells and wind turbines, more and more copper is needed.
3. A well-argued paragraph describing the environmental benefits of the chosen method.

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- Worksheet 12.6.3 Making magnesium chloride
- Interactive test

Prior learning

- Acidic solutions have a pH less than 1.

12.6 Student Book answers

1. A salt is a compound made when a metal ion replaces the hydrogen ion in an acid.
2. Filtration
3. zinc + hydrochloric acid → zinc chloride + hydrogen
   salt made – zinc chloride
4. Iron and sulfuric acid

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- Acidic solutions have a pH less than 1.

12.7 Student Book answers

1. **a.** Hydrochloric acid
   b. Sulfuric acid
   c. Nitric acid
2. Sulfuric acid and either copper oxide or copper carbonate
3. nickel carbonate + hydrochloric acid → nickel chloride + carbon dioxide + water

- A salt is a compound formed when a metal ion replaces the hydrogen ion in an acid.

12.8 Student Book answers

1. copper carbonate + sulfuric acid → copper sulfate + carbon dioxide + water
2. Chemical reaction, filtration, evaporation, crystallisation
3. The water bath heats the mixture more evenly, so spitting is avoided.
4. zinc carbonate + hydrochloric acid → zinc chloride + carbon dioxide + water
   salt made – zinc chloride
5. Magnesium carbonate and nitric acid

differently to make new substances.

12.9 Student Book answers

1. For example – fast, fireworks; slow – rusting.
2. $73\,cm^3$
3. The reaction is finished when the curve is horizontal.
4. To obtain reliable data.
5. $\frac{69 + 69 + 66}{3} = 68\,cm^3$

- The rate of a reaction measures how quickly a reactant is used up, or how quickly a product forms.

12.10 Student Book answers

1. Both variables are continuous.
2. **a.** As acid concentration increases, reaction rate increases.
   b. The more concentrated the acid, the more frequently its particles collide with the magnesium particles, and the faster the reaction.
3. Repeat the experiment above with the different acid. Compare the shape of the graph obtained with that above.

quickly a product forms.

12.11 Student Book answers

1. To reduce error and obtain reliable results.
2. **a.** As temperature increases, rate of reaction increases.
   b. Reactions happen when particles collide. At higher temperatures, particles move faster and collide more frequently, so reaction rate increases.
3. Pour a certain volume of hydrochloric acid into a conical flask. Measure the temperature. Add a known length of magnesium ribbon. Start the stopwatch. Stop the stopwatch when the magnesium ribbon is used up. Repeat twice more at room temperature, and then at four different temperatures. Plot the results on a graph of 'time for reaction to finish' vs 'temperature'.

quickly a product forms.

12.12 Student Book answers

1. Concentration of acid, volume of acid, temperature
2. **a.** As surface area increases, reaction rate increases.
   b. Substances can only react when their particles collide. If a substance is in the solid state, only its surface particles can react. The greater the surface area, the faster the reaction.
3. Temperature, concentration of solution

12.13 Review answers

Student Book answers

1. **a.** (ii) (iii) [2]
   b. lead + copper oxide → lead oxide + copper [2]
   zinc + lead oxide → zinc oxide + lead [2]
2. **a.** Copper and zinc sulfate [1]
   b. A more reactive metal (zinc) replaces a less reactive metal (copper) in its compound [1]
   c. i. Zinc, because it replaces nickel in its compound in a displacement reaction [1]
   ii. zinc + nickel nitrate → zinc nitrate + nickel [2]
   iii. There would be no reaction because nickel is less reactive than zinc/ nickel is lower in the reactivity series than zinc. [2]
3. **a.** Magnesium sulfate [1]
   b. Zinc chloride [1]
   c. Magnesium nitrate [1]
   d. Copper chloride [1]
   e. Zinc sulfate [1]
4. **a.** zinc + hydrochloric acid → zinc chloride + hydrogen [2]
   b. i. It might cause harm in eyes or in a cut [1]
   ii. One of the reactants (hydrochloric acid) and one of the products (zinc chloride crystals and concentrated zinc chloride solution) can damage the eyes [1]
   iii. The crystals are corrosive, so may burn the skin [1]
   c. The mixture is heated more evenly [1]
5. **a.** Carbon dioxide [1]
   b. i. B [1]
   ii. B [1]
   c. i. Size of calcium carbonate pieces [1]
   ii. Mass of reacting mixture [1]
   iii. Concentration of acid [1] and volume of acid [1]
   iv. B [1]

surface. It is made of the crust and the top of the mantle.

- The model of plate tectonics says that tectonic plates rest on – and move with – the mantle below.

13.1 Student Book answers

1. Continental drift – the movement of tectonic plates over millions of years.
2. Beneath the tectonic plates is the mantle. The mantle is heated by natural processes. The heat drives convection currents in the mantle, which make the tectonic plates above move.
3. **a.** Any two plates whose arrows show that they are moving towards each other.

   b. Any two plates whose arrows show that they are moving away from each other.

Prior learning

- Continental drift is the movement of tectonic plates over millions of years.
- Fossils provide evidence for continental drift.

13.2 Student Book answers

1. Trees cannot grow in Antarctica now, because its climate is too cold.
2. South America and Africa.
3. Fossilised remains of *Lystrosaurus* have been found on the two continents; fossilised remains of *Glossopteris* have been found on the two continents.

- Then play a video about scientists working to map the seafloor (search for *seafloor mapper Nautilus live.)* Student pairs discuss the good and bad points of the job – would they like to be a seafloor mapper? Ask if there are other jobs in science that involve getting out and about. Examples include conservation biologists, geologists, and vulcanologists.
- Play another video, on seafloor spreading (search for *seafloor spreading Sammartano).* Stop the video for discussion after each key piece of evidence is presented, and ask students to note down the evidence.
- Lead a discussion to elicit how seafloor spreading provides evidence for plate tectonics. Student Book pages 232–233 support this activity.
- Students then read Student Book pages 232–233 and answer questions 1–3.

Extension

Use the Internet to find out about science jobs that involve being outside. Talk about the scientists' work with a friend.

13.3 Student Book answers

1. Oceanic ridge – a mountain chain under the sea; seafloor spreading – the movement of the seafloor away from the two sides of an oceanic ridge.
2. Magma rises at the plate boundary. When it reaches the sea, it cools and solidifies, forming a mid-ocean ridge. The seafloor on the two sides of the ridge moves away from the ridge.
3. At an oceanic ridge, hot liquid rock – magma – cools and freezes. This makes new rock. Much magma is rich in iron compounds. This magma forms rock that is magnetised in the direction of the Earth's magnetic field. Every now and again, the Earth's magnetic poles flip. The magnetic North pole becomes the magnetic South pole, and the magnetic South pole becomes the magnetic North pole. Rock formed in these times is magnetised in the opposite direction. Every time the poles flip, a new stripe starts to form.

13.4 Review answers

Student Book answers

1. **a.** 12 [1]
   b. Solid [2]
   c. The mantle below has a higher density than the tectonic plate [1]
   d. Convection currents in the mantle make the mantle move [1] and the tectonic plates move on top of the moving mantle [1]
2. **a.** The movement of tectonic plates [1]
   b. The climate in Antarctica today is too cold for trees to grow, so Antarctica must have been further north, away from the South pole [1]
   c. i. the same animals lived on both continents [1]
   ii. the east coast of South America looks like a jigsaw fit with the west coast of Africa. [1]
3. **a.** Away from each other [1]
   b. i. Mountain chains under the ocean [1]
   ii. Freezing [1]
   c. i. Towards [1]
   ii. The moving plates collided with each other [1] and the edges of the continents crumpled together and piled up [1]
4. **a.** The plates on either side of it are moving away from each other [1] so new magma rises through the plate boundary gap [1] and solidifies to form new rock [1]
   b. The two plates are moving towards each other [1] the moving plates collided [1] and the edges of the plates crumpled together and piled up [1]
   c. The plates are moving past each other in opposite directions [1]
   d. 20 mm × 100 years = 2000 mm [2]