

Chemistry of the environment

Mark scheme and worked solutions for 30 questions: 15 multiple choice, 15 structured.

1 Core Water [1]

Answer: B

Worked solution

Two chemical tests for water are on the syllabus, and each has its own colour change. Anhydrous copper(II) sulfate starts white and turns blue when water is added. Anhydrous cobalt(II) chloride starts blue and turns pink. A good way to remember them: copper(II) sulfate goes white → blue, cobalt(II) chloride goes blue → pink. The copper(II) sulfate change is white to blue, so the answer is B.

2 Core Air quality and climate [1]

Answer: D

Worked solution

Learn the composition of clean, dry air: about 78% nitrogen, N₂, about 21% oxygen, O₂, and the remaining 1% is a mixture of noble gases (mainly argon) and carbon dioxide. Nitrogen is by far the most abundant gas, so any row where oxygen is larger than nitrogen (A) is wrong. Row C gives only 1% oxygen, which is far too low. Row B's 68% / 31% is not the accepted composition. Only row D matches 78 / 21 / 1.

3 Core Water [1]

Answer: C

Worked solution

Domestic water treatment has three jobs, each done by a different stage:

- sedimentation and filtration remove solids;
- treatment with carbon removes tastes and odours;
- chlorination kills microbes.

Check each row against this list. Only row C (filtration removes solids) matches. Rows A, B and D all give a stage the job of a different stage.

4**Core**

Fertilisers

[1]

Answer: C

Worked solution

Plants need nitrogen, phosphorus and potassium for improved growth. Ammonium salts and nitrates supply nitrogen. To supply potassium, the compound must contain potassium. Look at each name: only potassium nitrate contains potassium, and because it is a nitrate it also supplies nitrogen. So C supplies both elements in one compound.

5**Core**

Air quality and climate

[1]

Answer: A

Worked solution

When a carbon-containing fuel burns in plenty of oxygen, the carbon is fully converted to carbon dioxide: this is complete combustion. When oxygen is limited, combustion is incomplete and carbon monoxide (a toxic gas) and particulates (tiny bits of carbon) can form. So carbon dioxide comes from complete combustion and carbon monoxide from incomplete combustion, which is row A.

Mark scheme

(a)

[2]

- (anhydrous cobalt(II) chloride) starts blue (1)
- turns pink (with water) (1)

ALLOW add the liquid to (blue) cobalt(II) chloride paper; it turns pink

REJECT pink to blue (0 for both marks)

REJECT white to blue (this is copper(II) sulfate) (0)

(b)

[2]

- heat the liquid / boil it and measure the temperature at which it boils (with a thermometer) (1)
- pure water boils at 100 °C / if it boils at (exactly) 100 °C it is pure (1)

ALLOW impure water boils above 100 °C / over a range of temperatures, for the second mark

IGNORE reference to atmospheric pressure

(c)

[2]

- not pure (water) (1)
- pure water melts at 0 °C / the melting point is not 0 °C / the melting point is below 0 °C (1)
- The second mark can only be awarded if the first is correct or the conclusion is implied by the reason.

Worked solution

(a) A chemical test shows that water is present. Anhydrous cobalt(II) chloride is blue. If you add a drop of the liquid and it turns pink, the liquid contains water.

(b) A chemical test cannot tell you whether the water is pure, so we use a physical test. Heat the liquid and use a thermometer to measure its boiling point. Pure water boils at exactly 100 °C (at normal atmospheric pressure). If the liquid boils at a different temperature, for example above 100 °C, or boils over a range, it contains impurities.

(c) Pure water melts (and freezes) at exactly 0 °C. This liquid melts at –1.5 °C, which is not 0 °C, so it is not pure water. It must contain dissolved impurities.

Mark scheme

(a) [2]

- decomposition of vegetation (1)
 - waste gases from digestion in animals (1)
- ALLOW** rotting plants / rotting waste; cows / farm animals / livestock (digesting food)
- ALLOW** decomposing waste in landfill for the first mark

(b) [2]

- (increased) global warming (1)
 - (which leads to) climate change (1)
- ALLOW** the Earth / atmosphere gets warmer for global warming
- REJECT** acid rain / toxic / damage to the ozone layer (0)

(c) [1]

- photosynthesis (1)

Worked solution

(a) Methane enters the air from two main sources: vegetation decomposing (rotting), and the waste gases produced when animals such as cattle digest their food.

(b) Carbon dioxide and methane are greenhouse gases. Higher levels of them lead to increased global warming, and global warming leads to climate change. Neither gas causes acid rain, and neither is described as toxic.

(c) Green plants take in carbon dioxide from the air during photosynthesis, where carbon dioxide and water react to make glucose and oxygen.

Mark scheme

(a) [1]

- thermal (energy) (1)

ALLOW heat / infrared (radiation)

(b) *any four from:* [4]

- the Earth's surface absorbs energy from the Sun (and warms up) (1)
- the (warm) Earth's surface emits thermal energy (1)
- carbon dioxide / methane / greenhouse gases absorb (some of this) thermal energy (1)
- the greenhouse gases (re-)emit thermal energy in all directions / back towards the Earth (1)
- (so) less thermal energy is lost to space / thermal energy loss to space is reduced (1)

ALLOW heat / infrared for thermal energy throughout

REJECT greenhouse gases reflect the Sun's energy back to Earth / trap sunlight (do not award the absorption mark for "reflect")

REJECT any reference to the ozone layer / ozone hole (no credit)

Worked solution

(a) When the Earth's surface is warmed by the Sun, it gives out energy as thermal energy (infrared radiation).

(b) The steps are:

1. Energy from the Sun reaches the Earth. Some is reflected, but much of it is absorbed by the surface, which warms up.
2. The warm surface emits thermal energy back towards space.
3. Greenhouse gases such as carbon dioxide and methane absorb some of this thermal energy.
4. They then emit the thermal energy again in all directions, including back towards the Earth's surface.
5. This reduces the amount of thermal energy lost to space, so the Earth warms up.

More carbon dioxide and methane in the atmosphere means more thermal energy is absorbed and re-emitted, so global warming increases. A common mistake is to say the gases "reflect" heat; they absorb and re-emit it. Global warming has nothing to do with the ozone layer.

Mark scheme

(a) [2]

- dissolved oxygen (1)
- (needed) for aquatic life / fish / water animals (to breathe / respire) (1)
- The second mark depends on dissolved oxygen being identified.

(b) [1]

- fertilisers (from the farmland) (1)

| **ALLOW** fertiliser run-off / fertiliser washed off fields

(c) [2]

- sewage contains harmful microbes (1)
- (which) cause disease (1)

| **ALLOW** bacteria / germs / pathogens for microbes

| **ALLOW** named disease, e.g. cholera, for the second mark

(d) [1]

- harms aquatic life (1)

| **ALLOW** fish / birds / animals eat plastics / get trapped / tangled in plastics

| **REJECT** plastics cause deoxygenation

Worked solution

(a) Of the four substances, only dissolved oxygen is beneficial. Fish and other aquatic life need it to respire.

(b) Nitrates in rivers come from fertilisers that are washed off (run off) farmland by rain.

(c) Sewage contains harmful microbes. If people drink or swim in water containing these microbes, they can catch diseases.

(d) Some plastics harm aquatic life, for example animals swallow them or become trapped in them.

Mark scheme

(a) [2]

- nitrogen and oxygen (from the air) react (1)
- at the high temperature in the engine (1)

ALLOW nitrogen from the air combines with oxygen**REJECT** nitrogen comes from the fuel / petrol (0 for the first mark)

(b) [2]

- $2\text{CO} + 2\text{NO} \rightarrow 2\text{CO}_2 + \text{N}_2$
- correct products CO_2 and N_2 (1)
- correct balancing (1)

ALLOW multiples, e.g. $4\text{CO} + 4\text{NO} \rightarrow 4\text{CO}_2 + 2\text{N}_2$ **ALLOW** $\text{CO} + \text{NO} \rightarrow \text{CO}_2 + \frac{1}{2}\text{N}_2$ (2)

- The balancing mark can only be awarded if the products are correct.

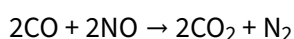
(c) [2]

- oxides of nitrogen / nitrogen monoxide are converted to nitrogen (1)
- (so) fewer oxides of nitrogen are released into the air / nitrogen does not cause acid rain (1)

ALLOW oxides of nitrogen are removed from the exhaust gases, for the first mark**Worked solution**

(a) Air drawn into a car engine contains nitrogen and oxygen. Normally nitrogen is very unreactive, but inside the engine the temperature is very high. At this high temperature, nitrogen and oxygen from the air react to form oxides of nitrogen such as NO.

(b) In the catalytic converter, carbon monoxide takes oxygen from nitrogen monoxide. The products are carbon dioxide and nitrogen. Balance it: nitrogen appears as N_2 , so two NO are needed; these give two O atoms, which convert two CO into two CO_2 .



Check: C $2 = 2$; O $2 + 2 = 4$ and $2 \times 2 = 4$; N $2 = 2$.

(c) Oxides of nitrogen cause acid rain. The catalytic converter changes them into nitrogen gas, which is harmless (it already makes up about 78% of the air) and does not form acid rain. So fewer oxides of nitrogen reach the atmosphere, and there is less acid rain.

11**Core**

Water

[1]

Answer: D

Worked solution

To test whether water is pure, measure its melting point and boiling point. Pure water melts at 0 °C and boils at 100 °C. Both values must match: if either one is different, the sample contains impurities. Check each row: A fails both, B fails the boiling point, C fails the melting point. Only D has 0 °C and 100 °C, so D is pure water.

12**Core**

Air quality and climate

[1]

Answer: B

Worked solution

Climate change is caused by increased global warming from greenhouse gases such as carbon dioxide. Green plants use carbon dioxide in photosynthesis (carbon dioxide + water → glucose + oxygen), so more trees means more carbon dioxide is taken out of the atmosphere. Catalytic converters, low-sulfur fuels and flue gas desulfurisation are all ways of reducing acid rain: they reduce emissions of oxides of nitrogen and sulfur dioxide, and none of them removes carbon dioxide. So the answer is B.

13**Supplement**

Air quality and climate

[1]

Answer: C

Worked solution

In photosynthesis, carbon dioxide and water react to form glucose and oxygen, so CO_2 and H_2O must be on the left and $\text{C}_6\text{H}_{12}\text{O}_6$ and O_2 on the right. That rules out D, which has them the other way round. Now count atoms in C:

- Left: 6CO_2 gives 6 C and 12 O; $6\text{H}_2\text{O}$ gives 12 H and 6 O. Total: 6 C, 12 H, 18 O.
- Right: $\text{C}_6\text{H}_{12}\text{O}_6$ gives 6 C, 12 H and 6 O; 6O_2 gives 12 O. Total: 6 C, 12 H, 18 O.

Everything balances. In A, the right side has only $6 + 6 = 12$ O atoms, so it is unbalanced, and in B nothing is balanced. The answer is C.

14**Core**

Fertilisers

[1]

Answer: B

Worked solution

Work out which elements each compound provides from its name:

- ammonium ... → nitrogen; ... nitrate → nitrogen
- ... phosphate → phosphorus
- potassium ... → potassium

A: ammonium nitrate (N) + potassium chloride (K): no P.

B: ammonium phosphate (N and P) + potassium chloride (K): N, P and K.

C: ammonium sulfate (N) + potassium nitrate (K and N): no P.

D: calcium phosphate (P) + ammonium nitrate (N): no K.

Only B provides all three elements.

15**Core**

Water

[1]

Answer: A

Worked solution

Tap water is safe to drink, but it still contains dissolved substances such as metal compounds and traces of chlorine. In an experiment these impurities could react or change the results. Distilled water has had most of these impurities removed, so it contains fewer chemical impurities. That is why it is used in practical chemistry. The answer is A.

Mark scheme

(a) [1]

- remove solids (1)

| **ALLOW** remove insoluble substances / particles / mud / sand / grit

(b) [1]

- to remove tastes and odours (1)

| **ALLOW** remove (unpleasant) smells / flavours

| **REJECT** to kill microbes

(c) [2]

- (chlorine) kills microbes (1)
- (microbes) cause disease / so the water is safe to drink (1)

| **ALLOW** bacteria / germs for microbes

(d) [1]

- nitrates are dissolved (in the water) (1)

| **ALLOW** nitrates are soluble / are not solids / pass through the filter

| **REJECT** nitrates are killed by chlorine

Worked solution

(a) In sedimentation, large solid particles settle to the bottom. Filtration then removes the smaller solid particles. Both stages remove solids.

(b) Carbon removes substances that give the water unpleasant tastes and odours.

(c) River water can contain harmful microbes, which cause disease. Chlorine kills these microbes so the water is safe to drink.

(d) Sedimentation and filtration only remove solids. Nitrates are dissolved in the water, so they pass straight through the filter along with the water.

Mark scheme

(a) [2]

- water (1)
- glucose (1)

ALLOW H₂O / C₆H₁₂O₆

REJECT sugar / starch for glucose

(b) [1]

- chlorophyll (1)

(c) [1]

- light (1)

ALLOW sunlight / the Sun

(d) [2]

- (concentration of dissolved oxygen) increases (1)
- (the plants) photosynthesise / photosynthesis produces oxygen (which dissolves in the water) (1)
- The second mark depends on "increases".

Worked solution

(a) Photosynthesis is the reaction between carbon dioxide and water to produce glucose and oxygen:
carbon dioxide + water → glucose + oxygen.

(b) The reaction needs chlorophyll, the green substance in leaves.

(c) The energy for photosynthesis comes from light.

(d) On a sunny day the water plants have plenty of light, so they photosynthesise quickly. Photosynthesis produces oxygen, and some of this dissolves in the pond water. So the concentration of dissolved oxygen increases.

Mark scheme

(a) [1]

- sulfur dioxide (1)

ALLOW SO₂

(b) [3]

- flue gas desulfurisation (1)
- calcium oxide removes / reacts with sulfur dioxide (1)
- (so) less sulfur dioxide is released into the air / atmosphere (so less acid rain) (1)

ALLOW desulfurisation for the first mark**ECF** the gas named in (a) for the second and third marks

(c) [1]

- use low-sulfur fuel / coal containing less sulfur (1)

ALLOW burn less coal / use renewable energy, e.g. wind or solar / use natural gas instead of coal

(d) [2]

- the pH increased (1)
- (less sulfur dioxide) so less acid rain / less sulfur dioxide dissolving in the rain (1)

ALLOW the rain became less acidic, for either mark but not both**ALLOW** pH rose from 4.2 to 5.4**Worked solution**

(a) When fuels containing sulfur compounds are burned, the sulfur forms sulfur dioxide. Sulfur dioxide causes acid rain.

(b) Passing the waste (flue) gases through calcium oxide is called flue gas desulfurisation. The calcium oxide reacts with the sulfur dioxide and removes it, so much less sulfur dioxide goes into the atmosphere and less acid rain forms.

(c) The power station could burn low-sulfur fuel, so less sulfur dioxide is made in the first place. Switching to renewable energy such as wind or solar would also work, because no fuel containing sulfur is burned.

(d) As the mass of sulfur dioxide released fell from 14 000 to 1800 tonnes, the pH of the rain rose from 4.2 to 5.4. A higher pH means the rain is less acidic. The reason is that less sulfur dioxide is going into the air, so less of it ends up in the rain and there is less acid rain.

Mark scheme

(a) [2]

- ammonium salts (1)
- nitrates (1)

ALLOW named examples, e.g. ammonium nitrate / ammonium sulfate for ammonium salts, potassium nitrate for nitrates (one mark per type)

- Two examples of the same type (e.g. ammonium nitrate and ammonium sulfate) score 1 mark only.

(b) [2]

- F (1)
- it contains (all three of) nitrogen, phosphorus and potassium (1)
- The second mark depends on F.

(c) [2]

- $34/100 \times 25 / 0.34 \times 25$ (1)
- 8.5 (kg) (1)
- Correct answer with no working scores 2.

(d) [1]

- to improve plant growth (by providing nitrogen, phosphorus and potassium) (1)

ALLOW to increase crop yield / make plants grow bigger / better

Worked solution

(a) Nitrogen is provided by two types of fertiliser compound: ammonium salts (such as ammonium sulfate) and nitrates (such as potassium nitrate).

(b) An NPK fertiliser provides nitrogen (N), phosphorus (P) and potassium (K). Only F contains all three elements. E contains only nitrogen and G contains only potassium.

(c) Fertiliser E is 34% nitrogen by mass. Mass of nitrogen = $34/100 \times 25 \text{ kg} = 8.5 \text{ kg}$. Check: $8.5 \div 25 = 0.34$, which is 34%.

(d) Plants need nitrogen, phosphorus and potassium to grow well. NPK fertilisers provide all three, which improves plant growth.

Mark scheme

(a) [1]

- 79 cm³ (1)

| **ALLOW** 78–80 cm³

(b) [1]

- nitrogen (1)

| **ALLOW** N₂

(c) *any two from:* [2]

- carbon dioxide (1)
- argon (1)
- any other noble gas, e.g. neon / helium / krypton / xenon (1)

| **ALLOW** "noble gases" as one answer (1)

| **REJECT** oxygen / water vapour / nitrogen

(d) [2]

- $21/100 \times 250 / 0.21 \times 250$ (1)

- 52.5 cm³ (1)

| **ALLOW** 52–53 cm³

| **ALLOW** 50 cm³ if the working shows the one-fifth (20%) approximation for oxygen (2)

- Correct answer with no working scores 2.

Worked solution

(a) Clean, dry air is about 21% oxygen. The copper removes all of the oxygen, so the volume falls by about 21 cm³ from 100 cm³. The final volume is about 100 – 21 = 79 cm³.

(b) The remaining gas is mostly nitrogen, which makes up about 78% of the air.

(c) The last 1% of air is a mixture of noble gases (mainly argon) and carbon dioxide. The copper does not react with these, so they remain.

(d) The decrease in volume is the volume of oxygen removed, which is 21% of the air. Decrease = $21/100 \times 250 = 52.5$ cm³. Check: $52.5 \div 250 = 0.21$, which is 21%.

21**Core**

Water

[1]

Answer: D

Worked solution

Take each substance in turn.

- Dissolved oxygen: fish and other aquatic life need it, so it is beneficial.
- Nitrates: they come from fertilisers. In river water they lead to deoxygenation of the water, which damages aquatic life, so they are potentially harmful. (A common mistake is to think nitrates are "good" because they help plants grow on farms.)
- Sewage: it contains harmful microbes that cause disease, so it is potentially harmful.

The pattern is beneficial, potentially harmful, potentially harmful, which is row D.

22**Core**

Water

[1]

Answer: B

Worked solution

Two substances in natural water come from fertilisers: nitrates and phosphates. Of these, only phosphates also come from detergents (washing products). Harmful microbes come from sewage, and dissolved oxygen is a natural, beneficial substance. So the answer is B.

23**Core**

Water

[1]

Answer: C

Worked solution

Match each remaining problem to the stage that deals with it:

- unpleasant smell → treatment with carbon (removes tastes and odours);
- harmful microbes → chlorination (kills microbes).

Sedimentation and filtration only remove solids, and they have already been done (the water is clear). So both carbon treatment and chlorination are needed, which is C. Each of the other options leaves at least one problem unsolved.

24**Supplement**

Air quality and climate

[1]

Answer: A

Worked solution

The Earth's surface absorbs energy from the Sun and then emits thermal energy. Methane (like carbon dioxide) absorbs some of this thermal energy and then emits it again in all directions. Some of it goes back towards the Earth's surface, so less thermal energy is lost to space and the Earth warms up. This matches statement A. Greenhouse gases do not work by reflecting sunlight (B) or by chemical reactions releasing heat (C), and they reduce, rather than increase, the energy escaping to space (D).

25**Core**

Air quality and climate

[1]

Answer: D

Worked solution

Each pollutant on the syllabus has its own adverse effects:

- carbon monoxide: toxic gas;
- methane: increased global warming, leading to climate change;
- sulfur dioxide: acid rain;
- oxides of nitrogen: acid rain, photochemical smog and respiratory problems.

Only oxides of nitrogen are linked to photochemical smog, so the answer is D.

Mark scheme

(a) [1]

- metal compounds (1)

ALLOW (dissolved) salts / minerals / named metal compound, e.g. calcium compounds

REJECT sand / mud / microbes

(b) [2]

- distilled water contains fewer (chemical) impurities / tap water contains (more) impurities (1)

- (impurities) could react / interfere with the experiment / affect the results (1)

ALLOW tap water contains dissolved substances / metal compounds / chlorine, for the first mark

(c) [2]

- both samples turn (the copper(II) sulfate from white to) blue (1)

- the test only shows that water is present / does not detect impurities (1)

ALLOW both contain water, so both give the same result, for the second mark

REJECT turns pink (0 for the first mark)

Worked solution

(a) When the tap water evaporates, the dissolved substances are left behind. These are mainly dissolved metal compounds (salts or minerals). Distilled water leaves no solid because these substances have been removed.

(b) The results show that tap water contains dissolved substances. These chemical impurities could react with the chemicals being used, or change the results of an experiment. Distilled water contains fewer chemical impurities, so it is used in practical chemistry.

(c) Both samples are mostly water, so both turn anhydrous copper(II) sulfate from white to blue. The test only tells you that water is present. It cannot tell you whether the water is pure. To test purity you would measure the melting point or boiling point instead.

Mark scheme

(a) [1]

- it decreases (1)

ALLOW halves / falls by 4.5 mg per dm³

(b) [3]

- (from) fertilisers (washed off / running off the fields) (1)
- (nitrates and phosphates) lead to deoxygenation of the water / less dissolved oxygen (1)
- (so) fish / aquatic life are damaged / die / have less oxygen to respire (1)

ALLOW less dissolved oxygen as shown by the data, for the second mark

IGNORE details of the eutrophication process (algae, bacteria) — not required, but not penalised if correct

ALLOW detergents as an additional source of phosphates, but fertilisers must be given for the first mark

(c) [2]

- mercury compounds are toxic / harmful / poisonous (1)
- calcium compounds provide essential minerals (for life) / are beneficial (1)

ALLOW calcium is needed for bones / teeth / shells, for the second mark

Worked solution

(a) The dissolved oxygen falls from 9.0 mg per dm³ at P to 4.5 mg per dm³ at Q. It decreases (by half).

(b) The nitrates and phosphates at site Q come from the fertiliser on the fields, washed into the river by rain. Nitrates and phosphates lead to deoxygenation of the water, which the data show: there is much less dissolved oxygen at Q. Fish need dissolved oxygen, so with less of it they are damaged and may die.

(c) Some metal compounds in water are harmful and some are beneficial. Mercury compounds are toxic to living things. Calcium compounds provide essential minerals that living things need. So the mercury compounds harm living things, while the calcium compounds benefit them.

Mark scheme

(a) [2]

- less fossil fuel is burned (to generate electricity) (1)
- (so) less carbon dioxide is released (1)

ALLOW renewable energy replaces fossil fuels, for the first mark

ALLOW less global warming, as an alternative to the second mark only if linked to less carbon dioxide

(b) [2]

- fewer animals so less methane (from digestion) (1)
- methane causes (increased) global warming / is a greenhouse gas (1)

ALLOW cows / cattle / sheep for animals

(c) [2]

- no carbon dioxide is produced (when hydrogen burns) (1)
- carbon dioxide causes (increased) global warming / is a greenhouse gas (1)

ALLOW less petrol / fossil fuel burned, so less carbon dioxide, for the first mark

Worked solution

Climate change is caused by increased global warming, which is caused by higher levels of greenhouse gases such as carbon dioxide and methane. Each strategy reduces one of these gases.

(a) Most electricity is still generated by burning fossil fuels, which releases carbon dioxide. Wind and solar farms generate electricity without burning fuel, so less fossil fuel is burned and less carbon dioxide is released.

(b) Farm animals such as cattle release methane as a waste gas from digestion. Fewer animals means less methane is released. Methane is a greenhouse gas, so there is less global warming.

(c) Petrol contains carbon, so burning it releases carbon dioxide. Hydrogen contains no carbon and burns to form only water, so no carbon dioxide is produced. Less carbon dioxide means less global warming and so less climate change.

Mark scheme

(a)

[2]

- vehicles / car engines burn (carbon-containing) fuels (1)
- incomplete combustion (of the fuel) produces carbon monoxide and particulates (1)

ALLOW not enough oxygen for complete combustion, for the second mark

(b)

[1]

- (it is a) toxic gas (1)

ALLOW poisonous

REJECT acid rain / global warming

(c)

[2]

- (increased risk of) respiratory problems (1)
- (increased risk of) cancer (1)

ALLOW breathing problems / lung disease / asthma for respiratory problems

ALLOW lung cancer

Worked solution

(a) Beside a busy road there are many vehicles. Their engines burn carbon-containing fuels such as petrol and diesel. Some of this fuel burns incompletely, because there is not enough oxygen, and incomplete combustion produces carbon monoxide and particulates. In the park there are no vehicles, so the concentrations are much lower.

(b) Carbon monoxide is a toxic gas.

(c) Particulates are tiny solid particles that can be breathed in. They increase the risk of respiratory problems and of cancer.

Mark scheme

(a)

[2]

- $6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$
- correct formulae of all reactants and products (1)
- correct balancing (1)
- The balancing mark can only be awarded if all formulae are correct.

ALLOW an equilibrium arrow; **IGNORE** state symbols

(b)

[1]

- 24 (1)

ECF from their balanced equation in (a) (their number of O_2 per glucose $\times 4$)

(c) *any three from:*

[3]

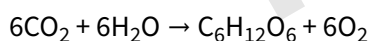
- fewer trees, so less photosynthesis (1)
- (so) less carbon dioxide is removed from the atmosphere (1)
- burning the trees releases carbon dioxide (1)
- carbon dioxide absorbs thermal energy (emitted by the Earth) and re-emits it (back towards the Earth) / reduces thermal energy loss to space (1)

ALLOW heat / infrared for thermal energy

REJECT reference to the ozone layer

Worked solution

(a) In photosynthesis, carbon dioxide and water react to form glucose and oxygen:



Check: C $6 = 6$; H $12 = 12$; O $12 + 6 = 18$ on the left and $6 + 12 = 18$ on the right.

(b) The equation shows that 6 molecules of oxygen are made for every 1 molecule of glucose. For 4 molecules of glucose: $4 \times 6 = 24$ molecules of oxygen. Check: $24 \div 6 = 4$ glucose.

(c) Cutting down and burning forests increases global warming in two ways. First, there are fewer trees photosynthesising, so less carbon dioxide is taken out of the atmosphere. Second, burning the wood (a carbon-containing fuel) releases carbon dioxide. Both effects increase the amount of carbon dioxide in the air. Carbon dioxide is a greenhouse gas: it absorbs thermal energy emitted by the Earth's surface and re-emits it, some of it back towards the Earth, so less thermal energy is lost to space and global warming increases.