AQA Combined Science Answers

CHECK IT!

Cell biology

Eukaryotic and prokaryotic cells

1 In the cytoplasm as a loop of DNA and maybe as plasmids.

2 5 µm **3** 2×10^2 nm

Animal and plant cells

1 Award one mark for each correct column:

Sub-cellular structure	Animal cells	Plant cells	Prokaryotic cells
Nucleus	✓	✓	
Mitochondria	✓	✓	
Ribosomes	✓	✓	✓
Cytoplasm	✓	✓	✓
Cell membrane	✓	✓	✓
Chloroplast		✓	
Permanent vacuole		✓	
Cellulose cell wall			✓

2 The more mitochondria there are, the more respiration will be carried out; Active cells need more energy.

3 The organism is not a plant; It has some features of plant cells/has chloroplasts/has a cellulose cell wall; It is one-celled/unicellular or plants are multicellular.

Microscopy

1 Higher magnification; Higher resolution/resolving power.

2 Magnification $= \frac{3\text{ cm}}{12\ \mu\text{m}}$

Magnification $= \frac{30\,000\ \mu\text{m}}{12\ \mu\text{m}}$

Magnification $= \times 2500$

3 Size of the image = Magnification x real size of cell

Size of the image $= 12\,000 \times 4$ µm

Size of the image $= 48\,000$ µm or 4.8×10^4 µm

Using a light microscope

1 x400 **2** 5 µm

3 *Any four of:* Place the blood sample onto a slide; Place the slide on the stage; Make sure light is passing through the sample/light is on; Bring the blood sample into focus by looking down the eyepiece lens and moving the coarse focus; Use a higher magnification objective lens and bring the blood sample into focus using the fine focus.

Cell specialisation

1 A cell that has differentiated in order to carry out a particular function.

2 A nerve cell has many dendrites for passing the nerve impulse onto nearby nerve cells.

A nerve cell has a long axon for allowing the nerve impulse to travel along a part of the body.

3 Sperm cells are not a tissue; as the cells do not work together to carry out their function.

4 Xylem cells have no ends and are hollow to make a tube for water to move through; lignin in the cell wall to waterproof and give strength to the cells to stop them collapsing and water leaking out.

Cell differentiation

1 Stem cell **2** Embryo; Plant

3 Cell divides; cell is exposed to a chemical/hormone; cell changes shape/acquires new sub-cellular structures.

Mitosis and the cell cycle

1 Growth; repair/replacement of cells; asexual reproduction.

2 At the beginning of mitosis, the chromosomes are already doubled inside the nucleus; The nucleus breaks down and the chromosomes line up in the centre of the cell; One set of chromosomes is pulled to each side of the cell to form two new nuclei; The cytoplasm and cell membranes divide to form two identical daughter cells.

3 Number of cells $= 1 \times 2^{24}$

$= 16\,777\,216$ cells

$= 1.7 \times 10^7$ cells

Stem cells

1 In the root/shoot tip.

2 Replacing cells; Development of the embryo; Medical treatment; Medical research.

3 Take cuttings from the root tip/shoot tip; Use the cuttings to produce many cloned plants; The plants would be genetically identical.

Diffusion

1 The movement of particles; from an area of high concentration to an area of low concentration.

2 *Any two of:* Increase the surface area; Increase the temperature; Increase the difference in the concentration of the particles.

3 Surface area $4 \times 4 \times 6 = 96$ cm^2;

Volume $= 4 \times 4 \times 4 = 64$ cm^3;

Surface area to volume ratio = 96:64 or 3:2 or 1.5:1

Osmosis

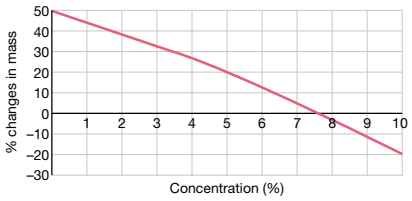
1 Water will move out of the animal cell by osmosis; The cell will shrivel and crenate.

2 Percentage increase in mass

$= \frac{(14 - 8)}{8} \times 100\%$

$= 75\%$

3



(x- and y-axis drawn correctly; X axis labelled as 'Concentration of salt solution (%)' and y-axis labelled as 'Percentage change in mass); points plotted correctly; points connected together with a straight line.)

Investigating the effect of a range of concentrations of salt or sugar solutions on the mass of plant tissue

1 **a** 6%

b Mass of potato cube = 5.3 g

c *Any two of:* Type of plant tissue/potato; Mass of original potato; Amount of time spent in sugar concentration; Volume of each sugar concentration.

Active transport

1 The difference between the two concentrations; the greater the difference, the greater the concentration gradient.

2 Respiration

3 Mineral ions move from a dilute concentration in the soil, to a higher concentration in the cell; They move through carrier proteins in the cell membrane; This requires energy.

Tissues, organs and organ systems

The human digestive system

1 In the pancreas.

2 To break down starch/carbohydrate; into sugars.

3 Bile emulsifies lipids into smaller droplets; This gives a larger surface area; for the lipase enzymes to digest the lipids.

Enzymes

1 pH3 is lower than the optimum pH for amylase, which is pH7; Amylase would lose activity/rate of reaction would decrease.

2 20/4 = 5 cm^3/min

3 The hydrogen bonds in the enzyme are broken; The active site is no longer the correct shape/complementary to the substrate; The substrate would no longer be able to bind to the enzyme's active site.

Using qualitative reagents to test for a range of carbohydrates, lipids and proteins

1 Contained protein.

2 Add ethanol to a food sample; Add distilled water to the food sample and observe if an emulsion formed.

3 Iodine would change pasta a blue-black colour; Benedict's reagent would remain blue; Pasta contains starch, but not sugars.

The effect of pH on amylase

1 Breaks down/digests starch (amylose) into sugars (maltose).

2 The rate of reaction would decrease; because the amylase loses activity above the optimum pH.

3 Rate of reaction = 0.033 cm^3/s

The heart

1 Pulmonary vein

2 To prevent the blood flowing backwards.

3 A group of cells in the right atrium maintain the resting heart rate; they make sure that the ventricles contract shortly after the atria; it is important to prevent the heart rate from becoming irregular.

The lungs

1 In the blood capillary.

2 The gases have less distance to travel; This speeds up the rate of diffusion.

3 The blood capillaries move the oxygen away from the alveoli; This means that the concentration of oxygen in the capillary next to the alveoli will always be lower than the concentration of oxygen inside the alveoli; This means that there is a greater concentration gradient between the alveoli and the blood capillaries.

Blood vessels

1 Vein **2** Aorta

3 Capillary walls are one cell thick; to allow a short diffusion pathway for gas exchange; in the tissues and around the alveoli.

Blood

1 *Any two from*: plasma; red blood cells; white blood cells; platelets.

2 Biconcave in shape; no nucleus; packed with haemoglobin.

3 The endoplasmic reticulum is the site of protein synthesis in the cell; Lymphocytes need to make many antibodies, which are a type of protein.

Coronary heart disease

1 *Any two from*: angina; heart attack; heart failure.

2 Build-up of fatty deposits and cholesterol; in the coronary arteries.

3 Blood would flow backwards; back into the heart/into the previous heart chamber; The heart would have to pump harder to pump blood through the heart.

Health issues

1 Positive correlation

2 As a histogram; because it is showing numerical data.

3 Fewer white blood cells; means that the person is less able to fight off pathogens.

Effect of lifestyle on health

1 *Any two from*: diet; smoking; exercise.

2 *Any one from*: cost of medicines; cost of hospital/doctor visits; time off work/not able to work.

3 Percentage decrease = 23%

Cancer

1 *Any two from*: genetic; smoking; diet; alcohol; ionising radiation.

2 Abnormal cell divides without being checked; Cells divide out of control to form a large mass.

3 More tumours to remove; More difficult to find the tumours in the body; Tumours may be impossible to remove by surgery; Medicine/chemotherapy/radiotherapy is needed.

Plant tissues

1 Xylem

2 4–5 cells drawn correctly; cells correctly labelled with cell wall, cell membrane, permanent vacuole, chloroplast, cytoplasm and nucleus; label lines drawn with a straight line.

3 To allow light to get to the palisade mesophyll/tissue; for photosynthesis.

Transpiration and translocation

1 Water moves into the root hair cells by osmosis; Water moves up the xylem; Water diffuses out of the leaves through the stomata.

2 Increasing temperature; Increasing light levels; Increasing air movement; Decreasing humidity.

3 Rate of transpiration $= \frac{\text{water lost}}{\text{time}}$

$= 3\ cm^3/hour$

Infection and response

Communicable diseases

1 *Any two from*: Common cold; Influenza; HIV; Measles; Any other virus.

2 Direct contact with person/animal/sharp object; Through air/coughing/sneezing/water droplets; In food/water.

3 Close contact with other people makes it easier to spread viruses/bacteria; Fungi like damp conditions so more likely to have a fungal disease; Insects like damp conditions and may carry diseases.

Viral diseases

1 In water droplets/coughs/sneezes; Direct contact with infected person.

2 Flu-like virus in the beginning; HIV attacks the cells of the immune system; Immune system stops working/unable to function.

3 TMV spreads by direct contact with plants; Removing the infected plants will reduce the spread of TMV; Uninfected plants may still be susceptible to TMV in the soil.

Bacterial diseases

1 Antibiotics

2 Salmonella can be found in poultry; To prevent the spread of salmonella.

3 The bacteria that causes gonorrhoea could be resistant to all antibiotics; It would not be possible to treat gonorrhoea; There would be more emphasis on preventing gonorrhoea infection.

Fungal and protist diseases

1 Antimalarial drugs

2 Prevents mosquitos from biting; Mosquitos carry the protist that causes malaria.

3 Remove any infected leaves; Spray the roses with fungicide.

Human defence systems

1 *Any two from*: Skin; Mucus in the nose, trachea and bronchi; Cilia in the trachea and bronchi; Hydrochloric acid in the stomach.

2 Phagocyte engulfs the pathogen; The cell membrane extends around the pathogen; Enzymes inside the phagocyte digest the pathogen.

3 Lymphocytes produce antibodies; against the toxins produced by bacteria; These antibodies are called antitoxins.

Vaccination

1 Dead/inactive pathogen

2 When most of a population is vaccinated against a pathogen; non-vaccinated people are protected from infection with that pathogen.

3 TB is not common in the UK; due to vaccination programmes in the past; TB vaccinations are given only if there is an outbreak of TB.

Antibiotics and painkillers

1 Penicillin; *Any antibiotic*.

2 Antibiotics only kill bacteria; Antibiotics would have no affect against/cannot kill viruses.

3 Percentage increase = 350%

New drugs

1 Found in plants/microorganisms; Make new compounds from already existing ones.

2 Drugs are tested on cells; Drugs are tested to check their toxicity/efficacy/dosage.

3 Need to make sure that the new drug works; better than the current drug.

Bioenergetics

Photosynthesis

1 Glucose; Oxygen

2 In the palisade mesophyll cells; because they have the most chloroplasts; to absorb a greater amount of sunlight.

3 The six carbon atoms are from the six molecules of carbon dioxide; The twelve hydrogen atoms are from the six molecules of water; The six oxygen atoms are from the six molecules of water.

Rate of photosynthesis

1 The factor that limits the rate of photosynthesis.

2 The rate of photosynthesis would decrease; Carbon dioxide is needed for photosynthesis to occur.

3 Rate of photosynthesis = 7 cm^3/min

Investigating the effect of light intensity on the rate of photosynthesis

1 At 0 and 10 cm from the plant, the rate of photosynthesis remained constant; After 10 cm from the plant, as the distance from the lamp increased, the rate of photosynthesis decreased.

2 *Any two from*: Temperature; The species/size of plant; The type/brightness of lamp; The time.

3 *Any three from*: Repeat the investigation; Use light probes to accurately measure the light intensity; Use oxygen probes to accurately measure the volume of oxygen released; Carry out the investigation in a dark room with the lamp as the only light source.

Uses of glucose

1 In the leaves.

2 Eating plants/fruit/vegetables.

3 More glucose is made/eaten than can be used at one time; Storage allows glucose to be used at a later time; Starch and glycogen can be broken down into glucose by enzymes.

Respiration

1 In the cytoplasm and the mitochondria.

2 The yeast carries out anaerobic respiration; Anaerobic respiration produces ethanol and carbon dioxide; The ethanol is the alcoholic content of wine, and carbon dioxide bubbles makes the bread rise.

3 There is a positive correlation between the temperature and the amount of carbon dioxide released; As the temperature increases, the volume of carbon dioxide produced increases. This is because the rate of respiration in yeast increases with temperature, up until the optimum temperature.

Response to exercise

1 12 x 4 = 48 beats per minute

2 To take in more oxygen; To supply the blood with oxygen more quickly.

3 The sprinters have been respiring anaerobically; They have a build-up of lactic acid in the muscle cells; The oxygen is needed to break down the lactic acid into glucose.

Metabolism

1 Any example where a complex molecule is made from simpler molecules; Any example where a complex molecule is broken down into simpler molecules.

2 For growth; Repair or replacement of cells or tissue; For energy storage as carbohydrates or lipids.

3 In respiration, glucose is broken down; Carbon dioxide and water are made.

Homeostasis and response

Homeostasis

1 The maintenance of a constant internal environment.

2 *Any one from*: temperature; blood glucose levels; water levels.

3 The coordination centre receives nerve impulses; from the receptor; the coordination centre then sends nerve impulses to the effector; to bring about a response which will return the condition to normal.

The human nervous system

1 Nerve cells/neurones

2 To receive electrical impulses from the receptors; To send electrical impulses to the effectors.

3 The central nervous system is made up of the brain and the spinal cord; The peripheral nervous system is made up of all the other nerve cells; The role of the central nervous system is to coordinate the electrical impulses; The role of the peripheral nervous system is to send and receive electrical impulses.

Reflexes

1 An automatic response.

2 *Any two from*: Blinking; Pupil contracting; Coughing; Knee jerk; *Any other reflex.*

3 The receptors in the eye send an electrical impulse along the sensory neurone; to a relay neurone in the spinal cord; The relay neurone passes the electrical impulse to a motor neurone; which sends an electrical impulse to the muscles in the eye to make the pupil contract.

Investigating the effect of a factor on human reaction time

1 The reaction time

2 To make the investigation reliable/To remove any anomalies from the data.

3 Caffeine stimulates the nervous system.

Human endocrine system

1 The adrenal gland.

2 One mark for the endocrine gland, one mark for the correct hormone.

3 Both systems send messages to target organs or cells; The endocrine systems acts more slowly than the nervous system.

Control of blood glucose concentration

1 The pancreas

2 Excess glucose is stored as glycogen; in the liver and muscle cells; When the blood glucose concentration is low, glucagon causes glycogen to be broken down into glucose.

H 3 When the blood glucose level is too high, insulin is released; The cells take up glucose and the blood glucose levels decrease to the normal level; When the blood glucose level is too low, glucagon is released; Glycogen is broken down into glucose and the blood glucose levels increase to the normal level.

Diabetes

1 Insulin injections

2 *Any two from*: shaking; dizziness; coma.

3 *Any two from*: eat a healthy; balanced diet; do plenty of exercise; maintain a healthy weight.

Hormones in reproduction

1 Testosterone

2 To cause the release of a mature ovum.

3 The level of progesterone would remain high; The level of oestrogen would remain high; The level of FSH would be inhibited; The level of LH would be inhibited.

Contraception

1 *Any one from*: Condoms/diaphragms; Spermicidal agent; Intrauterine device; Surgical method; Abstinence.

2 Oral contraceptives contain oestrogen and progesterone; which inhibit FSH and prevents the eggs maturing.

3 *Any two from*: Lasts for a longer time; Don't need to remember to take it every day; Fewer side effects.

Using hormones to treat infertility

H 1 FSH and LH

H 2 Eggs are removed from the mother's ovaries; Eggs are fertilised by the father's sperm in the laboratory; Embryos are implanted into the mother's uterus.

H 3 Multiple births are a health risk to mother and babies; IVF is emotionally and physically stressful; Not all embryos are implanted/some embryos are discarded.

Negative feedback

H 1 The endocrine system

H 2 *Any two from*: increase in heart rate; increase in breathing rate; blood diverted from skin and intestines to muscles; glycogen broken down into glucose; pupils dilated.

H 3 Adrenaline is not produced by the body all of the time; and so does not have a set level; Adrenaline is only produced at times of fear/stress.

Inheritance, variation and evolution

Sexual and asexual reproduction

1 *Any two from*: Binary fission; Budding; Runners/bulbs/tubers.

2 The first cell of a new organism; when the nuclei of two gametes fuse.

3 Only one parent needed; More time/energy efficient; Many identical offspring can be produced quickly.

Meiosis

1 Six chromosomes.

2 A type of cell division that produces two genetically identical daughter cells.

3 Each gamete contains half of the chromosomes as the body cell; The nuclei from a male and female gamete fuse; The fused nuclei contain the full number of chromosomes.

DNA and the genome

1 All of the genetic material of an organism.

2 A DNA molecule has two strands; that are wound around each other to form a double helix.

3 Find out about genes that cause disease; and how to treat inherited disorders; Look at genes to find out about human migration patterns from the past.

Genetic inheritance

1 There are two dominant alleles.

2 **a** X^cX; XX; X^cY; XY.

b One out of four children could be a boy with colour blindness; 0.25 probability.

Punnett squares

1 An allele that is always expressed.

2 3:1

H 3 All of the children will have the genotype, Cc.

Inherited disorders

1 Polydactyl

2 XY

3 25%

Variation

1 *Any one from*: Height; Weight; Amount of pigment in skin; *Any reasonable answer.*

2 A change in the base sequence in DNA.

3 The individual with the advantageous mutation is more likely to survive in the environment; The individual is more likely to have offspring; The mutation will spread through the population.

Evolution

1 A group of similar individuals that can breed together; and produce fertile offspring.

2 These individuals would be less likely to survive; and less likely to have offspring.

3 The two populations would not interbreed; Each population would undergo natural selection; The phenotypes of each population would become very different; The two populations would no longer be able to interbreed with each other to produce fertile offspring.

Selective breeding

1 *Any one from*: Increased yield in milk; Increased size of cauliflower heads; Increased muscle mass on animals; Disease resistance in plants; *Any sensible answer.*

2 Can eliminate disease; Increase yield.

3 Breeding is tightly controlled; Only organisms with the best characteristics are allowed to breed.

Genetic engineering

1 *Any one from*: Disease-resistant plants; Plants that produce bigger fruits; Bacteria that produce human insulin; Gene therapy to overcome some inherited disorders; *Any sensible answer*.

2 A gene from another organism is cut out of its genome; The gene is placed inside a plasmid/vector; The plasmid/vector is placed inside the cells of the organism.

3 The normal allele is inserted into the genome of the person with the disorder; This overcomes the effect of the faulty allele.

Evidence for evolution

1 The remains of an organism from millions of years ago found in rocks.

2 *Any two from*: Loss of habitat; Loss of food sources; Hunting of the species.

3 The bacteria that are resistant to the antibiotic survive; and are more likely to have offspring; The offspring also have the resistance gene.

Classification

1 Phylum; Order; Family.

2 The two-name system of naming organisms; The genus and the species.

3 The archaea are more closely related to eukaryotes than bacteria; Archaea are different biochemically to bacteria.

Ecology

Communities

1 A group of populations living and interacting with each other in the same area.

2 Interspecific

3 The population of frogs would increase, as they would no longer be eaten; The population of mayfly nymphs would decrease as there would be more frogs to eat them.

Abiotic factors

1 *Any two from*: Temperature; Light intensity; Moisture levels in the soil/air; pH of the soil; Wind intensity and direction; Carbon dioxide levels; Oxygen levels of the water.

2 Some plant species cannot grow in high or low pH; The number of plant species may be decreased.

3 The wind will remove water from the leaves of the tree; The plants may not receive as much water for photosynthesis as they would on a non-windy hillside; The plants' growth may be decreased.

Biotic factors

1 *Any two from*: food availability; predators; microorganisms in the soil; pathogens; competition within and between species; parasites; symbiosis; pollination.

2 Loss of habitat; Loss of food sources; The populations of other species would decrease in number.

3 The number of pea plants would decrease due the decrease in pollination by bees; The number of caterpillars would decrease due to the decrease in pea plants as a food source; The number of sparrows would decrease due to the decrease in caterpillars as a food source.

Adaptations

1 *Any one from*: thick fur; white fur; sharp claws; thick layer of blubber; *Any sensible answer.*

2 A behavioural adaptation is a change in behaviour to aid survival in the environment; A functional adaption is an adaptation that has evolved to overcome a particular problem.

3 They are adapted to living at high temperatures; They convert inorganic compounds into energy.

Food chains

1 An organism that feeds on primary consumers.

2 Grass → rabbit → fox (arrow pointing in the correct direction; correct organisms)

3 The energy decreases as it goes through each level on the food chain; There would not be enough energy to support another organism in the food chain.

Measuring species

1 Place the quadrat down randomly in an area; Record the types of species and the number of each species in the quadrat.

2 25 ÷ 5 = 5; 5 × 100 = 500 buttercups

3 So that the animals will not be easier to spot by predators; So that the animals will be able to move about in a natural way.

Measuring the population size of a common species

1 Use the animal traps to capture animals in a given area; Mark the captured animals and release them; Wait a period of time and then capture animals in the same area and count how many are marked; Use the number of captured and marked animals to estimate the population size.

2 16.5 snails

3 Deaths, or migration out of the area will decrease the population size; Births, or migration into the area will increase the population.

The carbon cycle

1 *Any one of*: aerobic respiration; combustion.

2 Microorganisms decompose decaying matter; Microorganisms respire carbon dioxide back into the atmosphere.

3 Increased amount of combustion of fossil fuels; Decreased amount of photosynthesis; due to increased deforestation.

The water cycle

1 Evaporation; Transpiration.

2 Heat energy from the Sun warms the water droplets on the surface of the ocean; Heating changes the state of the water from a liquid to a gas which evaporates into the atmosphere.

3 As the wind transports clouds over mountains, the clouds rise; The water in the cloud cools and precipitates on the land on one side of the mountain; The cloud contains little rain by the time it reaches the land on the other side of the mountain.

Biodiversity

1 Air pollution

2 Trees and plants are removed to make space to build houses; This removes habitats and food sources for other organisms; Animal species will migrate away from the area to find food and shelter.

3 There is a large amount of carbon in peat bogs; When peat is removed and burned, it releases carbon dioxide into the atmosphere; The carbon dioxide in the atmosphere is taken up by plants for photosynthesis.

Global warming

1 Carbon dioxide; Methane.

2 Radiation from the Sun warms the Earth; The heat is reflected from Earth where is absorbed by the greenhouse gases in the atmosphere; The temperature of the atmosphere increases.

3 Decreasing the use of fossil fuels in vehicles; Decreasing the use of fossil fuel power stations; Increased use of renewable energy; Decreased deforestation.

Maintaining biodiversity

1 *Any one of*: Combustion of fossil fuels; Pollution; Deforestation.

2 Hedgerows provide habitats and food sources for species; so the number of species in the ecosystem increases.

3 Limit numbers of tourists allowed each year; Recycle waste; Reduce pollution from tourists.

Atomic structure and the periodic table

Atoms, elements and compounds

1 Sodium atoms

2 There is only one type of atom present.

3 A compound

4 **a** Compound **b** Element

5 **a** Silver-1 atom; nitrogen-1 atom; oxygen-3 atoms.

b Iron-1 atom; nitrogen-3 atoms; oxygen-9 atoms.

Mixtures and compounds

1 In the mixture, the iron and sulfur are not chemically combined. In iron sulfide, the iron and sulfur are combined chemically.

2 **a** Add the mixture to water; stir; the salt will dissolve, resulting in a salt solution. The chalk can then be separated from the salt solution by filtration. The solid salt can be separated from the salt solution by crystallisation.

b Add the mixture of Q and R to petrol. Q would dissolve in the petrol but R would not. R can be separated by filtration. Solid Q can be obtained by gentle heating to evaporate off the petrol.

Scientific models of the atom

1 Cannot be split up any further.

2 Electrons, protons and neutrons

3 The nucleus contains the protons and neutrons. Around the nucleus are the electrons, which are arranged in shells.

Atomic structure

1 Oxygen has 8 protons, which means its atomic number is 8. The atomic number is unique to the element.

2 Protons and neutrons are both found in the nucleus and are much heavier than electrons, which are not in the nucleus.

3 $^{31}_{15}P$

4 10. There are 13 electrons in an aluminium atom and therefore there are 3 less in an Al^{3+} ion.

5 The atomic number is 11, therefore there are 11 protons and 11 electrons. There are 12 neutrons because the mass number = 23 and the number of neutrons = mass number − atomic number, or 23 − 11.

Isotopes and relative atomic mass

1 **a** They have the same atomic number, but different mass numbers

b protons and electrons = 18; neutrons = 20 and 22.

2 **a** Let there be 100 atoms, the mass of the atoms with atomic number 63 = 63 × 69 = 4347 atomic mass units (amu). The mass of the atoms with atomic number 65 = 65 × 31 = 2015 amu. This means: Total mass of 100 atoms copper = 4347 + 2015 = 63.6 amu.

b There are 29 protons and 29 electrons. In the isotope with atomic mass 63 there are 34 neutrons. In the isotope with atomic mass 65 there are 36 neutrons.

The development of the periodic table and the noble gases

1 Groups and periods.

2 Aluminium

3 Because he believed that some elements had not yet been discovered.

4 Because iodine would have been placed in group 6 and tellurium in group 7 which is the halogens, and this would be wrong. Similarly potassium would have been placed in the noble gases and argon in the alkali metals.

Electronic structure and the periodic table

1 In shells around the nucleus.

2 8

3 The electron arrangement is 2,8,8,1. It is in group 1 and period 4.

Metals and non-metals

1 On the left-hand side.

2 Sulfur is a non-metal. It is a dull solid that is a poor electrical and thermal conductor, and it is brittle. Sodium is a metal. It is a shiny solid, a good electrical and thermal conductor.

3 Sodium is a metal and forms a positive ion.

4 Phosphorus is placed on the right-hand side the periodic table. It is a non-metal and would therefore be expected to be a poor conductor of electricity.

Group 1 – the alkali metals

1 **a** Lithium 2,1, potassium 2,8,8,1

b Both have one electron in their outermost electron shell, therefore they are placed in group 1.

2 Any of soft, malleable and ductile, less dense than water, good electrical and thermal conductor and is a shiny silver-white solid at room temperature.

3 Potassium(s) + water(l) → potassium hydroxide(aq) + hydrogen(g)

$2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$

4 When sodium and lithium react they both lose their outermost electrons to form +1 ions. The outermost electron of sodium is further from the positively charged nucleus and feels less of an attractive force; it also has more shielding electrons between it and the nucleus.

5 **a** Rubidium is lower in the group than potassium and would therefore react more violently. When added to water it would melt, burst into flame

more violently than potassium as the hydrogen formed is ignited by the reaction.

b $2Rb(s) + 2H_2O(l) \rightarrow 2RbOH(aq) + H_2(g)$

6 The alkali metals are extremely reactive and in the presence of non-metals would react immediately.

Group 7 – the halogens

1 7 **2** Cl^- **3** 2,8,8

Displacement reactions in group 7

1 F_2

2 The solution would go brown or a purple solid would form.

3 **a** Bromine(l) + sodium iodide(aq) → iodine(s) + sodium bromide(aq)

$Br_2(l) + 2NaI(aq) \rightarrow I_2(s) + 2NaBr(aq)$

b Bromine is above iodine in the group and is more reactive than iodine. Therefore bromine will displace iodine from a solution of its salt to give iodine and sodium bromide.

H **c** $Br_2(l) + 2I^-(aq) \rightarrow 2Br^-(aq) + I_2(s)$

4 **a** You would also add the same volume of bromine to an equal volume of water. If there is no reaction you would still get an orange coloured solution.

b Chlorine is more reactive than bromine, when bromine is added to sodium chloride the bromine does not displace the chlorine from its salt, therefore no change is observed.

Bonding, structure and the properties of matter

Bonding and structure

1 Liquid

2 There are weak forces between the particles.

3 In the solid state the particles vibrate about fixed positions. When the substance melts the particles are free to move around and are randomly arranged.

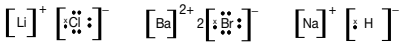
4 **a** **i** Liquid **ii** Gas

b (l)

H **5** There are several particles that are not spherically shaped. For example, polymers are linear. Particles are not solid. Atoms are mostly empty space.

Ions and ionic bonding

1 LiCl; $BaBr_2$; NaH

2 

3 When group 1 elements react they lose their outer electron in order to form a stable full outer electron shell. The particle formed has one fewer electron and is therefore a 1+ ion.

4 S^{2-}

5 The electrostatic attraction between the oppositely charged ions holds the ions together.

6 K_2S and MgI_2

The structure and properties of ionic compounds

1 The electrostatic attraction between the oppositely charged ions.

2 Because it is a giant structure all the strong ionic bonds have to be broken for melting to take place.

3 In the solid the ions are not free to move and cannot carry the current so does not conduct electricity. In the liquid the ions are free to move and can carry the current, making it a good conductor.

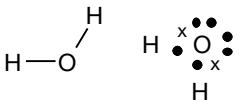
4 There are twice as many fluoride as magnesium ions.

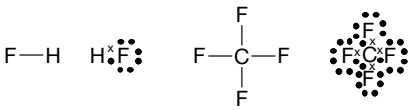
5 In CaO the ions present are Ca^{2+} and O^{2-} and in KBr they are K^+ and Br^-. Because of their higher charge the attractions between Ca^{2+} and O^{2-} are greater than between K^+ and Br^-. This means that CaO has the higher melting point.

Covalent bonds and simple molecules

1 A covalent bond is the sharing of a pair of electrons between two atoms, 1 electron coming from each atom.

2 Non-metallic

3 

4 

5 Low melting and boiling point; poor electrical conductor both as a solid and as a liquid.

Diamond, graphite and graphene

1 Giant covalent

2 All the atoms are joined by strong covalent bonds, all of these bonds have to be broken so lots of energy is required and the melting points are high.

3 The carbon atoms are arranged in layers of hexagonal rings. The layers are held together by weak intermolecular forces which are easily broken, this allows the layers to slide over each other and means that graphite is soft.

4 There are no charged particles or free electrons in diamond so it cannot conduct electricity in either the solid or liquid state. In the layers in graphite each carbon atom has a spare electron and these electrons are free to move, this means that graphite can conduct electricity.

5 The carbons are arranged in hexagonal rings and each carbon is joined to three others by strong covalent bonds.

6 Crystalline, very hard, high melting/boiling points; does not conduct electricity.

Fullerenes and polymers

1 **a** 60

b It has low melting and boiling points; it does not conduct electricity in either the solid or liquid state.

2 They are cylindrical fullerenes. They have a high length-to-diameter ratio.

3 The strong covalent bonds mean that they have a high tensile strength.

4 As a lubricant or to deliver drugs to their required sites within the body.

Giant metallic structures and alloys

1 Giant lattice of positive metal ions (cations) in a sea of delocalised electrons.

2 The delocalised electrons are free to move and carry the current in both liquid and solid states.

3 An alloy is a mixture of metals.

4 In the pure metal the layers of positive ions can slide over each other without disrupting the structure. This makes a pure metal soft and easily deformed. In alloys the ions of the other metal are of a different size to the main metal and make it harder for the layers to slide which means the alloy is harder.

Quantitative chemistry

Conservation of mass and balancing equations

1 **a** The reactants are magnesium and aluminium oxide; the products are magnesium oxide and aluminium.

b 72 + 103 = 175 g

2 **a** Hydrochloric acid + calcium carbonate → calcium chloride + water + carbon dioxide

b $2HCl(aq) + CaCO_3(s) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$

c See equation

d The carbon dioxide gas has a mass and is released from the reaction, therefore the mass decreases.

Relative formula masses

1 **a** 56 **b** 95 **c** 101 **d** 342

2 **a** 432 g

b The law of conservation of mass

The mole

H **1** Avogadro's number = $\mathbf{6.02 \times 10^{23}}$

H **2** It is the relative formula mass expressed in grams.

H **3** **a** $M_r = 32 + 2 \times 16 = \mathbf{64}$

b Number of moles = $\frac{m}{M_r} = \frac{1.6}{64} =$ $\mathbf{0.025\ (2.5 \times 10^{-2})mol}$

c No. of molecules = $0.025 \times 6.02 \times 10^{23}$ = $\mathbf{1.51 \times 10^{22}}$

Reacting masses and using moles to balance equations

H **1** 1 mol of copper gives 2 mol silver

63.5 g of copper gives 2 × 108 g of silver = **216 g**

1 g of copper gives $\frac{1}{63.5}$ × 216 g of silver

6.35 g of copper give $\frac{6.35}{63.5}$ × 216 g of silver = **21.6 g**

H **2** $M_r(AgNO_3) = 108 + 14 + 3 \times 16 = 170$; $A_r(Ag) = \mathbf{108}$

$M_r(NO_2) = 14 + 2 \times 16 = 46$; $M_r(O_2) = \mathbf{32}$

68 g of $AgNO_3 = \frac{68}{170} = \mathbf{0.4\,mol}$;

43.2 g of Ag = $\frac{43.2}{108} = \mathbf{0.4\,mol}$

18.4 g of $NO_2 = \frac{18.4}{46}$ mol = 0.4 mol; 6.4 g O_2 = **0.2 mol**

Therefore 0.4 mol $AgNO_3$ gives 0.4 mol Ag + 0.4 mol NO_2 and 0.2 mol of O_2;

Divide through by 0.2;

2 mol $AgNO_3$ gives 2 mol Ag + 2 mol NO_2 + 1 mol O_2;

The equation is $2AgNO_3 \rightarrow 2Ag + 2NO_2 + O_2$

Limiting reactant

H 1 **a** The sulfuric acid.

b From the equation 1 mol of magnesium reacts with 1 mol of sulfuric acid. The limiting reactant is the sulfuric acid because it is the smaller amount.

c From the equation the number of moles of H_2 are the same as the magnesium and sulfuric acid but the limiting reactant is the sulfuric; therefore 0.9 mol are formed.

Concentrations in solutions

1 a 500 $cm^3 = \frac{500}{1000} =$ **0.5 dm^3**

Concentration $= \frac{0.1}{0.5} =$ **2 mol/dm^3**

b 1 mol of HCl weighs 36.5 g; Therefore, concentration = 2 × 36.5 g/dm^3 = **71 g/dm^3**

2 n = C × V = 0.2 × 0.25 = **0.05 mol**

Chemical changes

Metal oxides and the reactivity series

1 A positive metal ion.

2 Carbon

3 Lithium hydroxide and hydrogen.

4 Hydrogen(g) + copper(II) oxide(s) → water(l) + copper(s)

$H_2(g) + CuO(s) \rightarrow H_2O(l) + Cu(s)$

5 Magnesium(s) + copper(II) sulfate → magnesium sulfate(aq) + copper(s)

$Mg(s) + CuSO_4(aq) \rightarrow MgSO_4(aq) + Cu(s)$

6 a Zinc chloride and hydrogen

b No reaction

Extraction of metals and reduction

1 a Oxidation **b** Reduction

2 Aluminium is oxidised, iron is reduced.

3 a By heating its oxide with carbon. Carbon reduces the lead oxide to lead.

b By electrolysis of an ionic compound of barium.

The reactions of acids

1 a An alkali is a soluble metal hydroxide.

b A base is an insoluble metal oxide or hydroxide.

2 a Sodium chloride **b** Sodium nitrate

3 The gas carbon dioxide is formed, and this produces effervescence.

4 a NO_3^-

b $Mg(NO_3)_2$

5 a $MgO(s) + H_2SO_4(aq) \rightarrow H_2O(l) + MgSO_4(aq)$

b $MgCO_3(s) + H_2SO_4(aq) \rightarrow H_2O(l) + MgSO_4(aq) + CO_2(g)$

c $Mg(OH)_2 + H_2SO_4(aq) \rightarrow H_2O(l) + MgSO_4(aq)$

H 6 **a** $2H^+(aq) + Mg(s) \rightarrow H_2(g) + Mg^{2+}(aq)$

b The hydrogen ions gain electrons and are reduced. The magnesium loses electrons and is oxidised.

The preparation of a soluble salt

1 a Either copper(II) oxide or copper(II) carbonate and sulfuric acid.

b Either zinc oxide, zinc hydroxide or zinc carbonate and nitric acid.

c Either magnesium, magnesium oxide, magnesium hydroxide or magnesium carbonate and hydrochloric acid.

2 a By filtration

b The excess base is insoluble and forms the residue on the filter paper and the soluble salt solution is the filtrate.

3 Yield = actual yield/theoretic yield × 100% $= \frac{4.5}{5} \times 100\% = 90\%$

4 a The insoluble magnesium carbonate would stop dissolving and the mixture would stop fizzing as no more carbon dioxide would be produced.

b Method A

Atom economy $= \frac{148}{166} \times 100\% = 89.2\%$

Method B

Atom economy$= \frac{148}{166} \times 100\% = 70.5\%$

Oxidation and reduction in terms of electrons

H 1 Oxidation is loss of electrons and reduction is gain of electrons.

H 2 **a** $Mg(s) + Zn^{2+}(aq) \rightarrow Mg^{2+}(aq) + Zn(s)$

b The magnesium has been oxidised.

The pH scale and neutralisation

1 H^+ ions

2 OH^- ions

3 $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

4 The hydrochloric acid is a strong acid and the ethanoic acid is a weak acid.

Strong and weak acids

H 1 A strong acid is fully ionised in water whilst a weak acid is only partially ionised.

H 2 A concentrated solution has a greater amount in moles of the solute dissolved in the same volume of water than a dilute solution.

H 3 The pH decreasing by 3 means that the hydrogen ion concentration has increased by 3 orders of magnitude, 10^3 times or 1000 times.

The basics of electrolysis and the electrolysis of molten ionic compounds

1 a The electrolyte

b The cathode

c The anode

2 a Chlorine

b Magnesium

H 3 **a** At the anode (+) $2Cl^- \rightarrow Cl_2 + 2e^-$

At the cathode (–) $Mg^{2+} + 2e^- \rightarrow Mg$

b The chloride ions lose electrons and loss of electrons is oxidation.

The electrolysis of aqueous solutions

1 a Na^+, Cl^-, H^+, OH^-

b Chlorine at the anode (+) and hydrogen at the cathode (–)

c Sodium hydroxide solution

H d At the anode(+) $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$ Oxidation

At the cathode (–) $2H^+(aq) + 2e^- \rightarrow H_2(g)$ Reduction

Extraction of metals by electrolysis

1 Aluminium, magnesium, calcium, lithium, sodium and potassium.

2 Because it is more reactive than carbon and this means that carbon cannot reduce aluminium oxide to aluminium.

3 Aluminium is extracted from its ore bauxite (aluminium oxide). The melting point of aluminium oxide is very high so to reduce the operating temperature the aluminium oxide is dissolved in cryolite. The aluminium ions are discharged at the negative cathode to give molten aluminium metal which is run off at the bottom of the cell. Oxygen is given off at the anode, because the anodes are made of carbon, the temperature is very high so the anodes burn away and have to be replaced at regular intervals.

H 4 At anode(+) $2O^{2-} \rightarrow O_2 + 4e^-$

At cathode $Al^{3+} + 3e^- \rightarrow Al$

Investigation of the electrolysis of aqueous solutions

1 At cathode is hydrogen; at anode is oxygen.

2 Because the product at the anode is bromine, and a weak solution of bromine water is yellow-orange in colour.

3 Hydrogen will give loud popping sound with a lighted splint.

The sodium hydroxide will turn purple using Universal Indicator solution.

Energy changes

Exothermic and endothermic reactions

1 a Exothermic

b i Final temperature = 45°C Exothermic

ii Temperature change = –5°C Endothermic

2 Thermal decomposition reactions. Some reactions of acids with hydrogen carbonates and carbonates.

The dissolving of ammonium compounds in water.

3 Hand warmers, cooking packs and coffee warmers

Investigation into the variables that affect temperature changes in chemical reactions

1 Amount of reactant, surface area of a solid reactant, the concentrations of any solutions involved, and the reactivity of any metals involved in the reaction.

2 a The reaction was between the magnesium and the acid, and the reaction was exothermic. As the

amount of magnesium was increased there were more reactions taking place, and the temperature increased.

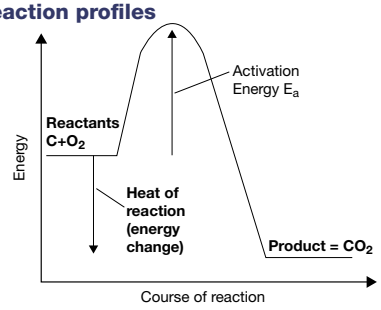
b At reaction 5 all of the acid had reacted and so the temperature rise was at a maximum. For reaction 6 adding more magnesium would have no effect so the temperature would not increase any more.

3 Metals with acids; neutralisation reactions – acids and alkalis.

4 Add measured amounts of hydrochloric acid to identical test tubes or calorimeters. Measure the temperature of the acid in each test tube/calorimeter. Add equal amounts of powdered metal to each test tube/calorimeter and measure the maximum temperature obtained in the reaction. The more reactive the metal the greater the temperature change.

Reaction profiles

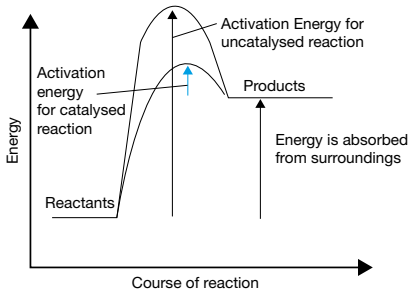
1



2 a i A catalyst speeds up a chemical reaction and is chemically unchanged at the end of the reaction.

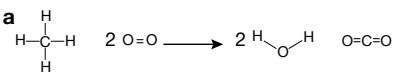
ii A catalyst allows the chemical reaction to proceed by an alternative route that has a lower activation energy.

b i and **ii**



The energy changes of reactions

H **1 a**



b

4 × 415 kJ	2 × 500 kJ	4 × 465 kJ	2 × 800 kJ
1660 kJ	1000 kJ	1860 kJ	1600 kJ

i 2660 kJ

ii 3460 kJ

iii 800 kJ/mol

c More energy is given out than taken in, therefore the reaction is exothermic.

Rates of reaction and equilibrium

Ways to follow a chemical reaction

1 a Follow the volume of CO_2 gas given off with time. Follow the reduction in mass with time.

b Follow the volume of H_2 gas given off with time. Time how long it takes for the magnesium to dissolve.

2 a The concentration of acid

b The volume of gas

3 a It relies on the senses (sight) to see when the cross is obscured, so could be inaccurate because of human error. When the reaction is slow it will be unclear when the cross is obscured. The darkness of the cross is variable and will give different results.

b i Place the bulb below the reaction vessel and the light datalogger above it. As the cloudiness increases the light reaching the datalogger will decrease.

ii The second method is better because it does not rely on the senses. It can also be used to measure the rate directly.

Calculating the rate of a reaction

1 Divide the total number of moles, total volume or total mass gained by the time taken for reaction to get to completion.

$$\text{OR mean rate} = \frac{\textit{amount of product formed in reaction}}{\textit{time taken for reaction to reach completion}}$$

2 a Plot graph

b i Draw tangents to graph at 0 s, 10 s and 30 s.

ii At 0 s rate = 7.25 cm^3/s; at 10 s rate = 2.25 cm^3/s

At 30 s rate = 0.68 cm^3/s

iii As the reaction progresses the concentration of the acid decreases and acid particles are less crowded and therefore there are fewer collisions per second and the rate decreases.

c The gradient is zero because all the acid has been used up and the reaction is complete.

H **d i** No. of moles of $CO_2 = \frac{80}{24000} = 3.33 \times 10^{-3}$

ii The number of moles of HCl = 2 × no. of moles of $CO_2 = 6.66 \times 10^{-3}$

iii Volume of acid = $\frac{100}{1000}$ dm^3 = 0.1 dm^3

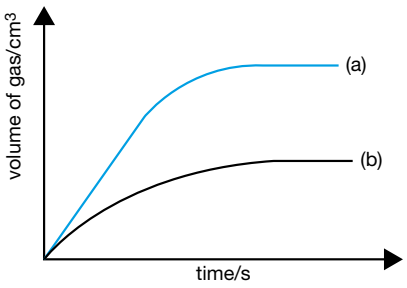
Concentration of HCl = $\frac{n}{V}$ = $6.66 \times 10^{-3}/0.1 = 6.66 \times 10^{-2}$ mol/dm^3

The effect of concentration and pressure on reaction rate and the effect of pressure on the rate of gaseous reactions

1 It decreases

2 As the concentration increases the reacting particles get more crowded and they collide more frequently increasing the chance of reaction.

3



Rates of reaction – the effect of surface area

1 Powder

2 As the surface area increases the number of solid particles exposed to reaction increases, therefore the frequency of collisions increases and so does the rate of reaction.

3 a By using lumps (small surface area) and powder (large surface area).

b Follow the volume of gas given off with time OR follow the loss in mass with time.

c Using a bar chart because lumps and powder are not continuous variables.

The effects of changing the temperature and adding a catalyst

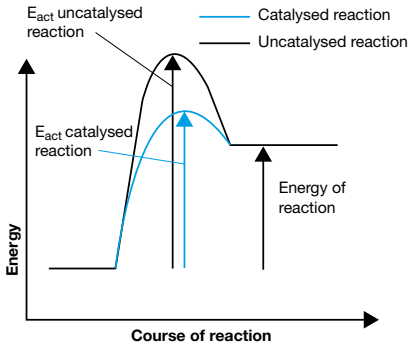
1 This increases the rate

2 As the temperature increases the particles collide more frequently and with greater force, so the frequency of effective collisions increases and so does the rate.

3 a A catalyst speeds up a chemical reaction and is unchanged at the end of the reaction.

b A catalyst allows the reaction to proceed by an alternative route which has a lower activation energy.

4



Investigation into how changing the concentration affects the rate of reaction

1 Volume of water missing values 20, 10, 0

Reaction rates of missing cells 0.0078; 0.016; 0.031; 0.045; 0.063

Variables kept constant - Temperature; concentration of acid; for the cross to be obscured these must be kept the same.

The line is a straight line and this shows that the rate of reaction is proportional to the concentration of sodium thiosulfate.

Reversible reactions

1 ⇌

2 It is a reaction where the reactants can react to form products and the products can react to form the reactants.

3 **a** A + B ⇌ Y + Z

b The forward reaction is exothermic and the reverse reaction is endothermic.

c Because not enough X and Y are present to form the reverse reaction.

d iii and iv

The effect of changing conditions on equilibrium

H 1 A chemical system is the reactants and products of a reversible reaction together in a closed container.

H 2 It means the reaction is reversible.

H 3 The reverse reaction is the reaction where the products of a reaction react together to form the reactants.

H 4 If a chemical system is at equilibrium and one or more of the three conditions is changed then the position of equilibrium will shift to remove the effects of the change; we get either more reactants or more products.

H 5 **a** If the pressure is increased it favours the reaction that forms fewer gas molecules and this is the forward reaction. This is the formation of ethanol.

b If the temperature is raised the equilibrium will shift so as to lower it. This means the endothermic reaction is favoured, this is the reverse reaction, and therefore less ethanol is formed.

c It has no effect. The catalyst speeds up the forward and reverse reactions equally and has no effect on the position of equilibrium.

Organic chemistry

Carbon compounds, hydrocarbons and alkanes

1 A compound of hydrogen and carbon only

2 A homologous series is a series of compounds that:

- Have the same general formula
- Have similar chemical properties
- Have the same functional group
- Show a gradation in physical properties like melting and boiling point as the molecules in the series get larger
- Each member of the series differs from the next one by $-CH_2-$

3 General formula = C_nH_{2n+2}; C_6H_{14}

Crude oil, fractionation and petrochemicals

1 Petroleum gases - fuels and feedstock for making other chemicals

Gasoline/petrol - fuel for cars

Naphtha - feedstock for other chemicals

Paraffin/kerosene - aeroplane fuel

Diesel oil - fuel for large cars and lorries

Lubricating oil - making parts of machinery work more efficiently and smoothly

Fuel oil - fuel for ships

Bitumen - road surfaces

2 Crude oil is a mixture of miscible liquids and gases with similar boiling points. The best way to separate such a mixture is by fractional distillation.

3 The boiling points get higher. As the column is descended the temperature increases and only fractions with higher boiling points will condense at these temperatures.

4 Fraction X has a lower boiling point, is lighter in colour, is less thick or less viscous, is easier to light.

5 The cobalt chloride paper changes from blue to pink. Limewater changes from colourless and clear to milky or cloudy.

6 **a** $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

b $C_4H_{10}(g) + 6½O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$

Cracking and alkenes

1 Cracking is the breaking down of large alkane molecules into smaller alkane molecules and alkenes.

2 The large alkanes are passed over a heated catalyst OR the alkanes are mixed with steam and heated to a high temperature.

3 **a** C_nH_{2n}

b If bromine water is added to an alkene, the bromine water is decolourised.

c Alkenes are used for making polymers.

4 After fractionation the amount of smaller alkanes such as the petrol fraction is not enough to meet the demand. For the fractions with large alkanes the amount from fractionation is greater than that required. Also, crude oil does not contain alkenes. Therefore cracking is used to make economically important and useful compounds from less useful ones.

5 **a** C_4H_8

b C_3H_8

c C_6H_{14}

Chemical analysis

Pure substances and formulations

1 A single element or a single compound.

2 It contains several different compounds.

3 A formulation is a mixture that is designed to improve upon the properties of the pure substance on its own.

4 Example is a drug which may include substances to make it more easily swallowed; substances that will bind it together and substances that prolong its shelf life.

Chromatography

1 Stationary phase = paper

Mobile phase = solvent

2 The pen will separate into its components and interfere with the chromatogram. The graphite in the pencil will not separate, so will not affect the chromatogram.

3 **a** B and C are pure substances.

b **i** It gives more than one spot.

ii B and C

c $\frac{7.3}{8.5} = 0.859$

Testing for gases

a (Oxygen) Relights a glowing splint.

b (Carbon dioxide) Turns limewater milky/cloudy.

c (Hydrogen) Pops with a lighted splint.

d (Chlorine) Bleaches blue litmus paper or UI paper.

Chemistry of the atmosphere

The composition and evolution of the Earth's atmosphere

1 Carbon dioxide, water vapour, methane, nitrogen and ammonia.

2

- Dissolving in water (the oceans)
- Taken up by plankton in the ocean to form calcium carbonate and these were compressed to form limestone
- Sometimes these marine animals were covered with mud and compressed to form oil
- Sometimes plants are covered by mud and compressed to form coal
- Photosynthesis uses carbon dioxide to form glucose and oxygen

3 Carbon dioxide + water → glucose + oxygen

$6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(s) + 6O_2(g)$

Climate change

1 Carbon dioxide and methane

2 The rise in carbon dioxide shows the same pattern as the rise in global temperature.

3 Infrared

4 The burning of fossil fuels.

The carbon footprint and its reduction

1 The total amount of carbon dioxide emitted over the lifetime of an activity or product.

2 **a** Removing carbon dioxide by planting trees and plants which remove carbon dioxide through photosynthesis.

b The carbon dioxide from power plants is pumped into porous rocks, especially those by disused oil wells deep below the sea.

3 *Two out of:*

- Countries and companies find it more economical to burn fossil fuels
- Disagreement over the cause of global warming
- People are reluctant to change their lifestyles

- Lack of awareness by people of the consequences of using lots of energy

4 Their manufacture requires energy

H 5 **a** Cavity wall insulation because a terraced house only has exposed front and back walls.

b Loft insulation saves emission of 990 kg of CO_2.

Mass of CO_2 = 990 × 10^3 g = 990 × 10^3/44 moles of CO_2 = 2.25 × 10^4 mol

c Volume of CO_2 = 2.25 × 10^4 × 24 = 5.4 × 10^5 dm^3

Atmospheric pollutants

1
- Carbon monoxide – toxic
- Particulates – cause respiratory problems and reduce sunlight reaching Earth's surface
- Oxides of nitrogen – dissolve in water to cause acid rain and also harmful to respiratory system
- Sulfur dioxide – dissolves in water to cause acid rain

2 If the room is not ventilated then there is insufficient oxygen present for complete combustion. The coal or wood then undergoes incomplete combustion to form carbon monoxide which is toxic.

H 3 **a** **i** $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

ii $CH_4(g) + 1\ ½O_2(g) \rightarrow CO(g) + 2H_2O(l)$

Using resources

Finite and renewable resources, sustainable development

1 **a** Finite resources will run out.

b These can be replaced at the same rate as they are used up. They are derived from plant sources.

c Sustainable development meets the needs of present development without depleting natural resources.

2
- Have reactions with high atom economy – this means that there is less waste
- Use renewable resources – this means that the process will not rely on resources that are running out
- Have as few steps as possible – the less the number of steps the less waste is produced, the less energy used and lower the amounts of resources use
- Use catalysts – using a catalyst saves energy and speeds up production

3 **a** The amount of coal remaining = 17.7 × 10^9 tonnes

The number of years left = 17.7 × $\frac{10^9}{175}$ × 10^6 = 101 years

Use alternative sources of energy; increased energy saving by domestic and industrial consumers.

Life cycle assessments (LCAs)

1 A life cycle assessment is an analysis of the environmental impact of a product at each stage of its lifetime from its production all the way to its disposal.

2
- The extraction/production of raw materials
- The production process – making the product, including packaging and labelling
- How the product is used and how many times it is used
- The end of the life of the product – how is it disposed of at the end of its lifetime. Is it recycled?

3 **a** Both forms of power generation burn fossil fuels and therefore emit large amounts of carbon dioxide which is a greenhouse gas.

b Silicon voltaic cells use solar radiation to power them and therefore do not burn fossil fuels. However, energy from fossil fuels is used in their production and disposal which explains the small amounts of greenhouse emissions. Similarly with nuclear power stations which use energy from nuclear fission for power generation. Fossil fuels are also burned in producing the materials used to build the nuclear power station.

4 **a** Energy is required to extract and produce the materials used for the cell and this energy comes from burning fossil fuels.

b The coal-powered power station burns large amounts of the fossil fuel during its lifetime and this is much larger than the equivalent amounts used when it is built and dismantled.

Alternative methods of copper extraction

H 1 **a** They are low in copper.

b **i** mass = $\frac{0.5}{100}$ × 1 × 10^6

= 5 × 10^3 tonnes

ii n = $\frac{mass}{relative\ atomic\ mass}$ = $\frac{5000}{63.5}$ = 78.7 mol

H 2 **a** Copper is less reactive than carbon and therefore carbon can be used to reduce copper oxide to copper.

b Firstly the copper carbonate is decomposed to copper oxide by heating:

$CuCO_3(s) \rightarrow CuO(s) + CO_2(g)$

Then the oxide is reduced to copper by heating with carbon:

$2CuO(s) + C(s) \rightarrow 2Cu(s) + CO_2(g)$

H 3 **a** Bacteria

b The advantages are that it works with low-grade ores and uses less energy than smelting to recover the copper. The disadvantage is that it is slow.

H 4 The impure copper is made at the anode. Copper from the anode dissolves into the electrolyte and is then deposited as pure copper on the cathode.

Making potable water and waste water treatment

1 **a** Water that is safe to drink.

b **i** Evaporate off the water.

ii Add dilute nitric acid followed by silver nitrate solution. If a white precipitate is formed then chloride ions are present.

c **i** Place some of the liquid being tested on blue cobalt chloride paper. If water is present the cobalt chloride paper turns pink. Alternatively the liquid under test can be added to anhydrous copper(II) sulfate. If water is present the anhydrous copper(II) sulfate turns from white to blue.

ii The boiling point of pure water is 100°C.

2 Filtration

3 **a** A process which takes place in the absence of oxygen.

b A process which takes place in the presence of oxygen.

c A process in which larger particles settle in a liquid by gravitation.

4 **a** The anaerobic digestion produces methane which can be used as a fuel for powering the water treatment process. This means that the water treatment process uses less energy derived from fossil fuels.

b The sludge remaining after anaerobic digestion can be used for fertilisers.

5 Filtration

H 6 **a** Both the chloride and bromide ions would react with the silver nitrate solution to form precipitates with very similar colours (white and pale cream). Therefore it would be very difficult to distinguish these precipitates and the answer would not be clear-cut.

b If chlorine gas was passed through one sample of the water, the chlorine would displace the bromide ions from solution. Bromine would be formed as a pale orange/yellow solution.

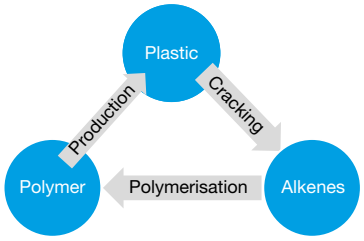
Ways of reducing the use of resources

1 *Any three from:*
- Saves energy because do not have to extract raw materials from the Earth
- Saves energy because no energy required for the production process
- Reduces waste from production process
- Conserves raw material in ground for future use – increases lifetime of raw material
- Increases awareness of public of the need to conserve materials
- Reduces greenhouse emissions

2 **a**
- Extraction of aluminium is expensive
- Bauxite, the ore of aluminium, is running out so recycling conserves the ore and increases its lifetime
- Reduces environmental destruction when mining for ore
- Reduces energy used in aluminium extraction

b Using a magnet. The aluminium is not magnetic.

3 Polymers are made from alkenes. Polymers are used to make plastics which can be cracked to form alkenes.



Analysis and purification of a water sample

1 **a** **i** A pH meter

ii It would not contaminate the water

b Hydrogen chloride (hydrochloric acid)

2
- Before distillation the water contained a dissolved compound
- This substance was a compound of sodium because it gave a yellow flame in the flame test
- It also contained iodide ions as shown by the yellow precipitate with silver nitrate solution
- The dissolved compound was sodium iodide
- The distillation was successful as it gave no flame and no precipitate when the tests were repeated.

Energy

Energy stores and systems

1 First, choose the start and end point; second, find the energy stores at those points; third, show which stores empty and which stores fill up.

2 **a** Electrical working

b Heating by particles

c Mechanical working

d Heating by particles

3 Example 1: A weightlifter lifting a weight transfers energy via mechanical working;
Example 2: A bonfire transfers energy via heating by radiation.

Changes in energy stores

1 301.6 J

2 1123 J

3 Cyclist A's E_k is 9 times higher than the E_k for cyclist B. This is because their speed is 3 times that of cyclist B, and $3^2 = 9$

Energy changes in systems – specific heat capacity

1 94 500 J

2 The thermal store will increase by 4200 J; as energy is conserved.

3 c

Power

1 (b) 850 W; because it transfers more energy per second to the water.

2 11 J

3 6930 J

Energy transfers in a system

1 Wear streamlined helmet and adjust body position to reduce air resistance; Lubrication between bike's chain and gears to reduce heating effects of friction; High pressure in tyres to reduce surface area of contact between the road and the tyres.

2 The infrared radiation from the heating elements in the toaster warms the surrounding air which rises; so not all the energy is transferred through heating by radiation to the toast.

3 Less fuel consumption; Tyres, brakes and other components do not get worn out as quickly.

Efficiency

1 Because in any change within a system some energy is dissipated to the surroundings.

2 Because the useful energy transferred is the numerator of the fraction and the input energy is the denominator; Since the useful energy transferred can never be greater than the input energy, the fraction can never return a value greater than 1.

3 Being only 25% efficient means that our body needs to transfer 4 times more energy from the chemical store to do the mechanical work needed during exercise, e.g. to lift a weight.

National and global energy resources

1 Renewable energy resources can be replaced (replenished); but non-renewable energy resources cannot be replaced and so will eventually run out if we keep using them.

2 Fossil fuels have high power output and are very reliable.

3 *Any one of:* Large areas are needed to harness it; It has a low power output; It has a low conversion efficiency; It can only be harnessed during daylight hours.

Electricity

Standard circuit diagram symbols

1 Ammeters have hardly any resistance; but voltmeters have very high resistance.

2 Their *I-V* characteristics are very similar and they both let current flow only in one direction; However, LEDs emit light, while diodes do not.

3 A diode in series with an LDR.

Electrical charge and current

1 An electrical current is the rate of flow of electrical charge.

2 Free electrons fill all the components of the circuit all the time, even when the circuit is open; So, when the circuit is closed all the free electrons will start drifting in the same net direction at the same time.

3 31.4 C

Current, resistance and potential difference

1 $I = \frac{V}{R}$ **2** 1560 V **3** 20 W

Resistors

1 The current through an ohmic conductor (at constant temperature) is directly proportional to the potential difference across the ohmic conductor (resistor).

2 The resistance of the diode is very high for all negative values of p.d., then it suddenly decreases as the p.d. reaches a certain positive value; As the p.d. increases further the resistance drops by greater and greater amounts for equal increments in p.d.

3 A linear relationship between two variables follows a straight line in a graph of the two variables; whilst a non-linear relationship follows a curved pattern.

Series and parallel circuits

1 0.75 V

2 Because each component is individually connected to the power supply in its own loop.

3 V across R_1 = 6V and V across R_2 = 3V

Mains electricity

1 Because this is always at a potential of about 230 V, so if a fault occurs and the user touches the live wire or the metal casing of the kettle (if it is touching the live wire), this could electrocute the user.

2 In a dc the potential difference provided by the battery does not change in direction (sign) or value; In an ac the potential difference continually alternates in direction (sign) and changes value.

3 Such an appliance would draw less current when plugged to the mains in the USA; so it might not perform as well; For example, a mobile phone charger might take longer to charge your phone.

Electrical power, energy transfers in appliances and the National Grid

1 The power of an appliance depends on the potential difference across the device and the current through it.

2 When a car engine is working, the chemical store transfers some energy to the kinetic energy store associated with the car, through mechanical working; Some of this energy transferred will fill the thermal store of the surroundings by heating the engine and the air around it.

3 0.33 mA or 3.3×10^{-4} A

Particle model

Particle model and the density of materials

1 The mass per unit volume.

2 1.7×10^{-4} m^3

3 $\rho_{\text{fresh water}} = \frac{0.250}{0.000250} = 1000$ kg/m^3;

$\rho_{\text{dead sea}} = \frac{0.250}{0.000202} = 1238$ kg/m^3;

So a human body of density 985 kg/m^3 would float in both fluids; but better in the dead sea, as it is denser than fresh water.

Changes of state and internal energy

1 The specific latent heat of a material is the amount of energy needed to for 1 kg of that substance to change state (without a change in temperature); The specific heat capacity of a material is the amount of energy needed to for 1 kg of that substance to increase its temperature by 1°C.

2 Those flat sections would be longer, because it would take longer for the substance to change state.

3 2060.8 kJ

Particle model and pressure

1 The particles of a gas constantly move with random motion, i.e. in all directions and with a range of speeds (random velocity).

2 Because pumping more air in the tyre causes the number of air particles in the system to increase and may also cause the temperature to rise; pV is only constant for a *fixed* mass of gas at *constant* temperature.

3 $p_2 = \frac{1}{3}p_1$ so the difference between them will be $\frac{2}{3}p_1$.

Atomic structure

The structure of the atom

1 +2

2 92 protons and 146 neutrons

3 10000 orders of magnitude

Developing a model of the atom

1 Positive charge fills the whole volume of the atom, with negatively charged particles (electrons) scattered inside the atom to balance its positive charge (the electrons resemble raisins inside a pudding).

2 In Rutherford's model the electrons can orbit the nucleus at any radius; but Bohr's model shows that only certain radii are allowed.

3 Because if the positive charge was spread out over a mass occupying the whole volume of the atom, it would not generate forces strong enough to cause an alpha particle to bounce off the atom with large angles; Therefore the mass and its positive charge must be concentrated in the centre of the atom.

Radioactive decay and nuclear radiation

1 Alpha and Beta particles and Gamma rays; Neutrons also accepted.

2 Neutrons because they are the most penetrating type of radiation; but they also interact with and can be absorbed by hydrogen-rich materials, like the water in our bodies, which can make our bodies radioactive and kill us.

3 Gamma radiation has no mass or charge, so it does not interact with other particles as strongly as alpha particles, which have a very high mass and charge; This means gamma radiation is not easily decelerated so it is more penetrating than alpha particles.

Nuclear equations

1 Its atomic number (number of protons).

2 ${}^{1}_{0}n$

3 The atomic number would remain the same, but the mass number decreases by 1.

Half-life of radioactive elements

1 The isotope in the sample and the number of radioactive nuclei left in the sample.

2 The time taken for the number of nuclei of the radioactive isotope in a sample to halve/the time taken for the count rate (activity) from a sample of radioactive isotope to decrease to half its initial level.

3 73 days

Forces

Forces and their interactions

1 Power is an example of scalar quantity and momentum is an example of vector quantity.

2 Contact forces act between objects that are 'touching' each other and non-contact forces act at a distance.

3 The mass of an object is a scalar quantity and is the same anywhere in the universe, while the weight of an object is a force, i.e. a vector quantity, and it changes depending on the gravitational field (9.8 m/s^2 on Earth).

Resultant forces

1 The resultant force and it is the sum of all the forces acting on the object.

2 807 N upwards

H 3 3.5 N; 3.5N

Work done and energy transfer

1 The force multiplied by the distance in the direction of the force.

2 530 J because work done equals energy transferred.

3 332 024 000 J

Forces and elasticity

1 Elastic deformation – the object returns to its original shape after deformation; Inelastic deformation – the shape of the object is permanently changed by the deformation.

2 70 N/m

3 0.0875 J; 0.0875 J

Distance, displacement, speed and velocity

1 Distance and speed are scalar quantities and scalar quantities have no direction; displacement and velocity are vectors, which are different to scalar quantities because vectors have direction; So, displacement is the distance travelled in a given direction, and velocity is the speed in a given direction.

2 4.32 km

3 5.9 m/s

Distance-time relationship

1 The speed of the object.

2 Because the lower the gradient of a distance–time graph, the slower the object is travelling; and when an object slows down this means it is decelerating.

3 That is the reaction time of the driver.

Acceleration

1 Acceleration is a vector quantity.

2 1.1 m/s^2

3 193 m

Newton's laws of motion

1 A resultant force needs to be applied on the object.

2 That the resultant force on an object is proportional to the mass of the object and its acceleration.

H 3 Inertia is the tendency to stay at rest or constant motion; It cannot be measured; Inertial mass is the measure of how difficult it is to change the velocity of an object, and it can be calculated using the formula $m = F/a$; So inertial mass is a way of comparing and quantifying inertia.

Stopping distance

1 The velocity of the vehicle; its mass; road conditions; efficiency of vehicle's brakes; driver awareness.

2 A lot of friction on brakes makes them overheat; could lead to skidding and loss of control of vehicle, especially in wet or icy conditions; can cause bodies and other objects inside the vehicle to jolt forwards which may result in damage, especially if seatbelt not worn, e.g. thrown through a window.

3 21.7 m/s

Momentum

1 The mass of the object multiplied by its velocity.

2 This means that the total momentum of a system before and after an event (like a collision) is the same.

3 0.99 kg m/s

Waves

Transverse and longitudinal waves

1 Measure the distance between the middle line and a peak or trough on the wave graph.

2 0.0038 s

3 0.048 m/s

Reflection and refraction

1 The light ray will reflect off the mirror at an angle of 32° from the normal.

2 The light ray will partially be refracted inside the material at a smaller angle than the angle of incidence and partially reflected with the same angle as the angle of incidence.

3 All other frequencies apart from frequencies that appear red to the human eye have been absorbed by the red filter.

Electromagnetic waves

1 Energy

2 They can travel through empty space.

3 EM waves of higher frequency, like gamma rays, carry more energy; so they can penetrate the body further and damage human tissue deeper inside the body.

Electromagnetism

Magnetism

1 Permanent magnets generate their own magnetic fields, e.g. a bar magnet; They retain their magnetism; Permanent magnets can cause two types of force: attraction and repulsion; Induced magnets are materials that become magnets when they are placed in a magnetic field, but lose their magnetism when they are removed from the magnetic field; Induced magnets can attract, but not repel other magnets.

2 The direction of magnetic field lines from a magnet can be plotted found using small magnetic compasses; The arrow of the compass points towards the south pole of the magnet and away from the north pole, which is the same direction as the magnetic field.

3 Like poles repel because the magnetic field lines from them each pole are in opposite direction to each other, i.e. they are opposite forces; Magnetic field lines cannot cross so they band away from each other creating a repulsive force.

Motor effect

1 The force on the wire will decrease in direction proportion.

2 Use Fleming's left hand rule; Using your left hand, point the first finger in your direction of the field, your second finger in your direction of the current and your thumb will point in the direction of the force.

3 $F = BIL$ so $B = F/IL$

$= 0.046/(0.21 \times 0.751)$

$= 0.29$ T