Biology

Cells and cell processes

Microscopes and micro-organisms
1 a) Bacteria
   b) Viruses
   c) Virus
   d) B is the correct statement.
2 A is a virus (1 mark); B is a fungus (yeast would be allowed) (1 mark); C is a bacterium (1 mark).

Types of cells
3 a) A = vacuole (1 mark); B = cell membrane (1 mark); C = cytoplasm (1 mark)
   b) To absorb light (for photosynthesis).
   c) A and D (2 marks)

Enzymes and other proteins
4 Indicative content:
   - The enzyme and the substrate each have a particular molecular shape.
   - These shapes must fit together for the enzyme to catalyse the breakdown of the substrate.
   - The part of the enzyme which attaches to the substrate is the active site.
   - Different chemicals will have different molecular shapes from hydrogen peroxide, and so they will not fit the enzyme’s active site.
   (Refer to the QWC mark scheme on pages 108–109 of the Revision Guide to see how this question would be marked.)
5 a) A = active site (1 mark); B = substrate (1 mark); C = enzyme-substrate complex (1 mark)
   b) The shape of its active site will change (1 mark) and the substrate will no longer fit (1 mark).
   c) It speeds up a chemical reaction.
   d) All enzymes belong to the same chemical group (proteins) (1 mark). They are made from a long chain of amino acids (1 mark). This chain is folded in a particular way to give the enzyme a shape which allows it to fit together with its substrate (1 mark).
6 a) i) True
   ii) False (enzymes do not react with their substrate, they just catalyse a reaction.)
   iii) False
   iv) True
   b) They could measure the diameter/area of the clear zone after a set time (1 mark) (2 marks)


Properties and uses of enzymes
7  a) Enzymes are a type of protein (1 mark). They increase (1 mark) the rate of chemical (1 mark) reactions in living cells. Each works best at a particular temperature (1 mark) and pH value. (4 marks)

b) They are denatured/destroyed. (No marks for ‘stop working’ or ‘killed’.) (1 mark)

c) i) 6.9 (6.8–7.0 accepted) (1 mark)

ii) 9 a.u. (1 mark)

8 a) Enzymes (1 mark)

b) 30–40 °C (2 marks) (1 mark if just 30 °C or 40 °C is mentioned.) (2 marks)

c) At 10 °C the enzymes do not work well because the temperature is too low (1 mark). At 60 °C the enzymes would have started to denature (1 mark). (2 marks)

d) Any two of: same cloth; same length of time in the wash/same wash programme; same washing machine. (2 marks)

e) To compare with/to see how much of the stain had been removed. (1 mark)

DNA and the genetic code
9 a) Sugar (1 mark) and phosphate (1 mark). (2 marks)

b) Base (1 mark)

c) The order in which bases occur along a DNA strand (1 mark) forms a ‘code’ which determines how different amino acids (1 mark) are linked together to form different proteins (1 mark). (3 marks)

d) Watson (1 mark) and Crick (1 mark) (2 marks)

10 a) Double helix (1 mark)

b) Sugar and phosphate. (2 marks)

c) The order in which different amino acids (1 mark) are linked to make proteins (1 mark). (2 marks)

d) Adenine, guanine, cytosine, thymine. (4 marks)

11 Indicative content:
- Watson and Crick worked out the structure.
- They used chemical theory and models.
- Franklin and Wilkins supplied data.
- They used X-ray crystallography.
- Avery discovered the link between nucleic acids and genes.

(Refer to the QWC mark scheme on pages 108–109 of the Revision Guide to see how this question would be marked.)

Cell division
12 a) A – 20; B – 20; C – 40; D – 40. (1 mark if A and B correct; 1 mark if C and D correct). (2 marks)

b) i) Meiosis (1 mark)

ii) Mitosis (1 mark)
13 a) Meiosis (1 mark)
  b) Meiosis (1 mark)
  c) Mitosis (1 mark)
  d) Meiosis (1 mark)
  e) Mitosis (1 mark)

**Differentiation and growth**

14 a) A cell which can differentiate into other types of cell. (1 mark)
  b) They could be used to repair any type of damaged cell in their body in the future. (1 mark)
  c) Meristems (1 mark)

15 Indicative content:
- Some religious groups think that making new tissues in this way is ‘playing God’ and should not be done.
- If stem cells are used from human embryos, the embryo is destroyed.
- Such embryos have the potential to grow into humans.

(Refer to the QWC mark scheme on pages 108–109 of the Revision Guide to see how this question would be marked.)

**How substances enter and leave cells**

**Transport in and out of cells**

16 a) i) Into the cell (1 mark)
    ii) Out of the cell (1 mark)
  b) Diffusion (1 mark)
  c) The concentration of glucose outside the cell is lower than that inside the cell. (1 mark)
  d) Active transport (1 mark)

17 a) False (1 mark)
  b) False (1 mark)
  c) True (1 mark)
  d) True (1 mark)
  e) True (1 mark)

**Osmosis**

18 a) i) 0.3 mol per dm³ (1 mark)
    ii) (No net gain/loss of water) because rate of entry = rate of exit. Explanation needed for why this occurs. (No mark if answer refers to ‘no osmosis’) (1 mark)
  b) +0.5 mm/increase of 0.5 mm (1 mark)
  c) Indicative content:
     - Water passes out from the weak solution to the concentrated solution (or from where water is at a high concentration to where it is at a low concentration)
Photosynthesis

The importance of photosynthesis

19 a) Green plants make their own food from **water** (1 mark) that is absorbed by the roots, **carbon dioxide** (1 mark) from the air and light energy from the **sun** (1 mark) which is absorbed by the **chloroplasts** (1 mark) in a leaf cell. (4 marks)

b) i) A (1 mark). The snails are respiring and producing carbon dioxide (1 mark). (2 marks)

ii) B (1 mark). The plant is photosynthesising which absorbs carbon dioxide (1 mark). (2 marks)

Environmental factors and photosynthesis

20 a) Because carbon dioxide levels change (throughout the 24-hour period/day and night). (1 mark)

b) i) The plants are photosynthesising below their optimum rate/at too low a rate or plants don’t have enough carbon dioxide to photosynthesise at high/maximum rate. (1 mark)

ii) To increase the carbon dioxide levels (1 mark) to 5500 ppm (1 mark) **not** 6000 ppm. (2 marks)

Respiration

Respiration and life

21 a) Respiration (1 mark)

b) Heat (1 mark)

c) Glucose/sugar (1 mark) and oxygen (1 mark) (any order). (2 marks)

22 a) A = lactic acid (1 mark), B and C = carbon dioxide and water (any order) (2 marks).

b) Complete breakdown of glucose/more energy released (per gram glucose) or provides more energy/more energy is produced or provided. (1 mark)

c) C (1 mark)

The human respiratory system

23 a) i) Balloons (1 mark)

ii) Glass tubing (1 mark)

iii) Plastic sheet (1 mark)

b) The volume in the bell jar increases (1 mark). The pressure in the bell jar decreases (1 mark). This allows the balloons to expand (1 mark). (3 marks)
c) Any one of: the rib cage/bell jar does not move in the model; the lungs are not hollow bags like balloons; the air space around the lungs/balloons is much bigger than in the respiratory system. (1 mark)

**Smoking and health**

24 a) (Giving up smoking) reduces the risk of lung cancer/longer or the sooner you give up, the lower the risk of dying from lung cancer. (1 mark)

b) Helps to make the test fair. (1 mark)

c) Emphysema/heart disease/mouth cancer/throat cancer (1 mark)

d) **Indicative content:** examples from:
   - fewer people smoking
   - smoking bans in public places
   - health warnings on cigarette packets
   - greater awareness of passive smoking
   - greater awareness of dangers of smoking during pregnancy.

(Refer to the QWC mark scheme on pages 108–109 of the Revision Guide to see how this question would be marked.)

**Digestion**

**Food and digestion**

25 a) Glucose ticked; all others crossed. (2 marks for all correct; deduct 1 mark for each mistake) (2 marks)

b) Add iodine solution (1 mark). Blue-black colour indicates starch present (1 mark). (2 marks)

c) It is selectively permeable/lets the same things through as the gut. (1 mark)

d) It is non-living/it does not move the contents around. (1 mark)

26 a) Protein and fats (1 mark). Substances need to be small and soluble (1 mark) to get through the gut wall/to get into the blood (1 mark). (3 marks)

b) Glucose (1 mark)

**The digestive system and enzymes**

27 a) Proteins are broken down into **amino acids** (1 mark).
Carbohydrates are broken down into **glucose** (1 mark).
Fats are broken down into **fatty acids** and glycerol (1 mark). (3 marks)

b) i) Digestion (1 mark)

ii) To allow food substances to pass through the gut wall into the blood or to make food chemicals simple and soluble. (1 mark)
28 a) | Region of digestive system | Enzyme | Action of enzyme |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Stomach</td>
<td>Protease</td>
<td><strong>Digests proteins into amino acids</strong> (1 mark)</td>
</tr>
<tr>
<td>Small intestine</td>
<td>Carbohydrase</td>
<td><strong>Digests starch to glucose</strong></td>
</tr>
<tr>
<td>(1 mark)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pancreas</td>
<td>Lipase</td>
<td><strong>Digests fats into fatty acids and glycerol</strong> (1 mark)</td>
</tr>
</tbody>
</table>

b) i) The liver (1 mark)
ii) The gall bladder (1 mark)
iii) It **emulsifies fats** (1 mark) to give a greater surface area for (lipase) enzymes to work (1 mark). (2 marks)

Biodiversity and the environment

Biodiversity

29 a) i) Their food is obtained from the river/they feed on fish, i.e. link fish and feeding. (1 mark)
ii) Setting up nests/perches (1 mark)
iii) **6000/5 = 1200** (1 mark)

b) i) **32 years** (1 mark)
ii) There has been successful breeding. (1 mark)

Measuring biodiversity

30 a) Area of quadrat = 1 m² (1 mark)
Number of snails = 5 (1 mark)
Number of snails in whole field = 5 × 2000 (1 mark) = 10000 (1 mark) (3 marks)

b) Any two of: the sample area was not chosen at random/David might have chosen an area with lots of snails; the sample area was too small, so it might not represent the whole field accurately; the conditions in the middle of the field might be different from other parts; whenever a sample is taken, the results are never completely accurate. (2 marks)

31 a) Number of snakes = 2 × (100 000/1000) (1 mark)
= 2 × 100 = 200 (1 mark) (2 marks)

b) A: true
B: true
C: true
D: true
(2 marks for all four; 1 mark for any three) (2 marks)
**Biological control**

32 a) A (non-native) species introduced into a country/habitat or an organism introduced into another country/habitat where it is not normally found. (1 mark)

b) Answers relating to a reduction in native plant species due to competition or a reduction in oxygen content in water could kill aquatic insects/fish/plants. (1 mark)

c) Reference to the biological control agents eating/destroying native/other plants/species/introducing disease/weevil preferable as it only eats floating pennywort (1 mark). Reference to biological control agents becoming pests themselves/no native predators so they breed and get out of control/reduce biodiversity (1 mark). (2 marks)

33 **Indicative content:**

- The insect may have no natural predators in the UK and so its population may grow uncontrollably.
- The insect may eat other native species.
- The insect may not be able to survive in the UK.
- The knotweed is widespread so a large population of insects will be required.
- The method will probably be expensive.

(Refer to the QWC mark scheme on pages 108–109 of the Revision Guide to see how this question would be marked.)

**The capture–recapture technique**

34 a) \[ N = \frac{(100 \times 60)}{5} = 1200 \] (1 mark)

b) White paint would make the animal more easily noticed by predators/scientists (1 mark). (2 marks)

c) Snails are not as active/move slower than centipedes (1 mark) and so the marked individuals would need longer to mix with the rest of the population (1 mark). (2 marks)
Atomic structure and the Periodic Table

Atomic structure

1 a) 13 (1 mark)
   b) 27 (1 mark)
   c) 14 (1 mark)
   d) 13 (1 mark). The number of electrons is always equal to the number of protons/atomic number (1 mark).

2 a) 3 (1 mark)
   b) 7 (1 mark)
   c) 1 (1 mark)
   d) Isotopes (1 mark)

Atoms and the Periodic Table

3 a) 18 (1 mark)
   b) 111 (1 mark)
   c) 98 (1 mark)
   d) 106 (1 mark)

4 Boron Magnesium

(1 mark)  (1 mark)

Neon

(1 mark)  (3 marks)
Reactions of the alkali metals and halogens

The alkali metals

5 a) i) (Good) electrical conductor (conductor accepted). (1 mark)
   ii) Low melting point/low boiling point/low density. (1 mark)

   b) Melting point > 0 and < 29, i.e. any positive number below 29 (1 mark).
      Reason: (melting points) decrease down the group so
      must be lower than caesium’s/below 29 (1 mark). (2 marks)

   c) Increases/goes up. (Not erratic/goes up, then down, then up.) (1 mark)

6 a) \(4K + O_2 \rightarrow 2K_2O\) (1 mark for both reactants, K, O;
    1 mark for product, K\(_2\)O;
    1 mark for balancing; reactants and product must be
correct before balancing mark awarded.) (3 marks)

   b) (Stored under/in) oil/liquid paraffin or kept away from air. (1 mark)

   c) Lilac (flame) (1 mark)

7 Put a piece of each metal in water or burn metal in air or oxygen (1 mark).
   Safety precaution, one of: safety glasses/goggles/safety screen/small piece
   of metal/tongs/tweezers to hold (1 mark).
   Expected observations: either in water lithium fizzes/moves on surface,
sodium melts into a ball, potassium gives a (lilac) flame (all three for 2
   marks, any two for 1 mark) or on burning lithium gives red flame, sodium
   yellow-orange and potassium lilac (all three for 2 marks, any two for 1
   mark). (4 marks)

The halogens

8 a) Iodine (or I\(_2\) or I) (1 mark)

   b) 7 (1 mark)

   c) Halogens (1 mark)

9 a) i) Halogen

<table>
<thead>
<tr>
<th>Halogen</th>
<th>Solution of halide ion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sodium chloride</td>
</tr>
<tr>
<td>Bromine, Br(_2)</td>
<td>✗</td>
</tr>
<tr>
<td>Chlorine, Cl(_2)</td>
<td>✗</td>
</tr>
<tr>
<td>Iodine, I(_2)</td>
<td>✗</td>
</tr>
</tbody>
</table>

   (All four correct for 2 marks, any three correct for 1 mark.) (2 marks)

   ii) Br\(_2\) + 2NaI \rightarrow I\(_2\) + 2NaBr (1 mark for products, NaBr, I\(_2\); 1 mark for balancing; products
      must correct before balancing mark awarded.) (2 marks)

   b) i) Yellow-orange (flame) (1 mark)

   ii) Yellow precipitate/yellow solid (1 mark)
Chemical bonding and chemical change

Chemical bonding 1

10 a) Ionic
   b) i) Free moving electrons
   ii) Brittleness

11 a) A and D (both needed for 1 mark) because conduct electricity/high melting point/high boiling point (1 mark).
   b) B (1 mark) because conducts electricity when in solution or molten (1 mark).

Chemical bonding 2

12 A – methane; B – diamond; C – graphite (2 marks for all three correct, 1 mark for any one correct)

13 a) C (1 mark); high melting/boiling point and does not conduct electricity or heat (1 mark).
   b) D (1 mark); low melting/boiling point/density (1 mark).

Smart materials

14 a) Thermochromic paint – changes colour when heated; shape-memory alloy – can regain its original shape; hydrogel – swells up to 1000 times in water (2 marks for all three correct, 1 mark for any one correct).
   b) i) Shape-memory alloy
   ii) Hydrogel

15 a) Similarity: both change colour (1 mark); difference: one responds to light, the other to heat/changes in temperature (1 mark).
   b) Hydrogel/polymer gel
   c) Unsure as to long-term effects on health.

Rate of chemical change 1

16 a) i) 30 cm³
   ii) 3.8–4.0 minutes
   b) 0.4 g
   c) Steeper slope/more gas produced in shorter time (or same time).

17 a) i) 70 cm³
   ii) 54–55 s
   b) Curve beginning at 0 and steeper (1 mark); ending at 120 (1 mark).
Rate of chemical change 2
18 a) Speeds up a reaction (1 mark) but is not used up (during the reaction) (1 mark). (2 marks)

b) i) Suitable axes (1 mark); all points correct +/- 1 square (2 marks)
(1 mark if just one incorrect point); smooth curve through points/best fit (1 mark). (4 marks)

ii) More catalyst = faster reaction (1 mark); maximum rate reached at 2.5 cm³ (of hardener) (1 mark). (2 marks)

iii) Greater/faster (1 mark)

Basic organic chemistry
Fractional distillation
19 a) i) The naptha fraction will have smaller molecules than the light oil fraction. (1 mark)

ii) The naptha fraction will have a lower boiling point than the light oil fraction. (1 mark)

b) The boiling point is so high that it does not form a gas at the temperature of the fractionating column. (1 mark)

c) The molecules contain only hydrogen and carbon. (1 mark)

20 a) 8 tonnes (1 mark)

b) Lubricating oils (1 mark)

c) 9 tonnes (1 mark)

d) Indicative content:
- Crude oil is heated.
- When the boiling point of a chemical is reached, it evaporates.
- Vapour rises up the column and cools.
- It condenses when it reaches its boiling point.
- It is collected at the point of condensation.
- Different fractions have different boiling point (ranges) and so they are separated.

(Refer to the QWC mark scheme on pages 108–109 of the Revision Guide to see how this question would be marked.)

Alkanes and alkenes
21 a) i) Carbon and hydrogen (1 mark)

ii) Ethane (1 mark)

iii) \[ \text{H} - \text{H} - \text{H} - \text{H} \] (1 mark)

b) Ethene (1 mark)
22 a) i) \( \text{C}_3\text{H}_8 \) (1 mark)
   ii) A (1 mark)
   iii) There is a carbon–carbon double bond or there are bonds available for more hydrogen atoms to attach to. (1 mark)

   b) Alkenes (1 mark)
   c) Alkanes (1 mark)
   d) i) Reacting with/adding hydrogen (1 mark)
   ii) Addition reaction/hydrogenation (1 mark)

**Polymerisation and plastics**

23 a)

<table>
<thead>
<tr>
<th>Name of monomer</th>
<th>Structural formula of monomer</th>
<th>Name of polymer</th>
<th>Repeating unit of polymer</th>
</tr>
</thead>
</table>
| Ethene (1 mark) | \[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{C} = \text{C} \\
\text{H} \\
\text{H}
\end{array}
\] | Poly(ethene) or polythene | \[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{H}
\end{array}
\]
| Tetrafluoroethene | \[
\begin{array}{c}
\text{F} \\
\text{F} \\
\text{C} = \text{C} \\
\text{F} \\
\text{F}
\end{array}
\] | Polytetrafluoroethylene (PTFE) | \[
\begin{array}{c}
\text{F} \\
\text{F} \\
\text{C} \\
\text{F} \\
\text{F}
\end{array}
\]
| Vinylchloride | \[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{C} = \text{C} \\
\text{Cl} \\
\text{H} \\
\text{H}
\end{array}
\] | Polyvinylchloride (PVC) | \[
\begin{array}{c}
\text{C} \\
\text{Cl} \\
\text{H} \\
\text{H}
\end{array}
\]

b) Addition (polymerisation) (3 marks)

24 a) Thermoset (1 mark)

   b) The covalent crosslinks are strong bonds (1 mark) which prevent the chains from sliding along one another (1 mark). (2 marks)

   c) Thermosets are resistant to heat (1 mark) and electrical components may get hot (1 mark). (2 marks)
Chemical calculations

Chemical calculations 1

25 a) i) 3.660 – 3.100 = 0.56 (1 mark)
   ii) 4.725 – 3.660 = 1.065 (1 mark)
   iii) Mass Fe = 0.56; 0.56/56 = 0.01
       Mass Cl = 1.065; 1.065/35.5 = 0.03 (1 mark)
       Therefore ratio of 1:3 = FeCl₃ (1 mark)
   b) i) \(M_r (\text{MgO}) = 24 + 16 = 40\) (1 mark)
       \(2\times24\) g of Mg gives \(2\times40\) g of MgO (1 mark)
       12 g Mg gives \(80/4 = 20\) g MgO (1 mark)
       ii) percentage yield = \((18 \times 100)/20\) (1 mark)
           = 90% (1 mark)

Chemical calculations 2

26 a) i) \(436 + 243\) (1 mark) = 679 (1 mark)
      ii) \(2 \times 432\) (1 mark) = 864 (1 mark)

   b) Any one from: (overall) energy change is negative; (overall)
      energy change is \(679 - 864\); (overall) energy change is \(-185\);
      energy needed to break bonds < energy released when
      bonds are formed. (1 mark)

27 \((4 \times 464) + (2 \times 144)\) (1 mark) = 2144 (1 mark)
   \((4 \times 464) + 498\) (1 mark) = 2354 (1 mark)
   2144 – 2354 = -210 (1 mark)

28 a) \(1370 – x = -486\)
    \(x = 1370 + 486 = 1856\) (1 mark)
   b) \(1856/4\) (1 mark) = 464 (1 mark)

Water

Water supply and conservation

29 a) Rivers/lakes/reservoirs (any two) (1 mark)
   b) i) Screening (1 mark)
      ii) Sedimentation (1 mark)
   c) Sand (1 mark)
   d) To kill harmful bacteria (1 mark)

30 a) Rainfall decreased between 2000 and 2011. (1 mark)
   b) The rainfall was not evenly spread throughout the country
      in 2007 or certain areas had very little rainfall (or reverse
      argument). (1 mark)
c) Any three from:
- having a shower rather than a bath
- not using too much water to flush the toilet
- not letting water run unnecessarily
- repairing dripping taps
- collecting rainwater for watering garden or washing car
- watering houseplants with waste washing-up water
- only using washing machine/dishwasher when full
- other reasonable suggestion. (3 marks)

Purification of water and solubility

31 a) A (1 mark)
   b) D (1 mark)
   c) A (1 mark)
   d) D (Saturated solution at 65 °C can dissolve 95 g; at 40 °C it can only dissolve 74 g.) (1 mark)
   e) A (1 mark)

Hard and soft water

32 a) i) Calcium (1 mark)
   ii) Chloride solutions other than calcium do not cause hardness. (1 mark)
   b) i) The thicker the limescale, the more energy is wasted. (1 mark)
   ii) 6% (1 mark)
   c) Calcium and magnesium (contained in hard water) are essential minerals for a healthy diet or calcium needed for healthy bones and teeth or magnesium may help prevent heart disease. (1 mark)

Chemical analysis

Chromatography and spectroscopy

33 a) i) A (1 mark)
   ii) E (1 mark)
   b) Graphite is insoluble in water/most solvents. (1 mark)
   c) Place the paper/chromatogram in water or cut out the three spots, place them on top of each other and add a drop of water. (1 mark)
Physics

Electricity

Simple electrical circuits 1

1  a) Incomplete (1 mark); off (1 mark) (2 marks)
   b) i) A and B (if C identified 0 marks) (1 mark)
      ii) C (only) (if A and/or B identified 0 marks) (1 mark)

2  a) 0.86 A (1 mark)
   b) S₁ on the A line (1 mark); S₂ on the horizontal line between B and C (1 mark) (2 marks)

Simple electrical circuits 2

3  a) \( I = \frac{V}{R} \) (1 mark); \( R = \frac{V}{I} \) (1 mark); resistance = \( \frac{6}{1.2} = 5 \Omega \) (3 marks)
   b) i) Increases (1 mark)
      ii) Decreases (1 mark)

4  a) Varying resistance (1 mark), changing the current/lamp voltage. (1 mark)
   b) i) \( I = \frac{V}{R} \) (1 mark); \( R = \frac{V}{I} \) (1 mark); \( R = \frac{4}{1.6} \) (1 mark) = 2.5 \( \Omega \) (4 marks)
      ii) \( P = I^2 \times R \) (1 mark); \( P = 1.6^2 \times 2.5 \) (1 mark); \( P = 6.4 \) (W) (3 marks)

Motion

Distance, speed and acceleration

5  a) Y (or ‘9’) (1 mark)
   b) Acceleration = change in velocity/time (1 mark) = 27/9 (2 marks)
      (= 3 \( m/s^2 \)) (0 marks for 9/27 = 3 \( m/s^2 \)) (3 marks)

6  a) (The carriage moves at) constant velocity (or steady pace/motion) of 5 \( m/s \). (1 mark)
   b) Acceleration = change in velocity/time (1 mark) = 45/5 (1 mark)
      = 9 \( m/s^2 \) (1 mark) (3 marks)

7  a) Acceleration = change in velocity/time (1 mark);
      change in velocity = \( (23 - 20) \) \( m/s \) (1 mark);
      acceleration = 3/5 (1 mark) = 0.6 (1 mark) \( m/s^2 \) (4 marks)
   b) The distance travelled (1 mark) during overtaking (1 mark). (2 marks)
   c) Distance travelled = area under graph between 10s and 20s.
      Method can involve counting squares, 1 square = 1 m, total distance = \( 215 \pm 2 \) m, or splitting shape into: triangle \( 3 \) \( m/s \) high \times
      10s wide (\( \frac{1}{2} \times \text{base} \times \text{height} = \frac{1}{2} \times 10 \times 3 = 15 \) m) (1 mark) and
      rectangle: 20 \( m \times 10 \) s = 200 \( m \) (1 mark); total distance = 215 \( m \) (1 mark). (3 marks)
Forces, energy and work

The effect of forces 1

8  a) 0.6 s  (1 mark)
   b) 1.8 s  (1 mark)
   c) Velocity  (1 mark)

9  a) i) Momentum = mass × velocity (1 mark)
    = 0.01 × 1000 = 10 (kg m/s) (1 mark)
    ii) Momentum = 10 − 9 = 1 kg m/s  (1 mark)
    iii) \( p = mv; \quad v = \frac{p}{m} \) (1 mark) = 10/0.01 = 100 m/s  (1 mark)

   b) \( v = \frac{p}{m} = 10/1.25 \) (1 mark) = 8 m/s  (1 mark)

The effect of forces 2

10  a) Smaller than  (1 mark)
   b) Equal to  (1 mark)
   c) Gets bigger (1 mark); continues to fall (1 mark)

11  a) i) \((3 \times 2000) = 6000\) N  (1 mark)
    ii) Resultant force upwards or upwards force is greater than the downwards force.  (1 mark)
    iii) \(6000 − 5000 = 1000\) N  (1 mark)
    iv) \( F = ma \) (1 mark); \( a = \frac{F}{m} = 1000/500 \) (1 mark)
      \(= \frac{2}{m} \) s²  (1 mark)

   b) i) \(500 − 20 = 480\) kg  (1 mark)
    ii) \(6000 − 4800 = 1200\) N  (1 mark)
    iii) Acceleration = \(1200/480 = 2.5\) m/s²  (1 mark)

   c) Resultant force increases or \( F/m \) increases (1 mark) because mass decreases/weight decreases/air resistance decreases with height/ gravity decreases with height (1 mark).  (2 marks)

Interactions between objects 1

12  a) Work done = \(2450 + 350 = 2800\) J (1 mark for working or answer)  (1 mark)
   b) Work done = force × distance (1 mark); force = work/distance
      \(= 2800/3.5 \) (1 mark) = 800 N  (1 mark)

13  a) Work done = force × distance (1 mark) = \(15000 \times 4 \)
      \(= 60000\) (1 mark)
   b) Work done = \(1000 \times 50 \) (1 mark) = \(50000\) (1 mark)
   c) i) Total work done = \(60000 + 50000 = 110000\) (1 mark)
      ii) Force = work done/distance (1 mark) = \(110000/50 \)
         \(= 2200\) N  (1 mark)
Interactions between objects 2

14 a) PE = mass \times \text{gravitational field strength} \times \text{change in height} (1\ mark);
\text{increase in potential energy} = 60 \times 10 \times 55 (1\ mark)
= 33\,000\,\text{J} (1\ mark) \quad (3\ marks)
b) i) 33\,000 - 18\,000 = 15\,000\,\text{J} (1\ mark)
ii) KE = \frac{1}{2}mv^2 (1\ mark); 18\,000 = (60 \times \text{speed}^2)/2;
rearrange (1\ mark) to get speed = 24.5\,\text{m/s} (1\ mark) \quad (3\ marks)
c) The weight/gravitational force is greater than (1\ mark) the air resistance (1\ mark).
(2\ marks)
d) i) 0 (1\ mark)
ii) 0 (1\ mark)
iii) 33\,000\,\text{J} (error carried forward from (a) allowed) (1\ mark)

Cars, the Highway Code and collisions

15 a) Time = 12/20 (1\ mark) = 0.6\,s (1\ mark) \quad (2\ marks)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Effect on thinking distance</th>
<th>Effect on braking distance</th>
<th>Effect on overall stopping distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor brakes</td>
<td>No change</td>
<td>Increases</td>
<td>Increases</td>
</tr>
<tr>
<td>Driver under the influence of alcohol</td>
<td>Increases</td>
<td>No change</td>
<td>Increases</td>
</tr>
<tr>
<td>Driver drives at a lower speed</td>
<td>Decreases</td>
<td>Decreases</td>
<td>Decreases</td>
</tr>
<tr>
<td>Wet road</td>
<td>No change</td>
<td>Increases</td>
<td>Increases</td>
</tr>
</tbody>
</table>

(1\ mark for each correct row; equivalent wording accepted e.g. gets more) \quad (3\ marks)

16 a) Indicative content:

- equation, kinetic energy = \frac{1}{2}mv^2, is stated and used to show that the initial kinetic energy is 375\,000\,\text{J}*
- relationship, work done = energy transfer, is stated and applied to the force exerted by the crumple zone and the energy transfer of 375\,000\,\text{J} (error carried forward allowed)
- equation, work = force \times distance, is used with the force of 480\,000\,\text{N} and work done of 375\,000\,\text{J} (error carried forward allowed) and re-arranged to show that the crumple distance is 0.78\,m.

(*The initial kinetic energy does not need to be evaluated explicitly for full marks – the expression \((\frac{1}{2} \times 1200 \times 252)\) can be used throughout.)

(Refer to the QWC mark scheme on pages 108–109 of the Revision Guide to see how this question would be marked.)
b) For crumple zone response, e.g: Work done is the same (1 mark) so if F is larger d would be smaller (1 mark) (or calculation of F needed for 0.6 m crumple zone).

For car mass response, e.g: Less work needs to be done (1 mark) because kinetic energy is lower (1 mark).

(1 mark for a correct and relevant statement of fact; another 1 mark only if a second point is correctly and coherently linked.)

(2 marks)

Radioactive decay, fission and fusion

Radioactive decay

17 a) Paper and aluminium have no effect on the mean count rate. (1 mark)

b) B (1 mark) because it is the only source from which count rate is affected by a piece of paper (1 mark). (2 marks)

c) i) Beta radiation (or electron) emitted (not ‘atom splits’) (1 mark) from the nucleus/to produce a stable nucleus (1 mark). (2 marks)

ii) \[ ^{90}\text{Sr} \rightarrow ^{0}\text{e} + ^{90}\text{Y} \]

\[ A = 90 \text{ (1 mark)}; \ Z = 39 \text{ (1 mark)}; \]

element = Y (yttrium) (1 mark) (3 marks)

Half-life and uses of nuclear radiation

18 a) i) 6 (hours) (1 mark)

ii) 6 hours (1 mark)

iii) 12 hours (1 mark)

b) Alpha is absorbed easily/would not be detected outside the body (1 mark). It is highly ionising/causes damage to (DNA in) cells/tissues/organs (not body) (1 mark). (2 marks)

19 a) Correctly determined points: after 5700 years activity = 32 counts/minute, after 11 400 years activity = 16 counts/minute, after 17 100 years activity = 8 counts/minute (1 mark); accurate plotting (1 mark); smooth line (1 mark). (3 marks)

b) i) C-14 begins to decay (amount decreases). (1 mark)

ii) 4500 +/- 300 years (1 mark) with lines shown on graph or written explanation (1 mark). (2 marks)

Fission and fusion

20 a) i) Hydrogen (1 mark)

ii) Fusion (1 mark)

b) High temperature/energy needed (for particles to overcome repulsive force), but that would melt container (1 mark). High pressure needed, so needs to be very strong containment (1 mark). (2 marks)
21 a) Atomic number of Ba = 56 (1 mark); mass number of Kr = 89 (1 mark).

b) i) Slows down (fast) neutrons. (1 mark)
   ii) Boron (steel) rods raised in/lifted from the reactor/add more fuel/or uranium/increase the number of successful collisions/absorb fewer neutrons. (1 mark)

c) Greater availability of fuel (1 mark); waste material is not/is less radioactive (1 mark); more energy is available from fusion than fission (1 mark). (3 marks)
Science skills

Experimental design and mathematical skills

1 Any two from: same volume of soap solution; same volume of water; same time for shaking. (2 marks)

2 \[ \text{resistance} = \frac{\text{voltage}}{\text{current}} \]

\[ \text{resistance} = \frac{4}{1.6} = 2.5 \Omega \text{ (answer must have units)} \] (1 mark)

3 a) To make sure that no heat was lost to the surroundings. (1 mark)

b) The seeds will need oxygen to survive (1 mark); and cotton wool will let oxygen through/a rubber bung would prevent oxygen getting through (1 mark). (2 marks)

Drawing and using graphs

4 a) 7 am (1 mark)

b) People may be cooking meals. (Just people being at home would not explain this, as it could not account for the drop between 6 and 9 pm.) (1 mark)

5 a) As temperature increases, the amount of starch digested increases, up to 35°C (1 mark). Above 35–45°C, the amount of starch digested decreases (1 mark). (2 marks)

b) The heat is denaturing/destroying the enzyme (1 mark); so that it cannot lock onto the substrate/cannot form enzyme-substrate complexes (1 mark). (2 marks)